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Measurement of Electromagnetic Field Radiation Level in Block 11 Building Site with Proposed Childcare Centre at Central Park Development, Sydney, NSW

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1. Introduction

The proposed new residential development termed Block 11 at Central Park, Sydney will contain a Childcare centre on the 1st floor. The existing part of the two storey building contains a disused pub will be retained and its upper floor will be forming a part of the Childcare Centre.

The purpose of this work was to measure the levels of the radio frequency (RF) electromagnetic field (EMF) within the area allocated for the proposed new residential building that will be containing a childcare centre and to compare the results with permissible exposure limits to RF EMF as specified by the appropriate national and international standards and guidelines.

Several types of mobile phone base stations that are currently in use in Australia operate in the frequencies range from 890 MHz - 960 MHz, 1.8 GHz, 2.1 GHz. Antennas of some of these mobile bases stations might be installed on top of building adjacent to the proposed new Block 11 building.

As part of this work the measurements of power frequency magnetic field were also conducted within the area and the results summarised in this report. The power frequency magnetic fields are produced as a result of the electric current passing through wires, cables, switchboards, transformers, motors, etc.

2. Background Information

In Australia, the largest digital mobile communication service operates in the frequency range of 890-960 MHz. However, there are also services and equipment that operate in the range of 1710-1880 MHz and in more resent times some services that operate in the range of 1920– 2170 MHz.

Concerns about human health effects from the exposure to RF signals from hand-held cellular phones exist because the antennas of these phones can deliver large amounts of RF energy to very small areas of the user's body. The Base Stations and their antennas, however, are usually located far away from users of the mobile phones, so the potential safety issues concerning the mobile phones usually less applicable to the base stations. Antennas of the mobile phones and base stations are the main sources of RF emission from this type of equipment.

The radio waves from some transmitters, particularly from FM and VHF-TV broadcasting stations, are absorbed more by humans than the radio waves from the sources such as mobile phone or mobile phone base stations as they operate in different spectrum of frequencies. The frequency is the rate at which the electromagnetic field changes direction and is measured in Hertz (Hz), where 1 Hz is one cycle (change in direction) per second, and 1 MegaHertz (MHz) is one million cycles per second. In addition, FM and TV transmitters are 100 to 5000 times more powerful than base station antennas.

Antennas of mobile phones and their base stations produce radio-frequency radiation. This RF radiation is "non-ionising", and its biological effects are fundamentally different from the "ionising" radiation produced by x-ray machines.

The interaction of biological material with an electromagnetic source depends on the frequency of the source. X-rays, radio waves and "EMF" from power lines are all part of the electromagnetic spectrum and each is characterised by its own frequency.

Electric power supply systems in Australia are operating at frequency of 50 Hz. AM radio has a frequency of around 1 MHz, FM radio has a frequency of around 100 MHz, microwave ovens have a frequency of 2450 MHz, and X-rays have frequencies above one million MHz.

X-rays damage the genetic material of cells as the electromagnetic particles have sufficient energy to break chemical bonds and cause ionisation, potentially leading to some pathological changes such as cancer or birth defects. At lower frequencies, such as radio waves, the energy of the particles is much too low to break chemical bonds and, therefore, the radio waves are "non-ionising".

2.1 Exposure Standards

There are safety guidelines for human exposure to the RF radiation produced by cellular phone and base station antennas. The most widely accepted standards are those developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

The standard specifies the *exposure* limits to RF radiation that regulate the rate at which the electromagnetic field energy is absorbed by human body. This is known as the specific absorption rate (SAR).

The SAR limit for all the mobile phones types, cordless phones and satellite phone handsets for sale in Australia is 1.6 watts per kilogram (averaged over 1 gram).

The basic parameter used in setting the limits is the lowest RF exposure level, confirmed by independent laboratory studies that show adverse biological effects in animals due to such exposure.

This biological effect was found to occur as a rise in body temperature by 1° C during the exposure. This is measured as Specific Absorption Rate (SAR). SAR is the rate at which RF energy is absorbed by a specified mass of biological tissue. The measurement is expressed in watts per kilogram (W/kg).

However, SAR cannot be easily and readily measured. Therefore, the RF exposure limits are expressed in so called *reference levels*. These are expressed in "unperturbed RMS field strength in V/m (volt per metre) and A/m (amps per metre)" for measurements very close to the sources and "plane wave power density measured in mW/cm^2 (milliwatts per square centimetre)" for measurements sufficiently far from the source.

In 1998 the International Commission on Non-Ionising Radiation Protection (ICNIPR) issued the “Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)”. In the guidelines the safe exposure limits to RF radiation in the frequency range:

<u>400-2000 MHz:</u>

For general public

E-field = $1.375 \cdot f^{0.5}$ V/m, H-field = $0.0037 \cdot f^{0.5}$ A/m, Power density = $f/200$ W/m^2

For occupational exposure

E-field = $3 \cdot f^{0.5}$ V/m, H-field = $0.008 \cdot f^{0.5}$ A/m, Power density = $f/40$ W/m^2

where: *f* is frequency in MHz.

<u>2 – 300 GHz:</u>

For general public

E-field = 61 V/m, H-field = 0.16 A/m, Power density = *1*0 W/m^2

For occupational exposure

E-field = 137 V/m, H-field = 0.36 A/m, Power density = *50* W/m^2

The Australian RF Exposure Standard specifies the same exposure limits.

It should be noted that the mandatory standard that was enforced in 1984 in the former USSR for the RF exposure limit for general public is much more stringent. For the RF frequency range of 300-300000 MHz the standard sets the exposure limit of 0.01 mW/cm^2 (0.1 W/m^2).

The public exposure standards apply to the power densities averaged over relatively short periods to time. Where there are multiple antennas, these standards apply to the total power produced by all antennas.

It should also be noted that performance of some bio-medical implants such as pacemakers and defibrillators can be affected by RF fields. The effects of RF fields on these devices are not covered by the exposure standards.

2.2 Cell Phone Base Stations

Exposure to radio waves can be hazardous if the exposure is sufficiently intense. Possible injuries include cataracts, skin burns, deep burns, heat exhaustion and heat stroke. Biological effects of exposure to RF are proportional to the rate of energy absorption.

A low-gain cellular base station antenna, mounted 10m or more off the ground and operated at the maximum possible intensity, may produce a power density as high as 0.02 mW/cm^2 on the ground near the antenna site; but ground level power densities will more often be in the 0.0001 to 0.005 mW/cm^2. These power densities are below the ICNIRP safe exposure limit, and the safety limit itself was set far below the level where potentially hazardous effects have been observed.

Within about 150m of the base of the antenna site, the power density may be greater at elevations above the base of the antenna site (for example, at the second floor of a building or on a hill). Even with multiple antennas on the same building or a tower, power densities will be less than 2% of the guidelines at all heights and at all distances of more than 50m away from an antenna site. Further than about 150m from the antenna site power density does not rise with increased elevation.

Reported in technical literature power densities measured around cell phone base stations show that for the 1600 W low-gain antennas on towers that ranged from 40 to 75 m in height, the maximum power density on the ground was 0.002 mW/cm^2, and the maximum was measured at 15-75m distance from the base of the towers. Within 100m of the base of the towers, the average power density was less than 0.001 mW/cm^2.

Generally, base station antennas are mounted on a 15 to 50 metre high tower, or on rooftops. These antennas typically emit a fan-shaped beam of RF that is roughly parallel to the ground.

Because of the narrow vertical spread of the beam, the RF field intensity on the ground directly below the antennas is low: at points where the public is likely to be exposed, emissions are usually 10,000 times below the level at which significant heating can occur.

There are some circumstances under which an improperly designed cellular phone and base station antenna could violate safety standards. Safety standards for uncontrolled (public) exposure could be violated if antennas were mounted in such a way that the public could gain access to areas within 10m (horizontal) of the antennas themselves. This could arise for antennas mounted on, or near, the roofs of buildings.

3. Frequency Band for Mobile Telecommunication Services in Australia

The frequency band allocated in Australia for the digital mobile communication service, known as GSM service, is as follows:

. GSM mobile transmit band (mobile hand sets)
- Telstra 890.0-898.4 MHz
- Optus 898.5-906.8 MHz
- Vodafone 906.9-915.0 MHz

. GSM mobile base transmit band (base station transmitter)
- Telstra 935.0-943.4 MHz
- Optus 943.5-951.8 MHz
- Vodafone 951.8-960.0 MHz

The separation between 'send' and 'receive' frequencies is 45 MHz.

4. Electromagnetic Field Measurements

The RF radiation measurements were conducted in all locations around the proposed Block 11 development site.

A floor plan with marking the area of the building proposed for the Childcare Centre is shown in Fig.1 below.

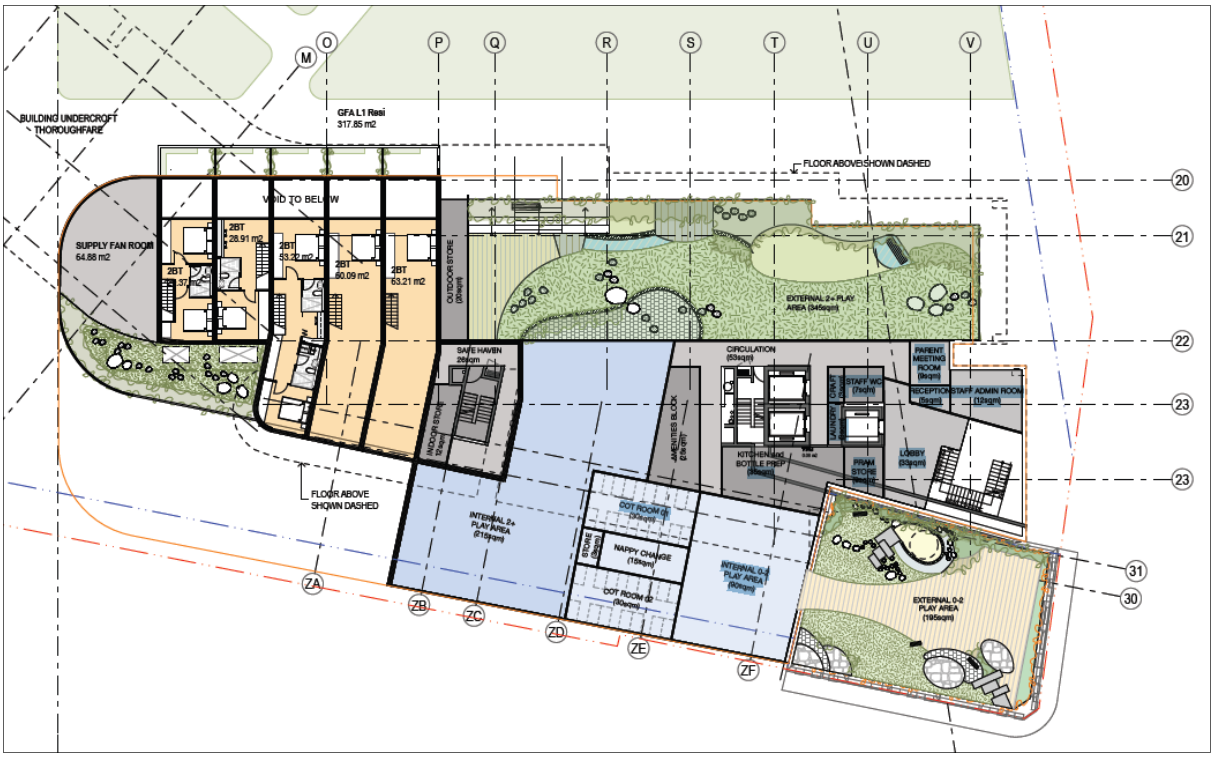

Fig.1 Part of Block 11 development site with proposed Childcare Centre

The meter that was used during the measurements was Narda RF Field Strength Meter, Model number NBM-550 fitted with EF0391 E-Field probe.

The basic specification of the meter is as follows:

Frequency range:	100kHz –3000 MHz
Frequency Accuracy:	± 3PPM
Result Units:	mW/cm2, W/m2, V/m, A/m, % of Standard
Display Range, Fixed Triads:	0.0001 to 9999 for all units (4 digits)
Display Range, Variable Triads:	0.01 V/m to 100 kV/m, 0.027 mA/m to 265.3 A/m, 0.265 $\mu W/m^2$ to 26.53 MW/m^2, 0.027 nW/cm^2 to 2.653 kW/cm^2, 0.0001% to 9999%
Result Types (Isotropic, RSS):	Actual (ACT), Maximum (MAX), Minimum (MIN), Average (AVG), Maximum Average (MAX AVG)
Result Types (X-Y-Z mode):	Actual X, Actual Y, Actual Z (requires a probe with separate axes)
Averaging Time:	Selectable, 4 seconds to 30 minutes (2 second steps)
Spatial Averaging:	Discrete or continuously
Antenna:	suitable for 800-2100 MHz cellular band.

The meter and its antenna have been calibrated by Narda Safety Test Solutions GmbH on the 19th of March 2014.

This meter is specifically designed for assessment of the RF radiation levels from various sources when assessing the level of human exposure to the RF fields from such sources.

RF emission measurements were made in all locations around the entire perimeter of the building site.

The measurements were made with the RF probe held at 0.5m, 1m and 1.5m height above the ground.

The results of the measurements are summarised below in units of W/m^2 and V/m:

- The maximum recorded RF level was 0.001 W/m^2 (1.0 V/m).
- The average of RF levels in other parts of the floor was 0.0006 – 0.0012 W/m^2 (0.5 – 0.7 V/m).

In accordance with ICNIRP guidelines, the limit of RF EMF exposure to 900 MHz, 1800 MHz and 2000 MHz are as follows:

For occupational exposure:

900 MHz	90.0 V/m
1800 MHz	127.3 V/m
2000 MHz	134.2 V/m

For general public

900 MHz	41.3 V/m
1800 MHz	58.3 V/m
2000 MHz	61.5 V/m

As can be seen, the results in the table are well below both, the occupational and general public RF EMF exposure limits.

The power frequency magnetic field measurements were carried out using HMI-1 EMF Survey Meter.

The HMI-1 meter has the following technical specification:

Number of axes	3
Measuring range	0.1-6000mG
Resolution	0.1mG
Accuracy Error	±(2% + 1 digit)
Frequency Response	50-1000Hz
Calibration Frequency	50Hz
Measurement type	true RMS

Calibration date: 17 February 2014

The EMF meter is equipped with three orthogonally oriented sensors to measure and display the root-mean-square (r.m.s.) value of the low frequency magnetic flux density in units of *milliGauss (mG)*. The meter measures and displays, in milliGauss, the r.m.s. value of each of the three vector components of the magnetic flux density.

The measurements were made around the perimeter of the building site with the hand-held meter was held at 1m above the floor or placed on the floor.

The results of the measurements are summarised below in units of milliGauss (mG):

- The maximum recorded low frequency EMF was 3 mG measured on the footpath closest to the existing 2 storey building housing a disused pub at the corner of Kensington and Wellington Streets.
- The EMF levels in other parts of the site were between 0.0 mG and 0.5 mG when

measured at 1m height above the ground

The two identified sources of EMF that were responsible for creating such EMF are an underground electrical cable and overhead aerial bunled conductors of LV power line that supplying the electric power to all residential and commercial tenancies along the street.

Both, the underground cable and the overhead line are located on the opposite side of Wellington Street in respect to the Block 11 building site.

In 2010 ICNERP released an updated set of guidelines containing a new set of permissible occupational and general public exposure limits to time-varying electric and magnetic fields.

In accordance with this new guidelines the maximum safe EMF exposure limit at the power frequency of 50Hz for the general public is 200μT or 2000 mG.

The principal limitation of the guidelines is stated in the "BASIS FOR LIMITING EXPOSURE" section as follows:

> *Induction of cancer from long-term EMF exposure was not considered to be established, and so these guidelines are based on short-term immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures resulting from absorption of energy during exposure to EMF.*

The guidelines further state that:

> *In the case of potential long-term effects of exposure, such as an increased risk of cancer, ICNIRP concluded that available data are insufficient to provide basis for setting exposure restrictions, although epidemiological research has provided suggestive, but unconvincing, evidence of an association between possible carcinogenic effects and exposure at levels of 50/60 Hz magnetic flux densities substantially lower than those recommended in these guidelines.*

Early in 2001 the Advisory Group on Non-Ionising Radiation (AGNIR) to the UK National Radiological Protection Board has published a report on power frequency electromagnetic fields and the risk of cancer.

In assessing the results of all Residential Exposure studies conducted around the world the report states that:

> *"… relatively heavy average exposure of 0.4 μT* (4 mG) *or more are associated with doubling of the risk of leukaemia in children under 15 years of age. The evidence, however, is not conclusive."*

The main conclusion of the report is:

> *"Laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general. There is, however, some epidemiological evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in children. In practice, such levels of exposure are seldom encountered by the general public in the UK. In the absence of clear evidence of a carcinogenic effect in adults, or of a plausible explanation from experiments on animals or isolated cells, the epidemiological evidence is currently not strong enough to justify a firm conclusion that such fields cause leukaemia in children. Unless, however, further research indicates that the finding is due to chance or some currently unrecognised artefact, the possibility remains that intense and prolonged exposure to magnetic fields can increase the risk of leukaemia in children."*

5. Conclusions and Recommendations

In all locations within the proposed area for the Childcare Centre in Block 11 of the proposed building site the measured RF was well below the permissible limit for occupational and general public exposure as set out in the ICNIRP exposure guidelines and in the Australian standard for safe RF exposure.

Notwithstanding the fact that the measured RF EMFs are well below the recommended safe exposure limit, we recommend that during the construction of the Childcare Centre all walls, including the stud walls that would be constructed to sub-divide the area into smaller rooms, should be internally lined with aluminium backed Sisalation Heavy Duty Foil (450), 1200mm wide. The same Sisalation paper should be installed on the ceiling and on the floor (below the carpet) of the Childcare centre. Due to the presence of aluminium foil in the Sasilation paper (thicker layer of aluminium is in the Heavy Duty paper), this aluminium foil can act as mild shielding medium to the RF radiation.

In respect to the power frequency EMF detected at 1m above the ground along Wellington Street boundary of the construction site, it should be noted that the EMF on the 1st floor of the new building could be somewhat larger than the level measured at the street level. This is because one of the two sources of such EMF is an overhead low voltage aerial bundled cable installed on poles on the opposite side of the street. However, the EMF on Level 1 of the building will still be within the acceptable safe limit for exposure to children and staff of the proposed Childcare Centre.