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## **MEASUREMENT AND ANALYSIS OF RF EME LEVELS FROM MOBILE TELEPHONE BASE STATIONS LOCATED AT LEICHHARDT, NSW**

### **INTRODUCTION**

The Electromagnetic Energy Public Health Issues Committee requested the Australian Radiation Laboratory to measure the exposure levels of radiofrequency (RF) electromagnetic energy (EME) radiated from mobile telephone base stations as part of the public information component of the RF EME program. Local Governments were asked to nominate mobile telephone base stations at two sites per capital city, which were of concern to local communities. The intent of the measurements was to determine if the level of RF EME over the frequency band 870 megahertz (MHz) to 960 MHz around a nominated site complied with the public exposure limit of 200 microwatt per centimetre squared ( $\mu\text{W}/\text{cm}^2$ ) recommended by the Australian Standard AS/NZS 2772.1(Int) - 1998<sup>1</sup>.

This report details the measurements made at the Leichhardt Council Building and five other locations throughout the city of Leichhardt. Leichhardt Council requested that measurements be made to determine the level of RF EME within their city boundaries, which were produced by mobile telephone base stations. While there were locations of particular concern, no particular base was singled out for extensive measurement and analysis. The signals measured were from digital (GSM) and analog (AMPS) mobile telephone base stations, which operate within the frequency band 935 MHz to 960 MHz and 870 MHz to 890 MHz respectively.

## MEASUREMENT METHOD

The method of measurement is detailed in the Appendix. In brief, three separate measurements were performed. These were:

- RF EME signals from mobile telephone base stations as well as all other significant signals from such sources as TV, FM radio and AM radio were measured. This measurement was performed on top the council building in Wetherill St., Leichhardt and is referred to as the environmental RF EME levels;
- measurement of all base station signals conducted over a 24 hour period. This was performed on top of the council building, and;
- measurement of RF EME base station signals at five specific sites within the city.

## SURVEY RESULTS

Graphs displaying the measured levels are shown at the rear of the report. The graphs depict the following:

Figure 1. Pie chart of all significant environmental RF EME levels including base station signals;

Figure 2. Variation of AMPS RF EME levels over a 24 hour period; and

Figure 3. Variation of GSM RF EME levels over a 24 hour period.

### Specific Site RF EME Levels ( Total of GSM and AMPS signals)

Site Location	RF EME Level ( $\mu\text{W}/\text{cm}^2$ )
94 Darling, St Balmain	0.000004
Alongside Balmain Town Hall	0.027
Driveway into Sydney College of The Arts	0.000013
Piper St, South Annandale	0.000075
79 John St, Ultimo	0.007

## **ENVIRONMENTAL RF EME LEVELS AT LEICHHARDT**

Most RF signals at Leichhardt are present throughout the day and come from a variety of communication sources including FM radio, AM radio, television and other broadcast services.

The dominant signal at Leichhardt came from AM radio transmitter antennae located in the region. The AM radio signals at the monitoring site contributed 86.17% (refer Figure 1) of the total RF EME level of  $0.084 \mu\text{W}/\text{cm}^2$ , while the sum of all base station EME levels was  $0.002 \mu\text{W}/\text{cm}^2$  or 2.38% of the total. RF EME levels have significant variations over short distances due to reflections from buildings and the ground. Hence, the ratio of signal levels from all sources can be expected to change as a consequence of local conditions. However, it is reasonable to assume that if a measurement of RF EME from all sources was made at other locations around Leichhardt, AM radio signals would still contribute the greatest proportion. AM radio signals have a long wave length and are therefore poorly absorbed by the human body. The GSM and AMPS base station signals present at the time of the measurement were only 2.38% of the total signal. The FM radio, VHF TV and UHF TV (to a lesser extent) signals are more readily absorbed by the body than both AM radio and mobile phone frequencies and total 11.25% of the total RF EME at the survey site.

## **RF EME EXPOSURE LEVELS AT SPECIFIC SITES**

The highest level of RF EME found at any of the five sites was  $0.027 \mu\text{W}/\text{cm}^2$  or 0.0135% of the AS/NZS 2772.1 public limit. This was found alongside the Balmain Town Hall at the entrance driveway to a child care centre and was opposite a base station which is located behind buildings on the other side of Darling Rd.

Figures 2 and 3 indicate how the telephone activity of the base stations vary over a 24 hour period. The measurement was performed by continually measuring the number and level of base station signals over a 24 hour period. The levels shown in Figure 2 for AMPS and Figure 3 for GSM signals were the average for the day. The GSM signals varied from a minimum of  $0.0005 \mu\text{W}/\text{cm}^2$  to a maximum of  $0.0013 \mu\text{W}/\text{cm}^2$ . The AMPS signals varied from a minimum of  $0.0002$  to a maximum of  $0.0028 \mu\text{W}/\text{cm}^2$ . The 24 hour measurement was performed on the top of the council building where there was line-of-sight to nearby base stations, consequently the level could be anticipated to be higher than that measured at street level. Depending on the

building cladding, RF EME levels within buildings could be reduced by as much as 1000.

## **CONCLUSION**

The highest level of RF EME from a base station when measured in the streets of Leichhardt was  $0.027 \mu\text{W}/\text{cm}^2$ , a level 7,400 less than the maximum limit permitted by AS/NZS 2772.1 (Int) - 1998 for members of the general public. Measurements of overall RF EME from all sources indicate that base station signals make a small contribution to the total RF EME level, with the largest contribution coming from TV and AM radio transmissions which service the population of Sydney.

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EMR and Optical Radiation Group

24 March 1998

## **REFERENCE**

(1) AS/NZS 2772.1(Int)-1998, " Radiofrequency fields Part 1: Maximum Exposure Levels - 3 kHz to 300 GHz" Standards Australia.

## **ACKNOWLEDGEMENTS**

Wayne Cornelius developed the control, logging and analysis software for this project.

Monica Grollo performed many of the tests which trialed the measurement procedures and helped with the data analysis.

# APPENDIX 1

## Method of RF EME Measurement around Mobile Telephone Base Stations

### 1. Equipment

All measurements were made with a Tektronix model 2712 spectrum analyser. This equipment functions as a sophisticated radio receiver, which allows each received radio signal to be analysed, allowing the accurate measurement of magnitude and frequency<sup>1</sup>. Recording of data from the spectrum analyser was performed by a lap-top personal computer (PC) which has a PCMCIA-GPIB communication card connection with the analyser. The PC controls the operation of the analyser and records all relevant data. The PC also logged position information derived from a Global Positioning System (GPS) receiver operating in differential mode. Signals measured by the analyser over the bands of interest were received by the following antenna:

- *Low frequency signals* (AM radio); loop antenna;  
EMCO model 6502 active loop, frequency response: 0.01 MHz - 30 MHz.
- *Very High Frequencies* (FM radio and TV); bi-conical antenna;  
A.H. Systems model SAS 200/541, frequency response: 20 - 320 MHz.
- *Ultra High Frequency* (UHF TV, mobile telephone); log periodic antenna  
A.H. Systems model SAS 200/510, frequency response: 300 MHz - 1000 MHz.
- *Mobile phone frequencies*; magnetic base vehicle roof mount antenna;  
supplied by Telstra Shop, frequency response: 870 MHz - 960 MHz.

Each antenna is calibrated to determine its receiving performance - this factor (gain) is used for the calculations of RF EME. The overall uncertainty of the measurements is estimated to be +/- 6dB.

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<sup>1</sup> The spectrum analyser measures the level of received signal in the power unit dBm. Calculation of field strength and hence power density requires a knowledge of the receiving antenna properties and system losses. Power density is commonly expressed in the unit of microwatt per centimetre squared ( $\mu\text{W}/\text{cm}^2$ ) and is calculated using the electric field strength and assumes far field conditions where the wave impedance is 377 ohms.

## 2. Environmental Measurements

The environmental levels of RF EME were measured according to the following protocol:

- All signals with power densities greater than 1% of the observed maximum for each frequency band were recorded individually.
- Paging system signals at VHF and UHF frequencies signals are intermittent, of short duration and with numerous close spaced narrow band carrier signals. Therefore, such signals were measured when observed and recorded if greater than 1% of the highest broadcast signal source. The sum of power densities in each frequency band were reported.
- Other signals, such as emergency services (police, ambulance etc.) and taxis, were recorded when observed.
- If possible, measurements were made in locations that maintain direct line-of-sight with known RF sources, at a height of approximately 1.7 m above ground. Where practical, measurement antennae were positioned in open areas away from likely sources of reflection. Antennas were positioned and oriented so as to obtain maximum signal strength for the particular frequency band being measured.

The above signals were measured during the day over a period of approximately one hour, at a location within 500 m of the base station.

### **3. Mobile Telephone Base Station RF EME Measurements**

24 hour measurements were used to determine the exposure levels from all mobile telephone services operating in the vicinity of the nominated location. This measurement was performed by continuously logging the signal data for both AMPS and GSM mobile phone systems that comes from only one transmitting antenna. The recorded data was used to determine time dependent “activity factors” for both AMPS and GSM systems over a 24 hour period. Activity factors are determined by counting the number of active time slots for the GSM network and the number of channels present for the AMPS network. (Note: GSM has a minimum of eight time slots and a maximum of 32, whereas AMPS has a minimum of one channel and a maximum of 32 channels (full capacity) for a given sector). These measurements were performed by the analyser continuously scanning across the mobile telephone frequency band; the number of scans is dependant on the number of signals present in the band. The “activity factors” are the average of the scans performed over a six minute period; higher “activity factors” may occur over a shorter period.

Analysing software processed only the signals identified as belonging to the base station in question.

### **4. Street Mapping of Power Density**

Where required, additional measurements but necessarily of limited nature, were made in the vicinity of the base station to determine the RF EME distribution in the streets around the base station. The average activity factor for the 24 hour activity measurement was applied to these additional AMPS and GSM measurements for a better assessment of the daily levels at each survey location in the mapping area. This information is presented as a map. The measurement was performed by equipment installed in a vehicle which recorded both signal data and position information. The received signals tracked by the equipment were the control channels identified as belonging to the base station in question.

# Environmental RF EME Levels

Leichhardt Council Building roof

**Total RF EMR:  
0.084 microwatt  
per centimetre**

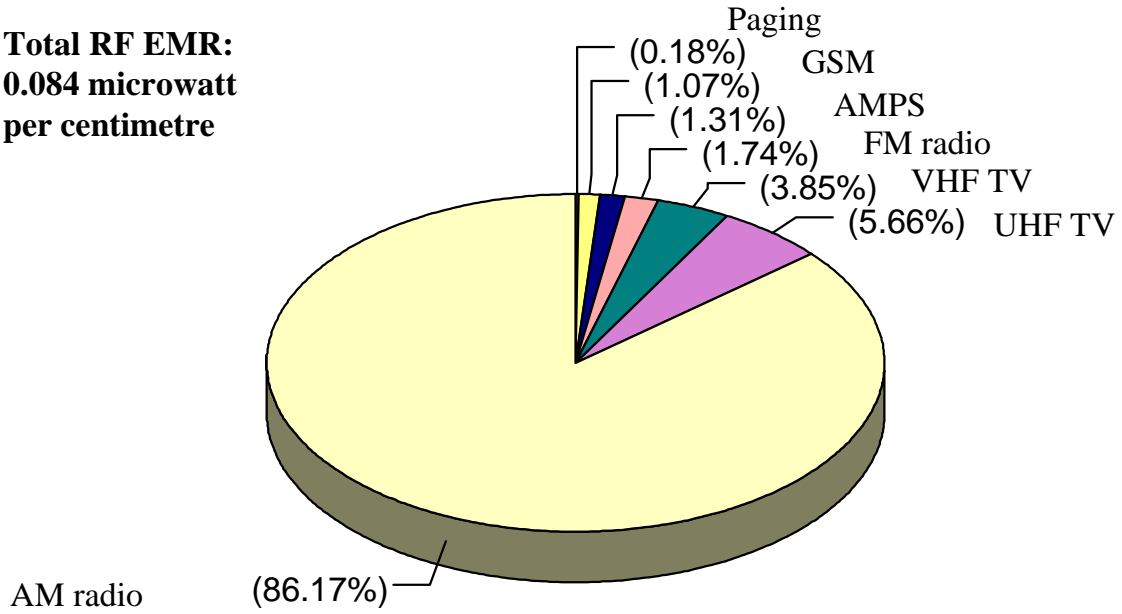


Figure 1

## Activity of AMPS Base Stations

Leichhardt Council Building roof top

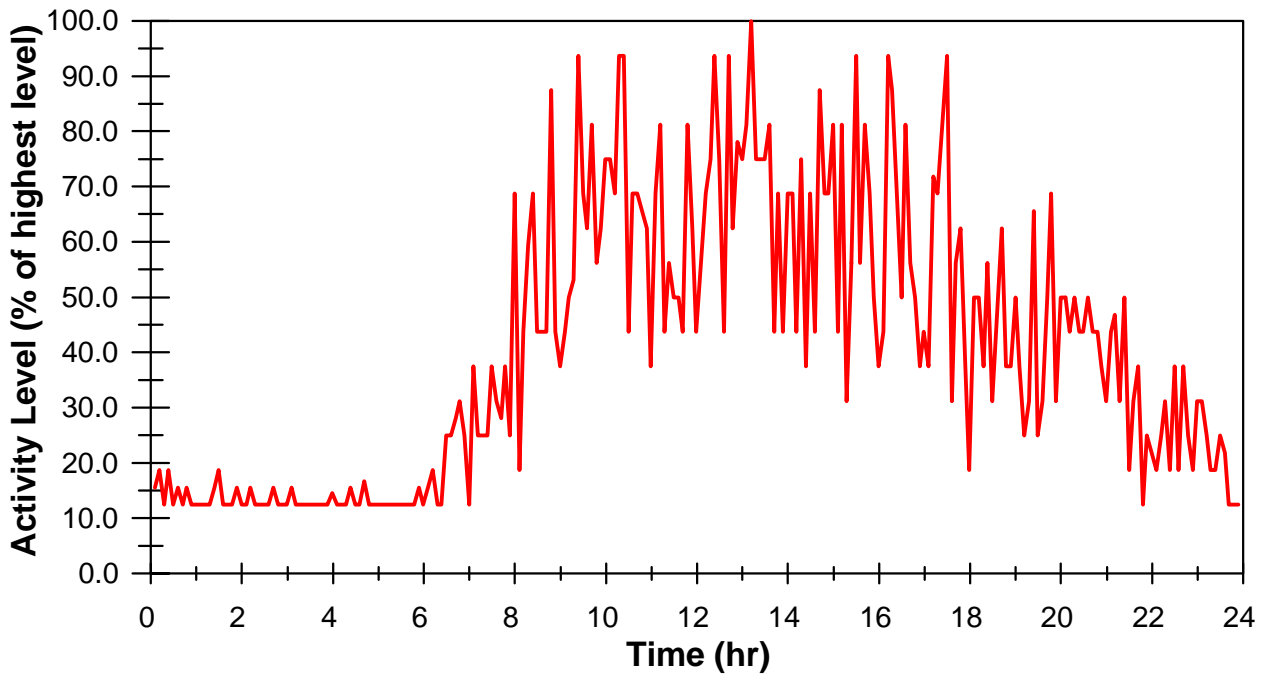


Figure 2

# Activity of GSM Base Stations

Leichhardt Council Building Roof

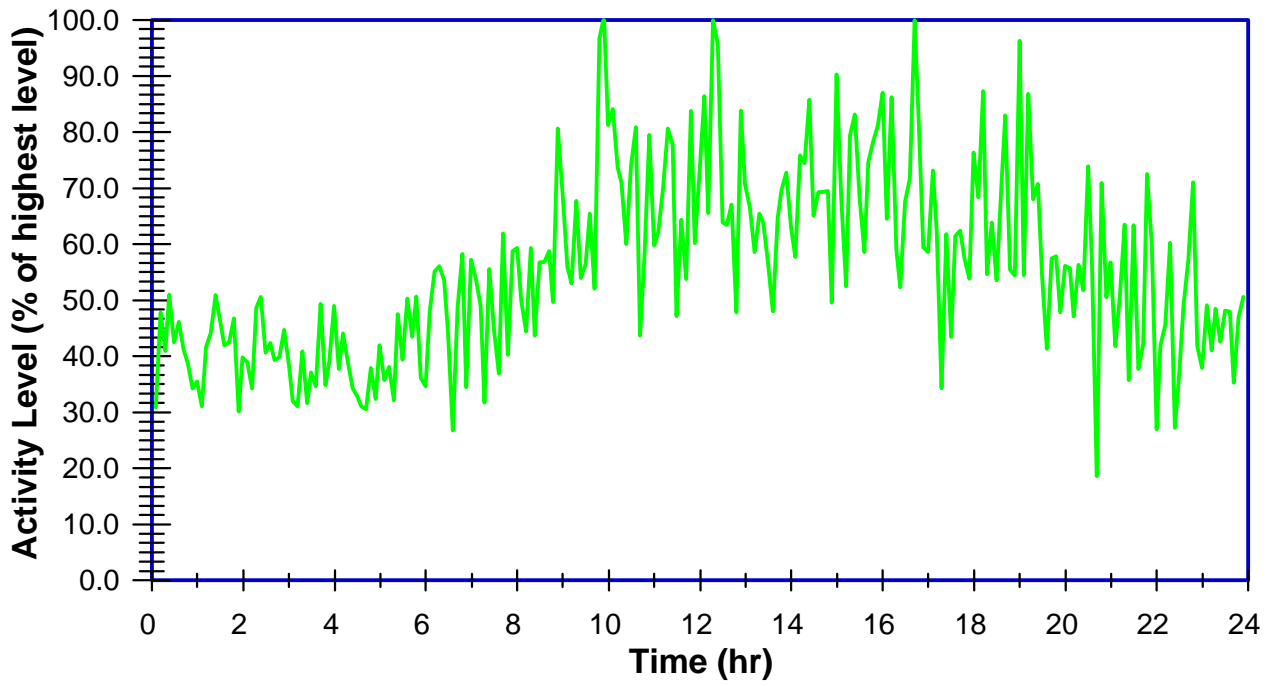


Figure 3