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MEASUREMENT AND ANALYSIS OF RF EME LEVELS FROM THE OPTUS MOBILE TELEPHONE BASE STATION LOCATED AT PALMERSTON, NORTHERN TERRITORY

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 ($\mu W/cm^2$) recommended by the Australian Standard AS/NZS 2772.1(Int) - 1998[1] .

This report details the measurements made around an Optus mobile telephone base station situated alongside University Avenue, Palmerston, N.T., adjacent to the local business centre. This base station was nominated by the Palmerston Council. The base station antennae on this site are omni-directional and not the more common panel antennae which divide the area around a base station into three sectors. The antennae are on a 40 metre tower which is co-located with large satellite communication antennae. The signals radiated are for digital mobile telephone base stations (GSM) and operate within the frequency band 935 MHz to 960 MHz.

MEASUREMENT METHOD

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

- mobile telephone base stations as well as all other significant RF EME signals from such sources as TV, FM radio and AM radio were measured. This measurement was performed adjacent to the Palmerston Council building car park and is referred to as the environmental RF EME levels;
- measurement of the base station signals conducted over a 24 hour period. This measurement was performed on top of the Palmerston Council building; and
- mapping the strength of signals radiated from the base station along the major roads surrounding the base station.

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 EME level over a 24 hour period; and
Figure 3. Colour coded map of Palmerston showing the level of base station signals along the main roads.

ENVIRONMENTAL RF EME LEVELS AT PALMERSTON

Most RF signals around Palmerston are present throughout the day and come from a variety of communication sources including FM radio, television and other broadcast services. The dominant signal in Palmerston came from two commercial FM radio transmitter antennae mounted on top of the water storage tank located in the centre of the Palmerston shopping centre. The FM radio signals at the monitoring site contributed 92.5% (refer Figure 1) of the total RF EME level of 0.028 $\mu W/cm^2$, while the sum of all GSM base station EME levels was 0.00027 $\mu W/cm^2$, or 0.94% 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 Palmerston, FM radio signals would still contribute the greatest proportion. The combined RF EME was more than 7,000 times less than the AS/NZS2772.1 limit of 200 $\mu W/cm^2$.

RF EME EXPOSURE LEVELS FROM OPTUS TOWER

The highest level of RF EME from the Optus base station around the tower at Palmerston was 0.0072 $\mu W/cm^2$ or 0.0036% of the AS/NZS 2772.1 public limit. This was found on the Stuart Highway near the intersection of University Avenue, at a distance of 500 m from the tower. The highest level in a residential area was 0.0033 $\mu W/cm^2$, with an average over the surveyed area of 0.00051 $\mu W/cm^2$. The RF levels fell away by a factor of 1000 at a distance of approximately 2 km. Similar lower levels were found in sheltered land depressions as a consequence of loss of line-of-sight transmission.

Figure 2 indicates how the telephone activity of the base station varies over a 24 hour period. At 100% activity, the base station is handling the absolute maximum capacity that any base station can provide. This requires four transmitters to deliver full power into the antennae and allows the maximum number of telephone calls to be handled and is operating at 100% activity. Not all base stations have four transmitters, but four is used as a maximum should further traffic demands require them. The minimum operation of a base station requires one transmitter to be in operation and operates at full power even when not handling any calls and is indicated as 25% on the graph. This usually occurs after midnight on most sites. As more people use the network, additional transmitters are turned on, with each allowing up to eight simultaneous telephone calls. With the digital network (GSM), voice communication occurs through the sequential transmission of brief packets of digital data. RF EME emission levels are therefore proportional to the activity of the base station. At Palmerston, the maximum activity occurred during the period 7.00 am to 8.00 pm. At the highest activity level of the Palmerston base station, the resulting RF EME levels were approximately double the minimum activity; when averaged over 24 hr the activity was 37% of full capacity. However, it is possible to operate four transmitters at busy base stations, and so a four fold change in RF EME levels may occur as a consequence

of variation in telephone traffic during the day.

The accompanying map ARF EME LEVELS@ (Figure 3) shows the average RF EME levels on a colour coded map. The highest signal levels are indicated by the larger coloured circles, while progressively smaller circles indicate decreasing levels.

CONCLUSION

The highest level of RF EME from the Optus tower when measured in the streets of Palmerston was 0.0072 $\mu W/cm^2$, a level 28,000 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 the Optus base station only adds slightly to the total RF EME level, with the largest contribution coming from the two FM radio transmitting antenna which are located on the water tank in the Palmerston central business district. Even though the total FM radio transmitter power is approximately 1000 times greater than the base station, the FM station's RF EME level near the base of the tank was low and of the order of 0.5 $\mu W/cm^2$.

Michael Bangay
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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 the 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 [1]. 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.

[1] 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 ($\mu W/cm^2$) 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

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

Palmerston Council carpark

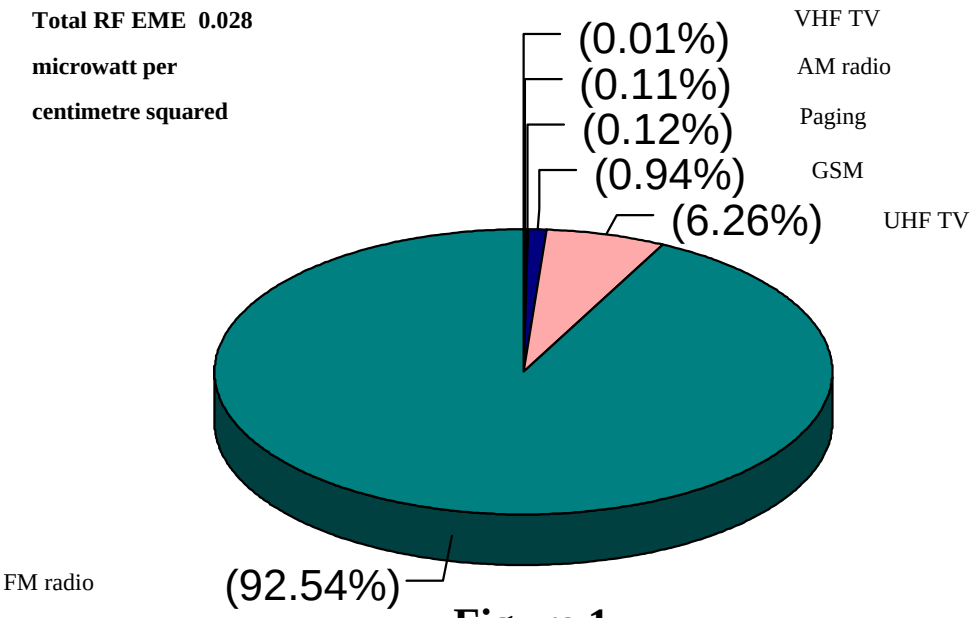

Figure 1

24 hour Activity Level of Base Station

Palmerston Council Building rooftop

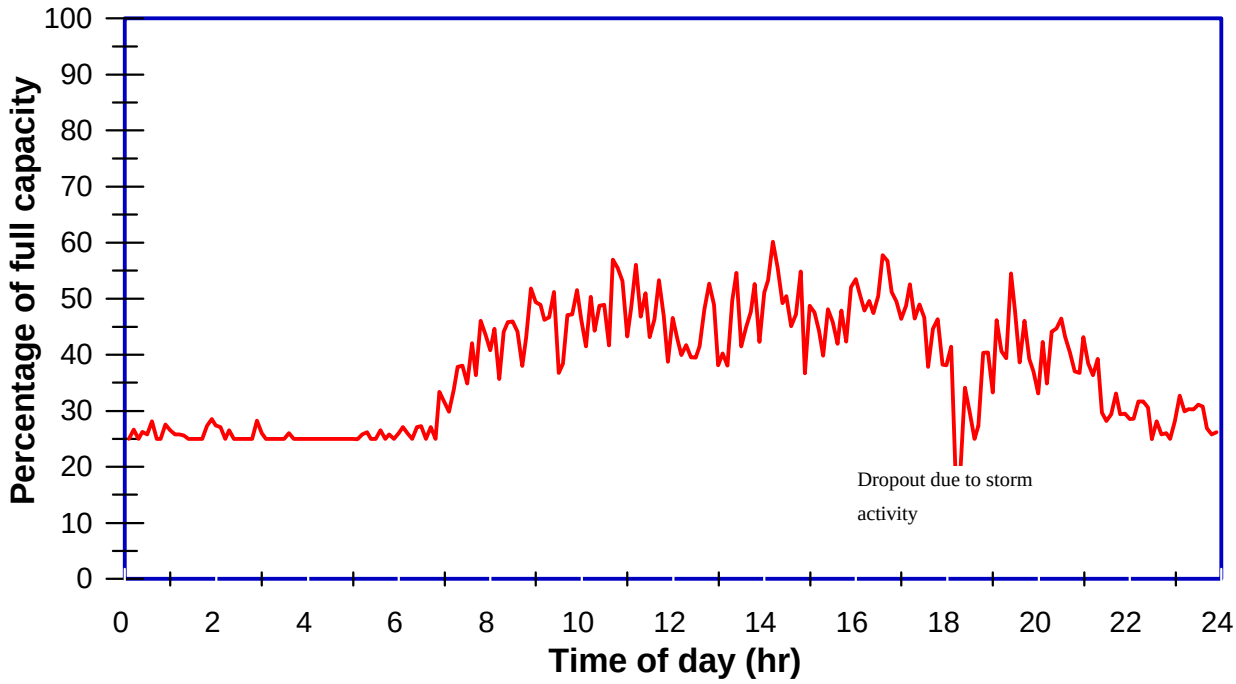

Figure 2

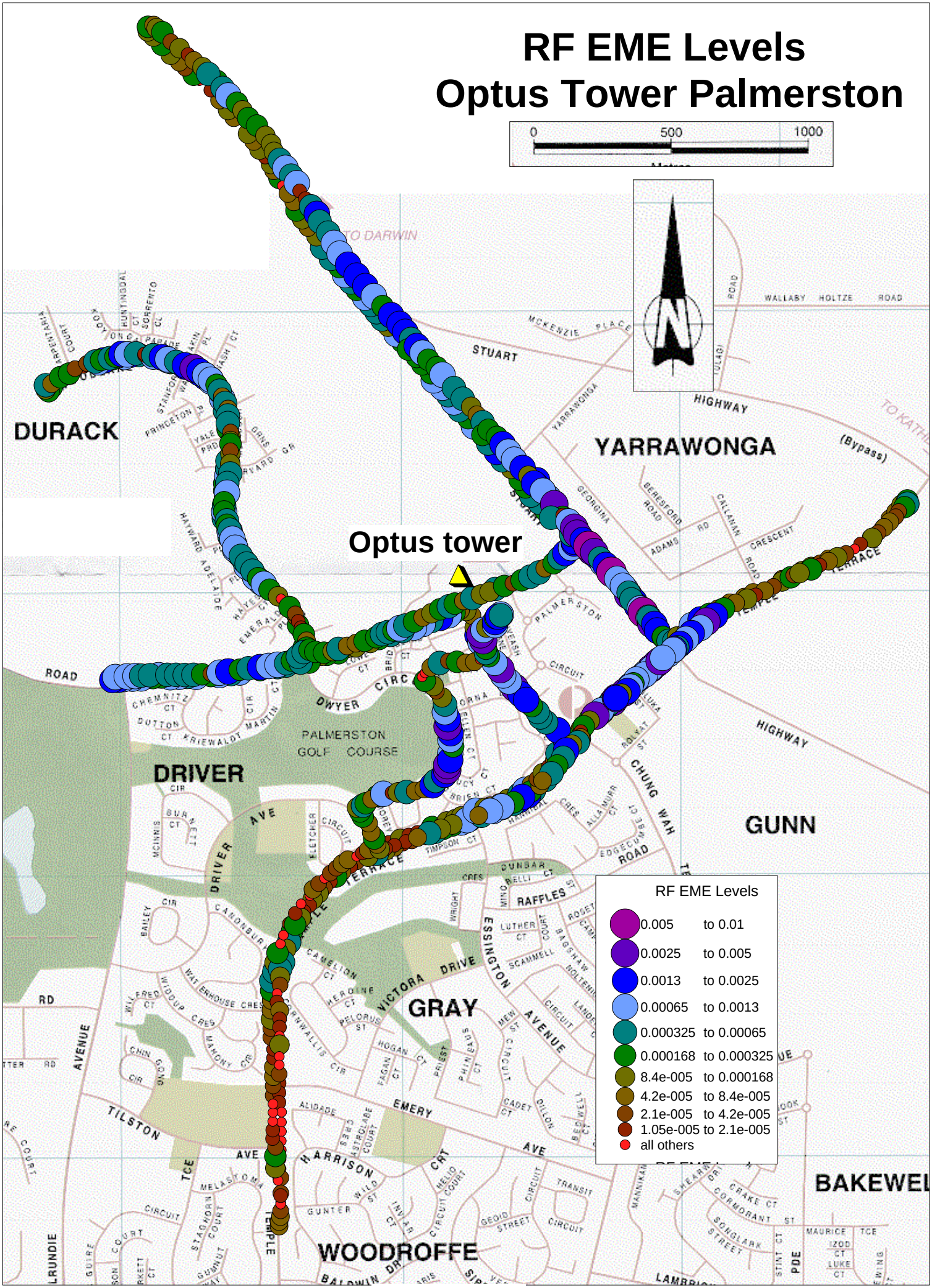
RF EME Levels
Optus Tower Palmerston
0
500
1000
Metres
N
Optus tower
DURACK
YARRAWONGA
DRIVER
GUNN
GRAY
WOODROFFE
BAKEWEL
PALMERSTON GOLF COURSE
STUART HIGHWAY
(Bypass)
DWYER CIRC
DRIVER AVE
TERRACE
CHUNG WAH TERRACE
VICTORIA DRIVE
ESSINGTON AVENUE
EMERY AVE
HARRISON CRT
TILSTON AVE
RAFFLES ST
EDGECUMBE ROAD
WALLABY HOLTZE ROAD
RF EME Levels
0.005 to 0.01
0.0025 to 0.005
0.0013 to 0.0025
0.00065 to 0.0013
0.000325 to 0.00065
0.000168 to 0.000325
8.4e-005 to 0.000168
4.2e-005 to 8.4e-005
2.1e-005 to 4.2e-005
1.05e-005 to 2.1e-005
all others

Figure 3