AUSTRALIAN RADIATION PROTECTION AND NUCLEAR SAFETY AGENCY

ARPANSA

Lower Plenty Road
YALLAMBIE VIC 3085
Phone 61 3 9433 2211
Fax 61 3 9432 1835

E-mail: arpansa@health.gov.au Web: www.arpansa.gov.au

MEASUREMENT AND ANALYSIS OF RF EME LEVELS FROM THE VODAFONE/OPTUS MOBILE TELEPHONE BASE STATIONS LOCATED AT NERANG, QUEENSLAND

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 a Vodafone/Optus mobile telephone base station tower situated at Nerang, QLD. This base station was nominated by the Gold Coast City Council and was in response to community concern. The base station antennae on this site are the more common panel antennae which divide the area around a base station into three sectors. The antennae are on a 30 metre tower which is shared by the two carriers; Optus and Vodafone. The signals transmitted by both carriers are for digital mobile telephones (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:

- 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 in front of the Nerang Elderly Citizens building, which is 100 m from the base station tower, this measurement 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 with the monitoring antenna placed on top of the Nerang Girl Guides Hall which is 100 m away from the base station, 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 the area surrounding the base station showing the level of base station signals along the main roads.

ENVIRONMENTAL RF EME LEVELS OUTSIDE ELDERLY CITIZENS BUILDING

Most RF signals around Nerang 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 RF EME signals at Nerang came from the base station tower at Nerang. The RF EME from the tower contributed 67.08% (refer Figure 1) of the total RF EME level of 0.00098 $\mu W/cm^2$. 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 Nerang out to a distance of 600 m from the tower, the base station signals would most probably contribute the greatest proportion. This would depend on line-of-sight transmission being maintained. At greater distances, UHF TV and FM radio would begin to dominate. The absence of VHF TV and AM radio transmitters in the region gives rise to the higher ratio of base station RF EME levels.

RF EME EXPOSURE LEVELS FROM VODAFONE/OPTUS TOWER

The highest level of RF EME from the base station tower at Nerang was 0.048 $\mu W/cm^2$ or 0.024% of the AS/NZS 2772.1 public limit. This was found in Stevens St. about a distance of 120 m from the tower. The average over the surveyed area was 0.0020 $\mu W/cm^2$.

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 the Optus and Vodafone telephone systems to each operate four transmitters at full power into the antennae, this allows the maximum number of telephone calls to be handled. 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 each carrier to have one transmitter in operation, this transmitter operates at full power even when not handling any calls and is indicated as 25% activity 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 Nerang, the activity levels varied between 25% and 41% with an average of 27%. At the maximum level of activity the RF EME levels would be about 60% higher than the minimum level of activity. The highest peak RF EME level around Nerang may then be in the order of 0.073 $\mu W/cm^2$. 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. If each base station did have four transmitters the highest peak RF EME level around Nerang

may then be in the order of 0.178 μW/cm^2.

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 average level of RF EME from the Nerang tower when measured in the streets of Nerang was 0.048 μW/cm^2, a level 4,200 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 emissions from the Nerang tower may contribute the highest percentage of RF EME in areas that are closer than 600 m of the tower

Michael Bangay
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 [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

Nerang Guide Hall

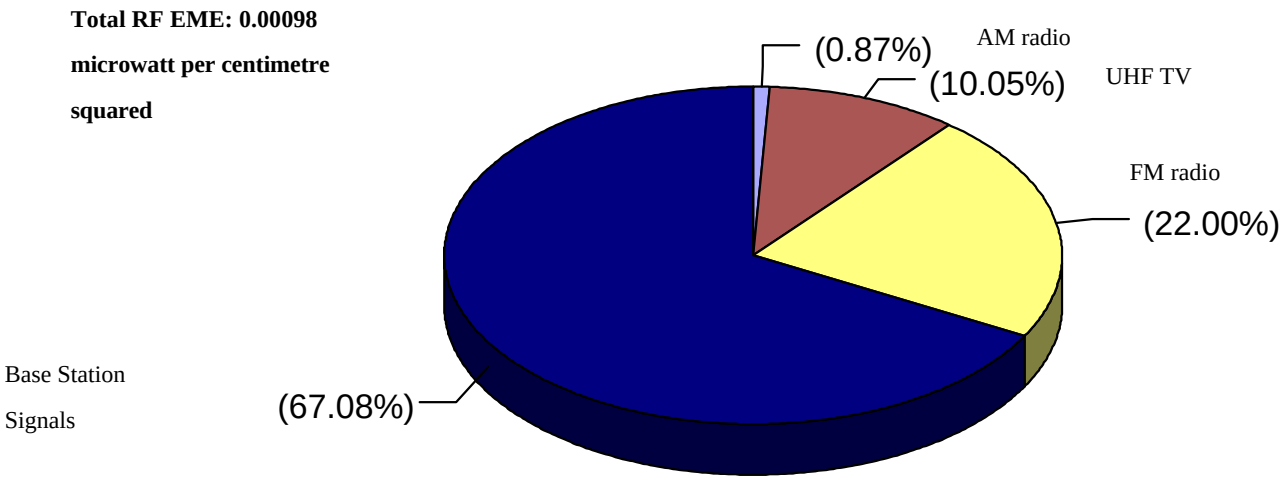

Figure 1

24 hr Activity level of Base Station

Nerang Guide Hall

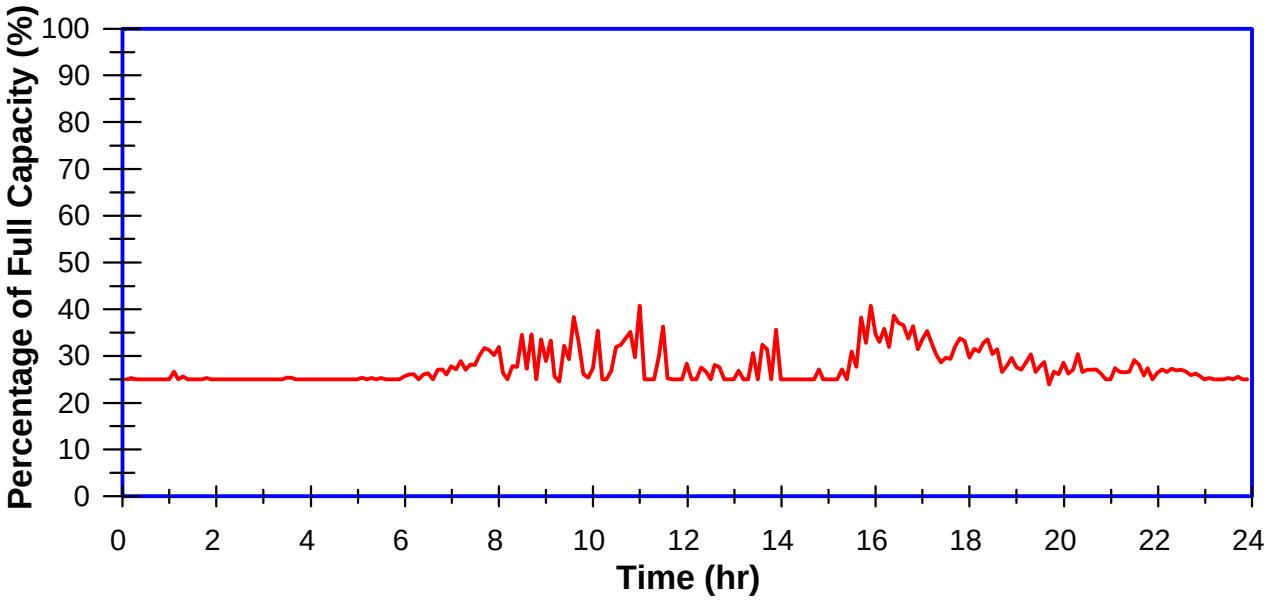

Figure 2

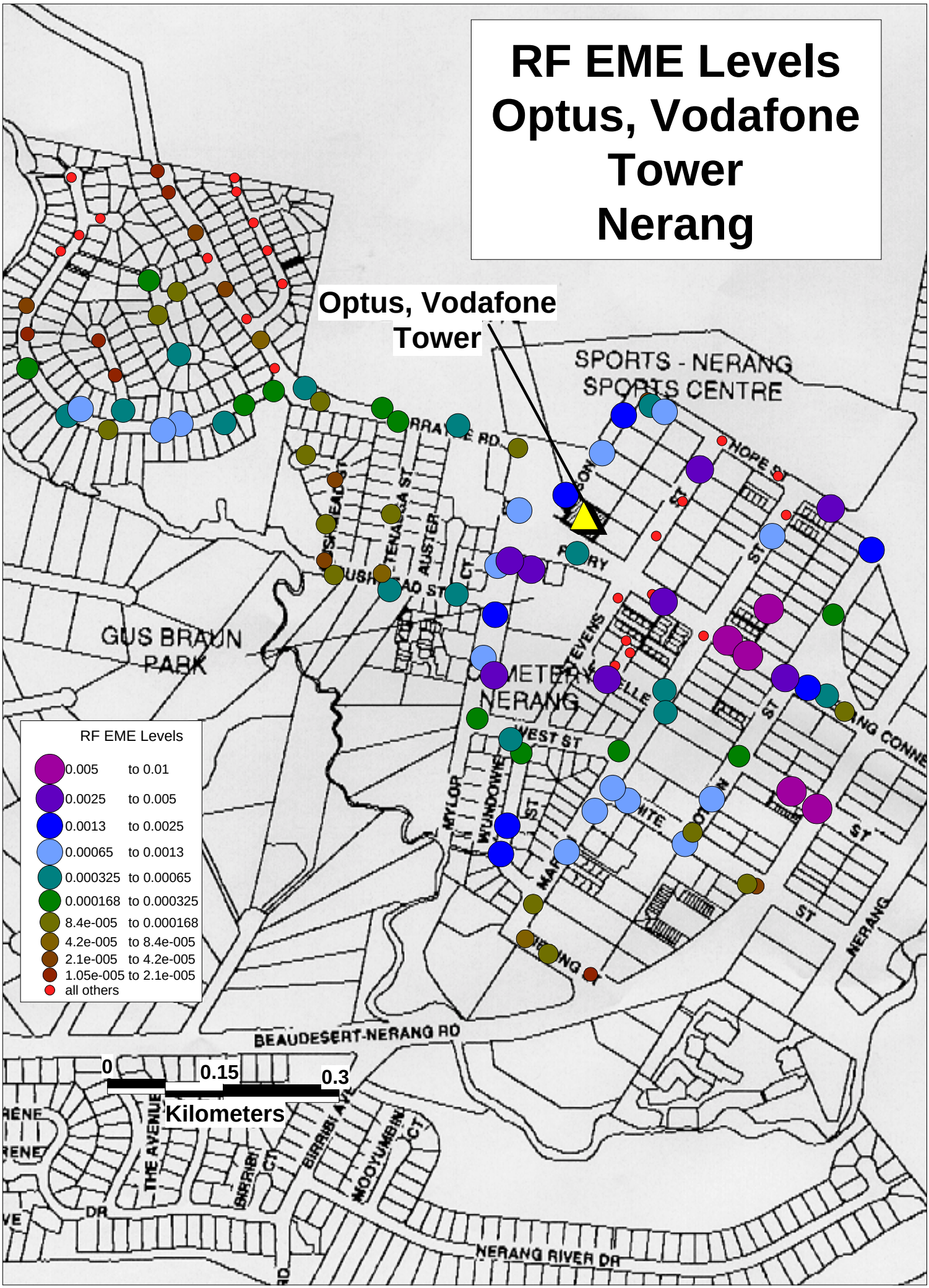
RF EME Levels
Optus, Vodafone
Tower
Nerang
Optus, Vodafone
Tower
SPORTS - NERANG
SPORTS CENTRE
GUS BRAUN
PARK
NERANG
BEAUDESERT-NERANG RD
NERANG RIVER DR
RF EME Levels
0.005 to 0.01
0.0025 to 0.005
0.0013 to 0.0025
0.00065 to 0.0013
0.000325 to 0.00065
0.000168 to 0.000325
8.4e-005 to 0.000168
4.2e-005 to 8.4e-005
2.1e-005 to 4.2e-005
1.05e-005 to 2.1e-005
all others
0
0.15
0.3
Kilometers

Figure 3