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Electromagnetic Radiation Exposure Assessment of the Satellite Antenna Equipment Proposed on the Rooftop of the National Playout Centre Building

for

Nine Entertainment Co.
12 Rodborough Rd, Frenchs Forest

by

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PhD MSc (Elect) SMIEEE

Signed:  4 June 2019

Geoffrey Garrett BE (Elect) Hons.

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APPLICABLE DOCUMENTS

[1] RPS3 (Radiation Protection Standard 3), Maximum Exposure Levels to Radio-Frequency Fields – 3kHz to 300GHz (2002), republished 31 May 2016 to include amendments to Schedule 5.

[2] ICNIRP (International Commission On Non-ionizing Radiation Protection) Guidelines, for Limiting Exposure to Time Varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz) published in: Health Physics 74 (4): 494-522; 1998

[3] AS/NZS 2772.2:2016 - Principles and methods of measurement and computation – Radio frequency fields 3 kHz to 300 GHz.

1 INTRODUCTION

Nine Entertainment Co. (Nine) has sought planning advice with regard to a proposal to erect a satellite antenna dish at the National Playout Centre located at 12 Rodborough Rd, Frenchs Forest (refer Figures 1 and 2). The proposed satellite antenna dish will be 7.3m in diameter and the structure would be approximately 10m in height above the existing roof height which is approximately 18m above ground level (AGL).

The antenna to be installed on the building roof top will be a GDSatcom Vertex 7.3m antenna operating at Ku band and facing up at about 47^{o} elevation to the true north sky.

An electromagnetic field theoretical assessment of the possible radiated emissions from the antenna was performed to determine the electromagnetic health and safety impact at the National Playout Centre facility and the surrounding general public areas. This report includes the assessment results, the possible impact of the electromagnetic field emissions, compliance with the applicable health and safety requirements, and provides a recommendation.

2 REQUIREMENT

The requirements of the electromagnetic radiation assessment are described in the points below:

a) Review the provided documents for electromagnetic radiation (EMR) issues.

b) Predict by calculation, using AS/NZS 2772.2:2016 methodology, the radio-frequency electromagnetic radiation (EMR) from the satellite transmitter equipment.

c) Establish the margin of compliance with the limits applicable to the Australian human exposure standard ARPANSA RPS 3.

d) Establish the boundary of any areas exceeding the above limits (if any).

e) A recommendation and/or an outline of a plan to mitigate any electromagnetic exposure non-compliance issues.

3 APPLICABLE STANDARDS

3.1 Human Exposure Limits – Radio Frequency Electromagnetic Fields

In February 1999 the Australian Communications Authority (ACA) mandated the limits of AS/NZS2772.1(Int)1998. These limits were replaced on the 1st March 2003 by those of a new Standard RPS3, that was published by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). For regulatory purposes, the new limits became effective from the 1st June 2003.

The ARPANSA RPS3 human exposure limits [4], and the World Health Organisation guideline limits [5] applicable to electromagnetic radiation, are summarized in the table below:

Table 1. - Time Averaged Human Limits of Exposure – 100kHz to 300GHz Electric & Magnetic Fields

Exposure Activity	Frequency Range	Electric Field Strength (V/m rms)	Magnetic Field Strength (A/m rms)	Equivalent Plane Wave power flux density (W/m²)
Occupational (whole working day)	100kHz-1MHz	614	1.63/f	-
	1MHz-10MHz	614/f	1.63/f	$1000/f^2$ (1)
	10MHz-400MHz	61.4	0.163	10 (1)
	400MHz-2GHz	$3.07\sqrt{f}$	$0.00814\sqrt{f}$	f/40
	2GHz-300GHz	137	0.364	50
General Public (up to 24hrs per day)	100kHz-150kHz	86.6	4.86	-
	150kHz-1MHz	86.6	0.729/f	-
	1MHz-10MHz	$86.6/\sqrt{f}$	0.729/f	-
	10MHz-400MHz	27.4	0.0729	2 (1)
	400MHz-2GHz	$1.37\sqrt{f}$	$0.00364\sqrt{f}$	f/200
	2GHz-300GHz	61.4	0.163	10

Note: 1. In the near field, both electric field and magnetic field limits are applicable rather than power flux density, which is applicable in the far field.
2. f is the frequency in MHz.

4 MEASUREMENT METHODOLOGY & ACCURACY

The procedure for estimating electromagnetic field emission levels is described in AS 2772.2 (Radiofrequency Radiation Part 2: Principles and methods of measurement – 300 kHz to 100 GHz).

According to Appendix E of AS 2772.2, the on-axis radio-frequency (RF) power density is given by the free-space transmission equation as

$$S = \frac{PG}{4\pi d^2} N$$

where

S is power flux density, in watts per square metre,
P is power transmitted, in watts,
G is far-field gain (power ratio),
d is distance from antenna, in metres,
N is near-field correction factor.

According to RPS3, to safely guard public from electromagnetic field exposure, the summed ratio of RF power density and standard limit over the frequency range from 100 kHz to 300 GHz should be not more than one.

5 RESULTS

5.1 Description of the Satellite Antenna

The proposed satellite antenna is a GDSatcom 7.3m Cassegrain parabolic reflector antenna as shown in Figure 3. The antenna has a 7.3 metre diameter, max TX Power =400 W, and operates at frequency range 13.75-14.5 GHz. Its look angle is to the Intelsat IS19 satellite @ 166°E - Elevation = 47.6° above the Horizon; Azimuth = 25.4° Relative to True North. The Intelsat satellite is understood to be currently utilized elsewhere by Nine.

The antenna gain is 58.1 dBi, the -3dB beamwidth is 0.20^{o}, and the -15 dB beamwidth is 0.42^{o}.

The horizontal and vertical polarization patterns are identical for this parabolic antenna, and both comply with ITU-RS580 sidelobe limits. The antenna patterns from -10^{o} to $+10^{o}$ are shown in Figures 4 and 5.

5.2 Predicted RF Power Density

RF power densities at the main beam (boresight) direction (47.6^{o} elevation) and at the horizontal direction have been calculated. The calculated results against the RPS3 limit at various distances away are listed in Table 3 below. Where the predicted power density exceeds 100% of the ARPANSA RPS3 general public limit, it will be unsafe for the general public to access, or occupy such locations. The areas exceeding the ARPANSA RPS3 general public and occupational limits are shown in yellow and red respectively in Figure 6.

Table 2. – Summary of Predicted RF Power Density in front of the Satellite Antenna

Distance from Satellite Antenna (m)	Calculated Power Density – Boresight Direction (W/m^2)	% of ARPANSA RPS3 General Public Limit – Boresight Direction [(1)(2)]	Calculated Power Density – Horizontal Direction (W/m^2)[(3)]	% of ARPANSA RPS3 General Public Limit – Horizontal Direction [(1)(2)]
0.5	82207249.66	822072496.63	82.21	822.07
0.64	50175323.28	501753232.81	50.18	501.75
1	20551812.42	205518124.16	20.55	205.52
1.43	10050277.48	100502774.79	10.05	100.50
2	5137953.10	51379531.04	5.14	51.38
5	822072.50	8220724.97	0.82	8.22
10	205518.12	2055181.24	0.21	2.06
50	8220.72	82207.25	0.01	0.08
100	2055.18	20551.81	0.00	0.02
200	513.80	5137.95	0.00	0.01
500	82.21	822.07	0.00	0.00
641	50.02	500.19	0.00	0.00
1000	20.55	205.52	0.00	0.00
1430	10.05	100.50	0.00	0.00
1500	9.13	91.34	0.00	0.00

Note 1: The estimated field levels are calculated on the maximum output power of the satellite antenna. The prediction does not include any attenuation due to foreign objects in the surrounding environment, however windows are transparent to these electromagnetic fields.

Note 2: Based on the 10 W/m^2 General Public limit in Table 1 (at Ku band), hence the % value is a conservative (worst case) value, unless otherwise specified.

Note 3: Based on the antenna patterns in Figures 4 and 5, it is assumed that the worst case radiated power level in the horizontal plane is 60 dB below that in the boresight direction.

6 ANALYSIS

The calculated results shown in Table 2 are provided for the worst case maximum transmitting power of 400 W applied to the satellite antenna. The predicted RF power densities are greatest at the locations close to the front of the satellite antenna. The predicted ARPANSA RPS3 general public and occupational exclusion zones are 1430 m and 641 m away in line with the boresight from the antenna aperture. Note that the prediction is based on the maximum licensed output power of the antenna, and the actual output power used could be lower than licensed and could at any time be increased to the maximum licensed; therefore the actual impacted areas could typically be smaller than the worst case prediction, though there is the potential for reaching the worst case prediction.

However, as shown in Figures 4 and 5 of the antenna patterns and the beamwidth specifications described in Section 5.1, the beam patterns are very narrow and the RF radiated power level from the antenna drops 15 dB and 60 dB at 0.5^o and 15^o away respectively, from the boresight direction. In the horizontal direction which is 47.6^o away from the boresight direction, the RF radiated power level will reduce more than 60 dB from that at the boresight direction, and becomes negligible. As shown in Figure 6, the red and yellow areas are the occupational and general public exclusion zones respectively.

7 CONCLUSION & RECOMMENDATION

A cylindrical radiation exclusion zone directly in front of the main reflector of the satellite antenna is identified, as shown in Figure 6, with the ARPANSA RPS3 Occupational and General Public exclusion zones being and up to 641 m and 1430 m away respectively. Due to the antenna side lobe characteristic, the exclusion zones could radially extend up to 0.64m and 1.43m beyond the antenna dish perimeter boundary for occupational and general public exclusion zones respectively.

Due to the highly directional emission characteristic of the parabolic antenna and that the satellite antenna will be pointed at the northern sky, there should be no concern of risk to the health and safety of persons accessing the areas located 1m or more radially away from the reflector of the proposed antenna, in the directions to the sides, or behind of (but not in front of), or from below including within the building, as the predicted emissions there are well below the ARPANSA RPS3 general public exposure limit.

As the satellite tracking movement of the satellite antenna dish should be limited to the direction of the satellite only, it is recommended that mechanical or electric stops be fitted or configured during installation to prevent movement beyond the necessary operational range of the elevation and azimuth angles, so as to prevent the exclusion zone broadening into other areas where radiation would otherwise be assumed at a safe level.

For assuring a safe exclusion zone distance away from the antenna, particularly due to the side lobe emissions, which can have some degree of uncertainty, it is recommended that an electromagnetic radiation survey be conducted when the antenna is being commissioned.

When the antenna is operational, access to the rooftop should be restricted by a key locked door, and non-ionizing radiation warning signage (refer Section10) should be erected at the entry point and at the exclusion zone boundary adjacent to the antenna. A site radiation folder will also need to be established for assuring the safety of persons accessing the rooftop.

Should there be significant change or alteration, to the proposed antenna or any additional wireless installations on the rooftop, then it is recommended that the electromagnetic field environment be re-assessed for health & safety compliance and assurance purposes.

8 APPENDIX

Figure 1. – National Playout Centre Building, Aerial View

Figure 2-1. – Proposed Satellite Antenna Location at National Playout Centre Building, Top View

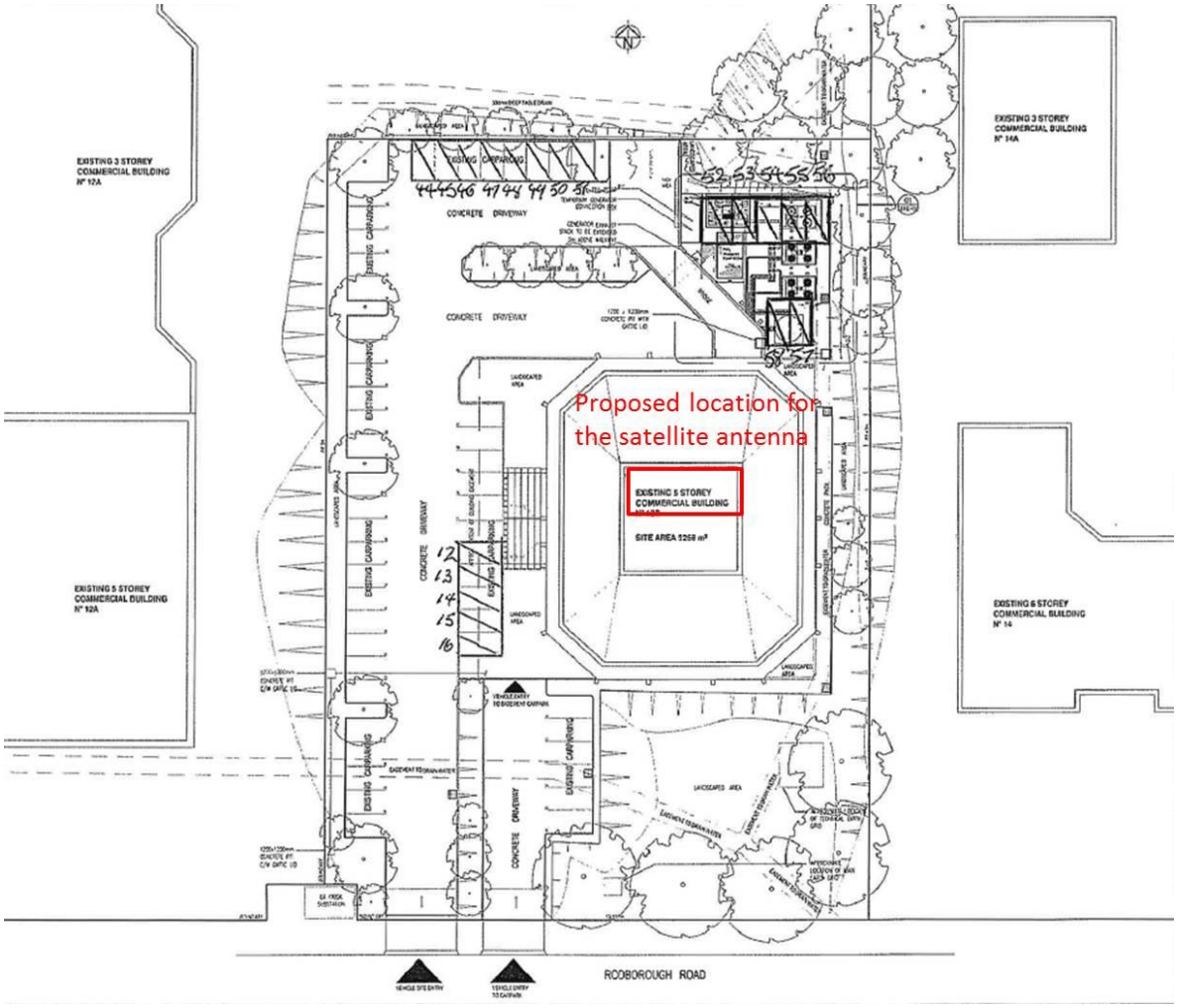


Figure 2-2. – Proposed Satellite Antenna Location at the National Playout Centre, West Elevation

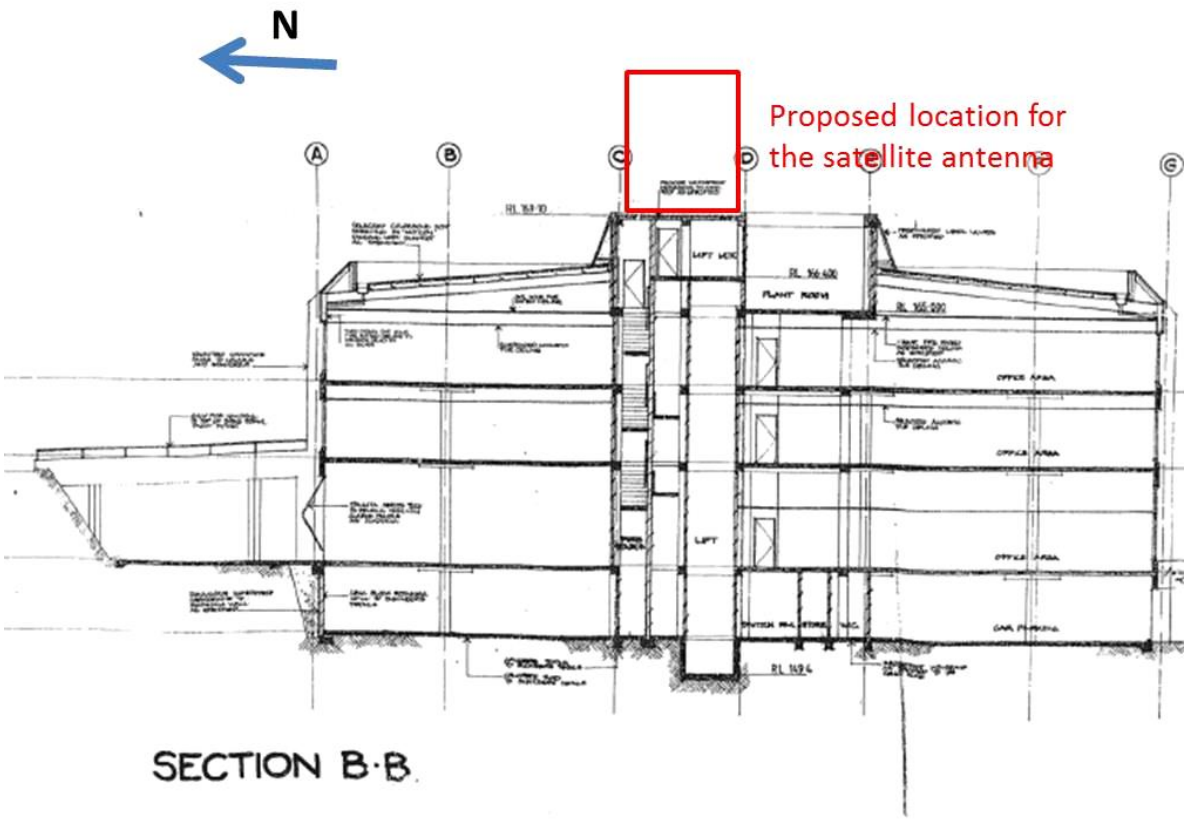


Figure 3. – GDSatcom 7.3m Satellite Antenna

Figure 4. – Elevation Pattern (+/- 10º) of GDSatcom 7.3m Satellite Antenna

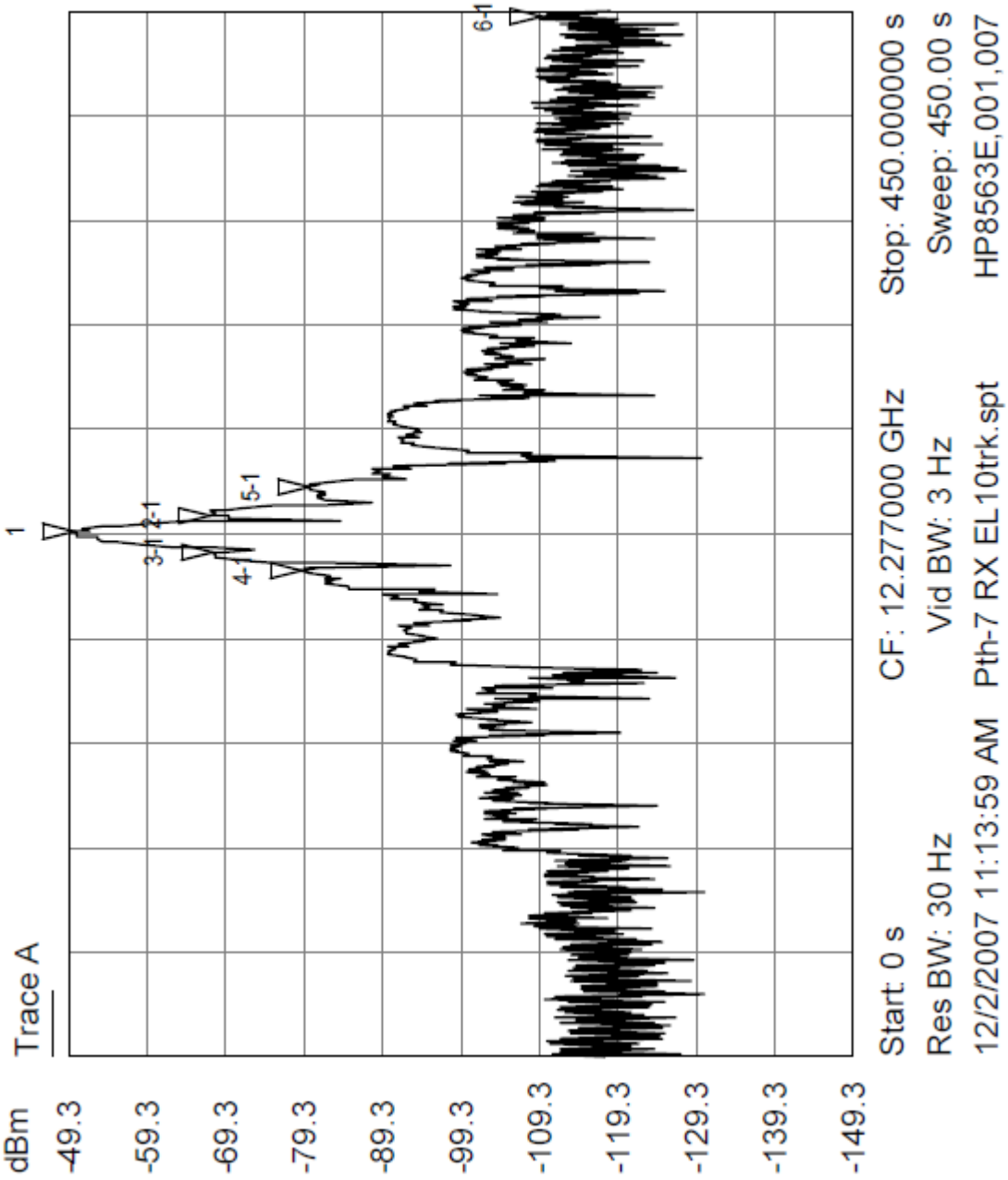


Figure 5. – Azimuth Pattern (+/- 10°) of GDSatcom 7.3m Satellite Antenna

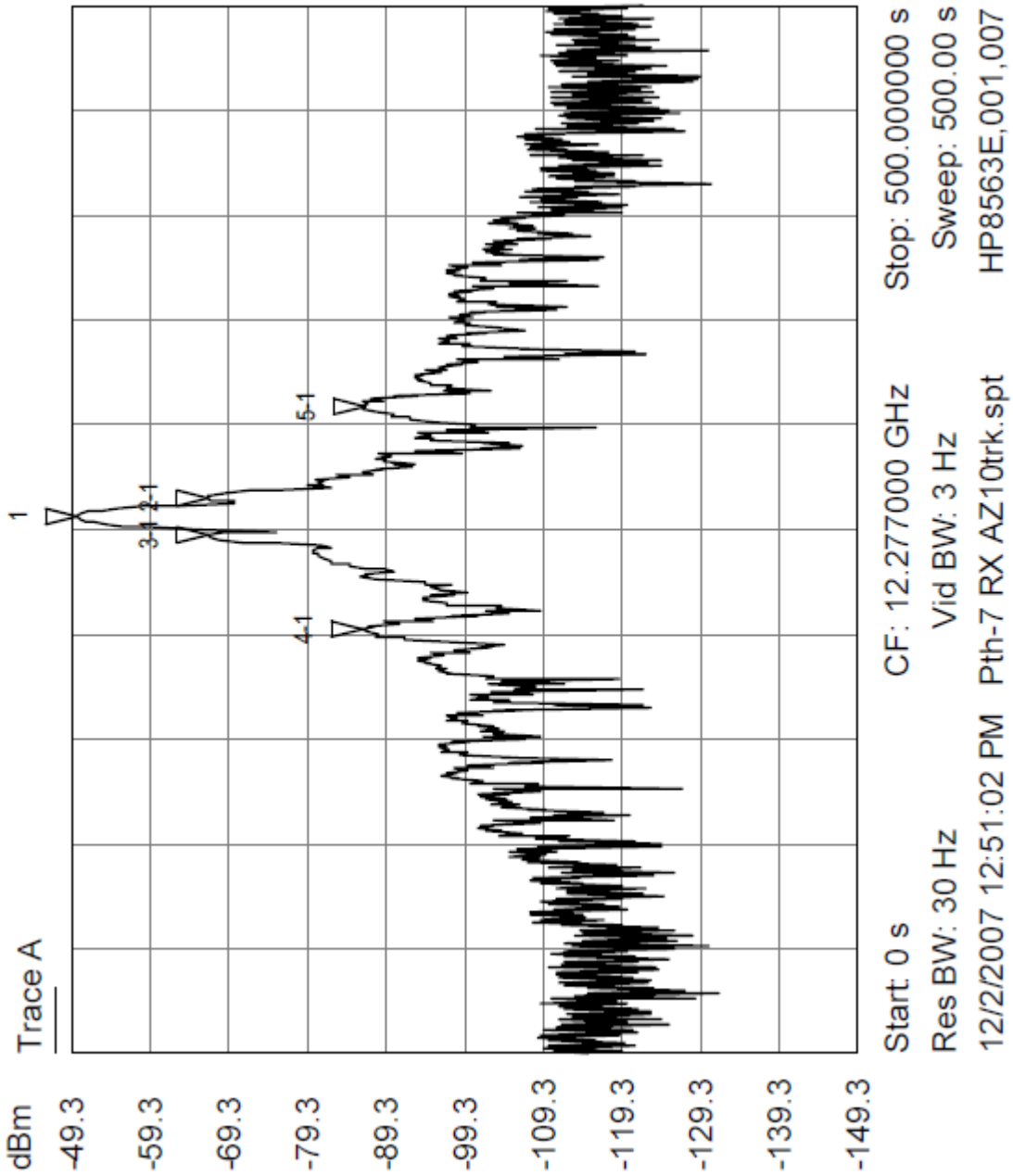
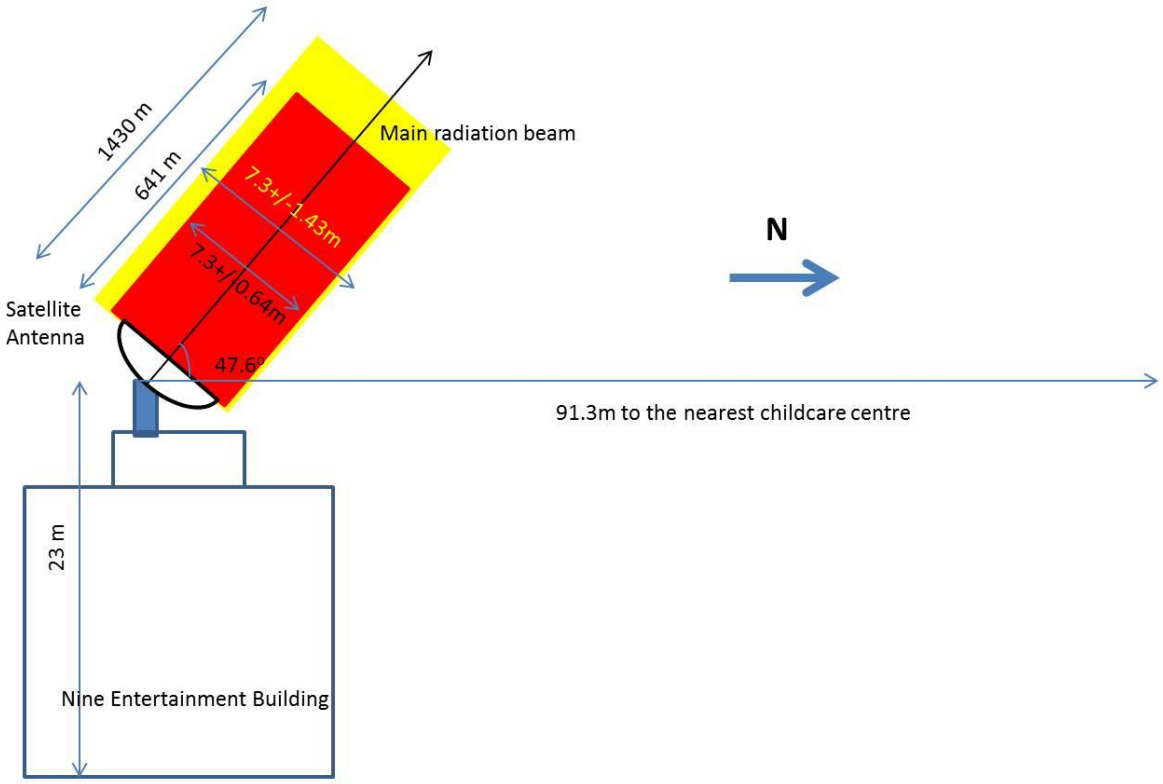


Figure 6. - East Elevation View of the Satellite Antenna Exclusion Zone

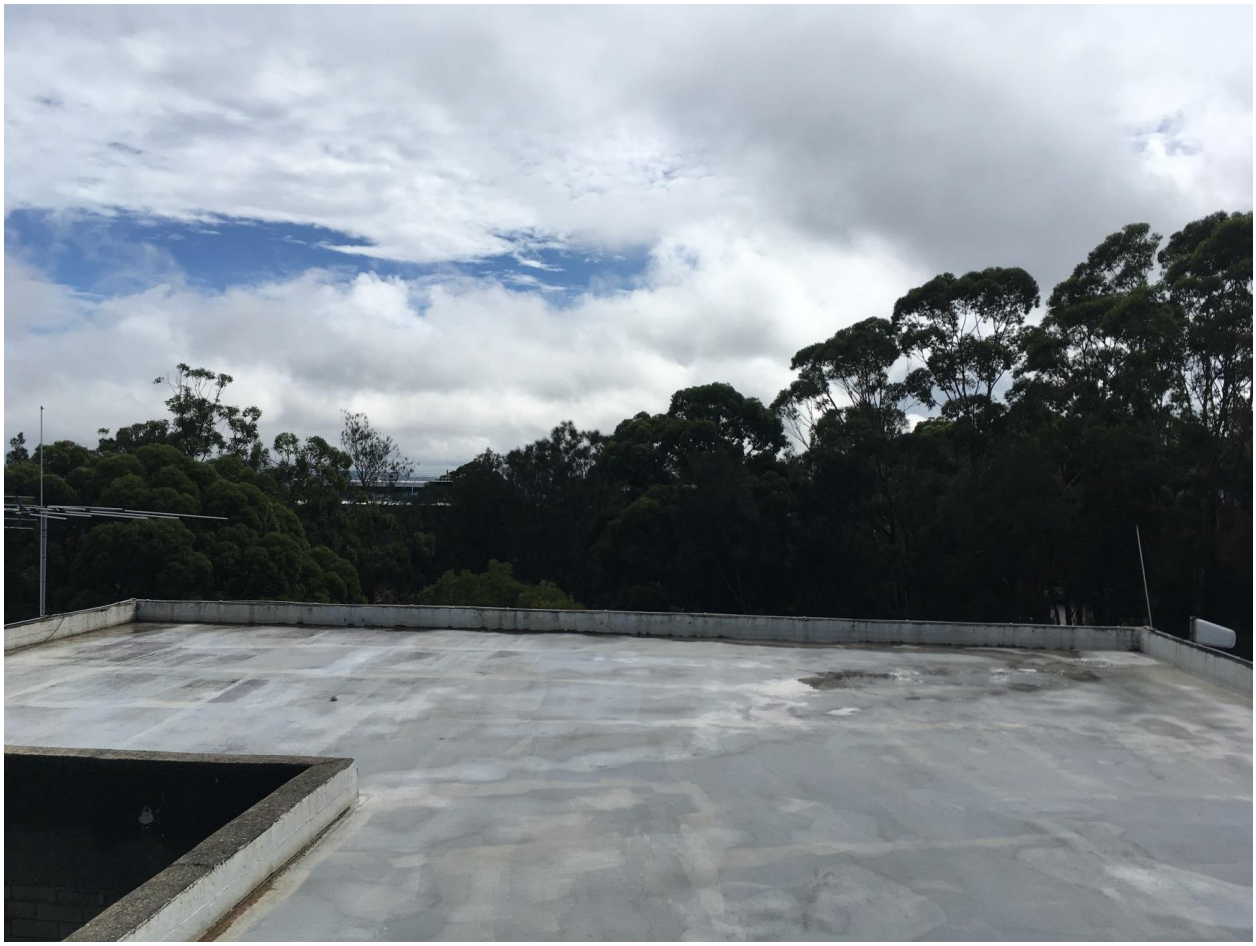


Red Areas - No access

Yellow Areas - Access for 'RF Workers' and 'Aware' persons, 8 hours only

Uncontrolled areas - Unlimited access

Photo 1. – Rooftop Site for Accommodating the Proposed Satellite Antenna



Note: The photo direction is looking northwards.

9 GLOSSARY

Broadband	In the context of an RF measurement, a broadband measurement measures the magnitude over a large (broad) frequency range. A broadband measurement is useful for providing the net magnitude of the emissions from multiple sources (eg. The combination of Radio, TV, WiFi, Mobile Phones, etc…) though does not provide the magnitude of individual frequency emissions.
Narrowband	In the context of an RF measurement, a narrowband measurement measures the magnitude over a small (narrow) frequency range. A narrowband measurement provides the magnitude of individual frequencies, and is useful for determining the emissions from the sources of interest (eg. WiFi only).
Power Frequency	A term typically used to describe mains power electromagnetic fields at 50Hz, though extends to other frequencies such as the harmonics of 50Hz, which may extend to approx. 3 KHz. Examples of sources that emit higher magnitudes of power-frequency electromagnetic fields include, power lines, electrical switch boards, electrical substations, electrical risers, high power electrical appliances, etc…
Radio Frequency (RF)	Radio Frequency is a term used for describing the range of oscillation of radio waves, which is generally from 3 KHz to 300 GHz. Some examples of radio waves are Radio & TV Broadcasts, Mobile Phone communications, WiFi, Bluetooth, etc…

10. SIGNAGE

The radiation warning sign shown in Figure 7 should be exhibited at the entrance point and on the boundary of the enclosure which contains a **Radiofrequency Hazard**.

This sign is the international symbol for identification of an area containing a non-ionising radiation hazard and is used to mark all areas which are:

a) A '**General Public**' exclusion zone

b) An '**Occupational**' exclusion zone

c) An antenna or radio frequency device around which a **General Public** or **Occupational** hazard/zone exists

d) An antenna or radio frequency device which may produce a **radiofrequency burn** or **shock** if contacted

Details of the nature of the risk hazard should be referenced or included on the sign but always available at the site of the hazard. The risk areas defined must be accessible only to **RF workers** or **Aware** persons as defined in ARPANSA RPS3.

Figure 7 . - Non-ionising Radiation Hazard Warning Signage