



# **PINNACLE TELECOM GROUP**

*Professional and Technical Services*

## **ANTENNA SITE FCC RF COMPLIANCE ASSESSMENT AND REPORT**

PREPARED FOR

**EXTENET SYSTEMS, INC.**

**POLE-MOUNTED DAS OPERATIONS**

**PELHAM, NY**

OCTOBER 22, 2014

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## Appendix A. BACKGROUND ON THE FCC MPE Limits

## EXECUTIVE SUMMARY

At the request of Extenet Systems, Inc. ("Extenet"), Pinnacle Telecom Group has performed an independent expert assessment of radiofrequency (RF) levels and related FCC compliance for "distributed antenna system" (DAS) operations in Pelham, NY.

The DAS antennas are to be mounted on poles, and will be capable of supporting transmission in the 1900 and 2100 MHz frequency bands, facilitating the provision of commercial wireless services.

The FCC requires antenna operators to perform an assessment of the RF emissions from their antennas, and to ensure compliance with the FCC's Maximum Permissible Exposure (MPE) limit. That limit, described in some detail in Appendix A, has been set in such a manner that continuous exposure to RF levels up to and including 100 percent of the MPE limit is safe for humans of either sex, any size, any age, and under any conditions.

The analysis described herein examines FCC compliance for the Extenet antenna operation for three possible exposure situations: (1) for people standing at street level below the antenna installation; (2) for antenna technicians or other workers climbing the pole; and (3) for people in buildings adjacent to and at the same general height as the antennas.

The analyses for each area of interest employ standard FCC formulas for calculating the RF effects of the antennas in a very conservative manner, in order to ensure "safe-side" (i.e., intentionally overstated) results and thus great confidence in conclusions regarding compliance with the applicable MPE limit.

The results of compliance analyses can be described in layman's terms by expressing the calculated RF levels as simple percentages of the applicable FCC MPE limit. If the reference for that limit is "normalized" to 100 percent, then calculated RF levels higher than 100 percent indicate the MPE limit is exceeded and there is a need to mitigate the potential exposure. On the other hand, calculated RF levels consistently below 100 percent serve as a clear and

sufficient demonstration of compliance with the MPE limit. Because of the conservatism encouraged by the FCC, calculations showing RF levels up to and even including 100 percent of the applicable MPE limit serve as proof of compliance.

The results of the RF compliance assessment in this case are as follows:

- ***For People Standing at Street Level around the Antenna:*** The conservatively calculated maximum RF level from the lowest-mounted Extenet DAS antenna operation is 0.1796 percent of the FCC MPE limit – a result that is less than 2/10<sup>th</sup>s of one percent of the limit, and which is clearly well below the 100-percent reference for compliance.
- ***For Workers Close to the Antenna:*** The near-field analysis shows that that the applicable FCC occupational MPE limit is satisfied at all same-height distances from the antenna.
- ***For People in an Adjacent Building:*** For someone inside a building at a distance of as little as 10 feet away from the antenna and at the same height as the antennas, the conservatively calculated RF level is 4.20 percent of the FCC general population MPE limit – well below the 100-percent reference for compliance. At distances greater than 10 feet from the antennas, or in positions lower or higher than the antennas, the RF levels are even less significant.

The results of the analyses of RF levels demonstrate satisfaction of the applicable FCC MPE limit in all areas of interest. Moreover, because of the conservative methodology and assumptions incorporated in the analysis, RF levels actually caused by the antennas in each area of interest will be even less significant than the calculation results indicate.

The remainder of this report provides the following:

- relevant technical data on the Extenet DAS antenna operations;
- a description of the applicable FCC mathematical models for assessing compliance, and application of the technical data to those models; and
- the results of the analysis, and the compliance conclusion for the proposed Extenet DAS operation.

In addition, Appendix A provides background on the FCC MPE limit, as well as a list of key FCC references on compliance.

## ANTENNA AND TRANSMISSION DATA

Transmission parameters for the DAS antenna operation are provided below.

<b>General Data</b>	
Frequency Bands	1900 MHz and 2100 MHz
Antenna Model	CellMax CMA-TRI/6515/E2
Antenna Length	22.9 in.
Antenna Mounting Height AGL	29.3 ft. (minimum)
<b>1900 MHz Transmission Data</b>	
Tot. Available RF Power	20 watts (maximum)
Antenna Line Loss	6.55 dB (minimum)
Max. Antenna Input Power	4.43 watts (maximum)
Max. Antenna Gain	15.0 dBi
<b>2100 MHz Transmission Data</b>	
Tot. Available RF Power	20 watts (maximum)
Antenna Line Loss	6.58 dB (minimum)
Max. Antenna Input Power	4.40 watts (maximum)
Max. Antenna Gain	15.5 dBi

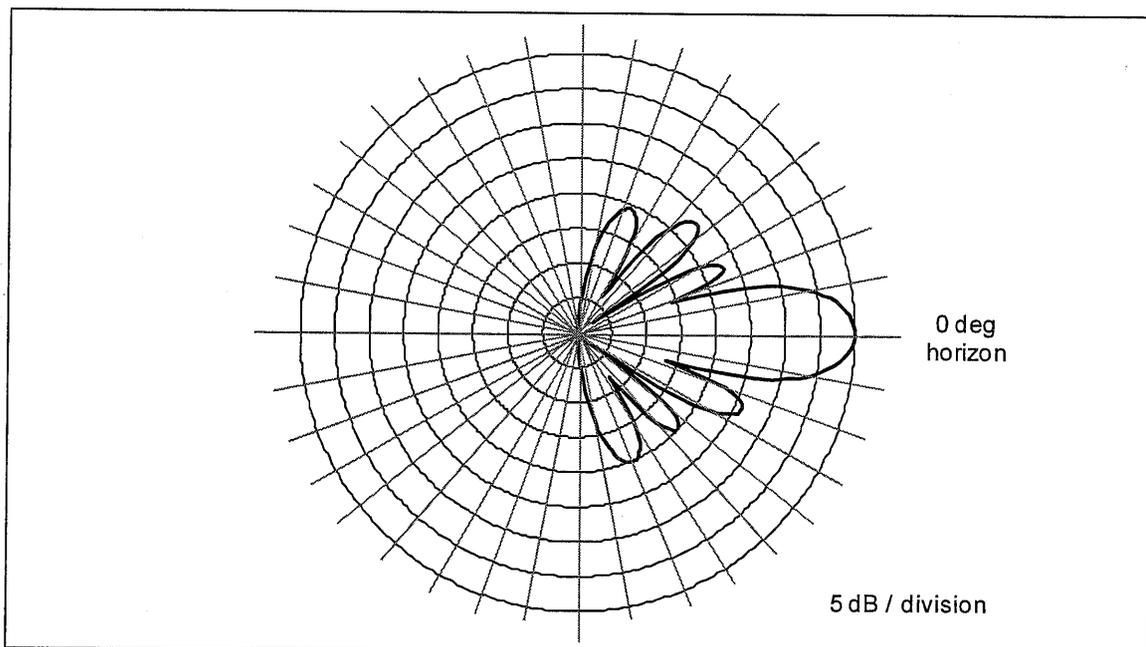
Note that this analysis is being performed on a worst-case basis, applying the lowest antenna height and the minimum antenna line loss.

The vertical-plane emission pattern of the antenna is used in the analysis of street-level compliance. Figure 1 that follows shows the manufacturer-specified vertical-plane pattern for the proposed antenna model in both frequency bands.

Note that the use of a decibel scale to describe the relative pattern at different angles incidentally serves to significantly understate the actual focusing effects of the antenna. Where the antenna pattern reads 20 dB, for example, the relative RF energy emitted at the corresponding downward angle is 1/100<sup>th</sup> of the maximum that occurs in the main beam (at 0 degrees); at a 30 dB point, the level is 1/1,000<sup>th</sup> of the maximum.

Note, finally, that the automatic pattern-scaling feature of our internal software may skew side-by-side visual comparisons of different antenna models, or even different parties' depictions of the same antenna model.

**Figure 1. CellMax CMA-TRI/6515/E2– 1900/2100 MHz Vertical-plane Pattern**



## Compliance Analysis

FCC Office of Engineering and Technology Bulletin 65 (“OET Bulletin 65”) provides guidelines for mathematical models to calculate the RF levels at various points around transmitting antennas.

In this case, there are two general areas of potential exposure interest: (1) at street level below and around the antenna installation; and (2) at the same relative height as the antenna. The FCC’s “far-field” model applies to the street-level analysis. The FCC’s “near-field” model applies to the analyses of RF levels closer to and at the same general height as the antennas, such as applies to utility pole workers and people in buildings adjacent to the antenna installations.

Each area of interest is addressed in the subsections that follow.

### ***Street-Level Compliance Analysis***

The areas at street level around an antenna installation are clearly open to unrestricted public access, and are subject to the FCC MPE limit for “uncontrolled” exposure, commonly called the “general population” limit.

At street-level, the RF levels from antennas are directly proportional to the total antenna input power and the relative antenna gain in the downward direction of interest – and the RF levels are otherwise inversely proportional to the square of the straight-line distance to the antenna. Conservative calculations also assume the potential RF exposure is enhanced by reflection of the RF energy from the intervening ground. Our calculations will assume a 100% “perfect” ground reflection, the absolute worst-case approach.

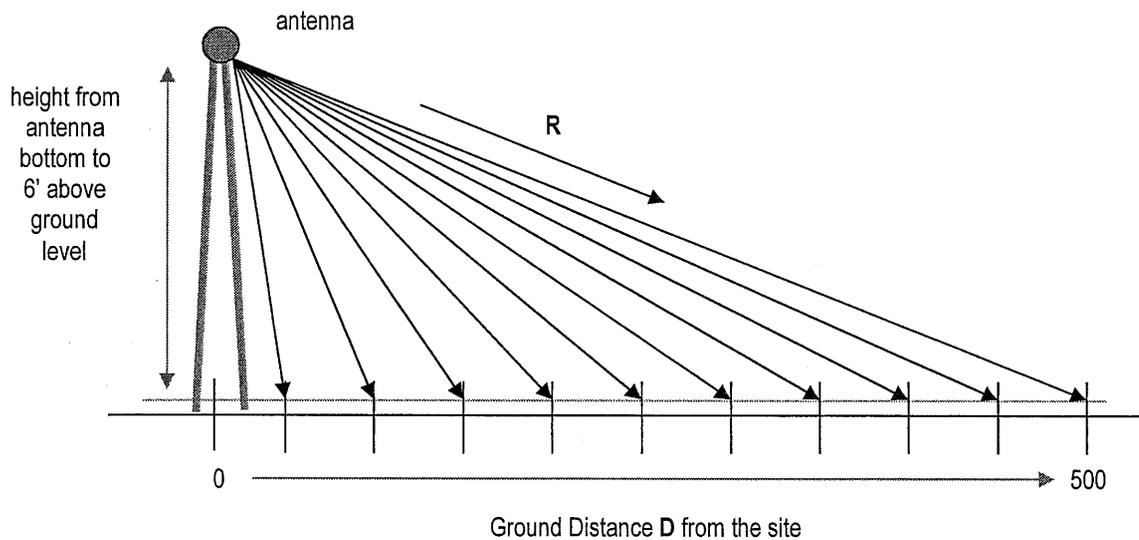
The formula for street-level RF compliance calculations for any given wireless antenna operation is as follows:

$$\text{MPE\%} = (100 * \text{InputPower} * 10^{(\text{Gmax-Vdisc}/10)} * 4) / (\text{MPE} * 4\pi * R^2)$$

where

- MPE% = RF level, expressed as a percentage of the MPE limit applicable to continuous exposure of the general public
- 100 = factor to convert the raw result to a percentage
- InputPower = maximum net power into antenna, in milliwatts, a function of the number of RF channels, the transmitter power, and line loss
- $10^{(G_{\text{max-Vdisc}}/10)}$  = numeric equivalent of the relative antenna gain in the downward direction of interest; data on the antenna vertical-plane pattern is taken from manufacturer specifications
- 4 = factor to account for a 100-percent-efficient energy reflection from the ground, and the squared relationship between RF field strength and power density ( $2^2 = 4$ )
- MPE = FCC general population MPE limit
- R = straight-line distance from the RF source to the point of interest, centimeters

We will conservatively perform the MPE% calculations out to a distance of 500 feet from the facility to points six feet off the ground, with the latter figure representing human standing height. The calculation geometry is illustrated in Figure 2 below.



**Figure 2. Street-level MPE% Calculation Geometry**

It is popularly understood that the farther away one is from an antenna, the lower the RF level – which is generally but not universally correct. The results of MPE% calculations fairly close to the base of the pole will reflect the variations in the vertical-plane antenna pattern as well as the variation in straight-line distance to the antennas. Therefore, RF levels may actually increase slightly with increasing distance within the range of zero to 500 feet from the site. As the distance approaches 500 feet and beyond, though, the antenna pattern factor becomes less significant, the RF levels become primarily distance-controlled, and as a result the RF levels generally decrease with increasing distance, and are well understood to be in compliance.

Street-level FCC compliance for a multiple-band antenna operation is assessed in the following manner. At each distance point along the ground, an MPE% calculation is made for the RF effect in each frequency band, and the sum of the individual MPE% contributions at each point is compared to 100 percent, which serves as the normalized reference for the FCC MPE limit.

We refer to the sum of the individual MPE% contributions as “total MPE%”, and any calculated MPE% total MPE% result exceeding 100 percent is, by definition, higher than the FCC limit and represents non-compliance and a need to mitigate the RF levels. If, on the other hand, all results are below 100 percent, that set of results serves as a demonstration of compliance with the MPE limit.

The following conservative methodology and assumptions are incorporated into the MPE% calculations on a general basis:

1. The antennas are assumed to be operating continuously at maximum power.
2. The power-attenuation effects of shadowing or other obstructions to the line-of-sight path from the antenna to the point of interest are ignored.
3. The calculations intentionally minimize the distance factor (R) by performing the calculations from the bottom (rather than the centerline) of the antenna.
4. The potential RF exposure at ground level is assumed to be enhanced

(increased) via a “perfect” mirror-like 100-percent field reflection from the intervening ground.

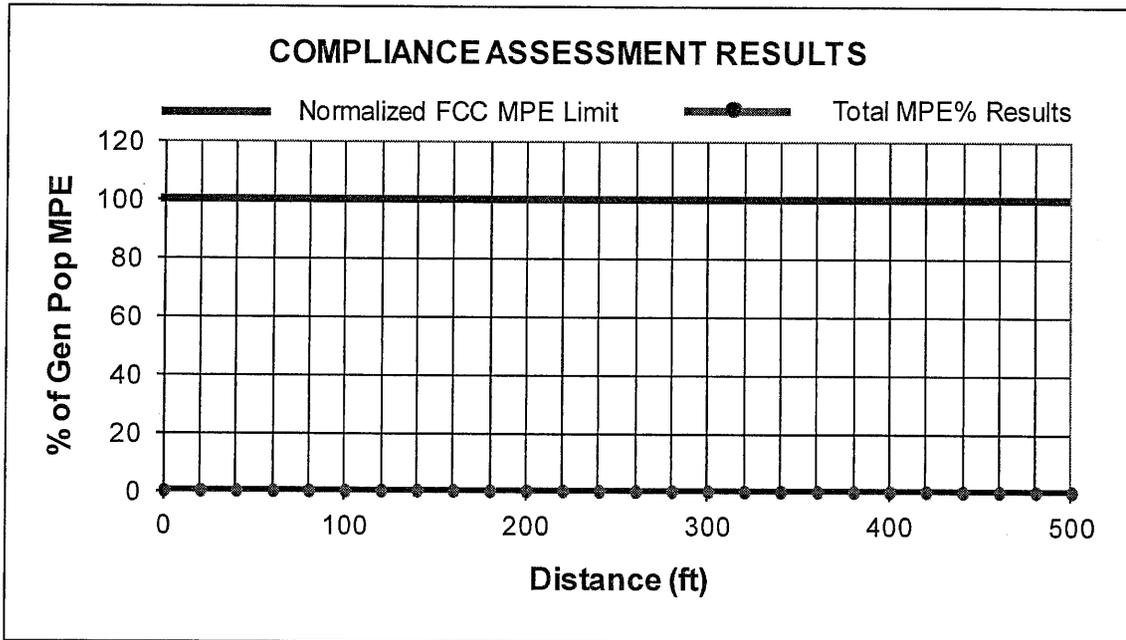
The net result of these assumptions is to significantly overstate the calculated RF exposure levels relative to the levels that will actually occur – and the purpose of this conservatism is to allow very “safe-side” conclusions about compliance.

The table below provides the results of the street-level MPE% calculations for each frequency band and the total, with the maximum (worst-case) calculated total MPE% effect highlighted in bold in the last column.

Ground Distance (ft)	1900 MHz MPE%	2100 MHz MPE%	Total MPE%
0	0.0009	0.0010	0.0019
20	0.0194	0.0216	0.0410
40	0.0353	0.0393	0.0746
60	0.0313	0.0349	0.0662
80	0.0044	0.0049	0.0093
100	0.0356	0.0397	0.0753
120	0.0850	0.0947	<b>0.1796</b>
140	0.0835	0.0930	0.1765
160	0.0817	0.0911	0.1728
180	0.0792	0.0883	0.1675
200	0.0762	0.0849	0.1610
220	0.0631	0.0703	0.1334
240	0.0610	0.0680	0.1289
260	0.0520	0.0580	0.1100
280	0.0503	0.0560	0.1063
300	0.0438	0.0488	0.0927
320	0.0386	0.0430	0.0815
340	0.0372	0.0415	0.0787
360	0.0332	0.0370	0.0702
380	0.0298	0.0332	0.0630
400	0.0269	0.0300	0.0569
420	0.0244	0.0272	0.0516
440	0.0223	0.0248	0.0471
460	0.0217	0.0242	0.0458
480	0.0199	0.0222	0.0421
500	0.0184	0.0205	0.0388

As indicated, the overall maximum calculated RF level is 0.1796 percent of the FCC MPE limit – less than 2/10<sup>th</sup> of one percent, and obviously well below the 100-percent reference for compliance with the FCC limit.

A graph of the overall calculation results, provided below, probably provides a clearer *visual* illustration of the relative insignificance of the calculated RF levels. As might be expected with such low calculated RF levels, the results line does not noticeably rise above the graph's baseline, and shows an obviously clear and consistent margin to the FCC MPE limit.



The results of this street-level compliance analysis are not at all unexpected, because of the low power level used by the antennas, the mounting of the antennas well overhead, and the vertical-plane directional characteristics of the antennas. Moreover, because of the conservative nature of the FCC's mathematical model, along with the operational assumptions we applied in the analysis, RF levels actually caused by the antennas will be less significant than these calculation results indicate.

### ***Near-field Analysis***

There are two considerations in the analysis of the RF levels at the same relative height as the antennas on the pole. The first consideration involves the possible

exposure of a utility worker or antenna technician climbing the pole or otherwise being in positions quite close to the antenna. The potential exposure for workers close to antennas is considered “controlled” because such workers are required to have had RF safety training and thus know how to ensure personal RF safety around antennas. As a result, the FCC “occupational” MPE limit applies to the analysis (see Appendix A). The second consideration involves the possible exposure of individuals in a building adjacent to a pole antenna installation (and at the same approximate height as the antenna). In this case the exposure is classified as “uncontrolled” and the FCC “general population” MPE limit applies, as can an assumption of a greater distance from the antennas than that which might apply to a pole climber.

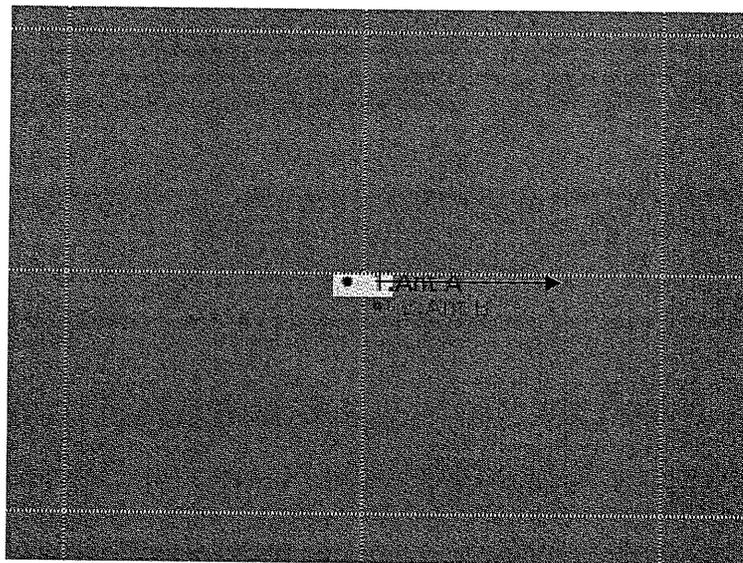
The analysis for each type of exposure involves the FCC’s “near-field” model, and the only differences in the analysis for each area of interest will be the range of assumed exposure distances and the applicable MPE limit. Note that the particular mounting height of the antennas above ground level does not affect the results of same-height RF exposure analyses.

In the near field of an antenna, the RF levels depend on the frequency band, antenna size, antenna input power, lateral distance from the antenna, and whether or not there is a difference between standing height and the subtended height of the antenna. The near-field compliance analysis was performed using the Richard Tell Associates *RoofView* program, which is based on the near-field models in FCC Bulletin OET65 and which is considered an industry standard and is accepted by the FCC for rooftop compliance analyses.

The *RoofView* program’s primary output is a color-coded depiction of the calculated RF levels in the vicinity of antennas. The color-coding scheme uses green for areas found to be subject to RF levels satisfying the FCC general population MPE limit, red for areas where the FCC occupational limit is exceeded, and yellow for RF levels between those extremes. In a grayscale printout, green appears as medium gray, yellow is a lighter gray, and red is a dark gray. Note that any color-coding of a pixel with a dot identifying an antenna location is not significant, as it represents an anomaly in the software related to a

“divide-by-zero-distance” issue. Note, too, that when multi-band antennas are used, the program requires individual entries for each operator and frequency band, and displays additional “antenna location dots” below and to the right of the actual antenna location. The additional dots are not significant to the analysis.

The graphic output of the *RoofView* program for potential same-height exposure is reproduced below (Figure 3). This is a “top-down” view, and focuses on assumed exposure directly in front of one of the three main lobes (pointed “right” on the page, as indicated by the arrow) of the tri-sector antenna. Note that the distance between the gridlines in the *RoofView* output is 10 feet.



**Figure 3. *RoofView* Graphic Output for Near-field Same-height Exposure**

As indicated by the color-coding, the FCC occupational MPE limit is satisfied at all same-height distances from the antenna.

The *RoofView* program includes a feature that provides one-at-a-time “pop-up” readouts of the calculation results for any specifically identified location. We used that feature to quantify the results of the analysis, which are summarized in the table on the next page.

<b><i>Lateral Distance (ft)</i></b>	<b><i>Same-Height Near-Field Occup. MPE%</i></b>
1	27.93
2	13.96
3	9.31
4	5.24
5	3.35
6	2.33
7	1.71
8	1.31
9	1.03
10	0.84

The near-field analysis for potential exposure to individuals inside a building adjacent to (and at the same height as) an Extenet antenna operation relies on the same near-field model, but with the “general population” MPE limit applied instead of the “occupational” limit. In addition, we can assume in this case that no building would be closer than 10 feet from an antenna, and will perform the calculations for a horizontal distance range of 10 to 20 feet, and we will further assume a clear line-of-sight to the antenna.

The table that follows provides the results of the calculations for people inside a building adjacent to, and at the same subtended height as, one of the Extenet antenna installations.

<b><i>Lateral Distance (ft)</i></b>	<b><i>Adjacent-Building Same-Height Near-Field Gen. Pop. MPE%</i></b>
10	4.20
11	3.45
12	2.90
13	2.50
14	2.15
15	1.85
16	1.65
17	1.45
18	1.30
19	1.15
20	1.05

As indicated in the table, even as the closest assumed distance of 10 feet, the conservatively calculated RF level – on a clear line-of-sight basis – is 4.20 percent of the FCC MPE limit, well below the 100-percent reference for compliance. Moreover, as the distance from the antennas increases, the RF levels decrease, and the RF levels inside a building at any distance from the antenna would be 10 times lower. Note, too, that at heights lower than or higher than the subtended antenna height, the RF levels are less significant than the results of these calculations.

## **COMPLIANCE CONCLUSION**

The results of the analyses of RF levels show compliance with the applicable FCC MPE limit in all areas of interest.

Moreover, because of the conservative methodology and assumptions incorporated in the analysis, RF levels actually caused by the antennas in each area of interest will be even less significant than the calculation results indicate.

## CERTIFICATION

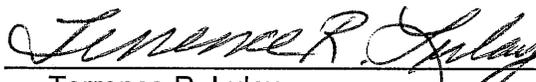
The undersigned certify as follows:

1. To the best of our knowledge, the statements and information disclosed in this report are true, complete and accurate.
2. The analysis of site RF compliance provided herein is consistent with the applicable FCC regulations, additional guidelines issued by the FCC, and industry practice.
3. The results of the analysis indicate that the subject antenna operations will be in compliance with the FCC regulations and limit concerning potential RF exposure.

  
\_\_\_\_\_  
Daniel J. Collins  
Chief Technical Officer

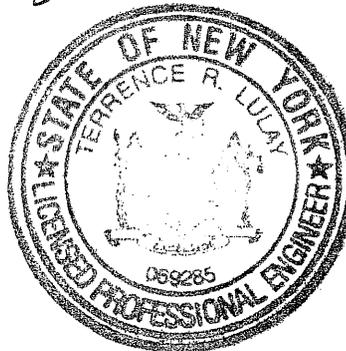
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Terrence R. Lulay  
Professional Engineer

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## Appendix A. Background on the FCC MPE Limits

### *FCC Regulations*

As directed by the Telecommunications Act of 1996, the FCC has incorporated into its Rules and Regulations a set of limits for maximum continuous human exposure to RF emissions from antennas.

The FCC maximum permissible exposure (MPE) limits represent the consensus of federal agencies and independent experts responsible for RF safety matters. Those agencies include the National Council on Radiation Protection and Measurements (NCRP), the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), the American National Standards Institute (ANSI), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA). In formulating its guidelines, the FCC also considered input from the public and technical community – notably the Institute of Electrical and Electronics Engineers (IEEE).

The FCC's RF exposure guidelines are incorporated in Section 1.301 *et seq* of its Rules and Regulations (47 CFR 1.1301-1.1310). Those guidelines specify MPE limits for both occupational and general population exposure.

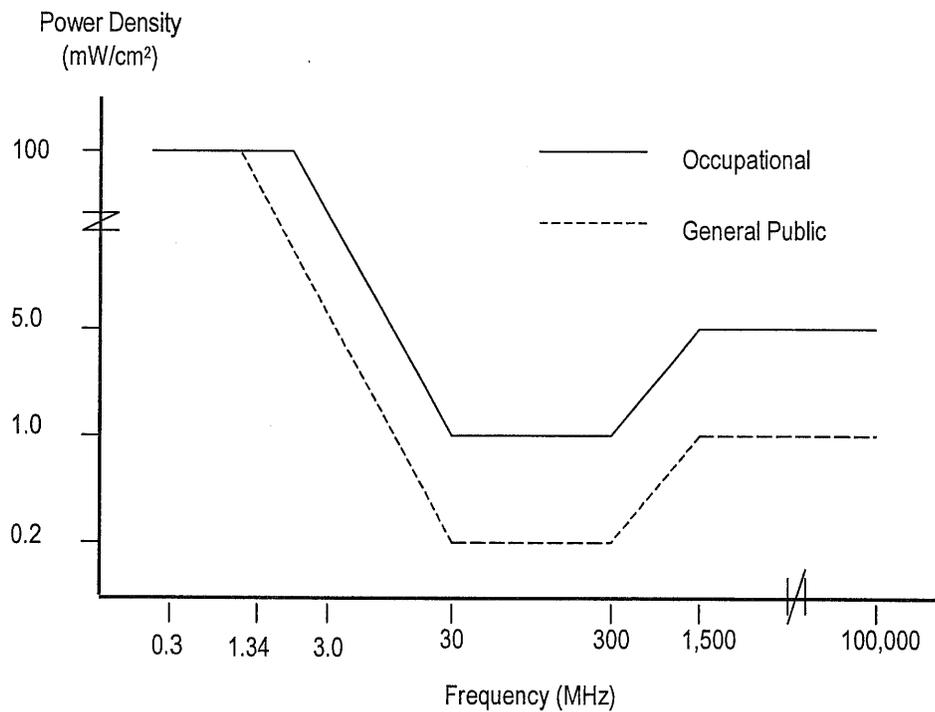
The specified continuous exposure MPE limits are based on known variation of human body susceptibility in different frequency ranges, and a Specific Absorption Rate (SAR) of 4 watts per kilogram, which is universally considered to accurately represent human capacity to dissipate incident RF energy (in the form of heat). The occupational MPE guidelines incorporate a safety factor of 10 or greater with respect to RF levels known to represent a health hazard, and an additional safety factor of five is applied to the MPE limits for general population exposure. Thus, the general population MPE limit has a built-in safety factor of more than 50. The limits were constructed to appropriately protect humans of both sexes and all ages and sizes and under all conditions – and continuous exposure at levels equal to or below the applicable MPE limits is considered to result in no adverse health effects or even health risk.

The reason for *two* tiers of MPE limits is based on an understanding and assumption that members of the general public are unlikely to have had appropriate RF safety training and may not be aware of the exposures they receive; occupational exposure in controlled environments, on the other hand, is assumed to involve individuals who have had such training, are aware of the exposures, and know how to maintain a safe personal work environment.

The FCC's MPE limits are expressed in two equivalent forms, using alternative units of field strength (expressed in volts per meter, or V/m), and power density (expressed in milliwatts per square centimeter, or mW/cm<sup>2</sup>). The table on the next page lists the FCC limits for both occupational and general population exposures, using the mW/cm<sup>2</sup> reference, for the different radio frequency ranges.

Frequency Range (F) (MHz)	Occupational Exposure (mW/cm <sup>2</sup> )	General Public Exposure (mW/cm <sup>2</sup> )
0.3 - 1.34	100	100
1.34 - 3.0	100	$180 / F^2$
3.0 - 30	$900 / F^2$	$180 / F^2$
30 - 300	1.0	0.2
300 - 1,500	$F / 300$	$F / 1500$
1,500 - 100,000	5.0	1.0

The diagram below provides a graphical illustration of both the FCC's occupational and general population MPE limits.



Because the FCC's RF exposure limits are frequency-shaped, the exact MPE limits applicable to the instant situation depend on the frequency range used by the systems of interest.

The most appropriate method of determining RF compliance is to calculate the RF power density attributable to a particular system and compare that to the MPE limit applicable to the operating frequency in question. The result is usually expressed as a percentage of the MPE limit.

For potential exposure from multiple systems, the respective percentages of the MPE limits are added, and the total percentage compared to 100 (percent of the limit). If the result is less than 100, the total exposure is in compliance; if it is more than 100, exposure mitigation measures are necessary to achieve compliance.

Note that the FCC "categorically excludes" all "non-building-mounted" wireless antenna operations whose mounting heights are more than 10 meters (32.8 feet) from the routine requirement to demonstrate compliance with the MPE limit, because such operations "are deemed, individually and cumulatively, to have no significant effect on the human environment". The categorical exclusion also applies to *all* point-to-point antenna operations, regardless of the type of structure they're mounted on. Note that the FCC considers any facility qualifying for the categorical exclusion to be automatically in compliance.

#### ***FCC References on RF Compliance***

47 CFR, FCC Rules and Regulations, Part 1 (Practice and Procedure), Section 1.1310 (Radiofrequency radiation exposure limits).

FCC Second Memorandum Opinion and Order and Notice of Proposed Rulemaking (FCC 97-303), *In the Matter of Procedures for Reviewing Requests for Relief From State and Local Regulations Pursuant to Section 332(c)(7)(B)(v) of the Communications Act of 1934 (WT Docket 97-192), Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation (ET Docket 93-62), and Petition for Rulemaking of the Cellular Telecommunications Industry Association Concerning Amendment of the Commission's Rules to Preempt State and Local Regulation of Commercial Mobile Radio Service Transmitting Facilities*, released August 25, 1997.

FCC First Memorandum Opinion and Order, ET Docket 93-62, *In the Matter of Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation*, released December 24, 1996.

FCC Report and Order, ET Docket 93-62, *In the Matter of Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation*, released August 1, 1996.

FCC Office of Engineering and Technology (OET) Bulletin 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition 97-01, August 1997.

FCC Office of Engineering and Technology (OET) Bulletin 56, "Questions and Answers About Biological Effects and Potential Hazards of RF Radiation", edition 4, August 1999.