PINNACLE TELECOM GROUP
Professional and Technical Services

ANTENNA SITE FCC RF COMPLIANCE ASSESSMENT AND REPORT

HOMELAND TOWERS, LLC

SITE "CT254"
515 MOREHOUSE ROAD
EASTON, CT

April 10, 2017

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Contents

Introduction and Summary

At the request of Homeland Towers, LLC, Pinnacle Telecom Group has performed an independent expert assessment of radiofrequency (RF) levels and related FCC compliance for wireless antenna operations on a proposed 150-foot monopole proposed at 515 Morehouse Road in Easton, CT.

Homeland Towers refers to the prospective site as "CT254", and the proposed pole will accommodate the directional panel antennas of Verizon Wireless, which plan to occupy the highest antenna mounting position on the pole, with an antenna center line of 145 feet. Easton Police Department and Easton EMS propose to mount antennas at the top of the pole at 150 feet. Easton Fire Department plans to mount antennas at 75 feet on the pole.

The FCC requires wireless antenna operators to perform an assessment of the RF levels from all the transmitting antennas at a site whenever antenna operations are added or modified, and ensure compliance with the FCC Maximum Permissible Exposure (MPE) limit in areas of unrestricted public access, i.e., at street level around the site.

This assessment of antenna site compliance is based on the FCC limit for general population "maximum permissible exposure" (MPE), a limit established as safe for continuous exposure to RF fields by humans of either sex, all ages and sizes, and under all conditions.

The result of an FCC compliance assessment can be described in layman's terms by expressing the calculated RF levels as simple percentages of the FCC MPE limit. In that way, the figure 100 percent serves as the reference for compliance, and calculated RF levels below 100 percent indicate compliance with the MPE limit. An equivalent way to describe the calculated results is to relate them to a "times-below-the-limit" factor. Here, we will apply both descriptions.

The result of the FCC compliance assessment in this case is as follows:

- At street level around the site, the conservatively calculated maximum RF level caused by Verizon Wireless' panel antenna operations and all other proposed antenna operation is 1.1226 percent of the FCC general population MPE limit, well below the 100-percent reference for compliance. In other words, even with calculations designed to significantly overstate the RF levels versus those that could actually occur at the site, the worst-case calculated RF level in this case is still more than 89 times below the limit defined by the federal government as safe for continuous exposure of the general public.
- The results of the calculations provide a clear demonstration that the RF levels, even under worst-case circumstances, would satisfy the FCC requirement for controlling potential human exposure to RF fields. Moreover, because of the conservative methodology and assumptions applied in this analysis, RF levels actually caused by any antenna operations at this site will be even less significant than the calculation results here indicate.

The remainder of this report provides the following:

- relevant technical data on the parameters for the wireless carrier and the proposed Municipal operations;
- a description of the applicable FCC mathematical model for assessing compliance with the MPE limit, and application of the relevant technical data to that model; and
- analysis of the results of the calculations, and the compliance conclusion for the proposed site.

In addition, two Appendices are included. Appendix A provides background on the FCC MPE limit, along with a list of key references. Appendix B provides a summary of the qualifications of the author of this report.

Antenna and Transmission Data

As described, the proposed 150-foot pole will accommodate Verizon Wireless. Verizon wireless proposes to occupy the highest mounting position on the pole, and this analysis will include an assumption of "worst-case" for a Verizon Wireless site with an antenna centerline of 145 feet.

Verizon Wireless is licensed to operate in the 700, 850, 1900 and 2100 MHz frequency bands. In the 700 MHz band, Verizon uses two 60-watt channels per antenna sector. In the 850 MHz band, Verizon uses eight 20-watt channels per antenna sector. In the 1900 MHz band, Verizon uses six 16-watt channels and two 60-watt channels per antenna sector. In the 2100 MHz band, Verizon uses two 60-watt channels per sector.

The area below the antennas, at street level, is of interest in terms of potential "uncontrolled" exposure of the general public, so the antenna's vertical-plane emission characteristic is used in the calculations, as it is a key determinant in the relative level of RF emissions in the "downward" direction.

By way of illustration, Figure 1 that follows shows the vertical-plane radiation pattern of the antenna model to be used by Verizon Wireless in the 1900 MHz frequency band. Note that in this type of diagram, the antenna is effectively pointed at the three o'clock position (the horizon) and the relative strength of the pattern at different angles is described using decibel units. The use of a decibel scale to describe the relative pattern at different angles incidentally tends to visually 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 1/100th of the maximum that occurs in the main beam (at 0 degrees); at a 30 dB point, the level is 1/1,000th of the maximum.

Note 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.

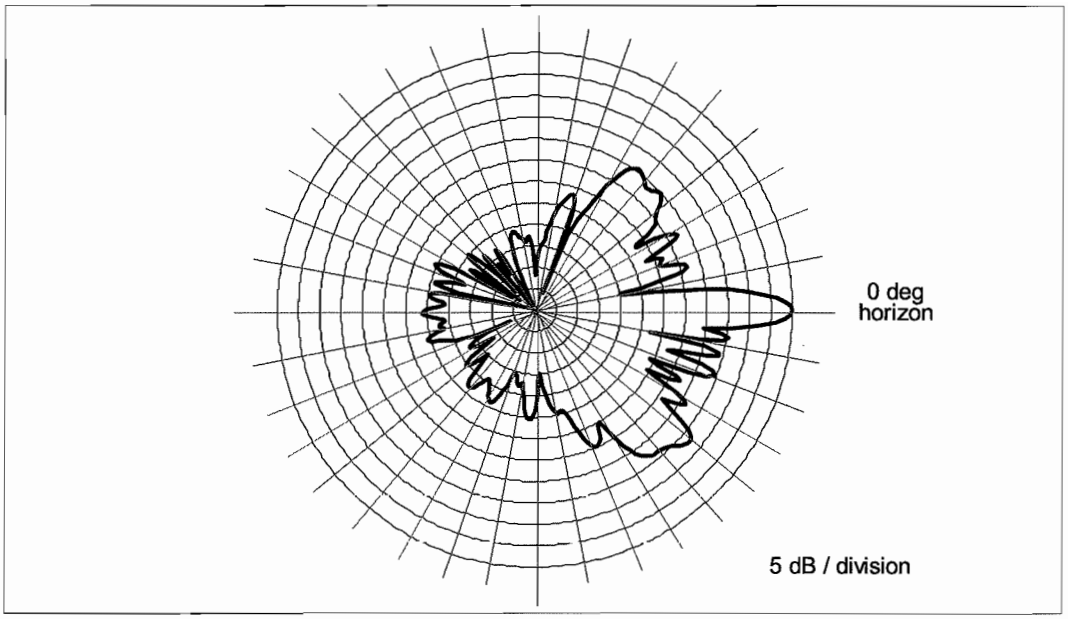


Figure 1. Commscope JAHH-65B-R3B Antenna – 1900 MHz Vertical-plane Pattern

In addition, and as mentioned at the outset, Easton Township Police, EMS and Fire have several omnidirectional (whip) antenna operations proposed at the site. A search of FCC records indicates the Easton Township is authorized for the following;

Freq. Band and Use	*Max. Authorized Transmitter power*
Easton EMS 155.295 MHz	110 watts
Easton Police Department 154.040 MHz	70 watts
Easton Fire Department 33.56 MHz	100 watts

Compliance Analysis

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

Around an antenna site at ground level (in what is called the "far field" of the antennas), the RF levels are directly proportional to the total antenna input power and the relative antenna gain (focusing effect) in the downward direction of interest – and the 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", mirror-like reflection, which is the absolute worst-case approach.

The formula for ground-level MPE compliance assessment of any given wireless antenna operation is as follows:

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

where

MPE%	=	RF level, expressed as a percentage of the FCC MPE limit applicable to continuous exposure of the general public
100	=	factor to convert the raw result to a percentage
TxPower	=	maximum net power into antenna sector, in milliwatts, a function of the number of channels per sector, the transmitter power per channel, and line loss
$10^{(Gmax-Vdisc)/10}$	=	numeric equivalent of the relative antenna gain in the direction of interest downward toward ground level
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

The MPE% calculations are normally performed out to a distance of 500 feet from the facility to points 6.5 feet (approximately two meters, the FCC-recommended standing height) off the ground, as illustrated in Figure 2 below.

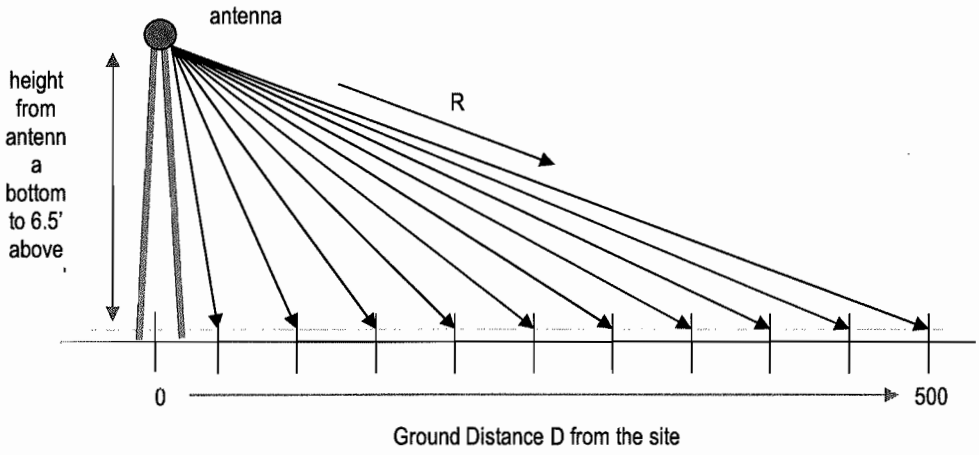


Figure 2. Street-level MPE% Calculation Geometry

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 site 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.

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. Note that according to the FCC, when directional antennas are used, the compliance assessments are based on the RF effect of a single antenna sector (or, in cases of non-identical parameters, the worst-case effect of any individual sector).

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, and at maximum channel capacity. In addition, the effects of antenna line loss are ignored wherever possible.

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 assuming a 6'6" human and performing the calculations from the bottom (rather than the centerline) of each operator's lowest-mounted antenna, as applicable.

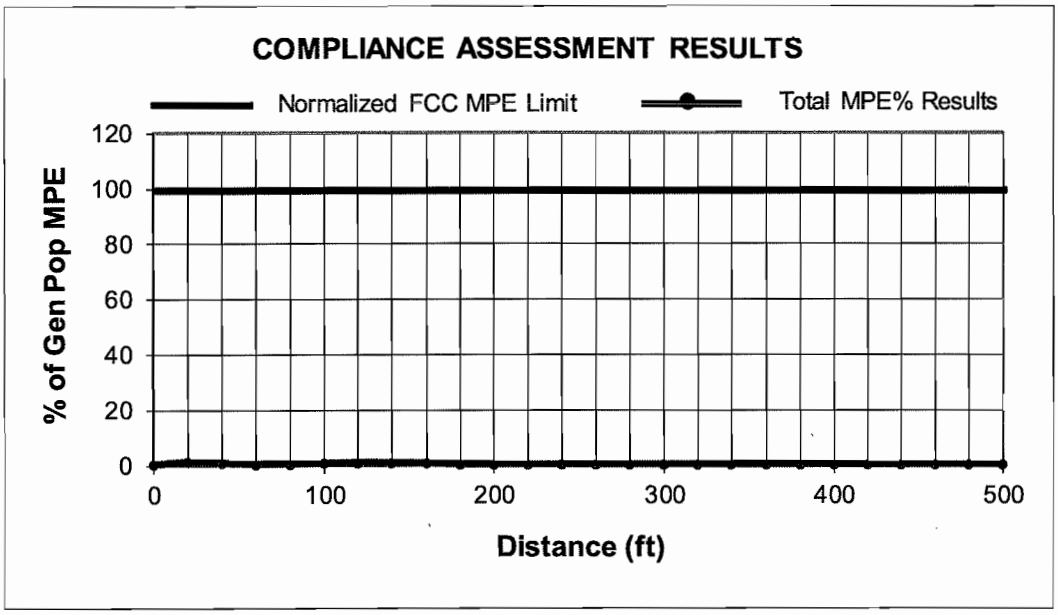
4. The potential RF exposure at ground level is assumed to be 100-percent enhanced (increased) via a "perfect" field reflection from the intervening ground.

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 that follows provide the results of the MPE% calculations for each operator, with the worst-case result highlighted in bold in the last column of the table.

Ground Distance (ft)	Verizon MPE% 700 MHz	Verizon MPE% 850 MHz	Verizon MPE% 1900 MHz	Verizon MPE% 2100 MHz	Easton EMS MPE% 155 MHz	Easton PD MPE% 154 MHz	Easton FD MPE% 33 MHz	Total MPE%
0	0.0040	0.0097	0.0000	0.0001	0.0222	0.0151	0.0886	0.1397
20	0.0017	0.0051	0.0021	0.0004	0.1986	0.1354	0.7793	**1.1226**
40	0.0019	0.0190	0.0104	0.0002	0.2365	0.1612	0.3235	0.7527
60	0.0094	0.0154	0.0419	0.0001	0.0947	0.0646	0.1585	0.3846
80	0.0764	0.0058	0.0033	0.0149	0.1199	0.0817	0.0985	0.4005
100	0.1463	0.0437	0.1805	0.0174	0.0506	0.0345	0.0937	0.5667
120	0.1060	0.1497	0.2856	0.0566	0.1112	0.0758	0.1541	0.9390
140	0.0361	0.1387	0.4062	0.1834	0.0021	0.0014	0.0450	0.8129
160	0.0132	0.0408	0.4437	0.1949	0.0197	0.0135	0.0042	0.7300
180	0.0043	0.0049	0.0268	0.1813	0.0544	0.0371	0.0195	0.3283
200	0.0087	0.0062	0.0276	0.0727	0.0434	0.0296	0.0114	0.1996
220	0.0153	0.0058	0.0792	0.0098	0.0100	0.0068	0.0032	0.1301
240	0.0190	0.0039	0.0072	0.0550	0.0321	0.0219	0.0113	0.1504
260	0.0270	0.0163	0.0262	0.0388	0.0350	0.0239	0.0338	0.2010
280	0.0437	0.0461	0.0404	0.0188	0.0231	0.0158	0.0588	0.2467
300	0.0503	0.0653	0.0179	0.0195	0.0030	0.0020	0.0763	0.2343
320	0.0608	0.1136	0.0137	0.0084	0.0002	0.0001	0.0674	0.2642
340	0.0556	0.1252	0.0393	0.0025	0.0034	0.0023	0.0689	0.2972
360	0.0457	0.1266	0.0550	0.0099	0.0048	0.0033	0.0538	0.2991
380	0.0323	0.1161	0.0441	0.0263	0.0048	0.0033	0.0484	0.2753
400	0.0178	0.0949	0.0167	0.0361	0.0045	0.0031	0.0283	0.2014
420	0.0056	0.0665	0.0001	0.0289	0.0029	0.0019	0.0257	0.1316
440	0.0051	0.0611	0.0001	0.0265	0.0026	0.0018	0.0085	0.1057
460	0.0020	0.0339	0.0121	0.0103	0.0008	0.0005	0.0078	0.0674
480	0.0064	0.0122	0.0427	0.0005	0.0001	0.0001	0.0072	0.0692
500	0.0059	0.0113	0.0396	0.0004	0.0001	0.0001	0.0038	0.0612

As indicated, the overall worst-case calculated result is 1.1226 percent of the FCC general population MPE limit – well below the 100-percent reference for compliance, particularly given the significant conservatism incorporated in the analysis.

A graph of the overall calculation results, shown below, provides perhaps a clearer *visual* illustration of the relative compliance of the calculated RF levels. The line representing the overall MPE% results barely rises above the graph's baseline, and shows a consistent, comfortable margin to the FCC MPE limit.



Compliance Conclusion

The FCC MPE limit has been constructed in such a manner that continuous human exposure to RF fields up to and including 100 percent of the MPE limit is acceptable and completely safe.

The conservatively calculated maximum RF effect at street level from the assumed worst-case operations is 1.1226 percent of the FCC general population MPE limit. In other words, even with an extremely conservative analysis intended to dramatically overstate the RF effects of any scenario at the site, the calculated worst-case RF level is still more than 89 times below the FCC MPE limit.

The results of the calculations indicate clear compliance with the FCC regulations and the related MPE limit, even for a worst-case scenario. Because of the conservative calculation methodology and operational assumptions applied in this analysis, the RF levels actually caused by the antennas will be even less significant than the calculation results here indicate, and compliance would be achieved by an even larger margin.

Certification

The undersigned certifies as follows:

1. I have read and fully understand the FCC regulations concerning RF safety and the control of human exposure to RF fields (47 CFR 1.1301 *et seq*).
2. To the best of my knowledge, the statements and information disclosed in this report are true, complete and accurate.
3. The analysis of site RF compliance provided herein is consistent with the applicable FCC regulations, additional guidelines issued by the FCC, and industry practice.
4. The results of the analysis demonstrate compliance with the FCC regulations and limit concerning the control of potential human exposure to the RF emissions from antennas.

Daniel Penesso

Daniel Penesso
Director- RF Engineering
Pinnacle Telecom Group, LLC

4/10/17
Date

Appendix A. Background on the FCC MPE Limit

As directed by the Telecommunications Act of 1996, the FCC has established limits for maximum continuous human exposure to RF fields.

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.

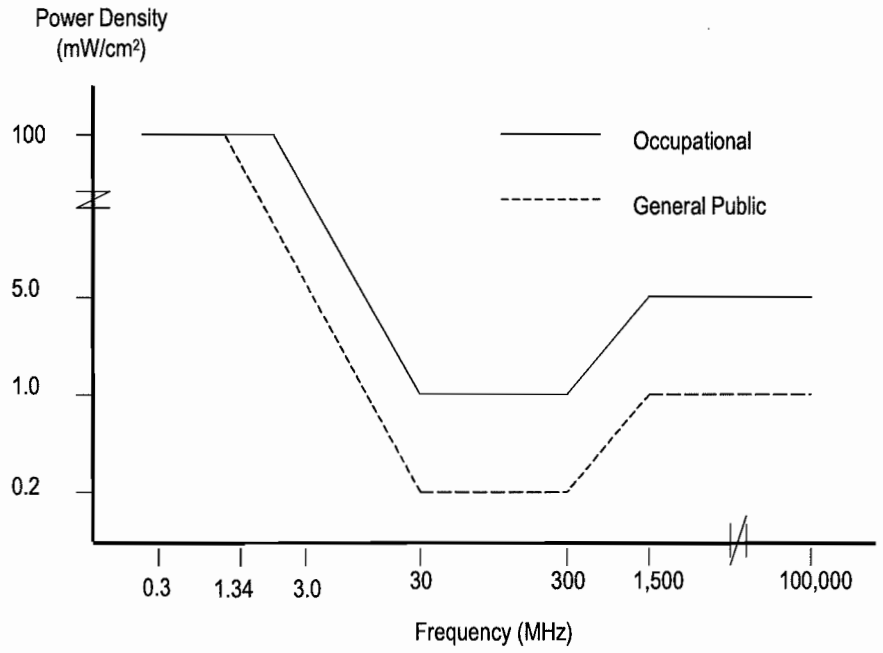
The specified continuous exposure MPE limits are based on known variation of human body susceptibility in different frequency ranges, and a Specific Absorption Rate (SAR) of 4 watts per kilogram, which is universally considered to accurately represent human capacity to dissipate incident RF energy (in 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 RF exposure 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^2). The table on the next page lists the FCC limits for both occupational and general population exposures, using the mW/cm^2 reference, for the different radio frequency ranges.

Frequency Range (F) (MHz)	Occupational Exposure (mW/cm^2)	General Public Exposure (mW/cm^2)
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.

Appendix B. Summary of Expert Qualifications

Daniel Penesso, Director – RF Engineering, Pinnacle Telecom Group, LLC

Synopsis:	• 19 years of experience in all aspects of wireless RF engineering, including network design and implementation, interference analysis, FCC and FAA regulatory matters, and antenna site compliance with FCC RF exposure regulations • Have performed RF engineering and FCC compliance work for all the major wireless carriers – AT&T, Verizon Wireless, Sprint, T-Mobile, and MetroPCS, as well as Crown Castle • Have served as an expert witness on RF engineering and/or FCC RF compliance more than 100 times before municipal boards in New Jersey and New York
Education:	• Bachelor of Science in Electrical Engineering, DeVry Institute of Technology, Chicago, IL, 1987
Current Responsibilities	• Manages PTG staff work involving FCC RF compliance for wireless antenna sites, including the provision of math- and measurements-based site compliance reports, related expert testimony in municipal hearings, and compliance-related support in client meetings with prospective site landlords and in town meetings • Provides math-based FCC compliance assessments and reports for PTG's wireless clients, including AT&T, Verizon Wireless, T-Mobile, Sprint, MetroPCS, and Crown Castle • Responsible for providing client consulting and in-house training on FCC and OSHA RF safety compliance
Prior Experience:	• Have served as senior RF engineer for four of the five national wireless carriers – AT&T, T-Mobile, Sprint, and MetroPCS – in the New York and New Jersey markets • Served as an RF engineer for Metricom, Triton PCS, Alltel Communications, and Western Wireless • Have worked as an RF engineer for several engineering services companies, including Sublime Wireless, Amirit Technologies, Celcite, and Wireless Facilities Incorporated