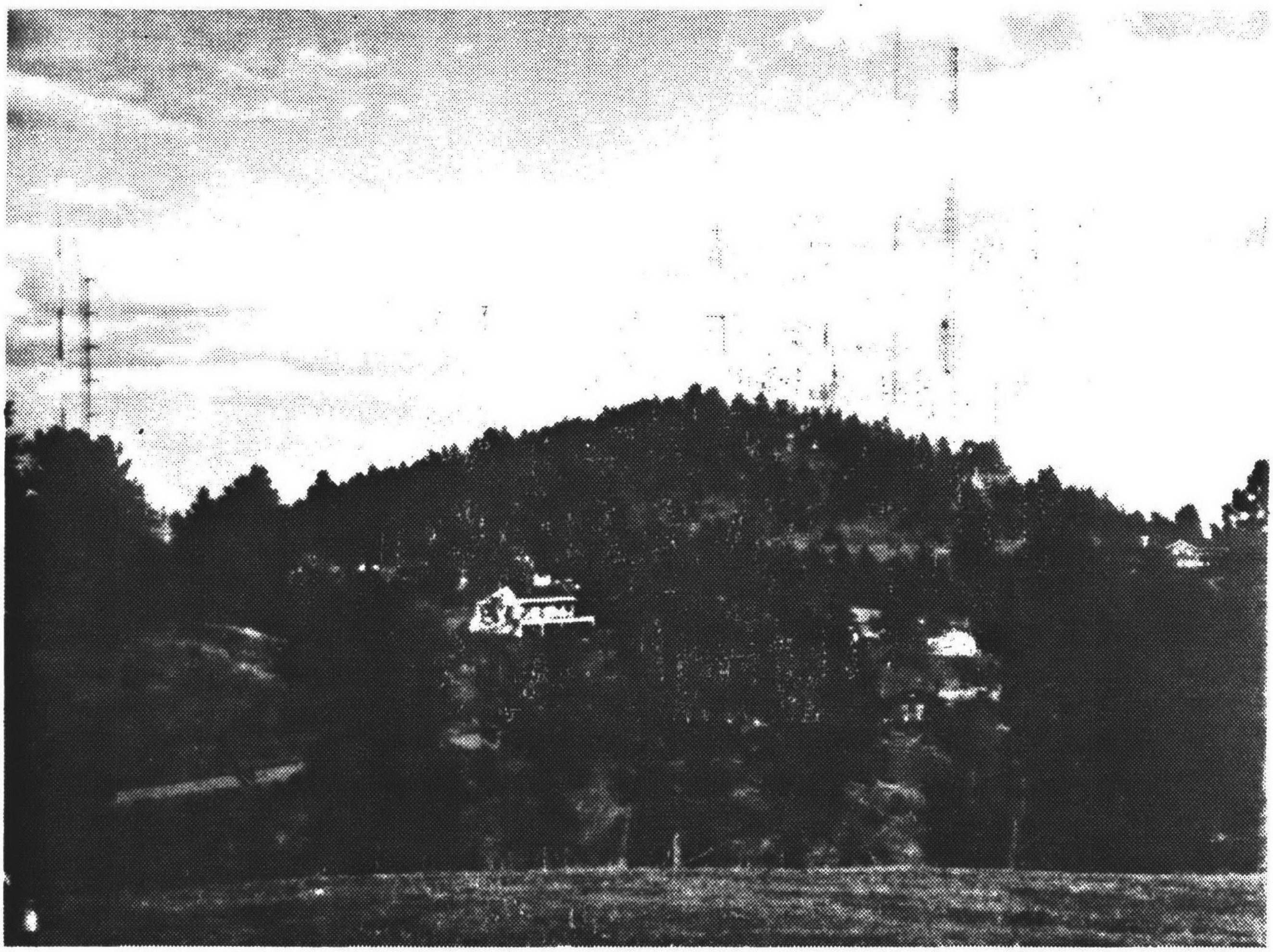
An Investigation of Radiofrequency Radiation Levels on Lookout Mountain, Jefferson County, Colorado September 22 - 26, 1986



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EXECUTIVE SUMMARY

During the week of September 22, 1986, Environmental Protection Agency and Federal Communications Commission personnel investigated radiofrequency radiation intensities near the Lookout Mountain antenna farms, west of Denver, Colorado. Typical power densities near several area residences did not exceed 100 $\mu W/cm^2$. The highest value found near the towers along Cedar Lake Road was 580 $\mu W/cm^2$, which is below the 1000 $\mu W/cm^2$ FCC guidelines. However, near the base of the KYGO-FM tower, a 10,000 $\mu W/cm^2$ value was found and power densities exceeding 1,000 $\mu W/cm^2$ were measured over a large area. The areas exceeding the FCC guidelines are in a residential area and are accessible to the public. EPA urges the FCC to order KYGO to correct the problem as soon as possible.

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BACKGROUND

Lookout Mountain is the location for broadcast antennas for many of the television and FM radio stations that serve the Denver area. The number of stations and their close proximity to one another and to residential areas make the Lookout Mountain antenna farms unusual. Table 1 lists these stations and their frequencies. Figure 1 shows the location of stations on a map of the Lookout Mountain area. Interference to consumer electronic devices and subsequent concern over possible health effects led the residents and the Jefferson County Planning Commission to request a survey of radiofrequency (RF) radiation levels on Lookout Mountain in 1983. That survey was conducted in 1983 and 1984 and found no locations where the RF intensity exceeded the American National Standards Institute RF protection guide of 1,000 $\mu W/cm^2$ (1). However the study was limited by the fact that permission was not obtained to investigate the RF levels on private property near some broadcast antennas. In 1986, residents contacted the Federal Communications Commission (FCC) seeking a more comprehensive study. The FCC consulted EPA, and EPA found that modeled power densities near the base of the KYGO-FM tower approached 10,000 $\mu W/cm^2$. The earlier study could not corroborate or refute this prediction since the owners of the property surrounding the KYGO tower (KYGO does not own the property) had not been reached to grant EPA permission to conduct measurements on their land in 1983 and 1984. Because the projected power density near KYGO was so high and because the accuracy of the calculational model had been verified with measurements in other locations, EPA Electromagnetics Branch personnel traveled to the Denver area to conduct a study on Lookout Mountain during the period September 22 to 26, 1986. This study was conducted at the request of the FCC under the provisions of an interagency agreement between the FCC and the EPA. Accordingly, FCC personnel were present and assisted in the study.

EQUIPMENT

RF field strength is usually measured using broadband isotropic electric or magnetic field strength meters, or tunable field strength meters connected to appropriate antennas. Broadband equipment is used to determine the total RF field at a point while narrowband equipment provides details of the RF field intensity at any particular frequency. This study employed both types of equipment.

For automated, narrowband measurements, two antennas were used. A NanoFast Fiber Optic Isolated Spherical Dipole (FOISD) was used for frequencies from 10 kHz to 700 MHz. A Watkins Johnson omnidirectional biconical antenna (OMNI) was used for frequencies above 500 MHz. Both detect electric fields and both are linearly polarized antennas. The axis of each antenna was oriented at 55° from the axis of its support mast. With this orientation, one can place the antenna in each of three orthogonal positions by rotating the support mast to three azimuths, 120° apart. Each OMNI and FOISD data value presented in this report is the result of three orthogonal measurements. All OMNI measurements were made with the antenna on a fiberglass mast above the roof of the measurement vehicle at a height of about 12 feet. Some of the FOISD measurements were also made at this height, but others were made at various heights between 1 and 8 feet above ground.

RF power directly proportional to the electromagnetic wave power density was conveyed via coaxial cable from the OMNI to a Hewlett Packard 8566A spectrum analyzer and from there to a Hewlett Packard 9845B computer. The computer applies antenna factors, combines the three orthogonal spectra and stores the results on disk.

In contrast to the Watkins Johnson OMNI antenna, the NanoFast FOISD does not conduct RF power directly to the analyzer. The conventional RF coaxial cable would act as part of the antenna itself and decrease the accuracy of the information collected by the FOISD at lower frequencies - particularly in the AM radio band. To avoid this source of error the FOISD does not use electrically conductive coaxial cable but rather a fiber optic cable which conducts light instead of RF power. The voltage that the electric field induces across the two halves of the FOISD is used to amplitude modulate a light signal. This light is conducted to the inside of the measurement vehicle via a fiber optic cable. The light signal is demodulated back to an RF signal, and fed to the spectrum analyzer via coaxial cable. Then, as with the OMNI antenna, the analyzer delivers frequency specific information to the computer for processing and storage.

Two computer programs were used to process the information supplied by the spectrum analyzer. The first, DRIVER, has been used for several years by the Electromagnetics Branch for similar field studies. It is especially useful for measuring peak spectra like those associated with radar and paging systems. Those measurements that were processed with the DRIVER system are identified with file names beginning with "I". The second program, ZOOM, was developed recently to allow more rapid and accurate measurements at predetermined frequencies. The measurements made using ZOOM are identified in the report with file names beginning with "Z". ZOOM was tailored before the study began to look only at the eight FM and six TV frequencies that are broadcasting from antennas on Lookout Mountain. These frequencies are the main consideration in this study (see Procedures and Results). The data collected with ZOOM are listed in Appendix A by file name.

Several different broadband instruments were brought for the Lookout Mountain study because this area presented a complex electromagnetic environment that could affect broadband instruments to extents that were not simple to predict. Bringing a variety of meters whose responses could be evaluated on Lookout Mountain would allow the study to be completed even if the limitations of some of the instruments made their use impractical for the Lookout Mountain measurements. Three Holaday Industries field strength meters with electric field probes, one Narda magnetic field probe/meter system, two Narda electric field probe/meter systems, and one Instruments for Industry (IFI) electric field meter were used. The Holaday and Narda probes are isotropic. The IFI unit detects only one polarization at a time and must be reoriented if three orthogonal measurements are necessary. These systems were calibrated at the Electromagnetics Branch laboratory during the summer of 1986. In addition, a Holaday Industries data logger was used to store and reduce large amounts of data for spatial averaging of RF levels. Appendix B contains more detailed information on the equipment and calibrations.

Although all the antennas used in the Denver study sense either electric or magnetic fields, the data presented here have been converted to conventional units of plane-wave equivalent power density.

PROCEDURE AND RESULTS

The Denver area measurements can be sorted into four categories: those conducted around the Cedar Lake Road circle near the Lookout Mountain towers, those near KYGO-FM, those at other nearby towers, and those near residences or public attractions. Each will be addressed in turn.

Cedar Lake Road

Spectrum Survey

The top of the access road leading from Cedar Lake Road to most of the Lookout Mountain towers is the highest point topographically in the area. Its elevation allows the best line of sight to the nearby antennas, and therefore measurements were made at this location in several frequency ranges in order to establish which bands were major contributors to power density on Lookout Mountain. These data are listed in Table 2. All these data were obtained with the antenna (FOISD or OMNI) mounted above the measurement vehicle. All values for broadcast frequencies represent average power densities. Values for land mobile, two-way radio, and radar frequencies are peak power densities. The peak radar value should be multiplied by the duty cycle of the pulse (determined from repetition rate and width) and the rotational duty cycle to obtain true average values for comparison to RF exposure guidelines. Typically these duty cycles are 0.001 and 0.01 respectively so the peak value would be multiplied by 0.00001 to obtain a typical average power density for the radar beam. Once this factor is applied, the radar power density is among the lowest in Table 2. Similarly, the power densities for land mobile and two-way radio would be reduced if the duty cycles for signals in these bands were incorporated; however, because even the peak values in these bands were relatively low and because determining duty cycle would be very time consuming, these peak power densities were not adjusted to reflect the lower, average values.

The power densities in Table 2 confirmed expectations that broadcast band sources, particularly FM radio, dominate the RF environment on Lookout Mountain. FM radio accounts for over twice the power density caused by VHF and UHF TV on Lookout Mountain. This information justified deleting all bands but radio and TV from further detailed investigation.

The data in Table 2 also provide quality assurance checks between antennas and between data reduction programs. Four bands were evaluated using both the DRIVER and ZOOM programs. The difference between the reported power densities in each band using the different programs ranged from 1 to about 2.5 dB, a reasonably good comparison for programs developed for different purposes. The ZOOM program was developed recently to increase the speed and accuracy with which measurements could be made at a set of predetermined FM and TV frequencies. The primary reason for greater accuracy in the ZOOM program is its use of narrow frequency ranges and the more accurate 1 dB per division display mode on the spectrum analyzer, rather than wide frequency ranges and the 10 dB per division display mode as used in DRIVER. ZOOM is designed to provide high accuracy in predetermined narrow frequency bands. DRIVER is better suited to studying unknown RF environments with widely disparate field intensities using the analyzer's wide dynamic range (10 dB/division) and its broad frequency range display. The ZOOM program was used for the remainder of the narrowband measurements in the Denver study.

A comparison between the data collected for UHF-TV Channel 31 using the DRIVER program shows a difference of less than 2 dB, between values obtained with the FOISD and OMNI antennas. This is probably due to the difference in the heights of the two antennas, causing them to intercept different electric field intensities along the short wavelength standing waves.

Cedar Lake Road Measurements

Narrowband measurements provide useful information concerning the particular frequencies that contribute to the power density at any location. However, narrowband antennas remain cumbersome to use, requiring a heavy base for support and three orientations for every measurement. They are not practical for investigating large areas to find locations of elevated power densities. The lightweight, isotropic, broadband instruments meet this need. Broadband instruments are not ideal, however, suffering from limitations that may be important in the presence of low frequency fields such as AM broadcasts, and multiple frequency, strong fields such as the FM and TV spectra on Lookout Mountain. Nevertheless, broadband equipment is used in order to help evaluate the RF environment in a timely manner. The question is how much faith, if any, should the investigator place in the data obtained with broadband equipment. To answer this question, six comparisons were made between the values obtained with the FOISD and the data collected with a few broadband survey instruments. The FOISD was considered the reference standard for these comparison measurements.

The comparison procedure consisted of the following steps. A Holaday was used to probe the area around a measurement site to locate the maximum electric field (E-field) value. The FOISD was then placed at the point of the highest E-field value to obtain the reference field value at that point. After measuring the field with the FOISD, the FOISD was removed from its supporting mast and the electric field probe of a broadband instrument was placed where the FOISD had been. These comparisons were made using the moveable FOISD base which allows measurements to be made close to the ground.

One of the survey instruments used in this comparison was a Narda magnetic field probe. The team did not have a magnetic field narrowband antenna system that could serve as a reference standard for this instrument as the FOISD had for the broadband electric field meters. Instead, the team used the FOISD as the reference as follows. Once the maximum electric field had been quantified and the FOISD had been removed, the area directly above and below the E-field maximum location was probed with the Narda 8616 meter and 8631 magnetic field (H-field) probe to find the H-field maximum associated with the standing wave. The E- and H-field maxima were then converted to units of plane wave equivalent power density for comparison.

Table 3 presents these comparison data for locations around Cedar Lake Road as well as for one additional location near the KYGO-FM tower, about one-third of a mile from Cedar Lake Road. The data collected near KYGO will be discussed later. The third column of Table 3 shows the power densities measured with the FOISD at six locations around Cedar Lake Road. None of the values approaches the 1000 $\mu W/cm^2$ American National Standards Institute Radiofrequency Radiation Protection Guide. This standard has been adopted by the Federal Communications Commission (FCC) for administrative use as a guide in the processing of license applications (2). However, near the KOSI tower, the power density exceeds the most stringent value (100 $\mu W/cm^2$) being considered by EPA (3) as it evaluates options for the protection of the general public from RF radiation exposure.

The data in Table 3 are listed in three categories defined by the frequency responses of the broadband instruments of interest. The first category includes all the frequencies used by broadcasters on Lookout Mountain (55 MHz to 578 MHz) including UHF Channel 31. Because broadcasters dominate the spectrum on Lookout Mountain, the FOISD values listed here are, for practical purposes, the total power density that one would find at these locations. The Holaday meters are designed to measure electric fields at all these FM and TV broadcast frequencies, so the Holaday data can be compared with the total power density FOISD values listed in the third column. With one exception, all the differences between the Holaday and FOISD values are less than 2 dB. The average deviation is less than 1 dB, showing good agreement for broadband meters in field measurements.

The second category, described on page 2 of Table 3, consists of data for frequencies below 200 MHz. This includes FM and VHF-TV. Two Narda probes and the IFI meter operate in this range. The FOISD value listed in this category includes the power density from all the Lookout Mountain broadcasters except Channel 31, which at 575 MHz is beyond the recommended range of these IFI and Narda broadband instruments. Comparisons between the FOISD values and the numbers reported by the Narda and IFI meters show good agreement in most cases. However the use of the Narda and IFI meters was limited by other considerations. When the IFI meter was used at Location B, it responded erratically, making an accurate reading impossible. The cause of this problem may have been a sensitivity to frequencies outside the design range for the meter such as the 575 MHz Channel 31 signal. Like the IFI, both Narda probes in category two responded accurately, but the Narda probes suffered from a zero-drift problem. This drift makes it difficult or impossible to obtain reliable data at relatively weak RF field levels. These problems led the team to abandon these instruments for routine measurements throughout the remainder of the study.

The third category in Table 3 includes data for frequencies only above 300 MHz. The only broadcast source on Lookout Mountain that operates above 300 MHz is KDVR-TV, Channel 31. The FOISD column in this category therefore lists only KDVR's power density. The only broadband instrument that the investigators had for which the operating range extends from 300 MHz upward, was the Narda 8621 E-field probe and meter. The sensitivity of the Narda 8621 is such that the relatively low power densities in the area could not be read reliably on the 8621 meter. Hence no Narda 8621 broadband meter data are included in Table 3.

The narrowband measurements made along Cedar Lake Road were useful for identifying the sources of the RF exposure and for evaluating the response of the broadband instruments. Based on this information, the team decided to use the Holaday meters to study typical exposure levels and to search for localized areas of elevated intensity.

The Holaday HI-3320 data logger was used with the Holaday HI-3001 meter (S/N 26046) to evaluate typical power densities along Cedar Lake Road. The data logger stores information from the meter at a rate of four values per second. At the conclusion of the sampling period, the logger reports the maximum, minimum, and average values that it recorded. For this part of the study, the Cedar Lake Road circle was divided into eleven segments of approximately 300 feet each. The endpoints of these segments are identified as locations A through K on Figure 1. The data were obtained as one of the investigators walked each of the segments, while continuously scanning with the Holaday probe from near ground level to a height of about eight feet. The data gathered in this way represent the spatially averaged power densities along Cedar Lake Road. Table 4 presents these data. None of the average values exceeds the FCC guideline or any standard that has been officially adopted or is being considered in the United States. Two of the maximum power densities exceed one of the proposed EPA guidance options (100 $\mu W/cm^2$), and one exceeds other standards (200 $\mu W/cm^2$) published by the National Council on Radiation Protection and Measurements (NCRP) (4) or the International Radiation Protection Association (IRPA) (5).

Measurements Near KOSI-FM

Both the narrowband measurement made near the base of the KOSI tower and the broadband spatially averaged survey of Cedar Lake Road indicated that the highest levels along the Cedar Lake Road loop were near the KOSI tower. Further measurements were made near the KOSI tower using the Holaday meter (S/N 26046). The highest value that could be found was about 580 $\mu W/cm^2$ in a limited area about 3 to 5 feet in front of the KOSI gate. This value does not exceed the FCC guideline, but it does exceed the nonregulatory 200 $\mu W/cm^2$ NCRP and IRPA standards. The investigators searched for the greatest distances from the KOSI tower at which 200 $\mu W/cm^2$ power densities could be measured, and found that 200 $\mu W/cm^2$ values were measurable out to a radius of about 27 feet centered on the KOSI gate. Since the surveyor searched for the greatest radius at which the 200 $\mu W/cm^2$ value could be found, even in localized areas, it follows that the power densities inside this semicircle did not always exceed 200 $\mu W/cm^2$. To estimate the typical values inside the 200 $\mu W/cm^2$ contour line, the surveyor again used the Holaday meter connected to the Holaday data logger, and made several traverses until he was confident that the power densities within the 200 $\mu W/cm^2$contour had been thoroughly sampled. This process was repeated to evaluate its reproducibility. The average power densities for the trials were 215 $\mu W/cm^2$ and 211 $\mu W/cm^2$. The minimum values were 35 $\mu W/cm^2$ and 24 $\mu W/cm^2$. The maximum values were 494 $\mu W/cm^2$ and 430 $\mu W/cm^2$. These data indicate that the typical power density averaged over the entire area within the 200 $\mu W/cm^2$ contour does exceed 200 $\mu W/cm^2$ although the power density at any particular location could be much higher or much lower. The generality of this correlation between average value within the boundary of a contour line and the value of the contour line itself has not been established.

One additional measurement was made to evaluate KOSI. Since the KOSI antenna is mounted close to the ground on a mountain slope, structures further up the slope could be in the main beam of radiation. A cursory inspection suggested this could be the case at a house painted green along the access road to the transmitter buildings on Lookout Mountain. A survey of the deck of this house using the Holaday (S/N 26046) found power densities to be generally between 50 and 100 μW/cm². These levels are well below the FCC guidelines.

Measurements near KYGO-FM

The KYGO-FM antenna is about one-third mile from the Lookout Mountain antenna farm. It differs from other antennas in the area because the KYGO antenna is mounted close to the ground with its bottom element at a height of about 30 to 35 feet. This prompted the investigators to survey the area in the immediate vicinity of KYGO. Near the fence at the base of the tower, the Holaday (S/N 26046 with 103GR probe) reported 10.35 mW/cm² (10,350 μW/cm²) and the Narda magnetic field system read 9.5 mW/cm² (9,500 μW/cm²). A typical value around the fence was 4.5 mW/cm² (4,500 μW/cm²) based on the Holaday and 4.4 mW/cm² (4,400 μW/cm²) as reported by the Narda. The electric and magnetic field data corroborated one another and confirmed that power densities ten times the FCC guideline could be found in publicly accessible areas near the KYGO tower. The lower typical value remained a factor of four over the FCC guideline.

These data led the investigators to map the distances and bearings from the tower to the 1000 μW/cm² and 200 μW/cm² contours. Table 5 presents these data. The locations of the 1000 μW/cm² power density were identified with the Holaday (S/N 26046) electric field meter. These locations were confirmed with magnetic field measurements using the Narda 8631 probe. The 1000 μW/cm² locations found with the Narda were within about five feet of the locations found with the Holaday. The 200 μW/cm² power densities were located using only the Holaday. The 1000 μW/cm² power densities extended to approximately 30 feet from the tower; 200 μW/cm² values were usually found at 50 to 70 feet from the tower. To be certain that KYGO was responsible for the elevated power densities, a FOISD narrowband measurement was made near the KYGO transmitter building. This measurement, saved as file ZOIXJN and summarized in Table 3, showed that KYGO was responsible for 99.7% of the FM and TV power density at the location of the measurement.

The base of the KYGO tower is fenced, but most of the area within the 1000 μW/cm² contour is not. The KYGO tower is located in a complex of buildings where some people live throughout the year and where seasonal, residential workshops are held to teach square dancing. Many people could therefore visit areas where power densities exceed 1000 μW/cm². The main building of the compound is located within about 100 feet of the KYGO tower. The team found maximum power densities of 59 μW/cm² in the laundry room, approximately 100 μW/cm² in the commissary and outside the dining hall, and up to 300 μW/cm² on the patio/deck. Electric and magnetic field measurements made outside a dormitory (the "Tiltin' Hilton") near the tower found 40 to 50 μW/cm² power densities.

Finally it is interesting to note the effect of different elevations (in mountainous areas) on the power densities one records. Another narrowband FOISD measurement (file ZOIZIu) made on top of the vehicle in the parking lot at 756 Lookout Mountain Road, in the property on which the KYGO antenna is located, found a power density of 37.2 µW/cm^2. This measurement location was perhaps 100 feet from the KYGO tower and below the center of radiation. The elevation increases as one moves across Lookout Mountain Road, approaching the apparent height of the center of radiation of the KYGO antenna. Another FOISD measurement (file ZOIZJD) was made at this higher, but more distant location (perhaps 200 to 300 feet from KYGO). Usually, tripling the distance from an antenna in this way would reduce the power density by a factor of 9. In this case however, the effect of greater distance was overcome by moving higher into the main beam of radiation. The power density rose to 85.8 µW/cm^2 in the driveway of a home across Lookout Mountain Road from KYGO. Even at 1054 Colorow Road, approximately 800 feet from KYGO but still elevated with respect to the base of the KYGO tower, the power density remains greater than in the parking lot at 756 Lookout Mountain Road. The power density measured near 1054 Colorow Road was 55.8 µW/cm^2 (file ZOIYQx). These data illustrate the need to consider the relative elevations of areas surrounding a station in the overall RF exposure evaluation.

<u>Measurements Near Other Lookout Mountain Towers</u>

Approximately three quarters of a mile from the Lookout Mountain antenna farm are two towers which support a variety of communications antennas, two FM antennas, and one VHF-TV antenna. KRMA-TV, KCFR-FM, and KUVO-FM are located at the Colorow Hill site. Electric field measurements were made at this site using two Holaday meters (S/N 26046, 26042). At the base of the broadcast tower the power densities ranged from 2 to 124 µW/cm^2. Between the antennas and Colorow Road power densities of 350 to 425 µW/cm^2 were found. Across the road values up to 200 µW/cm^2 were found.

These data prompted the team to search for the 200 µW/cm^2 contour along Colorow Road. Power densities up to 200 µW/cm^2 were found along a 125 foot length of Colorow Road, centered approximately at the door to the transmitter building. The 200 µW/cm^2 levels extended to about 12 feet beyond the far side of Colorow Road from the transmitter building. A FOISD narrowband measurement, made near the antennas reported a power density of 204 µW/cm^2. This file, identified as ZOIZMF, found the major contributor to be KCFR-FM. KUVO-FM and KRMA-TV were the next strongest contributors but together provided only about half the power density of KCFR at that location.

At another location, one third of a mile north of the Lookout Mountain antenna farm, is a smaller group of towers supporting antennas for TV and FM stations. A survey near these towers using the Holaday (S/N 26042) found locations where the power densities reached 273 µW/cm^2. However, power densities were usually below 200 µW/cm^2, and over the entire area the levels were generally between 50 and 100 µW/cm^2, well below the FCC guidelines.

<u>Community Measurements</u>

The purpose of studies like this one is to evaluate the extent of human exposure to RF radiation. This was a concern of many Lookout Mountain residents who attended an informal gathering with the EPA and FCC investigators on the evening of September 24. At that meeting, EPA agreed to make limited measurements at several homes in the area. These measurements included collection of narrowband FOISD data at each location and broadband survey data at several homes. For these measurements the FOISD was positioned on top of the vehicle, and the vehicle moved to an arbitrary point along the road or in the driveway. Because these locations were arbitrarily chosen, the FOISD power densities probably are neither maxima nor minima, but are useful because they indicate the major source(s) of the RF radiation at each location. Another measurement a few feet away would probably find a different absolute power density. The broadband data were collected with two Holadays. Table 6 presents all these data.

None of the power densities in Table 6 exceeds the FCC guideline. With only two exceptions, none of the values exceeds even the most stringent RF radiation safety guideline being considered in the United States. The two exceptions, a 200 $\mu W/cm^2$ power density near a trampoline spring and a 589 $\mu W/cm^2$ power density near a piece of metal furniture, are more representative of the concentrating effect metal objects have on electric field lines than they are representative of typical power densities. Electric field intensity can be dramatically increased near conductive objects, particularly if those objects have sharp corners. This is why lightning preferentially strikes lightning rods. However, the presence of another conductive object, such as a human, can further alter the electric field, generally lowering the intensity near pointed conductive objects. Because of this, the importance of high measured electric field intensities near conductive objects is controversial. Traditional thinking on this subject is that relatively high, localized fields, near conductive objects where the surrounding field is substantially less, do not cause energy absorption rates in tissue that would normally be associated with whole-body exposures to fields of the same high values.

In order to place these values into perspective, two measurements were made in an area that is relatively distant from the Lookout Mountain antennas. At the end of the 700 block of Chimney Creek Road in the Genesee residential area, power densities from Lookout Mountain broadcasters and from Mount Morrison broadcasters (located near Genesee) were measured with the FOISD. At this location, the power density from Lookout Mountain broadcast sources was 0.2 $\mu W/cm^2$ and that from the Mount Morrison FM broadcasters was 0.00015 $\mu W/cm^2$. These values can be compared with the 0.005 $\mu W/cm^2$ median level to which the populations of 15 major U.S. cities are exposed (6).

Holaday (S/N 26046) measurements were also made at the Buffalo Bill grave tourist attraction. At the overlook near the visitor center, the highest value found was about 2 $\mu W/cm^2$. At the grave itself, power densities up to 8 $\mu W/cm^2$ were measured. Typical values ranged from about 5 to 14 $\mu W/cm^2$ at the overlook near the grave.

DISCUSSION

The height and topographic location of the KYGO antenna make it a convenient "field laboratory" to illustrate two characteristics of FM signals. The KYGO antenna is unusually low on its tower causing excessive power densities directly below the elements. This is the "grating lobe" which points directly down to the ground and straight up into the air from the elements. Because the antenna is so low to the ground, moving a short distance away from the tower base places one at a large angle away from vertical with respect to the elements. The 10,000 $\mu W/cm^2$ value found at the base of the tower decreases rapidly as one moves away from the base of the tower and out of the grating lobe. The power density falls to 1000 $\mu W/cm^2$ at about 30 feet, and to 200 $\mu W/cm^2$ by 50 to 70 feet from the tower. The second point illustrated by KYGO is that in a mountainous area, one cannot rely on such a rapid reduction in power density with distance because the measurement locations may be moving up into the main-beam of radiation. Additional data collected near KYGO actually show an increasing power density with distance from the antenna as the measurement location moves closer to the main beam of radiation. RF hazard investigators should be aware of this property not only in mountainous terrain but also in urban environments where the main beam of radiation may be intercepted by nearby tall buildings.

A surprising finding in Table 3 is that the Holaday electric field meter reported values that were below the actual (FOISD) value. While the Holaday data in Table 3 are not far from the FOISD data, the Holaday values are almost always low. The authors' experience, however, is that diode detectors, such as the Holaday, tend to overrespond rather than underrespond in complex RF environments. Because of this, diode detectors have been considered conservative. However, the authors' judgement in this case is that the value reported by the FOISD represented the maximum field in an area with no nearby perturbations, while the Holaday values were collected in the presence of a 6 foot tall individual, the surveyor, within a few feet of the probe. It is likely that the presence of the person would lower the field at the probe, particularly when the probe is at the location of the maximum field value in the area, thereby causing the discrepancy. Additional comparison measurements in other complex environments will help resolve the issue. The IFI meter's erratic response at location B and the Narda system's zero drift problems further underscore the fact that no single meter is adequate for all monitoring situations.

It is worthy of note that the maximum value measured at the base of the KYGO tower compares closely with that predicted by an EPA program designed for this purpose. The program calculated a maximum power density of 9,620 $\mu W/cm^2$. The maximum values measured with electric and magnetic field meters were 10,350 $\mu W/cm^2$ and 9,500 $\mu W/cm^2$ respectively for a maximum difference between theory and data of about 0.3 dB. A similar comparison between predicted and measured values in an earlier study in Oregon, also found approximately 0.3 dB difference. This correspondence is encouraging because it helps EPA and FCC decide which antennas are likely to produce ground-level power densities that exceed the FCC guidelines. Output from this modeling technique could be used to identify areas of potentially high public exposures and to select additional areas for field study. The application of the model to other FM facilities has shown that power densities as great as that predicted at KYGO are unusual but not unique.

CONCLUSIONS

1. Near the base of the KYGO-FM tower power densities reach 10,000 μW/cm^2 in a publicly accessible area. This far exceeds the FCC 1,000 μW/cm^2 guideline (2) for FM frequencies. The KYGO tower is located in a complex of buildings where some people live throughout the year and where seasonal residential workshops are held to teach square dancing. EPA urges the FCC to order KYGO to correct these extreme values in publicly accessible areas as soon as possible. The few measurements made inside the main buidling of the compound found no power densities exceeding 100 μW/cm^2.

2. The maximum power density near the KOSI-FM tower, 580 μW/cm^2, is below the FCC guideline, however the spatially averaged power density within an area of about 1,000 square feet near the tower exceeds the 200 μW/cm^2 NCRP (4) and IRPA (5) standards and two of the options that EPA (3) is considering for RF radiation protection guidance.

3. With the exception of the area near the base of the KOSI tower, none of the averaged power density data collected around the Cedar Lake Road circle exceeds any recommendation that has been adopted or is being considered by major organizations within the United States.

4. Typical power densities at several residences on Lookout Mountain did not exceed 100 μW/cm^2, the most stringent value that exists (7) or is being considered in the United States although higher power densities of limited extent can be found, particularly near field-enhancing, metal objects. At a location more distant from the Lookout Mountain antennas, a power density of 0.2 μW/cm^2 was measured in the Genesee residential area.

5. TV and FM antennas on Colorow Road produce power densities that exceed 200 μW/cm^2 along a 125 foot length of Colorow Road. However, the maximum value found near the Colorow Hill antennas did not exceed the FCC guideline.

6. The maximum power density measured at the TV and FM towers along Lookout Mountain Road (one third mile north of the Cedar Lake Road area) was 273 μW/cm^2. However, power densities were typically between 50 μW/cm^2 and 100 μW/cm^2 in this nonresidential area.

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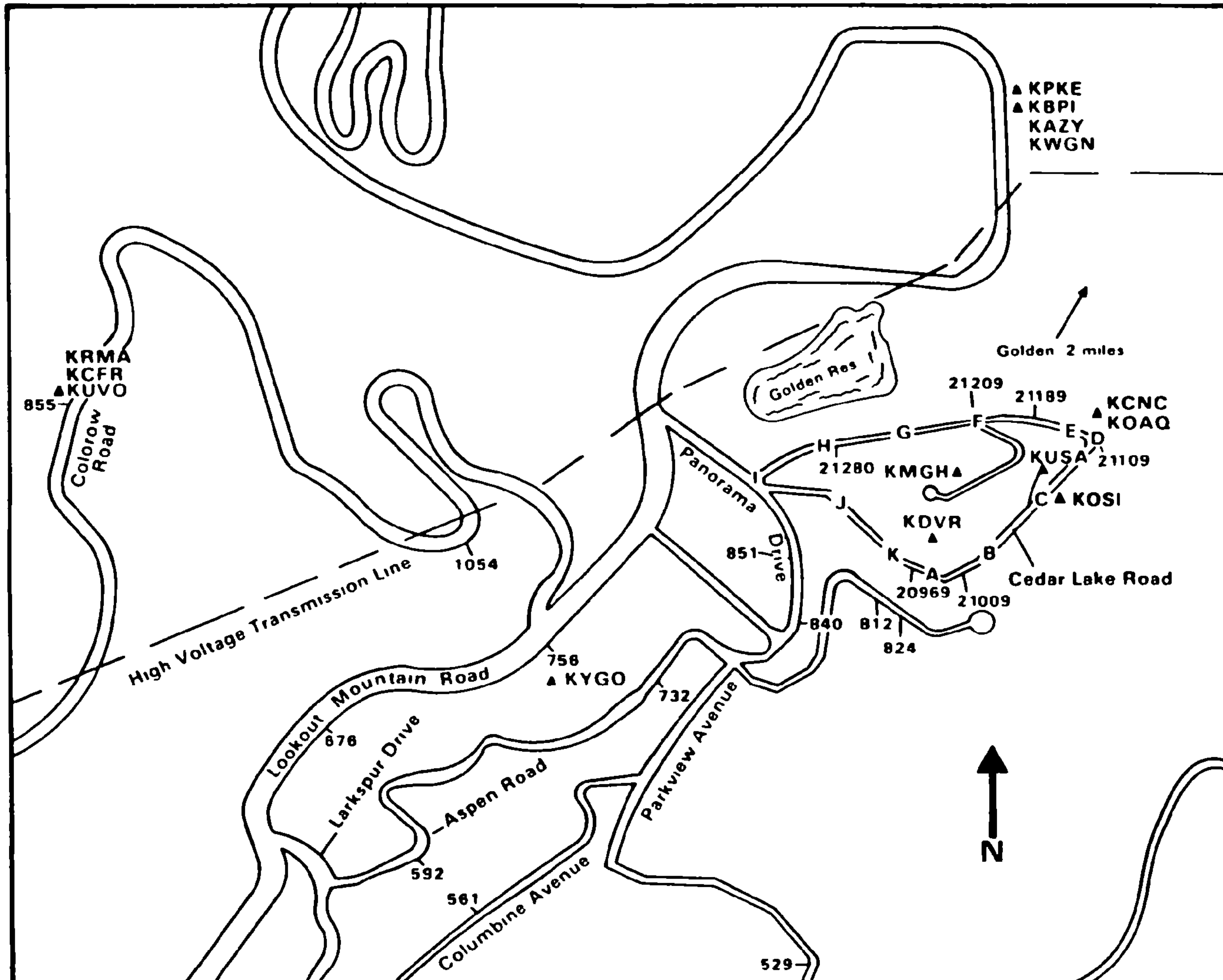

Figure 1. Map of Lookout Mountain

TABLE 1. Lookout Mountain Broadcasters, Grouped by Tower

Location of Tower	Call Sign	Frequency (MHz)
Lookout Mountain Road	KWGN-TV	57.5
	KBPI-FM	105.9
	KAZY-FM	106.7
Lookout Mountain Road	KPKE-FM	95.7
Colorow Road	KRMA-TV	85.5
	KCFR-FM	90.1
	KUVO-FM	89.3
Cedar Lake Road	KUSA-TV	189.5
Cedar Lake Road	KCNC-TV	69.5
	KOAQ-FM	103.5
Cedar Lake Road	KOSI-FM	101.1
Cedar Lake Road	KMGH-TV	177.5
Cedar Lake Road	KDVR-TV	575.5
Lookout Mountain Road	KYGO-FM	98.5

TABLE 2. Data Collected at Top of Access Road to Lookout Mountain Transmitters

Antenna	File Name	Frequency Range	Power Density ($\mu W/cm^2$)
FOISD	I26M57	AM Radio	0.0000874
FOISD	I26N09	Low VHF TV	0.601
FOISD	ZOIZMs	Low VHF TV	0.941
FOISD	I26N14	FM Radio	6.87
FOISD	ZOIZMs	FM Radio	8.66
FOISD	I26N47	Land Mobile VHF (peak)	0.0435
FOISD	I26N19	High VHF TV	0.946
FOISD	ZOIZMs	High VHF TV	1.66
FOISD	I26N31	Land Mobile UHF (peak)	0.462
FOISD	ZOIZMs	UHF Channel 31	1.01
FOISD	I26N24	UHF Channel 31	0.603
OMNI	I26006	UHF Channel 31	0.940
OMNI	I26014	Two-Way Radio (peak)	0.0539
OMNI	*	5.57 GHz Radar (peak)	11.4

*The data for radar were collected by reading directly from the screen of the spectrum analyzer as the antenna was positioned in three orthogoanl orientations. These data were not processed by the computer and therefore have no file name.

TABLE 3. Power Densities ($\mu W/cm^2$) Determined with Narrowband and Broadband Instruments

Location*	File Name	Category 1, 55 MHz to 578 MHz			
		FOISD	Holaday S/N 26046 up to 6000 MHz	Holaday S/N 26038 up to 6000 MHz	Holaday S/N 26042 up to 6000 MHz
A. Near KDVR	ZOIVRU	17.1	12.8	13.9	12.4
B. South of KOSI	ZOIWK2	46.5	30.6	22.3	29.7
C. Near KOSI	ZOIWLU	159	167	170	159
D. Near 21109 Cedar Lake Rd.	ZOIWPF	75.6	68.3	65.6	69.4
E. 60 ft. east of 21189 Cedar Lake Rd.	ZOIWQZ	48.5	40.6	44.6	37.2
later at same location	ZOIWRC	48.3			
F. Near 21209 Cedar Lake Rd.	ZOIWRv	22.5	18.5	20.2	17.4
Near KYGO transmitter building not at maximum E-field	ZOIXJN	1242	1072	976	1004

*See Figure 1 for locations of the measurement sites.

TABLE 3. Power Densities ($\mu W/cm^2$) Determined with Narrowband and Broadband Instruments (continued)

Location*	File Name	Category 2, Below 200 MHz: FOISD	Category 2, Below 200 MHz: IFI up to 200 MHz	Category 2, Below 200 MHz: Narda 8631 H Probe up to 300 MHz	Category 2, Below 200 MHz: Narda 8662 E Probe up to 300 MHz	Category 3, above 300 MHz: FOISD
A. Near KDVR	ZOIVRU	6.59		could not zero	noise level	10.5
B. South of KOSI	ZOIWK2	7.13	resonance problems	negative zero drift	could not zero	39.4
C. Near KOSI	ZOIWLU	153	202	157	197	5.24
D. Near 21109 Cedar Lake Rd.	ZOIWPF	75.1	88.9	42.8 at 2' above ground 55.1 at 7.5' above ground	89.6	0.456
E. 60 ft. east of 21189 Cedar Lake Rd.	ZOIWQZ	46.3	55.2	33.3	44.8	2.22
Later at same location	ZOIWRC	46.1				2.23
F. Near 21209 Cedar Lake Rd.	ZOIWRv	21.7	49.2	could not zero	26.9	0.855
Near KYGO transmitter building not at maximum E-field	ZOIXJN	1242	1487		1299	0.186

*See Figure 1 for locations of the measurement sites.

TABLE 4. Averaged Power Density in μW/cm^2 along Segments of Cedar Lake Road

Segment*	Minimum	Average	Maximum
A to B	0.515	11.1	35.6
B to C	1.15	34.4	181.0
C to D	5.51	86.6	505.0
D to E	0.791	15.7	80.4
E to F	0.773	11.3	30.3
F to G	0	6.48	25.0
G to H	0.036	4.18	10.8
H to I	0	2.12	9.13
I to J	0	3.82	13.3
J to K	0.293	7.19	35.1
K to A	0.577	7.54	21.3

*See Figure 1 for the locations of the segments

TABLE 5.

Approximate Greatest Distance and Magnetic Bearing from the Base of KYGO Tower to 1000 μW/cm^2 Power Density

Distance (feet)	Bearing
27	336°
28	312°
31	212°
32	196°
33	184°
37	148°
39	145°
36	87°
30	80°
27	12°

Approximate Greatest Distance and Magnetic Bearing from Base of KYGO Tower to 200 μW/cm^2 Power Density

Distance (feet)	Bearing
51	12°
70	144°
74	156°
89 (near guy wire pole)	158°
57	190°
53	210°
42	256°
50	326°

TABLE 6. Residential Power Densities

Location	FOISD Value/File Name	Holaday Serial Number	Holaday Value ($\mu W/cm^2$)
21109 Cedar Lake Road	58.9/ZOIYN8		
21280 Cedar Lake Road	10.9/ZOIYOU	26046	
deck, yard generally			7.07-11.8
deck, yard maximum			23.6
trampoline spring surface, maximum			200.0
21009 Cedar Lake Road	19.4/ZOIYOf	26046	
in front of garage, generally			23.6
on steps			11.8-18.8
on steps, maximum			23.6
porch and yard			4.71-16.5
porch and yard maximum			23.6
20969 Cedar Lake Road	7.91/ZOIYOo	26042	
yard and driveway			5.0-17.4
yard and drive maximum			24.8
inside house			5.0-24.8
inside house maximum			49.6
deck maximum			24.8
851 Panorama Drive	4.49/ZOIYOy	26046	
front yard			2.36-4.71
deck			4.71-14.1
backyard			2.36-11.8
840 Panorama Drive	5.81/ZOIYPF	26042	
in front of house			0-3.7
inside house			0-2.5
upper deck, rear			1.2-5.0
lower deck, rear			0-5.0
next to metal lounge, maximum			9.9
732 Aspen Road	5.53/ZOIYPR	26042	
driveway			0-7.4
front proch			0-5.0
676 Lookout Mountain Road	11.6/ZOIYP1	26046	
driveway near garage			1.2-3.5
upper deck			11.8-47.1
near metal furniture, maximum			589

TABLE 6. Residential Power Densities (cont.)

Locations	FOISD Value/File Name	Holaday Serial Number	Holaday Value (μW/cm^2)
561 Columbine Avenue	5.61/ZOIYPt	26042	
driveway			0.5-11.2
back porch			1.2-9.9
S.E. corner of house			12.4
back yard			1.2-16.1
front porch, away from KYGO			1.2-6.2
529 Parkview Avenue	7.88/ZOIYP2	26046	
driveway			1.2-4.7
near wood fence			4.7-9.4
front deck and back yard			2.4-4.7
near metal furniture, maximum			47.1
812 Aspen Road	4.57/ZOIYQT	26042	
road above house			1.2-9.9
drive and parking area			0-3.7
deck and stairs			0-3.7
side of house			1.2-7.4
front of house			0-2.5
592 Aspen Road	24.0/ZOIYPe		
824 Aspen Road	8.14/ZOIYQe		
756 Lookout Mountain Road	37.2/ZOIZIu		
1054 Colorow Road	55.8/ZOIYQx		
Across road from 756 Lookout Mountain Road	85.8/ZOIZJD		
Genesee, end of 700 block of Chimney Creek	0.237/ZOIYRS (Lookout Mountain Stations) 0.00015 ZOIYRq (Mount Morrison FM Stations)		

APPENDIX A

ZOOM Data Files

File Name ZOIVRU
F0ISD Full Scale Setting 20(V/m)   09/22/86   5 20 PM

FM Radio Station Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KUVO	89 3	-43 34	-33 75	-36 04	-31 45	36 45	112 00	04209
KCFR	90 1	-32 96	-28 95	-30 70	-25 80	36 45	117 65	15442
KPKE	95 7	-52 81	-37 46	-48 26	-37 00	36 45	106 45	01172
KYGO	98 5	-17 34	-13 73	-15 75	-10 58	36 45	132 87	5 13190
KOST	101 1	-26 51	-28 37	-41 79	-24 25	36 45	119 20	22044
KOAQ	103 5	-39 15	-36 89	-44 10	-34 38	36 45	109 07	02144
KBPI	105 9	-42 45	-33 32	-42 28	-32 35	36 45	111 10	03414
KAZY	106 7	-42 95	-36 03	-30 48	-29 22	36 45	114 23	07018
								----- --
					Total Power Density			5 68632

TV Video Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	* Electric Field (dBuV/m)	Power Density (uW/cm^2)
KWGN	55 25	-39 25	-44 73	-47 02	-37 64	36 45	101 81	00407
KCNC	67 24	-35 04	-36 60	-38 19	-31 68	36 45	107 77	01589
KRMA	83 24	-22 40	-27 68	-32 01	-20 92	36 45	118 53	18906
KMGH	175 25	-24 82	-23 33	-19 63	-17 25	36 45	122 20	44007
KUSA	187 24	-40 96	-34 80	-35 38	-31 54	36 45	107 91	01638
KDVR	573 25	-11 25	-9 97	-10 22	-5 67	37 61	134 93	8 25935
								- --- --
					Total Power Density			8 92478

* 4 dB subtracted from peak electric field to obtain RMS electric field

TV Audio Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KWGN	59 75	-47 50	-45 73	-51 44	-42 87	36 45	100 58	00303
KCNC	71 74	-43 67	-45 67	-45 29	-40 02	36 45	103 43	00585
KRMA	87 74	-43 27	-35 18	-40 70	-33 61	36 45	109 84	09557
KMGH	179 75	-28 38	-32 19	-28 87	-24 75	36 45	118 70	12684
KUSA	191 74	-43 54	-43 46	-43 00	-38 56	36 45	104 89	00819
KDVR	577 75	-18 87	-28 66	-18 56	-15 49	37 67	129 19	2 19976
								---- ---
					Total Power Density			2 43924

								---- --
					TV & FM Power Density			17 05034

File Name ZOIWK2
FOISD Full Scale Setting 50(V/m) 09/23/86 10 52 AM

FM Radio Station Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KUVO	89 3	-54 54	-59 70	-58 78	-52 28	44 35	99 07	00714
KCFR	90 1	-49 72	-49 17	-55 63	-45 93	44 35	105 42	00923
KPKF	95 7	-46 38	-46 72	-45 25	-41 30	44 35	110 05	02684
KYGO	98 5	-28 99	-35 44	-39 02	-27 77	44 35	123 58	60552
KOSI	101 1	-21 32	-27 63	-26 70	-19 49	44 35	131 86	4 06944
KOAQ	103 5	-32 81	-39 56	-27 54	-26 20	44 35	125 15	86734
KBPI	105 9	-43 63	-41 13	-44 40	-38 05	44 35	113 30	05671
KAZY	106 7	-36 29	-39 82	-43 03	-34 10	44 35	117 25	14079
								------- --
					Total Power Density			5 77804

TV Video Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field * (dBuV/m)	Power Density (uW/cm^2)
KWGN	55 25	-36 45	-35 58	-35 71	-31 13	44 35	116 22	11120
KCNC	67 24	-37 37	-39 30	-29 21	-28 24	44 35	119 11	21618
KRMA	83 24	-45 43	-42 73	-45 50	-39 58	44 35	107 77	01587
KMGH	175 25	-29 94	-27 54	-28 41	-23 75	44 35	123 60	60781
KUSA	187 24	-37 52	-40 94	-33 72	-31 66	44 35	115 69	09830
KDVR	573 25	-9 20	-13 29	-15 07	-7 03	45 51	141 48	37 28610
								------ -
					Total Power Density			38 33546

* 4 dB subtracted from peak electric field to obtain RMS electric field

TV Audio Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KWGN	59 75	-53 88	-49 80	-40 30	-39 67	44 35	111 68	03905
KCNC	71 74	-44 14	-54 32	-45 17	-41 39	44 35	109 96	02630
KRMA	87 74	-57 97	-56 38	-62 44	-53 50	44 35	97 85	00162
KMGH	179 75	-41 02	-37 33	-41 33	-34 72	44 35	116 63	12220
KUSA	191 74	-40 37	-38 70	-39 25	-34 61	44 35	116 74	12509
KDVR	577 75	-25 63	-29 57	-32 96	-23 62	45 57	128 95	2 08514
								- --- - --
					Total Power Density			2 39940
								-- -----
								----- - -
				TV & FM Power Density				46 51209

File Name ZOIWLu
FOISD Full Scale Setting 100(V/m) 09/23/86 11 46 AM

FM Radio Station Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KUVO	89 3	-59 37	-58 50	-54 23	-51 98	50 40	105 42	00925
KCFR	90 1	-54 39	-54 73	-51 25	-48 39	50 40	109 01	02114
KPKE	95 7	-42 86	-42 33	-43 38	-38 06	50 40	119 34	22763
KYGO	98 5	-45 10	-56 64	-54 41	-44 35	50 40	113 05	05347
KOSI	101 1	-18 57	-19 99	-11 06	-9 90	50 40	147 50	145 06927
KOAQ	103 5	-46 43	-53 37	-45 36	-42 48	50 40	114 92	08230
KBPI	105 9	-39 93	-38 38	-44 17	-35 45	50 40	121 95	41561
KAZY	106 7	-40 97	-42 68	-46 77	-38 10	50 40	119 30	22590
							Total Power Density	150 10453

TV Video Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m) *	Power Density (uW/cm^2)
KWGN	55 25	-42 70	-48 46	-42 38	-39 00	50 40	114 40	07298
KCNC	67 24	-41 36	-43 55	-40 44	-36 83	50 40	116 57	17049
KRMA	83 24	-46 19	-51 54	-48 21	-43 36	50 40	110 04	02679
KMGH	175 25	-33 83	-31 80	-46 89	-29 61	50 40	123 79	63553
KUSA	187 24	-28 65	-32 37	-37 60	-26 74	50 40	126 66	1 22092
KDVR	573 25	-24 61	-36 86	-25 75	-21 99	51 56	132 57	4 72215
							Total Power Density	6 87691

* 4 dB subtracted from peak electric field to obtain RMS electric field

TV Audio Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KWGN	59 75	-57 30	-51 12	-53 13	-48 40	50 40	109 00	02107
KCNC	71 74	-49 75	-59 87	-49 76	-46 54	50 40	110 86	03235
KRMA	87 74	-60 14	-61 26	-62 04	-56 30	50 40	101 10	00341
KMGH	179 75	-36 58	-43 78	-42 92	-35 05	50 40	122 35	45584
KUSA	191 74	-35 38	-51 77	-36 55	-32 86	50 40	124 54	25463
KDVR	577 75	-39 30	-49 21	-39 78	-36 30	51 62	122 33	45353
							Total Power Density	1 72087

TV & FM Power Density 158 70[illegible]

File Name Z01WPF
FUTSD Full Scale Setting 20(V/m) 09/23/85 3 05 PM

FM Radio Station Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KUVO	89 3	-53 64	-47 53	-47 28	-43 90	36 45	99 55	00239
KLTR	90 1	-54 69	-49 23	-42 43	-41 40	36 45	102 05	00426
KPKE	95 7	-23 54	-26 42	-26 60	-20 51	36 45	122 94	52210
KYGO	98 5	-40 63	-41 82	-48 23	-37 72	36 45	105 68	00982
KOSI	101 1	-10 87	-3 03	-13 95	-2 08	36 45	141 37	36 48723
KOAQ	103 5	-34 79	-19 76	-27 97	-19 03	36 45	124 42	73355
KBPT	105 9	-19 35	-23 66	-29 99	-17 72	36 45	125 73	99537
KAZY	106 7	-17 22	-29 78	-28 73	-16 70	36 45	126 75	1 25381
							Total Power Density	39 90653

TV Video Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	* Electric Field (dBuV/m)	Power Density (uW/cm^2)
KWGN	55 25	-36 90	-36 44	-39 95	-32 74	36 45	106 71	01240
KCNC	67 24	-31 75	-26 67	-31 15	-24 45	36 45	115 00	08386
KRMA	83 24	-38 53	-38 37	-36 58	-32 96	36 45	106 49	01182
KMGH	175 25	-27 90	-27 69	-27 16	-22 80	36 45	116 65	12262
KUSA	187 24	-4 54	-5 02	-2 73	79	36 45	140 24	28 03629
KDVR	573 25	-25 90	-23 57	-24 22	19 69	37 61	120 92	32795
							Total Power Density	28 59498

* 4 dB subtracted from peak electric field to obtain RMS electric field

TV Audio Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KWGN	59 75	-34 89	-41 89	-47 48	-33 90	36 45	109 55	02389
KCNC	71 74	-36 03	-33 31	-29 16	-27 15	36 45	116 30	11327
KRMA	87 74	-49 34	-43 58	-45 23	-40 68	36 45	107 77	00502
KMGH	179 75	-32 65	-32 86	-32 30	-27 83	36 45	115 62	09684
KUSA	191 74	-13 31	-12 43	-19 68	-9 41	36 45	134 04	6 22607
KDVR	577 75	-40 22	-29 26	-34 39	-27 84	37 67	116 84	12801
							Total Power Density	7 09309

TV & FM Power Density 75 59460

File Name Z01WQZ
FOISD Full Scale Setting 20(V/m) 09/23/86 4 25 PM

FM Radio Station Measurements

Call Sign	Frequency (MHz)	Px (dBm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KUVO	89.3	-49.66	-47.95	-39.96	-38.94	36.45	104.51	00750
KCFR	90.1	-39.05	-37.64	-36.92	-33.01	36.45	110.44	02934
KPKE	95.7	-17.64	-17.95	-25.14	-14.40	36.45	129.05	2.13168
KYGO	98.5	-39.08	-42.67	-49.24	-37.22	36.45	106.23	01113
KOSI	101.1	-20.48	-18.90	-21.96	-15.50	36.45	127.95	1.65566
KOAQ	103.5	-33.48	-26.91	-22.47	-20.89	36.45	122.56	47832
KBPI	105.9	-22.48	-18.53	-23.16	-16.11	36.45	127.34	1.43869
KAZY	106.7	-25.22	-24.03	-26.03	-20.24	36.45	123.21	55500

					Total Power Density			6.30232

TV Video Measurements

Call Sign	Frequency (MHz)	Px (dBm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field * (dBuV/m)	Power Density (uW/cm^2)
KWGN	55.25	-35.10	-31.61	-28.53	-26.19	36.45	113.26	05614
KCNC	67.24	-24.88	-28.89	-28.27	-22.20	36.45	117.25	14096
KRMA	83.24	-40.86	-39.84	-36.95	-34.12	36.45	105.33	00906
KMGH	175.25	-28.35	-20.04	19.36	-16.39	36.45	123.06	53653
KUSA	187.24	-1.75	-5.19	-6.30	81	36.45	140.26	28.12155
KDVR	573.25	-20.14	-15.31	-18.81	-12.82	37.61	127.79	1.59484

					Total Power Density			30.50908

* 4 dB subtracted from peak electric field to obtain RMS electric field

TV Audio Measurements

Call Sign	Frequency (MHz)	Px (dBm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KWGN	59.75	-34.48	-35.38	-48.17	-31.80	36.45	111.65	03883
KCNC	71.74	-38.46	-57.18	-33.23	-32.08	36.45	111.37	03638
KRMA	87.74	-50.90	-48.77	-44.65	-42.54	36.45	100.91	00327
KMGH	179.75	-31.39	-25.87	-21.80	-20.03	36.45	123.42	58241
KUSA	191.74	-10.81	-17.21	-11.25	-7.52	36.45	135.93	10.38953
KDVR	577.75	-27.77	-23.57	-26.82	-20.89	37.67	123.78	63399

					Total Power Density			11.68441

					TV & FM Power Density			48.50081

File Name ZOTWRC
FOISD Full Scale Setting 20(V/m) 09/23/86 5:02 PM

FM Radio Station Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KUVO	89.3	-50.44	-47.31	-40.25	-39.14	36.45	104.31	.00716
KCFR	90.1	-38.11	-37.61	-37.06	-32.80	36.45	110.65	.03080
KPKE	95.7	-18.12	-17.36	-24.91	-14.32	36.45	129.13	2.17264
KYGO	98.5	-39.22	-41.94	-50.29	-37.14	36.45	106.31	.01133
KOSI	101.1	-21.11	-18.72	-21.62	-15.52	36.45	127.93	1.64713
KOAQ	103.5	-30.90	-28.08	-22.51	-20.98	36.45	122.47	.46841
KBPI	105.9	-22.91	-17.86	-24.36	-15.99	36.45	127.46	1.47634
KAZY	106.7	-25.39	-23.24	-27.15	-20.20	36.45	123.25	.56124

					Total Power Density			6.37504

TV Video Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	* Electric Field (dBuV/m)	Power Density (uW/cm^2)
KWGN	55.25	-34.80	-32.44	-28.01	-26.05	36.45	113.40	.05802
KCNC	67.24	-25.17	-29.10	-27.82	-22.27	36.45	117.18	.13842
KRMA	83.24	-40.67	-39.39	-37.59	-34.26	36.45	105.19	.00876
KMGH	175.25	-29.68	-20.20	-19.07	-16.38	36.45	123.07	.53785
KUSA	187.24	-1.89	-4.58	-6.78	.81	36.45	140.26	28.16958
KDVR	573.25	-20.56	-15.68	-17.99	-12.86	37.61	127.74	1.57764

					Total Power Density			30.49027

* 4 dB subtracted from peak electric field to obtain RMS electric field

TV Audio Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KWGN	59.75	-35.02	-35.04	-45.41	-31.83	36.45	111.62	.03856
KCNC	71.74	-38.35	-53.97	-32.87	-31.76	36.45	111.69	.03913
KRMA	87.74	-51.20	-48.20	-45.54	-42.95	36.45	100.50	.00297
KMGH	179.75	-31.72	-25.31	-21.87	-19.95	36.45	123.50	.59400
KUSA	191.74	-10.58	-16.93	-11.89	-7.63	36.45	135.82	10.12561
KDVR	577.75	-28.72	-23.81	-25.47	-20.79	37.67	123.89	.64906

					Total Power Density			11.44933
								==========
					TV & FM Power Density			48.31465

File Name ZOTWRv
FOISD Full Scale Setting 20(V/m) 09/23/86 5 47 PM

FM Radio Station Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KUVO	89 3	-36 63	-35 42	-36 53	-31 39	36 45	112 06	04766
KCFR	90 1	-34 95	-31 79	-30 32	-27 19	36 45	116 26	11219
KPKE	95 7	-17 02	-24 27	-22 65	-15 32	36 45	128 08	1 70341
KYGO	98 5	-37 47	-34 53	-34 36	-30 47	36 45	112 98	05271
KOSI	101 1	-32 83	-39 60	-36 16	-30 59	36 45	112 86	05124
KOAQ	103 5	-26 14	-28 30	-25 76	-21 83	36 45	121 62	38544
KBPI	105 9	-21 26	-17 22	-23 34	-15 07	36 45	128 38	1 82357
KAZY	106 7	-22 24	-26 13	-28 55	-20 09	36 45	123 36	57555
							Total Power Density	4 74087

TV Video Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field * (dBuV/m)	Power Density (uW/cm^2)
KWGN	55 25	-33 59	-26 74	-29 24	-24 26	36 45	115 19	08757
KCNC	67 24	-30 97	-27 18	-23 20	-21 24	36 45	118 21	17550
KRMA	83 24	-24 12	-26 41	-25 60	-20 50	36 45	118 95	20828
KMGH	175 25	-7 23	-12 12	-9 65	-4 45	36 45	135 00	8 38990
KUSA	187 24	-19 72	-27 84	-16 01	-14 27	36 45	125 18	82337
KDVR	573 25	-20 88	-19 48	-30 11	-16 90	37 61	123 71	62272
							Total Power Density	10 35535

* 4 dB subtracted from peak electric field to obtain RMS electric field

TV Audio Measurements

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KWGN	59 75	-40 87	-40 00	-38 62	-34 96	36 45	108 49	01874
KCNC	71 74	-38 10	-45 44	-38 27	-34 78	36 45	108 67	01951
KRMA	87 74	-34 52	-41 02	-30 57	-28 83	36 45	114 62	07686
KMGH	179 75	-13 39	-13 61	-16 47	-9 51	36 45	133 94	6 56930
KUSA	191 74	-23 79	-50 04	-24 94	-21 31	36 45	122 14	46108
KDVR	577 75	-28 32	-32 61	-30 17	-25 25	37 67	119 42	23209
							Total Power Density	7 35058

TV & FM Power Density 27 45677