HETA 93-0734-2401
MARCH 1994
SANTA CLARA COUNTY ADMINISTRATIVE OFFICE BUILDING
SAN JOSE, CALIFORNIA

NIOSH INVESTIGATORS:
Allison Tepper, Ph.D.
C. Eugene Moss, H.P., C.S.S.
Don Booher

I. SUMMARY

In December 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the west wing of the Santa Clara County Administrative Office Building (SCCAOB) in San Jose, California. The request was submitted by the Service Employees International Union (SEIU), Local 715 because of concern among employees about exposure to electric and magnetic fields in the building. This concern arose from the occurrence of brain cancer among several current and former County employees working in the building. An epidemiological investigation of the brain cancer cases had been conducted by the California Department of Health Services (CDHS) and a report was issued in April 1992. The results of that investigation confirmed that the number of persons with brain cancers was statistically elevated. The CDHS investigation, however, did not identify hazardous chemical or physical agents that might be associated with the occurrence of cancer.

On April 23, 24, and 26, 1993, NIOSH investigators conducted a site visit to measure extremely low frequency (ELF) electric and magnetic fields both inside and outside the SCCAOB. Average magnetic field levels ranged from 0.1 to 10.7 milligauss (mG), and electric field levels ranged from 1.9 to 6.9 volts per meter.

Based on the data collected in this survey, and comparison with current occupational criteria, the NIOSH investigators concluded that no health hazard existed on the days of measurement from exposure to electric and magnetic fields in the ELF range. Moreover, the measurements made in this evaluation suggest that exposures to ELF fields in and around the Santa Clara County Administration Building are typical of modern office environments. Some recommendations are offered in Section VIII to further reduce exposure levels.

KEYWORDS: SIC 9222 (legal counsel and prosecution), brain cancers, ELF, EMF.

II. INTRODUCTION

In December 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the west wing of the Santa Clara County Administrative Office Building (SCCAOB), in San Jose, California. The request was submitted by the Service Employees International Union (SEIU), Local 715 because of concern among employees about exposure to electric and magnetic fields in the building. This concern arose from the occurrence of brain cancer among several current and former County employees working in the building. An epidemiological investigation of the brain cancer cases had been conducted by the California Department of Health Services (CDHS) and a report was issued in April 1992.[1] The results of that investigation confirmed that the number of persons with brain cancers (eight) was statistically unusual. In July 1992, NIOSH had received a request for a HHE concerning the brain cancer cluster and, in October 1992, issued a letter (Appendix A) indicating that a further epidemiologic investigation of the cluster was not warranted. Employees remained concerned about exposure to electric and magnetic fields in the building. As a result, a NIOSH field investigation was conducted at SCCAOB on April, 23, 24, and 26, 1993, to measure extremely low frequency (ELF) electric and magnetic fields in and around the building. The purpose of this evaluation was not to repeat the CDHS epidemiological investigation, or to make definitive statements about the relationship between ELF electric and magnetic fields and cancer.

III. BACKGROUND

The SCCAOB is an eight-story building (including basement). The west wing currently is occupied by staff of several county agencies. The District Attorney's Office, employing 312 persons, and the Public Defender's Office, employing 206 persons, occupy offices on the first through seventh floors. Thirty-three employees from Training and Staff Development, Human Relations, Planning and Development, and the Surveyor's Office occupy offices in the basement. The shaded area in Figure 1 shows the location of the SCCAOB's west wing where this evaluation was conducted.

According to both the original and modified building plans the building was originally constructed around 1960 and was modified in 1992. The original building had open floor space, while the modified (current) building enclosed much of that space into small office areas. The only area of the building that did not change over the years was the location of the elevators, stairs, bathrooms, ventilation, and electrical closets. However, the electrical closets on the third and fifth floors have had new step-down transformers installed to handle the increased electrical load.

IV. EVALUATION CRITERIA

At the present time there are no Occupational Safety and Health Administration (OSHA) or NIOSH exposure criteria for sub-radiofrequency (RF) fields. The American Conference of Governmental Industrial Hygienists (ACGIH) has published Threshold Limit Values (TLVs) for sub-radiofrequency electric and magnetic fields (30 kilohertz and below).[3] The TLV for magnetic flux density (B_{TLV}) in the sub-radiofrequency region states, "routine occupational exposure should not exceed

$$B_{TLV} \text{ (in mT)} = 60/f$$

where mT is millitesla and f is the frequency in hertz." Conversely, the electric field (E) TLV states, "Occupational exposures should not exceed a field strength of 25 kilovolts per meter from 0 Hertz (Hz) to 100 Hz. For frequencies in the range of 100 Hz to 4,000 Hz, the TLV is given by:

$$E_{TLV} \text{ in V/m} = 2.5 \times 10^6/f$$

where f is the frequency in Hz. A value of 625 volts per meter (V/m) is the ceiling value for frequencies from 4,000 to 30,000 Hz. The basis of the ELF electric field TLV is to minimize occupational hazards arising from spark discharge and contact current situations. The magnetic field TLV addresses induction of magnetophosphenes (a visual sensation of white light) in the visual system and production of induced currents in the body. Prevention of cancer is not a basis for either of these TLVs because exposure to ELF fields has not been conclusively linked to cancer.

V. METHODS

This evaluation was designed to assess occupational exposure to sub-radiofrequency fields in the range from 30 to 800 Hz on workers during a typical daily work regiment. The number and types of measurements performed in this evaluation were not intended to represent an in-depth investigation of exposure to all electric and magnetic fields present at the facility, but are intended to estimate occupational exposure levels from selected sources on the days of measurements.

The following equipment was used in this evaluation:

* Measurements were made with the EMDEX II exposure system, developed by Enertech Consultants, under project sponsorship of the Electric Power Research Institute, Inc. The EMDEX II is a programmable data-acquisition meter which measures the orthogonal vector components of the magnetic field through its internal sensors. Measurements can be made in the instantaneous read or storage mode. The system was designed to measure, record, and analyze power frequency magnetic fields in units of milligauss (mG) in the frequency range from 30 to 800 Hz.

* A Holaday Industries, Inc. model HI 3602 ELF sensor, connected to a HI-3600 survey meter, was used to document both the magnitude of ELF electric and magnetic fields as well as the waveforms produced by these fields. The electric field strength (E) was measured in V/m and the magnetic field strength (B) was measured in mG over the frequency range from 30 to 800 Hz.

* AMEX-3D exposure meter manufactured by Enertech Consultants. This small, lightweight three-axis magnetic field meter can either be worn by a worker or attached to objects. The meter measures average low-level magnetic fields. The AMEX-3D meter stores an electric charge, proportional to the time-integral of the magnetic field, which can then be read out and converted into average magnetic field values.

In performing this evaluation, the NIOSH investigators utilized data obtained from measurements made: (a) on a random sample of fixed locations within the SCCAOB, (b) a random sample of employees working in the SCCAOB, and (c) on a random sample of fixed locations outside the SCCAOB.

A. Fixed Location Field Measurements in the Building

At the request of the SEIU, the initial plans for the NIOSH evaluation of electric and magnetic fields involved comparing measurements in offices where persons with brain cancer had worked with measurements in randomly selected offices where persons with cancer did not work in the SCCAOB. NIOSH investigators requested the names of the persons with brain cancer whose diagnosis had been confirmed by the CDHS investigators. Confidentiality restrictions, however, limited the list to deceased individuals.

In the absence of complete information about the work locations of employees who had brain cancer, an alternate plan for selecting office areas for measurement was developed. Floor plans for the building were obtained from the County General Services Administration. On each of floors one through seven, three broad office areas were selected and one room within each area was selected at random as the measurement location. Additionally, three areas on the basement floor were also selected for measurements based on size and usage.

The technique used to document occupational exposures at fixed locations with the facility involved determining the average room magnetic field (ARMF) level. The area of each randomly selected room (three per floor) was determined and then multiplied by 0.3 (30%) to yield an effective worker area occupancy (EWAO) factor. The EWAO value represents the circular area, positioned about the room's center, where the room occupant would be expected to be found 90% of the time while in the room. Prior to this evaluation NIOSH investigators had performed studies at other office buildings and had observed that office workers tend to remain in the center of their workspace more than along the walls or in the doorway. The 30% figure was arrived at based on observations made at these other evaluations. It should be realized that the EWAO definition is generally valid only for small (100-400 ft^2), one-person offices, since in large rooms the ARMF technique could entirely miss the contribution from a source at a certain distance. After the EWAO level was evaluated the effective radius of that area was determined using the following equation:

$$R_{effective} = [EWAO/3.14]^{1/2}$$

A specially designed measurement device (Figure 2) denoted BOOM-1 was used to determine the magnetic field levels at every 30 degrees at a distance of R_{eff}. The BOOM-1 system used a measurement tape specially mounted onto a EMDEX unit and affixed to a four foot high PVC tube attached to a circular base marked off in degrees. The height of four feet was used because that distance represents the approximate location of a worker's head while seated in the office. When taking data, the measurement device was always positioned at the room's center. One investigator held the tape and EMDEX unit at a selected angle and the other investigator recorded the magnetic field level. A reading was recorded only after the magnetic field level was shown to be constant and reproducible. In this evaluation it was always possible to obtain a steady state reading within three to five seconds. Eleven different values were taken around the circumference and were then averaged to yield the ARMF level. Measurements of the electric and magnetic fields were made at the room center. The data was plotted to visually display the measurement values, see Figure 3.

Additional magnetic field data for this part of the investigation was obtained in selected rooms from mounting AMEX dosimeters to walls at a height of four feet from the ground. A total of five AMEX dosimeters were used and each operated over six hours.

Electric and magnetic field measurements also were made at waist level in the general vicinity of bathrooms, elevators, and stairwells on all floors to account for the fact that workers would spend some of their workday in these areas. Approximately 100 such measurements were made for this portion of the evaluation. The NIOSH investigators also toured other rooms, maintenance areas, the cafeteria, and locations in the west wing to assess the potential for EMF exposure at those locations where workers might visit.

B. Personal Field Measurements for Employees in the Building

EMDEX dosimeters were put on 10 randomly selected workers chosen to be proportional to the number of employees of the different agencies who work in the facility. At least

one EMDEX dosimeter was worn by workers on each of the eight floors. The EMDEX units were worn around the waist in special sashes provided by NIOSH and each worker was instructed not to wear the unit out of the building during the day. If they had to leave the building, they were told to leave the dosimeter on their desk.

C. Fixed Location Field Measurements Outside the Building

Electric and magnetic field measurements were made at all entryways immediately outside the facility, in the paved area immediately in front of the facility, and in the parking lot on two different days. Measurements were also made at the corners of the facility.

VI. RESULTS

A. Fixed Location Field Measurements in the Building

A total of 24 rooms on eight floors were measured for electric and magnetic field levels using the BOOM-1 system. The results of those measurements are shown in Table 1 by room number, average levels, range of average levels, and levels at center of room. The documented range of magnetic field levels from all 24 rooms was 0.1 to 10.7 mG. The ARMF level using the BOOM-1 system ranged from 0.1 to 1.71 mG. Magnetic field strength measured at the center of every room ranged from 0.1 to 1.3 mG, which were very close to the levels obtained using the BOOM-1 system. The E-field levels measured at the room centers ranged from 1.9 to 6.9 V/m. Of interest to note was there were only six rooms whose room center's magnetic field level were greater than the ARMF levels and those differences were very slight (i.e., from 0.01 to 0.04 mG).

The results from the five AMEX dosimeters, which were mounted to walls in rooms 413, 546, 556, 712, and in the basement, gave magnetic field levels ranging from 0.2 to 3.0 mG.

A total of 80 measurements were also made at the same relative location on every floor in the center area of the building to document possible exposure to fields produced in the vicinity of stairwells, elevators, bathrooms, and electrical and ventilation closets. The magnetic field levels ranged from 0.1 to 7.2 mG and the electric field levels ranged from 1.8 to 3.7 V/m. Of interest to note is that on some floors, levels up to 64 mG were found in the women's restrooms. These levels were generally found near light fixtures and in the ceiling corners of the space. It was reasoned that in some cases the back of the restroom was near to the electrical closet and its higher ELF levels.

Sources of ELF field exposure were prevalent throughout the SCCAOB. These sources included the items listed below.

soda machines	various electric lamps
wall and desk clocks	AM/FM radios
crock pots	computer plotters
microwave ovens	toasters
electric space heaters	coffee pots
roaster ovens	photocopy machines
broiler	video display terminals
FAX machines	electric calculators
refrigerators	hot drink maker
rotisserie unit	laser printers
electric pencil sharpeners	wall and desk fans
microfiche machines	dictaphones
electric fry pans	electric can openers
electric typewriters	vacuum cleaners
power strips	electric staplers

While measurements were not made on the above sources in this evaluation, results from previous NIOSH evaluations and other literature have clearly shown that very high localized magnetic field levels can and do exist in close proximity to these types of sources. In fact, the magnetic field levels from these sources at close distances are orders of magnitudes higher than what is reported in this evaluation for the ARMF levels. It should be kept in mind, however, that workers do not normally remain extremely near to such sources for long periods of time and that the magnetic fields do tend to fall off quickly as a function of distance from the source. These facts suggest that overall exposure contribution from these sources should be small. Nevertheless, the elimination of many of these non-essential sources from the workplace would produce a reduction in ELF fields.

B. Personal Field Measurements for Employees in the Building

While 10 EMDEX II units were initially distributed to randomly selected workers at SCCAOB, only data from seven units were recoverable for use in this evaluation. Data was lost from three units when workers wearing EMDEX units turned them off. The information from these seven units is shown in Table 2. The mean magnetic field levels from the workers who wore the EMDEX II units ranged from 0.74 to 3.35 mG. Figure 4 shows a typical time-intensity distribution for one of these dosimeters. It is apparent that workers undergo a change of exposure with time as they move in and out of proximity to various AC electrical devices. Exposure levels by floor show very little difference in mean and median values; however, the maximum levels can vary depending on location of the dosimeter and/or work task.

C. Fixed Location Field Measurements Outside the Building

Measurements made at waist positions at various sites outside the west building ranged from 0.1 to 140 mG and 0.1 to 3 V/m. The highest magnetic field levels were documented at small, outside lights used to illuminate the steps. However, most of the magnetic field levels measured at the outdoor sites were quite low and averaged less than 1 mG except for small spot sources.

VII. DISCUSSION AND CONCLUSIONS

Although employees may be concerned about ELF exposure even at levels below current occupational limits, there is currently no conclusive evidence to show that chronic exposure to power frequency fields causes adverse health effects. It should be noted, however, that research suggests that health effects related to ELF fields may be linked to many variables, of which field strength is only one. Therefore, depending on these other variables, weaker electric or magnetic fields (as shown in this evaluation) are not necessarily safer than stronger fields.

Table 3 shows all the measurement data obtained from this evaluation by type of measurement and location. When viewed in this way, the measurement data tend to suggest that the range of ELF electric and magnetic fields measured both inside and outside SCCAOB are relatively low, approximately the same magnitude reported by CDHS in their evaluation, within the range of exposure levels in office settings measured by NIOSH investigators in previous evaluations, and well below current occupational exposure limits.

VIII. RECOMMENDATIONS

The following recommendations are offered to reduce potential occupational exposures to ELF and safety risks at SCCAOB:

1. NIOSH investigators observed a wide range of items contributing to total ELF magnetic field exposure. Many items, such as video display terminals and photocopy machines, are essential to the modern office environment. Others, however, could be considered "non-essential" and their presence should be re-evaluated by employees concerned about their overall exposure to ELF electric and magnetic fields in the office. Electromagnetic field strength decreases in proportion to at least the square of the distance from the source. Thus, while "non-essential" sources in an employee's own work space may be relevant to his or her total exposure, such sources in a neighbor's work space should be of much less concern.
2. Electrical closets located near the center of the floor were observed on several occasions to be open and unlocked. On two floors chairs were seen in the electrical closets suggesting that workers were or had occupied these areas. To prevent electric shock injuries, the doors to all electric closets should be posted with warning signs and locked at all times.

IX. REFERENCES

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3. SEIU, Local 715
4. OSHA Region
5. NIOSH Washington Office

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Table 1

Results of Magnetic and Electric Fields Measured by Room

Santa Clara County Administrative Office Building
San Jose, California
H93-0734

Room Number	Floor	ARMF* (mG)	Range (mG)	Center		Area of Room (ft^2)
				E(V/m)	B(mG)	
Surveyor Rm	B	0.94	0.3 - 7.1	4	0.3	1890
Training Area	B	1.36	0.4 - 6.5	3.2	0.6	484
Break Rm	B	1.71	0.2 -10.7	2.6	0.6	373
124	1	1.21	0.2 - 6.1	2	0.4	89
162	1	0.3	0.1 - 1.8	4.8	0.1	93
164	1	0.19	0.1 - 0.3	1.9	0.2	93
262	2	0.1	0.1 - 0.1	1.9	0.1	84
249	2	0.1	0.1 - 0.1	1.9	0.1	103
250	2	0.1	0.1 - 0.1	1.9	0.1	103
323	3	0.18	0.1 - 0.3	5.3	0.2	281
318	3	0.17	0.1 - 0.3	1.9	0.2	114
319	3	0.21	0.1 - 0.6	1.9	0.1	114
413	4	0.19	0.1 - 0.5	2.9	1.3	2332
423	4	0.22	0.1 - 0.7	1.9	0.1	80
429	4	0.23	0.1 - 0.7	1.9	0.2	135
549	5	0.16	0.1 - 0.3	2.5	0.2	114
556	5	1.1	0.2 - 7.1	1.9	0.4	109
546	5	0.18	0.1 - 0.3	1.9	0.2	179
666	6	0.17	0.1 - 0.2	4.4	0.2	111
676	6	0.1	0.1 - 0.1	1.9	0.1	255
643	6	0.21	0.1 - 0.7	6.9	0.2	166
712	7	0.15	0.1 - 0.2	2.7	0.1	193
722	7	0.24	0.2 - 0.3	2	0.2	231
733	7	0.29	0.1 - 1.1	2	0.2	251

* ARMF = average room magnetic field

Table 2

ELF EMDEX Magnetic Field Exposure Measurements
Made at a 1.5s Sample Rate on Employees

Santa Clara County Administrative Office Building
San Jose, California
H93-0734

EMPLOYEE	MIN.	MAX.	MEAN	ST. DEV.	GEO. MEAN	ST. DEV.	MEDIAN	N	mG-HR
1	0.2	25.7	1.06	0.90	0.85	1.89	0.8	20,239	8.95
2	0.1	80.3	2.21	2.78	0.55	8.07	1.1	18,631	17.16
3	0.9	54.5	3.06	3.27	2.58	1.60	2.5	19,274	24.55
4	0.2	74.3	0.74	1.46	0.51	2.11	0.6	18,171	5.61
5	0.1	172.3	3.35	6.81	2.17	2.14	1.5	18,254	25.50
6	0.1	174.7	3.06	5.32	2.36	1.86	2.0	17,357	22.13
7	0.1	30.5	2.46	3.46	1.84	1.77	1.5	16,627	17.02

St. Dev. = Standard Deviation
Geo. Mean = Geometric Mean
N = Number of data points
mG-HR = milligauss-hour

Table 3

Range of Electric and Magnetic Field Values by Techniques

Santa Clara County Administrative Office Building
San Jose, California
H93-0734

Technique	Magnetic Field (mG)	Electric Field (V/m)	Number of Measurements
Within Building			
ARMF (Boom-1)	0.1 - 1.71		24
All Rooms	0.1 - 10.7		24
Electric Field (Center of Room)		1.9 - 6.9	24
AMEX	0.2 - 3.0		5
Center of Building	0.1 - 7.2	1.8 - 3.6	80
Personnel			
8-Hour Average	0.74 - 3.35	(See Table 2)	7
Outside			
Walk-Around	0.1 - 140	0.1 - 3	83

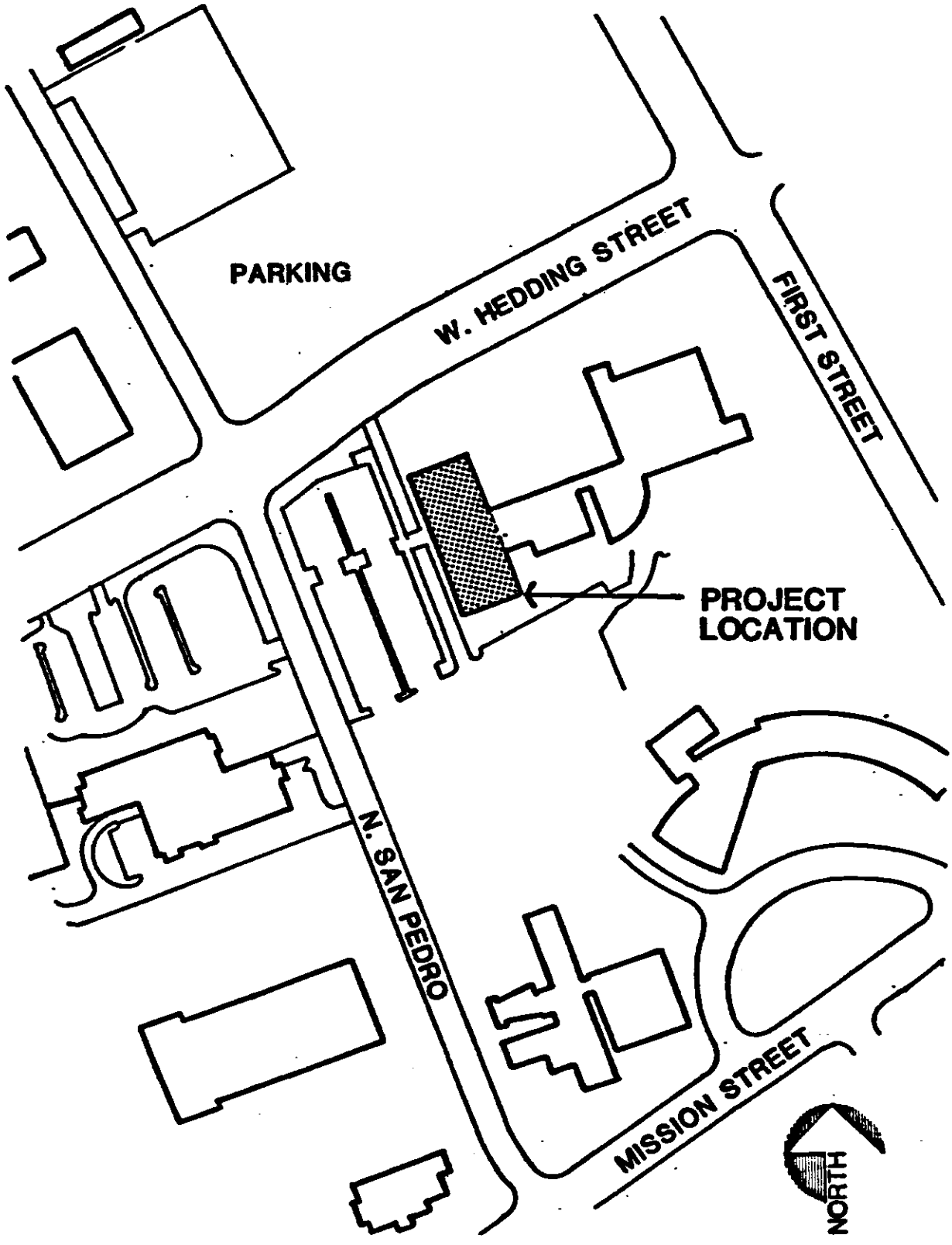

Figure 1. Location of Santa Clara County Administrative Office Building

Figure 2. Using the BOOM-1 Device to Determine the ARMF Level

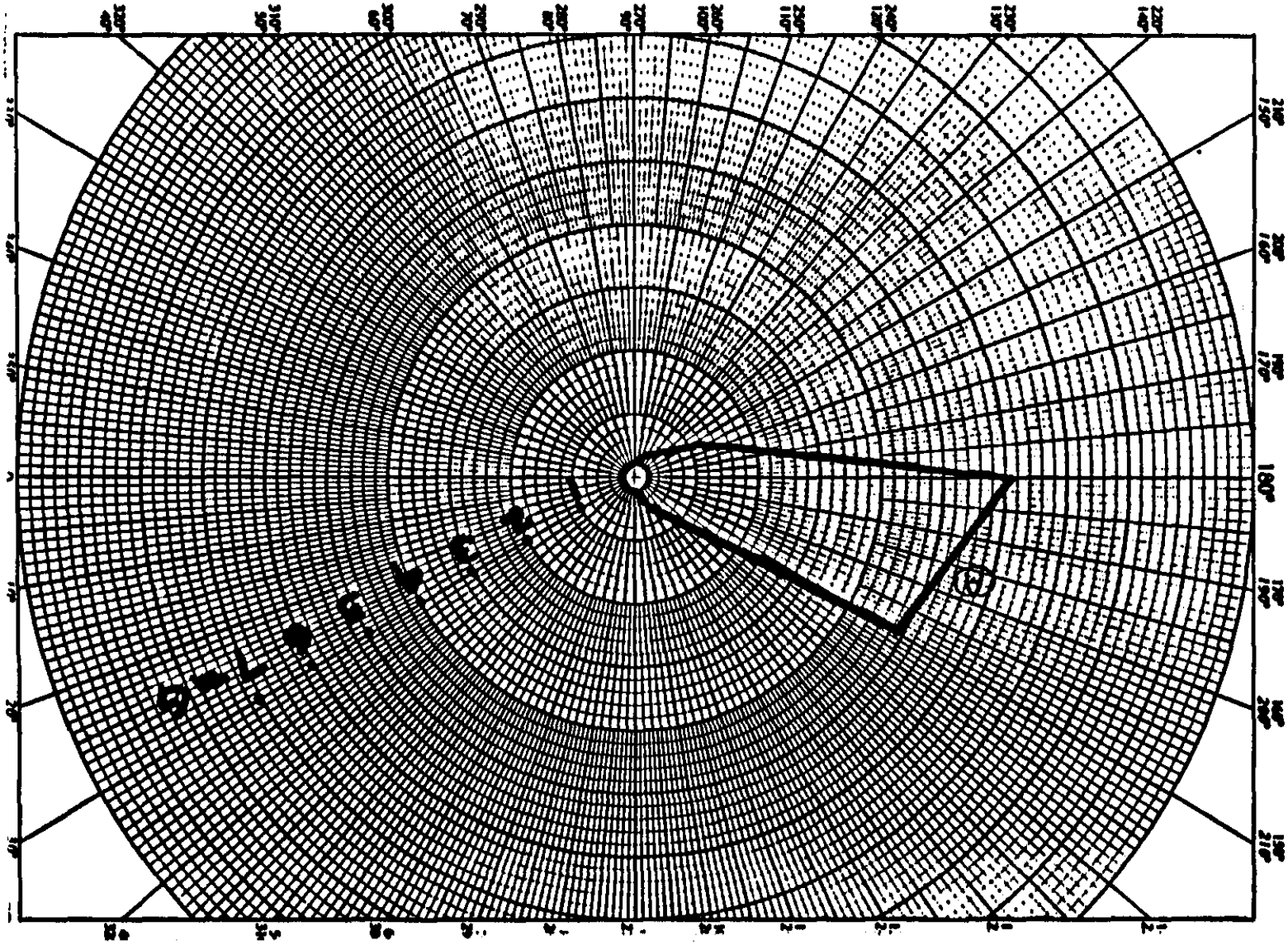

Figure 3. A Typical 360° Spatial Plot Showing Magnetic Field Isocontours at a R_m Distance of 2.9 Feet. A VDT System Was Located at Position A.

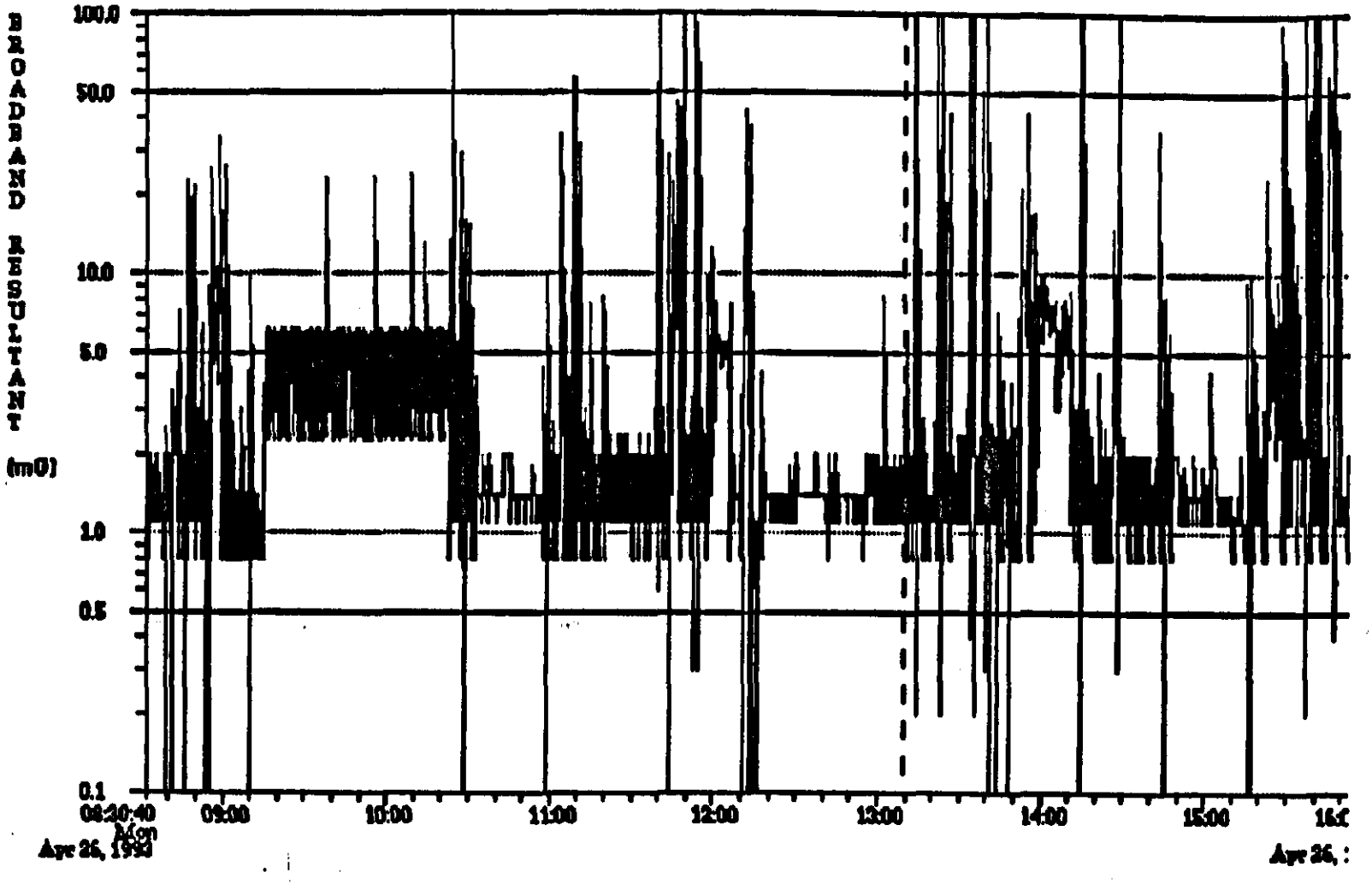

Figure 4. Typical Magnetic Field Time-Intensity Plot for Worker at Santa Clara County Administrative Office Building

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
National Institute for
Occupational Safety & Health
Robert A. Taft Laboratories
4676 Columbia Parkway
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October 19, 1992
HETA 92-343

Mr. Paul Sagers, Director
General Services Agency
County of Santa Clara
1555 Berger Drive, Building 3
San Jose, California 95112

Dear Mr. Sagers:

In July 1992, the National Institute for Occupational Safety and Health (NIOSH) received your request for a Health Hazard Evaluation (HHE) at the Santa Clara County Government Center in San Jose, California. Your letter accompanying the request indicated remaining concerns about a brain cancer cluster following an investigation by the California Department of Health Services (CDHS).

For the reasons given below, NIOSH investigators do not plan to further evaluate the Santa Clara County Government Center. The concerns that prompted your search for answers regarding the cause of the cancer deaths are understandable. Available information, however, indicates that these deaths cannot be attributed to the presence of hazardous agents in or around the building.

As you are aware, cancers often occur in clusters. Cases that are close together in time or space (for example, a neighborhood or workplace) may have a shared cause or may represent the coincidental occurrence of unrelated causes. Even if the number of cases represents a statistically significant excess, this may not indicate a causal link to the workplace environment. As noted in the CDHS report, the laws of probability indicate that some cancer clusters are expected to occur by chance. This does not imply that each individual case in the cluster occurs by chance, but that the cases are causally unrelated to each other.

The investigation conducted by the CDHS was appropriate. All reasonable hyoptheses were considered and no evidence was found of any unusual exposures in or around the building. In conversations with you, Ms. Shafran, and Dr. Ana Osorio (one of the CDHS investigators), I learned of several areas of particular concern following completion of the state's investigation.

Most of the concerns had to do with the possible presence of hazardous chemicals in the environment. If chemical exposures in the Santa Clara County Government Center were to cause brain cancer, reasonable opportunity for exposure would be required in addition to the mere presence of chemicals in the environment. Evidence that persons with brain cancer were more likely to have been more exposed to these chemicals than other workers in the building who did not develop brain cancer would support the relationship. Our review of the state's report, discussions with involved parties, and our experience with investigating cancer clusters in a wide variety of work settings provide no information suggesting that either of these requirements were met.

Considerable societal attention currently is focused on the possible relationship between exposure to electric and magnetic fields and adverse health effects. Many investigators have focused on reports of elevated brain cancer risk among workers in various electrical occupations, suggesting a link between brain cancer and exposure to extremely low frequency (ELF) electric and magnetic fields. In a January 1991 workshop sponsored by NIOSH, the epidemiologic information on the health effects of electric and magnetic fields on workers was reviewed.[1] For brain cancer, two types of studies provided important evidence. Among the case-control studies reviewed, most showed elevated risks for electrical-related occupations, but they assessed exposure only indirectly. Among the cohort studies of electrical workers, risks were elevated, but many were not statistically significant despite large sample sizes and long observation periods. Other reviewers have noted further limitations to previous investigations, including the possibility that the observed effects may be due to other exposures present in the industries and occupations that have been studied or that non-occupational risk factors for brain cancer were not adequately considered.[2] Currently, the general consensus is that the evidence for a carcinogenic effect of exposure to ELF fields is suggestive for brain cancer but is not conclusive.

In the absence of a well-established relationship between exposure to ELF electric and magnetic fields and brain cancer, additional measurements made in and around the Santa Clara County Government Center would not be helpful in establishing the cause of the cancer cluster. Although the CDHS investigation did not measure electric fields, did not comprehensively assess microwave transmissions, and did not completely map magnetic fields within the building, further data collection in this situation would not contribute to an improved understanding of the adverse effects of these exposures. Carefully designed epidemiologic studies that include: (a) adequate numbers of cancer cases or exposed individuals to provide statistically valid results, and (b) complete and unbiased characterization of exposure and ascertainment of

cases are needed. Unfortunately, these requirements cannot be met in the evaluation of the current cancer cluster among employees at the Santa Clara County Government Center.

As previously stated, the information presented above has led us to conclude that further investigation of the Santa Clara County Government Center by NIOSH is not warranted. If you have any questions, I can be reached at (513) 841-4386.

Sincerely yours,

Allison Tepper

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cc:
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