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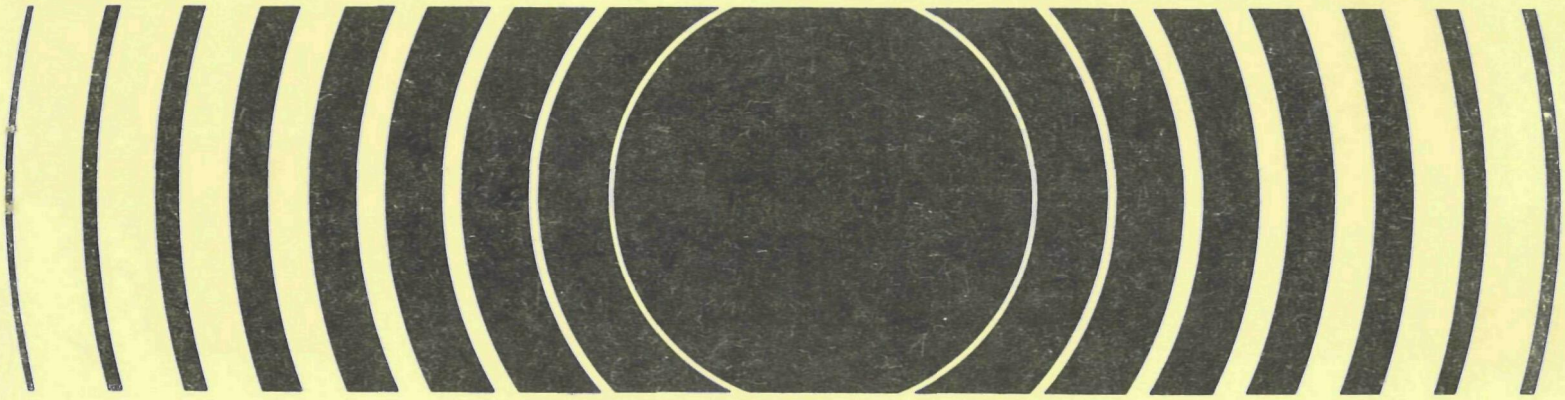

POPULATION EXPOSURE TO VHF BROADCAST RADIATION IN THE SEATTLE AND PORTLAND METROPOLITAN AREAS

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Introduction

The U.S. Environmental Protection Agency (EPA) conducts a nationwide program of monitoring and assessment of radiofrequency (RF) and microwave (MW) levels as they relate to the potential for hazards in the environment. EPA began measuring RF and MW radiation in urban areas in 1975 as part of a program to determine the need for standards to control environmental radiofrequency exposure. Current population exposure levels will be a major factor in determining if guidance is needed to limit population exposure. Seattle, Washington and Portland, Oregon were among 15 metropolitan areas surveyed for environmental levels (Table 1). This report provides the results of environmental measurements for the Seattle and Portland metropolitan areas and presents estimates of population exposure based upon the measurements. Measurements were made in urban areas because sources are concentrated in and around regions of high population density. Broadcast bands are the principal bands of interest with other bands contributing insignificantly to general environmental levels of radiofrequency radiation.

The measurement system is installed in a 27 foot van. The system consists of seven antennas, and a scanning spectrum analyzer interfaced to a minicomputer data acquisition system. Antennas are mounted on a telescoping mast which is elevated about six meters above ground level. Signals from the antennas are detected by the spectrum analyzer then digitized and processed by the minicomputer with data correction and analysis routines. A computer algorithm uses these measurements to estimate the broadcast exposure for census enumeration districts within the metropolitan boundaries.

Nonionizing Radiation Sources

Virtually everyone is exposed to radiofrequency waves. Nonionizing sources of interest include the following:

- radio and television broadcast stations
- radars
- satellite communications system earth terminals
- point to point microwave communications
- mobile communications systems
- microwave ovens
- industrial heating equipment

This paper is concerned only with nonionizing radiation from radio and television broadcast radiation. Ionizing radiation is a different kind of radiation which is produced by medical, dental, and industrial x-ray equipment and by radioactive materials which emit particles such as protons, betas, neutrons and alphas.

Previous studies have determined that FM radio and VHF and UHF television transmissions are responsible for almost all of the RF and MW exposure in the general environment. Table 2 summarizes the broadcast bands for which data is presented in this report. Though field intensity measurements were also performed in the AM standard broadcast band (0.54-1.6 MHz), these data are not considered here because of significantly decreased absorption of these lower radiofrequencies by the human body. No UHF television stations operate in Seattle or Portland. The frequency range of the surveyed sources was from 54 to 216 megahertz.

Effects of Nonionizing Radiation

Radiofrequency radiation can be absorbed by tissue and can interact with biological systems. Absorption depends on the radiation wavelength and its relationship to the physical shape, size and orientation of the body to the incident electromagnetic field, electrical characteristics of the body tissues at specific frequencies and the intensity of the radiation. Localized heating or nonuniform absorption can occur in humans because the complex tissue structure absorbs energy differently in different parts of the body.

Two kinds of effects on humans due to exposure to radiofrequency radiation are usually discussed: thermal effects from high-level exposures, and possible low-level or "nonthermal" effects.

Thermal effects, normally thought to result from irradiation with power densities above 10,000 microwatts/square centimeter (uW/cm2) involve tissue heating with the possibility of thermal damage. They may include increased body temperature and resulting heat stress, cataract formation, and testicular effects. (Table 3)

Low-level effects are a subject of controversy. Effects of exposure to 1,000 (uW/cm2) or less have not been well documented. In fact, all U.S. scientists do not agree that they exist. Some Russian scientists believe that they occur, but as a result of nonthermal effects or effects which occur without an increase in tissue temperature. Their views are based on animal research and statistical studies of workers' exposure histories and medical records. Considered to be mainly central nervous system effects, symptoms attributed to low-level nonthermal exposure include headache, weariness, dizziness, irritability, emotional instability, partial loss of memory, loss of appetite, cardiovascular effects, blood chemistry changes, changes in respiration, and possible genetic effects.

While U.S. scientists are skeptical of the conclusions of the Eastern European experts, there has been little research conducted in the U.S. involving long term exposures to low-level microwave and radiofrequency radiation. Some U.S. scientists believe that the effects observed, could result from non-uniform energy distributions and very small localized temperature changes in the body.

Exposure Standards

At present, there are no Federal standards or guides for controlling environmental levels of radiofrequency waves in the U.S. There is an advisory standard for occupational exposure issued by the Occupational Safety and Health Administration. This advisory standard specifies an upper limit of 10,000 uW/cm2 for exposure durations greater than 6 minutes and allows higher values for shorter durations. (Table 4)

The U.S.S.R has the most conservative standards with an occupational limit of 10 uW/cm2 and a general environmental exposure limit of one uW/cm2. Canada, Great Britian and West Germany have occupational exposure standards similar to those of the U.S. Canada is considering a general population standard of 1,000 uW/cm2. The U.S.S.R.'s more restrictive occupational and general population standards are presumably based upon the occurrence of nonthermal effects while the U.S. and most Western European standards are based upon thermal effects without consideration of possible nonthermal effects.

Population Exposure in Seattle and Portland

Population exposure to nonionizing radiation means the number of people exposed to various levels of power density. To obtain population exposure, two kinds of information are required; the distribution of the population and the distribution of power densities in the area of interest. The population is obtained through the use of the Census Bureau's Census Enumeration Districts (CED) and power densities are measured using EPA's electromagnetic radiation analysis van. Measurements were taken at 35 sites in metropolitan Seattle and at 38 sites in Portland. The measurement data was subsequently used in a computer modeling program to estimate the exposure which would exist at each CED in Seattle and Portland. Resulting exposure at each CED is assumed to apply to all the population within each CED. Final results are presented in terms of the accumulative fraction of the population which are exposed to certain power density levels. Summary field study information is presented in Table 5.

Table 6 lists each measurement location in Portland with the determined power density. Table 7 does the same for the Seattle area. The geographic location of all measurement locations are shown for Portland and Seattle on Maps 1 and 2. The location numbers in Tables 6 and 7 correspond to location numbers used on Maps 1 and 2.

Table 8 shows the fraction of Portland population exposed as a function of power density for FM radio, high VHF, low VHF television transmissions and the total exposure from all of these. Table 9 does the same for the population of Seattle. It can be seen that FM radio broadcast transmissions create the highest ground levels of field intensity and is clearly most responsible for overall exposure. Conversely, the high VHF and low VHF television transmissions make relatively small contributions to the total power density.

The results of the Seattle and Portland survey are presented in Table 10. Three different indices can be used to discuss the results. The first is the median exposure, that level to which 50 percent of the population are exposed less than and 50 percent are exposed to more than. The other indices are the percent of the population exposed to less than 1 uW/cm2 and the percent of the population exposed to more than 10 uW/cm2. In Seattle the median exposure level is 0.007 uW/cm2 which is exactly the median level for 10 other cities previously surveyed. The median exposure level for Portland is higher but is still only 0.020 uW/cm2. In both Seattle and Portland over 99 percent of the population is exposed to less than 1 uW/cm2. Only a small fraction of the population is exposed to more than 10 uW/cm2, 0.001 percent in Seattle and 0.016 percent in Portland.

The highest power density level in Portland was measured at site number 13. This level, 153 uW/cm2, was determined directly under a transmitter so the exposure levels in nearby houses would be somewhat lower. Site number 36 taken on Cougar Mountain had the highest power density level in the Seattle survey. The power density level of 87 uW/cm2 was not included in the Seattle results because the site was outside the area used for calculating population exposure. Cougar Mountain was a specific source type of measurement because of its location and the few people affected.

Summary

Environmental power densities have been measured and the population exposure estimated for the Seattle and Portland metropolitan areas.

FM radio transmitters are the most significant environmental sources of nonionizing radiation.

In Seattle, 99.81 percent of the population is exposed to less than 1 uW/cm2 and only 0.001 percent of the population is exposed to over 10 uW/cm2.

In Portland, 99.70 percent of the population is exposed to less than 1 uW/cm2 and only 0.016 percent of the population is exposed to over 10 uW/cm2.

There are no Federal standards or guides for controlling envirnomental levels of radiofrequency waves in the U.S. However, the environmental exposure levels for over 99 percent of the population in Seattle and Portland would meet the very restrictive U.S.S.R. standard of one uW/cm2.

Table 1. Environmental Surveys

	Survey Period	Sites Surveyed
Portland	7/25-8/5 1977	38
Seattle	7/10-7/21 1978	35

Table 2. Frequency Range of Measured Broadcast Bands

Frequency*	Use
54-88	Low VHF Television Broadcast
88-108	FM Broadcast
174-216	High VHF Television Broadcast

* Megahertz (millions of cycles per second)

Table 3

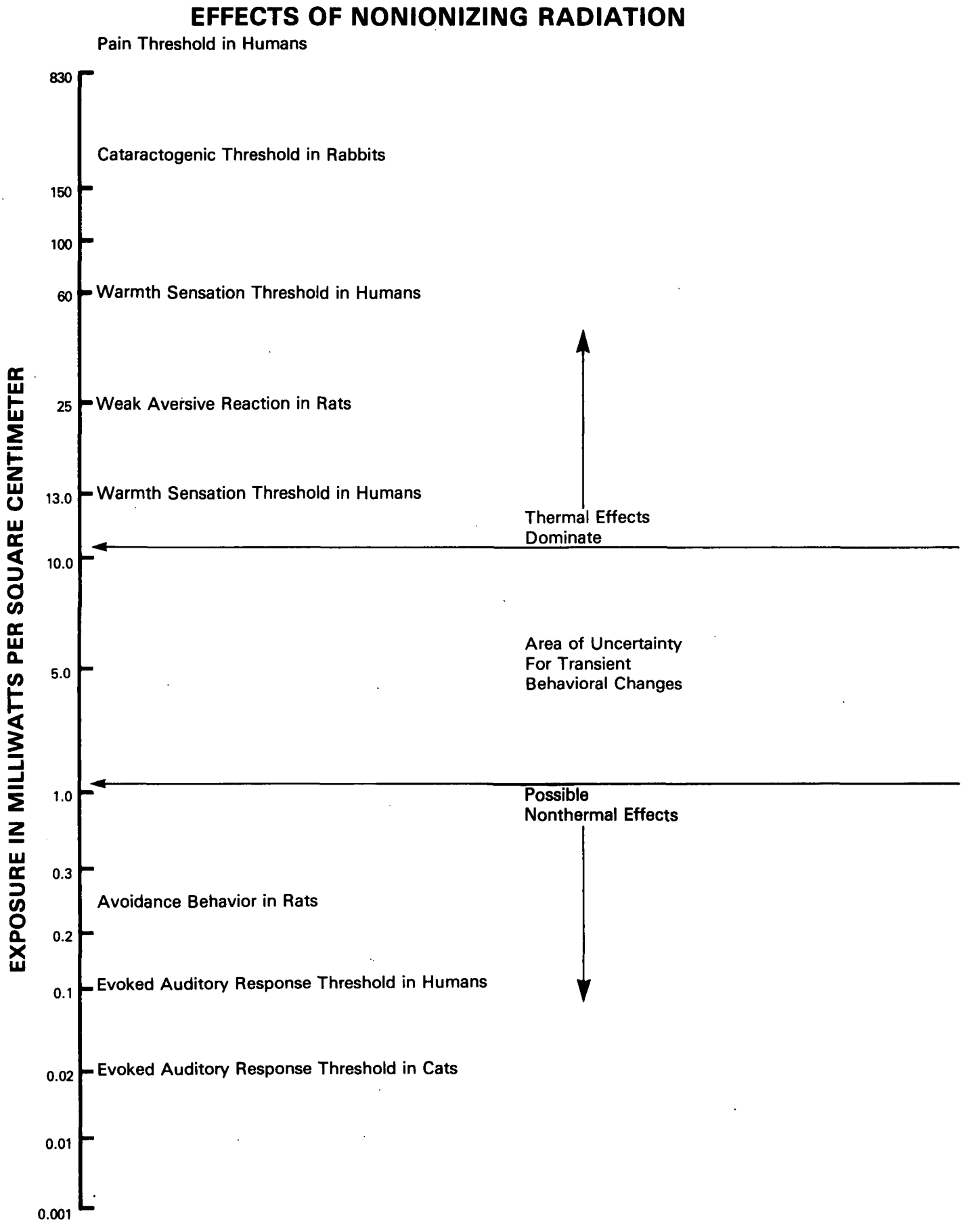

EFFECTS OF NONIONIZING RADIATION
Pain Threshold in Humans
830
Cataractogenic Threshold in Rabbits
150
100
60
Warmth Sensation Threshold in Humans
25
Weak Aversive Reaction in Rats
13.0
Warmth Sensation Threshold in Humans
Thermal Effects Dominate
10.0
Area of Uncertainty For Transient Behavioral Changes
5.0
1.0
Possible Nonthermal Effects
0.3
Avoidance Behavior in Rats
0.2
0.1
Evoked Auditory Response Threshold in Humans
0.02
Evoked Auditory Response Threshold in Cats
0.01
0.001
EXPOSURE IN MILLIWATTS PER SQUARE CENTIMETER

Table 4

NONIONIZING RADIATION STANDARDS

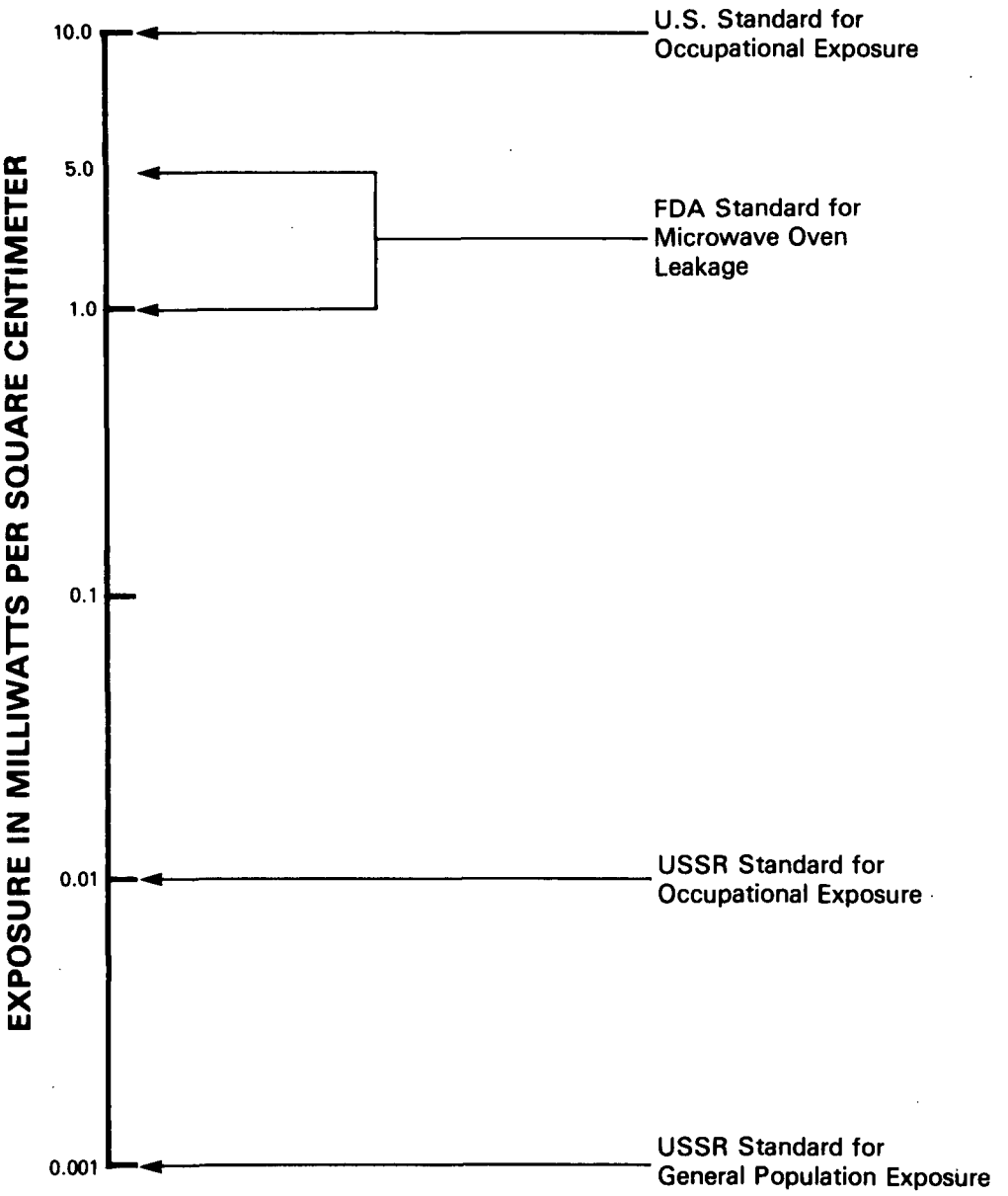


Table 5. Summary of Field Study Information

	CED's	Population	No. Field Strength Values	No. of Stations FM	VHF	VHF	Total	No. of Sites
Seattle	1315	872,442	820	16	2	2	20	35
Portland	1194	818,040	816	12	3	3	18	38

Radio-frequency detection van on display at University of Washington.

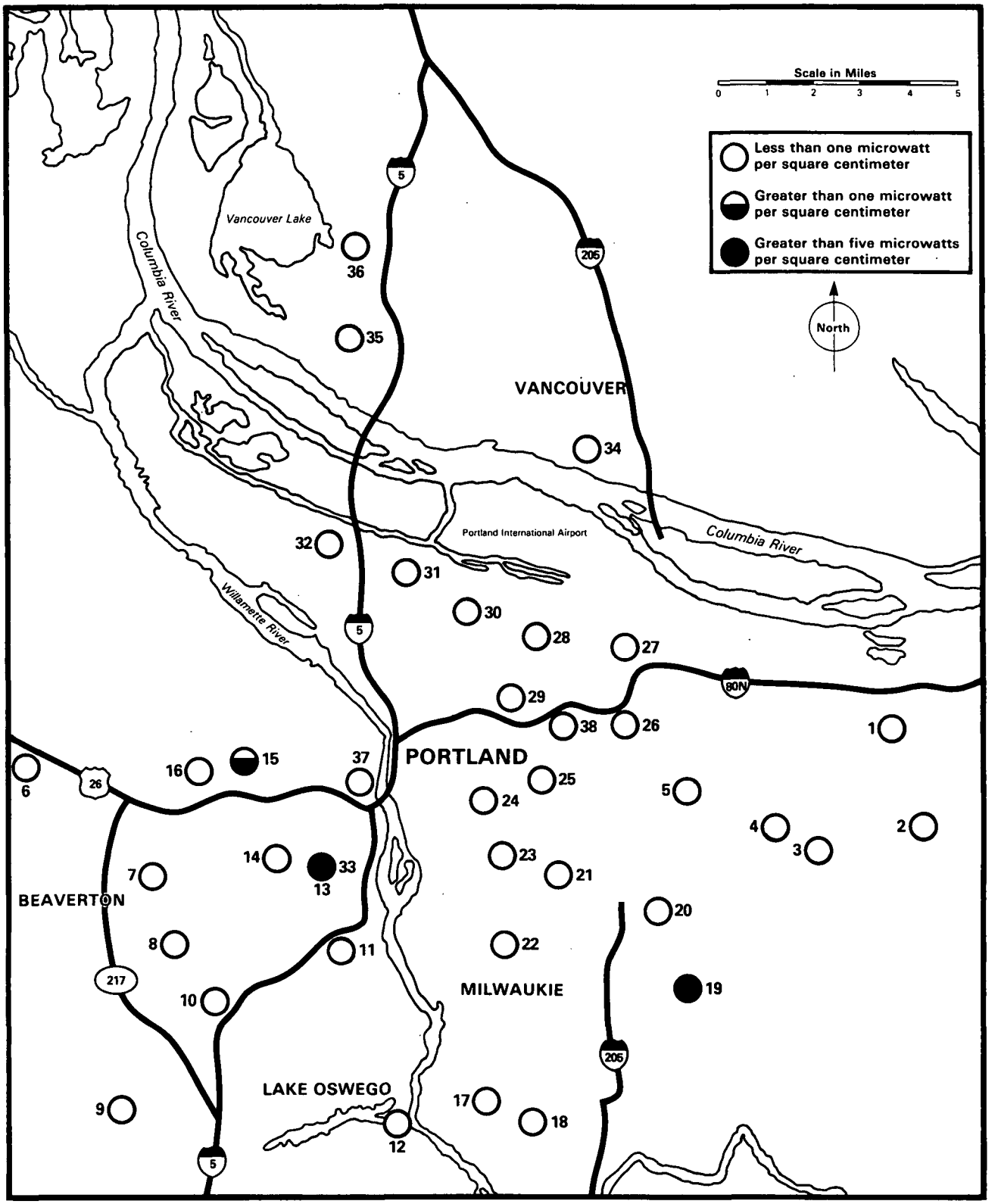
Table 6 Power Density Measurements for Portland Area
(microwatts per square centimeter)

Site Location Number	Total Power Density
1	.0109
2	.0101
3	.0258
4	.0651
5	.0334
6	.1090
7	.0549
8	.0149
9	.0775
10	.0991
11	.0726
12	.1090
13	153.7900
14	.5000
15	1.0600
16	.1660
17	.1140
18	.5330
19	16.4600
20	.5620
21	.1190
22	.2850
23	.1200
24	.1300
25	.1070
26	.0270
27	.0272
28	.0440
29	.0757
30	.0158
31	.0426
32	.0236
33	14.2600
34	.0172
35	.0826
	.0295
	.0686
	.0239

Table 7 Power Density Measurements for Seattle Area

Site Location Number	Total Power Density
1	.0872
2	.1450
3	.3200
4	.1650
5	.1730
6	.1650
7	.1910
8	.4330
9	1.4000
10	6.5300
11	22.7400
12	1.1900
13	.4340
14	.0175
15	.0315
16	.0685
17	.1170
18	.0576
19	.0555
20	.0264
21	.0224
22	.5010
23	26.6000
24	.8660
25	6.0400
26	.0195
27	.0280
28	.0949
29	.0093
30	.1180
31	.1930
32	.0207
33	.0270
34	.1130
35	.0337
36	87.9000

MAP 1: MEASUREMENT LOCATIONS IN THE PORTLAND AREA



MAP 2: MEASUREMENT LOCATIONS IN THE SEATTLE AREA

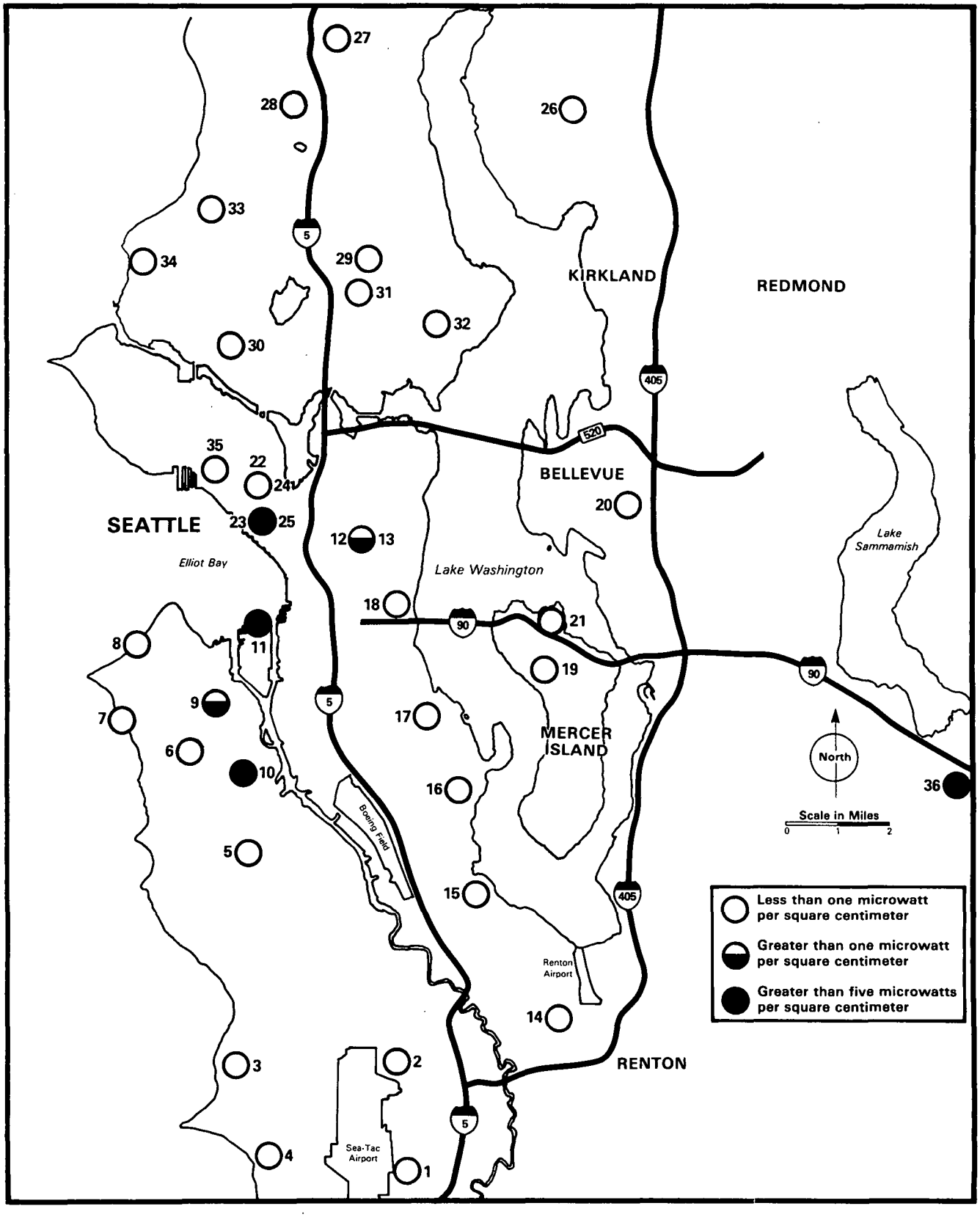


Table 8

FRACTION OF POPULATION EXPOSED AS A FUNCTION OF POWER DENSITY

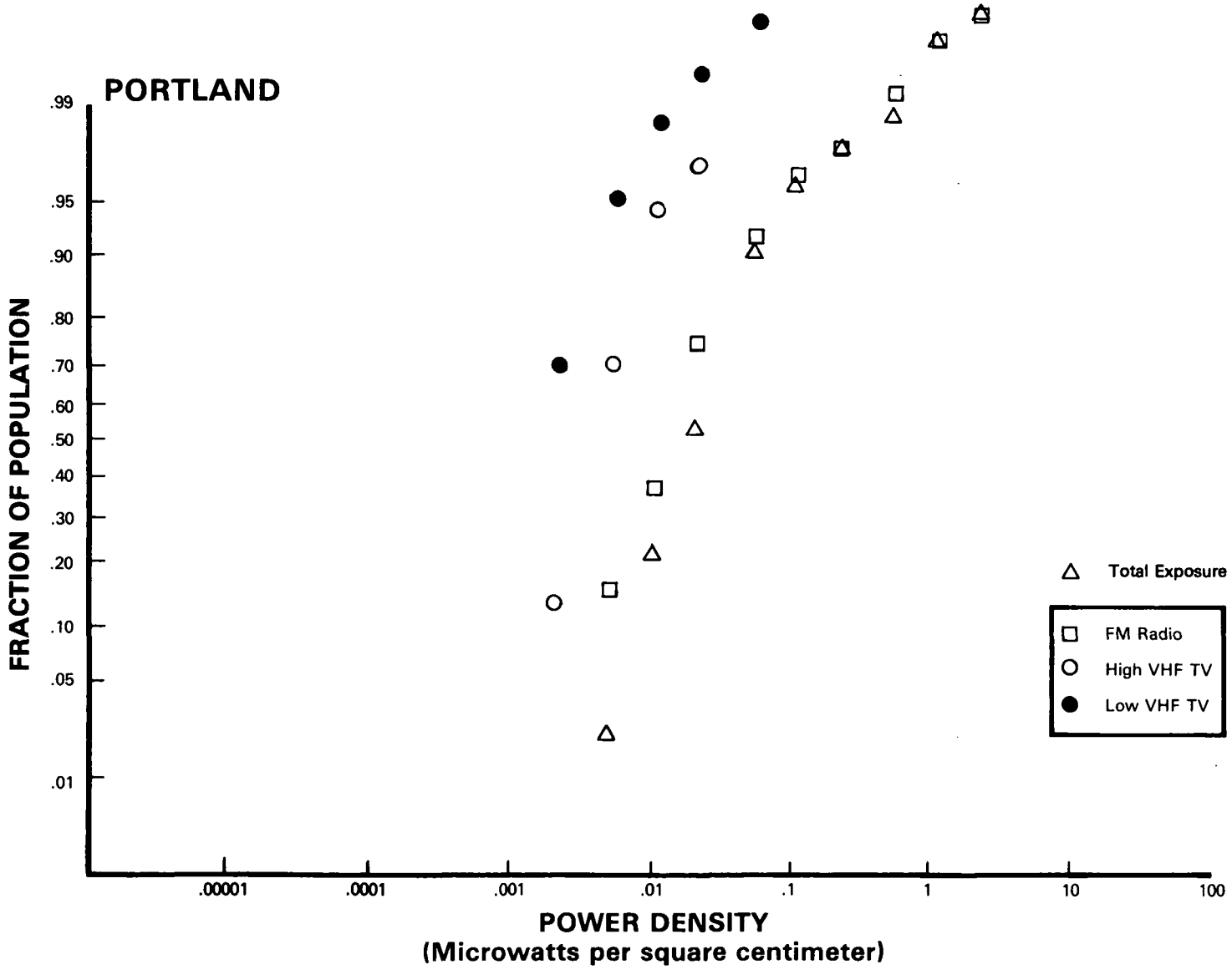


Table 9

FRACTION OF POPULATION EXPOSED AS A FUNCTION OF POWER DENSITY

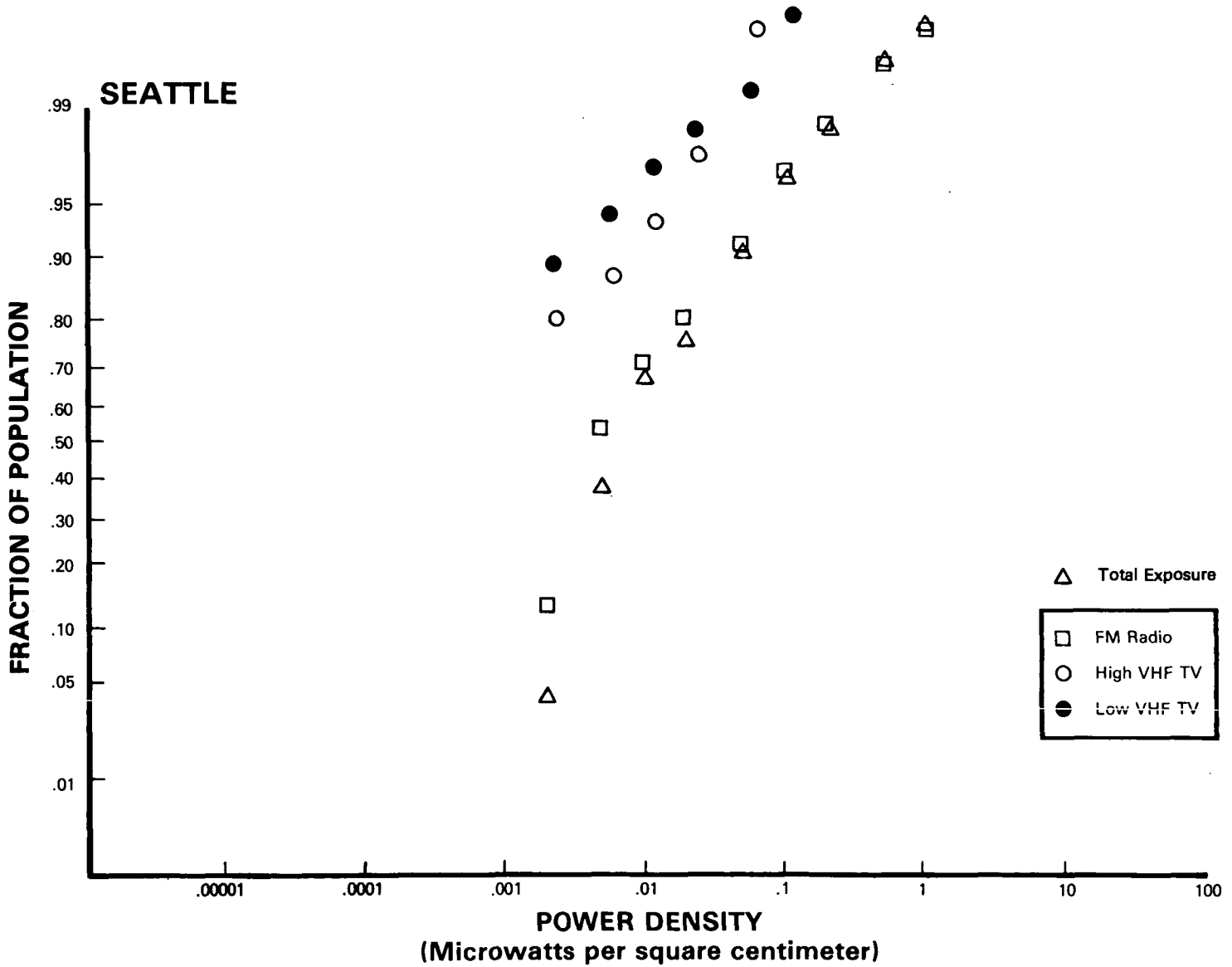


Table 10. Population Exposure Results for Seattle, Portland, and Ten other Cities

Location	Median Exposure	Percent of Pop Exposed to Less Than 1 microwatt	Percent of Pop. Exposed to More than 10 microwatt
Seattle	.007	99.81	.001
Portland	.020	99.70	.016
Ten Cities	.007	99.38	---

Radiofrequency detection equipment and minicomputer inside equipment van

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