POMONA OAKS EXPOSURE ASSESSMENT

Volatile Organics in Well Water
and Indoor Air

Environmental Health Program
Division of Epidemiology and Disease Control
New Jersey State Department of Health

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SECTION 1. INTRODUCTION

1.1 Volatile Organics in the Community

Synthetic chemicals and petroleum-based solvents have been developed and widely used in this country since World War II. These chemicals are now widely used to produce items that are an integral part of the modern American lifestyle. They are used by industry to manufacture clothing, furniture, housewares, pharmaceuticals, pesticides and almost everything consumed by the American family.

Most synthetic chemicals and solvents are known or suspected to be harmful to health when ingested and/or inhaled at or above certain concentrations. We have learned about the human health problems associated with exposure to certain levels of volatile organics primarily from occupational health studies of workers exposed to these substances and animal experiments in the laboratory. Estimates of the potential for human health problems at low levels of exposure usually must be extrapolated from data derived from higher exposures found in industry or used in laboratory experiments.

Residential exposures to volatile organics may occur through inhalation of contaminated air and/or ingestion of contaminated water, associated with inadequate air pollution control methods and/or waste disposal techniques. Because of low levels found in the community, public health concerns regarding volatile organics typically focus on potential chronic health effects. The first step in this assessment is the measurement of exposures. This can be accomplished from both environmental and biological monitoring surveys, when and where measurements are feasible.

At the present time, there are no Federal or State standards for levels of toxic chemicals in drinking water, except for trihalomethanes. There are also no standards for toxic chemicals in indoor air of private residences. If chemicals volatilize from contaminated hot water in the dishwater, bath/shower water and clothes washer water, then we need to look at inhalation as well as ingestion as the route or exposure.

Currently, the New Jersey Department of Environmental Protection's (NJDEP) Division of Water Resources (DWR) advises that water contaminated with toxic chemicals not be used for potable purposes when total volatile organics exceed 100 parts per billion (ppb). Persons who are advised by NJDEP-DWR to use alternate water supplies are not routinely told to discontinue showering and bathing in the contaminated water.

1.2 Benzene - A Contaminant of Particular Concern

Benzene is a clear, volatile, colorless, highly flammable liquid with a characteristic odor and is probably a human carcinogen (IARC).

Acute exposure in the workplace has been associated with local skin irritation; central nervous system effects like headache, dizziness, and nausea; and cardiovascular effects. More chronic exposures in the workplace have been associated with blood changes including aplastic anemia and malignancies (various types of leukemias). Health effects at the low exposure levels found in the environment, drinking water or a home have not been documented.

Benzenes are widely used in agricultural chemicals, pesticides, rubber, dyes, drugs, cigarettes, gasoline and household products such as moth balls and air fresheners (IARC). Research data indicate that the most common source of exposure is ambient air (EPA). In an urban environment, the daily background dose of benzene from background levels is estimated to be 0.6 milligrams (IARC). A dose of 20-100 milligrams per pack of cigarettes (estimated maximum level) may be added to the background level dose for smokers (Wynder and Hoffman). From May 1980 to August 1982, the Environmental Health Program (EHP) of the New Jersey Department of Health (NJDOH) took 188 outdoor air and 151 indoor air samples that were analyzed for volatile organics. Among the outdoor samples, 19.7% (37/188) had benzene but only 4.3% (8/188) had levels over 1 part per billion (ppb). Among the indoor samples, however, 25.8% (39/151) had benzene and 17.2% (26/151) had levels over 1 ppb. These data suggest that any health hazards associated with benzene are more likely to be present in the indoor environment, where exposures occur to higher levels and for longer periods of time.

Benzene has also been found by the NJDEP staff in New Jersey groundwater plumes (often associated with gasoline tank leaks or illegal chemical dumping) in Buena Boro and Galloway Township (Atlantic County); Little Egg Harbor and Dover Townships (Ocean County); Rockaway and Roxbury Townships (Morris County). About 5% of the 670 wells tested in a groundwater survey conducted by NJDEP had detectable levels of benzene, and about 1% had levels over 10 ppb (NJDEP). Benzene has also been found in soils, plants, foods, beverages and feeds.

1.3. Initiation of Investigation

During the Summer and Fall of 1982, several residents in Pomona Oaks noticed a bad taste and odor in their drinking water. The residents requested the help of the Atlantic County Health Department (ACHD). Ms. Gitchell of ACHD contacted Mr. Ray Barg of NJDEP (Division of Water Resources) who agreed to test some wells. She also used the services of a local private laboratory to analyze samples from additional wells. By mid-December, Ms. Gitchell had tested about 60 private wells, and had compiled a list and map of Pomona Oaks households (on West Terry Lane, Father Keis Drive and Donna Drive). The sample results were coded on the map as follows: (1) None detected (limit of detection = 2 ppb), (2) Less than ten parts per billion, (3) Ten to one hundred parts per billion, (4) Greater than one hundred parts per billion. The contaminated groundwater plume was clearly defined and the 10 benzene-positive homes were clustered on or near West Terry Lane. Based on these results, and recommendations made by NJDEP, ACHD informed the residents to stop drinking and cooking with the contaminated water.

During December 1982, Ms. Gitchell sent copies of the sampling results to the Environmental Health Program, and requested assistance regarding the toxicology of the chemicals found in the water and the proper recommendations regarding its use. On December 15, 1982, EHP staff met Ms. Gitchell in Atlantic County and were given a tour of the Pomona Oaks area. At a public meeting on December 16, 1982, Dr. Patel proposed that EHP conduct a study to determine the safety of showering in the contaminated water, since NJDEP did not ban non-potable uses of the water which remained a concern for the residents. He asked for the cooperation of the community to allow EHP personnel to sample their indoor air, interview them and collect biological samples. This initial study, the Pilot Study, was completed in December with the aid of the Atlantic County Health Department staff.

To the best of our knowledge, exposure to benzene was not occurring through ingestion of contaminated water during the above Pilot Study nor in January 1983. The households which had had water tests with total volatile organic levels greater than 100 ppb were using bottled water. The major route of exposure to benzene then was either skin absorption or inhalation of air contaminated by water during dishwashing, clothes washing, bathing and showering.

A Follow-Up Study which involved more extensive air sampling was conducted from May 1983 to May 1984.

1.4. Study Objectives

The Pilot, and Full Scale studies had the same goals of determining whether urinary phenol, a metabolite of benzene, was useful as a measure of benzene exposure. The Follow-up Study was conducted to assess the amount of benzene inhaled when showering with contaminated water.

1.4.a. Applied Public Health Objectives:

1. To determine the levels of exposure to volatile organics, particularly benzene, among Pomona Oaks residents,
2. To assess the exposures in terms of real or potential health risks,
3. To make recommendations regarding use of benzene-contaminated water for non-potable purposes, and
4. To provide a comprehensive data set of environmental results to help policy and decision-makers assist the community.

1.4.b. Research Objectives:

1. To predict benzene exposures when no air measurements are available, and
2. To compare urinary phenol levels among exposed and unexposed residents in order to evaluate the usefulness of the technique in assessing real exposures to benzene.

1.5. Description of Population Studied

The study population lives in a residential subdivision called Pomona Oaks which is a fifteen year old, middle class development. Pomona Oaks is located adjacent to Route 30 in Galloway Township (Map 1.1) in Northeastern Atlantic County, New Jersey. The closest major landmarks are Stockton State College (which is located nearby to the east) and Atlantic City (which is approximately fifteen minutes by auto to the southeast). Three studies were conducted by EHP in Pomona Oaks. The first, Pilot Study, was carried out on 20 December 1982 in nine households in Pomona Oaks. The second, Full Scale Study, was conducted on 25, 26, 27 January 1983 in thirty-seven households.

The third, Follow-up Study, was carried out from 5 May 1983 to 22 May 1984 and involved fourteen households.

Some households were included in all three studies. A total of 153 people were involved in all three studies. There was a nearly equally distribution of males and females. The age distribution for the studies was from 1 to 80; most of the study group were children between 10-19 years or adults between 30-39. All families in the studies were white, with the exception of one black family in the Full Scale Study. Maps 1.2-1.4 denote households that participated in the Pilot, Full Scale and Follow-up Studies respectively.

This report describes the events, methods and results of environmental sampling of air and water for volatile organics and biological monitoring for a benzene exposure assessment.

SECTION 2. MATERIALS AND METHODS

2.1. Pilot Study

2.1.a. Study Design

A cross-sectional survey of households known to have benzene exposures was conducted in order to define the extent of the contamination/exposure problem and to test whether urinary phenol levels could serve as an index of benzene exposure.

2.1.b. Sample Selection and Participation

On 17 December 1982, all twelve Pomona Oaks households that were known (from ACHD water sampling data) to have had benzene exposure were chosen for the Pilot Study, along with four households believed to be outside the contaminated plume area but otherwise similar to the exposed households. EHP and ACHD called residents of the selected households to ask whether they would participate in the survey. Eleven (seven exposed and four control households) of the 16 households selected and contacted by telephone agreed to participate, for a response rate of 68.8%. They were given appointments for simultaneous air sampling and questionnaire administration. The sampling and survey administration was conducted by EHP on 21 December with the assistance of ACHD staff. Due to equipment and personnel shortages, air sampling was completed in only seven (6 exposed and 1 control) homes, and no water data were collected in two control houses. Questionnaires were administered and urines were collected in all eleven homes.

2.1.c. Data Collection and Laboratory Analysis Techniques

Atlantic County Health Department personnel took water samples in nine of the eleven participating homes on the day previous to the air and urine samples. Cold water was run for 15 minutes at the kitchen or powder room tap before samples were collected in three 40-ml. glass containers. The samples were kept on ice until they were delivered to the laboratory within 24-hours of collection. The analysis for the water was done by a private laboratory in Gloucester County using gas chromatography. The results were reported to the residents by the ACHD and copied to the state.

Air samples were taken in seven homes by EHP staff from the room with the lowest elevation (which was usually the recreation room of these split level homes). DuPont pumps (Model 4000) with a charcoal collection medium encased in 50-ml glass tubes were used at a rate of one liter per minute for an average sampling time of three hours. The samples were delivered by EHP staff to the NJDOH Environmental Chemistry Laboratory within 24 hours after collection. The air samples were analyzed for total volatile organics, listed in Appendix IV. The method of analysis used by the lab for this set of samples was gas chromatography following standard procedures based on NIOSH guidelines.

The method for urine collection involved obtaining two samples of the same void in two plastic urine collection jars from each volunteer. In one of the two containers, a 10% CUS04 solution was placed as a preservative. All urines were refrigerated overnight, and the following day they were delivered to a private laboratory for analysis. Gas chromatography was used to analyze the samples, and yielded a total urinary phenol reading. This result would include phenols derived from benzene as well as from any salicylates commonly found in foods and phenols found in certain medicines.

The questionnaires (Appendix I and III) were developed by EHP staff to evaluate exposure to the contaminated well water other sources of exposures to benzene (such as smoking, heaters, hobbies and driving) and occurrence of health effects. ACHD staff were instructed on proper questionnaire administration techniques and then administered the questionnaire to the community. The questionnaire for the Pilot Study was filled out by the head of the household for all members of the home. The specific items included on the questionnaire are listed in the following section. The supplemental Interior Air Survey was not completed in two of the nine homes.

2.1.d. Data Management and Statistical Methods

On 30 December 1982 all air and urine results had been returned by the respective laboratories to EHP, as had all questionnaire answers. Water sampling data had been obtained from ACHD. The computerized SAS data set included the following:

Exposure Factors

1. Benzene in Water (ppb)
2. Total volatile organics in well water (ppb)
3. Benzene in Air (ppb)
4. Total volatile organics in indoor air (ppb)

5. Self-reported exposure to benzene and other chemicals at work or from hobbies
6. Use of kerosene heater, wood stove, or fireplace
7. Type of household fuel for cooking and for heating
8. Use of tobacco products
9. Presence of attached garage

Demographic and Health Factors

10. Age
11. Sex
12. Urinary Phenol (mg/liter)
13. Self-reported problems associated with air and/or water

In some cases where more than one water sample result was available for a residence, the value selected for the Pilot Study was the most recent. If the most recent sample was a "split" sample (taken both by ACHD and DEP), the highest value was used.

Because of the small number of people in the Pilot Study, largely descriptive analyses of the data were conducted. Cross-tabulations were prepared of urinary phenol groups by benzene exposure.

2.2 Full Scale Study - 25,26,27 January 1983

2.2.a. Study Design

The study design was cross-sectional, and included sampling of general indoor air and well water levels (for benzene, specifically) which would be compared to urinary phenol levels. An expanded questionnaire (Appendix II) was developed to help control for dietary and environmental factors that may act as confounders of the urinary phenol test. The purpose of the study was the same as the Pilot Study; i.e., to look for correlations between environmental benzene levels and urinary phenol levels and to use the correlations to make decisions about the exposure to benzene occuring in certain study households.

2.2.b. Sample Selection and Participation

On 20 January 1983, another public meeting was held in Galloway in order for Municipal, County and State officials to discuss the latest results and findings. At this meeting, EHP staff requested volunteer households for the Full Scale Study. Households were accepted for study on the basis of residence in the area, rather than on results of former environmental tests. Residents that had participated in the Pilot Study were eligible to participate in the Full Scale Study as well. Although staff and financial considerations had originally limited the survey to 35 households, three extra families were included at their requests giving a total of thirty-eight volunteer households. Fifteen of the 16 known benzene-contaminated households participated in this study, and the remaining 23 households were "unknowns" at the time of the Full Scale Study. The volunteer households were given appointments for either the 25th, 26th or 27th of January (one household later dropped out of the study leaving a total of thirty-seven households). The appointments included samples of air, water, urine and survey administrations. All sampling of the environment and questionnaire administrations occurred on the same day for given households; the urine sample was taken the following morning (first void) to represent exposure to the previous day's benzene levels.

2.2.c. Data Collection and Laboratory Analysis Techniques

Funding and management of water samples was provided by NJDEP. ACHD staff collected the water samples for NJDEP (as described in 2.1.c) and submitted them for analysis on the same day that sampling was conducted.

Air samples were taken mostly in bathrooms with no tap water running. Sampling times averaged three hours. The same monitoring equipment and lab analyses, as already discussed in 3.1.c., were used. The NJDOH laboratory analyzed the air and water samples for NJDEP using EPA's 624 method. The chemicals tested for are listed in Appendix IV.

The method for collecting urine was the same as in the Pilot Study (see 2.1.c.). The residents were given two urine containers on the day of the questionnaire administration; the urine sample was a first void the following morning and it was picked up at their home on the same morning. Urines were refrigerated at the ACHD and were delivered to the private laboratory the day after the completion of the study. The purpose was to get a urine that represented metabolism of benzene exposure from the shower of the previous evening.

ACHD and EHP staff administered two surveys, shown in Appendices II and III. The benzene exposure survey was the same first page as the Pilot Study; a second page was added to provide information needed to estimate exposures to volatile organics in shower air and dishwashing air. Questions were also added regarding past 24-hour mileage driven and consumption of foods containing salicylates (which confound the urinary phenol tests). The Supplemental Interior Air Survey was completed in all but one home.

2.2.d. Data Management and Statistical Methods

Data gathered in the study were mapped and tabulated by hand to look for geographic and dose-response trends. They were entered on computer and analyzed using SAS programs. Variables for all participants were as follows:

Exposure Factors

1. Source of Drinking Water (well vs. municipal)
2. Glasses of Water Consumed Per Day
3. Source of Bath Water
4. Number of Hours elapsed from Shower to Urine Sample
5. Dishwashing Times Per Week
6. Number of Hours elapsed from Dishwashing to Urine Sample
7. Pilot Study Benzene in Water
8. Full Scale Study Benzene in Water
9. Pilot Study Total VO in Water
10. Full Scale Study Total VO in Water
11. Presence of Odor in Water/Air
12. Smoking (ever/never, and amount/day)
13. Benzene in Work or Hobby Settings
14. Miles Traveled in the 24 hours Prior to Urine Sample
15. Attached Garage (yes/no)

16. Use of Fireplace/Woodstove/Kerosene Heater (during study)

17. Pilot Study Benzene in Air

18. Full Scale Study Benzene in Air

19. Sum of All Benzene Exposures in Air

20. Full Scale Study Ethanol in Air

21. Full Scale Study Toluene in Air

22. Pilot Study Total Volatile Organics (VO) in Air

23. Full Scale Study Total Volatile Organics (VO) in Air

24. Use of Phenol-Containing Antiseptics/Drugs

25. Use of Salicylate Medication (Aspirin)

26. Consumption of Salicylate Containing Foods

<u>Demographic and Health Factors</u>

27. Age

28. Sex

29. Specific Gravity of Urine

30. Pilot Study Urinary Phenol Level

31. Full Scale Study Urinary Phenol Level

The study classified urinary phenol levels as the outcome of interest; levels that exceeded 20 mg/l were considered high. Other health outcomes were skin rashes and detectable odors associated with potable water or indoor air. These were examined descriptively only. Other potential causes of high phenol levels (such as salicylates and/or phenols) were regarded as possible "confounders".

Urinary phenol levels were cross-tabulated with maximum levels of benzene in water and in air, with presence of other benzene sources, and consumption of foods and drugs containing salicylates. SAS was used to produce a X^2-test for each cross-tab in order to determine whether any significant associations were present in the dataset.

2.3 Follow-up Study

2.3.a. Study Design

A series of cross-sectional air and water sampling studies were conducted from May 1983 to May 1984. The primary purpose of these sampling sessions was to develop and apply a method of sampling moist air for levels of volatile organics, to estimate inhalation exposures to benzene from water levels of benzene, and to develop appropriate recommendations to protect the public's health. The residents generally were not consuming the water, but continued to be concerned about inhalation exposures to toxic chemicals associated with hot water usage in the home. Due to the typical duration of exposure and small dilution volume (of bathroom air), the non-potable practices of main concern were showering and bathing. The chemical of concern was benzene because of its known carcinogenicity.

2.3.b. Sample Selection and Participation

The development of the moist air sampling method took place in the home found to have the highest exposures to benzene in the Pilot or Full-Scale Study. The family involved volunteered their home on three occassions so that a series of technical problems could be resolved (see Appendix V).

Eventually fourteen homes found to have volatile organic exposures (in either of the prior two studies) were sampled in at least one of the three separate sessions between September 1983 and May 1984. All families who participated volunteered their homes for these monitoring sessions on an individual basis.

2.3.c. Data Collection and Laboratory Analysis

The developmental stages of the monitoring technique, described in Appendix V, were valuable in determining the total air volume that should be sampled, the placement of monitors in the home, the point in time when samples should be collected, and the type of sampling media that should be used.

All water samples in this series of surveys were taken using the standardized methods, described in Section 2.2.c., and were taken to the New Jersey State Department of Health Laboratory for analysis. Gas chromatography, using the EPA 600 series, was the analytic method, and the list of 26 volatile organics evaluated is shown in Appendix IV. A laboratory field blank was always taken on site during each sampling session.

All background air samples were taken using DuPont 4000 Personal Air Sampler pumps equipped with a charcoal sampling medium, encased in fifty-milliliter glass tubes. Dehydrated calcium sulfate ($CaSO_4$) encased in eight-inch teflon tubes was added on as a dessicant to prevent moisture from the shower's aerosol from reaching the DuPont pump. The "moist air" sampling set-up was in the following order: pump, $CaSO_4$, charcoal, environment (Figure 2.1). In the final sampling session, the position of the charcoal and the $CaSO_4$ was reversed and is referred to as the "dry air" method (see Figure 2.1).

The air sampling locations were selected to be representative of the breathing zone of bathers and other residents. All houses were built in the same year by the same builder. The sampling locations in the split levels included the upper level bathroom and master bedroom; the living room and kitchen on the middle level; and the hallway, powder room and laundry room on the lower level. The sampling locations for the ranchers were the bathroom, master bedroom, living room, kitchen and laundry area, which were all on the same floor.

Within the bathroom, there were three test locations, which are shown in Figure 2.2. Zone One was the area around the shower fixture where the water is first released. Zone Two was the breathing zone; it is where a person's head would typically be located when taking a shower. Zone Three was the floor level about three feet away from the bathtub.

The ideal air pumping rate for the 15-minute or longer term samples was one liter per minute, but that rate was not always achievable. The range of total volumes during the 15-minute sampling periods was 13.2 liters to 19.0 liters. To compare the results for all sampling sessions, we standardized the measured contaminant levels to 15.0 liters total volume.

Samples were taken before, during and after the shower was operated. Background Level samples were taken either in the living room or kitchen area for a 1½ to 3-hour time period that started before the pretest and that lasted throughout the exposure and dispersion tests. The 15-minute measurements taken in the bathroom before the shower air was sampled were called Pretest Levels. The 15-minute samples taken during shower operation (with the bathroom door and window closed) were called Exposure Levels. The shower was run for 15-minutes at a rate and temperature that most nearly simulated the family's typical use patterns. The sampling pumps were turned on and the room was vacated for the sampling time.

Because monitoring equipment was not available, no measurements were taken of air temperature, water temperature and humidity during any of the sampling sessions. At no time was anything in the bathroom removed or changed before or after testing.

Air samples were analyzed by the New Jersey State Department of Health's Environmental Chemistry Laboratory using standard gas chromatography techniques adopted from NIOSH methods. A list of all the chemicals in a routine NJDOH volatile organic scan is given in Appendix IV.

2.3.d. Data Management and Statistical Methods

Due to the limited size of the data base, the environmental information collected in the Follow-up Study was tabulated and analyzed descriptively. The maximum benzene exposure data were then used to conduct a risk assessment in order to evaluate the potential chronic health hazards associated with benzene levels found in the study.

2.4. Methods of Communication

Residents of Pomona Oaks who found themselves unable to use their water for potable purposes were frustrated and wanted prompt assistance because their water had to be delivered in 55-gallon drums by the Township. A neighborhood group was organized and Mr. Ray Adams was selected as the spokesperson. Public meetings were held regularly to exchange information among agencies and the residents; Mr. Adams routinely presented the agency representatives with lists of the community's questions. In order to avoid miscommunication, an effective network was arranged to keep all participants informed. The NJDOH-EHP reported test results by telephone or letter to the residents in the studies as soon as they were available.

SECTION 3. RESULTS

3.1. Pilot Study Results

3.1.a. Sample Studied

Originally there were 11 households and 34 people who volunteered for the study. Exposure data were not available for two houses, and three people in separate homes were not able to provide urine samples, so their data were not included in the results presented here. Thus, the study sample size was 9 homes and 25 people. The majority of the study population lived within a two block area, and all persons were both white and middle class (determined from self-reported occupation data only). Table 3.1 shows that the Pilot Study sample was 52% male and the median age group was 30-39.

3.1.b. Exposures

As shown in Table 3.2, volatile organics were found in the water samples collected in 8 (7 "exposed" and 1 control) of the 9 households studied. The chemicals most commonly found were benzene (77.7% of the homes); 1,2 dichloroethane (66.6%) and methylene chloride (22.2%). Six of the 7 "exposed" homes had total volatile organic levels that exceeded DEP's guideline of 100 ppb.

Of the 7 homes where air samples were taken, 6 (86%) had detectable levels of volatile organics and 5 of these had totals that exceeded 100 ppb (see Table 3.3). The chemicals most often found were 2-methylbutane (85.6%), benzene (57%) and pentane (57%).

All houses were about 15 years old and 66.7% had gas cooking stoves, smokers present in the home, and attached garages (see Table 3.4). It is apparent that numerous potential sources of benzene were present in these homes.

3.1.c. Response

Twenty-four percent (6/25) of the participants had urinary phenol levels over 20 mg/l, as shown in Table 3.5. While no one reported skin rashes due to the contaminated water, 44% (11/25) complained of odors associated with the water. It is interesting to note that 72% (18/25) stated that the water tasted bad, although only 40% (10/25) reported drinking the water.

3.1.d. Exposure-Response Relationship

The sample size was insufficient to statistically determine the presence of an exposure - response relationship. As a result, the data from the Pilot Study were reviewed on a descriptive level only. Table 3.5. shows that 20% of the study group had elevated urinary phenol levels and was also exposed to detectable benzene levels in the water supply.

3.2. Full Scale Study Results

3.2.a. Sample Studied

There were thirty-seven households and 142 respondents in the study. Three children did not contribute to the biological monitoring part of the study so their data was excluded from the results presented here. The study sample was 37 houses and 139 people. The percent of males and females was equal, and the respondents ranged from 1-80 in years of age (see Table 3.6). All but one family of the study population was white. Using self-reported occupational data, all families were found to be middle class.

3.2.b. Exposures

All of the Pomona Oaks houses studied were approximately fifteen years old and all had other potential sources of volatile organics (see Table 3.7.). All were either split level or rancher types, and 89% had natural gas stoves. Over 59% had smokers present and 65% had attached garages. Twenty-seven percent used wood stoves and 22% used kerosene space heaters during the study period.

Table 3.8. shows the frequency distribution and range of the detectable levels of volatile organic chemicals detected in the water samples. Total volatile organic concentrations in water ranged from non-detectable to 1500 ppb. Forty-six percent of the 37 homes studied had total volatile organic levels which did not exceed 1 ppb, while 24% had at least one chemical concentration over 99 ppb. The chemicals most often detected in the water samples included 1,1,1 trichloroethane (38% of the homes); chloroform (32%); trichloroethylene (32%); 1,1 dichloroethane (27%); and 1,2 dichloroethane (24%).

Table 3.9. presents the data on volatile organics found in the indoor air of the homes. While the range of total volatile organics was similar (non-detectable to 1420 ppb), 70% of the homes had total

concentrations over 99 ppb. The chemicals most commonly found included ethanol (73%), 2-methyl butane (65%), butane (62%), pentane (54%), and toluene (43%).

The chemicals found in <u>both</u> the air and water samples were: benzene, p-dichlorobenzene, ethyl benzene, methylene chloride, toluene, and 1,1,1-trichloroethane.

3.2.c. Response

Table 3.10. shows the distribution of urinary phenol levels in the Full-Scale Study. Eleven percent of the study group had levels over 20 mg/l.

During the Full Scale Study, 14.4% (20/139) of the participants complained of skin rashes, and 30.9% (43/139) reported odors associated with the well water. Again, 43.9% (61/139) reported that the water tasted bad although 51.1% (71/139) said they were using the water for drinking and cooking.

3.2.d. Exposure - Response Relationships

A home was considered benzene positive (any level over 1 ppb) if either the air or water samples had detectable levels of benzene. When the maximum benzene levels in water or air samples taken 24 hours before the urine samples in all homes were cross-tabulated with the urinary phenol levels (Table 3.10.), only 3% of the study population was found to be both exposed to benzene in water or air and had an elevated urinary phenol value. Neither the Chi-square test nor the odds ratio showed that the exposure and response were correlated. The small sample size prevented any further analysis of the data, controlling for confounders.

3.3. Follow-up Study

3.3.a. Sample Studied

Data from the 3 developmental monitoring sessions conducted from May to August 1983 in one home only are shown in Appendix V. The 3 monitoring sessions of the Follow-up Study were conducted in September 1983 (n = 3 homes), January 1984 (n = 14), and May 1984 (n = 6). Some homes were monitored more than once in the Follow-up Study. Fourteen households total volunteered to take part in this phase of the project. Not all of these homes had been monitored previously in the Pilot or Full Scale Studies. As before, all homes were about 15 years old and were in the Pomona Oaks development. No health data were obtained, because the purpose of these sampling sessions was to estimate the dose of benzene received while showering or bathing in contaminated water.

3.3.b. Exposures

Table 3.11 presents exposure data obtained in the September 1983 Follow-up Study. Three homes had data for both water and air, and thus were useful for determining the relationship between the air and water results for benzene. The air to water ratio for benzene levels in the 3 homes ranged from 1.7-4.6.

Table 3.12 shows that 36% of the January 1984 water samples had detectable levels of benzene, while only 7% of the samples had a total volatile organic level over 100 ppb. (It should be noted that 5 samples had from 2 to 17 unknown peaks during analysis.)

Table 3.13 shows that while 14% of the background air samples had detectable levels of benzene, 64% of the samples had total VOs over 100 ppb. The most commonly found chemicals were ethanol (65% of the homes), isobutane (35%), and butane (28%).

The moist air sampling data for the 14 homes are shown in Table 3.14. Thirty-six percent of the samples had total VO levels over 100 ppb, and 35% had detectable levels of benzene. Fifty-seven percent of the homes did not have detectable levels of any volatile organic chemical.

Five homes were monitored for volatile organics in water and air samples in the May 1984 sampling session. The benzene levels in water samples for all homes ranged from 31-700 ppb, and most of the samples had 12 or more unknown peaks during analysis.

Table 3.15 shows the chemicals and the levels found in the background air samples taken in the kitchen or living room while the shower air samples were also being collected. The volume of these air samples ranged from 160-412 liters. If the data were standardized to 15 liters, then no volatile organic chemicals would have been detected.

Tables 3.16 and 3.17 show the data for the shower air samples respectively by the moist and dry methods respectively. Three samples (one from each sampling zone) for each of the five houses studied are included. It is important to note that the data were not standardized to 15 liters of air, because it was found that the conversion would affect the distributions shown only by slightly reducing the number of results over 100 ppb. The dry sampling method tended to result in levels at least 10% higher than the levels found with the moist method. There are some differences between the frequency distributions, particularly for benzene, but the differences tend to be minimal.

Table 3.18 summarizes the data for benzene in the air samples taken in the three zones in the bathroom and in another room in the house. All data were standardized to 15 liters of air in order to compare the results obtained from the moist and dry methods used at the same place and time. The dry method almost always produced higher results, with the mean ratio of dry to moist being 1.28 and the range of the ratios being 0.92-1.85. Background levels of benzene were very low.

In order to determine whether there was a reliable ratio of air to water levels of benzene that could be used to estimate health risks, all shower air data were compared to the water data for each home. Table 3.19 presents the ratios of shower air data to water data by house, sampling zone (1-3) and method of sampling. The range of ratios is quite broad. The mean ratios are shown by zone and by sampling method.

3.3.c. Risk Assessment

In order to evaluate the toxicologic impact of the benzene levels seen, NJDEP staff conducted a risk assessment (Appendix VI) in which observed and estimated air levels of benzene were converted to doses, and the GLOBAL82 model was based on animal dose-response data. The quantitative risk assessment indicated that 1.7 cancers would occur among 10,000 people exposed to the observed levels of benzene. It was this finding that served as the basis for developing the public health policy recommendations shown in Table 4.2.

SECTION 4. DISCUSSION

4.1 Pilot Study

The purpose of this study was to assess the possibility of using urinary phenol to quantitate exposure to benzene in an environmental contamination situation.

The percentage of respondents with elevated urinary phenol levels was higher than has been found in other community surveys conducted by NJDOH (see Table 4.1). It can be seen, however, that the range of values was lower than in most other groups studied.

Although it was thought that all residents of benzene-positive homes had been advised to neither drink nor cook with their well water, 40% of the sample said that they were using it. The percentage of people who complained of odors and bad tastes associated with the water was higher than 40%, suggesting that either the time frame of the questions was not clear or even more than 40% of the respondents were still using well water.

The dataset was too small to determine statistically whether there was an association between benzene exposures and urinary phenol levels. The fact that 20% of the people were both exposed and had elevated levels, however, suggested that a more extensive study of the community was needed. Confounders such as foods and drugs containing salicylates needed to be controlled, using a large study population, to determine whether other factors explained the correlation seen in the Pilot Study.

Table 3.2 clearly shows that there were 7 households exposed to higher levels of benzene in their well water than were their neighbors.

All of the chemicals found in the water samples were also found in the indoor air samples, but many more chemicals were found in the air samples (see Table 3.3). These data suggest that there are other sources of indoor air contamination which need to be evaluated in a residential exposure assessment such as this. While Table 3.4 shows that numerous potential sources were present in the homes studied, the sample size was too small to statistically control their effects on the indoor environment.

4.2 Full Scale Study

The demographic data (Table 3.6) showed the participants to be typical community residents. The interior air survey data (Table 3.7) indicated that more potential sources of volatile organics were present in the 37 homes than in the Pilot Study homes. This increased reporting may reflect that the Full Scale Study respondents were more aware of potential sources in their homes than were the Pilot Study respondents. The large number of gas cooking stoves indicates that the principle source of heating and cooking fuel in Pomona Oaks is natural gas. It is also interesting to note that nearly 60% of the homes had smokers, in contrast to national averages showing that about 30% of the population smokes.

Many of the chemicals found in the water (Table 3.8) were also found in the air. More chemicals were found in the air than in the water, indicating that sources other than the water contributed to the contamination of air. The ranges of detectable levels of volatile organics were similar in the water and air samples. It is striking, however, that 70% of the homes had total volatile organic levels in air over 99 ppb, while only 46% of the homes had water levels that high. It is likely that the sources in Table 3.7 contributed significantly to the indoor air levels.

Only 11% of the Full Scale Study participants had elevated urinary phenols in contrast to the 24% seen in the Pilot Study group. As shown in Table 4.1, however, this finding is not different from urinary phenol results from other New Jersey communities studied to date. It is important to note that none of the other communities were using benzene-contaminated water.

As was found in the Pilot Study, a large portion (51.1%) of the study group reported using well water for drinking and cooking, while 43.9% said it tasted bad and 30.9% said the water gave off odors. It is likely that the time frame of these questions was not understood by the respondents, since all homes were then being supplied with water in drums by the town.

The cross-tabulation of benzene exposure and elevated urinary phenol levels did not show a statistically significant association. This finding, along with the fact that the urinary phenol level distribution in Pomona Oaks is not different from communities not exposed to benzene-contaminated water, suggests that the elevated values seen probably were not due to the benzene in the well water. If environmental exposures are related to urinary phenol levels, they are likely to be associated with long-term higher-level benzene exposures than seen in Pomona Oaks. Attempts were made to cross-tabulate the data to control for confounders, but the sample size was too small to pursue a statistical analysis.

We do not believe that this test is useful for exposure levels found in Pomona Oaks. The department intends to do further analysis of the urinary phenol from Pomona Oaks and other sites to determine what is the cause of the wide variation in results found. As stated above we do not believe that the presence of benzene in water is the cause.

4.3 Follow-up Study

The series of air and water sampling sessions in the Follow-up Study were designed to determine the level of benzene in the breathing zone of a shower, where the highest exposure levels were expected. It was hoped that any correlation found between air and water levels would provide a sufficient data base to estimate the toxicologic effects that would be expected from chronic exposures.

The initial monitoring conducted in one home (Appendix V) indicated that 15 liters of air was needed to detect the chemicals, that long-term sampling was needed for background air levels, that results differed depending on the location of the sampler in the bathroom, and that dishwashing and laundering did not release levels of volatile organics as high as those from showers.

The series of samples taken in homes between September 1983 and May 1984 provided some interesting results. While there are some home-specific variations in concentrations that suggest seasonal and/or migrational trends of the contaminated plume, the types and levels of volatile organics found in water were largely similar over time.

The different sampling methods used (moist and dry) resulted in some differences in the types and levels of volatile organics detected in air samples collected at the same time. Table 3.18 shows that for benzene levels the dry sampling method produced levels from 0.92-1.85 times higher than the moist method. There are numerous micro-environmental factors that were not studied but which could have affected the sampling results. Some of these factors are water temperature, air temperature, relative humidity, air exchange rate (although doors and windows were closed during sampling), and the presence of sinks (rugs, towels, etc.) for volatile organics.

To determine whether there was a reliable association between air and water benzene levels, the sampling data were standardized to 15 liters. Tables 3.18 and 3.19 indicate that both the proximity of the air sampler to the water source and the method of sampling affect the benzene levels obtained in air samples. Samplers placed by or near the shower head result in benzene levels up to four times higher than samplers placed 3 feet from the tab. This finding shows the importance of placing the sampler in the breathing zone in order to obtain data that represent actual human exposures.

The difference in benzene levels found using the moist and dry methods is more difficult to interpret. Without controlled laboratory studies of the methods, it will not be clear which method is a better measure of actual exposures. The wide range in the air/water ratio (0.27-4.41) suggests that there are important factors (droplet size, air and water temperature, etc.) not studied here that affect the sampling results, and thus the estimates of human exposure.

For the homes where air sampling were not available, the upper values of the air/water ratio was used to estimate the maximum benzene exposure for a 15-minute shower. The observed and estimated benzene values were then entered into the GLOBAL82 model, which is a multistage model for carcinogenesis. The range of exposure data resulted in upper estimates of lifetime cancer risk ranging from 1.4 cancer per 100,000 people exposed to 4.7 per 10,000.

As a result of the Follow-up Study findings, the residents of Pomona Oaks were advised to take several precautions to reduce their exposures to volatile organic chemicals in their water, until such time that an alternative water supply could be found. Table 4.2 lists the specific recommendations that were made to the residents.

4.4 Summary

Residents of the Pomona Oaks subdivision in Galloway Township (Atlantic County) were found to have levels of volatile organics in water exceeding the NJDEP guideline of 100 ppb. Benzene levels were found to be particularly high. Although the residents had been told to stop drinking or cooking with the water, they were concerned about exposures to toxic chemicals through skin absorption and inhalation.

The series of studies described here focused on assessing the types and levels of exposure to volatile organic chemicals, and particularly benzene because of its known carcinogenicity. New air sampling techniques were used and a risk assessment model was applied to the data to estimate the cancer risk associated with the benzene in air levels. When a level of risk was found that exceeded usual public health policy, recommendations were made to the residents to reduce their exposures.

4.5 Conclusions

The residents of Pomona Oaks have been exposed to well water contaminated with volatile organic chemicals. Although they are not consuming the water, the data presented here indicate that the toxicity of the chemicals found and the levels of contamination pose a health risk to the community through inhalation. The best way to reduce this risk is to replace the current water supply with a clean source. Until this can be accomplished, the residents have been advised to take specific steps to protect their health.

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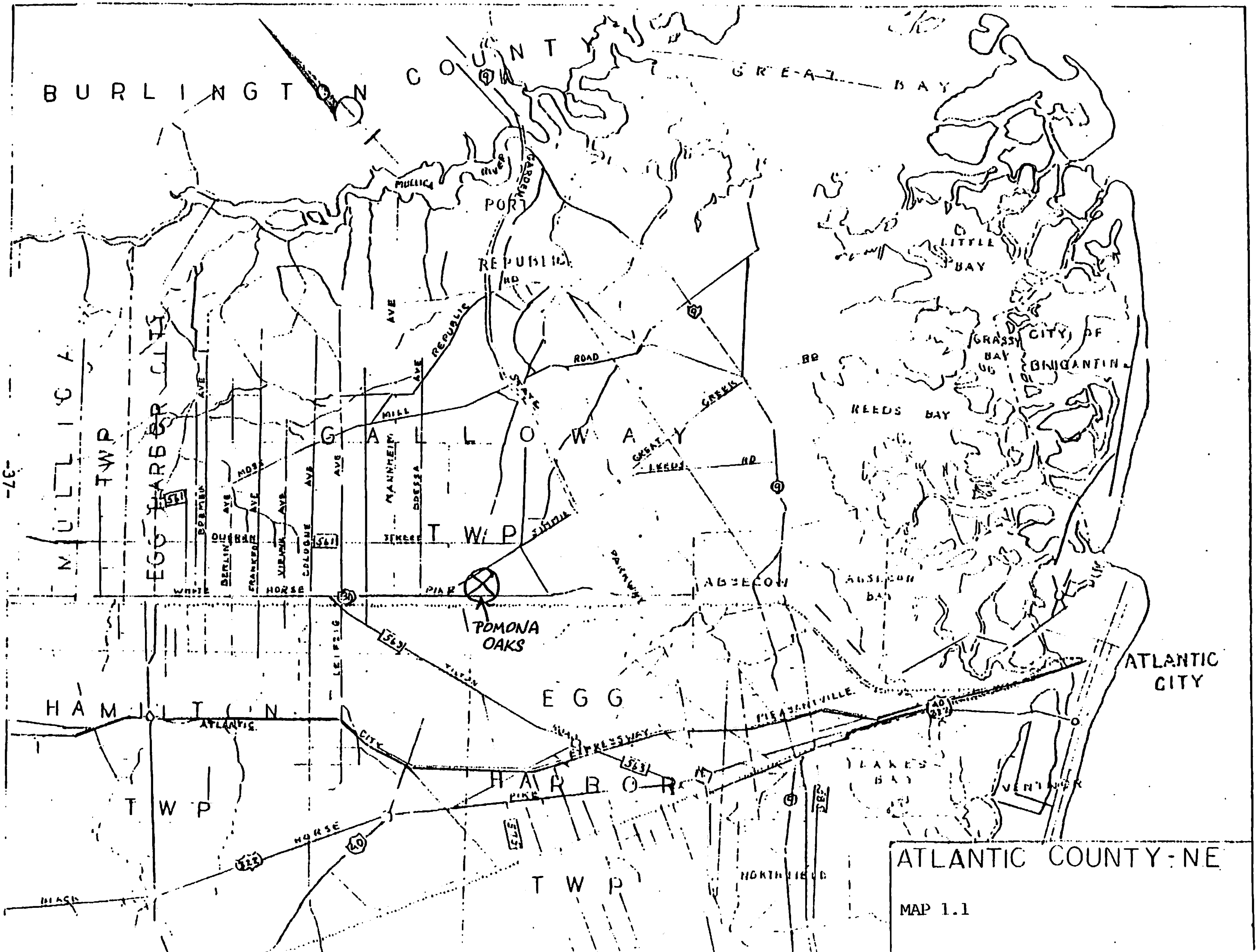
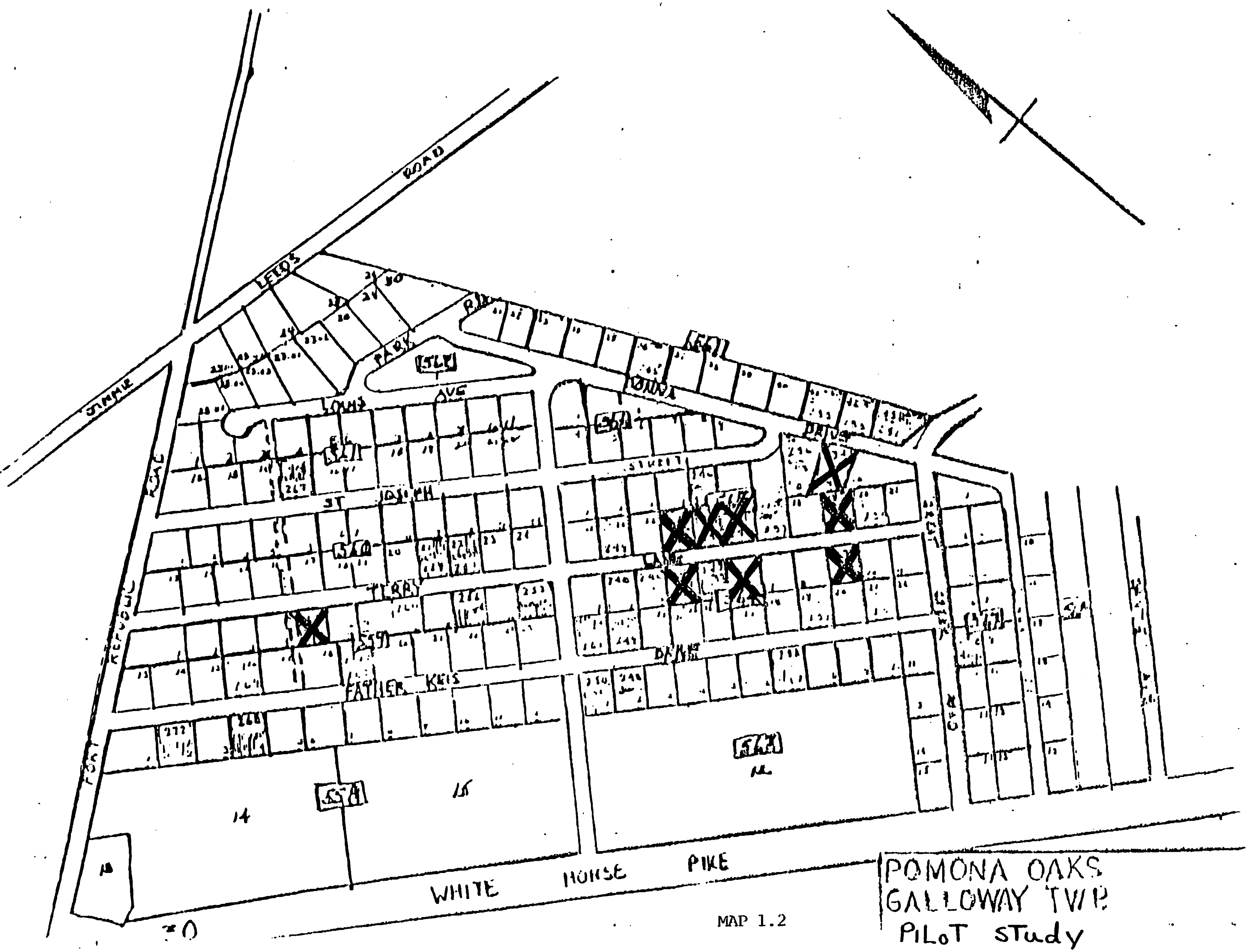


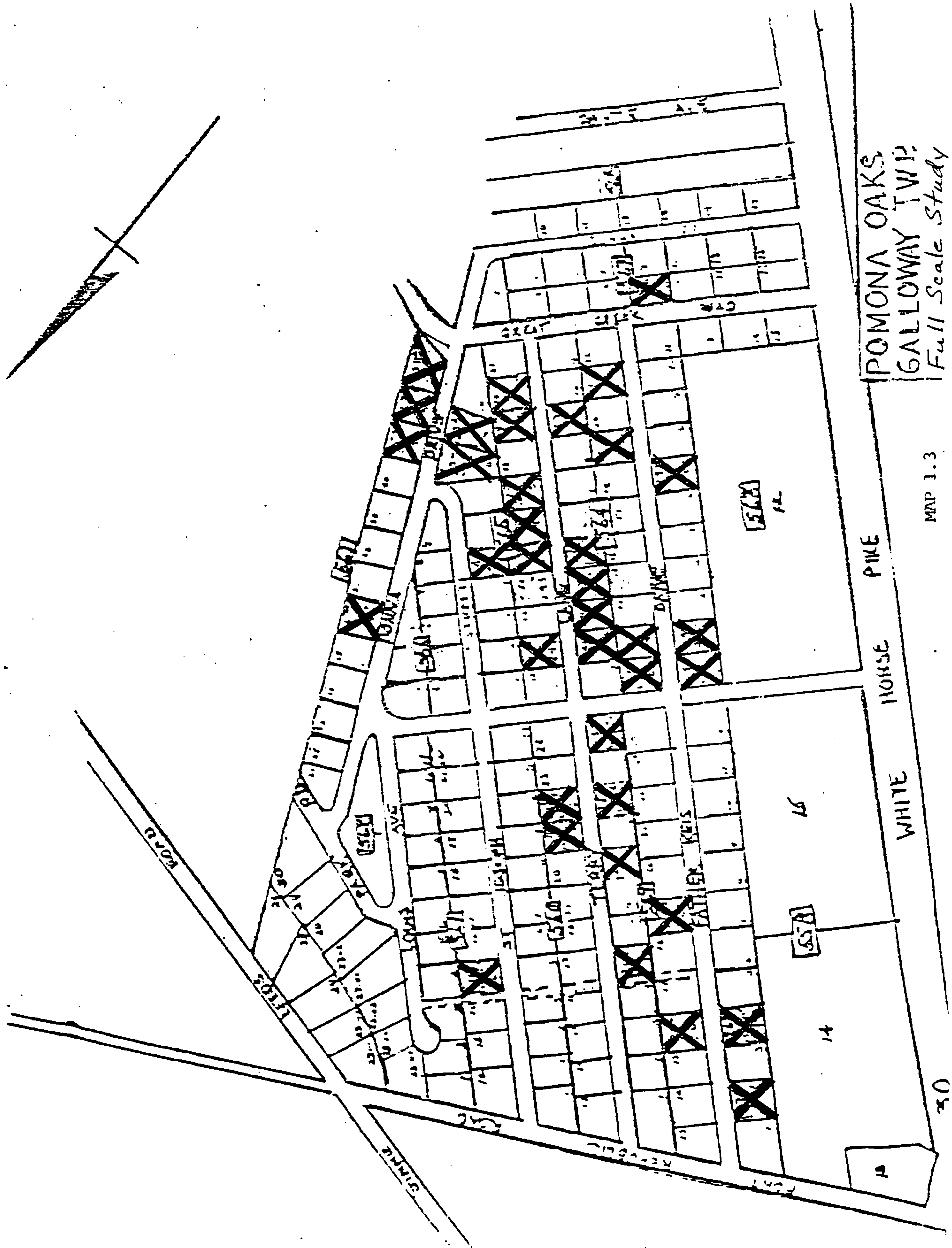
ATLANTIC COUNTY-NE

MAP 1.1



POMONA OAKS
GALLOWAY TWP.
PILoT STudy

MAP 1.2



MAP 1.3

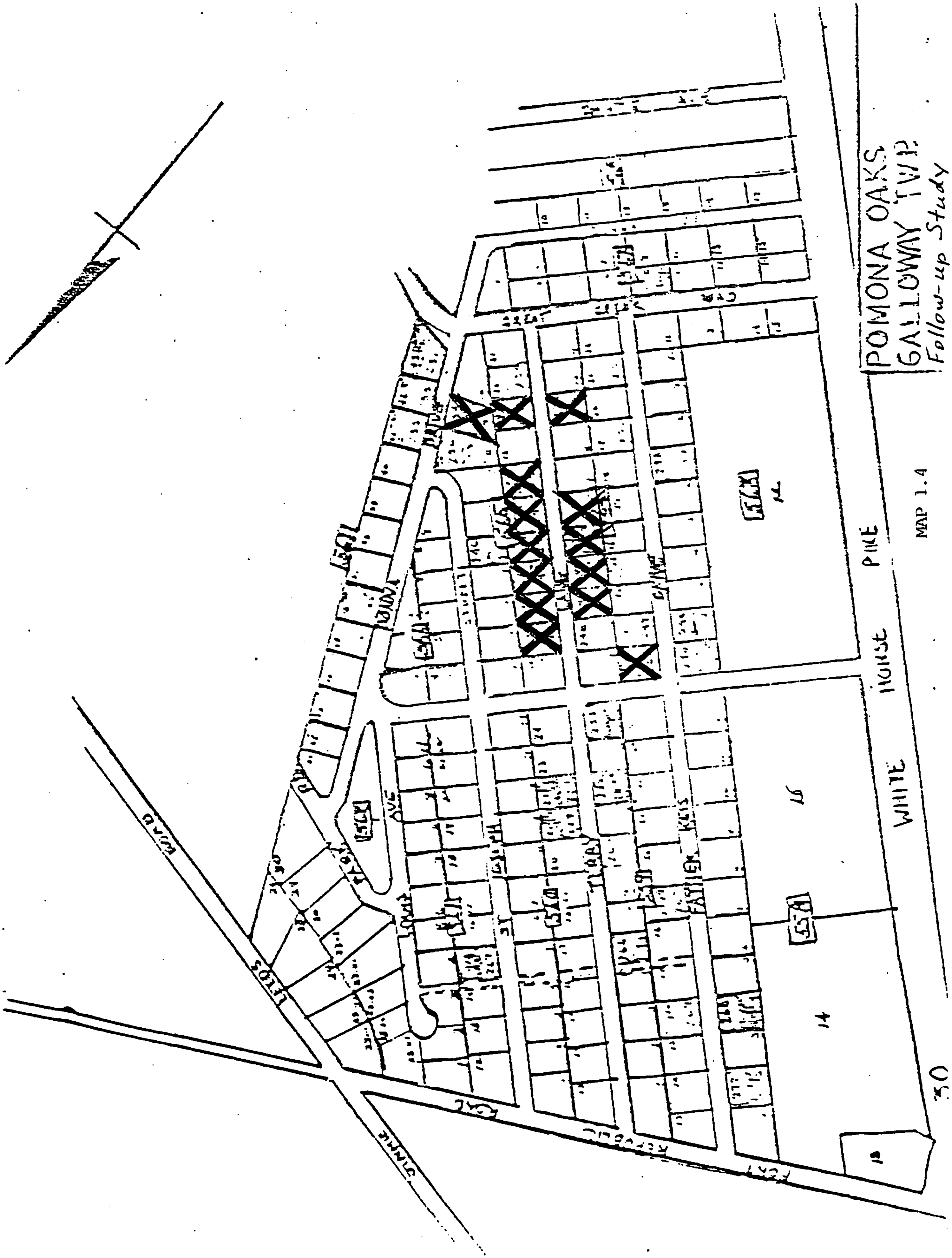

POMONA OAKS
GALLOWAY TWP.
Follow-up Study
MAP 1.4
WHITE HORSE PIKE
30

FIGURE 2.1

EQUIPMENT SET-UPS

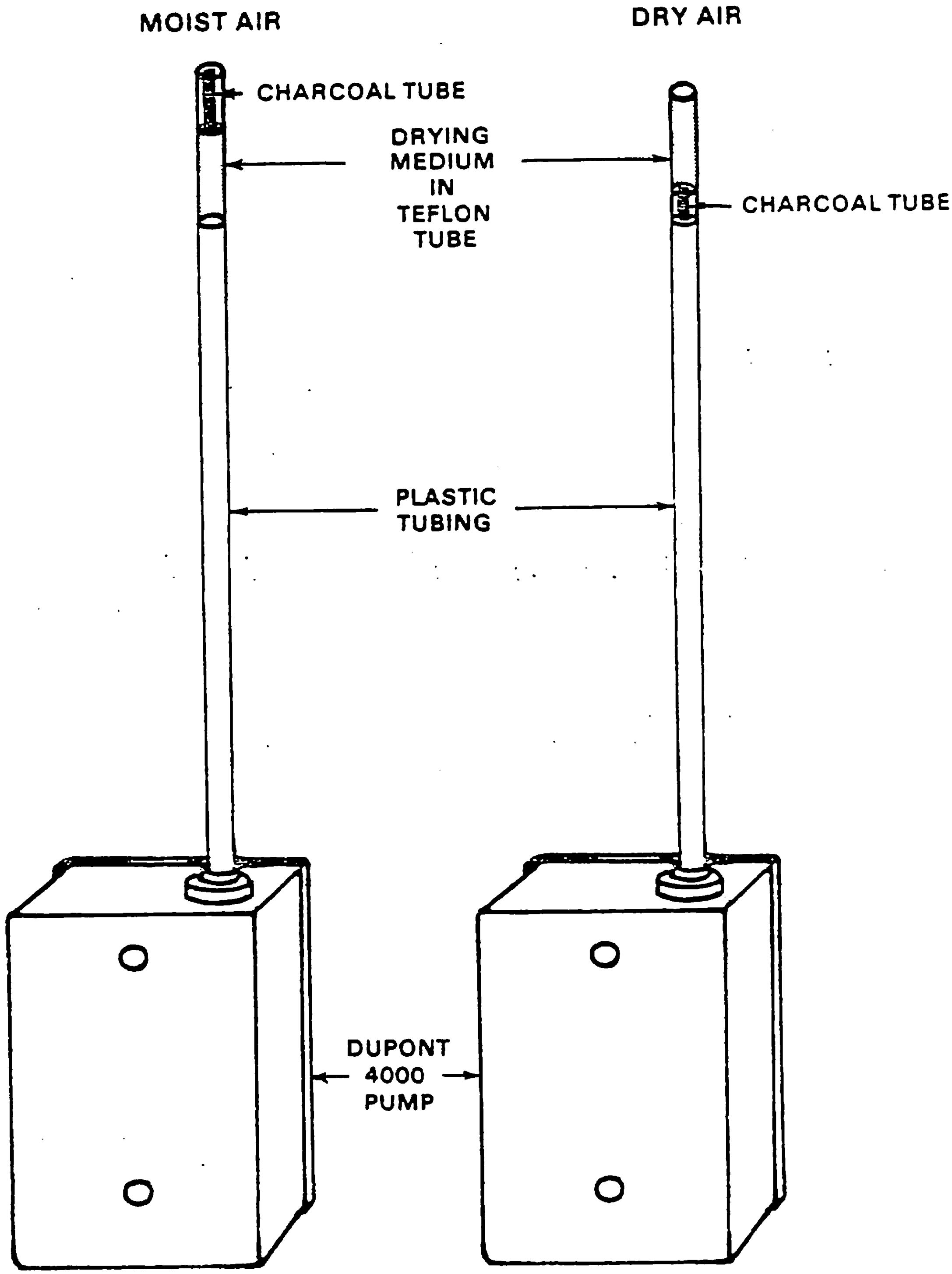


FIGURE 2.2

TEST ZONES

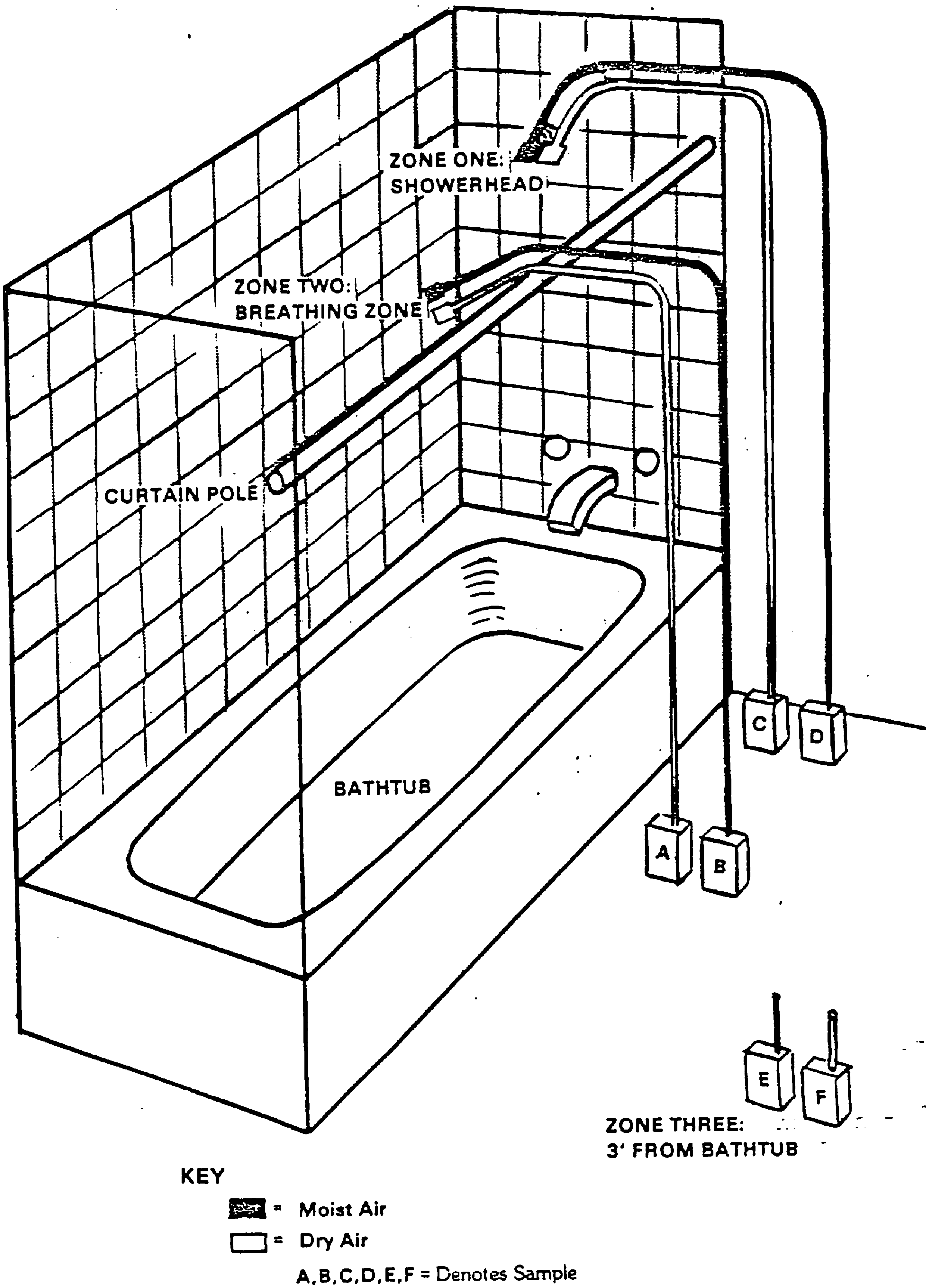


TABLE 3.1.

DISTRIBUTION OF PILOT STUDY PARTICIPANTS
BY AGE AND SEX

Age	MALES n	MALES %	FEMALES n	FEMALES %	TOTALS n	TOTALS %
0-9	2	(8)	0	(0)	2	(8)
10-19	3	(12)	5	(20)	8	(32)
20-29	1	(4)	1	(4)	2	(8)
30-39	4	(16)	4	(16)	8	(32)
40-59	2	(8)	2	(8)	4	(16)
50+	1	(4)	0	(0)	1	(4)
Total	13	(52)	12	(48)	25	(100)

TABLE 3.2.

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS OF VOLATILE ORGANIC CHEMICALS IN THE PILOT STUDY OF PRIVATE WELL WATER*

CHEMICAL	Frequency Distribution (ppb) ≤1 n	(%)	1-10 n	(%)	11-99 n	(%)	100+ n	(%)	Range of Detectable Levels (ppb)
Benzene	1	(11.1)	1	(11.1)	2	(22.2)	5	(55.5)	1-580
Butane	7	(77.7)	1	(11.1)			1	(11.1)	9-182
Chloroform	6	(66.6)	3	(33.3)					1-1.3
p -Dichlorobenzene	7	(77.7)	1	(11.1)	1	(11.1)			9-28
1,2 Dichloroethane	2	(22.2)	1	(11.1)	4	(44.4)	2	(22.2)	7-880
t-1,2 Dichloro-ethylene & Chloroform	8	(88.8)			1	(11.1)			31
Ethyl Benzene	8	(88.8)	1	(11.1)					1
Ethyl Toluene	8	(88.8)	1	(11.1)					4
Methylene Chloride	7	(77.7)			2	(22.2)			44-50
Toluene	6	(66.6)	2	(22.2)	1	(11.1)			2-11
1,1,1 Trichloro-ethane	6	(66.6)	3	(33.3)					2-8
Trichloroethylene	5	(55.5)	4	(44.4)					2-4.7
Total VO	1	(11.1)	1	(11.1)	1	(11.1)	6	(66.6)	1-1500

*N = 9 homes.

TABLE 3.3.

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS
OF VOLATILE ORGANIC CHEMICALS IN
THE PILOT STUDY OF INDOOR AIR*

CHEMICAL	Frequency Distribution (ppb) ≤1 n	(%)	1-10 n	(%)	11-99 n	(%)	100+ n	(%)	Range of Detectable Levels (ppb)
Benzene	3	(42.8)	3	(42.8)	1	(14.2)			4-43
Butane	5	(71.4)	1	(14.2)			1	(14.2)	9-182
Chloroform	6	(85.7)	1	(14.2)					1.2
Decane	5	(71.4)	2	(28.5)					2-3
p-Dichlorobenzene	6	(85.7)					1	(14.2)	112
Ethanol	3	(42.8)	1	(14.2)	2	(28.5)	1	(14.2)	4-400
Ethyl Benzene	6	(85.7)	1	(14.2)					5
Ethyl Toluene	6	(85.7)	1	(14.2)					4
Hexane	5	(71.4)	1	(14.2)	1	(14.2)			8-11
Iso-octane	6	(85.7)			1	(14.2)			13
Isopropanol	5	(71.4)			2	(28.5)			13-56
Limonene	6	(86.7)	1	(14.2)					4
2-Methylbutane	1	(14.2)	4	(57.1)	2	(28.5)			2.7-55
2-Methylpentane	4	(57.1)	2	(28.5)	1	(14.2)			3-13
Methylene Chloride	6	(86.7)			1	(14.2)			81
Pentane	3	(42.8)	2	(28.5)	2	(28.5)			3-34
1,1,2,2 Tetrachloro-ethylene	6	(85.7)	1	(14.2)					3
Toluene	4	(57.1)	2	(28.5)	1	(14.2)			5-22
1,1,1 Trichloro-ethane	6	(85.7)	1	(14.2)					2.5

TABLE 3.3. (CONTINUED)

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS
OF VOLATILE ORGANIC CHEMICALS IN
THE PILOT STUDY OF INDOOR AIR*

CHEMICAL	Frequency Distribution (ppb) ≤1 n	(%)	1-10 n	(%)	11-99 n	(%)	100+ n	(%)	Range of Detectable Levels (ppb)
Trichloroethylene	6	(85.7)	1	(14.2)					4.7
1,2,4 Trimethyl-benzene	6	(85.7)	1	(14.2)					4
m/p-Xylene	6	(85.7)	1	(14.2)					3
Total VO	1	(14.2)	1	(14.2)			5	(71.4)	1-850

*N = 7 homes
**One home also had 686 ppb acetate/acetane.

TABLE 3.4.
DISTRIBUTION OF SOURCES OF VOLATILE ORGANICS
IN THE PILOT STUDY HOUSES (n = 9)

Source	n	%
Any chemical products present	7	77.8
Attached garage	6	66.7
Smokers present	6	66.7
Gas cooking stove	6	66.7
Any remodeling	6	66.7
Wood stove in use	4	44.4
Kerosene heater in use	2	22.2
Fireplace in use	1	11.1
Any hobbies	1	11.1

TABLE 3.5.

DISTRIBUTION OF THE PILOT STUDY PARTICIPANTS BY URINARY PHENOL LEVELS AND BENZENE IN WATER

URINARY PHENOL (mg/l)

Level of Benzene in Water	0-20		21+		Totals	
	n	(%)	n	(%)	n	(%)
Benzene $\leq$ 1 ppb	6	(32%)	1	(17%)	7	(28%)
Benzene > 1 ppb	13	(68%)	5	(83%)	18	(72%)
Totals	19	(100%)	6	(100%)	25	(100%)

TABLE 3.6.

DISTRIBUTION OF THE FULL SCALE STUDY PARTICIPANTS
BY AGE AND SEX

	MALES		FEMALES		TOTALS	
Age	n	%	n	%	n	%
0-9	11	(8)	11	(8)	22	(16)
10-19	22	(16)	16	(12)	38	(27)
20-29	8	(6)	6	(4)	14	(10)
30-39	12	(9)	20	(14)	32	(23)
40-49	13	(9)	9	(6)	22	(16)
50-59	3	(2)	3	(2)	6	(4)
60+	0	(0)	5	(4)	5	(4)
Totals	69	(50)	70	(50)	139	(100)

TABLE 3.7.

DISTRIBUTION OF SOURCES OF VOLATILE ORGANICS IN THE FULL SCALE STUDY HOUSES (n = 37)

Source	n	%
Any chemical products present	36	97.2
Gas cooking stove	33	89.1
Attached garage	24	64.8
Smokers present	22	59.4
Any remodeling	22	59.4
Any hobbies	10	27.0
Wood stove in use	10	27.0
Kerosene heater in use	8	21.6
Fireplace in use	4	10.8

TABLE 3.8.

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS OF VOLATILE ORGANIC CHEMICALS IN PRIVATE WELL WATER*

CHEMICAL	Frequency Distribution (ppb) ≤1 n	(%)	1-10 n	(%)	11-99 n	(%)	100+ n	(%)	Range of Detectable Levels** (ppb)
Benzene	29	(78)	1	(3)	2	(5)	5	(14)	1.0 - 580.0
Chlorobenzene	36	(97)	1	(3)	0	(0)	0	(0)	-5.8-
Chloroform	25	(68)	12	(32)	0	(0)	0	(0)	0.7 - 7.2
Chlorovinyl Ether	36	(97)	1	(3)	0	(0)	0	(0)	-3.6-
p -Dichlorobenzene	31	(84)	2	(5)	4	(11)	0	(0)	1.8 - 76.0
1,1 Dichloroethane	27	(73)	9	(24)	1	(3)	0	(0)	0.7 - 60.0
1,2 Dichloroethane	28	(76)	1	(3)	5	(14)	3	(8)	2.5 - 880.0
1,1 Dichloroethylene	32	(86)	5	(14)	0	(0)	0	(0)	0.5 - 4.3
t 1,2 Dichloroethylene & Chloroform***	34	(92)	2	(5)	1	(3)	0	(0)	0.7 - 31.0
Ethyl Benzene	35	(95)	2	(5)	0	(0)	0	(0)	1.0 - 4.5
Methylene Chloride	35	(95)	0	(0)	2	(5)	0	(0)	17.0 - 50.0
Methylene Chloride and 1,2 Dichloroethane	35	(95)	2	(5)	0	(0)	0	(0)	3.0 - 5.0
1,1,2,2 Tetrachloro-ethane	36	(97)	1	(3)	0	(0)	0	(0)	-0.7-
1,1,2,2 Tetrachloro-ethylene	35	(95)	2	(5)	0	(0)	0	(0)	2.2 - 2.4
1,1,1 Trichloroethane	23	(62)	10	(27)	3	(8)	1	(3)	2.0 - 128.0
Toluene	34	(92)	2	(5)	1	(3)	0	(0)	2.0 - 11.0
Trichloroethylene	25	(68)	12	(32)	0	(0)	0	(0)	2.5 - 5.2
Trichlorofluoro-Methane	36	(97)	1	(3)	0	(0)	0	(0)	-1.9-
Total VO	17	(46)	4	(11)	7	(19)	9	(24)	2.5 - 1500.0

*N = 37 homes.
**If two sample results were available for the same household we used the highest number.
***Laboratory gave combined results.

TABLE 3.9.

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS OF VOLATILE ORGANIC CHEMICALS IN INDOOR AIR*

CHEMICAL	Frequency Distribution (ppb)** ≤1 n	(%)	1-10 n	(%)	11-99 n	(%)	100+ n	(%)	Range of Detectable Levels** (ppb)
Benzene	28	(75)	5	(14)	4	(11)	0	(0)	4.0 - 54.0
Butane	14	(37)	1	(3)	18	(49)	4	(11)	9.0 - 182.0
Cumene	36	(97)	1	(37)	0	(0)	0	(0)	-6.0-
Decane	32	(86)	4	(11)	1	(3)	0	(0)	2.0 - 25.0
p-Dichlorobenzene	33	(89)	1	(3)	1	(3)	2	(5)	8.0 - 164.0
Ethanol	10	(27)	1	(3)	10	(27)	16	(43)	4.0 - 717.0
Ethyl Benzene	35	(95)	2	(5)	0	(0)	0	(0)	5.0 - 8.0
Ethyl Toluene	35	(95)	2	(5)	0	(0)	0	(0)	4.0 - 8.0
Hexane	25	(67)	4	(11)	8	(22)	0	(0)	5.0 - 22.0
Isooctane	33	(89)	3	(8)	1	(3)	0	(0)	4.0 - 13.0
Isopropanol	33	(89)	0	(0)	3	(8)	1	(3)	13.0 - 103.0
Limonene	23	(62)	11	(30)	3	(8)	0	(0)	3.0 - 41.0
2-Methyl Butane	13	(35)	8	(22)	14	(38)	2	(5)	2.7 - 408.0
2-Methyl Pentane	22	(59)	10	(27)	5	(14)	0	(0)	3.0 - 29.0
3-Methyl Pentane	33	(89)	0	(0)	4	(11)	0	(0)	11.0 - 15.0
Methylene Chloride	35	(95)	0	(0)	2	(5)	0	(0)	27.0 - 81.0
Naphthalene	34	(92)	3	(8)	0	(0)	0	(0)	3.0 - 7.0
Nonane	36	(97)	0	(0)	1	(3)	0	(0)	-14.0-
Pentane	20	(46)	13	(35)	6	(16)	1	(3)	3.0 - 109.0
Petroleum Distillate	36	(97)	0	(0)	0	(0)	1	(3)	-498.0-
Pinene	35	(95)	2	(5)	0	(0)	0	(0)	3.0 - 4.0
Propane	36	(97)	0	(0)	1	(3)	0	(0)	-23.0-
1,1,2,2 Tetrachloro-ethylene	36	(97)	1	(3)	0	(0)	0	(0)	-3.0-

TABLE 3.9. (Continued)

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS OF VOLATILE ORGANIC CHEMICALS IN INDOOR AIR*

CHEMICAL	Frequency Distribution (ppb)** <1 n	(%)	1-10 n	(%)	11-99 n	(%)	100+ n	(%)	Range of Detectable Levels** (ppb)
Toluene	21	(57)	9	(24)	7	(19)	0	(0)	5.0 - 82.0
1,1,1 Trichloro-ethane	36	(97)	0	(0)	1	(3)	0	(0)	-33.0-
1,2,4 Trimethyl-benzene	32	(86)	5	(14)	0	(0)	0	(0)	4.0 - 10.0
Undecane	32	(86)	5	(14)	0	(0)	0	(0)	2.0 - 9.0
o-Xylene	35	(95)	2	(5)	0	(0)	0	(0)	-8.0-
m-Xylene	30	(81)	7	(19)	0	(0)	0	(0)	4.0 - 8.0
p-Xylene	36	(97)	1	(3)	0	(0)	0	(0)	-4.0-
m/p-Xylene	34	(92)	0	(0)	3	(8)	0	(0)	20.0 - 24.0
Total Volatile Organics	2	(5)	1	(3)	8	(22)	26	(70)	2.7 - 1420.0

*N = 37 homes.

**If two sample results were available for the same household the highest was used for this table.

TABLE 3.10.

DISTRIBUTION OF FULL SCALE STUDY PARTICIPANTS
BY URINARY PHENOL LEVEL AND BENZENE EXPOSURE

Level of Benzene in Water or Air	URINARY PHENOL (mg/l) 0-20		21+		Totals	
	n	(%)	n	(%)	n	(%)
Benzene ≤ 1 ppb	102	(82)	11	(73)	113	(81)
Benzene > 1 ppb	22	(18)	4	(27)	26	(19)
Totals	124	(100)	15	(100)	139	(100)

$X_1^2 = 0.24$, $p = 0.62$

Odds Ratio = 1.69

95% Confidence Interval = 0.41 - 6.51

TABLE 3.11.

RANGE OF LEVELS OF VOLATILE ORGANIC CHEMICALS IN THE SEPTEMBER 1983 FOLLOW-UP STUDY*

	Range of Levels (ppb)		
Chemical	Water	Pretest Air	Shower Air**
Benzene	ND***-370	ND	ND-620
1,2 Dichloroethane	ND-12	ND	ND
Hexachlorobutadiene	ND-7	ND	ND
Isobutane	ND	ND-84	ND
2-Methylbutane	ND	ND	ND-84
2-Methylpentane	ND	ND	ND-62
Naphthalene	ND-15	ND	ND
Toluene	ND-5	ND	ND
1,2,4 Trimethylbenzene	ND-18	ND	ND
m-Xylene	ND-82	ND	ND
m/p-Xylene	ND	ND	ND-173
o-Xylene	ND-87	ND	ND-96
p-Xylene	ND-26	ND	ND-83
Total VO	ND-603	ND-84	ND-1035

*N = 3 homes with both water and air data.

**Moist method.

***ND = None Detected.

TABLE 3.12.

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS
OF VOLATILE ORGANIC CHEMICALS IN THE
JANUARY 1984 FOLLOW-UP STUDY OF PRIVATE WELL WATER*

CHEMICAL	Frequency Distribution (ppb) <1 n	(%)	1-10 n	(%)	11-99 n	(%)	100+ n	(%)	Range of Detectable Levels (ppb)
Benzene	9	(64)			4	(29)	1	(7)	33-113
Toluene	13	(93)	1	(7)					3
Total VO	9	(64)			4	(29)	1	(7)	33-116

*N = 14 homes

TABLE 3.13.

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS OF VOLATILE ORGANIC CHEMICALS IN THE JANUARY 1984 FOLLOW-UP STUDY OF BACKGROUND AIR-STANDARD METHOD*

CHEMICAL	<1 n	<1 (%)	1-10 n	1-10 (%)	11-99 n	11-99 (%)	100+ n	100+ (%)	Range of Detectable Levels (ppb)
	Frequency Distribution (ppb)								
Benzene	12	(86)	1	(7)	1	(7)			4-24
Butane	10	(71)			2	(14)	2	(14)	12-169
p-Dichlorobenzene	12	(86)			2	(14)			13-28
Ethanol	5	(36)			5	(36)	4	(29)	28-213
Hexane	13	(93)	1	(7)					3
Isobutane	9	(64)			2	(14)	3	(21)	63-814
Isopropanol	12	(86)			2	(14)			15-32
Limonene	12	(86)	2	(14)					4-6
2-Methylbutane	8	(57)	4	(29)	2	(14)			5-39
2-Methylpentane	11	(79)	3	(21)					4-10
3-Methylpentane	13	(93)	1	(7)					2
Pentane	10	(71)	3	(21)	1	(7)			5-12
Toluene	7	(50)	5	(36)	2	(14)			5-13
m/p-Xylene	13	(93)	1	(7)					9
o-Xylene	13	(93)	1	(7)					4
Total VO	1	(7)	1	(7)	3	(21)	9	(64)	4-1538

*N = 14 homes. Two homes had levels of gasoline (0.6-1.2 mg/m^3) + petroleum (0.7 mg/m^3).

TABLE 3.14.

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS OF VOLATILE ORGANIC CHEMICALS IN THE JANUARY 1984 FOLLOW-UP STUDY OF SHOWER AIR-MOIST METHOD*

CHEMICAL	≤1 n	≤1 (%)	1-10 n	1-10 (%)	11-99 n	11-99 (%)	100+ n	100+ (%)	Range of Detectable Levels (ppb)
Benzene	9	(64)			2	(14)	3	(21)	55-620
Butane	13	(93)					1	(7)	589
p-Dichlorobenzene	13	(93)					1	(7)	189
Isobutane	13	(93)					1	(7)	505
1,2,4 Trimethyl-benzene	13	(93)			1	(7)			60
m/p-Xylene	12	(86)			1	(7)	1	(7)	80-226
o-Xylene	13	(93)					1	(7)	110
Total VO	8	(57)	0	(0)	1	(7)	5	(36)	55-1094

Frequency Distribution (ppb)

*N = 14 homes.

TABLE 3.15.

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS
OF VOLATILE ORGANIC CHEMICALS IN THE MAY 1984
FOLLOW-UP STUDY OF BACKGROUND AIR*

CHEMICAL	Frequency Distribution (ppb) <1 n	(%)	1-10 n	(%)	11-99 n	(%)	100+ n	(%)	Range of Detectable Levels (ppb)
Benzene	2	(40)	1	(20)	2	(40)			5-20
Butane	3	(60)	1	(20)	1	(20)			8-26
Hexane	3	(60)	2	(40)					7-8
Isobutane	4	(80)			1	(20)			12
2-Methylbutane	2	(40)	2	(40)	1	(20)			6-20
2-Methylpentane	4	(80)	1	(20)					8
Pentane	2	(40)	2	(40)	1	(20)			5-12
Toluene	2	(40)	3	(60)					6-9
m/p-Xylene	3	(60)	2	(40)					5-6
Total VO	1	(20)	1	(20)	2	(40)	1	(20)	1-109

*N = 5 homes.

TABLE 3.16.

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS OF VOLATILE ORGANIC CHEMICALS IN THE MAY 1984 FOLLOW-UP STUDY OF SHOWER AIR-MOIST METHOD*

CHEMICAL	Frequency Distribution (ppb) ** ≤1 n	(%)	1-10 n	(%)	11-99 n	(%)	100+ n	(%)	Range of Detectable Levels (ppb)
Benzene	1	(7)			6	(40)	8	(53)	58-1950
Butane	9	(60)					6	(40)	102-281
m/p-Ethyltoluene	13	(87)			2	(13)			55-81
o-Ethyltoluene	14	(93)			1	(7)			37
Hexane	11	(73)			4	(27)			34-67
2-Methylbutane	9	(60)			1	(7)	5	(33)	64-233
Methylcyclopentane	12	(80)			3	(20)			48-78
2-Methylpentane	9	(60)			5	(33)	1	(7)	45-154
3-Methylpentane	13	(87)			2	(13)			52-53
Pentane	10	(67)			3	(20)	2	(13)	64-141
1,2,3-Trimethyl-benzene	14	(93)			1	(7)			37
1,2,4-Trimethyl-benzene	11	(73)			2	(13)	2	(13)	46-195
Toluene	13	(87)			2	(13)			51-71
m-Xylene	11	(73)					4	(27)	121-512
m/p-Xylene	14	(93)			1	(7)			60
o-Xylene	11	(73)			2	(13)	2	(13)	85-297
p-Xylene	11	(73)			2	(13)	2	(13)	49-174
Total VO	3	(20)			4	(27)	8	(53)	1-4004

*N = 5 homes and 3 samples/home for a total of 15 samples

**Sampling volumes range from 16.5-19.5 liters.

TABLE 3.17.

FREQUENCY DISTRIBUTION AND RANGE OF DETECTABLE LEVELS OF VOLATILE ORGANIC CHEMICALS IN THE MAY 1984 FOLLOW-UP STUDY OF SHOWER AIR-DRY METHOD*

CHEMICAL	Frequency Distribution (ppb) ** ≤1 n	(%)	1-10 n	(%)	11-99 n	(%)	100+ n	(%)	Range of Detectable Levels (ppb)
Benzene	5	(33)			2	(13)	8	(53)	43-1750
Butane	9	(60)					6	(40)	98-468
m/p-Ethyltoluene	13	(87)			2	(13)			59-68
o-Ethyltoluene	14	(93)			1	(7)			30
Hexane	12	(80)			3	(20)			34-73
Isobutane	14	(93)					1	(7)	101
2-Methylbutane	8	(53)			1	(7)	6	(40)	57-290
Methylcyclopentane	11	(73)			4	(27)			48-85
2-Methylpentane	10	(67)			1	(7)	4	(27)	90-134
3-Methylpentane	13	(87)			1	(7)	1	(7)	31-157
Pentane	10	(67)			3	(20)	2	(13)	90-189
1,2,3-Trimethyl-benzene	14	(93)			1	(7)			30
1,2,4-Trimethyl-benzene	10	(67)			3	(20)	2	(13)	50-161
Toluene	13	(87)			2	(13)			51-64
m-Xylene	10	(67)					5	(33)	133-466
o-Xylene	10	(67)			1	(7)	4	(27)	92-264
p-Xylene	10	(67)			3	(20)	2	(13)	55-155
Total VO	5	(33)			2	(13)	8	(53)	1-4485

*N = 5 homes and 3 samples/home for a total of 15 samples

**Sampling volumes range from 16.5-19.5 liters.

TABLE 3.18.

BENZENE LEVELS FOUND IN SHOWER AIR SAMPLES IN THE MAY 1984
FOLLOW-UP STUDY*

House Code	Location of Sample	Method of Sampling	Volume (liters)	Benzene (ppb)	Benzene Level (ppb) Standardized to 15 l	Ratio of Dry/Moist
A	Shower head (Zone 1)	Moist	18.0	61	51	
		Dry	18.0	ND**	ND	
	Breathing Zone (Zone 2)	Moist	19.5	58	45	
		Dry	18.0	81	68	1.44
	Bath Floor (Zone 3)	Moist	16.5	ND	ND	
		Dry	16.5	ND	ND	
	Living Room	Standard***	221.0	ND	ND	
B	Shower Head	Moist	18.0	252	210	
		Dry	18.0	257	214	1.02
	Breathing Zone	Moist	19.5	240	185	
		Dry	18.0	296	247	1.34
	Bath Floor	Moist	16.5	ND	ND	
		Dry	16.5	ND	ND	
	Kitchen	Standard***	307.0	5	ND	
C	Shower Head	Moist	18.0	1520	1267	1.04
		Dry	18.0	1580	1317	
	Breathing Zone	Moist	19.5	1950	1500	
		Dry	18.0	1750	1458	0.97
	Bath Floor	Moist	16.5	415	377	
		Dry	16.5	746	678	1.80
	Kitchen	Standard***	216.0	18	1	

TABLE 3.18. (CONTINUED)

BENZENE LEVELS FOUND IN SHOWER AIR SAMPLES IN THE MAY 1984 FOLLOW-UP STUDY*

House Code	Location of Sample	Method of Sampling	Volume (liters)	Benzene (ppb)	Benzene Level (ppb) Standardized to 15 l	Ratio of Dry/Moist
D	Shower Head	Moist	18.0	59	49	
		Dry	18.0	ND	ND	
	Breathing Zone	Moist	19.5	43	33	
		Dry	18.0	61	61	1.85
	Bath Floor	Moist	16.5	ND	ND	
		Dry	16.5	ND	ND	
	Kitchen	Standard***	252.0	ND	ND	
E	Shower Head	Moist	18.0	730	608	
		Dry	18.0	912	760	1.25
	Breathing Zone	Moist	19.5	652	502	
		Dry	18.0	730	608	1.21
	Bath Floor	Moist	16.5	182	165	
		Dry	16.5	166	151	0.92
	Kitchen	Standard***	160.0	20	2	

*N = 5 houses.

**ND = None Detected.

***Standard is method with no $CaSO_4$ filter.

TABLE 3.19.

RATIO OF SHOWER AIR TO WELL WATER BENZENE LEVELS
IN THE MAY 1984 FOLLOW-UP STUDY*

House Code	Benzene in Water (ppb)	Shower Air			Ratio of Air/Water
		Zone	Sampling Method	Benzene (ppb)**	
A	31	1	M	51	1.65
		2	M	45	1.45
			D	68	2.19
B	56	1	M	210	3.75
			D	214	3.82
		2	M	185	3.30
			D	247	4.41
C	700	1	M	1267	1.81
			D	1317	1.88
		2	M	1500	2.14
			D	1458	2.08
		3	M	377	0.54
			D	678	0.97
D	48	1	D	49	1.02
		2	M	33	0.69
			D	61	1.27
E	550	1	M	608	1.11
			D	760	1.38
		2	M	502	0.91
			D	608	1.11
		3	M	165	0.30
			D	151	0.27
Ranges	31-700			33-1500	0.27-4.41

TABLE 3.19. (CONTINUED)

RATIO OF SHOWER AIR TO WELL WATER BENZENE LEVELS
IN THE MAY 1984 FOLLOW-UP STUDY*

	Shower Air			
	Zone	Sampling Method	Number of Ratios	Mean Ratio of Air/Water
Mean Ratios	1	M	4	2.08
		D	4	2.02
	2	M	5	1.70
		D	5	2.21
	3	M	2	0.42
		D	2	0.62
	1		8	2.08
	2		10	1.96
	3		4	0.52
		M	11	1.60
		D	11	1.85
Total			22	1.73

*Of 30 samples, only 22 had detectable levels of benzene in bath water and air.

**The benzene in air data were standardized to 15 liters.

TABLE 4.1.

THE DISTRIBUTION OF URINARY PHENOL LEVELS AMONG FIVE COMMUNITY GROUPS STUDIED BY NJDOH FROM 1982 - 1983

		URINARY PHENOL (mg/l)				
		0-20		21+		RANGE
LOCATION	N	n	%	n	%	
Bayway	70	57	81.4	13	18.6	ND- 157
Malaga	20	17	85.0	3	15.0	ND- 30
Belleville	254	224	88.2	30	11.8	ND- 230
Pomona Oaks (Pilot Study)	25	19	76.0	6	24.0	ND- 70
Pomona Oaks (Full Scale)	136	121	89.0	15	11.0	ND- 376

TABLE 4.2

CONTAMINATED WATER USE RECOMMENDATIONS

Drinking and Cooking

(1) Don't Drink Your Well Water.

(2) Don't Cook With Your Well Water.

(3) Use an Alternate Supply For Drinking and Cooking.

Showering

(1) Use a Coarse Rather Than A Fine Spray.

(2) Use Tepid Rather Than Hot Water.

(3) Keep The Flow Rate Of The Water Slow.

(4) Limit The Time You Shower To Less Than Fifteen Minutes.

(5) Ventilate The Room Before, During And After Showering.

(6) Shower In An Alternate Water Supply If/When Possible.

Bathing

(1) Use Tepid Water.

(2) Limit The Time To Less Than Fifteen Minutes.

(3) Ventilate The Room Before, During And After Bathing.

(4) Bathe In An Alternate Water Supply If/When Possible.

Other Household Water Uses

(1) Use Cold Water To Wash Laundry.

(2) Close Off The Area Between The Laundry And Living Areas During And After Its Use.

(3) Ventilate The Dishwasher Area During And After Its Use.

(4) Ventilate The Area Where Handwashing Of Dishes Is Done.

APPENDIX I.
GALLOWAY TOWNSHIP QUESTIONNAIRE

NAME ______________________ AGE ______ SEX ______

Address ______________________________________

Phone (Home) ____________________ (Work) ____________________

Case or control no. ______________________________

1) What is your source of drinking and cooking water? (check)
   A) Supplied by Township______   C) Own home well______
   B) Bottled______   D) Neighbor's well______

2) If well water, how many glasses of water do you drink per day at home?________

3) What is your source of water for bathing, washing dishes, clothes and cleaning purposes?______________________

4) How many times per week do you wash dishes by hand?______________

5) How many times per week do you take a bath or shower at home?______________

6) Do you suffer from any skin problems such as rashes, peeling or burning irritation? Yes, specify______________________
   ______________________ No ______________________

7) Do you smoke cigarettes? Yes______ No______
   If yes, how many do you usually smoke in a day?______________

8) Do you use any of the following medications? listerine Yes______ No______
   cepacol Yes______ No______; sucrets Yes______ No______

9) What kind of work do you do? ______________________
   ____

10) Are you exposed to benzene either at work or home thru a hobby?
    Benzene Yes______ No______

11) Are you exposed to other chemicals at work or home thru a hobby?
    Yes (specify)______________________ No______

12) Are you bothered by odor of the well water? Yes______ No______
    Are you bothered by the taste of the well water? Yes______ No______

13) Is there anything we have not discussed but you would like to tell me about?
    Please explain (health, pets, property damage, visitors' remarks) etc.
    ____
    ____
    ____

Laboratory Results ______________________________
____
____

APPENDIX II

Case Number ______

GALLOWAY TOWNSHIP QUESTIONNAIRE

Name ______ Age ______ Sex ______

Address ______ Mailing ______

Phone (Home) ______ Phone (Work) ______

1. What is your source of drinking and cooking water? (check)
   A) Supplied by Township ____ C) Personal home ____
   B) Purchased in bottles ____ D) Neighbor's well ____

2. How many glasses of water do you drink per day at home? ______

3. What is your source of water for bathing, washing dishes, clothes and cleaning purposes? ______

4. How many times per week do you wash dishes by hand? ______

5. How many times per week do you take a bath or shower at home? ______

6. Do you suffer from any skin problems such as rashes, peeling or burning? No ______ Yes, specify ______

7. Do you smoke cigarettes? Yes ___ No ___
   If yes, how many do usually smoke in a day? ______

8. Do you use any of the following medications? Listerine Yes __ No ____
   Cepacol Yes ___ No ____ Sucrets Yes ____ No ____

9. What kind of work do you do? ______
   Where is your job located? ______

10. Are you exposed to benzene either at work or home thru a hobby?
    Yes ____ No ____

11. Are you exposed to other chemicals at work or home thru a hobby?
    Yes, specify ______ No ____

12. Were/are you bothered by odor of the well water? Yes ____ No ____
    Were/are you bothered by the taste of the well water? Yes ____ No ____

13. Is there anything we have not discussed but you would like to tell me about? Please explain (health, pets, property damage, visitors' remarks) etc. ______

______

PLEASE READ CAREFULLY AND FILL IN WHERE APPROPRIATE.

PARTICIPANT: Fill out below at time of urine collection

1. Urine Collection: Time ________ Date ________________

2. Shower/Bath: Time ____________ Date ____________________
(Please list time/date of your most recent shower/bath taken at home)

3. Hand-washing of dishes: Time __________ Date ___________
(Please list time/date of your most recent dishwashing). If you do not wash dishes, put "NA".

4. Estimated Mileage: Within the 24 hours previous to the urine sample, approximated mileage traveled (not necessarily as the driver) in a car, bus, etc. was ____________ miles.

THERE MAY BE A RELATIONSHIP BETWEEN ASPIRIN AND SOME FOODS IN THE DIET AND THE RESULTS OF THE URINALYSIS. IN ORDER TO DETERMINE IF THAT IS TRUE, QUESTIONS ABOUT DRUG USE AND YOUR DIET FOR THE TWENTY FOUR HOUR PERIOD BEFORE TAKING THE URINE SAMPLE ARE ASKED BELOW:

5. Within the past 24 hours have you taken aspirin or aspirin-containing drugs? Yes____ No______

6. Within the past 24 hours if you ate any of the following nature foods/spices, please check.

(a) Apricots___ (b) Prunes____ (c) Peaches____ (d) Grapes____
(e) Cucumbers____ (f) Tomatoes___ (g) Black pepper___
(h) Red pepper ___

7. Within the past 24 hours if you ate any food ARTIFICIALLY FLAVORED with the following flavors, please check:

Wintergreen____, Lime/lemon____, Strawberry____, Mint_____, Raspberry____, Grape____,

(a) Bake goods _____ (b) Ice Cream ____ (c) Chewing Gum____
(d) Gelatin___

C O N S E N T

I have been informed that the New Jersey State Department of Health is conducting a study of environmental factors and their effect on the health of individuals. This study involves obtaining information from me about my residence, occupation, and health, as well as some information about substances I may have been exposed to. I understand it may be necessary to contact me again.

I have agreed to take part in this study and to give information to the interviewer understanding that:

1. My responses will be kept completely confidential unless ordered to release the information by a court.
2. My participation is voluntary and I am free to discontinue participation at any time.
3. The information in this study will be summarized by the New Jersey State Department of Health to determine whether environmental factors in this area may contribute to health problems.

____

Name of Participant (Print) Signature Date

____

Name of Interviewer Case No.

APPENDIX III

New Jersey State
Department of Health

INTERIOR AIR SURV

Investigation No.

Name	Home Telephone No.	Work Telephone No.

Address

Sample Type Volume Sample No.

Results (PPM)

Weather Temperature
Exterior Temperature ____________
Interior Temperature ____________

Weather Conditions ____________________
Windows Open ☐ Yes ☐ No

Exact Location Where Sample was Collected

Do you have any of the following in your home, either stored or recently used in your home? Check, if Yes.

_____ Paint
_____ Paint Thinner
_____ Shellac
_____ Paint Remover
_____ Solvents
_____ Kerosene
_____ Gasoline
_____ Spirits
_____ Dyes
_____ Moth Balls
_____ Glues
_____ Printing Ink
_____ Lighter Fluid
_____ Butane Lighters
_____ Room Deodorizers
_____ Pesticides, Weed Killers (Herbicides)
_____ Fertilizers
_____ Photo Developers
_____ Chemical Products
_____ Lacquers
_____ Cleaning Agents
_____ Hair Sprays
_____ Perfumes
_____ Oven Cleaner
_____ Furniture Polishes

Where are these items stored and used recently in relation to area sampled? Be specific and continue on back of this sheet.

A-III

INTERIOR AIR SURVEY

Do you use a Kerosene Heater? ☐ Yes ☐ No

If Yes, when did you last use it (day and time) ____________________

Do you use fuel oil for heating your home? ☐ Yes ☐ No

If Yes, when did you have your last delivery (date) ____________________

Did you have any recent oil spill? ☐ Yes ☐ No When ____________________

Have you done or had any remodeling done in your home (i.e., wallpapering, vinyl flooring, painting, insulation, new carpeting, new furniture) etc.

What ____ When ____________________

What ____ When ____________________

What ____ When ____________________

Does anyone in the house have hobbies like furniture refinishing, model building, auto body work, etc.? ☐ Yes ☐ No

Type hobbies: 1. ____________________ 2. ____________________

3. ____________________

Do you use cooking gas? ☐ Yes ☐ No

Do you have a fire place? ☐ Yes ☐ No

Do you have a wood stove? ☐ Yes ☐ No

Was it in use recently ☐ Yes ☐ No When ____________________

How heat efficient is your home - has extra insultation, caulking, tape, etc. been added to reduce heat loss? ☐ Yes ☐ No

Describe ____

____

____

Are you bothered by an indoor odor? ☐ Yes ☐ No

Describe ____

____

Does anyone in the household smoke? ☐ Yes ☐ No

INTERIOR AIR SURVEY

Are there any industries or businesses near your home which you believe may relate to odors in or outside you home? ☐ Yes ☐ No

Describe ______________________________

____

Approximate Distance from Home ______________________________

____

Do you have an attached garage? ☐ Yes ☐ No

If Yes, are there any rooms above the garage? ☐ Yes ☐ No

Do you keep your car in the garage or is it for storage?

____

____

Has your home recently been extermined? ☐ Yes ☐ No

If Yes, when ______________

Chemicals used if known ______________________________

Comments:

Signature	Date

P5195

APPENDIX IV

POTABLE WATER VOLATILE ORGANICS ANALYSIS

New Jersey State Department of Health
Public Health and Environmental Laboratories

Benzene

Bromodichloromethane

Bromoform

Carbon Tetrachloride

Chlorobenzene

2-Chloroethylvinyl ether

Chloroform

Dibromochloromethane

1,1-Dichloroethane

1,2-Dichloroethane

1,1-Dichloroethene

1,2-Dichloroethene

1,2-Dichloropropane

1,3-Dichloropropene

Ethylbenzene

Methylene Chloride (Dichloromethane)

1,1,2,2-Tetrachloroethane

Tetrachloroethene

Toluene

1,1,1-Trichloroethane

1,1,2-Trichloroethane

Trichloroethene

Trichlorofluoromethane

Bis(chloromethyl) ether

Acrolein

Acrylonitrile

APPENDIX IV

CHEMICALS INCLUDED IN A ROUTINE AIR SAMPLE ANALYSIS BY THE NJDOH LABORATORY

AROMATICS

Benzene
Toluene
o-Xylene
p-Xylene
m-Xylene
Ethylbenzene
o-Ethyltoluene
m-Ethyltoluene
p-Ethyltoluene
o-Diethylbenzene
m-Diethylbenzene
1,2,4-Trimethylbenzene
1,3,5-Trimethylbenzene
(mesitylene)
1,2,3-Trimethylbenzene
1,2,4,5-Tetramethylbenzene
Styrene
Propylbenzene
Isopropylbenzene (cumeme)
Butylbenzene
Isobutylbenzene
p-Cymene
Indane
Napthalene
2-Methyl Napthalene
1-Methyl Napthalene
Biphenyl
Diphenyl Methane
Camphene
Limonene
Pinene

ACETATES

Ethyl Acetate
Isopropyl Acetate
Isobutyl Acetate
n-Butyl Acetate
Isoamyl Acetate
Propyl Acetate
2-Methoxyethyl Acetate
2-Ethoxyethyl Acetate
2-Butoxyethyl Acetate

CN COMPOUNDS

Acetonitrile

FREONS

Trichlorofluoromethane
1,1,2-Trichlorotrifluoroethane
1,1,1-Trichlorotrifluoroethane

EPOXIDES

1,8-Cineole

HYDROCARBONS

Methane
Ethane
Propane
Butane
Pentane
Hexane
Heptane
Octane
Nonane
Decane
Undecane
Dodecane
Tridecane
Tetradecane
Pentadecane
Hexadecane
Heptadecane
C 18
C 19
C 20 (Eicosane)
Cyclopentane
Methylcyclopentane
Cyclohexane
Methylcyclohexane
Ethylcyclohexane
1,1-Dimethylcyclohexane
1,2-Dimethylcyclohexane
1,3-Dimethylcyclohexane
1,4-Dimethylcyclohexane
2,2-Dimethylbutane
2,3-Dimethylbutane
2-Methylpentane
3-Methylpentane
2,3-Dimethylpentane
2,4-Dimethylpentane
2,3,4-Trimethylpentane
2,2,4-Trimethylpentane
(Isooctane)
2-Methylhexane
3-Methylhexane
2,5-Dimethylhexane
2,2,5-Trimethylhexane
3-Methylheptane
2-Methylbutane
2-Methylheptane
2-Methyldecane

KETONES

Acetone
2-Butanone (MEK)
Cyclopentanone
Cyclohexanone
4-Methyl-2-Pentanone
(MIBK)

CHLORINATED COMPOUNDS

1,1-Dichloroethane
(Ethylidene Chloride)
1,2-Dichloroethane
(Ethylene Dichloride)
1,1,1-Trichloroethane
1,1,2-Trichloroethane
cis-1,2-Dichloroethylene
trans-1,2-Dichloroethylen
Trichloroethylene
Tetrachloroethylene
1,1,1,2-Tetrachloroethane
Chlorobenzene
o-Dichlorobenzene
p-Dichlorobenzene
m-Dichlorobenzene
1,2,4-Trichlorobenzene
o-Chlorotoluene
m-Chlorotoluene
p-Chlorotoluene
Methylene Chloride
Chloroform
Carbontetrachloride

ALCOHOLS

Isopropanol
Methanol
Propanol
Butanol
Pentanol
Ethanol
2-Methyl-1-Propanol
(Isobutyl alcohol)

ETHERS

1,4-Dioxane
Diethyl ether
Ethylene glycol
monoethyl ether
(2-Ethoxy Ethanol)
Ethylene glycol monobutyl
ether (2-Butoxy Ethano
Diethylene glycol monobut
ether

ACRYLATES

Methyl Acrylate
Ethyl Acrylate
Methyl Methacrylate
Ethyl Methacrylate

NITRO COMPOUNDS

Nitrobenzene
2-Nitropropane

TABLE I

RESULTS OF POMONA OAKS PRELIMINARY SAMPLING SESSION I, MAY 1983

AIR SAMPLE INFORMATION			BENZENE LEVELS (ppb)	
TYPE OF TEST	LOCATION	VOLUME (liters)	AIR LEVEL	WATER LEVEL
EXPOSURE (dry)	Bath Floor	15.0	156	90
EXPOSURE (moist)	Bath Floor	15.0	138	90
EXPOSURE (moist)[1]	Bath Floor	5.0	ND[2]	90
EXPOSURE (moist)[1]	Bath Floor	5.0	ND	90
EXPOSURE (moist)[1]	Bath Floor	5.0	ND	90
BACKGROUND	Bedroom	272.0	6[3]	90
BACKGROUND	Basement	274.0	ND	90

1. Three consecutive five minute air samples taken during same time as continouous fifteen minute samples

2. ND = None Detected

3. Also detected (ppb): Isopropanol (30); Ethanol (61)

TABLE 2

RESULTS OF POMONA OAKS PRELIMINARY SAMPLING SESSION II, JULY 1983

AIR SAMPLE INFORMATION			BENZENE LEVELS (ppb)		
TYPE OF TEST	LOCATION	VOLUME (liters)	AIR LEVEL	WATER LEVEL	RATIO OF AIR TO WATER
PRETEST	Bathroom	14.5	ND(1)	210	-
	Bedroom	19.6	ND	210	-
	Basement	15.0	ND	210	-
EXPOSURE (moist)	Breathing Zone	13.2	1170(2)(3)	210(4)	5.6
	Bath Floor	9.0	426	210	-
DISPERSION - I Immediately after exposure test	Bedroom	19.6	154	210	-
	Basement	15.0	ND	210	-
DISPERSION - II One hour after first dispersion test completed	Bathroom	14.5	ND(1)	210	-
	Bedroom	19.6	ND	210	-
	Basement	15.0	ND	210	-

1. ND = None Detected.

2. Standardized to a level corresponding to fifteen liters of air by linear methods.

3. Also detected in shower air at 13.2 liter and standardized to 15 liters (ppb): 2-methylbutane (71); 2 methylpentane (639); m-xylene (317); o-xylene (168); 1,2,4-trimethylbenzene (56).

4. Also detected in water (ppb); 1,2 dichloroethane (12); 1,1,1 trichloroethane (2); toluene (10).

TABLE 3

RESULTS OF POMONA OAKS PRELIMINARY SAMPLING SESSION III, AUGUST 1983

AIR SAMPLE INFORMATION			BENZENE LEVELS (ppb)	
TYPE OF TEST	LOCATION	VOLUME (liters)	AIR LEVEL	WATER LEVEL
EXPOSURE(1) (moist)	Breathing Zone	30.0	1060(2)	510
BACKGROUND	Bedroom	107.0	18	510
	Basement	104.0	ND	510
SPECIAL STUDY (moist)	Dishwasher Area (Kitchen)	26.1	42	510
	Clotheswasher Area	39.7	55	510

1. Sample was not taken in the standard manner and is not part of the summary statistics shown on graphs and tables. Sample represents thirty minutes at 1 liter a minute of an air sample during which the first 15 liters were taken in standard breathing zone sample manner but during the last 15 liters the water was turned off.
2. Also detected in air sample (ppb): m/p xylene (346); o-xylene (186); 1,2,4 trimethylbenzene (56).
3. NA = Does not apply due to change in circumstances during sample from running water to water off.
4. ND = None Detected.

Table 2

Upper Bound Estimates of Lifetime Cancer Risks
from Benzene Exposures in 15 Minute Shower Air

Observed and Estimated Levels of Benzene in Daily 15 Minute Showers (Your Tables II & IV)		Continuous * Exposure Levels			Global 82 95% Upper Confidence Limit of Lifetime Cancer Risk from NTP Animal Data on Zymbal Gland Carcinomas and Malignant Lymphomes					
					Zymbal Gland Carcinomas				Malignant Lymphomes	
ppb	ppm	ppm*	ug/m^3**	mg/kg/day***	Male Rats	Female Rats	Male Mice	Female Mice	Male Mice	Female Mice
91	9.1×10^{-2}	9.5×10^{-4}	3.08	.0009	1.9×10^{-5}	3.8×10^{-5}	3.2×10^{-5}	1.4×10^{-5}	7.1×10^{-4}	5.6×10^{-5}
347	34.7×10^{-2}	3.6×10^{-3}	11.75	.0033	7.0×10^{-5}	1.4×10^{-4}	1.2×10^{-4}	5.1×10^{-5}	2.6×10^{-4}	2.1×10^{-4}
620	62.0×10^{-2}	6.4×10^{-3}	20.99	.0060	1.3×10^{-4}	2.5×10^{-4}	2.1×10^{-4}	9.2×10^{-5}	4.7×10^{-4}	3.7×10^{-4}
616	61.6×10^{-2}	6.4×10^{-3}	20.85	.0059	1.3×10^{-4}	2.5×10^{-4}	2.1×10^{-4}	9.2×10^{-5}	4.6×10^{-4}	3.7×10^{-4}
770	77.0×10^{-2}	8.0×10^{-3}	26.07	.0074	1.6×10^{-4}	3.1×10^{-4}	2.6×10^{-4}	1.1×10^{-4}	5.8×10^{-4}	4.6×10^{-4}
1364	1.364	1.4×10^{-2}	46.18	.0131	2.8×10^{-4}	5.5×10^{-4}	4.6×10^{-4}	2.0×10^{-4}	1.0×10^{-3}	8.2×10^{-4}
1513	1.513	1.6×10^{-2}	51.22	.0145	3.1×10^{-4}	6.1×10^{-4}	5.1×10^{-4}	2.2×10^{-4}	1.1×10^{-3}	9.1×10^{-4}
2723	2.723	2.8×10^{-2}	92.18	.0262	5.6×10^{-4}	1.1×10^{-3}	9.2×10^{-4}	4.0×10^{-4}	2.1×10^{-3}	1.6×10^{-3}

* Continuous exposure levels were obtained from measured levels by assuming 15 min. Daily exposures (i.e. cont. expos. level = meas. level x $\frac{15 \text{ min.}/60 \text{ min.}}{24 \text{ hrs.}} = \frac{\text{meas. level}}{96}$)

** Dose in ug/m^3 obtained from dose in ppm using the conversion 3250 ug/m^3 = 1 ppm

*** Dose in mg/kg/day obtained from dose in ug/m^3 using the conversion ug/m^3 x (2.84×10^{-4}) = mg/kg/day assuming air intake for 70 kg person is 20m^3 per day.