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The Ground Water Supply Survey

Summary of Volatile Organic Contaminant Occurrence Data

by

James J. Westrick
J. Wayne Mello
Robert F. Thomas

Technical Support Division
Office of Drinking Water
Office of Water
Environmental Protection Agency
Cincinnati, Ohio

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Executive Summary

In response to the increasing nationwide concern over contamination of ground water supplies by volatile organic chemicals (VOCs), the Office of Drinking Water (ODW) of the Environmental Protection Agency is considering possible regulatory options for limiting VOCs in drinking water. In order to strengthen the VOC occurrence data base and to encourage state involvement in the VOC problem, ODW conducted a sampling and analysis program on finished water from 945 water supplies which use underground sources. The sampling program was conducted from December 1980 to December 1981. One hundred eighty-six (186) supplies from a random list of systems serving more than 10,000 persons and 280 supplies selected at random from systems serving less than 10,000 persons were sampled to provide estimates of national occurrence. An additional 479 supplies were selected by state agencies for sampling and analysis. This group of supplies was designated the nonrandom sample. The states were encouraged to choose supplies for the nonrandom sample for which no prior VOC data were available and which the state agencies believed had a higher than normal probability of contamination by VOCs, based upon their knowledge of local conditions, i.e., proximity to landfills, industrial activity, etc.

An extensive quality assurance protocol was followed which provided careful monitoring, control, and documentation of the quality of the analytical data and resulted in a high degree of confidence in the identification and quantitation of VOCs.

The percentages of supplies containing various levels of VOCs are shown below.

	Number of Supplies	% of Supplies with Summed Concentrations of VOCs Greater than the Value Shown					
		> OL	> 1.0	> 5.0	> 10	> 50	> 100
Random Sample							
< 10,000	280	16.8	7.1	2.9	1.8	0.4	0
> 10,000	186	28.0	14.0	6.5	3.4	0.5	0
Nonrandom Sample							
< 10,000	321	22.4	12.8	4.7	3.1	0	0
> 10,000	158	37.3	27.2	17.7	13.9	3.8	1.9

NOTE: Concentrations are in ug/l
OL - Lower quantitation limit

Of the small systems in the random sample, 16.8% contained at least one VOC above its quantitation limit, 2.9% had levels totaling more than 5.0 ug/l, and 0.4% had summed VOC concentrations exceeding 50 ug/l. Twenty-eight percent (28%) of the randomly selected systems serving more than 10,000 persons contained measurable VOCs, while 6.5% had summed VOC concentrations above 5.0 ug/l and 0.5% were contaminated with VOCs totaling more than 50 ug/l.

The nonrandom sample showed higher frequencies of occurrence for both large and small systems at all levels. The percentages of large and small systems contaminated at any level in the nonrandom sample were both only 33% higher than those in the random sample. However, in the

higher levels of contamination, the percentages of "hits" were two to four times greater in the state-selected sample than in the random sample.

The five compounds that occurred most frequently in the samples analyzed during the survey are shown below, along with their frequencies of occurrence in the subsets of the random and nonrandom samples.

	Frequency of Occurrence, %			
	Random		Nonrandom	
	< 10,000	> 10,000	< 10,000	> 10,000
trichloroethylene	3.2	11.3	7.2	24.1
1,1,1-trichloroethane	4.3	8.1	8.1	15.8
tetrachloroethylene	4.6	11.3	8.4	11.4
cis/trans-1,2-dichloroethylene	1.1	7.0	3.4	17.1
1,1-dichloroethane	3.6	4.3	1.9	10.8

In the random sample, trichloroethylene occurred at levels greater than 5 ug/l in 2 of 280 small systems and in 3.2% of the large systems (6 of 186). Trichloroethylene exceeded 50 ug/l in one of the randomly selected systems serving more than 10,000 persons. Eight other compounds exceeded 5 ug/l at least once in the random sample.

In the state selected sample there were 52 occurrences of single compounds above 5 ug/l, with trichloroethylene, cis/trans-1,2-dichloroethylene, and tetrachloroethylene accounting for 18, 11, and 10 of these 52 occurrences, respectively. Trichloroethylene was found 3 times at concentrations

exceeding 50 ug/l. Tetrachloroethylene and cis/trans-1,2-dichloroethylene were each found once at levels above 50 ug/l in the nonrandom supplies. Thirty-six of the 52 occurrences over 5 ug/l were in systems serving more than 10,000 persons.

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Background

Volatile organic contaminants (VOCs) are a general category of synthetic organic chemicals which include low molecular weight, volatile aliphatic and aromatic hydrocarbons, many of which are halogenated. The presence of VOCs in ground water supplies has been reported with increasing frequency as the use of the sophisticated analytical techniques required for their detection grows, along with public concern over the potential for contamination of ground water by chemical spills, improper chemical waste disposal practices and other of man's activities.

In order to supplement existing data on the occurrence of VOCs in drinking water, for purposes of development of regulatory alternatives,[1] the EPA, Office of Drinking Water (ODW), Technical Support Division (TSD), Cincinnati, Ohio, has conducted an extensive sampling and analysis program to examine the occurrence of VOCs in drinking water from ground water sources. The sampling program was initiated in December 1980 and completed in December 1981. The major objectives of the program were twofold: 1) provide additional data for the estimation of the nationwide occurrence of VOCs in drinking water supplied from underground sources; and 2) to collect information and the physical characteristics of the well field and the surrounding area in an effort to develop a predictive capability for locating contaminated ground water. Only the occurrence data is discussed in this report.

The survey was divided into two parts. One half the sampling and analytical resources were dedicated to the development of data from a random sample of ground water supplies drawn from the inventory of public water systems maintained in the Federal Reporting Data System (FRDS). A list of 500 supplies was selected at random from the national inventory. The list was developed from two subsets. Three hundred supplies were drawn from systems serving fewer than 10,000 persons, while the remaining 200 supplies served more than 10,000 persons. A second randomly generated two-part list of supplies provided replacement sampling sites in cases where the supplies on the primary list of 500 were inappropriate or non-existent. This could occur if, for example, a utility had recently begun to purchase its water from another utility which used a surface water source.

VOC occurrence data gathered by TSD from analysis of samples collected from ground water systems during the Community Water Supply Survey (CWSS) of 1978[2] were used to estimate the necessary sample sizes. The frequency of occurrence of any of the 10 VOC parameters for which analyses were conducted in samples from 301 ground water systems in the CWSS serving less than 10,000 persons was 0.12 (12% of the systems). Forty-five percent (0.45) of the 29 large ground water systems studied contained at least one VOC. Using these occurrence frequencies as estimates of what might be found in this survey, it was determined that sample sizes of 300 small systems and 200 large systems would allow at least 0.95 confidence that the size of the error of estimating occurrence frequencies would be no more than 0.036 (30% of the CWSS point estimate) for small systems and 0.069 (15% of the CWSS point estimate) for large systems.[3]

The second part of the survey was utilized to encourage the state agencies to attempt to identify problem supplies. This would not only expand state involvement in the VOC problem, but also provide the Office of Drinking Water with some information on the frequency and extent of serious problems that could be found based on the state agency's knowledge of local conditions. Each state was assigned a number of sampling sites (supplies) roughly proportional to its fraction of the total number of ground water systems nationwide; this was designated the nonrandom sample. The target number of nonrandom sites was also 500. The state agencies were encouraged to select supplies that they suspected might be contaminated by VOCs because of the proximity of the well field to industries, landfills, or other potential sources of contamination. They were also encouraged to choose supplies for which no VOC data were available in an effort to maximize the discovery of previously unknown contamination.

Approach

To obtain information from a maximum number of supplies within the available resources, it was decided to collect one sample of finished water from each utility at a point near the entrance to the distribution system. The VOC concentrations in water supplied from a single well that is not pumped continuously can vary depending on pumping rate and schedule and the hydrodynamics of the plume of contamination. If multiple wells supply a system at a single entry point and some wells are contaminated while others are not, the VOC concentration in the sample

at the entry point could vary greatly, depending on which wells were in operation at the time of sampling. In systems with more than one entry point, a single sample would obviously represent only those wells contributing to that entry point. With these limitations in mind, the sample of finished water taken at or near a point of entry provides a reasonable compromise between the information obtained from a single sample from a single well and that from multiple samples taken throughout the system.

State drinking water agencies played a major role in the planning and execution of this survey. Each state with primary Public Water System enforcement responsibility (primacy) was contacted through the regional EPA drinking water offices. Most of the states indicated a willingness to assist in the project. State involvement in planning consisted of reviewing the primary random list for errors or inappropriate/non-existent systems, filling in missing information on the random supplies, selecting systems for inclusion in the nonrandom portion of the survey, and providing scheduling information to the TSD project engineer. In most cases, state personnel traveled to the sampling sites, collected the samples and site information and shipped the samples in ice to the TSD laboratory in Cincinnati, Ohio, using sampling supplies (bottles, insulated shipping boxes, etc.) provided by TSD. In non-primacy states and states that were unable to assist in the planning or the sampling because of budgetary or other constraints, regional EPA personnel provided the necessary assistance. TSD personnel collected some samples that were obtainable within reasonable driving distance

from Cincinnati or when it was not possible for either state or regional EPA personnel to travel to the sampling locations.

After the first round of sampling and analysis was completed, the states were offered the opportunity to resample finished water and water from various wells in systems found, in the initial round of sampling, to be contaminated. This would not only be of assistance to the states in their investigation of the extent of contamination, but would also provide additional data to EPA. An examination of the resample data could provide insight as to the variability of contaminant concentration with time and also lend confidence in the results obtained from the initial round of sampling and analysis.

Logistics

A sampling kit was prepared at TSD for each sampling location. Amber bottles of 60 ml and 250 ml capacity were dosed with a preservative (mercuric chloride at 10 mg/l), capped with teflon septa and screw caps, labelled with preprinted labels which had been stamped with the sample identification numbers, and secured in "styrofoam" boxes. A shipping blank (250 ml bottle containing organic-free water and preservative) was also included with the sampling kit. The shipping blanks were to remain with the sampling kit through all stages of transportation and storage. Any possibilities of contamination from the surroundings could be investigated by analysis of the shipping blank. The styrofoam boxes had been custom molded to hold the proper number of bottles. The bottles, along with a plastic bag and tie, a sampling site data sheet, sampling and shipping instructions, and shipping labels and forms were shipped to

the sample collectors on a schedule which had been prearranged with the states. The sample collectors took the samples, filled in the labels and site data sheets, iced and secured the boxes, and delivered them to an overnight freight delivery service. All shipping costs were paid by EPA.

Samples were received at TSD on the day after they were collected. They were unpacked, logged in, and any unusual circumstances were noted. The sample bottles were then placed in storage in a cold room free of organic vapor contamination until they were repacked for shipment to the chemical analysis contract laboratory, SRI International, Inc., Menlo Park, California. Replicate samples were collected at each site so half the bottles were shipped to the contract laboratory and half were held in cold storage at TSD. This was necessary for occasional analysis of sample duplicates by TSD chemists or for quick-response, in-house verification of contract laboratory results.

When the samples were shipped to the contract laboratory, the pertinent sample information was entered into the TSD data system for tracking purposes. Primary analysis of the samples was completed within 30 days of collection. The contract laboratory was provided access to the data system, so upon completion of the analyses for a sample the data were entered at the contractor's terminal and retrieved by the TSD project engineer in Cincinnati. The results for each sample were examined by the TSD contract project officer and verified by agreement between the project officer and the SRI project leader after consideration of quality assurance information. The verified data were then entered into a confirmed data file for data analysis and reporting.

Analytical Considerations

A total of thirty-four parameters were selected for analysis by purge and trap gas chromatographic methods. The parameters are listed in Table 1. Any discussion of VOCs in this report includes only the 29 non-trihalomethane compounds listed. Five trihalomethanes (THMs), chloroform, bromodichloromethane, dibromochloromethane, dichloroiodomethane, and bromoform were included in the analysis, even though their presence nearly always results from the reaction of chlorine and precursor substances upon disinfection. The samples had not been dosed with a reducing agent, so the THM formation reaction proceeded until the time of analysis or until the depletion of either chlorine or precursor material.

The two isomers of 1,2-dichloroethylene could not be separately determined by the analysis and thus are considered in this report to be one parameter. The same is true for ortho- and para-xylenes. Methylene chloride originally was to be determined, but this compound is a very widely used laboratory solvent and appears frequently as a laboratory contaminant. Because it was found in all the analyzed shipping blanks, it was virtually impossible to ascertain whether the methylene chloride detected in a sample was originally present or if the sample had become contaminated from the surrounding atmosphere. Therefore, results for methylene chloride could not be validated and none are included in this report.

The purge and trap GC analyses were conducted according to EPA methods 502.1[4] and 503.1[5] with a significant modification. The non-destructive photoionization detector for analysis of aromatics and the Coulson electrolytic conductivity detector for the analysis of halocarbons

were directly coupled in series, allowing analysis for the complete list of thirty-four compounds with one sample purge. A comparability study conducted prior to the survey showed that the serial analysis gave results equivalent to separate analyses for the two types of compounds. This technique proved to be very beneficial in terms of the time for and cost of analysis. An additional benefit resulted from the acquisition of extra information by using the two detectors in series. The photoionization detector can assist in identifying and quantifying compounds that co-elute from the primary GC column or that have poor responses with the Coulson detector.

Residual chlorine was measured by a colorimetric kit in samples from supplies that practice chlorination. This measurement was done to provide information supplemental to the THM data. As a general indicator of non-specific organic content, total organic carbon (TOC) was measured on all samples by means of a low level carbon analyzer. Because TOC and residual chlorine measurements are of secondary interest, those data are not presented here but will be included in a later report.

Quality Assurance

When the contract for analytical services was written for the Ground Water Supply Survey, a detailed quality assurance protocol was included to monitor and maintain the quality of data generated in the analyses. This protocol was followed throughout the survey and the validating data were continuously scrutinized by the Project Officer. Table 2 is a summarized list of the quality assurance employed.

EPA Reference Samples

The precision and accuracy for analysis of the EPA halocarbon and aromatic reference samples, which were analyzed weekly, easily met the QA specifications. This was true for both the primary and confirmatory analytical schemes. The EPA reference samples contained known concentrations of compounds including the four common trihalomethanes and nine frequently found VOCs. The precision measure for the analysis of reference samples used herein is coefficient of variation, the relative standard deviation. This is the standard deviation of approximately 50 analyses divided by the mean of those values. The precision of the primary analysis of reference samples at levels below 5 ug/l averaged ±13% with a range of ±8% for tetrachloroethylene to ±22% for 1,1,1-trichloroethane. For reference samples containing levels greater than 5 ug/l, the precision ranged from ±6% for trichloroethylene to ±20% for 1,1,1-trichloroethane with an average precision of ±11%. Accuracy is indicated by the percent error, that is the difference between the mean of the measured values and the expected (true) value divided by the expected value. This parameter ranged from 0% for tetrachloroethylene at 5.9 ug/l to -19% for dibromochloromethane at 2.1 ug/l with averages of -9% below 5 ug/l and -4% above 5 ug/l. Negative error indicates that the mean of the measured values was less than the expected value.

Duplicate Analyses

As another gauge of precision, the contract called for duplicate analyses to be performed on a minimum of 10% of the samples. The duplicates

were to agree within 40% for compounds present below 5 ug/l and within 20% above 5 ug/l. The precision measure used here is the percent difference, 100 times the absolute difference in the duplicate values divided by the mean of the two values. Data were gathered on 16 individual compounds present collectively in the duplicate analyses. A total of 84 quantifiable results less than 5 ug/l were duplicated with all but five meeting the precision criterion. The average percent difference for the quantifiable low level duplicate results was 17%. Eighteen quantifiable pairs of duplicate results greater than 5 ug/l were reported, with four of the eighteen falling outside the precision limits. The average precision of the eighteen pairs of higher lever determinations was 13%. Although these figures cannot be compared directly to the precision obtained with the EPA reference samples, they are of a similar magnitude and reflect the consistency of replicate analyses done in the contractor's laboratory.

Confirmatory Analyses

All samples found or suspected to contain purgeable aromatic and halocarbon compounds other than the THMs were reanalyzed using different chromatographic columns that elute the compounds in different orders. In addition, samples containing chloroform at concentrations greater than 40 ug/l were reanalyzed using the confirmatory column because chloroform at this concentration level could mask small quantities of 1,2-dichloroethane. Approximately 33% of all samples were reanalyzed by second column chromatography for halocarbons and 6% for aromatics. Although it was not required by the

contract, the contract laboratory reported not only confirmatory identification but also concentration of compounds run by second column chromatography. Precision and accuracy for the analyses of 19 EPA reference samples for halocarbons and 11 EPA reference samples for aromatics were documented. All accuracy values were within the contract limits for the primary analyses and the precision values for all but two of the compounds fell within the primary analysis error limits. In addition, approximately 5% of all the samples were reanalyzed by gas chromatography/mass spectrometry for additional confirmation and tentative identification of unknown peaks.

Blind Samples

Five blind samples were prepared by TSD in the initial phase of the survey to ascertain the contractor's ability to qualitatively identify particular compounds and quantitatively measure them. The blinds consisted of five different mixtures of compounds, spiked into organic-free distilled water. These were periodically sent to the contractor early in the survey period disguised as survey samples. The mixtures were designed to pose selected anomalies in the analytical system, such as interferences or compounds with similar gas chromatographic retention times. Prior to shipment, the blinds were analyzed by TSD and these results were compared to those subsequently reported by the contractor. In every case, the contractor correctly identified the spiked compounds. Although there were no quantitative criteria established for the blind samples, the percent differences

between SRI's results and TSD-determined concentrations were within the error limits for duplicates for 27 of 32 pairs of values.

TSD Analysis of Duplicate Samples

Replicate samples were collected in separate bottles and stored at TSD so they could be analyzed as an additional check on the contract laboratory results. The TSD-analyzed check samples were chosen from those that the contractor had reported to contain one or more of the purgeable organics. Although there were no quantitative criteria established for inter-laboratory analysis of duplicate samples, the percent differences between SRI's results and those of TSD were within the error limits established for duplicate analyses for 48 of 64 pairs of values above the lower quantitation limits. The error limits used for the comparison here are those established for a single laboratory conducting duplicate analyses of the same sample. Larger percent differences were expected for this comparison since the analyses were done on duplicate samples and analyzed by totally independent systems. It is important to note that these duplicate samples often contained several compounds at widely varying concentrations, from <1 ug/l to over 100 ug/l.

The quality assurance program was a major, critical part of the analytical activity. It consumed a significant fraction of the analytical resources expended by the contract laboratory and required considerable time and effort by TSD personnel. Careful attention to the monitoring, control, and documentation of the data quality resulted in a high

degree of confidence that the identification and quantitation of compounds were accurate.

The data supporting the preceding discussion and an in-depth description of the analytical quality assurance program for this survey can be found in the contractor's final report[6] and in a recent paper by Kingsley.[7]

Results

The distribution of both random and nonrandom samples is shown in Table 3 and Figures 1 and 2. The final numbers of random systems sampled were 280 serving fewer than 10,000 persons and 186 serving more than 10,000, 34 systems less than the target of 500 random systems. The final tally for state-selected sites was 479. Because of the random selection process, the number of random sample sites located in each state should be roughly proportional to the number of ground water systems in that state. The number of nonrandom samples allocated to a state was also based approximately on its number of ground water systems. Figures 1 and 2 are pictorial representations of all sampling locations. The open circles represent sampling sites where no VOC contamination was detected and the closed circles represent locations of samples that contained at least one VOC above the quantitation limit. The quantitation limits are not the same for all compounds as can be seen from subsequent tables. In most cases, the quantitation limit is either 0.2 ug/l or 0.5 ug/l. This difference in lower quantitation limits can confuse the interpretation of data somewhat, and the occurrence data presented herein should be viewed with the different quantitation limits in mind.

For purposes of this report, unless otherwise stated, an occurrence is defined as any specific organic parameter which is found at or above its lower quantitation limit.

Tables 4 and 5 provide summary occurrence data from the random sample for each of the 34 parameters. Table 4 contains data for all specific parameters from the random sample of systems serving fewer than 10,000 persons and Table 5 contains the results for systems serving over 10,000 persons. The quantitation limit for each parameter, the frequency of occurrence (number and percent of samples in which each contaminant was found), the median concentration of the positive values of each compound and the highest concentration found are presented.

Because the two parts of the random sample were selected independently and because a much higher percentage of large systems than small systems were included (15% of roughly 1200 systems serving greater than 10,000 vs. 0.6% of nearly 48,000 systems serving fewer than 10,000 persons), the data from the large systems and the small systems are not combined for analysis. The normal curve approximation to the binomial distribution for large samples was used to conduct tests of significance of the difference in frequency of occurrence of compounds.[3] The large system frequency of occurrence was significantly greater than the small system frequency for trichloroethylene, 1,2-dichloroethylene, and tetrachloroethylene at the 0.01 significance level, and for 1,2-dichloropropane, carbon tetrachloride, and 1,1,1-trichloroethane at the 0.05 significance level. No other significant differences in the occurrence of specific parameters could be discerned between the large system and small system samples.

While the data clearly indicate that the frequency of occurrence of several of the compounds is higher among the larger communities sampled, a similar inference cannot be drawn regarding the severity of contamination from a casual observation of the data in Tables 3 and 4. The highest concentrations of 1,2-dichloropropane, trichloroethylene, and benzene were found in samples from the larger communities, while small system samples contained the highest levels of 1,1,1-trichloroethane, carbon tetrachloride, and tetrachloroethylene. Because of the possibly large variability in concentration at each sample point anything more than a cursory examination of the concentration distribution is beyond the scope of the available data.

Trihalomethane data are also shown in the tables. Trihalomethanes occurred more frequently in the larger system samples, but this could result from the higher percentage of large systems that chlorinate their water supplies (85% of the large systems sampled vs. 56% of the smaller systems sampled). The THM concentrations were generally low, as demonstrated by the median values, while it is also evident that some ground waters can produce very high THM values. Again, the variable lower quantitation limits must be recognized in considering both the frequency of occurrence and the median of the positive values for the THMs. Since the samples were normally analyzed after about 1-4 weeks of low temperature storage, the THM concentrations reported are undoubtedly higher than they would have been had the THM formation reaction been stopped by a reducing agent at the time of sampling and may or may not be representative of concentrations in the distribution systems. However, the

data do provide a good indication of the tendency for THM formation in ground water supplies.

Examination of the individual supply data and site information indicated that there may have been a few THM occurrences which were not the result of chlorination of the water supply (probably no more than six, all with very low concentrations). Because the focus of this survey was on VOCs other than THMs, the THM data will not be addressed further in this report.

There is no evidence in the literature that chlorination of drinking water causes the formation of any of the non-THM VOCs. There have been reports that commercial chlorine can contain traces of carbon tetrachloride which can contaminate chlorinated drinking water. Therefore, the carbon tetrachloride occurrence data presented herein should be qualified by the possibility that the cause of some carbon tetrachloride occurrences may be contaminated chlorine.

The data from the random sample of systems serving less than 10,000 persons were examined for any other possible effects of chlorination. There was no significant difference in occurrence frequencies for any of the VOCs between small systems that chlorinate and those that do not. The larger systems which do not chlorinate are too few in number to provide a valid comparison with larger systems which do chlorinate.

The number and percentage of contaminated supplies in each part of the random sample are listed by the number of contaminants in Table 6. Of 280 small systems, 47 contained one or more of the 29 VOCs included in the analysis. Of those 47 supplies, 19 supplies had multiple contaminants

above the quantitation limit. Of the 186 larger systems, 52 contained at least one contaminant. Twenty-five of those 52 supplies contained more than one VOC.

Water samples from 16.8% of the systems serving less than 10,000 persons and 28.0% of the larger systems contained at least one VOC. Therefore, based on data from this survey alone, the point estimates of the probability that systems serving under and over 10,000 persons are contaminated with at least one VOC above its quantitation limit are 16.8% and 28.0% respectively. A computer program was written to calculate the confidence limits of the estimates based on the binomial distribution.[3] The confidence interval is a function simply of the observed frequency and the sample size and does not account for any uncertainty due to analytical variability or variation in water quality. The frequency of occurrence in all systems serving less than 10,000 persons can be estimated with 95% confidence to lie within the range 12.9% - 21.7%. Likewise, the large system frequency of occurrence can be estimated to lie within the 95% confidence interval 22.1% - 35.0%. The frequency of occurrence for the large systems was greater than that for the small systems at the 0.01 significance level.

Information on the concentration distributions of the VOCs that occurred in the random sample is further broken down by smaller population categories in Table 7. There were 16 occurrences greater than 5.0 ug/l. Trichloroethylene was found at > 5.0 ug/l in eight supplies, once at > 50 ug/l.

Table 8 is a summary of the data by the same population categories and concentration cells used in Table 7, but showing the number of supplies with a summed concentration falling within various concentration ranges. For example, there were 88 supplies in the population category 101-500. Of those 88 supplies, 77 contained no VOC above its quantitation limit, 9 contained one or more contaminants with the sums of the concentrations less than 5.0 ug/l, and two supplies had a summed VOC concentration in the range 11 ug/l - 50 ug/l. The point estimate of the probability of a system that serves more than 10,000 people containing a summed VOC concentration of more than 5.0 ug/l was 6.5% (12 of 186) with a 95% confidence interval of 3.8% - 11%. Eight of 280 small systems (2.9%) contained a VOC total of > 5.0 ug/l, resulting in a 95% confidence interval for the estimate of 1.5% - 5.6%. The frequency of occurrence of summed VOCs > 5.0 ug/l was greater in large systems than in small systems at the 0.05 significance level.

The Nonrandom Sample

Because of the nature of the nonrandom sample, where the states selected sites that they suspected might be contaminated, no statistical interpretation of the data will be attempted here. All the nonrandom sample data are presented in Tables 9 through 14 in the same format as the random sample data. Obviously higher frequencies and concentrations were found in this sample set than in the random sample. Nearly one-fourth of the large systems and 7% of the small systems selected by the state agencies were contaminated with trichloroethylene. Other compounds appearing frequently included cis/trans-1,2-dichloroethylene, 1,1,1-trichloroethane, tetrachloroethylene, and 1,1-dichloroethane. Of the

131 systems found to be contaminated with VOCs, over half showed the presence of more than one contaminant; the water from one smaller community contained eight VOCs. Trichloroethylene, tetrachloroethylene, and cis/trans-1,2-dichloroethylene were found at levels greater than 5.0 ug/l 18, 11, and 10 times, respectively. Trichloroethylene occurred three times at greater than 50 ug/l, tetrachloroethylene and cis/trans-1,2-dichloroethylene once each. All xylene occurrences were in supplies serving less than 10,000 persons; in fact, only seven occurrences of aromatic compounds were found in the larger supplies. Although 1,1,1-trichloroethane was the second most frequently found compound, it was found only four times over 5.0 ug/l. Thirty-seven percent of the larger supplies selected by the States did indeed have at least one measurable VOC and 18% had a summed VOC concentration of $\geq$ 5.0 ug/l. Of the smaller systems selected, 22% showed some contamination with the summed VOC concentration exceeding 5.0 ug/l in 5% of the samples.

Resampling of Contaminated Supplies

Approximately 100 contaminated supplies were resampled. The states were asked to resample the finished water and were also given the opportunity to collect several raw water samples of their choosing. In many cases, the original sample point was not resampled or the sampling points were not described well enough to enable comparison of the original sample and the resample.

An example of data from a supply which did resample finished water serves to point out some interesting aspects of ground water VOC data. The concentrations of VOCs found in samples of finished water from a single well owned by a small town (City A) collected nine months apart are shown in Table 15.

These two samples show very much the same pattern of contamination with a possible slight decrease in concentration. Trichloroethylene, which was counted as an occurrence in the original sample, was not found above the quantification limit in the resample. Table 15 illustrates several commonly occurring circumstances. When the original sample and the resample represented water from a single well, both usually contained nearly identical patterns of contamination. This increases confidence that the original results were accurate. It also reinforces the belief, widely held, that ground water contamination levels usually change very slowly. It was not uncommon that the occurrence of a compound at or near the quantitation limit was not repeated in the resample. For example in 37 supplies for which the original sample point was resampled, there were 25 occurrences which did not recur in the resample (many of the supplies resampled had multiple occurrences). However, there were also 16 instances when a compound that was not found in the original sample was quantified in the resampled finished water. This non-repeatability occasionally occurred in well defined, single well samples such as those shown in Table 15 for very low level contaminants. This situation could result from either the normal analytical variability or from actual changes in concentration at the well. It was more common in larger systems where the finished water was a blend of water from multiple wells with varied levels of contamination. In these cases, changes in the contaminant concentrations could result from changes in the relative contributions of the various wells as determined by their pumping rates. Temporal concentration changes could also result from

relatively rapid movement of the plume of contamination, which could occur under certain conditions of recharge and withdrawal in a highly permeable aquifer.

The data from resampling finished water from individual wells reinforce confidence that the identifications and quantitation of compounds in the samples were accurate. The data from larger, multiple well systems indicate that concentrations of compounds in a finished water can vary considerably over a period of time. Sampling a large number of supplies, as was done in this survey, is necessary to provide an accurate representation of the percentage of systems with water containing VOCs and a good indication of the magnitude of the concentration levels.

Finished water quality variability in ground water supplies is virtually site specific and not amenable to definition by a national survey such as this. It was recognized in the beginning that, in the face of uncertainty, the sampling approach taken would be a compromise between broad national coverage and a high degree of representativeness. Subjective evaluation of the resample data has substantiated that approach.

Conclusion

The Ground Water Supply Survey was undertaken principally to strengthen the body of data on the occurrence of VOCs in ground water supplies. Careful attention was paid to all aspects of quality assurance in order to provide a reliable representation of VOC occurrence in the Nation's ground water supplies. The frequencies of occurrence of 29 volatile compounds in samples collected from 466 randomly selected communities and 479 communities selected by the State agencies were determined. The three most frequently detected compounds were trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane. The percentages of supplies containing at least one VOC above its quantitation

limit in the various subsets of the survey were: random < 10,000 persons - 16.8%, random > 10,000 persons - 28.0%, nonrandom < 10,000 persons - 22.4%, and nonrandom > 10,000 persons - 37.3%. The percentages of supplies whose finished water contain summed VOC concentrations greater than 5 ug/l were: random < 10,000 persons - 2.9%, random > 10,000 persons - 6.5%, nonrandom < 10,000 persons - 4.7%, and nonrandom > 10,000 persons - 17.7%.

Simple statistical tests, based on the random parts of the survey revealed significant differences in the frequencies of occurrence in the larger and smaller community subsets of the random sample. The results of the random sample were also used to construct confidence limits around estimates of probabilities of occurrence.

The nonrandom portion of the sample provides additional data on the "high side" of the occurrence curve, since the sites were selected in hopes of finding a greater frequency of higher level contamination. For example, six of the eight supplies with summed VOC concentrations > 50 ug/l were from the nonrandom sample, including all three of the supplies with summed VOC concentrations > 100 ug/l.

Resampling of contaminated supplies tended to strengthen confidence in the quality of the analytical data. It also showed that finished water quality, with respect to VOCs, can vary with time especially in larger systems with multiple wells.

This report is offered as a summary discussion of the Ground Water Supply Survey and its results. Additional analysis of the data generated by the survey will appear in the occurrence documents prepared by the Agency in support of VOC regulatory activity.

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References

1. U.S. Environmental Protection Agency, "National Revised Primary Drinking Water Regulations, Volatile Synthetic Organic Chemicals in Drinking Water; Advanced Notice of Proposed Rulemaking." Federal Register 47: 9350, March 4, 1982.
2. Brass, H.J., Weisner, M.J. and Kingsley, B.A., "Community Water Supply Survey: Sampling and Analysis for Purgeable Organics and Total Organic Carbon." Presented at the American Water Works Association Annual Conference, St. Louis, MO, June 1981.
3. Miller, I. and Freund, J.E., Probability and Statistics for Engineers. Prentice-Hall, Inc., Englewood Cliffs, NJ, 1965.
4. U.S. Environmental Protection Agency, "The Determination of Halogenated Chemicals in Water by the Purge and Trap Method." Method 502.1, EPA #600/4-81-059, April 1981.
5. U.S. Environmental Protection Agency, "The Analysis of Aromatic Chemicals in Water by the Purge and Trap Method." Method 503.1, EPA #600/4-81-057, May 1980.
6. SRI International, Final Report, EPA Contract No. 68-03-3031, "Determination of the Quality of Ground Water Supplies." December 1982.
7. Kingsley, B.A., "Quality Assurance in a Contract Laboratory." Presented at the American Water Works Association, Water Quality Technology Conference, Nashville, TN, December 1982.

Table 1

Specific Organic Parameters

Ground Water Supply Survey
(December 1980 - December 1981)

vinyl chloride	1,1,2-trichloroethane
1,1-dichloroethylene	1,1,1,2-tetrachloroethane
1,1-dichloroethane	1,1,2,2-tetrachloroethane
cis and/or trans-1,2-dichloroethylene	chlorobenzene
1,2-dichloroethane	1,2-dibromo-3-chloropropane
1,1,1-trichloroethane	n-propylbenzene
carbon tetrachloride	o-chlorotoluene
1,2-dichloropropane	p-chlorotoluene
trichloroethylene	m-dichlorobenzene
tetrachloroethylene	o-dichlorobenzene
benzene	styrene
toluene	isopropylbenzene
ethylbenzene	chloroform
bromobenzene	bromodichloromethane
m-xylene	dibromochloromethane
o+p-xylene	dichloroiodomethane
p-dichlorobenzene	bromoform

Table 2

Quality Assurance Protocol for the Analysis of VOCs

QA Analysis	Frequency or Amount	Specified Contract Limits	<5 ug/l	>5 ug/l	Source of Sample
EPA Reference Samples	1/week for each instrument	Precision: Accuracy:	±40% ±40%	±20% ±20%	EMSL-Cin
Duplicate Analyses	10% of samples	Agreement:	40%	20%	Survey samples
Confirmatory Analyses	100% of positives	Qualitative Agreement			Survey samples
Blind Samples	variable	none specified			TSD generated
TSD Analysis of Duplicate Samples	10% of positives	none specified			Survey samples

Table 3

Number of Supplies Sampled
By State

Ground Water Supply Survey
(December 1980 - December 1981)

State	Random	Non-random	State	Random	Non-random
Alabama	7	5	Nebraska	8	6
Alaska	4	4	Nevada	2	3
Arizona	8	9	New Hampshire	2	4
Arkansas	3	4	New Jersey	17	5
California	34	30	New Mexico	1	6
Colorado	2	6	New York	22	25
Connecticut	8	7	North Carolina	13	31
Delaware	1	1	North Dakota	-	3
Florida	44	31	Ohio	14	15
Georgia	14	13	Oklahoma	4	5
Hawaii	-	2	Oregon	7	7
Idaho	6	8	Pennsylvania	16	26
Illinois	15	12	Rhode Island	1	2
Indiana	8	8	South Carolina	5	11
Iowa	12	13	South Dakota	4	4
Kansas	11	6	Tennessee	6	4
Kentucky	4	3	Texas	41	33
Louisiana	14	10	Utah	8	2
Maine	-	2	Vermont	2	3
Maryland	4	6	Virginia	9	18
Massachusetts	11	4	Washington	19	10
Michigan	8	12	West Virginia	4	5
Minnesota	10	9	Wisconsin	7	13
Mississippi	14	14	Wyoming	-	2
Missouri	6	10	Puerto Rico	2	2
Montana	4	5			

Summary of Occurrence Data[a]

Random Sample

Supplies Serving Less Than 10,000 Persons[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter	Quantitation Limit	Occurrences No.	Occurrences %	Median of Positives	Maximum Value
vinyl chloride	1.0	0	0	-	-
1,1-dichloroethylene	0.2	4	1.4	1.2	6.3
1,1-dichloroethane	0.2	10	3.6	0.51	3.2
cis and/or trans-1,2-dichloroethylene	0.2	3	1.1	0.23	1.7
1,2-dichloroethane	0.5	0	0	-	-
1,1,1-trichloroethane	0.2	12	4.3	0.32	18
carbon tetrachloride	0.2	5	1.8	0.37	16
1,2-dichloropropane	0.2	1	0.4	0.75	0.75
trichloroethylene	0.2	9	3.2	0.88	40
tetrachloroethylene	0.2	13	4.6	0.35	23
benzene	0.5	1	0.4	0.61	0.61
toluene	0.5	4	1.4	0.62	0.85
ethylbenzene	0.5	2	0.7	0.94	1.1
bromobenzene	0.5	3	1.1	1.9	5.8
m-xylene	0.2	6	2.1	0.32	1.5
o+p-xylene	0.2	6	2.1	0.34	0.59
p-dichlorobenzene	0.5	2	0.7	0.60	0.68
1,1,2-trichloroethane	0.5	0	0	-	-
1,1,1,2-tetrachloroethane	0.2	0	0	-	-
1,1,2,2-tetrachloroethane	0.5	0	0	-	-
chlorobenzene	0.5	0	0	-	-
1,2-dibromo-3-chloropropane	5.0	1	0.4	5.5	5.5
n-propylbenzene	0.5	0	0	-	-
o-chlorotoluene	0.5	0	0	-	-
p-chlorotoluene	0.5	0	0	-	-
m-dichlorobenzene	0.5	0	0	-	-
o-dichlorobenzene	0.5	0	0	-	-
styrene	0.5	0	0	-	-
isopropylbenzene	0.5	0	0	-	-
chloroform	0.2	104	37.1	1.4	140
bromodichloromethane	0.2	100	35.7	1.4	60
dibromochloromethane	0.5	87	31.1	2.1	52
dichloroiodomethane	1.0	2	0.7	2.8	4.1
bromoform	1.0	44	15.7	2.4	54

[a] All concentrations are in ug/l

[b] 280 sample sites

Table 5

Summary of Occurrence Data[a]

Random Sample

Supplies Serving More Than 10,000 Persons[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter	Quantitation Limit	Occurrences No.	Occurrences %	Median of Positives	Maximum Value
vinyl chloride	1.0	1	0.5	1.1	1.1
1,1-dichloroethylene	0.2	5	2.7	0.28	2.2
1,1-dichloroethane	0.2	8	4.3	0.54	1.2
cis and/or trans-1,2-dichloroethylene	0.2	13	7.0	1.1	2.0
1,2-dichloroethane	0.5	3	1.6	0.57	0.95
1,1,1-trichloroethane	0.2	15	8.1	1.0	3.1
carbon tetrachloride	0.2	10	5.4	0.32	2.8
1,2-dichloropropane	0.2	5	2.7	0.96	21
trichloroethylene	0.2	21	11.3	1.0	78
tetrachloroethylene	0.2	21	11.3	0.52	5.9
benzene	0.5	2	1.1	9.0	15
toluene	0.5	2	1.1	2.6	2.9
ethylbenzene	0.5	1	0.5	0.74	0.74
bromobenzene	0.5	1	0.5	1.7	1.7
m-xylene	0.2	2	1.1	0.46	0.61
o+p-xylene	0.2	2	1.1	0.59	0.91
p-dichlorobenzene	0.5	3	1.6	0.66	1.3
1,1,2-trichloroethane	0.5	0	0	-	-
1,1,1,2-tetrachloroethane	0.2	0	0	-	-
1,1,2,2-tetrachloroethane	0.5	0	0	-	-
chlorobenzene	0.5	0	0	-	-
1,2-dibromo-3-chloropropane	5.0	0	0	-	-
n-propylbenzene	0.5	0	0	-	-
o-chlorotoluene	0.5	0	0	-	-
p-chlorotoluene	0.5	0	0	-	-
m-dichlorobenzene	0.5	0	0	-	-
o-dichlorobenzene	0.5	0	0	-	-
styrene	0.5	0	0	-	-
isopropylbenzene	0.5	0	0	-	-
chloroform	0.2	106	57.0	1.6	300
bromodichloromethane	0.2	101	54.3	1.6	71
dibromochloromethane	0.5	96	51.6	2.9	59
dichloroiodomethane	1.0	3	1.6	1.8	4.1
bromoform	1.0	57	30.6	3.8	50

[a] All concentrations are in ug/l

[b] 186 sample sites

Table 6

Summary of Multiple Occurrences

Random Sample

Ground Water Supply Survey
December 1980 - December 1981

Number of Contaminants	Supplies Containing Listed Number of Contaminants			
	Population Category			
	< 10,000		> 10,000	
	No.	%	No.	%
0	233	83.2	134	72.1
1	28	10.0	27	14.5
2	10	3.5	8	4.3
3	6	2.1	6	3.2
4	1	0.4	5	2.7
5	1	0.4	3	1.6
6	0	0	2	1.1
7	1	0.4	1	0.5
	280	100%	186	100%

Table 7

Occurrence of Purgeable Synthetic Organic Contaminants[a]
by Population Category and Concentration

Random Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter[d]	Population	Number of Supplies With Listed Concentration[c]					
		Below QL	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
trichloroethylene (0.2)							
	< 100	78	1	-	1	-	-
	101 - 500	87	1	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	30	1	-	-	-	-
	2,501 - 5,000	33	2	-	1	-	-
	5,001 - 10,000	15	2	-	-	-	-
	10,001 - 100,000	154	13	3	2	1	-
	> 100,000	11	2	-	-	-	-
	Total	436	22	3	4	1	-
tetrachloroethylene (0.2)							
	< 100	76	4	-	-	-	-
	101 - 500	85	2	-	1	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	30	1	-	-	-	-
	2,501 - 5,000	33	3	-	-	-	-
	5,001 - 10,000	15	2	-	-	-	-
	10,001 - 100,000	153	19	1	-	-	-
	> 100,000	12	1	-	-	-	-
	Total	432	32	1	1	-	-
1,1,1-trichloroethane (0.2)							
	< 100	76	4	-	-	-	-
	101 - 500	88	-	-	-	-	-
	501 - 1,000	27	1	-	-	-	-
	1,001 - 2,500	29	1	1	-	-	-
	2,501 - 5,000	33	2	-	1	-	-
	5,001 - 10,000	15	2	-	-	-	-
	10,001 - 100,000	158	15	-	-	-	-
	> 100,000	13	-	-	-	-	-
	Total	439	25	1	1	-	-
cis and/or trans-1,2-dichloroethylene (0.2)							
	< 100	79	1	-	-	-	-
	101 - 500	88	-	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	31	-	-	-	-	-
	2,501 - 5,000	35	1	-	-	-	-
	5,001 - 10,000	16	1	-	-	-	-
	10,001 - 100,000	162	11	-	-	-	-
	> 100,000	11	2	-	-	-	-
	Total	450	16	-	-	-	-

Table 7 (Cont'd.)

Occurrence of Purgeable Synthetic Organic Contaminants[a]
by Population Category and Concentration

Random Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter[d]	Population	Number of Supplies With Listed Concentration[c]					
		Below QL	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
1,1-dichloroethane (0.2)							
	< 100	78	2	-	-	-	-
	101 - 500	84	4	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	30	1	-	-	-	-
	2,501 - 5,000	35	1	-	-	-	-
	5,001 - 10,000	15	2	-	-	-	-
	10,001 - 100,000	166	7	-	-	-	-
	> 100,000	12	1	-	-	-	-
	Total	448	18	-	-	-	-
carbon tetrachloride (0.2)							
	< 100	80	-	-	-	-	-
	101 - 500	87	-	-	1	-	-
	501 - 1,000	27	1	-	-	-	-
	1,001 - 2,500	29	2	-	-	-	-
	2,501 - 5,000	35	1	-	-	-	-
	5,001 - 10,000	17	-	-	-	-	-
	10,001 - 100,000	163	10	-	-	-	-
	> 100,000	13	-	-	-	-	-
	Total	451	14	-	1	-	-
1,1-dichloroethylene (0.2)							
	< 100	79	1	-	-	-	-
	101 - 500	87	1	-	-	-	-
	501 - 1,000	27	-	1	-	-	-
	1,001 - 2,500	31	-	-	-	-	-
	2,501 - 5,000	35	1	-	-	-	-
	5,001 - 10,000	17	-	-	-	-	-
	10,001 - 100,000	169	4	-	-	-	-
	> 100,000	12	1	-	-	-	-
	Total	457	8	1	-	-	-
o+p-xylene (0.2)							
	< 100	78	2	-	-	-	-
	101 - 500	87	1	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	30	1	-	-	-	-
	2,501 - 5,000	34	2	-	-	-	-
	5,001 - 10,000	17	-	-	-	-	-
	10,001 - 100,000	171	2	-	-	-	-
	> 100,000	13	-	-	-	-	-
	Total	458	8	-	-	-	-

Table 7 (Cont'd.)

Occurrence of Purgeable Synthetic Organic Contaminants[a] by Population Category and Concentration

Random Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter[d]	Population	Number of Supplies With Listed Concentration[c]					
		Below QL	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
1,2-dichloroethane (0.5)							
	< 100	80	-	-	-	-	-
	101 - 500	88	-	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	31	-	-	-	-	-
	2,501 - 5,000	36	-	-	-	-	-
	5,001 - 10,000	17	-	-	-	-	-
	10,001 - 100,000	170	3	-	-	-	-
	> 100,000	13	-	-	-	-	-
	Total	463	3	-	-	-	-
m-xylene (0.2)							
	< 100	78	2	-	-	-	-
	101 - 500	87	1	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	30	1	-	-	-	-
	2,501 - 5,000	34	2	-	-	-	-
	5,001 - 10,000	17	-	-	-	-	-
	10,001 - 100,000	171	2	-	-	-	-
	> 100,000	13	-	-	-	-	-
	Total	458	8	-	-	-	-
1,2-dichloropropane (0.2)							
	< 100	80	-	-	-	-	-
	101 - 500	87	1	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	31	-	-	-	-	-
	2,501 - 5,000	36	-	-	-	-	-
	5,001 - 10,000	17	-	-	-	-	-
	10,001 - 100,000	168	4	-	1	-	-
	> 100,000	13	-	-	-	-	-
	Total	460	5	-	1	-	-
benzene (0.5)							
	< 100	80	-	-	-	-	-
	101 - 500	88	-	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	31	-	-	-	-	-
	2,501 - 5,000	36	-	-	-	-	-
	5,001 - 10,000	16	1	-	-	-	-
	10,001 - 100,000	171	1	-	1	-	-
	> 100,000	13	-	-	-	-	-
	Total	463	2	-	1	-	-

Table 7 (Cont'd.)

Occurrence of Purgeable Synthetic Organic Contaminants[a]
by Population Category and Concentration

Random Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter[d]	Population	Number of Supplies With Listed Concentration[c]					
		Below QL	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
toluene (0.5)							
	< 100	79	1	-	-	-	-
	101 - 500	87	1	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	30	1	-	-	-	-
	2,501 - 5,000	36	-	-	-	-	-
	5,001 - 10,000	16	1	-	-	-	-
	10,001 - 100,000	171	2	-	-	-	-
	> 100,000	13	-	-	-	-	-
	Total	460	6	-	-	-	-
p-dichlorobenzene (0.5)							
	< 100	80	-	-	-	-	-
	101 - 500	87	1	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	31	-	-	-	-	-
	2,501 - 5,000	36	-	-	-	-	-
	5,001 - 10,000	16	1	-	-	-	-
	10,001 - 100,000	170	3	-	-	-	-
	> 100,000	13	-	-	-	-	-
	Total	461	5	-	-	-	-
vinyl chloride (1.0)							
	< 100	80	-	-	-	-	-
	101 - 500	88	-	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	31	-	-	-	-	-
	2,501 - 5,000	36	-	-	-	-	-
	5,001 - 10,000	17	-	-	-	-	-
	10,001 - 100,000	172	1	-	-	-	-
	> 100,000	13	-	-	-	-	-
	Total	465	1	-	-	-	-
ethylbenzene (0.5)							
	< 100	78	2	-	-	-	-
	101 - 500	88	-	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	31	-	-	-	-	-
	2,501 - 5,000	36	-	-	-	-	-
	5,001 - 10,000	17	-	-	-	-	-
	10,001 - 100,000	172	1	-	-	-	-
	> 100,000	13	-	-	-	-	-
	Total	463	3	-	-	-	-

Table 7 (Cont'd.)

Occurrence of Purgeable Synthetic Organic Contaminants[a]
by Population Category and Concentration

Random Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter[d]	Population	Number of Supplies With Listed Concentration[c]					
		Below QL	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
bromobenzene (0.5)							
	< 100	80	-	-	-	-	-
	101 - 500	87	1	-	-	-	-
	501 - 1,000	26	1	1	-	-	-
	1,001 - 2,500	31	-	-	-	-	-
	2,501 - 5,000	36	-	-	-	-	-
	5,001 - 10,000	17	-	-	-	-	-
	10,001 - 100,000	172	1	-	-	-	-
	> 100,000	13	-	-	-	-	-
	Total	462	3	1	-	-	-
1,2-dibromo-3-chloropropane (5.0)							
	< 100	80	-	-	-	-	-
	101 - 500	88	-	-	-	-	-
	501 - 1,000	28	-	-	-	-	-
	1,001 - 2,500	31	-	-	-	-	-
	2,501 - 5,000	35	-	1	-	-	-
	5,001 - 10,000	17	-	-	-	-	-
	10,001 - 100,000	173	-	-	-	-	-
	> 100,000	13	-	-	-	-	-
	Total	465	-	1	-	-	-

[a] Does not include THMs

[b] 466 supplies

[c] All concentrations are in ug/l

[d] Number in parenthesis is the lower quantitation limit, QL, in ug/l

Table 8

Occurrence Data for the Summation of
Purgeable Synthetic Organic Contaminants
by Population Category and Summed Concentration[a]

Random Sample

Ground Water Supply Survey
December 1980 - December 1981

Population	Number of Supplies with Listed Summed Concentration					
	Below QL[b]	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
< 100	70	9	0	1	0	0
101 - 500	77	9	0	2	0	0
501 - 1,000	24	2	2	0	0	0
1,001 - 2,500	26	4	0	1	0	0
2,501 - 5,000	26	8	1	0	1	0
5,001 - 10,000	10	7	0	0	0	0
10,001 - 100,000	123	38	5	6	1	0
> 100,000	11	2	0	0	0	0

a Summed concentration is summation of all purgeable synthetic organic contaminants, exclusive of THMs, in ug/l.

b No contaminants found above the quantitation limit.

Table 9

Summary of Occurrence Data[a]

Nonrandom Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter	Quantitation Limit	Occurrences No.	Occurrences %	Median of Positives	Maximum Value
vinyl chloride	1.0	6	1.3	2.7	8.4
1,1-dichloroethylene	0.2	15	3.1	0.35	3.0
1,1-dichloroethane	0.2	23	4.8	0.63	4.2
cis and/or trans-1,2-dichloroethylene	0.2	38	7.9	1.7	120
1,2-dichloroethane	0.5	7	1.5	2.5	9.8
1,1,1-trichloroethane	0.2	51	10.6	1.0	21
carbon tetrachloride	0.2	15	3.1	0.45	15
1,2-dichloropropane	0.2	7	1.5	1.2	18
trichloroethylene	0.2	61	12.7	1.4	130
tetrachloroethylene	0.2	45	9.4	0.73	69
benzene	0.5	8	1.7	1.6	12
toluene	0.5	5	1.0	0.73	1.5
ethylbenzene	0.5	3	0.6	0.87	0.95
bromobenzene	0.5	2	0.4	0.97	1.2
m-xylene	0.2	8	1.7	0.38	0.83
o+p-xylene	0.2	10	2.1	0.44	2.5
p-dichlorobenzene	0.5	4	0.8	0.73	0.90
1,1,2-trichloroethane	0.5	0	0	-	-
1,1,1,2-tetrachloroethane	0.2	0	0	-	-
1,1,2,2-tetrachloroethane	0.5	0	0	-	-
chlorobenzene	0.5	1	0.2	2.7	2.7
1,2-dibromo-3-chloropropane	5.0	0	0	-	-
n-propylbenzene	0.5	1	0.2	0.98	0.98
o-chlorotoluene	0.5	1	0.2	2.4	2.4
p-chlorotoluene	0.5	0	0	-	-
m-dichlorobenzene	0.5	0	0	-	-
o-dichlorobenzene	0.5	2	0.4	2.4	2.7
styrene	0.5	0	0	-	-
isopropylbenzene	0.5	0	0	-	-
chloroform	0.2	255	53.2	1.9	430
bromodichloromethane	0.2	244	50.9	2.1	110
dibromochloromethane	0.5	222	46.3	3.9	63
dichloroiodomethane	1.0	13	2.7	1.2	4.2
bromoform	1.0	148	30.9	4.2	110

[a] All concentrations are in ug/l

[b] 479 sample sites

Table 10

Summary of Occurrence Data[a]

Nonrandom Sample

Supplies Serving Less Than 10,000 Persons[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter	Quantitation Limit	Occurrences No.	Occurrences %	Median of Positives	Maximum Value
vinyl chloride	1.0	0	0	-	-
1,1-dichloroethylene	0.2	5	1.6	0.35	3.0
1,1-dichloroethane	0.2	6	1.9	0.62	1.2
cis and/or trans-1,2-dichloroethylene	0.2	11	3.4	1.3	17
1,2-dichloroethane	0.5	3	0.9	2.9	3.4
1,1,1-trichloroethane	0.2	25	7.8	1.2	8.2
carbon tetrachloride	0.2	9	2.8	0.44	15
1,2-dichloropropane	0.2	3	0.9	1.2	1.4
trichloroethylene	0.2	23	7.2	1.2	29
tetrachloroethylene	0.2	27	8.4	0.79	21
benzene	0.5	5	1.6	1.6	12
toluene	0.5	4	1.2	0.67	0.79
ethylbenzene	0.5	3	0.9	0.87	0.95
bromobenzene	0.5	2	0.6	0.97	1.2
m-xylene	0.2	8	2.5	0.38	0.83
o+p-xylene	0.2	10	3.1	0.44	2.5
p-dichlorobenzene	0.5	4	1.2	0.74	0.90
1,1,2-trichloroethane	0.5	0	0	-	-
1,1,1,2-tetrachloroethane	0.2	0	0	-	-
1,1,2,2-tetrachloroethane	0.5	0	0	-	-
chlorobenzene	0.5	1	0.3	2.7	2.7
1,2-dibromo-3-chloropropane	5.0	0	0	-	-
n-propylbenzene	0.5	1	0.3	0.98	0.98
o-chlorotoluene	0.5	0	0	-	-
p-chlorotoluene	0.5	0	0	-	-
m-dichlorobenzene	0.5	0	0	-	-
o-dichlorobenzene	0.5	1	0.3	2.2	2.2
styrene	0.5	0	0	-	-
isopropylbenzene	0.5	0	0	-	-
chloroform	0.2	155	48.3	1.6	100
bromodichloromethane	0.2	144	44.9	2.0	49
dibromochloromethane	0.5	135	42.1	3.5	63
dichloroiodomethane	1.0	5	1.6	1.4	4.2
bromoform	1.0	88	27.4	3.7	110

[a] All concentrations are in ug/l

[b] 321 sample sites

Table 11

Summary of Occurrence Data[a]

Nonrandom Sample

Supplies Serving More Than 10,000 Persons[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter	Quantitation Limit	Occurrences No.	Occurrences %	Median of Positives	Maximum Value
vinyl chloride	1.0	6	3.8	2.7	8.4
1,1-dichloroethylene	0.2	10	6.3	0.34	0.64
1,1-dichloroethane	0.2	17	10.8	0.87	4.2
cis and/or trans-1,2-dichloroethylene	0.2	27	17.1	2.7	120
1,2-dichloroethane	0.5	4	2.5	1.8	9.8
1,1,1-trichloroethane	0.2	26	16.5	0.93	21
carbon tetrachloride	0.2	6	3.8	0.70	9.4
1,2-dichloropropane	0.2	4	2.5	0.70	18
trichloroethylene	0.2	38	24.1	1.5	130
tetrachloroethylene	0.2	18	11.4	0.66	69
benzene	0.5	3	1.9	2.7	12
toluene	0.5	1	0.6	1.5	1.5
ethylbenzene	0.5	0	0	-	-
bromobenzene	0.5	0	0	-	-
m-xylene	0.2	0	0	-	-
o+p-xylene	0.2	0	0	-	-
p-dichlorobenzene	0.5	0	0	-	-
1,1,2-trichloroethane	0.5	0	0	-	-
1,1,1,2-tetrachloroethane	0.2	0	0	-	-
1,1,2,2-tetrachloroethane	0.5	0	0	-	-
chlorobenzene	0.5	0	0	-	-
1,2-dibromo-3-chloropropane	5.0	0	0	-	-
n-propylbenzene	0.5	0	0	-	-
o-chlorotoluene	0.5	1	0.6	2.4	2.4
p-chlorotoluene	0.5	0	0	-	-
m-dichlorobenzene	0.5	0	0	-	-
o-dichlorobenzene	0.5	1	0.6	2.7	2.7
styrene	0.5	0	0	-	-
isopropylbenzene	0.5	0	0	-	-
chloroform	0.2	100	63.3	2.1	430
bromodichloromethane	0.2	100	63.3	2.2	110
dibromochloromethane	0.5	87	55.1	4.6	51
dichloroiodomethane	1.0	8	5.1	1.2	4.1
bromoform	1.0	60	38.0	5.1	68

[a] All concentrations are in ug/l

[b] 158 sample sites

Table 12

Summary of Multiple Occurrences

Nonrandom Sample

Ground Water Supply Survey
December 1980 - December 1981

Number of Contaminants	Supplies Containing Listed Number of Contaminants			
	Population Category			
	< 10,000		> 10,000	
	No.	%	No.	%
0	249	77.6	99	62.7
1	35	10.9	19	12.0
2	15	4.7	14	8.9
3	11	3.4	7	4.4
4	7	2.2	7	4.4
5	2	0.6	7	4.4
6	0	0	4	2.6
7	1	0.3	1	0.6
8	1	0.3	0	0
	321	100%	158	100%

Table 13

Occurrence of Purgeable Synthetic Organic Contaminants[a] by Population Category and Concentration

Nonrandom Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter[d]	Population	Number of Supplies With Listed Concentration[c]					
		Below QL	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
trichloroethylene (0.2)							
	< 100	35	-	-	-	-	-
	101 - 500	41	2	-	-	-	-
	501 - 1,000	33	-	1	-	-	-
	1,001 - 2,500	69	1	-	1	-	-
	2,501 - 5,000	55	7	-	1	-	-
	5,001 - 10,000	65	8	-	2	-	-
	10,001 - 100,000	104	23	3	6	2	-
	> 100,000	16	2	-	1	-	1
	Total	418	43	4	11	2	1
tetrachloroethylene (0.2)							
	< 100	29	5	1	-	-	-
	101 - 500	41	1	-	1	-	-
	501 - 1,000	31	3	-	-	-	-
	1,001 - 2,500	70	1	-	-	-	-
	2,501 - 5,000	56	5	2	-	-	-
	5,001 - 10,000	67	5	2	1	-	-
	10,001 - 100,000	125	11	1	-	1	-
	> 100,000	15	3	-	2	-	-
	Total	434	34	6	4	1	-
1,1,1-trichloroethane (0.2)							
	< 100	32	3	-	-	-	-
	101 - 500	41	2	-	-	-	-
	501 - 1,000	32	2	-	-	-	-
	1,001 - 2,500	68	3	-	-	-	-
	2,501 - 5,000	53	9	1	-	-	-
	5,001 - 10,000	70	5	-	-	-	-
	10,001 - 100,000	117	18	2	1	-	-
	> 100,000	15	5	-	-	-	-
	Total	428	47	3	1	-	-
cis and/or trans-1,2-dichloroethylene (0.2)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	33	1	-	-	-	-
	1,001 - 2,500	70	1	-	-	-	-
	2,501 - 5,000	60	3	-	-	-	-
	5,001 - 10,000	69	5	-	1	-	-
	10,001 - 100,000	114	16	3	4	-	1
	> 100,000	17	2	1	-	-	-
	Total	441	28	4	5	-	1

Table 13 (Cont'd.)

Occurrence of Purgeable Synthetic Organic Contaminants[a]
by Population Category and Concentration

Nonrandom Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter[d]	Population	Number of Supplies With Listed Concentration[c]					
		Below QL	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
1,1-dichloroethane (0.2)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	32	2	-	-	-	-
	1,001 - 2,500	71	-	-	-	-	-
	2,501 - 5,000	60	3	-	-	-	-
	5,001 - 10,000	74	1	-	-	-	-
	10,001 - 100,000	123	15	-	-	-	-
	> 100,000	18	2	-	-	-	-
	Total	456	23	-	-	-	-
carbon tetrachloride (0.2)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	30	3	-	1	-	-
	1,001 - 2,500	70	1	-	-	-	-
	2,501 - 5,000	61	2	-	-	-	-
	5,001 - 10,000	73	2	-	-	-	-
	10,001 - 100,000	133	4	1	-	-	-
	> 100,000	19	1	-	-	-	-
	Total	464	13	1	1	-	-
1,1-dichloroethylene (0.2)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	32	2	-	-	-	-
	1,001 - 2,500	71	-	-	-	-	-
	2,501 - 5,000	61	2	-	-	-	-
	5,001 - 10,000	74	1	-	-	-	-
	10,001 - 100,000	128	10	-	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	464	15	-	-	-	-
o+p-xylene (0.2)							
	< 100	34	1	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	33	1	-	-	-	-
	1,001 - 2,500	70	1	-	-	-	-
	2,501 - 5,000	59	4	-	-	-	-
	5,001 - 10,000	72	3	-	-	-	-
	10,001 - 100,000	138	-	-	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	469	10	-	-	-	-

Table 13 (Cont'd.)

Occurrence of Purgeable Synthetic Organic Contaminants[a] by Population Category and Concentration

Nonrandom Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter[d]	Population	Number of Supplies With Listed Concentration[c]					
		Below QL	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
bromobenzene (0.5)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	33	1	-	-	-	-
	1,001 - 2,500	71	-	-	-	-	-
	2,501 - 5,000	62	1	-	-	-	-
	5,001 - 10,000	75	-	-	-	-	-
	10,001 - 100,000	138	-	-	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	477	2	-	-	-	-
chlorobenzene (0.5)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	34	-	-	-	-	-
	1,001 - 2,500	70	1	-	-	-	-
	2,501 - 5,000	63	-	-	-	-	-
	5,001 - 10,000	75	-	-	-	-	-
	10,001 - 100,000	138	-	-	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	478	1	-	-	-	-
o-dichlorobenzene (0.5)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	34	-	-	-	-	-
	1,001 - 2,500	70	1	-	-	-	-
	2,501 - 5,000	63	-	-	-	-	-
	5,001 - 10,000	75	-	-	-	-	-
	10,001 - 100,000	137	1	-	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	477	2	-	-	-	-
n-propylbenzene (0.5)							
	< 100	34	1	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	34	-	-	-	-	-
	1,001 - 2,500	71	-	-	-	-	-
	2,501 - 5,000	63	-	-	-	-	-
	5,001 - 10,000	75	-	-	-	-	-
	10,001 - 100,000	138	-	-	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	478	1	-	-	-	-

Table 13 (Cont'd.)

Occurrence of Purgeable Synthetic Organic Contaminants[a]
by Population Category and Concentration

Nonrandom Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter[d]	Population	Number of Supplies With Listed Concentration[c]					
		Below QL	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
1,2-dichloroethane (0.5)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	34	-	-	-	-	-
	1,001 - 2,500	71	-	-	-	-	-
	2,501 - 5,000	61	2	-	-	-	-
	5,001 - 10,000	74	1	-	-	-	-
	10,001 - 100,000	134	3	1	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	472	6	1	-	-	-
m-xylene (0.2)							
	< 100	34	1	-	-	-	-
	101 - 500	42	1	-	-	-	-
	501 - 1,000	33	1	-	-	-	-
	1,001 - 2,500	70	1	-	-	-	-
	2,501 - 5,000	61	2	-	-	-	-
	5,001 - 10,000	73	2	-	-	-	-
	10,001 - 100,000	138	-	-	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	471	8	-	-	-	-
1,2-dichloropropane (0.2)							
	< 100	34	1	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	34	-	-	-	-	-
	1,001 - 2,500	69	2	-	-	-	-
	2,501 - 5,000	63	-	-	-	-	-
	5,001 - 10,000	75	-	-	-	-	-
	10,001 - 100,000	134	3	-	1	-	-
	> 100,000	20	-	-	-	-	-
	Total	472	6	-	1	-	-
benzene (0.5)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	34	-	-	-	-	-
	1,001 - 2,500	70	1	-	-	-	-
	2,501 - 5,000	59	3	-	1	-	-
	5,001 - 10,000	75	-	-	-	-	-
	10,001 - 100,000	135	2	-	1	-	-
	> 100,000	20	-	-	-	-	-
	Total	471	6	-	2	-	-

Table 13 (Cont'd.)

Occurrence of Purgeable Synthetic Organic Contaminants[a]
by Population Category and Concentration

Nonrandom Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter[d]	Population	Number of Supplies With Listed Concentration[c]					
		Below QL	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
toluene (0.5)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	34	-	-	-	-	-
	1,001 - 2,500	70	1	-	-	-	-
	2,501 - 5,000	62	1	-	-	-	-
	5,001 - 10,000	73	2	-	-	-	-
	10,001 - 100,000	137	1	-	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	474	5	-	-	-	-
p-dichlorobenzene (0.5)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	34	-	-	-	-	-
	1,001 - 2,500	70	1	-	-	-	-
	2,501 - 5,000	61	2	-	-	-	-
	5,001 - 10,000	74	1	-	-	-	-
	10,001 - 100,000	138	-	-	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	475	4	-	-	-	-
vinyl chloride (1.0)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	34	-	-	-	-	-
	1,001 - 2,500	71	-	-	-	-	-
	2,501 - 5,000	63	-	-	-	-	-
	5,001 - 10,000	75	-	-	-	-	-
	10,001 - 100,000	132	3	3	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	473	3	3	-	-	-
ethylbenzene (0.5)							
	< 100	35	-	-	-	-	-
	101 - 500	42	1	-	-	-	-
	501 - 1,000	34	-	-	-	-	-
	1,001 - 2,500	70	1	-	-	-	-
	2,501 - 5,000	63	-	-	-	-	-
	5,001 - 10,000	74	1	-	-	-	-
	10,001 - 100,000	138	-	-	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	476	3	-	-	-	-

Table 13 (Cont'd.)

Occurrence of Purgeable Synthetic Organic Contaminants[a] by Population Category and Concentration

Nonrandom Sample[b]

Ground Water Supply Survey
December 1980 - December 1981

Parameter[d]	Population	Number of Supplies With Listed Concentration[c]					
		Below QL	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
o-chlorotoluene (0.5)							
	< 100	35	-	-	-	-	-
	101 - 500	43	-	-	-	-	-
	501 - 1,000	34	-	-	-	-	-
	1,001 - 2,500	71	-	-	-	-	-
	2,501 - 5,000	63	-	-	-	-	-
	5,001 - 10,000	75	-	-	-	-	-
	10,001 - 100,000	137	1	-	-	-	-
	> 100,000	20	-	-	-	-	-
	Total	478	1	-	-	-	-

a Does not include THMs

b 479 supplies

c All concentrations are in ug/l

d Number in parenthesis is the lower quantitation limit, QL, in ug/l

Table 14

Occurrence Data for the Summation of Purgeable Synthetic Organic Contaminants by Population Category and Summed Concentration[a]

Nonrandom Sample

Ground Water Supply Survey
December 1980 - December 1981

	Number of Supplies with Listed Summed Concentration					
Population	Below QL[b]	QL - 5.0	5.1 - 10	11 - 50	51 - 100	> 100
< 100	24	10	1	0	0	0
101 - 500	38	4	0	1	0	0
501 - 1,000	27	5	0	2	0	0
1,001 - 2,500	62	8	0	1	0	0
2,501 - 5,000	43	18	0	2	0	0
5,001 - 10,000	55	12	4	4	0	0
10,001 - 100,000	85	29	6	13	3	2
> 100,000	14	2	0	3	0	1

a Summed concentration is summation of all purgeable synthetic organic contaminants, exclusive of THMs, in ug/l.

b No contaminants found above the quantitation limit.

Table 15

Volatile Organic Contaminants
Found in Original and Resample
City A

Parameter	June 1981	March 1982
1,1-dichloroethane	0.62	0.51
1,1,1-trichloroethane	1.9	1.4
trichloroethylene	0.21	< 0.2
tetrachloroethylene	1.3	0.94

All concentrations ug/l

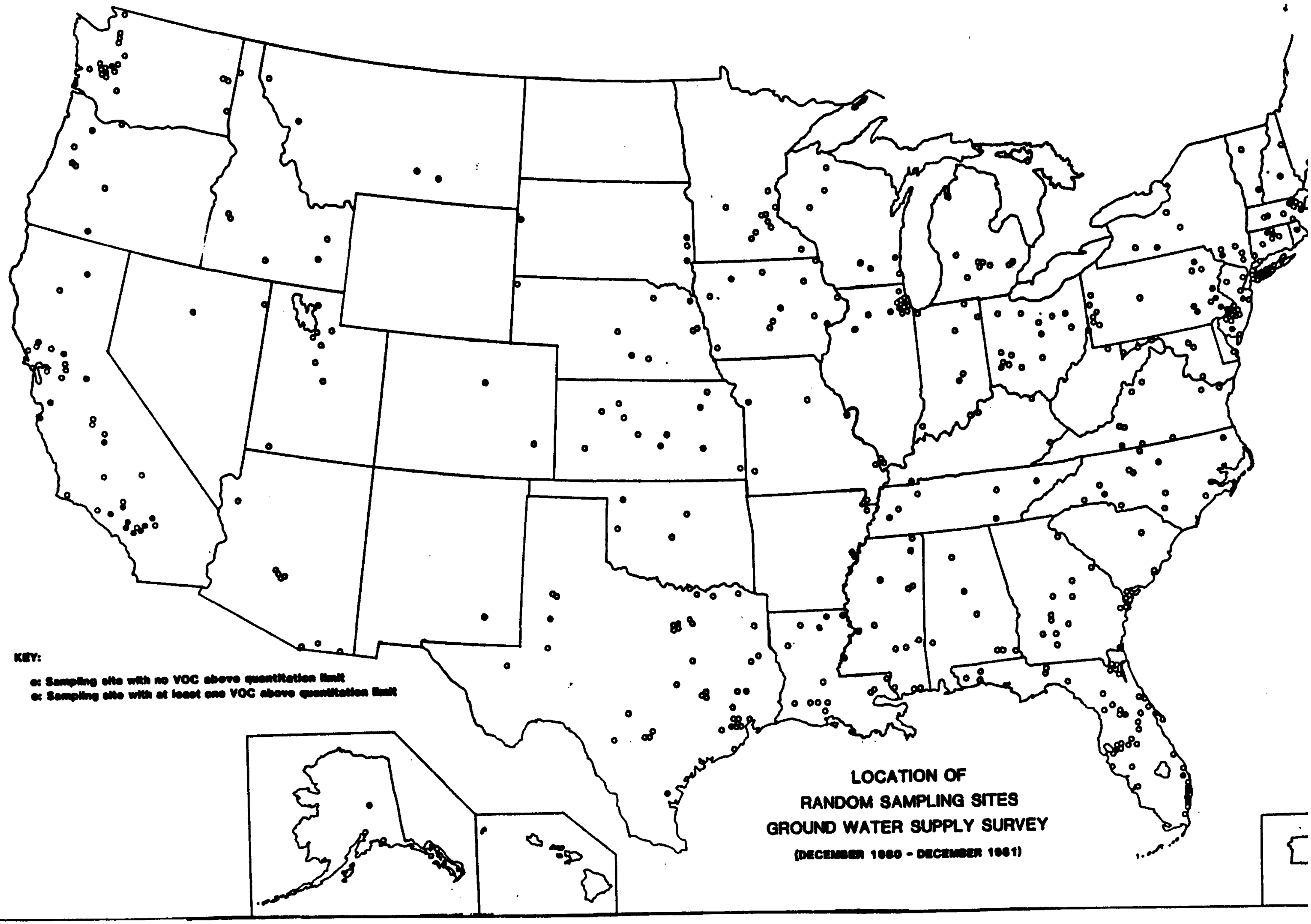
KEY:
o: Sampling site with no VOC above quantitation limit
●: Sampling site with at least one VOC above quantitation limit
LOCATION OF
RANDOM SAMPLING SITES
GROUND WATER SUPPLY SURVEY
(DECEMBER 1980 - DECEMBER 1981)

Figure 1

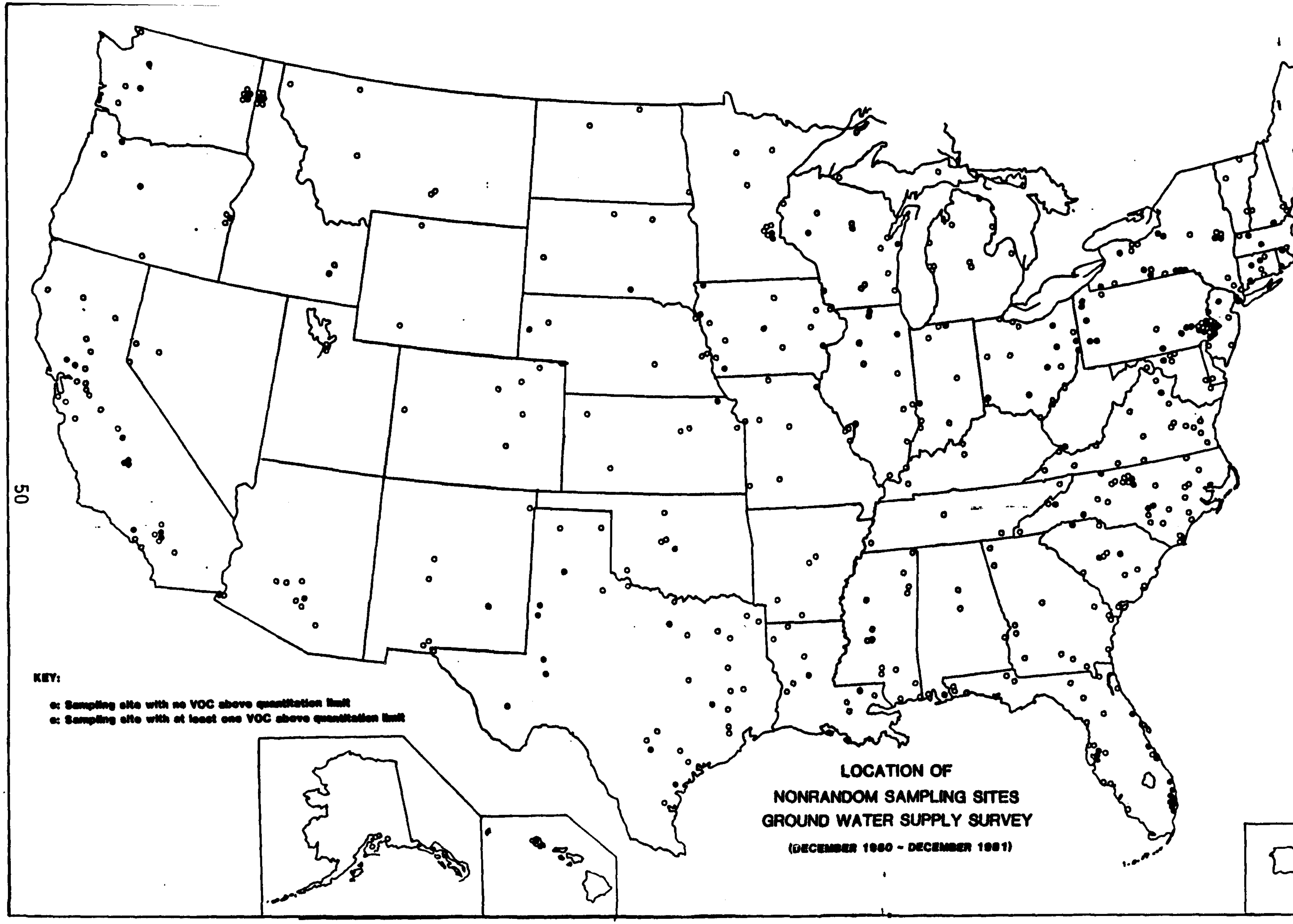
KEY:
o: Sampling site with no VOC above quantitation limit
●: Sampling site with at least one VOC above quantitation limit
LOCATION OF
NONRANDOM SAMPLING SITES
GROUND WATER SUPPLY SURVEY
(DECEMBER 1980 - DECEMBER 1981)

Figure 2