THE OCCURRENCE OF VOLATILE SYNTHETIC ORGANIC CHEMICALS IN DRINKING WATER

SCIENCE AND TECHNOLOGY BRANCH
CRITERIA AND STANDARDS DIVISION
OFFICE OF DRINKING WATER
U.S. ENVIRONMENTAL PROTECTION AGENCY

December, 1981

Preface

This document summarizes the available occurrence data that have been assembled to date on volatile synthetic organic chemical (VOCs) contamination of drinking water. Information is presented on both surface and ground waters but the primary focus is upon VOC contamination of ground waters. The data included are not meant to be represented as a comprehensive data set but rather that which the Office of Drinking Water has been able to collect and assemble at this time. Data collection efforts are continuing and the reader is requested to provide any additional information and data that might be available.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

VOLATILE SYNTHETIC ORGANIC CHEMICAL CONTAMINATION OF DRINKING WATER

Analytical techniques now permit detection of organic contaminants in water at low levels. This enhanced analytical capability has resulted in the detection of contamination by a number of synthetic organic chemicals in both surface and ground sources of drinking water.

The widespread occurrence of organic chemicals in drinking water is of concern because of the potential health risks associated with human exposure to them. Several of these chemicals are suspected carcinogens, others are known mutagens and/or teratogens. Available data show that one class of compounds, termed volatile synthetic organic chemicals (VOCs), occur in both surface waters and ground waters. Surface waters, when contaminated, are typically contaminated by a broad spectrum of synthetic organic chemicals at relatively low concentrations while ground waters can be subject to contamination by one, two or several discrete compounds, sometimes at high concentrations.

Ground water has generally been viewed as a pristine resource, unspoiled by human activities. The contamination of ground water by synthetic organic chemicals was viewed as a series of isolated problems caused by the accidental "mishandling" of chemicals. The results of EPA surveys and the efforts of many states have changed the perception of ground water quality. Typically, major treatment is not considered necessary for drinking water drawn from ground water sources and treatment is generally not used. Over 100 million people currently use ground water as their source of drinking water; approximately 50,000 public water systems and over 11 million private wells draw upon ground water sources. Contamination of ground water with volatile organics has been most common in urban or industrial areas. Such contamination is generally believed to be a result of improper surface or underground disposal of hazardous waste from industrial activities. A ground water, once contaminated, is likely to remain so for a long period of time, since no natural cleansing processes are known to be associated with its movement within the earth.

Since the passage of the Safe Drinking Water Act, EPA has initiated six major national monitoring efforts to gain perspective on the frequency and intensity of organic chemical contamination of drinking water supplies. The surveys include:

- National Organics Reconnaisance Survey (NORS)
- National Organics Monitoring Survey (NOMS)
- National Screening Program for Organics in Drinking Water (NSP)
- Community Water Supply Survey (CWSS)
- Rural Water Survey (RWS)
- Ground Water Supply Survey (GWSS)

Each survey focused on different sources of water, different segments of the population and different chemical pollutants. The number of systems sampled and chemicals that were analyzed in each survey are shown in the Appendix. The results of four surveys, NORS, NOMS, NSP and CWSS, form the basis of the current knowledge about the occurrence of volatile synthetic organic chemicals in the nation's drinking water supplies. Two other limited surveys have also been conducted and are referenced in several tables in this document as the "Region V Survey" and the "OTS survey." Results from the CWSS represent the best available data at this time showing a national picture of the occurrence of VOCs in drinking water from ground water sources. However, EPA initiated the GWSS to provide a "statistically unbiased national view" of how frequently public supplies using ground water sources are contaminated by VOCs.

The GWSS includes sampling of approximately 1,000 public water supply systems served by ground water supplies. The objective of this survey is to further assess the frequency and intensity of volatile organic chemical contamination in the nation's ground water supplies. The final results are expected in 1982. Results of the RWS will describe the quality of well water serving individual homes and small communities and will be available around March 1982.

Data from state agencies and EPA regional offices show that most of the public water supplies drawing from wells are free of VOCs. However, the results of nationwide studies indicate that there are numerous examples of VOC contamination of ground water. Current data on ground water contamination points towards a potential for continued deterioration of the drinking water quality of many wells across the United States. Volatile organic chemicals have been found in drinking water supplies in 46 states. The CWSS found that 13 of 29 samples taken from ground waters serving communities over 10,000 people had detectable levels of some VOCs. Thirty seven of 301 samples from wells in communities serving less than 10,000 people using ground water had detectable levels of some VOC. For the great majority of these systems, contamination was at the low ug/l level. However, according to other data collected by state agencies, the level of contamination in well water can be extremely high. Indeed, in one case as much as 35,000 ug/l of trichloroethylene was detected.

Data are limited, but several comprehensive state surveys have shown that ground water contamination can be locally intense. Maine, testing all ground water supplies, reported that 19 of 87 municipal wells contained one or more VOCs. California, testing 296 wells in the San Gabriel Valley, found that 210 contained at least a trace quantity of trichloroethylene or tetrachloroethylene. In 1977, the Connecticut legislature directed the Department of Health Services to monitor the organic chemical content of all public water supplies to determine what potential carcinogens were present. This testing program resulted in the detection of VOCs, including TTHMS, in 87 percent of the wells tested serving populations of 1,000 or more persons. This percentage is based upon testing wells used by 78 of the 95 utilities.

Forty-four communities in Massachusetts have had some of their public water supply wells severely contaminated with one or more VOCs, while it is known that at least 16 incidents have occurred in Connecticut, 25 in Pennsylvania, 12 in New York and one or more in at least 40 other States.

This document presents the available data accumulated to date on the occurrence of VOCs in drinking water supplies. The VOCs that appear to be found most frequently include the following:

- trichloroethylene
- tetrachloroethylene
- carbon tetrachloride
- 1,1,1-trichloroethane
- 1,2-dichloroethane
- vinyl chloride
- methylene chloride
- trichlorobenzene
- 1,1-dichloroethylene
- cis-1,2-dichloroethylene
- trans-1,2-dichloroethylene
- benzene
- chlorobenzene
- dichlorobenzene

Tables 1 and 2 provide an overview of the occurrence of several VOCs in finished surface water and groundwater, respectively, obtained from EPA surveys.

Finished drinking water may simultaneously contain a number of VOCs. One hundred thirty-six drinking water supplies drawing water from surface waters tested by EPA were found to contain one or more volatile organic compounds in one collected sample. Water samples from 35 of these sites contained two volatile organics simultaneously. An additional 33 of these sites contained three or more of these chemicals. As shown in Table 1, the concentration of each individual chemical was generally at low microgram per liter levels (e.g. trichloroethylene: the maximum level detected in the 43 positive samples of a total of 133 sampled was 3.2 ug/l.). Recognizing that the data are limited, comparison of the Tables 1 and 2 in general, shows a higher frequency of occurrence in surface waters but higher levels of VOCs in ground waters. Contamination, when found, is commonly much less than 10 ug/l with smaller percentages in the 10 to 100 ug/l and 100 to 1,000 ug/l ranges, respectively. The State data, in particular, reflect noticeably higher levels of contamination than the EPA surveys. This would be expected since State sampling is often in response to a specific problem, such as a spill or citizen complaints of taste and odor problems. The finding of one of these compounds, regardless of level, is a concern since these compounds are man-made chemicals not normally present in the environment, and their presence indicates the potential for further contamination of that source of drinking water.

The discussion that follows in this document is limited to six compounds for which data are currently available: trichloroethylene, tetrachloroethylene, carbon tetrachloride, 1,1,1-trichloroethane, 1,2-dichloroethane and vinyl chloride. Similar data are being assembled and evaluated for all of the other listed compounds. Discussions of the occurrence of VOCs in air and food and the possible relative contribution to total exposure from air, food, and water are included in the draft health criteria documents for each VOC. An exposure assessment has not yet been conducted but will be part of future analyses.

The data in this report comes from studies that were carried out by the Environmental Protection Agency over the last six years. In interpreting this data, the reader is cautioned that extrapolations of this data should be made in the context of the individual study. Generalizations above that made in this report, or applications of this data to specific situations, should not be made without reference to specific protocols used in each individual study. For example, the quality of the analytical instrumentation has improved over the period of these studies and therefore the lower limit of detection has decreased and the precision and accuracy has increased. Therefore, the later studies may have reported values that could not be detected in earlier studies. Other issues may include single "grab" samples being taken from systems which might have had several wells or sources of water. Also, as systems may have made changes in water sources and treatment methods, the present water quality may be significantly different from the quality at the time of sampling and analysis. These and similar study characteristics have been included in the following discussion, but the reader is referenced to the individual studies in making additional interpretations of the data.

TABLE 1

OCCURRENCE OF SELECTED VOCs IN
FINISHED SURFACE WATER (EPA SURVEYS)

	# SITES SAMPLED	% POSITIVE SAMPLES	MEAN* ug/l	MAX. ug/l
TRICHLOROETHYLENE	133	32.3	0.47	3.2
CARBON TETRACHLORIDE	144	35.7	3.46	30
TETRACHLOROETHYLENE	180	12.8	1.49	21
1,2-DICHLOROETHANE	196	13.8	0.93	4.8
1,1,1-TRICHLOROETHANE	133	16.5	0.56	3.3
CIS-, TRANS-, AND 1,1-DICHLOROETHYLENE	103	4.9	0.66	2.2
METHYLENE CHLORIDE	178	18.0	1.8	13
VINYL CHLORIDE	133	2.3	3.43	9.8

*Of the positive samples

TABLE 2

OCCURRENCE OF SELECTED VOCs IN
FINISHED GROUND WATER - (EPA SURVEYS)

	# SITES SAMPLED	% POSITIVE SAMPLES	MEAN* ug/l	MAX.CONC. ug/l
TRICHLOROETHYLENE	402	4.0	24.8	210
CARBON TETRACHLORIDE	432	3.0	1.7	13
TETRACHLOROETHYLENE	413	5.6	2.8	30
1,2-DICHLOROETHANE	418	1.9	0.6	1.2
1,1,1-TRICHLOROETHANE	399	4.5	30.0	650
CIS-, TRANS-, AND 1,1-DICHLOROETHYLENE	390	3.3	10.4	82
METHYLENE CHLORIDE	38	2.8	7.0	7.0
VINYL CHLORIDE	25	4.0	76	76

*Of the positive samples

Trichloroethylene

Trichloroethylene (TCE) is a high volume industrial chemical which is used extensively as a solvent for degreasing metals. In 1978 over 301 million pounds of this chemical were produced in the United States. TCE is a component of many commercial and consumer products. Because TCE is volatile, it is readily lost into the environment at points of manufacture, use or disposal. An estimated 267 million pounds were released to the environment in 1978. TCE is only produced synthetically; it is not a naturally occuring substance.

Trichloroethylene in air is broken down by ultraviolet light and decomposes by reacting with free radicals such as NOx. The calculated half-life of TCE in air ranges from 2 to 42 days. TCE is soluble in fats and therefore can enter the food chain and can be passed along to higher organisms through the consumption of fatty foods. TCE spilled into porous soil can move downward toward ground water and contaminate an aquifer. The reported half-life of TCE in water is between 7 and 30 months.

Levels in Drinking Water

The reported levels of trichloroethylene in drinking water are summarized in Table 3. A total of 133 locations using surface water supplies have been sampled during EPA surveys. The finished waters serving 43 of these sites were found to contain some TCE. The concentration of TCE in these water supplies ranged from 0.06 to 3.2 ug/l. The average concentration in positive water supplies was 0.47 ug/l. Forty supplies contained a level of TCE which was below 1 ug/l. Three of the supplies contained a concentration between 1 to 3.2 ug/l (Figure 1).

A total of 25 locations that draw water from ground water sources were sampled for TCE during the NOMS, NORS, NSP and EPA Region V surveys. Nine of these finished waters were found to contain detectable concentrations of this chemical. The median level detected was 0.31 ug/l with a range from 0.11 to 53.0 ug/l.

The Community Water Supply Survey examined an additional 330 ground water systems selected randomly from across the country. Four percent of these systems were found to contain a detectable level of trichloroethylene. TCE was found in finished water from small and large systems alike. However, 3 of 29 of the systems serving 10,000 to 100,000 people were reportedly positive while only 3 of 156 of these serving 25 to 500 population group were positive.

State-supplied data show one case where a well contained as much as 35,000 ug/l of TCE. The greatest concentration of TCE reported in New Jersey was 1,900 ug/l yet the mean was 90.2 ug/l.

Table 3

Levels of Trichloroethylene in Drinking Water

Survey	# Sampled	Positive	Range
State Data ***	2894	810	Tr-35,000 ug/l
NOMS**	113	16	0.2-49.0 ug/l
NSP*	142	36	Tr-53 ug/l
CWSS	452	15	0.5-210 ug/l

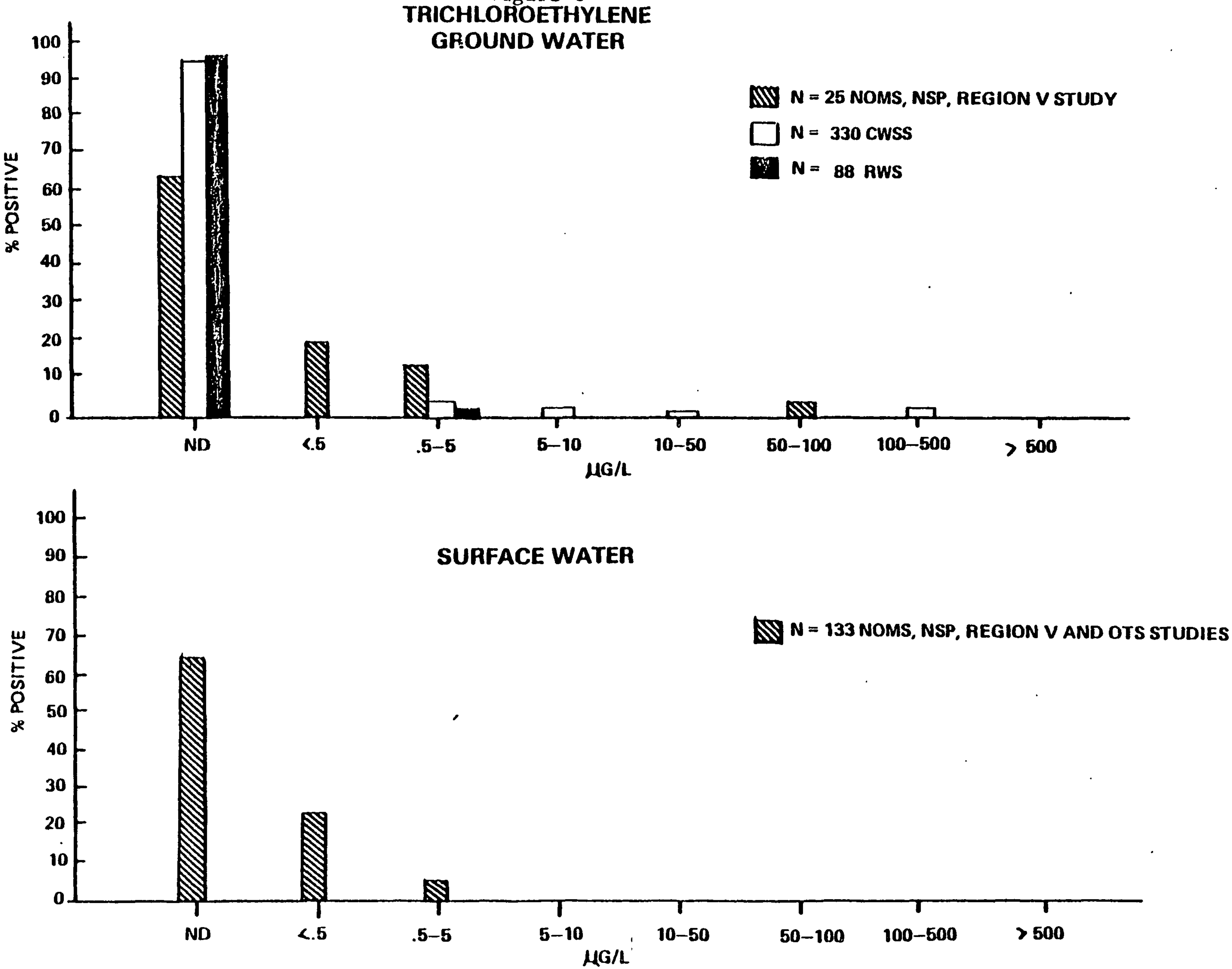
* G.C. single column tentative identification, preliminary data

** Average of phases 1, 2, 3, quenched and terminal

*** May include well water not used for drinking water supply

State data is based on ground water sampling only; all other surveys include both ground and surface water sources.

Figure 1


TRICHLOROETHYLENE
GROUND WATER
N = 25 NOMS, NSP, REGION V STUDY
N = 330 CWSS
N = 88 RWS
% POSITIVE
100
90
80
70
60
50
40
30
20
10
0
ND
<.5
.5–5
5–10
10–50
50–100
100–500
> 500
μG/L
SURFACE WATER
N = 133 NOMS, NSP, REGION V AND OTS STUDIES
% POSITIVE
100
90
80
70
60
50
40
30
20
10
0
ND
<.5
.5–5
5–10
10–50
50–100
100–500
> 500
μG/L

Tetrachloroethylene

Tetrachloroethylene (PCE) is a chlorinated industrial chemical that is used for scouring and dry cleaning textiles, degreasing metal, fluorocarbon production, aerosols, speciality laundry treatment and anthelminthic medicinals. Tetrachloroethylene is an ingredient in 33 pesticide formulations used in fogging machines, livestock sprays and dips, household sprays, moth proofers, fly sprays and fumigating gases. In 1978, over 725 million pounds of PCE were produced at 11 plants in the United States. It has been estimated that nearly 606 million pounds of PCE were liberated into the environment in 1978. The half-life of PCE in air is estimated to be between 1 and 27 days. Sunlight hastens the breakdown of tetrachloroethylene and while accumulation in the upper atmosphere is limited, the concentration in ambient air can increase when air movement is limited. PCE spilled into surface waters will evaporate into the air in less than one week. However, PCE trapped in the soil or contaminating ground water will remain as a contaminant for years or decades.

Levels in Drinking Water

Forty-three of 180 surface supplies were found to contain at least a trace quantity of PCE. The vast majority of these were found to contain less than 3 ug/l.

The degree of contamination of underground aquifers is not clearly known. Prior to 1980, a limited number of public water systems (36) using ground water were included in EPA studies. Nine of these sources were found to contain a measurable quantity of PCE. The majority of these public water systems were found to contain less than 3 ug/l of PCE in their finished product, but one system showed levels of contamination above 30 ug/l.

Since then, the Community Water Supply Survey has sampled an additional 330 public water supplies which use ground water. Eighteen were found to have detectable levels of PCE, ranging from 0.5 ug/l to 30 ug/l. It appears that systems serving greater than 10,000 persons may be contaminated more frequently than smaller size systems (i.e., 4 of 29 showed evidence of contamination).

Data reportedly collected by state agencies shows that 231 of the 1600 plus wells tested across the country have been found to be positive for PCE; the maximum level of contamination approached 3,000 ug/l. Ten of sixteen States which have looked for tetrachloroethylene have found detectable levels. In New Jersey, 22 of 160 wells tested contained tetrachloroethylene. The maximum value of the positives was 90.6 ug/l, and the mean was 6.4 ug/l. Available data are summarized in Table 4 and Figure 2.

Table 4

Levels of Tetrachloroethylene in Drinking Water

Survey	# Sampled	# Positive	Range
State data ***	1652	231	Tr-3,000 ug/l
NOMS**	113	22	Tr-3.1 ug/l
NSP*	142	24	Tr-3.2 ug/l
CWSS	452	22	0.5-30 ug/l

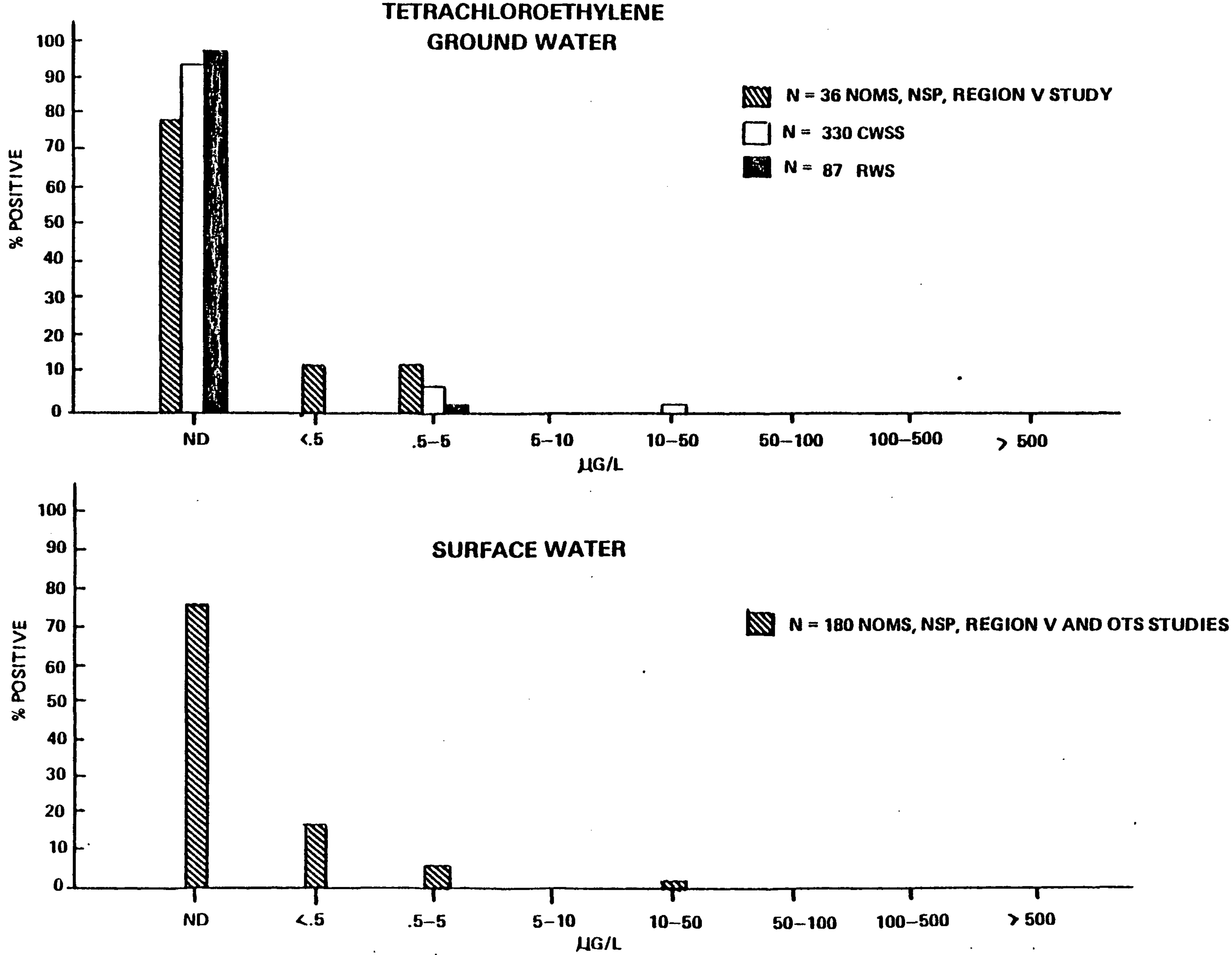
* G.C. single column identification, preliminary data

** Average of phases 1, 2, 3, quenched and terminal

*** May include well water not used for drinking water supply

State data is based on ground water sampling only; all other survey data includes both ground and surface water sources.

Figure 2



TETRACHLOROETHYLENE
GROUND WATER
% POSITIVE
N = 36 NOMS, NSP, REGION V STUDY
N = 330 CWSS
N = 87 RWS
ND
<.5
.5–5
5–10
10–50
50–100
100–500
> 500
µG/L
SURFACE WATER
% POSITIVE
N = 180 NOMS, NSP, REGION V AND OTS STUDIES
ND
<.5
.5–5
5–10
10–50
50–100
100–500
> 500
µG/L

Carbon Tetrachloride

In 1978, approximately 739 million pounds of carbon tetrachloride were produced at 7 sites in the United States. The bulk of this product was used as a starting material in manufacture of fluorocarbon aerosol propellants. On October 15, 1978 FDA and EPA banned the manufacture of fluorocarbons for the aerosol market. These federal regulations may have resulted in a marked decline in the production of carbon tetrachloride.

Historically, carbon tetrachloride has had a wide range of applications. Since the 19th century, it has been used extensively as an industrial chemical solvent, a metal degreaser, a dry cleaning fluid and an ingredient in fire extinguishers. Carbon tetrachloride can be a trace contaminant in chlorine.

EPA currently registers over 140 pesticidal products containing carbon tetrachloride. In 1973 nearly 50 million pounds of carbon tetrachloride were used as a fumigant to kill insects in grains, households furnishings and fabrics. In 1977-78, over 19 million pounds of carbon tetrachloride were used to fumigate grains off of farms; an additional 3.5 million pounds were used on the farm.

An estimated 96 million pounds of carbon tetrachloride were released to the environment in 1978. Because of its volatility, most of this carbon tetrachloride ends up in air. Although carbon tetrachloride is extremely stable in water the evaporative half-life of carbon tetrachloride in water at ambient temperatures is only minutes. Carbon tetrachloride is highly soluble in organic matter and therefore accumulates slightly in plant and animal tissue.

Levels in Drinking Water

Carbon tetrachloride is a relatively common contaminant of finished drinking water. Of the systems tested in EPA surveys which drew water from surface waters, 110 were found to contain some level of carbon tetrachloride. On occasion, the concentration of carbon tetrachloride was found to be in excess of 10 ug/l. However, some of the surface water data relates to a number of cases of carbon tetrachloride contamination of effluent discharges that are now known to no longer exist. Some wells have also been found to be contaminated with carbon tetrachloride. In an initial sampling of systems providing ground water to large cities, carbon tetrachloride was observed in treated well water for 9 of 39 systems. However, of the 330 ground water systems studied during the Community Water Supply Survey, only 6 were found to be contaminated. State data reveals that higher levels of contamination do occur. In New Jersey, 94 wells out of 394 tested were found to contain carbon tetrachloride. The maximum value was over 100 ug/l.

Available data concerning carbon tetrachloride are summarized in Table 5 and Figure 3.

Table 5

Levels of Carbon Tetrachloride in Drinking Water

Survey	# Sampled	# Positive	Range
State data ***	1659	166	Tr-170ug/l
NOMS**	113	8	0.2-29 ug/l
NSP*	142	37	Tr-30 ug/l
CWSS	452	9	.5-2.8 ug/l

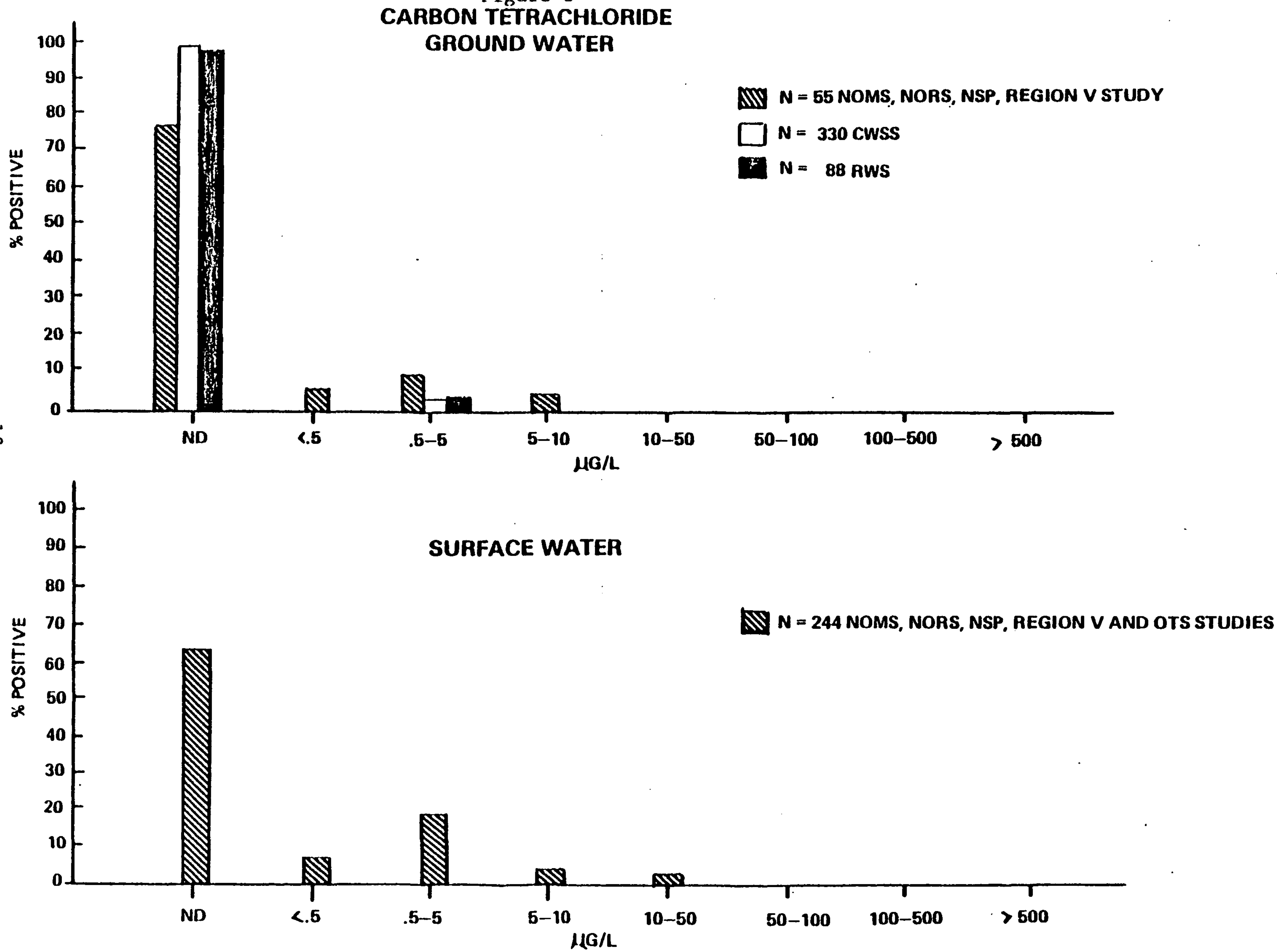
* G.C. single column tentative identification, preliminary data

** Average of phases 1, 2, 3, quenched and terminal

*** May include well water not used for drinking water supply

State data is based on ground water sampling only; all other surveys include both ground and surface water sources.

Figure 3


CARBON TETRACHLORIDE
GROUND WATER
% POSITIVE
N = 55 NOMS, NORS, NSP, REGION V STUDY
N = 330 CWSS
N = 88 RWS
ND
<.5
.5–5
5–10
10–50
50–100
100–500
> 500
µG/L
SURFACE WATER
% POSITIVE
N = 244 NOMS, NORS, NSP, REGION V AND OTS STUDIES
ND
<.5
.5–5
5–10
10–50
50–100
100–500
> 500
µG/L

1,1,1-Trichloroethane (Methyl Chloroform)

Methyl chloroform is a volatile organic compound which is used primarily for metal cleaning, leather tanning, and as a vapor depressant in aerosols and a solvent for adhesives, inks, drain cleaners and pharmaceuticals. In 1978 over 625,000 million pounds of this compound were manufactured in the United States and an estimated 533 million pounds were released to the environment. It has been estimated that over 88 percent of the environmental emissions go directly into the air.

The major process for removing methyl chloroform from the atmosphere appears to be photodegradation. The estimated half-life for this compound in the troposphere is 4 to 12 years. Methyl chloroform is fat soluble and can be incorporated into plant and animal tissue. Methyl chloroform is not highly water soluble, but can move through soil to become a ground water contaminant.

Levels in Drinking Water

Methyl chloroform has been detected in 33 of the 133 samples of finished drinking water analyzed in the NOMS, NSP, and Region V monitoring surveys conducted by EPA. These data indicate that the concentrations in ground and surface water are generally in the low ug/l range. Results from the Community Water Supply Survey showed that 3 of 106 surface water samples and 15 of 330 ground water water samples contained methyl chloroform. However, data from state agencies indicate that some wells supplying potable water have become highly contaminated with levels of methyl chloroform as high as 401,300 ug/l being reported.

Available data concerning 1,1,1-trichloroethane are summarized in Table 6 and Figure 4.

Table 6

Levels of 1,1,1-Trichloroethane in Drinking Water

Survey	# Sampled	# Positive	Range
State Data ***	1611	370	Tr-401,300 ug/l
NOMS**	113	9	Tr-1.3 ug/l
NSP*	142	32	Tr-21 ug/l
CWSS	452	19	0.5-650 ug/l

* G.C. single column tentative identification, preliminary data

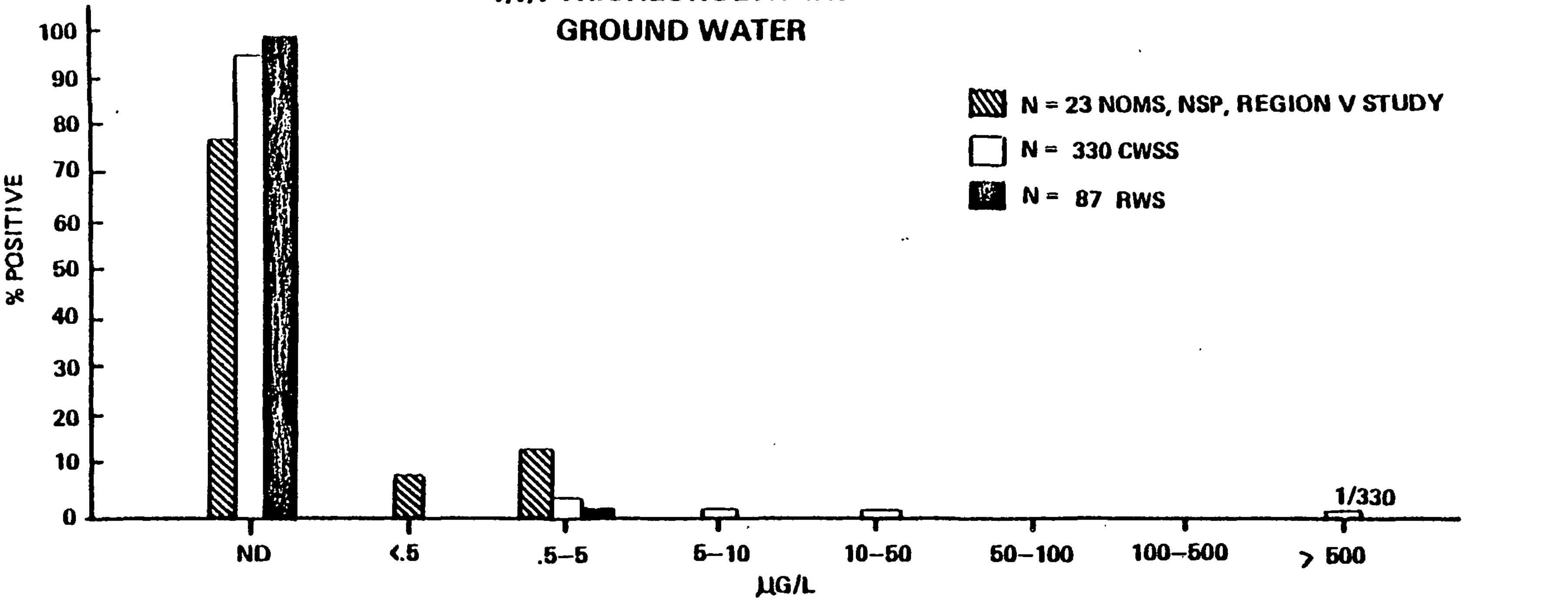
** Average of phases 1, 2, 3, quenched and terminal

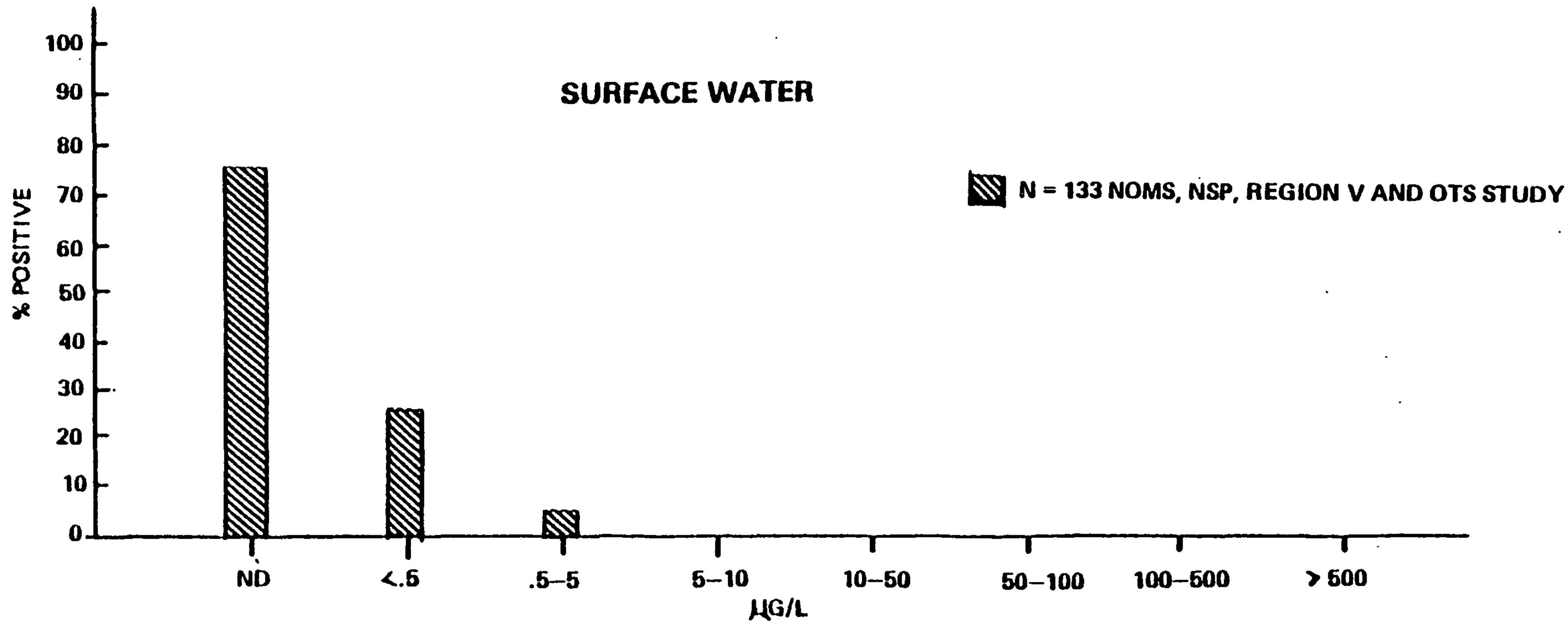
*** May include well water not used for drinking water supply

State data is based on ground water sampling only; all other surveys include both ground and surface water sources.

Figure 4

1,1,1-TRICHLOROETHANE





1,2-Dichloroethane (ethylene dichloride) (DCE)

DCE is the largest volume chlorinated organic chemical in production in the United States. Eleven billion pounds of DCE were produced in the United States in 1977. It is estimated that nearly 10 percent of the amount produced enters the environment at production, use and disposal sites across the nation.

A large amount of the DCE produced in the United States is used as a raw material to produce vinyl chloride monomer, vinylidene chloride, trichloroethylene, 1,1,1-trichloroethane (methyl chloroform), perchloroethylene and ethyleneamines. In 1977, it was estimated that nearly 96 percent of the DCE production was used as an intermediate or a gasoline additive. It was also used as a solvent for paints and coating, an extraction solvent, a cleaning solvent, a pesticide and in color film production.

DCE is highly volatile having an evaporation rate that is approximately 78 percent that of either carbon tetrachloride or gasoline. DCE can combine with water to form an azeotrope which distills at 71.9 C. DCE is fairly soluble in water but is preferentially taken up in organic media.

Levels in Drinking Water

To date, water from 196 public water systems using surface water have been included in EPA monitoring programs. DCE has been found in 7 of those samples. The highest concentration of DCE found was 4.3 ug/l. Most samples recorded as positive contained less than 1.0 ug/l. Recent data from an additional 211 utilities failed to detect DCE.

DCE has also been reported as a contaminant in well water analyzed from eight States, the majority of positive samples being from northeastern States. Eighty-four of the 1,200 well water samples analyzed by various state agencies have found DCE in finished drinking water.

A maximum concentration of 400 ug/l in well water has been reported by state agencies. However, the next highest concentration found was 100 ug/l and the third highest was 18.2 ug/l. Of the 12 States that have undertaken programs to detect 1,2-dichloroethane in drinking water, eight States have reported finding some evidence of contamination. Initial data from EPA surveys show that only one of the 25 ground water supplies sampled contained DCE with the concentration being approximately 0.2 ug/l.

In addition to those EPA studies, the Community Water Supply Survey examined 329 public ground water supply systems and found only four which contained DCE. The maximum value reported in this study was 1.8 ug/l.

Available data concerning 1,2-dichloroethane are summarized in Table 7 and Figure 5.

Table 7

Levels of 1,2-Dichloroethane in Drinking Water

Survey	# Sampled	#Positive	Range
State Data***	1212	85	Tr-400 ug/l
NOMS**	113	2	1.2-1.8 ug/l
NSP*	142	2	Tr-4.8 ug/l
CWSS	451	4	0.5-1.8 ug/l

* G.C. single column tentative identification, preliminary data

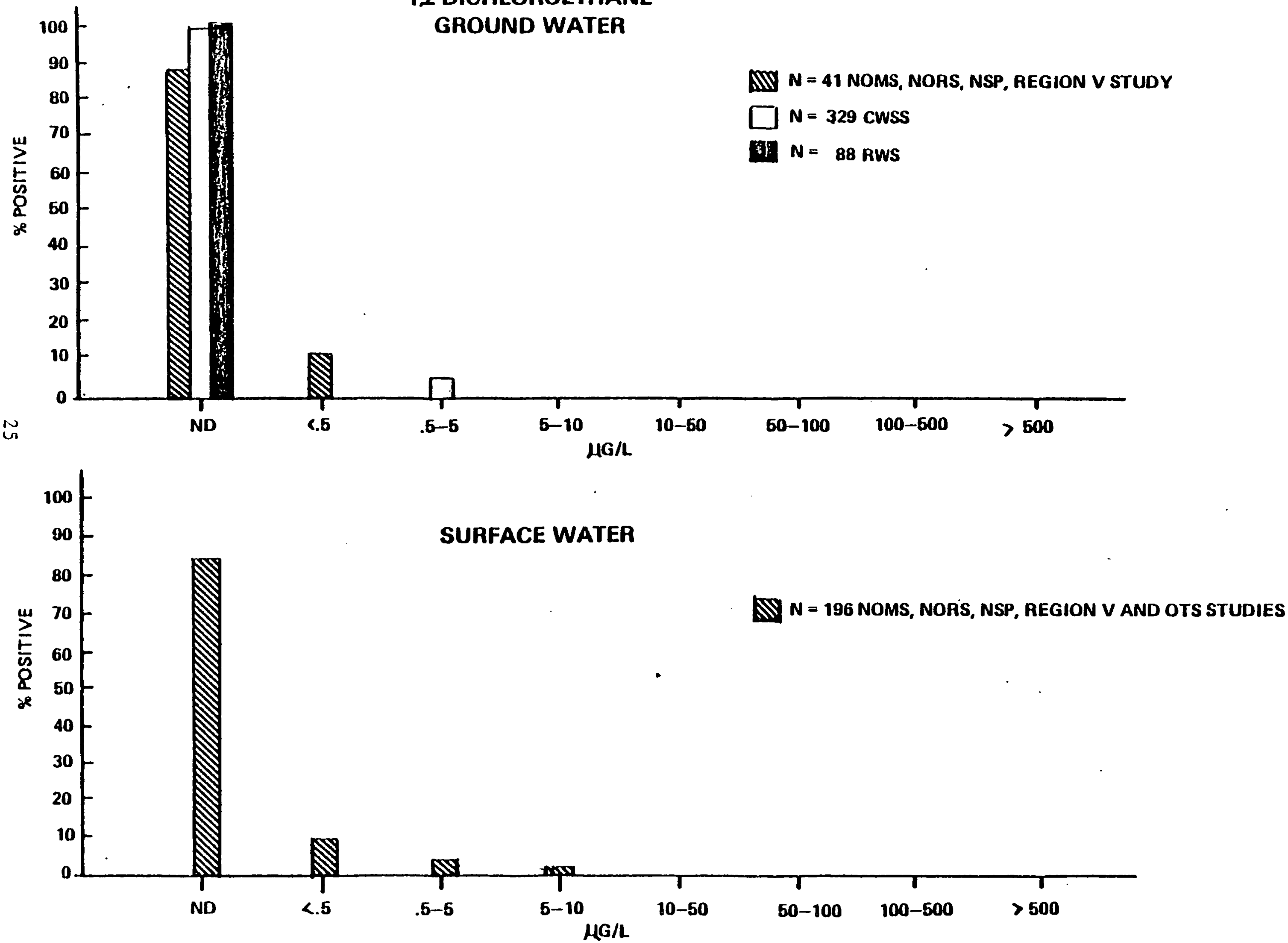
** Average of phases 1, 2, 3, quenched and terminal

*** May include well water not used for drinking water supply

State data is based on ground water sampling only; all other surveys include both surface and ground water sources.

Figure 5

1,2-DICHLOROETHANE



Vinyl Chloride

In 1975 nearly 7 billion pounds of vinyl chloride monomer, (VC) were produced in the United States. Polyvinyl chloride (PVC), a resin used for consumer and industrial products, is produced from VC. According to the National Occupational Hazard Survey, vinyl chloride is released into the work environment at 1,400 to 36,000 plant sites across the country. The high volatility of vinyl chloride allows it to enter the environment from a number of sources, including VC and PVC plants. The trapped vinyl chloride monomer, is also easily liberated from PVC products, as well as industrial wastes.

Levels in Drinking Water

VC was found in 3 of the 133 cities which draw upon surface waters for potable water that have been sampled during EPA surveys. The concentration ranged from 0.1 to 9.8 ug/l. The mean concentration in finished water from positive supplies was 3.4 ug/l.

A total of 25 cities that get their water from ground water sources have been tested by EPA surveys for the presence of VC. Only three of these finished waters were found to contain a detectable level of vinyl chloride. The highest level detected was 76 ug/l. However, State supplied data has shown that contaminated ground water supplies may contain as much as 380 ug/l.

Available data concerning vinyl chloride are summarized in Table 8 and Figure 6.

Table 8

Levels of Vinyl Chloride in Drinking Water

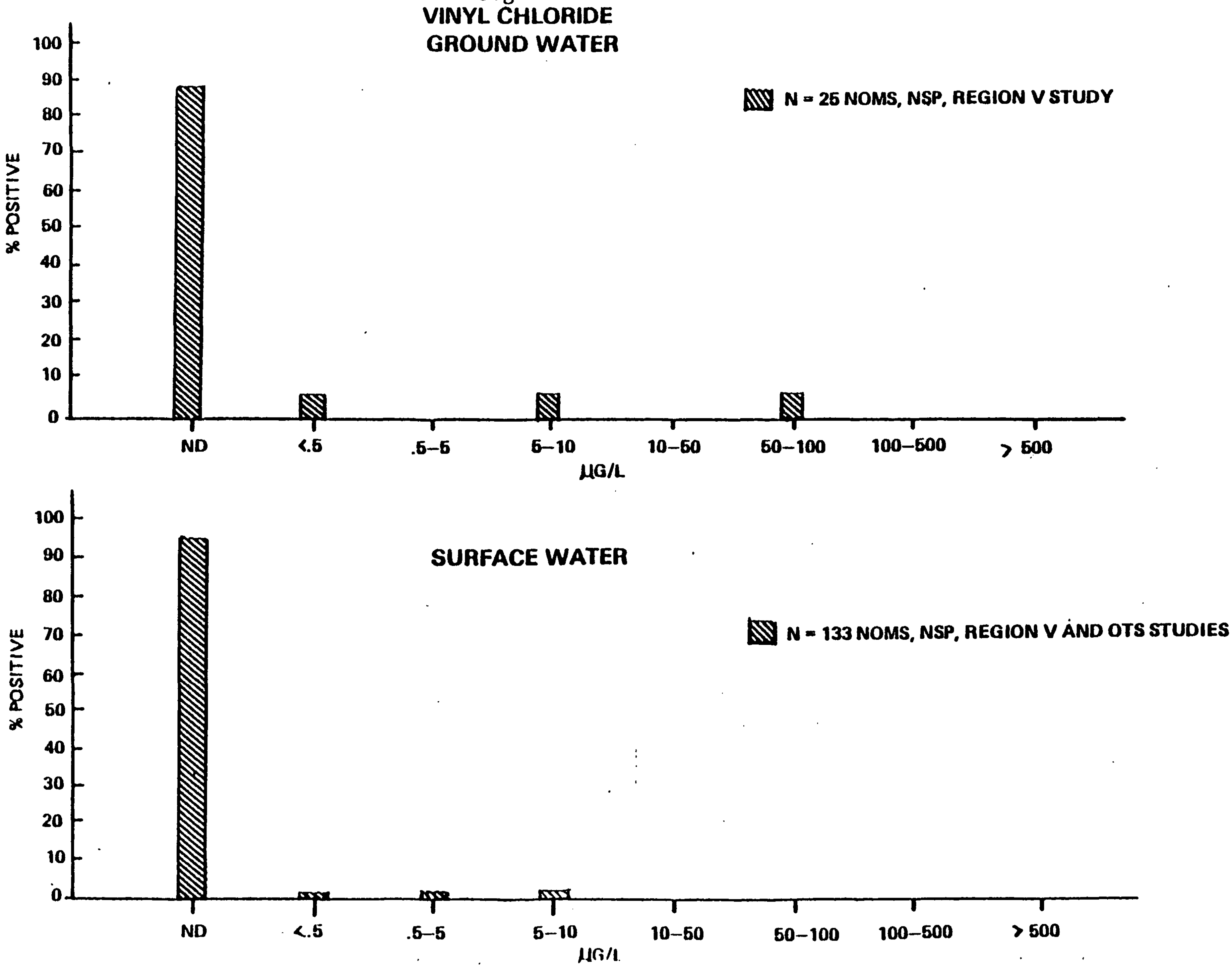
Survey	# Sampled	# Positive	Range
State Data	1033	73	Tr-380 ug/l
NOMS*	113	2	0.1-0.18 ug/l
NSP**	133	6	Trace-76 ug/l

* Average of phases 1, 2, 3, quenched and terminal

** GC single column tentative identification, preliminary data

State data is based on ground water sampling only; all other surveys include both ground and surface water sources.

Figure 6


VINYL CHLORIDE
GROUND WATER
% POSITIVE
100
90
80
70
60
50
40
30
20
10
0
N = 25 NOMS, NSP, REGION V STUDY
ND
<.5
.5–5
5–10
10–50
50–100
100–500
> 500
µG/L
SURFACE WATER
% POSITIVE
100
90
80
70
60
50
40
30
20
10
0
N = 133 NOMS, NSP, REGION V AND OTS STUDIES
ND
<.5
.5–5
5–10
10–50
50–100
100–500
> 500
µG/L

Occurrence Data from State Surveys

A number of States have conducted comprehensive surveys of public water systems within their boundaries for the purpose of assessing VOC contamination of drinking water. In addition, several States have conducted limited surveys of certain water systems in response to incidences of spills or citizen complaints of poor water quality. Several of these surveys and resulting data are discussed briefly in the following sections.

In general, the state data are extremely limited; all state data compiled thus far are from secondary sources. No verifications are currently available; the conditions of sampling, analysis and quality control are unknown. Table 9 summarizes these data. The data and following discussion do not represent a national picture since comprehensive State surveys were available for very few States. The objective is to portray the data that are available and attempt to provide some idea of the contamination characteristics of incidences of VOCs in drinking water.

Examples of State surveys from several States are provided below:

New Jersey

In a March 1981 report entitled, "Ground Water Quality in New Jersey," reported the results of state sampling surveys of 670 wells (including potable, industrial and monitoring wells). Fifty chemicals were looked for including VOCs, pesticides, and metals. One or more of eight VOCs were found at concentrations above 10 ug/l in 111 of the wells tested (includes chloroform). In 21 of the wells, one or more of the eight VOCs were above 100 ug/l. These results are shown in Table 10 (excluding chloroform). Several other VOCs were looked for but were found much less frequently as shown in Table 11.

TABLE 9

SUMMARY OF STATE DATA

CHEMICAL	# STATES TESTED	# WELLS* TESTED	% POSITIVE**	MAX. ug/l
TRICHLOROETHYLENE	8	2894	28	35,000
CARBON TETRACHLORIDE	4	1659	10	379
TETRACHLOROETHYLENE	5	1652	14	50
1,2-DICHLOROETHANE	2	1212	7	400
1,1,1-TRICHLOROETHANE	3	1611	23	401,300
1,1-DICHLOROETHANE	9	785	18	11,330
DICHLOROETHYLENES (3)	8	781	23	860
METHYLENE CHLORIDE	10	1183	2	3,600
VINYL CHLORIDE	9	1033	7	380

*Ratio of community wells to private wells is not known.

**Not a statistical value.

Table 10

VOCs - Most Frequently Found in New Jersey

	No. wells >10 ug/l	No. wells >100 ug/l	% Samples >Detection Limit	Detection Limit (ug/l)	Maximum Found ug/l
Carbon Tetrachloride	5	2	26.8	0.1	360
1,2-Dichloroethane	18	0	5.8	1.6	40
Tetrachlorethylene	16	2	22.7	0.1	--
1,1,1-Trichloroethane	65	5	21.0	2.0	600
Trichloroethylene	27	12	26.4	0.3	600
Dichlorobenzene	8	2	4.8	2.2	8000
Trichlorobenzene	4	1	1.5	2.0	450

Table 11

VOCs - Less Frequent Occurrence in New Jersey

Methyl chloride	0	N.D.
Vinyl chloride	0.4	9.5
1,1,2,2-Tetrachloroethane	2.1	2.7
1,1,2-Trichloroethane	2.0	31.1

New York

As a result of finding organic chemicals in public water supplies in Nassau County in New York, a state-wide survey was initiated in 1978 to assess the extent of contamination of drinking water from ground water supplies. These surveys were reported in "Organic Chemicals and Drinking Water." Table 12 presents the results of the Nassau County surveys which showed that TCE and PCE were found in 56 and 48, respectively, of the 372 wells tested. Table 13 presents results of surveys of non-community water supply wells in Nassau County. Surveys were also conducted of Suffolk County community water supply wells and TCE and PCE were found at similar frequencies. As a result, 13 community water supply wells in Suffolk County and 15 community wells in Nassau County were closed.

Table 12

VOCs Detected in Community
Water Supply Wells - Nassau County 4/78

	Wells Tested	Wells Positive	Maximum Level Detected ug/l
Tetrachloroethylene (PCE)	372	56	375
Trichloroethylene (TCE)	372	48	300
1,1,1-Trichloroethane	372	33	10
Carbon tetrachloride	372	1	21

Table 13

VOCs Detected in Non-Community
Water Supply Wells - Nassau County

	Wells Tested	Wells Positive	Maximum Level Detected ug/l
Tetrachloroethylene	49	5	367
Trichloroethylene	49	3	30
1,1,1-Trichloroethane	49	4	150

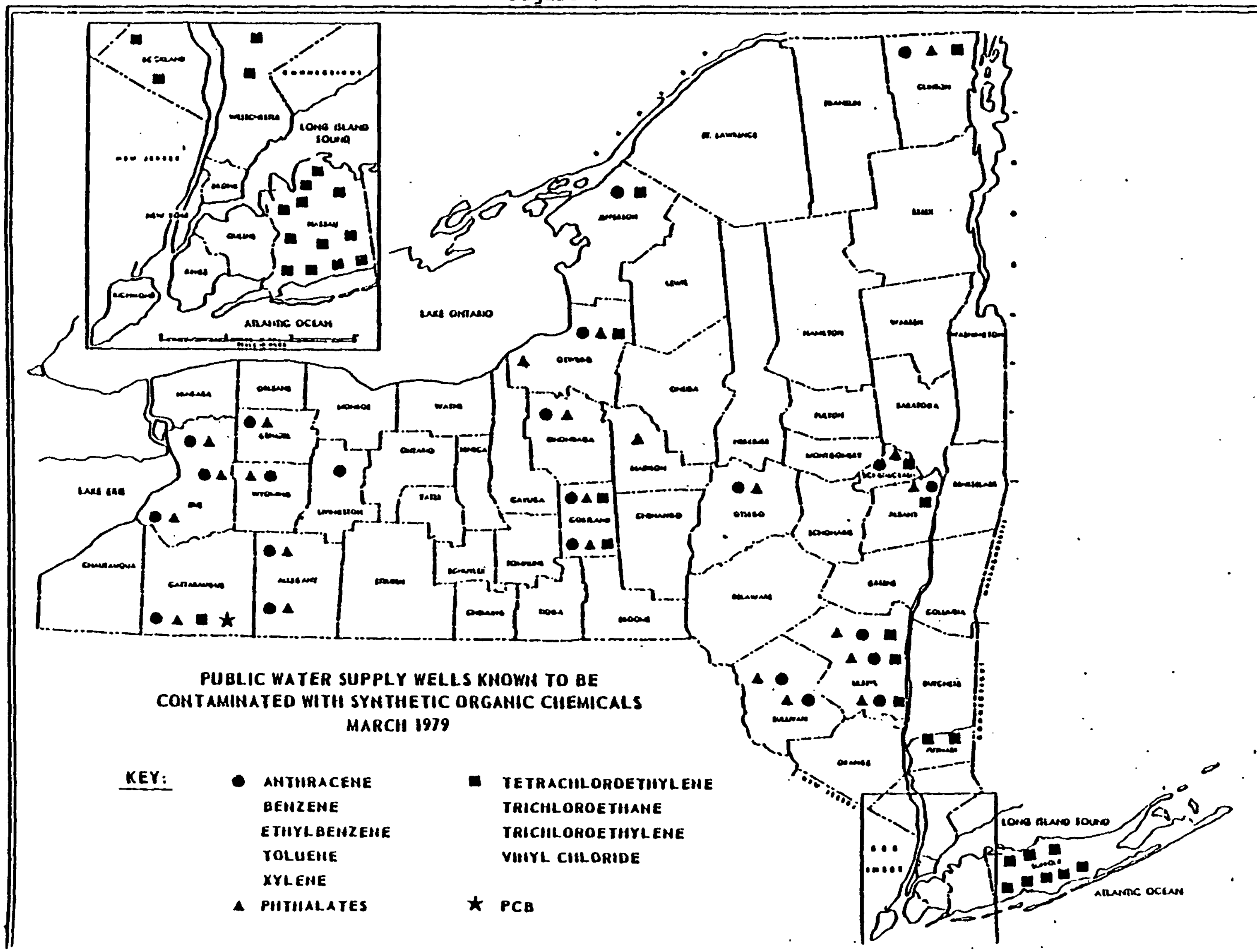
The state-wide survey was conducted in 1978 by the United States Geological Survey under contract to the New York State Health Department. Thirty public water systems were sampled during 1978 including a total of 47 samples from 39 wells. Table 14 summarizes the ten most commonly found synthetic organic chemicals (includes more than just the VOCs). Figure 7 graphically displays where the VOCs were found.

Table 14

The Ten Most Commonly Found Organic Chemicals Detected in New York Water System Wells - 10/78

Contaminants	Wells Tested	Wells Positive	Maximum Level Detected (ug/l)
Bis (2-ethylhexyl)phthalate	39	36	170.0
Toluene	39	33	10.0
Di-n-butyl phthalate	39	21	470.0
Trichloroethylene	39	18	19.0
Ethylbenzene	39	17	40.0
Diethyl phthalate	39	13	4.6
Trichlorofluoromethane	39	11	13.0
Anthracene/Phenanthrene	39	7	21.0
Benzene	39	6	9.6
Butyl benzyl phthalate	39	5	38.0

Figure 7


PUBLIC WATER SUPPLY WELLS KNOWN TO BE
CONTAMINATED WITH SYNTHETIC ORGANIC CHEMICALS
MARCH 1979
KEY:
● ANTHRACENE
BENZENE
ETHYLBENZENE
TOLUENE
XYLENE
▲ PHTHALATES
■ TETRACHLORDETHYLENE
TRICHLOROETHANE
TRICHLOROETHYLENE
VINYL CHLORIDE
★ PCB

California

In response to detection of VOCs in ground water in several California water basins and in other States, the California Department of Health Services conducted a survey to determine the extent of VOC contamination of public water supplies using wells. This was reported by Nelson, Kalifa and Baumann in "Purgeable Organics in Four Ground Water Basins." Four water basins were included in the survey: San Gabriel, Bunker Hill (in San Bernardino Valley), northern Santa Clara Valley, and the Owens Valley. Each basin was studied in two phases. Initially all available wells supplying "large" public water systems were sampled for TCE and PCE. The second phase involved resampling of at least 13 percent of the wells for purgeable halocarbons and aromatics.

Results of the TCE and PCE testing are shown in Figures 8 through 11. (Where wells of similar TCE/PCE levels are nearby, only one symbol has been used to indicate the wells.) The larger circles indicate locations of wells sampled for purgeable organics. The results of purgeable organics tests showing contamination are listed in Table 15.

In the San Gabriel Vally, 82 wells were tested for TCE and PCE, and 36 for purgeable organics. The predominant constituents identified, TCE and PCE, mark the areas of organic contamination. Only one well free of TCE and/or PCE contained other organics (7 ug/l of benzene). The contaminated areas are generally near and downgradient of major industrial areas.

One hundred thirty-eight wells were sampled for TCE and PCE in the Bunker Hill Basin, with 24 wells sampled for purgeable organics. The only contaminants found were TCE and PCE. TCE and PCE occurred in discrete areas. Overall contaminant levels were lower in this basin than in the San Gabriel Valley.

No serious volatile organic contamination was found in the Santa Clara Valley wells sampled (183 and 24 wells sampled for TCE/PCE and purgeable organics, respectively). The extent of contamination in this basin differs little from that in the Owens Valley.

In the Owens Valley Basin, one out of 27 wells showed a trace of PCE in the initial sampling. The purgeable organics retest did not indicate any contamination.

Table 15

Results of Samples with Detectable Purgeable Organics (ug/l)

Well	TCE	PCE	CCl_4	1,1,1-trichloro-ethane	Benzene	Ethyl Benzene	Toulene
San Gabriel Basin							
A					7		
B	2.9						
C	6.5						
D	33	2.6					
E	3.2						
F	4.2	5.0	3.5				2.0
G	11	12					
H	4.0	12					
I	17	11					
J	9.0	4.2					
K	15	6.2				0.5	0.5
L	7.3	6.8		18.0			0.5
M	12.0	6.0	17.1			0.5	0.5
N	9.2	4.4					
O	11.0	8.1	23.0			0.5	0.5
P[2]	102.0	39.4	1.0	2.1			
Bunker Hill Basin							
A	7.4	16.0					
B	2.9	5.2					
C	3.9	19.0					
D		1.5					
E	6.2						
F	176.0						
G		Trace					

Notes: 1. Sensitivity 0.5 ug/l for all compounds.
2. Sample P also has: 1,1-dichloroethene (0.8 ug/l); 1,2-dichloroethene (0.5 ug/l); chloroethane (0.7 ug/l) 1,1- and 1,2-dichloroethene (1.0 and 1.6 ug/l)

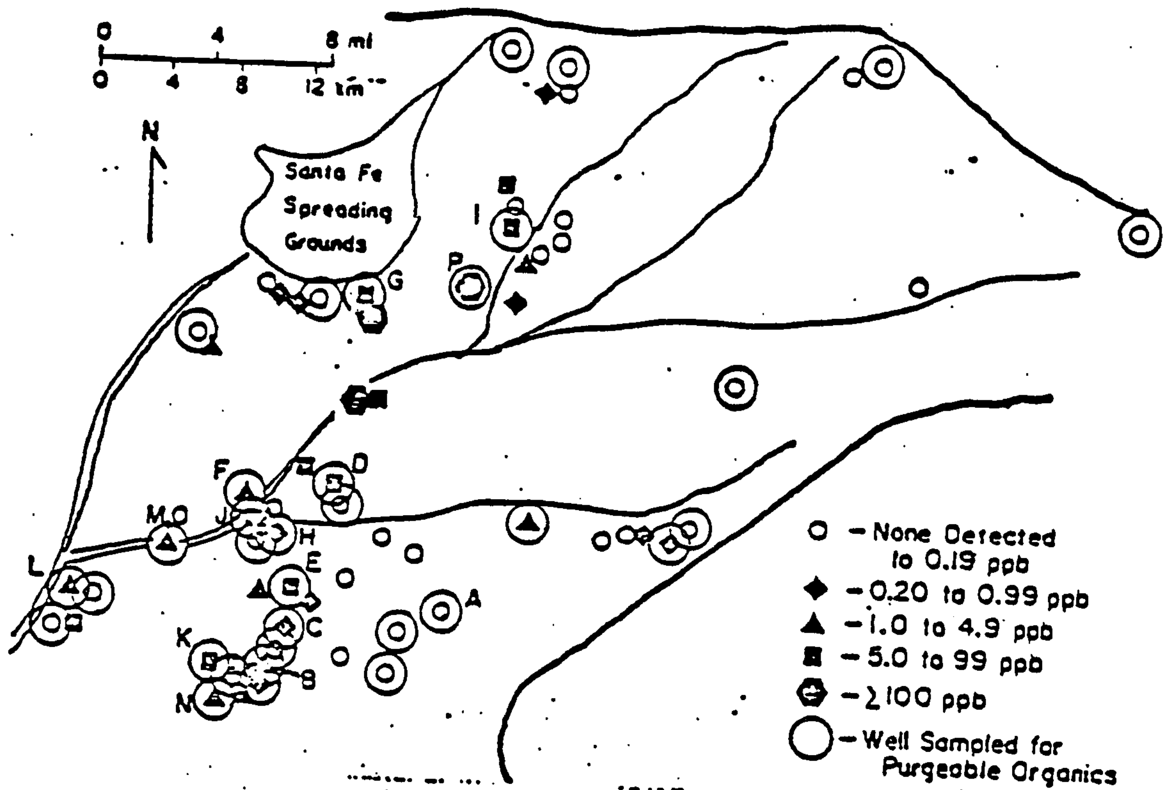


Figure 8. Results of San Gabriel Basin TCE/PCE Samples

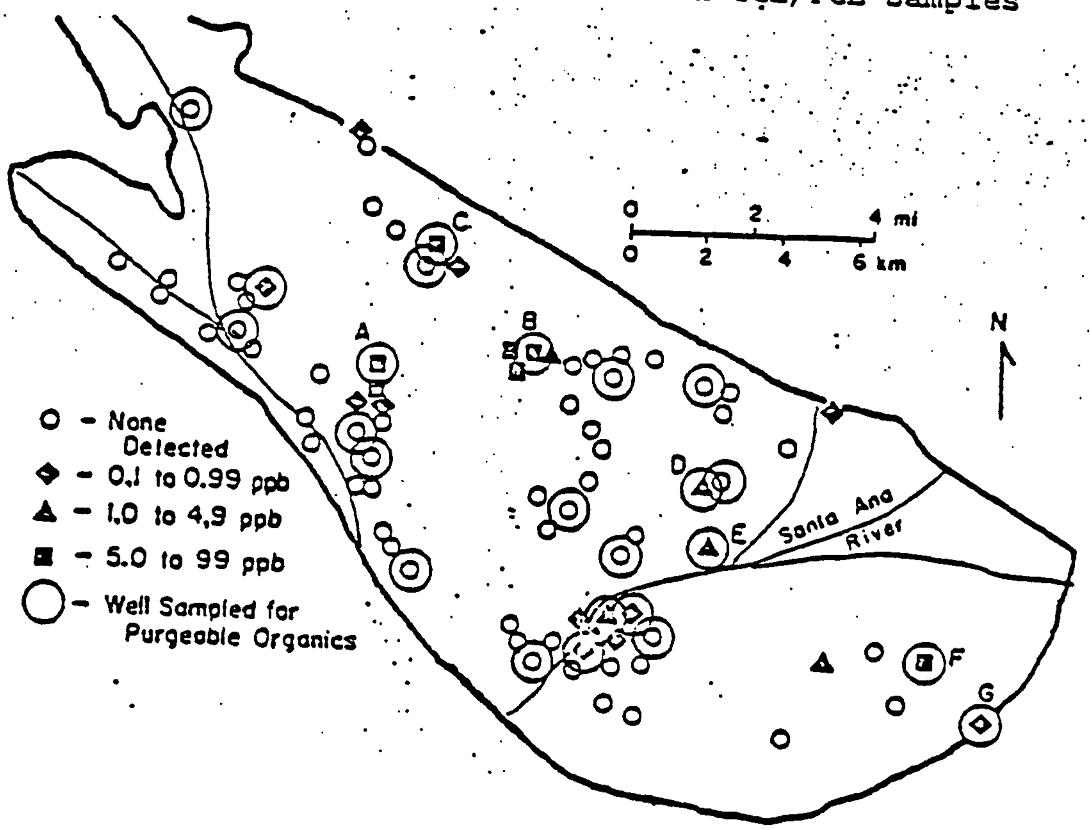


Figure 9. Results of Bunker Hill Basin TCE/PCE Samples

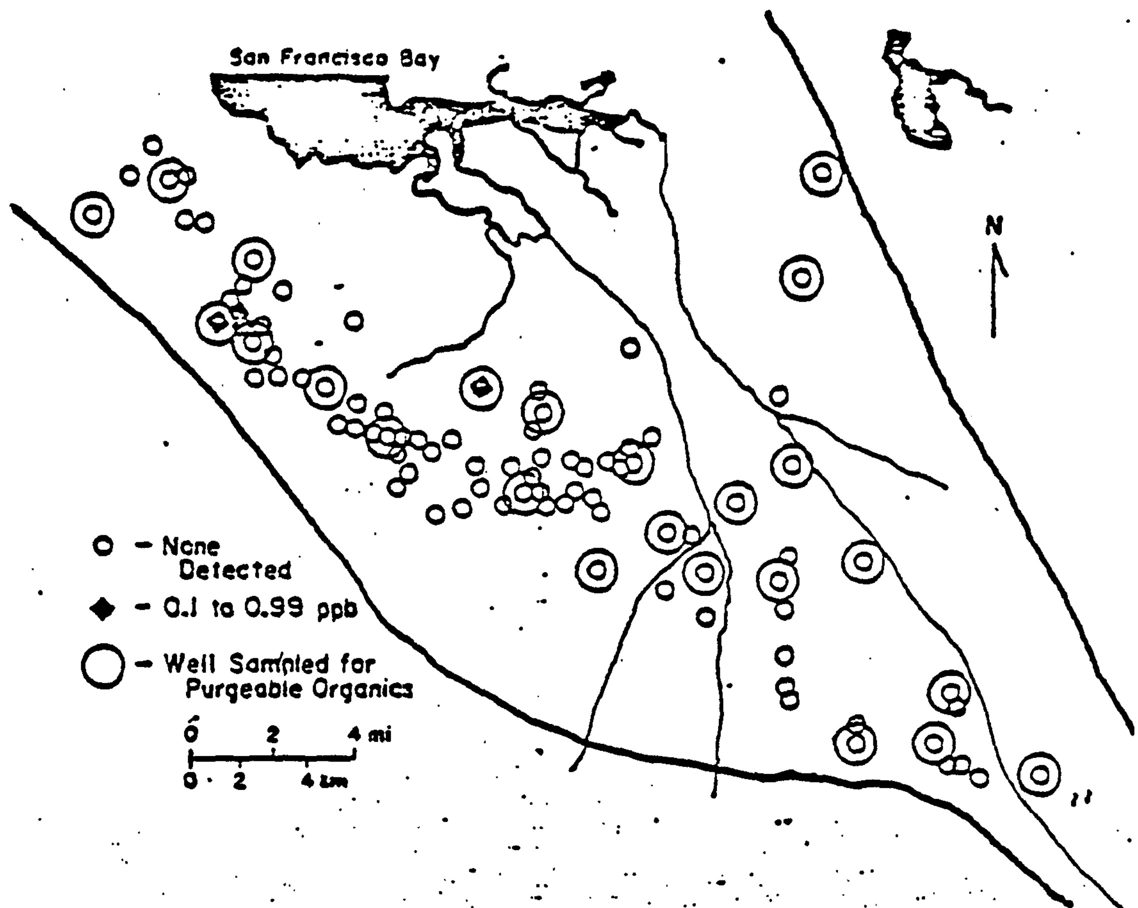


Figure 10. Results of Santa Clara Valley TCE/PCE Samples

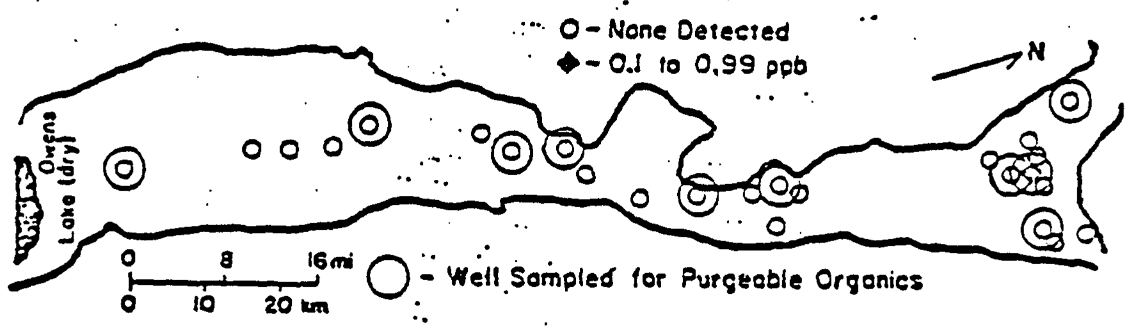


Figure 11. Results of Owens Valley TCE/PCE Samples

Bibliography

1. Chemical Economics Handbook, Stanford Research Institute, CEH Manual of Current Indicators, Supplemental Data June 1980.

2. International Commission for Radiological Protection, Report of the Task Group on Reference Man, IRCP Publication, 23 Pergamon Press, 1975.

3. Nelson, Stephen J., Kalifa, S., Baumann, F., "Purgeable Organics in Four Ground Water Basins," California Department of Health Services, June 5, 1981.

4. Kim, Nancy, and Stone, Daniel, "Organic Chemicals and Drinking Water." New York State Department of Health, undated (approx. 1980).

5. Occupational Safety and Health Administration, National Occupational Hazard Survey Data Search for Specific Compounds, November 1976.

6. Tucker, Robert, "Ground Water Quality in New Jersey - An Investigation of toxic Contaminants," Office of Cancer and Toxic Substances Research, State of New Jersey, March 1981.

7. U.S. Environmental Protection Agency, Level I Materials Balance, 1,2-Dichloroethane (JRB Associates), February 1980.

8. U.S. Environmental Protection Agency, Draft Criteria Document for 1,2-Dichloroethane (Office of Drinking Water), November 1981.

9. U.S. Environmental Protection Agency, Draft Criteria Document for Chloride (Office of Drinking Water), November 1981.

10. U.S. Environmental Protection Agency, Materials Balance for Methyl Chloroform, Level II (JRB Associates), January 1980.

11. U.S. Environmental Protection Agency, Draft Criteria Document for 1,1,1-Trichloroethane (Office of Drinking Water), November 1981.

12. U.S. Environmental Protection Agency, Rebuttable Presumption against Registration and Continued Registration of Certain Pesticide Products - Carbon Tetrachloride. Federal Register 45 (201) Part IV 68534-68584, October 1980.

13. U.S. Environmental Protection Agency, Draft Criteria Document for Carbon Tetrachloride (Office of Drinking Water) November 1981.

14. U.S. Environmental Protection Agency, Draft Criteria Document for Tetrachloroethylene (Office of Drinking Water), November 1981.

15. U.S. Environmental Protection Agency, Preliminary Study of Selected Potential Environmental Contaminants (Franklin Institute), July 1975.

16. U.S. Environmental Protection Agency, Air Pollution Assessment of Tetrachloroethylene (MITRE Corporation), February 1976.

17. U.S. Environmental Protection Agency, Draft Criteria Document for Trichloroethylene (Office of Drinking Water), November 1981.

18. U.S. Environmental Protection Agency, An Assessment of the Need for Limitations on Trichloroethylene, Methyl Chloroform and Perchloroethylene (Midwest Research Institute), July 1979.

19. U.S. Environmental Protection Agency, Level I Materials Balance, Trichloroethylene (JRB Associates), April 1980.

20. U.S. Environmental Protection Agency, Environmental Sources of Trichloroethylene Exposure, Source Contribution Factors (MITRE Corporation), November 1978.

21. U.S. Environmental Protection Agency, Compilation of Incidents of Drinking Water Contamination With Volatile Organic Chemicals (Office of Drinking Water), November 1980.

22. U.S. Environmental Protection Agency. Survey of EPA Regional Drinking Water Representatives to Determine the Ground Water Monitoring Data Developed by State Agencies, February 1980.

23. U.S. Environmental Protection Agency, Survey of Operating and Financial Characteristics of Community Water Systems (Temple, Barker and Sloane), April 1977.

24. U.S. Environmental Protection Agency, Quantitative Risk Assessment for Community Exposure to Vinyl Chloride (Kuzmack, A. M. and McGaughy, R. E.), December 1975.

25. U.S. Environmental Protection Agency, Briefing The Occurrence of Volatile Organics in Drinking Water (Office of Drinking Water), March 1980.

26. U.S. Environmental Protection Agency, Analysis by the Office of Drinking Water of Unpublished Ground Water Data from the Massachusetts Department of Environmental Quality Engineering, July 1980.

27. U.S. Environmental Protection Agency, Compilation of data from: A Preliminary Report on the Findings of the State Ground Water Monitoring Project and A Second Preliminary Report on the Findings of the State Ground Water Monitoring Project, State of New Jersey, Department of Environmental Protection, March and December 1978.

28. U.S. Environmental Protection Agency, Analysis by the Office of Drinking Water of Unpublished Ground Water Data from Maine Department of Human Resources, April 1978.

29. U.S. Environmental Protection Agency, Analysis by the Office of Drinking Water of Unpublished Ground Water Data from California Department of Health Services, November 1980.

30. U.S. Environmental Protection Agency, Community Water Supply Survey (Office of Drinking Water), March 1981.

31. U.S. Environmental Protection Agency, National Organics Screening Program (SRI), March 1981.

32. U.S. Environmental Protection Agency, National Organics Reconnaisance Survey (Office of Drinking Water).

33. Woodhull, R. S., Ground Water Contamination in Connecticut, July, 1980.

APPENDIX EPA SURVEYS: CHARACTERISTICS

NATIONAL ORGANICS RECONNAISSANCE SURVEY

The National Organics Reconnaissance Survey (NORS) was conducted early in 1975 for the purpose of determining levels of four trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane, and bromoform), carbon tetrachloride, and 1,2-dichloroethane in finished water supplies from 80 cities across the country (65 cities used surface water sources and 15 used ground water sources). A population base of 36 million was covered during the study. Analysis of samples was performed by the Water Supply Research Laboratory of the EPA in Cincinnati using a purge and trap GC technique.

The chemicals included in the analysis of samples are listed below:

chloroform
bromodichloromethane
dibromochloromethane
bromoform
1,2-dichloroethane
carbon tetrachloride

NATIONAL ORGANICS MONITORING SURVEY

The National Organics Monitoring Survey (NOMS) was conducted to determine the frequency of occurrence of specific organic chemicals in finished water supplies of 113 cities across the country, 19 of which used ground water sources. Among the chemicals surveyed for were trihalomethanes, 1,2-dichloroethane, carbon tetrachloride, trichloroethylene, benzene, vinyl chloride, dichlorobenzene, trichlorobenzene, and others. Data from three phases of the study were collected over a year's time (1976) to reflect any long term or seasonal variations. The analytical treatment of the samples was similar to that for the National Organics Reconnaissance Survey samples. The chemicals included in the analysis of samples is given below:

chloroform
bromodichloromethane
dibromochloromethane
bromoform
dichloroiodomethane
1,2-dichloroethane
carbon tetrachloride
methylene chloride
vinyl chloride
trichloroethylene
tetrachloroethylene
1,1,1-trichloroethane
bis (2 chloroethyl) ether
benzene
pentachlorophenol
PCBs
flouranthene
3,4-benzoflouranthene
3,4-benzopyrene
indeno (1,2,3-CD) pyrene
p-dichlorobenzene
m-dichlorobenzene
1,2,4-trichlorobenzene
2,4-dichlorophenol

NATIONAL SCREENING PROGRAM FOR ORGANICS IN DRINKING WATER

EPA conducted a study from June 1977 to March 1981 entitled National Screening Program for Organics in Drinking Water in which raw and finished drinking water samples were collected from 169 water facilities, 12 of which used ground water sources. The facilities were located in 33 states including Alabama, Arizona, California, Colorado, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Missouri, Minnesota, Nebraska, New Jersey, New York, Ohio, Oklahoma, Oregon, Pennsylvania, Tennessee, Texas, Vermont, Virginia, Washington, West Virginia, and Wisconsin.

The samples were analyzed for 23 halocarbons, 6 aromatics, and 22 pesticides, phenols, and acids. The methods used for analysis included gas chromatography/mass spectrometry. The chemicals included in the analysis of samples is given below:

PURGEABLE HALOCARBONS

Bromobenzene
Bromodichloromethane
Bromoform
Carbon Tetrachloride
Chlorobenzene
Chloroethane
Chloroform
Chloromethane
Dibromochloromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
cis 1,2-Dichloroethylene
trans-1,2-Dichloroethylene
Dichloromethane
p-Dichlorobenzene
1,1,1,2-Tetrachloroethane
Tetrachloroethylene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Trichlorofluoromethane
Vinyl chloride

BASE/NEUTRAL EXTRACT FRACTION

Alachlor
Atrazine
Benefin
Biphenyl
Bis (2-chloroethyl) ether
Bromacil
1,4-Bromochlorobenzene
Butachlor
Cyanazine
Diazinon
Diphenylhydrazine
Disulfoton
Endrin
Hexachlorobenzene
Hexachloro-1,3-butadiene
Hexachloroethane
Indene
Malathion
Methoxychlor
Methyl parathion
Nitralin
Parathion
PCMB (pentachloronitrobenzene)
Phorate
Propachlor
Propanil
Propazine

BASE/NEUTRAL EXTRACT FRACTION

Pyrene
Simazine
Treflan
1,2,4-Trichlorobenzene

PURGEABLE AROMATICS

Benzene

Styrene
Toluene
o-Xylene
m-Xylene

ACID EXTRACT FRACTION

2,4-Dichlorophenoxyacetic Acid (2,4-D)
Dicamba (banvel D)
2,4-Dichlorophenol
2,4-Dimethylphenol
o-Methoxyphenol
Penylacetic acid
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)
2-(2,4,5-Trichlorophenoxy) propionic acid (Silvex)
2,4,5-Trichlorophenol

COMMUNITY WATER SUPPLY SURVEY

The Community Water Supply Survey (CWSS) sampled a total of 452 water supplies, of which 330 used ground water sources, in 1978 for trihalomethanes and other volatile organic chemicals. The system sizes sampled ranged from 25 to 100,000 persons served, and data are available for 7 system size categories based on population served. One to five samples were collected from each system and included raw, finished and distribution water. The chemicals included in the analysis of samples is given below:

chloroform
dibromochloromethane
bromodichloromethane
bromoform
1,2-dichloroethane
carbon tetrachloride
chlorobenzene
cis + trans dichloroethylene
tetrachloroethylene
1,1,1-trichloroethane
trichloroethylene
toluene
benzene
xylenes

RURAL WATER SURVEY

The Rural Water Survey, conducted in 1978, was carried out in response to the Safe Drinking Water Act which mandated that EPA "conduct a survey of the quantity, quality and availability of rural drinking water supplies." Eight hundred samples collected from across the U.S. were analyzed for trihalomethanes and for carbon tetrachloride, 1,2-dichloroethane, cis- and trans-1,2-dichloroethylene, tetrachloroethylene, 1,1,1-trichloroethane, and trichloroethylene. The results, which will describe the presence of these chemicals in supplies serving single households as well as some larger systems, are expected to be available in March 1982.

GROUND WATER SUPPLY SURVEY

The Ground Water Supply Survey (GWSS) involves the sampling of 1000 public water supply systems across the country using groundwater sources for VOC contamination. Five hundred of the systems were selected randomly while the other five hundred were selected with state and EPA regional input on the basis of the likelihood of VOC contamination. The results are expected in early 1982 and will be available from EPA when compiled. The chemicals included in the analysis of samples is given below:

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