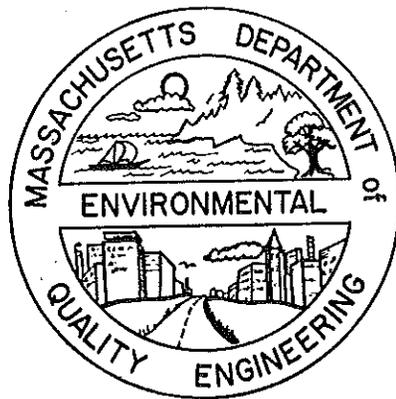


The Commonwealth of Massachusetts

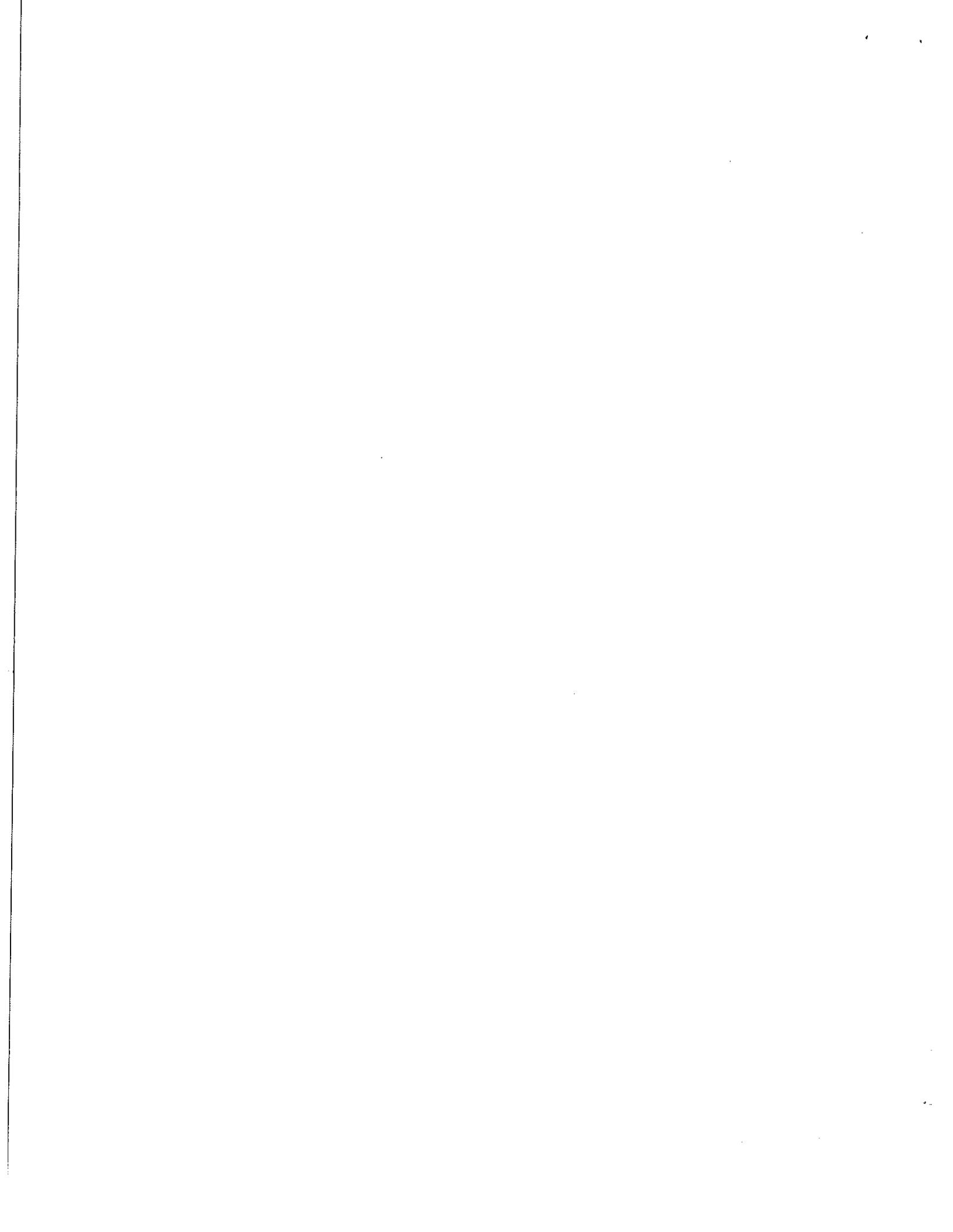
Department of Environmental Quality Engineering

**Tetrachloroethylene In Public
Drinking Water Supplies**



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Interim Report on Tetrachloroethylene Contamination
of Public Drinking Water Supplies caused by
Vinyl-Lined Asbestos Cement Pipe

September 1980

Dept. of Environmental Quality Engineering
Division of Water Supply

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I - Problem Statement:

This past winter, Massachusetts and the other five New England States discovered a problem with the chemical tetrachloroethylene leaching into some of their drinking water because of the type of pipe used in some parts of the water distribution system.

Tetrachloroethylene is an organic chemical which is slightly soluble in water. It is used in a variety of ways including the dry cleaning process, as a degreasing solvent and as a heat transfer medium. The chemical has also been used in the manufacture of vinyl-lined asbestos cement pipes as a solvent or vehicle for the resin.

Asbestos cement (AC) pipes have been in use since the 1930's. The lined variety has been in use for approximately twelve years in New England. The vinyl lining reportedly was developed as a response to customer complaints about the taste and odor of water coming into contact with the asphaltic coating used on water supply pipes, especially on dead end situations.

In July of 1976, tetrachloroethylene was discovered in a distribution system in Newport, Rhode Island. An investigation to determine its source at that time was inconclusive and the significance of the problem was not fully understood.

In 1978 and 1979, there was correspondence about Newport's problem between Johns-Manville officials and Rhode Island officials. The Rhode Island officials periodically updated the other New England states but information was meager and inconclusive. During this time, there was a growing feeling that the problem had something to do with the manufacture of the pipe as opposed to installation practices.

By December, 1979 circumstantial evidence showed that lined AC pipes were leaching tetrachloroethylene. A piece of four inch lined AC pipe was shipped in December, 1979 from Newport to EPA's Municipal Environmental Research Laboratory in Cincinnati for testing. The experiment, run twice in January 1980, verified that tetrachloroethylene came from the lined pipe. At the end of January, this information went to each state in EPA Region I.

Discovery of the problem in Massachusetts came about in late January, 1980 as a result of DEQE testing in Westford to determine the parameters of a water supply contamination problem. This was in connection with the discovery of a storage area containing barrels of chemical waste. Private wells in the vicinity of the storage area were sampled and a tap on the public supply was also sampled. The sample taken from the public supply showed over 1100 ppb of tetrachloroethylene. A second sample from the same tap showed over 1000 ppb. Other samples in town showed no amounts of the chemical.

Investigation showed that in 1977, the town had installed 8500 feet of 12 inch vinyl-lined asbestos cement pipe in the area in which the tap at the end of the line was sampled by DEQE. Detention time in this segment was calculated to be eleven days. Samples were collected upstream of the line, midway, and at the end and showed concentrations of 0 ppb, 40 ppb, and 1000 ppb, respectively. This led to the conclusion that tetrachloroethylene was leaching out of the pipe.

The Regional Offices of DEQE were instructed to immediately identify and sample several installations in their region where:

- 1) Lined AC pipe was in use.
- 2) The pipe was installed in a dead-end or low flow location.

In conducting this first testing, we were interested in determining as quickly as possible the extent and severity of the problem.

The results of this first sampling showed that the problem likely existed to some extent among all installations of lined AC pipe.

DEQE proceeded to mail a questionnaire to all water department superintendents throughout the state to determine the number of miles of this pipe in use and approximately how many "dead end" situations existed. It was deemed unlikely that this kind of pipe would have been installed by owners of property served by private wells.

Data gathered from that questionnaire showed that parts of 83 public water supplies with a total length of over 700 miles of pipe were involved.

Massachusetts then requested a meeting with officials of Johns-Manville from the factory at Manville, New Jersey to get factual and first hand information on the manufacturing process. It was at this meeting on March 20, 1980, that it was definitely learned about the chemicals used, the mixing procedure and the application technique.

Another meeting was held between Johns-Manville officials from Denver, Colorado and Massachusetts officials on April 1, 1980 to obtain more information on the extent of the problem and to discuss possible solutions. Representative of the EPA and the other New England states were invited to this meeting. It is important to note that at all times during this process, there was a dialogue and exchange of information and experience going on not only within each state but between the states and EPA.

A previously scheduled meeting between EPA and the New England states was held in Boston on April 2 and 3. This problem was the main topic of discussion and it was agreed that since it was a region-wide problem, that a joint announcement and press conference would be appropriate. This was to be done on April 14 prior to which Massachusetts made plans to alert the affected water supply agencies, local officials and legislators beforehand on April 11 so they would be able to respond to the public in an informed manner. A question and answer package on tetrachloroethylene was developed for the media and the public at this time.

However, the press picked up the story in Connecticut on April 9 and it was reported in the Boston Globe on April 10.

Massachusetts also identified two other manufacturers, Certain-Teed and Capco which used this type of lining. Fortunately, their sales in the area were limited and identifiable.

From the time that the problem was first identified, DEQE regional field staff have spent considerable time working with each affected water supplier in an effort to:

- (a) Pinpoint areas of concern.
- (b) Provide advice and some laboratory testing support to lower the levels of tetrachloroethylene and to monitor the effects of control efforts.

In addition, DEQE has initiated or participated in a number of studies designed to find short term and long term solutions to this problem.

The EPA has undertaken several studies, provided guidance in the area of health risk associated with the problem and provided information on the effectiveness of carbon as a removal agent.

One of the studies which is still ongoing by EPA is to collect all the physical and analytical data from all the states on this problem and analyze this information by computer so see if any common trends are indicated.

II - Health Effects

Tetrachloroethylene is rapidly absorbed through the lung and skin. Although no studies have been done on its absorption through the gastrointestinal tract, chemical properties of tetrachloroethylene indicate that it should be rapidly and completely absorbed as well. The majority of absorbed tetrachloroethylene is rapidly eliminated from the body. Only a minor portion of the total (less than 2%) is retained in tissues.

Because of the nature of the tetrachloroethylene problem associated with viny lined pipes - long term exposure to relatively low levels of the chemical - we are primarily concerned with chronic toxicity and potential carcinogenicity of tetrachloroethylene.

Exposure to tetrachloroethylene has been shown to cause damage to liver and kidneys as well as to affect the central nervous system, which is manifested by dizziness, headaches and fatigue. These effects are mild and in most inhalation studies, doses well in excess of 100 parts per million (100,000 ppb) were used before any toxic (poisonous) effects could be detected. Toxic effects of tetrachloroethylene are frequently reversible if the exposure is stopped.

The results of several studies conducted to assess the carcinogenic potential of tetrachloroethylene are conflicting; the chemical gave positive response in some and negative in others. By far, the most comprehensive study was completed in 1977 by the National Cancer Institute (NCI). In that work massive doses of tetrachloroethylene were given to both laboratory mice and rats. The lack of carcinogenic response in rats should be interpreted with caution, however, since the survival of experimental rats was very poor due to the toxic effects of tetrachloroethylene.

There are three epidemiological studies in progress concerning tetrachloroethylene. The results of one, conducted by the National Institute for Occupational Safety (NIOSH) are expected to be released at the end of calendar year 1980. Preliminary results of a second study by the NCI on dry cleaning workers in St. Louis indicate an increased risk for cancer within this occupational group (Blair, AM.J. Public Health 69,508 (1979)). A third study conducted by Dr. Nabih Assad of Oklahoma University on dry cleaning workers in Oklahoma, indicates an increased death from kidney cancer. The results of the last two studies have to be considered as suggestive evidence because of several limitations of the studies.

In summary, the positive evidence provided by the NCI mouse study, suggestive evidence of the NCI epidemiological study and the similarity of tetrachloroethylene to the known chemical carcinogens vinyl chloride and vinylidene chloride, provide substantial evidence that tetrachloroethylene is likely to be a human carcinogen. (Roy Albert, Carcinogen Assessment Group, EPA, July 25, 1980).

Establishment of a SNARL (Suggested No adverse Response Level) by EPA for chronic exposure to tetrachloroethylene can be based either on its toxicity or carcinogenicity. In the latter approach, the results of the NCI study with mice which showed higher incidence of liver cancer than other animals were extrapolated to man. This was done by a complex extrapolation of the data, using computer programs based on the most conservative (linear) of many different mathematical theories of cancer formation. A level of 40 ppb resulted from these calculations. It means that drinking of 2 liters of water, containing 40 ppb of tetrachloroethylene per day, for 70 years will contribute to no more than one additional cancer in 100,000 people exposed.

In the approach to a SNARL setting based on toxicity of tetrachloroethylene the arithmetic is much simpler. A published study was chosen as a basis of the calculations, where inhalation of large doses of tetrachloroethylene had a detectable effect on the liver and kidneys of experimental rabbits. The animal data were then extrapolated to man taking into consideration: 1. route of exposure (ingestion versus inhalation); 2. body weight (20 lb. child has to be protected); 3. daily intake (1 liter of water per day per child); 4. absorption rate by the digestive system (to protect the public, 100% is assumed). The number arrived at 17,000 ppb, was then divided by 1000 to provide a wide safety margin and rounded up.

(For comparison, the average safety margin used by EPA in setting Air Quality Standard is less than 2.) The resulting SNARL of 20 ppb, based on toxicity of tetrachloroethylene, turned out to be more stringent than that based on carcinogenicity (40 ppb). Because tetrachloroethylene is not an overtly toxic chemical and because a 1000-fold safety margin is built into the 20 ppb SNARL, the EPA's panel of scientists concluded that the potential carcinogenicity of this chemical (however, uncertain) is of greater concern to human health than its general toxicity at low levels. In addition, since the presence of tetrachloroethylene in drinking water means a short term rather than a lifetime exposure, EPA adopted the 40 ppb level for chronic exposure to tetrachloroethylene. Using similar procedures to that described for the chronic exposure SNARL, a one day SNARL of 2300 ppb and a ten day SNARL of 175 ppb were established by EPA.

SNARLS are not magic numbers. They are only an attempt made by a group of experts to express our present incomplete scientific knowledge in a numerical form. The degree of uncertainty and possible controversy in setting of those numbers can be illustrated by this example. A one-day SNARL for tetrachloroethylene for a 20 lb. child was set at 2300 ppb by the EPA and at 24,000 ppb by the National Academy of Sciences. The only difference in methodology was a choice of the scientific study on which the calculations were based resulting in a 10-fold difference in the final numbers.

It should be stressed, however, that all of the assumptions and generalizations made in the process of standard setting are made in such a way as to protect public health. This is the essence of the conservative approach of the government agencies in determining the safe levels of tetrachloroethylene and other chemicals.

Arthur D. Little Inc., is near completion of a comprehensive study on all environmental aspects of tetrachloroethylene for EPA. DEQE will obtain a copy of this report as soon as it is published and consider its findings and conclusions in a future update.

III Testing Program

The testing program conducted by DEQE has been undertaken in essentially 3 phases. The first was to quickly determine the extent of the problem, the second was to further identify areas where the problem might be most serious and the third was to support efforts and experiments to find solutions or determine effectiveness of control measures.

PHASE I:

Original testing was performed in Westford on one section of the AC pipe with vinyl lining in late January, 1980, The analysis of samples

collected showed levels of tetrachloroethylene exceeding 1,000 parts per billion of water (ppb). These few samples led to further testing in 23 communities.

Testing in these 23 communities was done on:

- . unlined AC pipe
- . lined AC pipe under normal flow conditions
- . lined AC pipe under low flow conditions

Both ground and surface supplies were tested.

The analyses of samples collected showed that:

- . unlined AC pipe gave no tetrachloroethylene
- . lined AC pipe under normal flow conditions generally gave low or intermediate levels
- . dead end or low flow conditions gave concentrations of tetrachloroethylene in the high hundreds to several thousands of parts per billion.

PHASE II:

Because of the concentrations of tetrachloroethylene discovered in phase one, each water supply system was contacted, and samples were collected where vinyl lined AC pipe was present in water distribution systems. The Department (DEQE) requested a distribution map from each water department in the affected communities to determine the location of the pipe, its age, and the number of customers served. Communities were ranked by DEQE for priority of assistance based upon mileage of the pipe and general response to the questionnaire sent out in April. DEQE met with the local water suppliers on the basis of this priority list and established a limited sampling program based on the analytical resources available to the Department.

Samples were also collected and analyzed to determine the effects of pipe age, detention time, or other conditions affecting tetrachloroethylene concentration. This phase of sampling eliminated many areas from future consideration because of the low level detected. It also showed some areas where the concentrations were above guidelines and indicated the need for looping, flushing, installation of bleeders or some other control measure. During this testing phase 75 water supply systems were sampled and 574 samples analyzed.

PHASE III:

Many samples were collected and analyzed to determine the effects of flushing, bleeding, use of faucet aerators, pH control, chlorination, cement lining, etc., on tetrachloroethylene concentrations. This phase will continue as required. Approximately 248 samples from 13 systems have been analyzed.

The original testing procedure used at the Lawrence Experiment Station involved the gas chromatograph. About 50 minutes were required for each sample. In addition, known standards had to be run for quality control and time had to be devoted to machine maintenance.

The Experiment Station has been able to develop an acceptable variation in the procedure and reduce the time needed to process a sample for tetrachloroethylene. The laboratory estimates that when down time, quality assurance, machine maintenance and other requirements are factored in about 50 tetrachloroethylene samples per week can be performed on a sustained basis. This commitment will require the assignment of a laboratory machine and a trained chemist to this program alone and will require a redefinition of priorities for the laboratory. This will mean a reduction in other samples being analyzed at the laboratory.

IV Studies and Solutions:

During the course of this problem, there have been many suggestions and recommendations about avenues which should be pursued in looking for a solution.

The following is an attempt to summarize the strengths and weaknesses of the various investigations which have been made.

Faucet Aeration

An attempt was made to determine the effect of faucet aerators on the tetrachloroethylene content of affected homes.

From this very limited study, it can be concluded that household aerators have no significant effect on tetrachloroethylene content.

Since the problem lies in the distribution system and not the source, the only reasonable place to consider aeration would be at the point-of-use.

Dilution

Dilution is a very effective method of reducing the concentration of material in a water supply by mixing that water supply with another cleaner source of water.

In the situation before us, that is tetrachloroethylene emanating from the distribution system itself, it would seem that the only way to provide such dilution would be to lay a new pipeline of different material on each affected road and mix with the affected water. Naturally, if this were to be done it would be just as easy to eliminate the affected water by replacing the pipes.

There does not appear to be any practical way of providing dilution to solve this particular problem.

Cleaning and/or Lining

A research program was recently conducted by Haley and Ward, Inc., to find a cost-effective method of treating asbestos-cement vinyl lined (A.C.-V.L.) pipe to reduce the leaching rate of tetrachloroethylene thus reducing the concentrations.

A test site was constructed in Ashland, Mass., consisting of 156 linear feet of A.C.-V.L. pipe installed within an earthen berm, in four separate sections.

- . Section "A" consisted of 52 L.F. of pipe, with the vinyl liner removed by wire brushing and a cement liner installed.
- . Section "B" consisted of 52 L.F. in which the cement liner was installed directly over the vinyl liner.
- . Sections "C" and "D", 26 L.F. each, were left in the original condition.

All sections were chlorinated, flushed and refilled with clean water, and samples were taken approximately every 7 days for a period of 60 days, with analyses done by the DEQE Laboratory at Lawrence. For this particular installation, a consistent 97-99% reduction in TCE concentration was realized for sections "A" and "B", compared to Sections "C" and "D". It should be understood that this was a short term test (60 days), for pipe 6-months old prior to installation and under static (no flow, no pressure) conditions. The results to date indicate that this method of treatment does show promise, and could be utilized at approximately 1/3 the cost of complete pipe replacement.

One concern has been expressed to a solution such as this where, in effect, another barrier membrane is being placed between the water and the vinyl lining. It is not known but it can be projected with some degree of confidence that the long term effect will be to lower the concentrations but extend the period of time over which the leachable tetrachloroethylene residual in the pipe will leach into the water. However, even if a pipeline originally showed levels of over 1000 ppb lining the pipe would probably keep the long term level below 40 ppb.

This experiment is continuing.

The method of placing a cement lining over the vinyl lining has been estimated to cost \$10.00 per foot. To remove the vinyl lining from the pipe and then apply the cement lining could be done for approximately \$15.00 per foot.

Additional testing was also attempted by Haley and Ward, at this site, on similar asbestos-cement vinyl lined pipe. The first test consisted of directing a high temperature (200°F), high pressure water jet from a machinery cleaning apparatus, on a specific location on the vinyl liner, for a period of 5-minutes. There was no measurable reduction in thickness. Sandblasting equipment was also available at the site, and an attempt was made to remove the liner with this equipment. Within one second of operation, the liner was removed but there was so much damage to the pipe itself that this method was judged impracticable and the test was suspended.

Flushing and/or Bleeding

Extensive sampling of vinyl lined pipes by the DEQE has revealed a definite and direct relationship between residence time (the length of time the water is in contact with the pipe) and the tetrachloroethylene level observed. Accordingly, it was logical to assume that reducing the residence time by flushing and/or bleeding would result in a reduction of the tetrachloroethylene level.

Almost from the outset, the DEQE was aware that flushing would lower tetrachloroethylene levels but that the level would recover when flushing was terminated. Recognizing the need to be able to predict the rate, duration, and frequency of flushing required to maintain acceptable levels, the DEQE has participated in

studies designed to provide such information. Data gathered to date relative to high velocity flushing (1 turnover per hour or greater) indicates that 2 complete turnovers will reduce the tetrachloroethylene level to less than 1% of the original level and that the maximum rate at which the tetrachloroethylene recovers to the initial level is approximately 10% per day.

Continuous bleeding at the terminus of dead ends at a rate of 1 turnover per day appears to be even more effective than high velocity flushing in that there is less fluctuation in the tetrachloroethylene level. Sampling results from approximately 10 locations show that continuous bleeding has consistently lowered the level to below 40 ppb which in most cases represents less than 10% of the original level.

This information on the effectiveness of installing a bleeder on the system is consistent with some work done by Johns-Manville (J-M) in Simsbury, Connecticut. There it was found that maintaining flow rates as low as 2 to 3 gallons per minute was adequate to maintain low TCE levels. The tests were all conducted on 8 inch lines but the J-M report indicates similar results could be expected for 10 and 12 inch lines. Pipes used in the J-M experiment were installed in 1977, 1978 and 1979.

Flushing and/or bleeding is reported to be the method employed in controlling this problem in the other New England States. This solution or control measure is not without its drawbacks. Water conservation is a stated goal and program of the Commonwealth. Continuous wasting of water is inconsistent with that program. Many communities are water short and cannot afford to waste water. The question has also been raised about a bleeder being left running in the winter weather causing a safety hazard by forming ice in the street.

The Department has determined that a bleeder line may be discharged into a catch basin or similar receiving area without constituting a cross-connection if:

- (1) The supplier provides the Department with a listing giving the location of each installation.
- (2) A pressure type vacuum breaker is installed on the line.
- (3) The water supplier periodically (at least bi-weekly) inspects the vacuum breaker to see that it is in operating condition.
- (4) The supplier agrees to shut off and physically remove all piping associated with the bleeder when the problem is solved.

Attachement "C" to this report lists the provisionally approved types of vacuum breakers and outlines a simple testing procedure which requires no special equipment.

The question has been raised about the effect a flushing or bleeding program might have on other parts of the environment. The DEQE does not believe that there will be adverse effects caused by the discharge of this water to waste

because of the low levels and the probable dilution in the ground.

Since vinyl lined pipe contains a finite amount of tetrachloroethylene, it follows that even normal water flow in the distribution system will eventually remove all of the chemical originally present. Evaluation of the results of 230 samples collected in S.E. Massachusetts shows that the tetrachloroethylene level decreases as the age of the pipe increases. The mean (average) level has been found to be less than 40 ppb in pipe which is 5 yrs., or older. (See Attachment "A") Similar information compiled on 82 samples in the State of Maine supports this finding.

Carbon Filtration

It has long been the position of most state and federal agencies that the drinking water being delivered to the ultimate consumer should be safe and that the consumer should not have to install and/or operate any type of device at the point-of-use to insure this safety. If treatment of a public water supply is necessary, it should be accomplished at a central plant where the treatment is under the control of a trained operator.

This philosophy is still valid except that in the present situation, the contamination is occurring at discreet locations in the distribution system and not at the source.

Given the fact that the problem will eventually disappear through use and that ingestion of the water is the only real concern about its use, we can, by making some assumptions and using laboratory test data supplied by the E.P.A. suggest the following as one way the concerned individual home owner could address the problem.

EPA's Office of Drinking Water has very recently (July 1980) published a Fact Sheet/Update on their testing of Home Water Treatment Units. Under a contract some 30 commercially available activated carbon units were tested to determine their effectiveness in removing certain organics, bacteria and endotoxins. Of particular interest for this report is the fact that the removal efficiency for tetrachloroethylene should be of the same order of magnitude as that for trihalomethanes, which was actually one of the organics studied.

Thus, if a home owner chose to install a unit with a reported efficiency of 95% for example for trihalomethane (THM) removal, that unit should reduce water with a tetrachloroethylene level of 800 ppb down to 40 ppb for the indicated test life of the filter cartridge.

Assuming a family of four, the amount of water actually used for drinking and cooking purposes probably amounts to no more than five gallons per day. Thus if a carbon filter were installed just ahead of a faucet used only to obtain water for these purposes and the filter had an indicated test life of 500 gallons, the carbon cartridge would have to be replaced at approximately 3 month intervals. Use of this tap for other purposes such as dishwashing would reduce the useful life of the filter.

A copy of pertinent parts of this report is available from the Department or the Environmental Protection Agency on request.

Boiling:

EPA laboratories in Cincinnati and Lexington have done some experiments to determine the effectiveness of boiling water as a means of removing chemical contamination. The two compounds actually chosen for the experiment were trichloroethylene and tetrachloroethylene but it is reasonable to assume that other chlorinated hydrocarbons would follow the same trend.

The results show that after five minutes of a vigorous boil less than 1% of the tetrachloroethylene remained.

There are a number of cautions which should be observed in using this solution to the problem.

1. The person should not stand over the pot of boiling water where the vapors can be breathed.
2. A range hood should be used.
3. A timer is a must. An accurate time of boiling is difficult to judge.
4. The inorganic quality of the water should be considered. If the water is heavy with iron for example, boiling will tend to concentrate the iron.

For maximum effectiveness, the depth of water should be no greater than 2 inches. Either glass or metal pans are suitable.

The Department feels that boiling can be an effective method of reducing the concentration of tetrachloroethylene in drinking water, but that because of the variabilities with respect to original concentration and other cautions, it may not be a practical long term solution.

pH Adjustment

At the same time the presence of tetrachloroethylene in vinyl lined asbestos cement pipe was confirmed, a town in Central Massachusetts was about to begin the addition of potassium hydroxide to the town's water supply. This addition was for the purpose of corrosion control and was in no way related to the tetrachloroethylene problem. It was recognized that this afforded an excellent opportunity to study the effect of pH on the concentration of tetrachloroethylene.

The town has one vinyl lined asbestos cement pipe in a low flow location. This line is 1500 feet long, 10" diameter, and serves 5 houses. The calculated residence time is 4.9 days. Several samples were collected from a hydrant at the end of this line before the KOH was added, with results as follows:

March 18	123 ppb
April 24	38 ppb (after flushing)

The addition of potassium hydroxide was begun on May 9, 1980 and the pH raised to 8.2. The line was flushed to waste for a period of two weeks to draw the high pH water through the line. At the end of that time samples were collected weekly, with results as follows:

May 9	150.4 ppb
May 16	Less than 5 ppb (while flushing)

June 3	3.3 ppb
June 10	91.8 ppb
June 17	144 ppb
June 25	137 ppb
July 9	285 ppb
July 16	180 ppb
July 23	140 ppb

At the time of the latest sampling, the pH was 8.2 at the station and 8.9 at the hydrant.

It can be seen that within a short time, the level of tetrachloroethylene reverted to its original level and increasing the pH has no effect on reducing the tetrachloroethylene concentration.

SUPERCHLORINATION

Dufresne-Henry, Consulting Engineers for a town in Southeastern Massachusetts recently designed a water transmission main using vinyl lined AC pipe. After installation, samples of water taken from the transmission line showed concentration levels of tetrachloroethylene above the recommended level of 40 ppb.

To determine the effectiveness of superchlorination in reducing the tetrachloroethylene concentrations, the pipe line was chlorinated at a level of 50 ppm and the chlorinated water allowed to flow through the pipe at 20 (gpm) gallons per minute for 16 days then allowed to stand in the pipe for 5 days. Chlorinated water was flushed out of the pipeline and the pipeline was periodically re-sampled.

The periodic sampling showed that tetrachloroethylene concentrations, after chlorination and flushing, returned to their original levels.

The Environmental Protection Agency has also done some bench studies on the effect of chlorination on vinyl lined asbestos cement pipe and has observed generally similar results.

Replacement

Asbestos cement, vinyl lined pipe is located in areas across the Commonwealth, from Clarksburg in the Berkshires to Provincetown on the tip of Cape cod, including the off shore islands. The sizes vary from 6 inches up to 16 inches with the majority being 6 inches and 8 inches in size. Several lines are short spur lines that dead end, many less than 2400 feet in length. To replace this pipe, dig it up, would create a costly problem for the communities. Our best estimate of quantity is 644 miles or 3,400,320 feet of pipe in the ground.

Replacement of the pipe would entail more than just digging it up and relaying. Any house service on the existing line would have to be re-connected; this would also mean hydrant connections; plans and specifications would also have to be prepared for bidding; and engineering inspection for the contract would be another cost.

Currently, contractor bids for laying 6" mains are \$35.00 per foot; 8" mains are \$40.00 per foot; and 10" mains are \$45.00 per foot. Using the 10 inch cost per foot as an average, the raw replacement of the mains would be:

Total Replacement	644 miles	\$153,014,400
75% Replacement	483 miles	\$114,760,800
50% Replacement	322 miles	\$ 76,507,200
25% Replacement	161 miles	\$ 38,253,600

To these costs must be added the costs of:

- 1) Plans and Specifications
- 2) Bidding
- 3) House Service Connections
- 4) Hydrant Connections
- 5) Construction Inspection
and
- 6) Repair of streets, sidewalks and driveways affected.

There are no specific state or federal programs that exist for problems of this type for cost sharing, so the entire cost of replacement must be borne by the water supplier.

Bottled Water - Alternate Water Supply

Bottled water as an alternate supply is usually available in either one gallon plastic jugs at the supermarket or five gallon carboys from a company which will deliver to the home. The testing of bottled water is not as comprehensive a program as is the testing of public water supplies.

In many communities there is no problem with tetrachloroethylene in any part of the water system and even in the affected communities not all parts of the system are affected. This raises the possibility of taps in public buildings (libraries, fire stations, the well or treatment plant) being made available to people who wish to draw water for drinking and culinary purposes.

Legal Responsibilities and Liabilities

The Department has consulted with the Attorney General's Environmental Protection Division concerning possible legal action concerning tetrachloroethylene distribution pipes. The Attorney General's Office has determined that it will ask the manufacturers of the pipe to pay for remedial steps that are taken by the cities, towns and districts as a result of the problem. As soon as a program of remedial action is formulated, the manufacturers will be contacted.

If the manufacturers refuse to pay the costs of a reasonable remedial program, the Attorney General will institute legal action on behalf of the water suppliers. The Department and the Attorney General's Office believe that the manufacturers should reimburse the water suppliers for expenses in correcting the situation.

In order to prepare for such a case, the water suppliers should return the contract information forms which were distributed at the meeting of the water suppliers and the Attorney General on July 15, 1980.

Blank copies of the form can be obtained from Malcolm Pittman, Assistant Attorney General, Environmental Protection Division, Department of the Attorney General, 1 Ashburton Place, 19th Floor, Boston, Massachusetts 02108.

Water distributors should keep accurate records of the expenses of remedial actions to facilitate reimbursement from the manufacturers.

Conclusions and Recommendations

The problems are:

- (1) This contaminant is in the distribution pipe and not the source.
- (2) It is not amenable to treatment with another waterworks chemical, i. e., chlorination, corrosion control chemicals, etc.
- (3) There is no Maximum Contaminant Level yet established which would provide a regulatory agency with an absolute number to determine whether or not a particular water is meeting the standard.
- (4) Since the lining was applied by hand rather than an automated process, the amount of vinyl lining can vary. In at least one case it is reported that the local water department was dissatisfied with the amount of material on some pipe they bought and it was sent back to the factory to be lined. This, coupled with the varying age of pipe in the systems tested, the lack of knowledge about how old the pipe was before it was laid and the difference in flow patterns that the pipe is subject to in the systems, make it impossible to draw more than broad and general conclusions from the data. Significantly more amounts of testing probably will not allow us to be any more precise with general conclusions. The degree of the problem is to a large extent site specific and must now be dealt with on that basis.

The possible solutions to the problem are several in number and the selection of the most advantageous one (or combination of several) must depend on decisions made at the local level.

The possibilities to be considered include:

- (a) Providing a program of bleeding and/or flushing.
- (b) Providing an alternate water supply.
- (c) Providing for carbon filtration.
- (d) Looping dead end situations or making other structural changes to provide for a better flow of water.
- (e) Boiling water used for consumption.
- (f) Scraping and/or relining pipe in place.
- (g) Replacing the pipe.

The eventual goal is to provide water in all locations where samples of water in the pipes under normal use conditions is consistently less than 40 ppb. The sampling program could then be discontinued. Further use and aging of the pipe will eventually lower this level to 0 ppb, well within the 70 year time span on which the SNARL is based.

To solve the problem of tetrachloroethylene in water pipes, each supplier must submit a written action plan to the Department indicating how they propose to address their problem.

The Department will assign one water supply engineer in each region whose priority responsibility will be to work with the water suppliers on this problem, to collect such additional samples as are felt necessary to assess the success of the efforts and to keep a current record on each affected supplier's efforts and the results of those efforts so that as areas of concern fall below the 40 ppb level, they can be eliminated from further testing. Samples collected by these engineers in furtherance of this effort will be analyzed by the Department. However, neither the Commonwealth nor the EPA have the laboratory capability to do all of the monitoring work that will be required. Suppliers should contract with private laboratories to do the routine analytical work, keeping a record of all expenses incurred as recommended in the "legal" section.

It is the responsibility of the water supplier to provide the best possible quality of water to the consumers. If, despite his best efforts there is still a problem, the ultimate consumer must then be made aware of the quality of the supply by the water supplier. The consumer will at least then be aware of the problem and the factors which have gone into any decision and can make informed judgements about using or not using the water for various purposes.

Strategy for Dealing with the Problem

The following strategy is suggested as a possible plan of action.

1. Water suppliers identify all areas where vinyl lined AC pipes have been installed.
2. Those areas where the pipe is in a constant flow situation and those areas where the pipe is five years old or older be tested and eliminated from future testing if the concentration is 40 ppb or less.
3. Those areas where previous sampling has shown the concentration to be 40 ppb or less under normal use conditions be eliminated from future testing.
4. Those areas where previous sampling or new sampling shows the concentration to be between 40 ppb and 100 ppb under normal flow conditions be immediately flushed and equipped with a bleeder. The bleeder should be protected with a backflow device such as a pressure type vacuum breaker if necessary. One sample should be collected from these locations every six months to confirm that the level is being maintained below 40 ppb.
5. Those areas where the concentrations are above 100 ppb under normal use conditions to be identified and:

- a) Flushed and bleeders installed where appropriate.
- b) Sampled on a monthly basis by the water supplier. The frequency of this sampling can be reduced to once every 6 months, provided that 3 consecutive month's samples show tetrachloroethylene levels below 40 ppb.

If steps (a) and (b) show that the concentration is not being kept below an average of 40 ppb over a six month average, or if any monthly sample exceeds 175 ppb which is the 10 day SNARL, then the supplier must initiate a program for the affected area whereby:

- a) The consumers in the affected area are formally notified of the problem and the water suppliers intended further actions to correct it.
- b) The affected consumers be advised of possible alternative such as:
 - Obtaining water from another nearby source which is not affected.
 - Installation of an appropriate carbon filtration unit.
 - Boiling water used for consumption.

As an indication of their concern and awareness of this problem, it is suggested that the supplier, as a matter of policy, keep the consumers affected by this problem informed about its prevalence within the system, the efforts being made to solve the problem, the outcome of these efforts, the results of testing, etc., as this information becomes known.

The essence of the program should be that the average level of tetrachloroethylene is maintained at, or below, 40 ppb even though the short-term (less than a month) levels may be higher than that. The Department believes that, despite these short-term variations in excess of 40 ppb, the long-term effects of tetrachloroethylene present no danger to the health of the exposed population, based on two liters of water ingested per day for 70 years.

GRAPH SHOWING RELATIONSHIP BETWEEN
TCE LEVEL AND AGE OF PIPE
(BASED ON 232 SAMPLES FROM
SOUTHEASTERN MASSACHUSETTS)

TCE LEVEL (IN PARTS PER BILLION)

500

400

300

200

100

0

Attachment A

NOTE: AVERAGE REDUCED TO
27 P.P.B. IF ONE SAMPLE
IS ELIMINATED

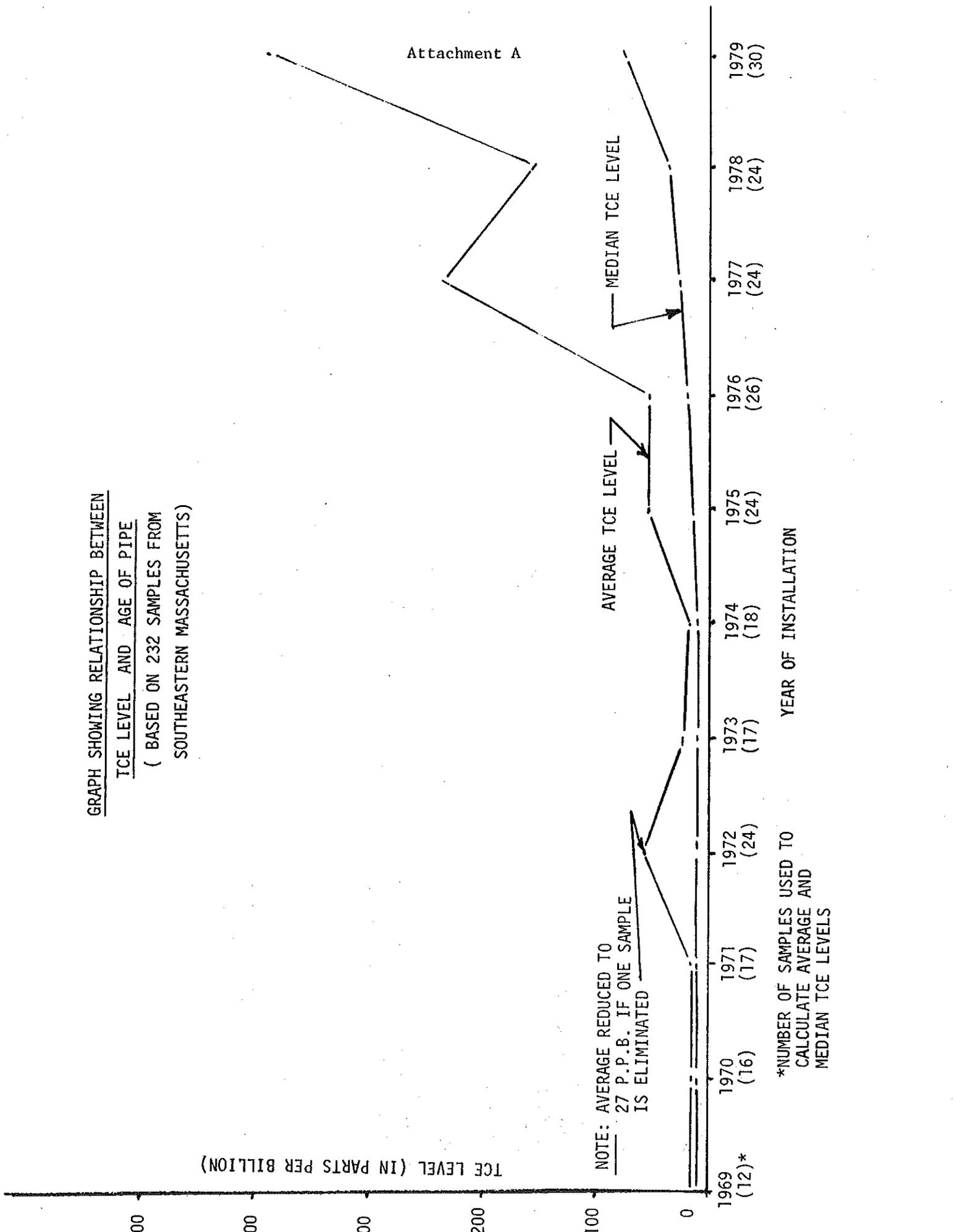
AVERAGE TCE LEVEL

MEDIAN TCE LEVEL

1969 (12)* 1970 (16) 1971 (17) 1972 (24) 1973 (17) 1974 (18) 1975 (24) 1976 (26) 1977 (24) 1978 (24) 1979 (30)

*NUMBER OF SAMPLES USED TO
CALCULATE AVERAGE AND
MEDIAN TCE LEVELS

YEAR OF INSTALLATION



WATER SUPPLIES WITH ASBESTOS CEMENT VINYL LINED PIPE

SOUTHEAST

Acushnet
 Barnstable: Water Company
 Bourne: Bourne Water District
 North Sagamore Water District
 South Sagamore Water District
 Brewster
 Bridgewater
 Chatham
 Dartmouth
 Sudbury
 East Bridgewater
 Edgartown: Water Company
 Fairhaven
 Falmouth
 Franklin
 Gosnold: Water Company
 Halifax
 Hanover
 Hanson
 Harwich
 Kingston
 Marion
 Marshfield
 Mashpee: Highwood Water Company
 Mattapoisett
 Nantucket: Wannacomet Water Company
 Norwell
 Oak Bluffs
 Pembroke
 Plymouth
 Provincetown
 Raynham: Raynham Center Water District
 North Raynham Water District
 Sandwich
 Scituate
 Sharon
 Taunton
 Tisbury
 Wareham: Wareham Fire District
 Onset Fire District
 West Bridgewater
 Wrentham

WESTERN

Amherst: (Belchertown)
 Barnardston: Fire & Water District
 Chicopee
 Clarksburg: Red Mills Water Supply
 Deerfield: South Deerfield Water Dist.
 Deerfield Fire District
 Easthampton
 Hatfield
 Longmeadow
 Northfield: Water District
 Southampton
 Sunderland

NORTHEAST/METROPOLITAN

Arlington
 Ashland
 Burlington
 Cohasset
 Dracut
 Essex
 Hamilton
 Haverhill
 Ipswich
 Lincoln
 Norfolk
 Rowley
 Salisbury
 West Newbury
 Winchester
 Woburn

CENTRAL

Ayer
 Brookfield
 Boylston: Water District
 Douglas
 East Brookfield
 Holden
 Holliston
 Littleton
 Lunenburg
 Maynard
 Milford: Water Company
 North Brookfield
 Northborough
 Paxton
 Rutland
 Shirley: Mass. Correctional Institute
 Shrewsbury
 Southborough
 Sterling
 Stow
 West Boylston: Water District
 West Brookfield
 Westford
 Westminster

Attachment C
PRESSURE TYPE VACUUM BREAKERS

The model and size of pressure type vacuum breakers listed below are not yet fully approved by the Department. In accordance with our policy of requiring evaluation under field conditions before full approval is given they will be allowed to be used on bleeder lines from public water supply distribution systems to lower the tetrachloroethylene levels. The water supplies must make application to the Department for each installation although no formal permit will be issued or fee charged.

<u>Company</u>	<u>Model</u>	<u>Sizes</u>
FEBCO	765	1/2", 3/4", 1", 1-1/4", 1-1/2" and 2"
WATTS	No. 8000 series	3/4", 1", 1-1/4", 1-1/2" and 2"
RAINBIRD	PVB 075	3/4"
	PVB 100	1"
	PVB 125	1-1/4"
	PVB 150	1-1/2"
	PVB 200	2"
NEPTUNE	720	1/2", 3/4", 1", 1-1/4", 1-1/2" and 2"

TEST PROCEDURE FOR PRESSURE VACUUM BREAKER

1. Remove canopy from top of vacuum to expose air inlet tube.
2. Close shutoff valve No. 2 on discharge side of vacuum breaker.
3. Close shutoff valve No. 1 on inlet side of vacuum breaker.
4. Slowly open test cock No. 2, watching guide in air inlet tube. Valve must be fully open by the time the water stops running from test cock No. 2. If it is not open, then air inlet is sticking and valve must be repaired.
5. Close test cock No. 2.
6. Open inlet shutoff valve No. 1 very slightly and allow water to fill to the top of the air chamber. Then close shutoff valve No. 1 tightly.
7. Open test cock No. 1.
8. The water level in the air inlet tube will drop initially due to the seating of the diaphragm. After the initial drop, the level of the water should remain fixed in the air inlet. If it continues to drop, then check valve is leaking and should be replaced.
9. If both 3 and 7 test satisfactorily, restore all shutoff valves and test cocks to initial positions.

NOTES: Open shutoff valve No. 2 on the discharge side of the vacuum breaker before opening the shutoff valve No. 1. This eliminates any shock that might cause the diaphragm to blow due to the compressed air and resultant shock wave.

TEST PROCEDURE FOR PRESSURE VACUUM BREAKER

