VOLUME IV-B

APPENDIX-B
TO
PUBLIC HEARINGS
before
ASSEMBLY AGRICULTURE AND ENVIRONMENT COMMITTEE
on
WATER POLLUTION AND RELATED ISSUES

MEMBERS OF COMMITTEE:

Assemblyman Raymond J. Lesniak (Chairman)
Assemblyman Anthony S. Marsella

ALSO:

Norman Miller, Research Associate
Office of Legislative Services
Aide, Assembly Agriculture and Environment Committee

Mark O. Smith, Research Associate
Office of Legislative Services
Aide, Assembly Agriculture and Environment Committee

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ADDENDUM TO STATEMENT OF

DENNIS SULICK

We strongly support the concept of Assembly Bill 280. We think it important for water systems to determine what organic chemical contaminants, if any, exist in their system and the quantity of any contaminant found. Furthermore, we think that information should be available to those who are consuming that water. Not only is it important for the water systems to know what contamination exist and for the consumers, but also for the regulatory authorities in order that they may determine what corrective action, if any, is appropriate. For all those reasons, we strongly support the concept of Assembly Bill 280.

However, we feel there are some significant deficiencies in the Bill as it is currently drafted. First, we believe the list of chemicals which Assembly Bill 280 would require be tested for is too long and would therefore impose an unwarranted financial burden on the affected water systems.

Assembly Bill 280, as drafted, would literally require testing for hundreds of compounds. Several of these, the pesticides methoxychlor; toxaphene; endrin; and lindane and the inorganics, arsenic; cadmium; chromium; lead; mercury; and selenium are already covered by Federal requirements which require that water systems monitor for their presence. To that extent, the list duplicates existing requirements.

The cost of conducting the monitoring required by this legislation could be reduced substantially if the list of chemicals to be monitored is limited to those which are found with sufficient frequency in drinking water to be of major concern. Based on studies conducted to date, this is about twelve organic chemicals. We recommend, however, that the Department of Environmental Protection be given the authority to add additional compounds to the list upon a finding of potential adverse effects on human health from consumption of a chemical in drinking water and a finding that there is reason to believe that the chemical may be found in drinking water systems. In this way, the list could be expanded as new information is developed.

In this context, we would also like to point out that the exact coverage of the proposed legislation is hard to determine because of the use of the phrases "including but not necessarily limited to" which appears in Paragraphs 2 and 3 of Section 1(a) of the Bill, and by the use of the word "including" which appears in Paragraph 1 of that Section and which implies that other compounds might be defined as purgeable organics and, hence, be covered by this legislation.

We also question the need to establish an Aggressivity Index. The theory behind requiring that testing is that it is a measure of corrosivity which could contribute to contamination of the water through corrosion of the pipes. We think a preferable way of dealing with that issue is to provide in the monitoring regulations that the samples be taken at the end of the system. Then any contaminants which have been contributed to the water through corrosivity will be measured in the samples taken. That is really what we are concerned with; not with the Aggressivity Index. Furthermore, the Aggressivity Index, once established, will not change significantly unless the water source is changed. Therefore, if the Legislature should see fit to retain the requirement of establishing an Aggressivity Index, it should be required only once, as long as the water source remains unchanged.

Another concern we have with Assembly Bill 280 is that there is no requirement to report the results to any State agency. As indicated earlier,

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we feel one of the important reasons for enacting this legislation is so that the regulatory authorities can determine what corrective action, if any, should be taken. It is therefore, in our opinion, important that the regulatory authorities know the results of the testing performed. Therefore, we recommend that the statute provide that results of the testing be reported to the Department of Environmental Protection within some specific time period after the results become available, for example, thirty days.

The Bill, as currently drafted, provides that the results of the monitoring are to be retained for public inspection. However, it is not specific as to where those records are to be retained. We recommend that the statute be specific in that regard and that it be modeled after the Federal regulatory requirement. Furthermore, we suggest that the legislation provide that these records be retained for five years, which would be consistent with the Federal requirement.

By making these provisions consistent with Federal regulatory requirements, the water system has one set of record retention requirements that they must comply with and is not bothered with having different record retention requirements for different records depending on whether they are maintained under this statute or under the other provisions of the Safe Drinking Water Act.

We have emphasized on several occasions that we think it important that this monitoring be performed in order that the regulatory authorities can make decisions about what corrective action, if any, should be taken. To fully implement that concept, we think that legislation should require that the Department of Environmental Protection make a report to the Legislature at some appropriate time after the first test results become available as to what steps the Department of Environmental Protection thinks should be taken to protect the citizens of the State from contaminated drinking water.

We would also like to make one final observation with regard to Assembly Bill 280. Section 4(b) provides that the penalties for non-compliance are to be in addition to the penalties provided in Section 10 of the Safe Drinking Water Act. This seems inappropriate. It would mean that someone found guilty of violating this monitoring requirement would be subject to a greater fine than someone who had violated one of the maximum contaminant levels and who had, in fact, jeopardized the health of the customers of the water system. We see no need to make a violation of this monitoring requirement subject to any greater penalty than failure to comply with any other monitoring requirement contained in this statute. We would, therefore, recommend the elimination of Section 4 of the Bill.

We hope that these observations about Assembly Bill 280 are helpful. If desired, Counsel for Calgon will be glad to make specific language recommendations to you concerning improving Assembly Bill 280, while retaining the objective of the legislation.

. . . NOR ANY DROP TO DRINK!:
PUBLIC POLICIES TOWARD CHEMICAL CONTAMINATION OF DRINKING WATER

by

Grace L. Singer

February 1982

Center for Energy and Environmental Studies
Princeton University
Princeton, New Jersey 08544

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PUBLIC POLICIES TOWARD CHEMICAL CONTAMINATION OF DRINKING WATER

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ABSTRACT

Increasing indications of chemical contamination of drinking water throughout the United States have raised public policy questions about the causes, ubiquity, and remedies of this problem. How is government responding to recent discoveries of toxic chemicals, especially in ground water once assumed to be relatively safe? And what about revelations that chlorination of drinking water itself may be causing threats to public health?

Section I of the report gives an overview of the national issue. This serves as the context for Section II, a case study of New Jersey, one of the nation's most prolific chemical and toxic waste producers, now facing serious drinking water contamination problems. This analysis illustrates some of the institutional and financial difficulties as the state struggles to find remedies. Current federal budget cutbacks and a negative federal regulatory stance are likely to impede some of these efforts. An interview survey and selected plant tours were conducted with 21 of the state's largest water suppliers to learn of their practices and attitudes in coping with chemical pollution a problem more insidious and subtle than bacterial contamination of the past.

This study points up the institutional, legal, and scientific gaps which have prevented more effective public health protection from chemical contamination in drinking water. Section III offers conclusions and recommendations emphasizing prevention and some innovative approaches to the problem.

. . . NOR ANY DROP TO DRINK!:

PUBLIC POLICIES TOWARD CHEMICAL CONTAMINATION OF DRINKING WATER

INTRODUCTION

> Water may be considered good when it is fresh, limpid, inodorous, not inclined to become turbid when boiled; leaves but little sediment after evaporation; when its taste is sweet and pleasant, and neither salty nor insipid; when it holds air in solution; when it melts soap easily without forming clots, and when it boils vegetables well.....
>
> Gaston Tissander, The Wonders of Water (1872)[1]

By 1978, some 700 chemical contaminants, most of them tasteless, odorless, and colorless -- and many of them dangerous to public health -- had been identified in America's drinking water.[2] They were clearly coming from the burgeoning and now ubiquitous chemical-based industry. Some of these chemicals were suspected of causing cancer, although the scientific evidence was so complex that in only a few cases could the causal connection be absolutely proven and quantified. Yet the list of contaminants was growing, and demands for effective public policy response were beginning to be heard.

In 1980, the nation used approximately 235 billion gallons of fresh water daily — 50 percent of it for agriculture, 40 percent for industry and 10 percent for residential use. In the East, 12 percent was used for irrigation; in the West the quantity was 52 percent.[109] The average person uses about 83 gallons of water daily: 32 for bathing, laundry, and dishwashing; 25 for swimming pools and lawn watering; and 24 for flushing. Only two gallons are used for drinking and cooking.[109a]

Chemical contamination has been found in surface water supplies of drinking water, and even more seriously in underground aquifers. While large cities still obtain most of their water from surface sources, fifty percent of the drinking water in the United States as a whole is now derived from ground water. The number of gallons being withdrawn from this source has been growing at 25 percent per decade as housing and commercial development spread into new areas.[14]

The challenge of protecting the public from health hazards in drinking water is certainly not new. In the 1800s, public authorities around the world faced similar uncertainties with respect to bacterial contamination of drinking water. In 1847, for example, the Lambeth Water Company in London decided, on the basis of a tentative connection between water and cholera proposed by Dr. John Snow, to move its intake on the Thames from the immediate metropolitan area to a point some distance upstream. This move protected its consumers from the cholera epidemic of 1853 that severely affected customers of competing water companies which continued to draw their water from the lower Thames. Lambeth's decision to move the intake upstream was made <u>before</u> there was <u>proof</u> that the water supply was responsible for cholera; in fact, the germ theory of disease had not yet been formulated. The company's officials decided to act on the basis of the tentative correlatons suggested by Snow.[3]

After the turn of the century, chlorination and sand filtration of drinking water entered into common use as the way to protect consumers from bacterial infection. Municipal water suppliers thus were able to draw their water from nearby rivers, streams, and lakes, even when these sources contained bacteria and suspended solids. This was the first, and critical, milestone in water purification.

Now we face a new set of problems brought about by the growing presence of complex chemical wastes in drinking water sources, and by the process of chlorination itself. As before, choices must be made on the basis of incomplete scientific knowledge. And as before, skepticism is being expressed by those unwilling to take preventive measures before absolute proof is available.* This time, however, the casual relationship between chemical contaminants in drinking water and health effects is even more difficult to prove than for bacteria. This difficulty is due in part to the decades-long time lag between initial contact with carcinogens and the onset of cancer.**

I. THE NATIONAL PROBLEM

1. Overview

Toxic Wastes and Water Contamination

We are just beginning to assess the magnitude of the drinking water problem, and identify its principal causes. The "chemical revolution" that began with World War II brought about a massive introduction of synthetic organic compounds, some of them carcinogenic: trichloroethylene, carbon tetrachloride, vinyl chloride, tetrachloroethylene, dichloroethane, chloroform, and so on. Approximately 63,000 chemicals are currently in commercial use, with 1,000 new ones coming on the market every year.[4] Total synthetic chemical production has doubled every seven or eight years since the war's end.

Since many of these compounds are not easily degradable, they remain unchanged in the biosphere, entering drinking water supplies from various sources including: urban and agricultural runoff, industrial effluents and impoundments, municipal sewage, septic tanks and cesspools (and their chemical cleansers), underground injection wells, mining and petroleum development, accidental spills, illegal waste dumping, and primitive methods of waste disposal in landfills, a principal cause of ground water contamination. Because of institutional, budgetary, and scientific constraints in assessing the huge

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*Discussions of such skepticism/controversies are on pp. 23, 31-34, 80-86.

**Further discussion pp. 16, 17.

quantity of chemicals and their synergisms, nearly all enter the environment before their health effects are really known.

Until the mid-1970s ground water was commonly thought to be protected by overlying soils, and to be in relatively pristine condition. This myth has been shattered during the past decade by widespread findings of SOCs in ground water across the country. Figure 1 illustrates the principal sources of ground water contamination.

The evidence on ground water contamination is fragmentary but disturbing. The President's Council on Environmental Quality reported that toxic organic chemicals have been identified in drinking water wells in at least 34 states, and probably in 40 or more.[12] Almost 1,400 wells from coast to coast had been closed due to chemical contamination by early 1980.[13] Over 200 contaminated wells have been identified in California, including 39 public wells serving 400,000 people in 12 communities. On New York's Long Island, where ground water is the sole source of drinking water for three and a quarter million residents, 35 public wells have been closed and "all three of the island's principal aquifers are seriously and dangerously contaminated."[9] In New Jersey, almost 500 private wells and at least 18 public wells have been contaminated. In Connecticut, a 1979 state survey of all ground water supplies serving 1,000 people or more resulted in detection of volatile organic compounds in 87 percent of the wells tested.[11] In Bedford, Massachusetts, eight public wells were contaminated with industrial solvents, including TCE.* As a result, Bedford lost 75 percent of its water supply and city residents had to pay two and a half times the normal rate to import water from neighboring towns.[10]

To put together the pieces of this fragmented picture, EPA in 1980 launched a ground water monitoring program. It is still too soon, however, to see results from this effort.

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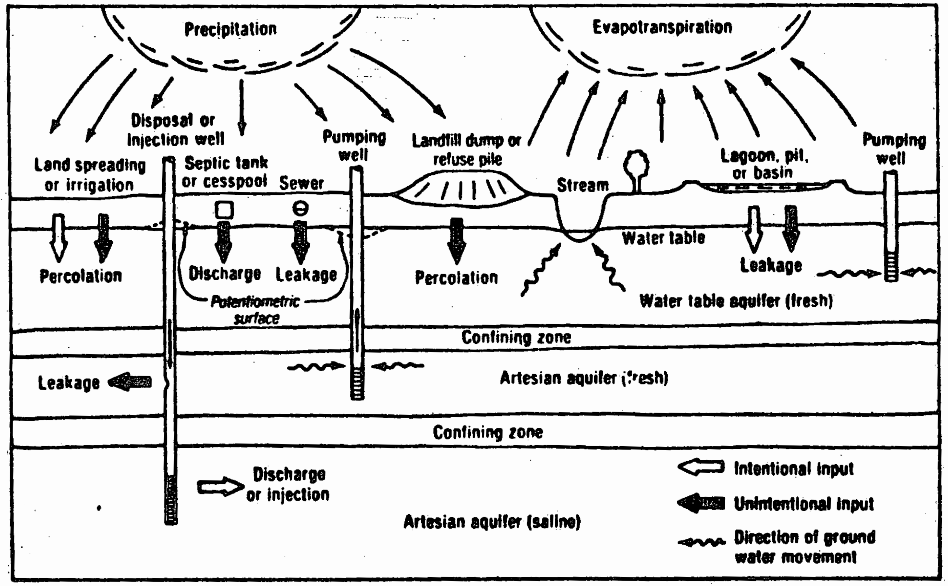
* Trichloroethylene.

Figure 1

Principal Sources of Ground Water Contamination



Source: U.S. Environmental Protection Agency, Office of Water Supply and Solid Waste Management Programs, *Waste Disposal Practices and Their Effects on Ground Water: Executive Summary* (Washington D.C.: U.S. Government Printing Office, 1977), p. 8.

An 11-state survey conducted for the U.S Environmental Protection Agency (EPA) in 1977 at 50 land disposal sites that had received large volumes of industrial wastes demonstrated that toxic wastes can and do migrate from their source. Of the 50 sites tested with monitoring wells, 48 showed confirmed migrations of one or more hazardous chemical compounds.[6] Even "secure" landfills with plastic or clay liners are vulnerable to leakage over time -- and often it does not take much time for them to fail. For example, four of the five "secure" landfills (all less than four years old) studied in New Jersey were found to be already leaking through one of their double liners.[5] Because disposal of industrial and other wastes constitute the most important source of ground water contamination, EPA conducted a survey of 25,000 industrial surface impoundments. Half contained hazardous wastes. Seventy percent were unlined. Nine hundred of the 12,500 unlined hazardous waste sites were situated over pervious soils within one mile of a water supply well. In 95 percent of the cases the company in charge of the pond performed no monitoring at all.[4b]

EPA estimates that 75 percent of all active and inactive waste disposal sites are leaking contaminants into the ground and its underlying water. About 50,000 of the approximately 100,000 active and 75,000 abandoned landfills throughout the nation are believed to contain potentially dangerous amounts of toxic wastes.[6a] Though many of these are municipal landfills receiving primarily household refuse, these also pose potential dangers to water supplies because of the great number of toxic products deposited there, including: insecticides, herbicides, motor oils, plastics, and batteries containing cadmium and lead. Leachate from one such landfill in New Jersey was found in 1975 to have a lead content of 300 ppb, six times the drinking water standard of 50 ppb set under the SDWA.[7] The most serious ground water contaminants, because they occur most frequently and sometimes at higher levels, are chlorinated organic solvents. One of these, TCE, an industrial solvent and degreaser also used to clean septic tanks, was found in one third of 8,000 water samples taken nationally by EPA.

Although often discussed as separate sources, ground and surface waters are in fact part of a single hydrological cycle. Surface water recharges ground water: during times of flooding recharge may occur at two to three times the normal flow. In times of low precipitation, ground water is the source for streams. Because of this interrelationship, the quality and quantity of one source can affect the other.

Surface waters can be cleansed somewhat by exposure to air, by dilution, and by rapid movement. In contrast, once ground water becomes contaminated it can remain so for decades. Ground water moves very slowly. River flow is measured in feet per second, ground water movement in feet per year. Since ground water is not exposed to the atmosphere, organic compounds in acquifers do not readily dissipate. Because of these differences, ground water contaminants are often orders of magnitude more concentrated than are contaminants in even the most polluted surface water supplies. For example, several Pennsylvania wells contained TCE up to 27,300 ppb, while surface waters there contained less than 160 ppb.[12] (EPA's proposed criterion for TCE in ambient water is 2.1 ppb.[12a*] See Appendix A.)

In addition, it is often very difficult and expensive to determine if a plume of contamination exists in ground water. Monitoring wells can easily miss narrow streams of pollution in a large aquifer. Monitoring is time consuming and tedious, and costs can run very high. If several potential sources of contamination exist, or if the geology is complex, monitoring costs can approach a half million dollars per contamination episode. Costs could rise to two to three million dollars per project if the acquifer is deep or surface indicators do not help to determine the hydrogeology of the area.[14a]

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[*] The proposed criteria (or calculated risk level) given throughout this report serve only as guidelines under the Federal Water Pollution Control Act, whereas, en- able maximum contaminant levels (MCLs) under the Safe Drinking Water Act are legal standards. These criteria are based on a one in a million risk of contracting cancer as a result of water consumption with the contamination level indicated.

While ground water pollution has only recently become a widely recognized phenomenon, surface water pollution associated with industrial effluents, municipal sewage discharges, and runoff (nonpoint pollution) from urban and agricultural sources has been evident for many years. The Federal Water Pollution Control Act (FWPCA) has improved surface water quality in many areas. Current programs are, however, inadequate to cope with the enormous proliferation of toxic waste. For example, the National Pollutant Discharge Elimination System (NPDES), the major regulatory mechanism to control industrial and sewage effluents, has been criticized by the U.S. General Accounting Office (GAO) for serious enforcement deficiencies.* Even new sewage treatment plants built since 1972 in the nation's largest pollution abatement effort have been found to be violating federal standards.** Treatment of industrial waste before it enters sewage treatment plants not designed for toxic substances is inadequate.***

Nonpoint sources of pollution present one of the most difficult surface water management problems because they are diverse, diffuse, and have politically sensitive remedies related to the politics of land use control. To address this complexity, EPA, under Section 208 of the FWPCA, has provided funding for regional or state agencies to prepare area wide plans identifying problems and proposing solutions.

One of the consequences of surface water pollution is that fishing has been prohibited or restricted in several of the nation's major rivers, also used as drinking water supplies. The Great Lakes, which contain 95 percent of America's surface fresh waters and are a drinking water source, have also been seriously affected. PCBs have been found in all five of the Great Lakes,

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*See pages 36, 61, 62 for further details.

**In a major effort under the FWPCA, 18,000 communities were to construct waste water treatment facilities. Since 1972 2,000 plants have been completed. According to various Congressional and EPA samplings more than half of these plants malfunction at any given time. In many instances, this is caused by the lack of adequately trained sewage plant operators. A 1980 GAO report concluded that "violations of pollution permits is the norm, not the exception."[4c] In addition, fewer than half of the 3,700 largest U.S. cities can meet federal sewage effluent standards.[4d]

***See p. 37 for an illustration of inadequate pretreatment.

with highest concentrations in Lake Michigan. Other toxic substances found in one or more of the Greal Lakes include the pesticides mirex and DDT, mercury, polychlorinated dibenzofurans (PCDF), and asbestos. As a result, commercial fishing for salmon, trout, and carp has been severely curtailed and it is estimated that overall commercial fishing in the Great Lakes has been limited by 50 percent in recent years.[13a] Like the coal miners' canary, fish biology is used in scientific tests as a barometer of water quality.

The debate over remedies to this situation is underway. Some argue that it is too costly to act -- we should essentially do nothing and hope for the best.* One strategy in line with this viewpoint is to abandon specific ground water sources once they have been found to be contaminated. Water shortages are, however, becoming more serious just as greater contamination is being discovered. In additon, the economic impact of abandonment can be severe. It may include the expense of obtaining a new water supply -- if available -- and a new treatment plant, adverse effects on property values, and production losses. Often victimized communities have to bear these costs because the responsible polluters cannot be identified or brought to justice.

The Safe Drinking Water Act (SDWA) was passed in 1974 in response to revelations that America's drinking water contained a veritable alphabet soup of chemicals, from BCEE to TCE.** The act carries a strong preventive mandate for EPA to establish maximum contaminant levels (MCLs) for all substances which "<u>may</u> have any adverse effect on the health of persons."[3a] Regulations under the act to date, however, do not offer this assurance, especially with respect to chemical contamination.

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*See pp. 31-34 and 80-86 for a discussion of controversies over control technologies to remove chemical contaminants from drinking water.

**Bis(2-chloroethyl) ether and trichloroethylene, both carcinogens.

This gap between goal and reality has several dimensions. First, only a very limited number of synthetic organic compounds (SOCs) are regulated under the SDWA: six pesticides (and 10 inorganics -- heavy metals) compared to EPA's list of 129 "priority pollutants."* Second, infrequent chemical monitoring is required of water suppliers: every three years for organics in surface water, with no specific requirement to monitor organics in ground water. And third, many state agencies -- the principal authorities under the SDWA -- are unable adequately to carry out the act's mandates. This is particularly troublesome in relation to the thousands of small water suppliers which have inadequate resources to meet federal and state standards.

We can approach the many facets of the drinking water problem in a concerted effort to protect public health and natural resources. This effort would include both a hard look at new chemical production, relying in large measure on the Toxic Substances Control Act, and an innovative approach to toxic waste disposal under the Resource Conservation and Recovery Act, including industrial waste exchanges, recycling, resource recovery, above ground waste storage, and better waste treatment technology. To encourage these measures, economic incentives and disincentives would have to be implemented. We can improve our institutional mechanisms under the FWPCA and SDWA to assure better water quality. This is especially true for the state agencies which have prime responsibility to carry out the mandates of the SDWA, but lack the federal incentives offered by the FWPCA.

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*The 129 Priority Pollutants are listed in tables 2 and 2a. This list was formulated as a result of a consent decree obtained in federal court in 1976 by public interest groups. The criteria for selecting these 129 pollutants included hazard, frequency of occurrence in water, chemical stability, amount of the chemical produced and the availability of chemical standards for measurement.[3b] (Further discussion on p. 36.)

Three key programs which would begin to remedy ground water contamination are in the formative stages. All will require strong government and industry support to be effective. These are regulations under the Resource Conservation and Recovery Act of 1976 to deal with future hazardous wastes, the "Superfund" legislation of 1980 to help states clean up old toxic dumps, and EPA's proposed Ground Water Strategy of 1980 to coordinate the statutory authority for ground water management under various laws and government agencies. All of these steps will take time and may be greatly impeded by the current antiregulatory attitude in Washington.

Given the severity of present contamination problems, prevention alone is not enough. The quickest and most direct means to remove SOCs from drinking water is by control technology. The particular system employed in European drinking water treatment plants is granular activated carbon (GAC), a technology resisted by American water purveyors primarily on the basis of cost.* However, based on water suppliers' own estimates in New Jersey, these costs to the consumer would be nominal: approximately $19 to $27 a year for an average household, much less by EPA estimates.** Such costs can be put in perspective by comparing them to a consumer alternative, bottled water, estimated to cost over $500 per year for an average household. Even at this price, the consumer has no assurance that bottled water is free of chemical contamination because of deficiencies in standards under the SDWA. These standards are applied to bottled water in only sporadic surveillance by the federal Food and Drug Administration.***

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*Opposition to GAC based on cost and other factors is discussed on pp. 23,31 to 34, and 80 to 86.

**Details of the New Jersey GAC costs are on p. 81.

***Currently over 10 million U.S. consumers (the rate is growing at 10 percent a year)[31a] are spending $400 to $500 million annually for bottled water and another consumer alternative, home filter devices. Most of these devices are ineffective in removing organic chemicals for several reasons including too little activated carbon and too limited contact time with tap water. In addition, filters must be changed frequently or they can be more harmful than using nothing. Moreover, without routine sampling of tap water -- an expensive exercise for most homeowners — one cannot be sure that the investment, which can amount to several hundred dollars for the better filters is worthwhile. (See p. 82 for a discussion of bottled water vis a vis GAC costs in the New Jersey case study.)

Just as chlorine was the broad spectrum remedy to cope with numerous bacteria, SOC control technology offers the hope of better health protection from numerous chemicals -- some still unidentified -- in drinking water. This should, however, not be a substitute for prevention through ambient water quality improvement, which still offers the best long term solution.

"How safe is safe enough?" is currently more a social question than a scientific one. Given the opposing points of view on costs and benefits, perhaps only an informed citizenry can give the answer.

Disinfection By-Products: Trihalomethanes

Health problems associated with industrially-produced synthetic organic compounds(SOCs) are not the only public policy issue in the drinking water field. A second contamination issue concerns the direct and indirect additives introduced by water treatment and delivery systems themselves. Chlorine, caustic soda, coagulant aids, and other direct additives are mixed into water during the treatment process primarily to destroy bacteria, adjust pH, and eliminate solids. Other indirect additives leach into water from paints and coatings used in pipes, storage tanks, and other equipment. For example, tetrachloroethylene is found at high levels -- up to 3000 ppb*[4b] -- in drinking water supplied through a particular kind of asbestos-coated cement pipe.** In addition, ancient water delivery systems frequently found in large, financially pressed urban areas are leaky, wasting huge amounts of water.***

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*EPA's proposed criterion for tetrachloroethylene in ambient water is 0.2 ppb.

**Higher rates of cardiac disease have been associated with corrosive or "soft" drinking water. While this causal connection has not been scientifically established and cardiac disease could be related to the lack of certain minerals or other water-related factors, acidic water does promote leaching of such metals such as lead, cadmium and copper from water pipes. In addition, some water artificially softened with sodium could increase the risk of cardiac disease and high blood pressure.[13c]

***In Boston, it is estimated that water lines leak two gallons for every gallon delivered. New York City's water system loses about 100 million gallons a day. In New Jersey, the water mains for Jersey City to Hoboken are causing an estimated loss of 50 million gallons a year.[13b]

Chlorination is, however, of greatest concern because of its ubiquity, and the recent discovery that chlorine forms suspected carcinogens -- trihalomethanes(THMs)-- when combined with natural organics (humics and fulvics), the products of living and decayed plant and animal matter found in nearly all surface water sources. This is significant because surface sources are used for most water supplies serving populations of more than 100,000 people. THM concentrations vary with such factors as the amount of chlorine used; the contact time between the organic matter and chlorine; the amount and type of natural organic material in raw water; temperature; and pH (a measure of acidity/alkalinity).

Most of the natural organics in water are thought to be of little toxicological significance. Their chemical reaction with chlorine during disinfection, however, produces a series of chlorinated and non-chlorinated organic compounds, most of which remain to be identified. Four THMs -- chloroform, bromodichloromethane, dibromochloromethane, and bromoform -- are by far the most ubiquitous and concentrated organic compounds in drinking water. Chloroform is a known animal -- and suspected human -- carcinogen based on findings by the National Cancer Institute in 1976.

Chlorine was first used to treat sewage effluent in 1803 at Brewster, New York. The first continuous municipal application of chlorine to disinfect drinking water began in 1908 at the Boonton Reservoir, the supply for Jersey City. Currently about 23,000 water treatment facilities in the U.S., serving over 150 million people, use chlorine for disinfection.[30] Widespread use of chlorine has made one of the most significant contributions to public health in history; the death rate in developed countries from typhoid, cholera, and other waterborne diseases has been reduced virtually to zero. Now, however, there is great concern over recent negative findings of chlorine's impact in creating THMs in drinking water.

Table 1

National Monitoring Surveys for Organics, Including THMs

National Organics Reconnaissance Survey	80 cities	1974-75
National Organics Monitoring Survey	113 cities	1975-76
National Screening Program	140 cities	1978-80
Community Water Supply Survey	430 cities	1978-80
Rural Water Survey	2600 cities and private homes	1977-80

Source: U.S. Environmental Protection Agency, Humics, Chlorination and Drinking Water Quality -- Report to Congress, (Washington: Office of Drinking Water, Criteria and Standards Division), September 1980, p. 2.

Since 1972-74 when THMs in potable water were discovered, EPA has conducted five major national monitoring surveys for organics, including THMs (Table 1). These have shown that chloroform and other THMs invariably were present in drinking water which had been chlorinated. In raw water sources, THMs were present in much lower concentrations or were absent altogether. Miami, which uses ground water with a high natural organic content, had the highest THM concentration (311 ppb) found in EPA's 80-city nationwide survey.[31] EPA's proposed maximum contaminant level (MCL) for THMs is 100 ppb.*

There are several approaches to reducing THMs in drinking water:

1. treat the raw water to reduce concentrations of natural organic precursors prior to disinfection;**
2. change the point of disinfection to later in the water treatment process, to reduce the contact time with precursor organic material;
3. use less chlorine (while still maintaining adequate disinfection);
4. use a disinfectant that produces less THMs, e.g., ozone or chlorine dioxide;
5. treat drinking water to reduce disinfection by-products after their formation.

Based on epidemiological and other studies (discussed in the next section, on health effects), EPA has come to the following conclusions which form the basis for its regulatory position on THMs:***

1. THMs in drinking water pose a public health hazard;
2. Scientific methods are not yet available to identify all by-products formed in drinking water from the reaction of disinfectants and natural organics;
3. Although many of the identified chemicals do not appear to be toxic, some have the potential of causing adverse effects upon extensive exposure. However, little is known about the effects of long-term, low levels of exposure;
4. All types of oxidant disinfectants (such as chlorine) used in drinking water will react with natural organics to form new chemical compounds of currently unknown toxicity;

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*In Europe, the proposed THM standard is 1 ppb. Currently in West Germany and Switzerland the standard is 25 ppb.

**In Conncecticut, the measurement of water color has been made more stringent than the federal standard and is used as an indication of precursor organic levels.

***EPA's regulations are discussed on pp. 29 to 35.

5. While the toxicity of individual compounds is being studied, the reduction of THMs in drinking water supplies is prudent and generally can be readily accomplished in the water industry, often at little or no cost while maintaining adequate disinfection.[32]

Although many of the remedies to reduce THMs in drinking water would be simple and relatively inexpensive -- far less costly than those proposed to remove SOCs -- the water supply industry has taken legal action to oppose THM regulation, just as the industry has opposed use of GAC to remove other synthetic organics.*

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*Pages 23, 24, 31, 32, 85 and 86 contain further discussion of this opposition.

2. The Health Effects Dilemma

Widespread concern about chemicals in drinking water dates roughly from events of the mid-1960s in Louisiana, where the Mississippi River serves as the drinking water source to a population of more than one million people. At least 50 of the largest chemical and petrochemical manufacturers in the U.S. discharge their wastes into the 130 miles of river between Baton Rouge and New Orleans alone.[33] Complaints from residents and fishermen of foul tastes and smells in the water led to a federal monitoring study of the industrial effluents in the river beginning in 1967. Seven years later, two nearly simultaneous reports brought the case to national attention.

One of these, from the EPA, reported that the New Orleans water supply contained 66 organic chemicals, six of them suspected carcinogens.[34] The second study was issued by the Environmental Defense Fund (EDF), a public interest citizens' group of scientists and lawyers.[33a] This study showed a correlation between consumption of New Orleans water and increased cancer mortality in white males.[33a] Based on these findings, Consumer Reports in the summer of 1974 published the first of three articles by Robert Harris and Edward Brecker charging that New Orleans officials were ignoring a potentially serious cancer threat in the form of toxic chemicals in their drinking water. Harris and Brecker pointed out that systems to treat the water by activated carbon granules could readily be installed to reduce the level of these chemicals. The EDF report was the key catalyst that led to passage in 1974 of the Safe Drinking Water Act (SDWA).

In 1974-75 EPA followed up the New Orleans findings with a national survey to detect the presence of suspected carcinogens in drinking water. This survey confirmed the presence of at least small quantities of organic compounds in all of the 80 city water supplies monitored. Later EPA surveys (Table 1) have identified 129 specific chemicals of concern, which the agency has labeled "priority pollutants". These are shown in Tables 2 and 2a. The National Academy of Sciences already has identified 22 of these 129 chemicals as carcinogens.[39]

Epidemiological Studies

Since 1974 some 18 epidemiological studies and associated commentaries have provided some evidence of correlations between cancer mortality and drinking water quality.[33a1] Earlier studies had shown that communities which take their drinking water downstream from discharge points for industrial and sewage effluents have the highest overall mortality rates.* These are generally cities located in industrial valleys with multiple exposure to pollution. Statistics also suggest that deaths from cancer of the gastro-intestinal and urinary tracks are one-and-one-half to two times as common in persons who use chlorinated water as compared to unchlorinated water.[33b]

Despite the growing circumstantial evidence, a definitive causal relationship cannot presently be substantiated. Many factors make the results of these studies — which vary in method and design -- difficult to interpret. For example, available data on water quality went back less than five years while the latency period of most cancers is measured in decades; mortality data and water quality data are generally available for different geographic areas; and human cancers may be the result of several factors, including smoking. A

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*Wastewater discharges upstream often constitute a significant portion of downstream municipal water supplies. Twenty cities with a total population of seven million use water supplies containing 2.3 to 16 percent wastewater during average flow conditions, and much higher wastewater concentrations during dry seasons.[31] In New Jersey, one large water utility's river source contains a 65 percent concentration of effluents from over 100 waste water treatment plants and 2,500 industries.

Table 2

Priority Toxic Pollutants

1. acenaphthene
2. acrolein
3. acrylonitrile
4. benzene
5. benzidine
6. Carbon tetrachloride (tetrachlormethane)
chlorinated benzenes (other than dichlorobenzenes):
7. chlorobenzene
8. 1,2,4-trichlorobenzene
9. hexachlorobenzene
chlorinated ethanes (including 1,2-dichloroethane, 1,1,1-trichloroethane and hexachloroethane):
10. 1,2-dichloroethane
11. 1,1,1-trichloroethane
12. hexachloroethane
13. 1,1-dichloroethane
14. 1,1,2-trichloroethane
15. 1,1,2,2-tetrachloroethane
16. chloroethane
chloroalkyl ethers (chloromethyl, chloroethyl and mixed ethers):
17. bis (choloromethyl) ether
18. bis (2-chloroethyl) ether
19. 2-chloroethyl vinyl ether (mixed)
chlorinated naphthalene:
20. 2-chloronaphthalene
chlorinated phenols (other than those listed elsewhere; includes trichlorophenols and chlorinated cresols):
21. 2,4,6-trichlorophenol
22. parachlorometa cresol
23. chloroform (trichloromethane).
24. 2-chlorophenol
dichlorobenzenes:
25. 1,2-dichlorobenzene
26. 1,3-dichlorobenzene
27. 1,4-dichlorobenzene
28. 3,3-dichlorobenzidine
dichloroethylenes (1,1-dichloroethylene and 1,2-dichloroethylene):
29. 1,1-dichloroethylene
30. 1,2-trans-dichloroethylene
31. 2,4-dichlorophenol
dichloropropane and dichloropropene:
32. 1,2-dichloropropane
33. 1,2-dichloropropylene (1,3-dichloropropene)
34. 2,4-dimethylphenol
dinitrotoluene:
35. 2,4-dinitrotoluene
36. 2,6-dinitrotoluene
37. 1,2-diphenylhydrazine
38. ethylbenzene
39. flouranthene
Haloethers (other than those listed elsewhere):
40. 4-chorophenyl phenyl ether
41. 4-bromophenyl phenyl ether
42. bis (2-chloroisopropyl) ether
43. bis (2-chloroethoxy) methane
halomethanes (other than those listed elsewhere):
44. methylene chloride (dichloromethane)
45. methyl chloride (chloromethane)
46. methyl bromide (bromomethane)
47. bromoform (tribromomethane)
48. dichlorobromomethane
49. trichloroflouromethane
50. dichlorodiflouromethane
51. chlorodibromomethane
52. hexachlorobutadiene
53. hexachlorocyclopentadiene
54. isophorone
55. naphthalene
56. nitrobenzene
nitrophenols (including 2,4-dinitrophenol and dinitrocresol):
57. 2-nitrophenol
58. 4-nitrophenol
59. 2,4-dinitrophenol
60. 4,6-dinitro-o-cresol
nitrosamines:
61. N-nitrosodimethylamine
62. N-nitrosodiphenylamine
63. N-nitrosodi-n-propylamine
64. pentachlorophenol
65. phenol
phthalate esters:
66. bis (2-ethylhexyl) phthalate
67. butyl benzyl phthalate
68. di-n-butyl phthalate.
69. di-n-octyl phthalate
70. diethyl phthalate
71. dimethyl phthalate
polynuclear aromatic hydrocarbons:
72. benzo (a) anthracene (1,2-benzanthracene)
73. Benzo (a) pyrene (3,4-benzopyrene)
74. 3,4-benzoflouranthene
75. benzo (k) flouranthane (11,12-benzoflouranthene)
76. chrysene
77. acenaphthylene
78. anthracene
79. benzo (ghi) perylene (1,2-benzoperylene)
80. phenathrene
81. fluroene
82. dibenzo (a,h) anthracene (1,2,5,6-dibenzanthracene)
83. indeno (1,2,3-cd) pyrene (2,3-o-phenylenepyrene)
84. pyrene
85. tetrachlorethylene
86. toluene
87. trichloroethylene
88. vinyl chloride (chloroethylene)
pesticides and metabolites:
89. aldrin
90. dieldrin
91. chlordane (technical mixture & metabolites)
DDT and metabolites:
92. 4,4'-DDT
93. 4,4'-DDE (p,p'-DDX)
94. 4,4'-DDD (p,p'-TDE)
endosulfan and metabolites:
95. a-endosulfan-Alpha
96. b-endosulfan-Beta
97. endosulfan sulfate
endrin and metabolites:
98. endrin
99. endrin aldehyde
heptachlor and metabolites:
100. heptachlor
101. heptachlor epoxide
hexachlorocyclohexane (all isomers):
102. a-BHC-Alpha
103. b-BHC-Beta
104. r-BHC (Lindane)-Gamma
105. g-BHC-Delta
polychlorinated biphenyls (PCB's)
106. PCB-1242 (Arochlor 1242)
107. PCB-1254 (Arochlor 1254)
108. PCB-1221 (Arochlor 1221)
109. PCB-1232 (Arochlor 1232)
110. PCB-1248 (Arochlor 1248)
111. PCB-1260 (Arochlor 1260)
112. PCB-1016 (Arochlor 1016)
113. Toxaphene
114. Antimony (Total)
115. Arsenic (Total)
116. Asbestos (Fibrous)
117. Beryllium (Total)
118. Cadmium (Total)
119. Chromium (Total)
120. Copper (Total)
121. Cyanide (Total)
122. Lead (Total)
123. Mercury (Total)
124. Nickel (Total)
125. Selenium (Total)
126. Silver (Total)
127. Thallium (Total)
128. Zinc (Total)
129. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

Source: Environmental Quality, Ninth Annual Report of the Council on Environmental Quality. U.S. Government Printing Office, Stock No. 041-011-00040-8, 12/78.

Table 2a

129 Priority Toxic Pollutants by Classes

Pollutant	**Characteristics**	**Sources**	**Remarks**
Pesticides Generally chlorinated hydrocarbons	Readily assimilated by aquatic animals, fat soluble, concentrated through the food chain (biomagnified), persistent in soil and sediments	Direct application to farm- and forestlands, runoff from lawns and gardens, urban runoff, discharge in industrial wastewater	Several chlorinated hydrocarbon pesticides already restricted by EPA: aldrin, dieldrin, DDT, DDD, endrin, heptachlor, lindane, and chlordane
Polychlorinated biphenyls (PCBs) Used in electrical capacitors and transformers, paints, plastics, insecticides, other industrial products	Readily assimilated by aquatic animals, fat soluble, subject to biomagnification, persistent, chemically similar to the chlorinated hydrocarbons	Municipal and industrial waste discharges disposed of in dumps and landfills	TSCA ban on production after 6/1/79 but will persist in sediments; restrictions on many freshwater fisheries as a result of PCB pollution (e.g., lower Hudson, upper Housatonic, parts of Lake Michigan)
Metals Antimony, arsenic, beryllium, cadmium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc *Other inorganics* Asbestos and cyanide	Not biodegradable, persistent in sediments, toxic in solution, subject to biomagnification *Asbestos* May cause cancer when inhaled, aquatic toxicity not well understood *Cyanide* Variably persistent, inhibits oxygen metabolism	Industrial discharges, mining activity, urban runoff, erosion of metal-rich soil, certain agricultural uses (e.g., mercury as a fungicide) *Asbestos* Manufacture and use as a retardant, roofing material, brake lining, etc.; runoff from mining *Cyanide* Wide variety of industrial uses	
Halogenated aliphatics Used in fire extinguishers, refrigerants, propellants, pesticides, solvents for oils, and greases and in dry cleaning	Largest single class of "priority toxics," can cause damage to central nervous system and liver, not very persistent	Produced by chlorination of water, vaporization during use	Large volume industrial chemicals, widely dispersed, but less threat to the environment than persistent chemicals
Ethers Used mainly as solvents for polymer plastics	Potent carcinogen, aquatic toxicity and fate not well understood	Escape during production and use	Large volume industrial chemicals, widely dispersed, but less threat to the environment than persistent chemicals
Phthalate esters Used chiefly in production of polyvinyl chloride and thermoplastics as plasticizers	Common aquatic pollutant, moderately toxic but teratogenic and mutagenic properties in low concentrations; aquatic invertebrates are particularly sensitive to toxic effects; persistent; and can be biomagnified	Waste disposal vaporization during use (in nonplastics)	
Monocyclic aromatics (excluding phenols, cresols and phthalates) Used in the manufacture of other chemicals, explosives, dyes and pigments, and in solvents, fungicides, and herbicides	Central nevous system depressant; can damage liver and kidneys	Enter environment during production and byproduct production states by direct volatization, wastewater	
Phenols Large volume industrial compounds used chiefly as chemical intermediates in the production of synthetic polymers, dyestuffs, pigments, pesticides, and herbicides	Toxicity increases with degree of chlorination of the phenolic molecule; very low concentrations can taint fish flesh and impart objectionable odor and taste to drinking water; difficult to remove from water by conventional treatment; carcinogenic in mice	Occur naturally in fossil fuels, waste water from cooking ovens, oil refineries, tar distillation plants, herbicide manufacturing, and plastic manufacturing; can all contain phenolic compounds	
Polycyclic aromatic hydrocarbons Used as dyestuffs, chemical intermediates, pesticides, herbicides, motor fuels, and oils	Carcinogenic in animals and indirectly linked to cancer in humans: most work done on air pollution; more is needed on the acquatic toxicity of these compounds; not persistent and are biodegradable though bioaccumulation can occur	Fossil fuels (use, spills, and production), incomplete combustion of hydrocarbons	
Nitrosamines Used in the production of organic chemicals and rubber; patents exist on processes using these compounds	Tests on laboratory animals have shown the nitrosamines to be some of the most potent carcinogens.	Production and use can occur spontaneously in food cooking operations	

Source: Environmental Quality, Ninth Annual Report of the Council on Environmental Quality. U.S. Government Printing Office, Stock No. 041-011-00040-8, December 1978.

formidable list of unknown factors in such studies has been compiled by one epidemiologist:

1. "Existing analytic chemical techniques can only identify approximately five percent of the organic contaminants in drinking water.

2. Of the identified fraction, only about 10 percent has been adequately tested for carcinogenicity/mutagenicity.

3. Of the trihalomethanes, the brominated species lack available carcinogenicity data, although they may be as potent as chloroform.

4. Levels of these compounds in drinking water vary with season, thereby altering exposure over time.

5. Exposure to trihalomethanes of a population served by a single water treatment plant is dependent on the travel time of the water from plant to tap (exposure goes up with travel time).

6. Changes in exposure over a 15 to 20 year period may be a function of changing or increasing precursors (from industry and so forth) leading to the production of chloroform.

7. Knowledge of the interaction of contaminants is almost nonexistent.

8. Migration within the United States makes it difficult to determine accurately who was exposed to what, and for how long.

9. There may be considerable individual variation in water consumption.

10. In many communities there is more than one water source, and persons may live in one water district yet work in another."[35]

Most of the epidemiological studies to date have dealt with formation of THMs in chlorinated surface water, rather than with the presence of industrial (synthetic) organic contaminants in ground water. In most cases the mixture of synthetic organic chemicals (SOCs) found in contaminated ground water is different from that found in surface water. The Council on Environmental Quality (CEQ) in 1980 identified a number of SOCs that are present in significant concentrations in some ground water supplies (Table 3). Two

Table 3 Some Synthetic Organic Chemicals Detected in Drinking Water Wells

CHEMICAL	NIOSH REGISTRY NO.	MAXIMUM CONCENTRATION PPB	LOCATION	EVIDENCE FOR CARCINOGENICITY[b]
Benzene	CY1400000	230	New Jersey	H
α-BHC (α-Hexachlorocyclohexane)	GV3500000	6	California	CA
β-BHC	GV4550000	3.8	California	NT
γ-BHC (Lindane)	GV4900000	22	California	CA
Bis (2-ethylhexyl) phthalate	TI0350000	170	New York	NT
Bromoform	PB5600000	20	Delaware	NT
Butyl benzyl phthlate	TH9990000	38	New York	NT
Carbon tetrachloride	FG4900000	400	New Jersey	CA
Chloroform	FS9100000	490	New Jersey	CA
Chloromethane	PA6300000	44	Mass.	NT
Cyclohexane	GU6300000	540	New Jersey	NT
DBCP (Dibromochloropropane)	TX8750000	137	Arizona	CA
Dibromochloromethane	PA6360000	55	New York	NT
1-1, Dichloroethane	KI0175000	7	Maine	SA
1-2, Dichloroethane	KI0525000	100	New Jersey	CA
1-1,Dichloroethylene	KV9275000	280	New Jersey	NT
1-2,Dichloroethylene	KV9360000	323	Mass.	NT
Di-n-butyl phthlate	TN0875000	470	New York	NT
Dioxane (1-4, Dioxane)	JG8225000	2100	Mass.	CA
EDB (ethylene dibromide) (1-1,Dibromoethane)	KH9275000	300	Hawaii	CA
Isopropyl benzene	GR8575000	290	New Jersey	NT
Methylene chloride	PA8050000	47	New York	NT
Parathion	TF4550000	4.6	California	SA
PCE (Tetrachloroethylene)	KX3850000	1500	New Jersey	CA
Toluene	X55250000	260	New Jersey	NT
1,1,1-Trichloroethane	KJ2975000	5100	New York	NA
1,1,2-Trichloroethane	KJ3150000	20	New York	CA
TCE (Trichloroethylene)	KX4550000	27,300 14,000	Penn. Penn.	CA
Triflurotrichloroethane	KJ3975000	135	New York	NT
Vinyl Chloride	KU9625000	50	New York	H, CA
Xylene	ZE2100000	300	New Jersey	NT

Source: Council on Environmental Quality, Drinking Water and Cancer, (Washington) December 1980, pp. 48, 49.

[a] List of chemicals, maximum concentrations and locations compiled by staff of Council on Environmental Quality (CEQ).

[b] CODE:
H-confirmed human carcinogen
CA-confirmed animal carcinogen
SA-Suggestive animal carcinogen
NA-negative evidence of carcinogenicity from animal bioassay

of the chemicals - benzene and vinyl chloride -- are known human carcinogens. Human data are not available for the other 29 compounds, although 14 have been tested for carcinogenicity in animal tests.[36]

The recognized limitations of health effects studies have led to the use of other methods. Analysis of occupational exposure offers the advantage of work place conditions where people and chemicals are concentrated. While extrapolations from high-dose to low-dose effects may be uncertain, these studies offer valuable information on human toxicity which cannot be gained in laboratory experiments. Another opportunity to gather data on human reaction to chemical exposure exists in acutely exposed communities. Such studies were to be conducted at Love Canal in Niagara Falls, New York. The Center for Disease Control (CDC) in Atlanta and the State University of New York had to abandon this proposal, however, because Congress failed to fund the study.[51]

One comprehensive new study nearing completion correlates bladder cancer and drinking water. It involves interview data from over 3000 newly diagnosed cases of bladder cancer and over 6000 persons in a control group. These data should permit controls for numerous confounding factors which have not been adequately controlled in previous studies based on death certificates.[52] Another study being initiated currently will investigate the connection between lifestyle and cancer. This will include interview questions on such topics as use of caffeine in coffee and cola drinks and other diet habits, smoking patterns, and use of certain consumer products including drugs.[53]

Risk Assessment

Currently there are not enough toxicologists, pathologists, animal suppliers, and laboratory facilities to test all chemicals -- certainly not all the approximately 1,000 new compounds introduced each year. It is estimated that no more than 500 chemicals could be started annually on bioassays, which take two or more years to complete.[32a] As a result, a great many compounds will go untested by government regulators for many years while they are free to circulate in the environment and in drinking water supplies. In view of this, EPA has attempted to minimize exposure to the extent feasible by setting limits for THMs and other toxic chemicals in drinking water. The limits are not "safe doses," since there are no such safety levels established for carcinogens, but are low levels that the agency believes are technologically achievable, taking cost into consideration. Making tradeoffs and comparing economic benefits with human health risks is inherent in this process, a highly subjective operation at best.

Such risks are evident in a recent report from the U.S. Surgeon General's office which concluded that "virtually the entire population of the United States carries body burdens of one or more long-lasting synthetic chemicals known to cause severe health problems at higher levels....we are dealing with ....very possibly the worst threat to human health in the nation today."[44] Over 90 percent of the human population in the U.S. is believed to have measurable levels of PCBs in their tissues. Human breast milk is heavily contaminated and the average nursing infant exceeds by ten times the maximum daily intake level for PCBs set by the Food and Drug Administration. The levels of contamination and the number of people affected continue to increase each year.[45]

Human biological tolerance to carcinogens and the existence of safe thresholds must be considered in light of the multiple forms of exposure to which humans are subjected. David Rall of the National Institute of Environmental Health Sciences discussed the issue of adding new carcinogens to the present pool: "It may indeed be demonstrated in a good laboratory that a mouse exhibits a threshold for any given chemical. But, a mouse doesn't smoke, doesn't breathe hydrocarbons or sulfur oxides from fossil fuels, doesn't take medicines, doesn't drink alcohol, and doesn't eat bacon or smoked salmon or well-done hamburgers."[47] On the other side of the threshold debate, Perry Gehring of Dow Chemical Company contends that "...fully 95 percent of all chemicals, whether man-made or naturally occurring, have the capability of reacting with DNA."[48] In his book The Politics of Cancer, Samuel Epstein, M.D., discussed the complications in attributing disease to different factors but pointed out that "New Jersey and Wyoming, for instance, have almost identical per capita tobacco sales, but New Jersey's cancer rate is 36 percent higher than Wyoming's."[49]

While the debate about causes of cancers and human thresholds continues, current estimates are that synthetic chemicals cause somewhere between five to twenty percent of all cancers.[50] Five percent of all cancer deaths in the U.S. would amount to some 17,500 people annually.*

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*Of approximately two million total deaths per year in the U.S., about 350,000 are attributed to cancer. Thus, cancer from various causes accounts for about 18 percent of the deaths in the U.S. annually. Each person has a lifetime risk of about one in six of dying of cancer. When the occurrence of nonfatal cancers is considered, the risk of an individual developing cancer in a lifetime is about 25 percent, or one in four.[50a]

Government regulation of voluntary risks, such as smoking and driving raises very different questions from prevention of involuntary risks, such as drinking contaminated water or breathing polluted air. The issue of risk ultimately comes down to personal values and judgment. For most pollutants, available scientific knowledge can offer only rough guidance for regulation. In the view of Douglas M. Costle, EPA Administrator in the Carter Administration, this should not, however, prevent action: "Given the potential for long-term damage, it seems to me the case for a policy that emphasizes protecting health where the scientific evidence is inconclusive should be irrefutable. Yet, as many of you know, it's getting more and more difficult to carry that argument in Washington these days, given the antiregulatory climate in town."[54] As Marvin Schneiderman of the National Cancer Insitute remarked:

> "Some historical perspective may be in order here. During the 19th century when germs were being discovered thick and fast, much as carcinogens are today, the same sort of skepticism prevailed as this or that microbe was reported as the cause of one or another disease. And there were the same kinds of arguments about whether, in the face of scientific uncertainties, it would pay to clean up the environment. Yet when the public water supplies of northern Europe were, in fact, cleaned up.....epidemics of cholera and other gastrointestinal infections virtually disappeared."[41a]

In spite of uncertainty, decisions must be made; and they must inevitably depend on someone's estimate or judgment of acceptable risk. Many government analysts, for example, assume that a lifetime cancer risk of one in a million is "acceptable." They contend that this risk level is a "prudent, ethical, and economically realistic guideline for decision making."[41] But getting agreement on numerical bounds is, of course, difficult. As one toxicologist remarked: "estimates of one in a million and so on are fine as long as you are not the one."[43]

Unfortunately, in the real world even the one-in-a-million standard is exceeded. One estimate, using a highly contaminated well (in New Jersey - see Table 4) and a "worst case" analysis, found a one in 400 risk of cancer. If a population of one million were to consume this water for a lifetime, 2,500 people would be expected to contract cancer as compared with the single person usually regarded as an acceptable level of risk in federal regulations.[42]

In struggling to create a scientific basis for assessing "the irreversible effects of long-continued exposure to carcinogenic substances at low dose rates", the National Academy of Sciences (NAS) in a 1977 report to Congress (an outgrowth of the 1974 Safe Drinking Water Act) concluded that:

1. "Effects in animals, properly qualified, are applicable to man.
2. Methods do not now exist to establish a threshold for long-term effects of toxic agents.
3. The exposure of experimental animals to toxic agents in high doses is a necessary and valid method of discovering possible carcinogenic hazards in man.
4. Material should be assessed in terms of human risk, rather than as 'safe' or 'unsafe.'"[38]

On the basis of various tests, including some conducted by the NCI in 1976, the NAS concluded further that chloroform and other THMs present a health hazard and that steps should be taken to prevent their formation or to remove them from drinking water.

Table 4

Synthetic Organic Chemicals Detected in a Highly Polluted New Jersey Well

Chemical	Concentration (ppb)	Upper limits on lifetime cancer risks
Trichloroethylene (TCE)	1,530	4.6×10^{-4}
Trichloroethane	965	1.3×10^{-4}[a]
Chloroform	420	1.4×10^{-4}
Carbon tetrachloride	400	7.6×10^{-4}
Xylenes	300	No positive data
Toluene	260	No positive data
Benzene	230	1.1×10^{-3}
Dichloroethylene	58	No positive data
Methylene chloride	11	No positive data

[a] Assuming the 1,1,2-trichloroethane isomer.

Source: Council on Environmental Quality, Contamination of Ground Water by Toxic Organic Chemicals, (Washington) January 1981, p. 71.

These conclusions are not universally accepted, however. For example, the Coalition for Safe Drinking Water, a group of about 90 utilities that collectively provide water to approximately 30 million people in the U.S., has strongly opposed EPA's proposed regulations for both THMs and SOCs on the grounds of their cost. The group further contends that: 1) the NCI assay was not intended to be used to extrapolate health effects of chloroform to the low levels that might be found in drinking water; and 2) they find no hard evidence to support NAS's concern that the low levels of SOCs generally found in drinking water pose a potential health risk. In particular, the coalition contends that animal studies are inconclusive since the high doses overburden the animals' defense system, impair the liver's detoxifying ability, and produce a cancer that would not occur under the low-dose conditions to which people are exposed in drinking water.*[40]

The technique of exposing animals to high doses is used to overcome the low-effect, time-delay problem that would otherwise make testing for chronic effects of low-level exposure impossible. By giving large doses of a chemical to a small animal with a rapid metabolic rate, short normal life span, and fewer cells, scientists can get a reasonable approximation of what may happen in humans whose metabolic rate is slower and who have many times more cells and a longer life expectancy. This technique and one pioneered by Bruce Ames to test chemicals for mutagenicity (thought to be closely related to carcinogenicity) by using salmonella bacteria are widely used as alternatives to epidemiological studies.

Some fundamental observations about the water supply industry can help to explain its attitudes and actions in opposing EPA's regulations. In general, it is a conservative group whose practices

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The Coalition has taken legal action on the THM regulations, which are currently before the courts. They also have been instrumental in the defeat of EPA's 1978 proposal for use of granular activated carbon to remove SOCs in drinking water, a common practice in Europe have changed very little since the advent of chlorination in the early 1900s. In addition, water suppliers operated with relative autonomy prior to passage of the SDWA. They resent government intrusion in their bailiwick. Moreover, water suppliers have developed a strong defensive reaction to revelations that chlorination -- seen for decades as the miraculous solution to bacterial contamination of drinking water -- is itself causing the formation of THMs, including chloroform. This can be described as a "white hat/black hat" syndrome in which the industry's self-image of performing an honorable and critical public service ("white hat") is now perceived as being tarnished by revelations of chemical contamination of drinking water ("black hat").

Risk assessment ultimately involves comparisons of economic costs with human health risks. Because of this, risk benefit analysis is highly sensitive to political pressure. Since absolutely safe levels do not exist, an informed public will have to decide. This was recognized by Gus Speth, Chairman of the Council on Environmental Quality in the Carter Administration:

> "Of all the chemicals that have been released into the human environment, we know that a small number cause cancer in humans. We know this for the best and most tragic of reasons; they have caused cancer in people... But we cannot wait patiently for other carcinogens to make themselves known in this manner. Having learned all we can from our technicians we are forced to realize that...social value judgments frequently exceed the decision making prerogatives of any profession or discipline. It is both the glory and the burden of democracy that lay citizens must make the final choice."[55]

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*Related issues are discussed further on pp. 31 to 34 and 80 to 86.

The Laws Affecting Drinking Water

Historical Context

Drinking water was first regulated in the United States by a 1914 Congressional action which enabled the U.S. Public Health Service (PHS) to promulgate national standards. These standards, however, applied only to water moving in interstate commerce (e.g., use of common drinking water cups on trains), and they concerned bacterial rather than chemical contamination. In 1925, 1942, and 1946 some chemical standards, primarily for metals, were added.* In 1946 the standards were generally made applicable to all interstate U.S. water suppliers.

New standards were promulgated by the PHS in 1962. These recommended the use of qualified personnel to operate water supply systems, and established maximum concentration limits for the regulated chemicals.[55a] The 1962 standards also recommended that water supplies be obtained from a "protected source"; and efforts were to be made to prevent or control pollution of this source. As defined, treatment by natural means included dilution, storage, sedimentation, aeration, and/or exposure to sunlight. Other treatment, including chlorination, was to be applied to those water sources which were not adequately protected from contamination.[55b] Again, these federal standards were designed primarily to protect against infectious disease.** They were, however, to prove inadequate to cope with the explosive "chemical revolution" after World

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*1925: reference to control of lead, copper and zinc.
1942: maximum levels for lead, fluoride, arsenic and selenium. Also, where more suitable water supplies were available, sources with certain chemical concentrations were not to be used, e.g., copper, iron plus manganese, magnesium, zinc, chloride, sulfate, phenolic compounds.
1946: prohibition of use of certain chemicals in the water treatment process, e.g., salts of barium, hexavalent chromium, heavy metals.[55a1]

**In 1967 an advisory committee to the PHS recommended maximum concentrations for various organic chemicals, including several pesticides, e.g., aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, epoxide, lindane, methoxychlor, toxaphene, organic phosphates and carbamates. In attempting to promulgate these recommendations, howevever, "someone remembered that the legislative base for the standards was restricted to the control of communicable diseases" and it was held that the PHS had no authority to establish drinking water standards for chemicals.[55b1]

War II which created a new and intensified burden on water systems. Discoveries in the late 1960s and early 1970s of toxic chemical contaminants in drinking water supplies, particularly in New Orleans, exposed the inadequacies in existing laws to assure safe drinking water.

A series of reports and media exposure of these findings, especially by Dr. Robert Harris of the Environmental Defense Fund, created enough political support for passage of the Safe Drinking Water Act (SDWA) on December 16, 1974. This act had lain dormant since 1970 when it was first introduced by Congressman Harold Robison of New York, acting on a Public Health Service study of community water supplies released earlier that year. The PHS study documented the widespread inability of state and local water supply agencies to monitor, treat, and deliver drinking water that was free of the threat of bacterial and chemical contamination.*

A variety of federal laws regulate toxic substances (Table 5). In addition to the SDWA, the principal laws affecting toxics in drinking water are the Federal Water Pollution Control Act (FWPCA), the Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), the Food, Drug, and Cosmetic Act (FDCA) (for bottled water), the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), and the Comprehensive Environmental Response Compensation and Liability Act, more commonly known as the "Superfund" Act of 1980. The last-named law provides for the clean-up of old chemical dumpsites which endanger the public. The SDWA, FWPCA, and RCRA have the most direct effect on drinking water, and will be discussed in more detail below.

As noted in Table 5, laws vary in the degree of certainty required in knowledge of a hazard before it is to be regulated. For example, the FWPCA protects against pollutants that "will" cause death, disease, etc., where the SDWA and the RCRA refer to contaminants which "may" adversely affect

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*This study, issued by the U.S. Department of Health, Education and Welfare, is discussed in greater detail on pp. 69, 70.

Table 5

The Laws Regulating Toxic Substances

Legislation	Definition toxic or hazard	Type of regulation	Degree of protection	Balancing of costs	Burden of proof
Clean Air Act (as amended) (CAA) 1970 1977	"an air pollutant ...which...may cause, or contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating illness." Sec. 112(a)(1)	Emission standards	"...an ample margin of safety to protect the public health..."	No	EPA
Federal Water Pollution Control Act (as amended) (FWPCA) 1972 1977	"...pollutants which will...cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions...or physical deformations." Sec. 502(13)	Effluent standards, ambient standards	"...ample margin of safety."	No	EPA
Occupational Safety and Health Act (OSHA) 1970	Not defined	Exposure standards	"adequately assures to extent feasible that no employee will suffer material impairment of health or functional capacity..." Sec. 6(b)(5)	Yes Sec.6(b)(5)	OSHA
Toxic Substances Control Act (TSCA) 1976	those substances "...presenting an unreasonable risk of injury to health or the environment...." Sec. 6(a)	Pre-market notification and testing; prohibitions on manufacturing, processing, and distribution; information on chemical components must be supplied to EPA	Not specified	Yes Sec.2(b)(5)	Proponent

continued

health. (The Clean Air Act also uses the stronger criterion, "may.") This is an especially important feature of the SDWA in light of uncertainties about the long term health effects of toxic chemicals found in surface and ground water supplies.* The importance of establishing control before certainty has been proven was shown in the actions to prevent cholera in the face of scientific uncertainty about the causes of the disease. Nevertheless, most of the laws, including the SDWA, place the burden of proof on the EPA rather than on polluters .

The laws vary also in the degree to which they make protection dependent on cost. For example, the FWPCA requires ample margins of safety for public protection and does not require cost balancing.** The SDWA also allows for safety margins, but only "....to the extent feasible....(taking costs into consideration)...."[56] Cost considerations were at the heart of the political battles over EPA's 1978 proposed regulation of synthetic organic chemicals in drinking water, an issue to be discussed later in this section.

Safe Drinking Water Act (SDWA)

The SDWA directs the EPA Administrator to:

1) establish national primary and secondary (for aesthetics) standards to protect public health and welfare;

2) establish maximum contaminant levels (MCLs) at a point at which "no known or anticipated adverse effects on the health of persons occur and which allows a margin of safety";[57]

3) establish minimum requirements for state programs to prevent underground injection which endangers drinking water sources, including designation

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*In 1980 a strong attempt was made in Congress by Representative Phil Gramm of Texas to seriously weaken the SDWA by removing its preventive mandate exemplified by use of the word "may" and by removing EPA's ability to require control technology where chemical standards cannot be formulated or monitoring is not feasible. This effort was narrowly defeated. The issue is, however, of continuin concern because of similar legislation introduced in early 1982 by Gramm and others. [56]

**The Supreme Court recently reiterated the mandates of the FWPCA relating to cost of compliance in a case affecting crushed stone and gravel pollution from coal and mining industries by stating that the government can require polluters to meet minimum water pollution standards without weighing their "economic capability" of "sole source aquifers";

4) delegate enforcement responsibility to qualifying states and intervene in cases where states are not meeting this responsibility;

5. provide for exemptions and variances due to economic or physical limitations;

6. establish a laboratory certification program;

7. provide for public notification of a violation of MCLs and certain other provisions;

8. allow private citizens to bring civil actions against any person alleged to be in violation of any prescribed requirement, and against the EPA Administrator under certain circumstances.

Numbers three and seven above are particularly interesting features of the law and deserve further comment.

Although the SDWA provides for protection of sole source aquifers and EPA regulations to implement this were published in 1977, they were never promulgated in final form. This is explained by the lack of resources which EPA has had to implement all of the SDWA features, and priorities which have had to be set. EPA officials deny that the political sensitivity of "sole source" designation and the concomitant land use controls which might ensue have played a part in this decision.[57a] Currently under the SDWA a community can petition EPA to have an aquifer designated its sole source of drinking water, and seven such designations have been made nationally. After that designation is granted, EPA may delay or halt federal assistance for projects which would contaminate the aquifer and endanger public health. This process, if initiated in time, might have prevented contamination of some of the aquifers under New York's Long Island. There all three aquifers, upon which 3.25 million people depend for drinking water supplies, have been seriously affected.

The public notification provision of the SDWA is an innovative feature of the Act.* Since the public must pay for drinking water improvements, it is important that information about water quality be disseminated. People are becoming aware of chemical contamination of drinking water, and notification offers specific information about individual water supplies.

Maximum Contaminant Levels. The MCL's established under the SDWA cover chemical contaminants, microbiological contaminants, radionuclides, and turbidity (which can interfere with disinfection). Although the act has been in effect since December 1974, MCLs have been established under the National Interim Primary Drinking Water Regulations only for a limited number of chemicals. Table 6 lists the 10 inorganics (heavy metals) and 6 organics (pesticides) regulated under the Act. Of the thousands of synthetic chemicals believed to exist in in water supplies, 700 have been identified, and several are known carcinogens or mutagens. Yet only eight of the 129 chemicals on EPA's list of "priority pollutants" (Table 2) are currently regulated under the SDWA.

Table 6

Maximum Contaminant Levels
Under the Safe Drinking Water Act

Inorganics	ppb	Organics	ppb
*Arsenic	50	*Endrin	0.2
Barium	1,000	Lindane	4
*Cadmium	10	Methoxychlor . . .	100
*Chromium	50	Toxaphene	5
Fluoride	1,400 to 2,400	2,4,5-TP Silvex . .	10
*Lead	50	2,4,D	100
*Mercury	2		
Nitrate	10,000		
*Selenium	10		
*Silver	50		

*on EPA's list of 129 "priority pollutants"

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*Such notification is to be via media announcements and direct mailings to the affected public. Enforcement of this requirement has been weak at the

In fact, EPA's Interim Regulations under the SDWA established MCLs for the same inorganics regulated under the 1962 Public Health Service standards, only adding some pesticides. Although the revised regulations were to include MCLs for additional organics and were to be implemented after the SDWA-mandated National Academy of Sciences report of 1977, such progression has not occurred. This void is especially puzzling because of the SDWA's strong mandate to control contaminants which "may" have adverse health effects. When probed, EPA officials explain that they committed their available resources to the control of SOCs and THMs in their proposed 1978 regulation (discussed below), and that EPA plans to propose MCLs for six (and perhaps 12) of the most ubiquitous organic compounds, primarily industrial solvents:[57b] 1,1,1-trichloroethane, carbon tetrachloride, 1,2-dichloroethane, vinyl chloride, trichloroethylene, and tetrachloroethylene. In mid-1980 it was expected that these additions could be in place by mid-1981.[58] By mid-1981, however, it was apparent that the earliest implementation possible was 1983.[58a] Much of the current delay can be attributed to the regulatory slowdown of the Reagan Administration.

Because of EPA's failure to include MCLs for more organic chemicals which are known or suspected carcinogens, in 1975 the Environmental Defense Fund brought a lawsuit against the agency. This step, and the change in national administration in 1976, resulted in 1978 in a comprehensive EPA regulatory proposal to reduce concentrations of organic contaminants in drinking water.

Monitoring Time Frames. The schedule of monitoring for toxic chemicals is another area of concern. The 1974 federal regulation under the SDWA requires that drinking water be tested for inorganics annually for those suppliers using surface water sources, and every three years for ground water sources. For organics, testing in surface sources is required every three years, whereas testing for organics in ground water is left entirely to state discretion. These monitoring schedules are too infrequent to offer public protection and produce an adequate data base.*

The lack of ground water monitoring for organics resulted from several factors. The 1974 regulation was framed before discovery in ground water of organics, particularly industrial solvents. The six organics (pesticides) regulated were not found in ground water. In addition, analytical methods now in use were not readily available in 1974.[58b]

Proposed New Regulations in 1978. In the SDWA, Congress recognized two fundamental problems of regulating chemical contamination: first, that there is no known way to measure a safe level of exposure to carcinogens; and second, that the majority of water supply plants are unable to monitor for most chemicals because they lack the necessary instrumentation and personnel. To surmount these problems, EPA was granted not only authority to establish MCLs but also authority to require water treatment plants to use "best available" treatment techniques.

In early 1978, EPA announced plans to employ both of these regulatory tools. It proposed to establish an interim MCL of 100 ppb for trihalomethanes as a group, and to require larger communities with significant levels of synthetic organics in their source water to install granular activated carbon (GAC) filters, commonly used in Europe. GAC is a "porous form of carbon with an enormous surface area that can adsorb contaminants. A handful of activated carbon has a surface area totaling about one acre. It has distinctive chemical surface properties, including carboxyl, hydroxyl, and other oxygen-containing chemical groups that help bind chemicals to the carbon. The very chemicals that are most insoluble in water, such as DDT and PCBs, are adsorbed most readily."[59]

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*In Europe, drinking water is monitored much more frequently. For example, in the Netherlands monitoring for organics and inorganics takes place every three months. In Zurich, Switzerland such tests are conducted monthly.[58c]

EPA's proposed requirements were strongly opposed by the water supply industry. A vigorous campaign of opposition was launched by the Coalition for Safe Drinking Water, a spinoff group of the American Water Works Association (AWWA), an organization of public and private water utilities. AWWA's views on the regulations are that 1) expanded and accelerated health effects research on THMs and SOCs should be conducted to establish "a scientific basis for regulation"*; 2) a 100 ppb level for THMs should be established only "as a goal" for public water supply systems, not as a requirement; 3) EPA's proposed requirement that GAC be used as a treatment technique should be eliminated, to be replaced by four plant-size research projects underwritten by the government "to gather financial, operating and scientific data"; 4) EPA's proposed monitoring program for THM should be adopted, except that public notification should not be required (since systems would work toward a "goal", rather than an MCL standard); 5) any monitoring program for SOCs should be "financed and operated by EPA."[59a]

Opposition to new public policies by drinking water utilities is not new. Arguments have been presented in the past against such now-accepted practices as the use of sand filtration and banning of the common drinking water cup on interstate carriers. Ripley Nichols of MIT stated in 1884 that he doubted whether the results of sand filtration were worth the cost, and warned communities not to embark on such a plan of "artificial" filtration unless prepared to spend a possible $2.50 per million gallons for operation alone.[59b] Elimination of the common drinking water cup on interstate carriers also met strong opposition with the hypothesis that if the cups became unavailable,

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*See pp. 23, 24.

people so deprived of drinking facilities would have their health seriously endangered and might succumb to the temptation of alcoholic beverages.

Originally, EPA's GAC regulation was to apply to 400 or so water supplies serving 75,000 and more people.[65] The proposal was revised as a result of opposition. It hence stipulated that the only systems required to add GAC were those using a "vulnerable" surface source: one with more than 100 upstream discharges as defined under the FWPCA,* more than 1,000 tons/year of industrial or agricultural chemicals transported on the waterway, and likely to be impacted by these sources due to geographic factors such as proximity to discharges and significant nonpoint discharges.[98] The GAC regulation has been stalled, ostensibly because EPA is now concentrating on the newly discovered prevalence of industrial solvents, particularly in ground water. In reality, the political pressure generated by the water industry's opposition had a great impact on EPA's decision.** The THM regulation went into effect in November 1980, but it required only monitoring for the first year at plants serving populations of 75,000 or more.[60] In November 1981 plants serving population of 10,000 to 75,000 commenced monitoring. In January 1980, before the regulation took effect, the AWWA legally challenged EPA on the THM regulation and the matter is now pending before the courts for a "review of a final rule."[60a] Such a final rule may include remedial action to lower THM levels; currently only monitoring is required.

Cost was one of the focal points of the industry's opposition. Industry expressed concern over the projected consumer price increases which would ensue. Drinking water rates in the U.S. traditionally have been low -- on the average, about $1.00 per thousand gallons or $100/year per household. Europeans, on the other hand, are accustomed to paying an average of $3.00 per thousand gallons,[60b] but

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*There are about 60 water supplies with more than 100 upstream discharges as defined under the FWPCA.[98] Data for those suppliers eligible for GAC use under the other listed criteria were not available at this time.

**The EPA is also investigating other SOC controls, including the use of resins.

they do have more sophisticated treatment processes for removal of organic chemicals. These systems, in about 35 European municipalities include GAC and ozone. Ozone, used for disinfection in place of chlorine, does not promote THM formation. It does, however, promote the breakdown of toxic chemicals, allowing GAC to do a more efficient removal job.

EPA noted in its 1975 report to Congress, "thus far, the best method for removing environmental contaminants such as carbon tetrachloride, dieldrin and haloethers (all carcinogens) from raw water is the use of beds of granular activated carbon (GAC)."[61] Currently, however, U.S. drinking water treatment plants do not use GAC filters to reduce the levels of organic chemicals in drinking water.* The National Academy of Sciences has also approved of GAC for drinking water treatment.[61b] About 60 U.S. drinking water plants do use GAC for taste and odor control, but this use requires much less frequent regeneration or replacement of the filters (two to three years vs. two to three months) and is thus less expensive. One estimate puts the cost of GAC for organic removal for treatment plants serving populations of 75,000 to one million people at $7 to $16 per year for a family of three.[62] EPA estimates an increase in the cost of water production of 10 to 15 cents per thousand gallons.[63] Some water suppliers do not agree with these estimates and have complained that the original capital outlays are too high and that the operating cost of regenerating GAC filters are a considerable additional expense.**

<u>Comments on Safe Drinking Water Act</u>. In assessing the effectiveness of the SDWA mandates and their implementation, several factors become apparent. First, it is essential to expand the list of toxic chemicals covered under the National Primary Drinking Water Regulations to include those now commonly found: e.g. industrial solvents in ground water.

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*Recent installation of GAC filters in Rockaway, New Jersey is discussed on page 48. The City of New Orleans is considering use of GAC as an addition to its current water filtration system.

**The matter of costs is discussed further on pp. 81-84 in connection with a water purveyor survey.

(An added benefit of this expansion would be felt in bottled water quality, since MCLs under the SDWA are adopted for bottled water by the Food and Drug Administration.) Second, under the SDWA, all suppliers currently must monitor and test for the same elements in drinking water, regardless of local conditions. As knowledge is gained about the discharge of specific toxic pollutants, this information could be applied to monitor watersheds specifically for those chemicals known to be a local problem. Water suppliers should be more aware of industrial watershed discharges and their impact on source waters. Third, monitoring for hundreds of known toxic chemicals in drinking water is problematic because of the expensive equipment and highly trained laboratory personnel required. Greater reliance must therefore be placed on prevention of contamination and, under the SDWA, removal of contaminants in the water treatment process by installation and use of best available control technology such as GAC.

Implementation of the SDWA relies heavily on state leadership. The act also relies on self-enforcement by the water supply industry, which is responsible for monitoring and notifying the public when standards have been violated. The effectiveness of this decentralized mode, involving approximately 61,000 community water systems of varying size and capabilities, is highly dependent on these institutions' ability and willingness to cooperate. Because a community water system is defined by SDWA as any one with at least 15 connections or with service to at least 25 customers, a significant number of small suppliers which formerly were not regulated by state agencies are now covered, straining state budgets. The SDWA also required a more sophisticated management approach and closer cooperation with county and local health officers to augment state enforcement. Most states are still struggling to achieve these goals.*

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*The fragmented U.S. approach to drinking water management is exemplified by the 61,000 community water suppliers, up from 20,000 in 1963. In Europe just the opposite trend is occurring with consolidation of waterworks notably in Great Britain and Germany. This has created more substantial waterworks capability to deal with the complexities of chemical contamination.

The Federal Water Pollution Control Act (FWPCA) (Clean Water Act)

The FWPCA[64] is the principal law regulating the quality of surface drinking water sources. The original law was passed in 1948; it has been amended many times, including in 1972 and 1977. New amendments are expected to be debated in Congress in 1982. The present goal of the law is to make all U.S. surface waters "fishable and swimmable" by 1983, and to achieve zero discharge of pollutants by 1985.* Each state is required to adopt water quality standards that meet or exceed the federal criteria. The law does not apply to ground water.

The National Pollutant Discharge Elimination System (NPDES) was established in 1972 as the basic regulatory mechanism for water pollution control. Under this program, EPA (and the states under federal delegation) were given authority to issue permits to point source dischargers provided the dischargers agreed to meet standards of three types: 1) source-specific effluent limitations; 2) toxic pollutant regulations; and 3) regulations applicable to oil and hazardous substances liability.

As a result of lawsuits brought in 1976 by three public interest groups -- Natural Resources Defense Council, Environmental Defense Fund, and Citizens for a Better Environment -- EPA was forced to promulgate standards to assure regulation of toxic substances. This involved developing effluent guidelines for 65 classes of pollutants, including 129 "priority pollutants". (Tables 2 and 2a). The consent decree stipulated that 21 categories of industry be covered by these effluent limitations. (Table 7). Standards for these sources are to reflect the best available technology economically achievable.

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*The FWPCA is scheduled for renewal by Congress in 1982 when these goals and other features of the law may be altered. Given the Reagan Administration's support of weakening amendments to the Clean Air Act in 1982 (HR5252, introduced December 1981), environmentalists and others are concerned about similar mores against the FWPCA.

Table 7

Industrial Categories to be Covered In Accordance with the NRDC vs. EPA Consent Decree

1. Timber products processing
2. Steam electric power plants
3. Leather tanning and finishing
4. Iron and steel manufacturing
5. Petroleum refining
6. Inorganic chemicals manufacturing
7. Textile mills
8. Organic chemicals manufacturing
9. Nonferrous metals manufacturing
10. Paving and roofing materials (Tars and asphalt)
11. Paint and ink formulation and printing
12. Soap and detergent manufacturing
13. Auto and other laundries
14. Plastic and synthetic materials manufacturing
15. Pulp and paperboard mills, and converted paper products
16. Rubber processing
17. Miscellaneous chemicals
18. Machinery and mechanical products manufacturing
19. Electroplating
20. Ore mining and dressing
21. Coal mining

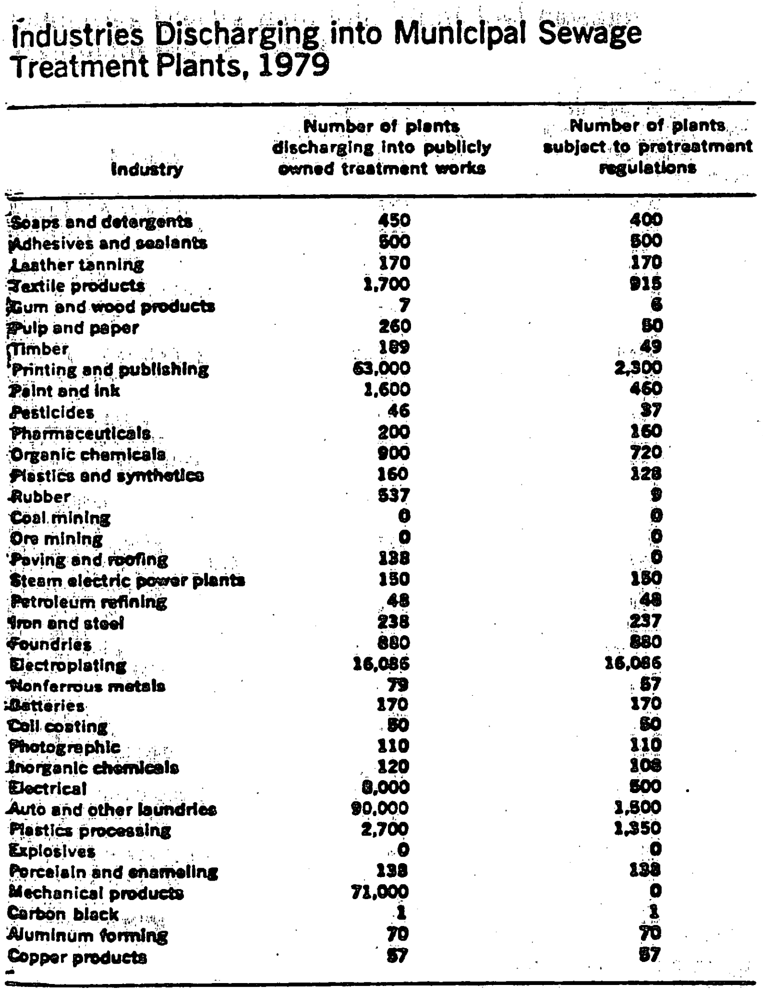
Source: U.S. Environmental Protection Agency, A Handbook of Key Federal Regulations and Criteria for Multimedia Environmental Control, (Washington, Office of Research and Development), August 1979, p. 67.

The settlement also required EPA to set pretreatment standards for this group of industries to assure the protection of publicly-owned (sewage) treatment works (POTW) and the protection of the environment from contaminated sewage sludge. By 1980, pretreatment standards had been proposed for nine industrial categories: leather tanning and finishing, textile mills, timber products processing, gum and wood chemicals, rubber manufacturing, petroleum refining, paint formulating, ink formulating, and inorganic chemicals manufacturing.[64a]

One case illustrates the problem here. In 1975 in samples taken in Philadelphia, EPA discovered the highest concentrations of bis(2-choroethyl)ether (BCEE), a carcinogen, ever measured in drinking water. The BCEE originated at a Rohm and Haas Company factory which discharged its waste water into the local municipal sewage system. The standard treatment process at such plants is largely ineffective in removal of organic compounds, and the BCEE was discharged into the Delaware River about five miles downstream from the Philadelphia water supply intakes. Because the Delaware at this point is an estuary, at high tides the BCEE was carried back upstream to the city's water supply intake.[83] Thus, even after treatment in two processing plants, one for sewage effluent and the other for drinking water, organic chemicals can emerge at levels which endanger public health.

As EPA gathers data on toxic substances in those industries which fall under these regulations, valuable information will be developed which should assist drinking water utilities in their efforts to assess the potential impact of inudstries known to be located in their watershed. Water utilities can inquire about upstream dischargers' NPDES permit conditions -- what are they allowed to discharge? (See Table 8 for industries discharging into municipal sewage treatment plants.) These regulations are, however, highly vulnerable under the Reagan Administration's _laissez_ _faire_ policies. Implementation of

Table 8



Industries Discharging into Municipal Sewage Treatment Plants, 1979

Industry	Number of plants discharging into publicly owned treatment works	Number of plants subject to pretreatment regulations
Soaps and detergents	450	400
Adhesives and sealants	500	500
Leather tanning	170	170
Textile products	1,700	915
Gum and wood products	7	6
Pulp and paper	260	50
Timber	189	49
Printing and publishing	63,000	2,300
Paint and ink	1,600	460
Pesticides	46	37
Pharmaceuticals	200	160
Organic chemicals	900	720
Plastics and synthetics	160	128
Rubber	537	9
Coal mining	0	0
Ore mining	0	0
Paving and roofing	138	0
Steam electric power plants	150	150
Petroleum refining	48	48
Iron and steel	238	237
Foundries	880	880
Electroplating	16,086	16,086
Nonferrous metals	79	57
Batteries	170	170
Coil coating	50	50
Photographic	110	110
Inorganic chemicals	120	108
Electrical	8,000	500
Auto and other laundries	90,000	1,500
Plastics processing	2,700	1,350
Explosives	0	0
Porcelain and enameling	138	138
Mechanical products	71,000	0
Carbon black	1	1
Aluminum forming	70	70
Copper products	57	57

Source: Council on Environmental Quality, Environmental Quality-1980, (Washington), December 1980, p. 129.

the pretreatment rules and other environmental regulations was halted, at least temporarily, by the Office of Management and Budget (OMB) early in 1981.

Legal Challenges to the Federal Water Pollution Control Act. A challenge to EPA's authority to issue uniform curbs on an industry-wide basis was brought by eight chemical companies in 1976. They contended that the guidelines should be on a plant-by-plant basis. In February 1977 the Supreme Court unanimously upheld EPA's authority to issue industry-wide regulations. The Court's opinion, written by Justice John Paul Stevens, said that the plant-by-plant application sought by the companies "would place an impossible burden on EPA" that Congress had not intended. The Court held that some allowance must be made for variations in individual plants, except for new plants on which Congress intended to impose "absolute prohibitions" on pollution. Stevens asked EPA, however, to "give individual consideration to the circumstances of each of the more than 42,000 dischargers who have applied for permits" to allow time for industry to install the necessary pollution control equipment.[66] In a 1978 suit brought by the Chemical Manufacturers Association, the court's decision allowed a change in a combined waste treatment regulation, primarily to clarify this provision. The result of this change, however, was also to bring fewer toxic wastes under control.[67]

In another legal case, the FMC Corporation's Charleston, West Virginia, plant was shut down for ten days under court order in March, 1977 for discharging carbon tetrachloride, a cleaning agent, into the drinking water source of communities along the Kanawha and Ohio Rivers. The temporary restraining order was sought by EPA which charged the company with responsibility for at least 20 spills of the chemical into the water supplies for the preceding two years, including the day before the closure order was issued. EPA stated that the chemical contaminant caused liver damage in human beings. The production ban was the first such legal action taken under emergency provisions of the FWPCA and the SDWA.[68] FMC took remedial action by fixing pipes broken by winter freezes, and by installing dikes to prevent chemical spills. EPA, however, brought criminal charges against two company executives, one of whom was in charge of corporate environmental matters. The case was pursued by the U.S. Justice Department, and in the end the executives were charged with lying about discharge data given to EPA. They were fined but spared jail sentences. The company was made to pay over a million dollars to be spent on pollution research.[68a] This is somewhat like the court settlement in the 1970s with the Allied Chemical Company accused of discharging Kepone into Virginia's James River. Allied paid several million dollars to be used for environmental improvement.

Gaps in Coverage Under Federal Law. Control of point sources of toxic substance discharging directly into waterways has had a slow and faltering start, and EPA has needed much prodding from environmental groups. But a beginning has been made. For tw other areas of water quality protection, however, there are a void: nonpoint sources of pollution and ground water protection.

The FWPCA gives EPA no specific authority to regulate pollution from nonpoint sources. EPA has attempted to address this problem primarily through the Water Quality Management Program created by Section 208 of the Act. Regional planning agencies or the states must prepare "208" plans to identify and propose area wide solutions to water quality problems. The plans must include botn point and nonpoint sources of pollution to both surface and ground waters. Under Section 208 EPA has focused on two nonpoint sources: urban storm runoff and agricultural runoff. Controls are, however, difficult to implement and progress has been imperceptible.

Currently there are no federal standards regulating ground water quality. Because of increased evidence of ground water contamination, EPA in November 1980 did propose a new Ground Water Protection Strategy.[69] The strategy does not require new legal authority, but would rely on existing laws which contain scattered references to ground water protection. Currently no one agency is responsible for protecting this resource. EPA intends to take this responsibility by identifing the goals, priorities, and necessary management approach. The stated goal of the proposed strategy is:

> "It shall be the national goal to assess, protect, and enhance the quality of ground waters to the levels necessary for current and projected future uses and for the protection of the public health and significant ecological systems."

The plan's stated objectives for 1985 are:

1) to initiate ground water protection strategies in all states aimed at meeting the goal....;
2) to implement fully current federal regulations which affect ground water, e.g., the Resource Conservation and Recovery Act. Underground Injection Control Program and Surface Mining Reclamation Act, and Superfund when implemented;
3) to evaluate ground water quality, to ameliorate the most hazardous conditions discovered, and to develop methods of managing newly discovered contamination;
4) to provide a process whereby state and local governments and the public can set priorities among competing activities which may use or contaminate ground water;
5) to ensure that each state has a fully implemented program to manage ground water.

The proposed management approach to implement the ground water strategy includes:

1) state ground water protection strategies which may be partially funded as part of the State/EPA Agreements (SEAs);

2) classification of ground water to be based on such factors as: present and projected future uses; current quality; volume of water available; availability of alternative water supplies; and vulnerability to contamination. Until this classification system is in place ground water that is "currently of drinking water quality or better will be provided protection to ensure that its utility for this use is not impaired";

3) minimum national requirements for selected high priority problems. This could include "highly toxic chemicals and pesticides where product bans or restrictions are appropriate";

4) EPA coordination to bring consistency among existing federal programs with ground water protection authority. This will include EPA's encouragement and assistance to the states to expand monitoring to detect ground water contamination.

EPA's ground water strategy represents an important commitment to protection of a critical resource. It will involve a huge undertaking including evaluation of ground water quality and locating critical aquifer recharge areas. This is a long term commitment which will necessitate, among other things, the resolution of conflicting land uses, always a sensitive political issue. But at stake is the availability of ground water upon which half of the U.S. population now depends.

Comparisons between the SDWA and the FWPCA. Some interesting comparisons can be made between the SDWA and the FWPCA. The laws are administered differently. The SDWA places heavy emphasis on state and local authority, while the FWPCA sets a much stronger federal presence. This presence is tied to the huge construction grants for sewage treatment systems provided by the federal government under the FWPCA, an estimated $30 billion outlay since 1972, the largest public works project ever undertaken.[70a] Under the SDWA, EPA was given neither the necessary grant money nor the powers to impose economic sanctions as incentives for strong state drinking water programs.[71]

The absence of significant federal funding or compliance initiatives has greatly affected progress in the drinking water program. For example, partly because of heavy reliance on consumer payments for system improvements and approvals from state public utility commissions or public bonding, the industry has been largely resistant to federal regulations calling for use of GAC to remove synthetic organic chemicals. This is compounded by the law's requirement that costs be taken into consideration in mandating public protection. Because of the reliance on public acceptance of costs for improved drinking water, public education is more critical to the effective implementation of the SDWA than to other federal laws. This was recognized when the public notification feature was included in the SDWA.* Water suppliers, however, could take a more vigorous educational role in bringing watershed conditions to public attention, thereby gaining support for pollution abatement efforts and lessening the need for expensive treatment.**

Another interesting comparison between the SDWA and the FWPCA is seen in their orientation to water quality. The FWPCA's goal is to have "fishable and swimmable" waters throughout the U.S. by 1983. No references are made to "drinkable" quality. Similiarly the SDWA fails to emphasize use of the purest possible sources of water.

Resource Conservaton and Recovery Act (RCRA)

Under RCRA, EPA in February 1981 proposed hazardous waste management standards for land disposal facilities as a means of protecting ground water sources. Generally, degradation of ground water is permissible under the proposed regulation but EPA intends "that the environment should not be degraded at any existing or potential point of use unless or until the degree of degradation is determined or predicted, evaluated and found to be accept-

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*In 1979 more than 33,000 public notifications were issued by systems in violations of the SDWA regulations. This figure is thought to be lower than it should be because of the lack of enforcement of this requirement on the part of state agencies.[72]

**In Europe the waterworks are involved in public education of watershed conditions as a means of soliciting support for pollution clean-up.

able."[70] These standards include:

1) prohibition of disposal of hazardous waste on land unless subsurface discharges will not affect any ground water which is being or may be collected or withdrawn for any use;

2) authorization for a variance from this prohibition based on a finding by EPA that the ground water will not be adversely affected for such uses, and that public health and the environment will not be adversely affected;

3) numerical criteria and prohibitions on certain chemicals for disposal facilities that discharge into a portion of an aquifer which is or may be a source of drinking water;

4) requirements for permit writers to take into consideration such factors as social and economic need for a facility, practical options for waste reductions, and detailed predictions of the generation, transport, and fate of individual contaminants as well as assessments of the risk of exposure to them;

5) general design and operating standards for land disposal facilities covering factors such as collection of run-off, liners and leachate monitoring systems, leaving much discretion to permit writers;

6) requirements for both a RCRA and an Underground Injection Control permit for the injection of hazardous waste into wells above the upper aquifer or where ground water can be withdrawn now or in the future;

7. a requirement for triennial "reprediction" of leachate migration for RCRA permits.

The major provisions under RCRA for controlling hazardous waste are: definition of hazardous waste; a manifest system to track hazardous waste from its generation to its final disposal; standards for generators and transporters of hazardous waste; permit requirements of facilities that treat, store, or dispose of hazardous waste; and requirements for state hazardous waste programs. RCRA and its regulations are quite complex and it will take years before a truly effective system is worked out.

II. FOCUS: NEW JERSEY

New Jersey is the nation's most densely populated and heavily industrialized state, and chemicals, especially petrochemicals, are this state's largest industry. With only 0.21 percent of the nation's land area and 3.5 percent of America's population, New Jersey accounts for 12.4 percent of the nation's chemical production.[18a]

Not surprisingly, New Jersey ranks first in the U.S. in hazardous waste generation.[18] Some 10,000 generators produced 720,000 tons of hazardous waste in 1979, according to industry and state manifest system records which track wastes from the generator to their ultimate treatment or disposal. State officials acknowledge, however, that this figure may represent as little as one-third of the actual production of hazardous wastes in the state since the required forms can be readily falsified or avoided altogether.[15]

New Jersey's cancer mortality rates are significantly higher than those of the rest of the nation for the most frequently fatal forms of cancer, including cancer of the bladder, breast, large intestine, rectum, lung and stomach.[25] For example, 18 of New Jersey's 21 counties rank in the top ten percent of all counties nationally for bladder cancer in white males.[25a] Though the causal chain from chemical production through toxic waste generation and drinking water contamination to cancer is not well established nor quantified, the evidence is disturbing. Thus New Jersey has been struggling to discover the truth and settle on a course of action.

This detailed examination of the situation in New Jersey should help illuminate the broader national issues discussed in section I of this report.

1. Waste Problems and Water Pollution

Ground Water Contamination

New Jersey ranks seventh among all 50 states in gallons of ground water pumped per square mile, yet its ground water pollution problems are among the worst in the nation.[21] Virtually every aquifer in the state already has some signs of chemical contamination. Based only on problems which have been reported rather than on any formal effort to seek out polluted wells, the state by mid-1981 had identified at least 18 contaminated public water supply wells with a combined capacity of approximately 15 million gallons per day[21a] (Table 9). In addition, approximately 500 individual household wells had been closed, nearly all because of toxic chemical contamination.[21b]

The Council on Environmental Quality (CEQ) in a December, 1980 report identified the most highly polluted well of which it was aware nationally: this well was located adjacent to a disposal dump near suburban Princeton, New Jersey. Table 4 lists the extraordinarily high concentrations of organic chemicals found at this well, along with estimates of lifetime cancer risks from water contaminated at such a level.

Major sources of ground water contamination in New Jersey include over 300 old chemical dumps, illegal disposal of septic and industrial wastes, more than 300 municipal landfills, and more than 400 industrial lagoons.[24] Many cases of ground water contamination have been documented for the five years ending in mid-1980. These include 20 cases of illegal dumping, 97 of pollution from industrial spills, 17 cases of pollution traced to sanitary landfills, and three cases of pollution from septic systems.[22] It is likely that such documentation represents only the tip of the iceberg, especially for illegal dumping. New Jersey experienced a 171 percent increase in accidents of all types involving hazardous materials during the five years

Table 9

Known New Jersey Public Wells Contaminated by Chemicals

URVEYOR	WELL/S I.D.	APPROX. DATE CLOSED	CAPACITY MGD	% of TOTAL SUPPLY	CHEMICAL AVG. CONC.	REMARKS
llendale ater Dept.	2,3,4	April 78	#2 0.216 #3 0.144 #4 0.173	36%	Tetrachloro-ethylene #2 15.8 PPB #3 50.7 ppb #4 100.7 ppb	Wells #2,#4 have been allowe to return to limited service based on satisfactory analytical results
amden ater Dept.	16	May 78	1.2	4%	Trichloro-ethylene 250 ppb	Projects submitted for 3 new wells, other wells being monitored
over ater Dept.	4	Oct. 78	2.16	30%	Tri and Tetra chloroethylene 118-122 ppb respectively	June 81 well being pumped to waste
airlawn ater Dept.	10,11 14,24	Jan. 79	0.344	10%	Tetrachloro-ethylene 300 ppb	Increased bulk purchase from Passaic Valley Water Commission
ranklin Boro .P.W.	1	Dec. 80	0.21	18%	Trichloro-ethylene 5100 ppb	Propose interconnecting with Hamburg Borough
ahwah ater Dept.	15	Feb. 79	1.4	22%	Trichloro-ethylene 200 ppb	Proposing New Well-Monitorin for other Existing Wells
erth Amboy ater Dept.	Bennet Suction Line	1971	Approx. 2.5	25%	General Industrial Contamination	Major Court Case against polluting industries
ockaway Boro ater Dept.	1,6	Aug. 80	#1 0.67 #6 0.79	67%	Tetrachloro-ethylene 100-600 ppb	Temporarily out of service until GAC filters installed
ockaway Twp. ater Dept.	4,6	Feb. 80	#4 0.4 #6 0.76	47%	Trichloro-ethylene 67-163 ppb	Well 4 on standby -- Using GAC to remove SOCs
ocky Hill ater Dept.	2	Nov. 79	0.52	100%	Trichloro-ethylene 170 ppb	Buys all water from Elizabethtown Water Company
outh runswick ater Dept.	11	Dec. 77	1.8	32%	111-trichloro ethylene 400 ppb Tetrachloro-ethylene 150 ppb	Recently purchased a well from Monroe Twp. M.U.A.

Source: New Jersey Department of Environmental Protection, Division of Water Resources, Correspondence from William J. Laffey, Supervising Environmental Engineer, Bureau of Potable Water, July 28, 1981.

between 1975 and 1980. There were 885 such accidents recorded in 1980 compared to 635 in 1979 and 326 in 1975.[23]

New Jersey's largest and potentially most important source of ground water is the Cohansey Aquifer, a 17 trillion gallon reservoir underlying the porous sandy soils of the Pinelands region. (Figure 3) This reservoir, part of the larger Atlantic coastal plain, is not only the largest on the East Coast; it is also very vulnerable to pollution. Although the state and federal governments have be trying to protect 1.1 million acres of the Pinelands, land speculators' pressures and recent federal budgetary cutbacks may thwart these efforts, especially the plans for public land acquisition. There are already 42 active municipal landfills in the Pinelands. State records show that the two largest of these, a 200-acre site in Manchester Township and a 400-acre site in Ocean Township, have accepted wastes containing arsenic, cyanide, cadmium, chromium, chloride, lead, mercury, selenium, phenols, oil, grease, and many other chemicals.[17] As one member of the Pinelands Commission staff put it: "we simply do not know what has been dumped in those landfills — nor do we know what it is doing to the water because the state is not testing for chemical contamination."[17a]

Two examples serve to illustrate the growing contamination of the Cohansey Aquifer. In Jackson Township, 165 private residential wells were closed in 1980 because of chemical contamination from a four-mile long toxic plume in the aquifer. Jackson residents attribute a high incidence of serious health problems here to their water supply which included excessive amounts of chloroform, benzene, toluene, acetone, lead, mercury, and cadmium.[17b] The insidious nature of the hazardous waste problem is illustrated by the physical appearance of Jackson's offending landfill. In contrast to some others, which present a landscape of rusted and leaking drums, the Jackson landfill presents nothing to the eye but clean white sand. Liquid chemical wastes deposited here percolated rapidly through the sandy soil to the underlying aquifer leaving virtually no surface evidence of contamination.

Atlantic City's water is threatened by contamination from toxic wastes at Price's Pit, a nearby dumping site. Here a toxic plume is slowly moving through the ground water; by mid-1981 it had come within about 1,000 feet of the city's potable supplies. The dumpsite had been a gravel and sand pit; mining left a large hole several dozen feet below the surface. Because of the porous nature of the soil and the high water table, contaminants move very rapidly into the ground water. One test well drilled near the city's well field showed varying amounts of toxic substances far in excess of allowable amounts. These include: benzene, cadmium, chloroform, 1,2-dichloroethane, lead, vinyl chloride, methylene chloride, and trichloroethylene.[8]

Because of the state's high incidence of cancer deaths, Governor Brendan Byrne in 1975 ordered a concerted effort to learn the reasons and possible remedies for this condition. As part of that effort, extensive testing of ground water was started in 1977 with a focus on 50 chemicals in three different groups: volatile organic compounds, chlorinated pesticides and related compounds, and metals. This New Jersey ground water survey was the first of its kind in the nation; EPA is now conducting a national survey of this kind.* Experts tested 670 wells and 1,118 samples in New Jersey. Volatile organic contamination above 100 ppb was found in 3.1 percent of the wells, above 10 ppb in 16.6 percent; federal standards for metals were exceeded in 29 wells (4.3 percent); and 31 wells had problems with low levels of pesticides even though use of these compounds had been banned or greatly restricted in recent years.[26] Table 10 lists the volatile organic compounds often found in New Jersey's ground

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*New Jersey's Office of Cancer and Toxic Substance Research, within the Department of Environmental Protection, conducts research on various aspects of the interface between toxic substances and their effects on public health. The ground water survey was administered through this office.

Table 10

Volatile Organic Compounds with Widespread Occurrence in New Jersey Groundwater

Chemical	No. of Samples > 10 ppb	No. of Wells > 10 ppb	No. of Wells > 100 ppb
Carbon tetrachloride*	6	5	2
Chloroform*	24	24	3
1,2-Dichloroethane*	22	18	0
Tetrachloroethylene*	16	16	2
1,1,1-Trichloroethane	83	65	5
Trichloroethylene*	52	27	12
Dichlorobenzene	8	8	2
Trichlorobenzene	4	4	1
	215	167	27
Actual number of wells		111	21

*Carcinogens

Note: Numbers of wells are less than the totals in the columns because some wells have more than one contaminant.

Source: Robert K. Tucker, Toxics in Ground Water, (Trenton: New Jersey Department of Environmental Protection, Office of Cancer and Toxic Substances Research) March 1981, p. 5.

water. Of the volatile organic compounds found, the most common is 1,1,1- trichloroethane, an industrial metal cleaner and degreaser. Concentrations as high as 1,900 ppb were discovered in some areas. Although not a carcinogen, the amounts of this chemical found in ground water far exceed values in surface waters where disipation is more extensive.[27]

Plumes of contaminated water may remain in the ground for decades, even after the original source of contamination has been eliminated. Although it is virtually impossible in most cases to remove such a plume once it has formed, in exceptional circumstances, however, cleansing, although costly, may be feasible. The state has been experimenting with various methods of cleansing. One method involves pumping out of polluted ground water, treating it to remove chemicals and then recharging the water back to the aquifer. Another technique involves introduction of special bacteria to consume spilled gasoline. By mid-1980 the state had 16 active ground water decontamination projects.[23a]

The three wells constituting the public water supply of suburban Rockaway Township in northwestern New Jersey were contaminated with trichloroethylene (TCE). Here a municipal rehabilitation effort was notable as the first use in the state of granular activated carbon (GAC) filters for chemical decontamination of public drinking water. The GAC system, installed in November 1980, has reduced TCE concentrations from 100 ppb to an undetectable level. (EPA's proposed criterion for TCE in ambient water is 2.1 ppb.) Rockaway, a community of 20,000 people, has paid $150,000 in original installation costs for its GAC system. The township originally had estimated filter replacement costs to be $40,000 annually. However, the discovery of other chemical contaminants in the water supply after the GAC was installed -- believed to be the result of a gasoline spill, with temporary effects -- will make more frequent replacement of the filters necessary. If continued, this new situation, could run the cost of filter replacement to $112,000 annually. Consumers who have paid an average $31 annually for water could expect to pay perhaps twice that amount, their first rate increase in 25 years. Even with the increase, however, this community will continue to have one of the lowest rates in the county. Rockaway had little choice but to cleanse its ground water since it cannot easily develop an adequate alternative water supply. Additional concerns have been expressed for the township's 2,000 or so private wells, some of which are exhibiting chemical contamination.[23b] Neighboring Rockaway Borough (population: 6,700) is also installing GAC filters to remove tetrachloroethylene found at 500 ppb. (EPA's proposed criterion for tetrachloroethylene in ambient water is 0.2 ppb.) This discovery had necessitated the closure of one of its three public wells and the use of outside water.[23c] Because many smaller communities which depend on ground water sources have few if any alternative water supplies, once chemical contamination is discovered use of GAC may be more acceptable to them than to the large surface water purveyors who have resisted its use.

Surface Water Contamination

Because of the seriousness and newness of its discovery, ground water contamination currently is receiving the most public attention. Surface water discharges of toxic substances are, however, of continuing concern. The quality of these waters is especially important because the state's largest drinking water suppliers, serving its most densely populated areas, rely primarily on surface water sources.

Approximately 600 municipal sewage treatment plants in New Jersey discharge 1.3 billion gallons of effluent per day into the state's surface waters. Many of these effluents include industrial wastes which may or may not have been treated adequately. In addition, about 900 industrial plants contribute 300 million gallons of industrial waste and 1.5 million gallons of cooling water daily to the state's waters.[24a]

As a result of the Federal Water Pollution Control Act Amendments of 1972, surface water quality in large rivers has improved in the last decade over most parts of the state. Now toxic waste disposal, nonpoint source pollution, and the newly-discovered ground water contamination are of greatest concern. The urban northeast, portions of the lower Delaware River, and the eastern half of Camden County still have the poorest water quality.[82]

One example of this in the northeast is the Passaic River, the source for the Passaic Valley Water Commission. This water purveyor serves nearly a million people. Its Passaic River source has at least 2,500 industrial discharges and over 100 sewage treatment plants, creating a 65 percent effluent content in the river in times of low precipitation.

Historically, the state was the owner of rights to most of the water in wells, streams and, in some cases, entire rivers. This changed about 100 years ago when New Jersey lawmakers gave away these rights.[84] Ever since, the conflict between water quality and quantity has existed. As the Department of Environmental Protection's (DEP) first Commissioner, Richard Sullivan, stated "you don't have enough water unless you have clean water."[85] This issue has become more critical during recent water shortages in New Jersey and the Northeast, generally.

Institutional Problems

The preceding paragraphs gave a brief overview of the physical condition of New Jersey's ground and surface waters. The following paragraphs discuss the institutions -- the purveyors, regulators, testing laboratories, and others -- which are responsible for delivering public drinking water.

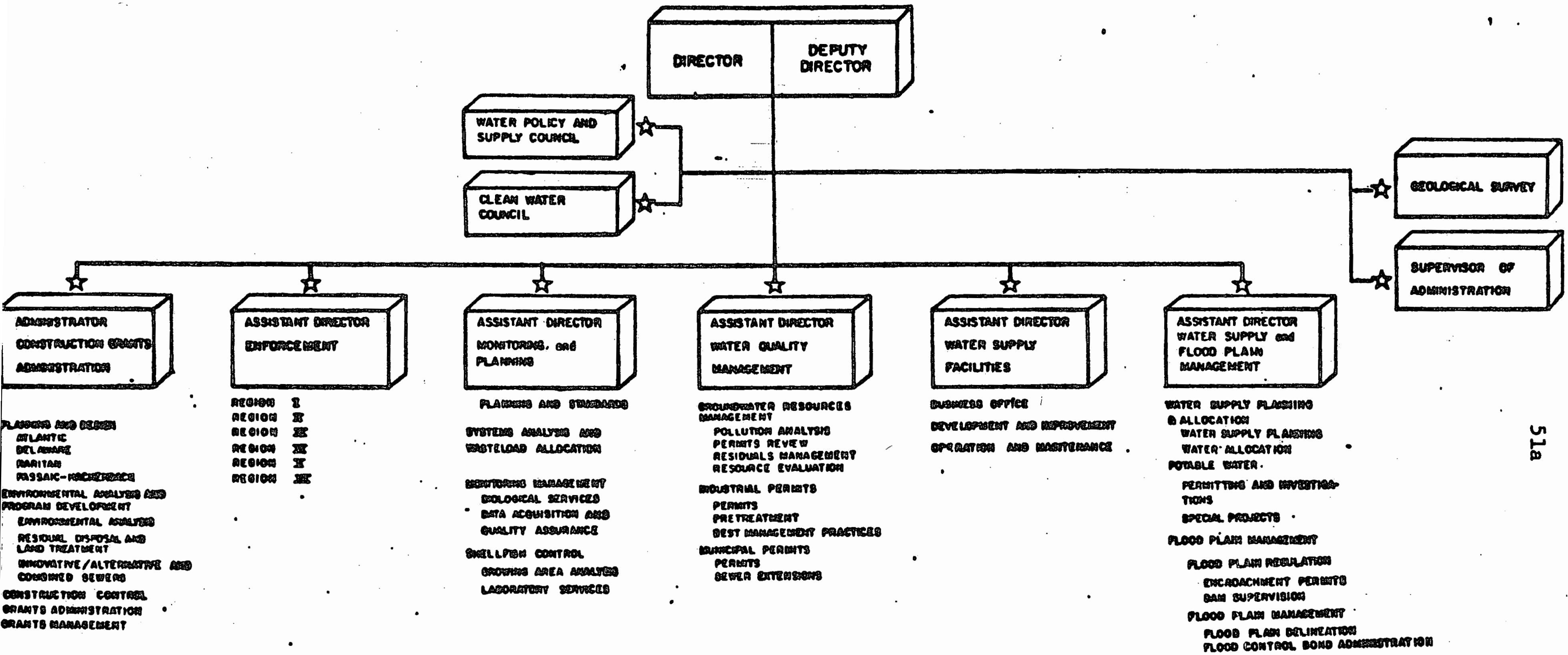
The DEP Role. The Division of Water Resources (DWR) of the Department of Environmental Protection (DEP) is responsible for implementation of regulations pertaining to drinking water. DWR has principal authority in New Jersey under the federal Safe Drinking Water Act. Figure 2 shows DWR's organizational structure. The division had 240 employees in 1970 when DEP was created. Its budget was $1.9 million, with less than two percent coming from the federal government. Today DWR employs nearly 700 workers. Its $11 million budget is among the largest of any division of state government. Sixty percent of its budget now comes from federal funds, primarily for water pollution control and flood plain management.[86] Federal funding is, however, expected to drop sharply after the large budget cuts voted in Congress in 1981.

Over the years, the DWR has been plagued by a morass of organizational problems and high employee turnover. Several studies have pointed out that New Jersey's salary range for engineers was the lowest of any government agency

Figure 2

DIVISION OF WATER RESOURCES

DEPARTMENT OF ENVIRONMENTAL PROTECTION



Source: New Jersey Department of Environmental Protection,
Division of Water Resources, 1981.

in the northeast. Young engineers and other professionals have stayed just long enough to gain needed experience before taking higher paying jobs with private industry. According to one former DWR official, now with EPA, the state's civil service system made it difficult to attract and keep people in state government who are equivalent to what one would find in the private sector."[87]* As he put it: "the lack of continuity at the top of the Division, coupled with the combination of stagnant mid-level management and soaring entry-level turnover, sapped the division of any imaginative leadership it might have possessed."[87a] As one attorney, a former staff counsel to the County and Municipal Study Commission which examined the Division, stated: "They are more hardworking than most, but I don't see the imaginative approach. They would not fight for their programs."[88] Examples of management deficiencies are seen in occurrences after the drought of the mid-1960s. Small, inadequate water suppliers were permitted to proliferate, and existing water utilities were allowed to take on new customers without proving they possessed adequate supplies. Also, numerous warnings that growing ground water contamination could diminish existing sources went unheeded.

The Bureau of Potable Water, within DWR, has direct responsibility for insuring that public potable water supplies will not endanger public health. The Bureau's increased workload and the complexity of the problems it faces -- especially toxic substance contamination of public and private wells and the 1980-81 drought -- have not elevated its organizational position from the lower rungs of the DWR , which remains heavily oriented toward administering federal and state grants for construction of waste water treatment plants. In 1977, in recognition of its increased responsibilities under the Safe Drinking Water Act, the Bureau was given additional funding to increase its staff positions from 5 to 32

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*In Europe, notably West Germany, government employees are generally paid as well as they would be for equivalent jobs in industry thus maintaining performance quality and low turnover.

Its 1980 budget was $890,000 ($540,000 from federal funds and $350,000 from the state).[88a] However, by early 1981 only 21 of the 32 positions, including five clerical jobs, had been filled. Most of the 11 remaining positions were given to other DWR sections, primarily the Enforcement and Regulatory Services Element which in January 1981 took over drinking water enforcement from the Bureau. The removal of enforcement responsibilities from the Bureau was a recognition of its inability to conduct this function adequately because of its greatly increased program responsibilities, insufficient funding, and inadequate leadership. A significant number of small drinking water suppliers, which formerly did not come under the scrutiny of the Bureau, now fall within its jurisdiction. These include motels, restaurants, trailer parks, and similar facilities. Nevertheless, the Bureau's limited resources are still concentrated on the largest of the 620 community water purveyors, 10 percent of whom serve approximately 90 percent of the state's nearly 7.5 million residents.

Table 11 summarizes DEP responsibilities before and after passage of the SDWA. To some degree, the limitations on the Bureau of Potable Water's effectiveness come from the fact that the SDWA provides for a lesser governmental presence and far less funding than does the FWPCA. Moreover, John Wilford -- DWR's Assistant Director in charge of the Bureau until his removal from this position in August 1981 -- has been philosophically and openly opposed to those basic tenets of the SDWA which apply to regulation of maximum contaminant levels and control technology for chemical contaminants. His opposition is based in part on skepticism about the health effects of chemical compounds in drinking water.[88b] This leadership attitude further restrained any regulatory zeal on the part of people within the Bureau. This is particularly important since some large

TABLE 11

DEP RESPONSIBILITIES PRIOR TO AND AFTER ENACTMENT OF THE SAFE DRINKING WATER ACT

Agency Responsibilities Prior to SDWA Enactment	Additional Agency Responsibilities After SDWA Enactment
Adoption of Primary Drinking Water Regulations (partial)	Authority to Apply State Drinking Water Regulations to All Public Water Systems
Inventory of Public Water Systems (partial)	
Conduct of Sanitary Surveys (partial)	Adoption and Implementation of an Adequate Plan for the Provision of State Drinking Water Under Emergency Circumstances
Use of State Laboratory Facilities to Analyze Potable Water Quality	
Permit Program for Design, Construction, or Modification of All Public Water Systems	Authority to Issue Variances and Exemptions as Provided for by the U.S. SDWA
Authority to Sue to Enjoin Threatened Supplies or Continued Violators of Regulations	
Right of Entry for Inspection	Establishment and Maintenance of a Laboratory Certification Program
Authority to Require Purveyors to Keep Appropriate Records	
Authority to Seek Civil and Criminal Penalties for Violation of Regulations	Authority to Require Suppliers to Give Public Notice of Violations of SDWA Regulations
Establishment and Maintenance of Record-keeping System to Document State Activities (partial)	

Source: The Statewide Water Supply Master Plan (Interim Output for Task 8F) (Trenton: New Jersey Department of Environmental Protection), March 1978.

water purveyors in New Jersey were prominent in opposing federal regulation of chemical contaminants in drinking water proposed in 1978.

Interestingly, in 1965 all public water supply systems in the state were ordered to chlorinate their drinking water. This was done for administrative convenience, since state regulators could not know of all bacterial threats in water supplies. This preventive approach was taken even for relatively protected ground water sources. This philosophy has not, however, been replicated in use of control technology for removal of toxic chemicals, both identified and unidentified. Such an approach would lessen the heavy reliance on self-monitoring by purveyors and alleviate the resulting regulatory morass compounded by inadequate government resources to implement the law fully. This is particularly true because the SDWA chemical monitoring regulations are not well understood by many government officials — state and federal -- nor by even some of the large water purveyors.*

DWR's Enforcement and Regulatory Services Element, with a staff of 80, functions through six regional water districts. It is charged with enforcing regulations under the FWPCA (waste water and NPDES permits) and the SDWA. Enforcement under the SDWA comprises 20 to 35 percent of this unit's activities. Recent discoveries of ground water contamination by synthetic organic compounds (SOCs) not regulated by the Act has, at times, increased overall attention to drinking water problems to 50 to 60 percent of the element's workload.[88c]

Violations of drinking water standards are brought to the attention of the enforcement unit by its Compliance Monitoring Program. This program relies on a combination of physical inspections by state officials and self-monitoring of drinking water by purveyors. State inspections are conducted annually at community water systems, once every four years at non-community

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*Control technology to remove chemical contaminants is discussed on pp. 31-34 and 80-86.

systems,* and once every two years at hotels and other public facilities. Although enforcement actions may also result from consumer complaints, physical inspections by outsiders are the most common way to identify violations. Self-monitoring by purveyors has yielded primarily information on bacterial and turbidity infractions; virtually no chemical contamination violations have been identified. The lack of such violations is attributable in part to the limited numbers of toxic chemicals regulated under the SDWA, and to the fact that those chemicals which are regulated are not the principal contaminants found in drinking water. In particular, the organic compounds -- chiefly industrial solvents -- which now comprise the greatest source of drinking water contamination are not currently regulated. Only emergency ad hoc state action is taken on these toxic substances.**

The failure of purveyors to report is a persistent problem, though it affects primarily small, investor-owned water suppliers. In early 1981 about 100 of the state's 620 community water suppliers were failing to report. Reports are supposed to be submitted monthly and should give information on MCLs and any general problems encountered by the purveyor. Fifty percent of the state's 620 community water suppliers -- primarily small ones -- are repeated MCL violators, generally of bacteria and turbidity standards.[88d]

Persistent violators are handled in an innovative manner in New York State. Here the Department of Health in 1978 established its own legal mechanism -- the Administrative Tribunal -- which holds hearings for water supply violators and sets fines for those found guilty. If the purveyor agrees to comply with the state's sanitary code within a given schedule, the fines are usually waived. Considerable progress in purveyor compliance reportedly has been made in New York as a result of this innovation.[88e]

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*Non-community systems, serving less than 25 people, are subject to lesser requirements for monitoring of drinking water contaminants; tests for only bacteria and nitrates are mandated by law.

**Such ad hoc action is described on p. 79.

Problems with Small Suppliers. Recurring problems with small water suppliers exist in New Jersey, as they do nationally.* Many of these small suppliers provide substandard service to residential subdivisions and small communities. In New Jersey, the problem often originated when a residential developer was unable or unwilling to connect his proposed development to an existing community water system. In order to proceed with construction plans, the developer either assumed responsibility for water service or established a new water company solely to serve the needs of the subdivision. The cost of this capital outlay was generally incorporated into the price of the houses to be sold.

Recently, the state has attempted enforcement actions against small water companies that have not provided adequate customer service or that do not comply with the mandates of the SDWA to conduct laboratory analyses of their water and make test results available to DEP. In a two-month period in 1980, 65 small and 7 medium-size water companies (out of 620 community water purveyors) had not reported testing results.[89] This does not include the multitude of small water companies that have avoided identification and regulation by the state altogether. Enforcement is often difficult since merely locating the responsible party presents an obstacle.

In order to meet the SDWA mandates, some assistance in grants, services, and/or loans to financially strapped small water utilities will be necessary to ensure that the size of the water utility does not determine water service and quality. Municipal authorities, who have principal jurisdiction over land use decisions, may have to demand performance bonds or otherwise take greater responsibility for these small water companies. In some cases, regionalization of water supply systems may offer the answer to better service.**

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*In New Jersey, an informal definition of water supplier size according to population served is: up to 1,000 = small; 1,000 to 100,000 = medium; 100,000 and over = large. Most of the 620 purveyors fall in the medium category, with only a dozen in the large classification.

**State legislation, discussed on p. 67, may remedy some of the problems with small water companies.

Laboratory Problems. Determining trace amounts of hundreds of toxic chemicals in water is a job fraught with pitfalls. According to one of the professors supervising such analyses for New Jersey's ground water sampling, "This is a scary region....that makes everyone fairly nervous."[103] Part of this nervousness is based on the newness of the science of testing for trace chemical contaminants in drinking water, a science that uses sophisticated and expensive equipment,[*] and in which some techniques are still close to the frontiers of knowledge. "If we have no information we know we are ignorant. If we have wrong information, we have confusion and worse," is the way Professor Joseph Hunter of Rutgers University stated the dilemma.[105**]

Both the SDWA and the FWPCA require laboratory testing. Responsibility for tests of drinking water under the SDWA rests with the water purveyors, who are required to use state-certified laboratories. Under FWPCA, a National Pollutant Discharge Elimination System (NPDES) permit is required of dischargers to all U.S. waterways. As a condition of their permit, dischargers must submit reports on the amount and chemical composition of pollutants. This also requires laboratory testing.

An NPDES quality assurance study conducted in New Jersey in March 1979 indicated that only 21 (27 percent) of 77 participating laboratories performed acceptably. Four did not return data and 12 laboratories demonstrated "serious nonconformity to approved test procedures."[97] The EPA review concluded that the state "is not capable of monitoring and enforcing water quality standards according to federal criteria."[100]

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[*] One of these instruments is the gas chromatograph (GC). Another is the gas chromatograph/mass spectrometer (GCMS), a more complex and far more costly machine ($150,000 compared to $20,000). It is used to analyze many of EPA's "priority pollutants" such as volatile organics. The GCMS gives a more certain measurement than the GC. Atomic absorption is used to test for heavy metals (inorganics).

[**] Much of the state's ground water testing has been conducted at Rutgers.

The state's own Department of Health Laboratory, which tests New Jersey's drinking water for the DEP and which had certified 177 private laboratories that analyze water quality for municipalities, water purveyors, and industry, was also found to be deficient in many of its basic functions. In a September 1979 letter to the DEP Commissioner, EPA asserted that: "The Department of Health's chemical laboratory's quality assurance program definitely requires major upgrading to be considered adequate. A lack of adherence to approved methodology, poor equipment maintenance, poor chemical control, and general unfamiliarity of the analysts with acceptable analytical and quality control procedures were observed by our evaluator." The EPA concluded that the state's Division of Water Resources is "neither adequate in size nor does it have authority to make the program work."[101]

Thus, under requirements of both the Federal Water Pollution Control Act and Safe Drinking Water Act, serious inadequacies have been found in the state's basic structures for assessing water quality. Since the 1979 EPA study, the Department of Health's laboratory seems to have improved . It received EPA accreditation in 1980. In addition, in 1981 the state established standardized laboratory regulations. Currently 124 laboratories have been certified as capable of testing in one or more of four categories: 1) microbiology, 2) limited chemistry (nitrate and chloride), 3) atomic absorption for heavy metals, and 4) gas chromatography (and mass spectrometry) for organics, including THMs. Only about 15 to 20 percent of these laboratories are capable of conducting analyses in the third and fourth categories, and only two or three of them can conduct the most extensive chemical testing, e.g., for EPA's 129 priority pollutants.[101a] Radionuclide analyses are done at the DEP Radiation Laboratory as well as the Department of Health Laboratory.

Some of the certified laboratories are onsite facilities operated by the water purveyors. Many of these conduct bacteriological analyses, though several of the largest do more sophisticated chemical testing. Heavy dependence on the purveyors for basic information on drinking water quality obviously could lead to regulatory conflicts of interest. On the other hand, there is much to be said for the expertise and professionalism that purveyor-owned laboratories bring to the industry. Perhaps the best solution is for the state to encourage self-monitoring, but to oversee the system by increased independent random sampling.

In early 1982 the state's new DEP Pesticides Laboratory was completed. While it is expected that some other analyses related to hazardous waste may also be conducted here, the new facility is not designed to handle the volume now required. Thus, the reaccredited Department of Health laboratory will still be the state's mainstay. To handle the increased volume of drinking water analyses, the Department of Health Laboratory may have to expand its working capacity to seven days a week to meet increasing revelations of toxic contamination, rather than the "business as usual" five day work week now in existence.

2. State Actions to Improve Water Quality

Despite its institutional weaknesses and financial burdens, New Jersey has been struggling to cope with the staggering problems that chemical pollution is imposing on it. The following paragraphs briefly review the most important recent state efforts.

NPDES Permits

As part of its takeover of the NPDES program from the EPA, the state in March 1981 promulgated regulations to classify ground water, to establish ground water quality standards (including a general nondegradation clause), and to set rules for point source effluents.[73] This program also incldues a FWPCA-RCRA consolidated permit mechanism designed to achieve better coordination. Under its previous regulations, the state could take action against pollution of ground water only when contamination already was evident in drinking water. In contrast, the new rules take a preventive approach. The new program will also include policies and procedures for selecting waste disposal sites and allocating ground water supplies.

All "significant industrial uses," designated according to volume and type of effluent, must now obtain state permits for discharges to either ground or surface waters. Using criteria based on the federal 129 priority pollutants and on categorical standards for 21 primary industries, the New Jersey permit system (NJPDES) would be applied to control the following potential water pollutant sources:

direct point discharges into surface waters
underground injection wells
industrial waste management facilities
indirect discharges (e.g., industrial flows into sewage treatment plants)
discharges from surface impoundments
land application of sludge and septage
land application of effluents by spray irregation
land application of effluents by overland flow
land disposal by infiltration-percolation lagoons
discharges from sanitary landfills

Decisions must be made as to whether municipal sewage plants can treat industrial waste effluent, or if pretreatment of these industrial wastes is necessary prior to discharge of the wastes to the sewage system.[74]

As New Jersey approaches its takeover of the NPDES program, concerns are being raised about its ability to handle the mammoth job (1,000 NPDES permits just for industries with toxic wastes). According to the Director of DEP's Division of Water Resources, the section which will manage permitting is "in a shambles."[78] DEP may upgrade its ability, but cutbacks in federal funding for water quality programs are not harbingers of hope.

In a critique of the NPDES system, the New Jersey Public Interest Research Group (PIRG), which has studied water quality issues, charged that EPA's failure to ensure that dischargers obtain NPDES permits has caused many pollution sources to go unmonitored. For example, only 67 percent of industrial facilities examined in a 1978 EPA study had obtained permits. A 1980 study conducted by PIRG's "Stream Walkers" in Essex County discovered that 80 percent of those who discharged into the waterways had failed to obtain permits, even though permits had been required since 1974.

Another problem involves the Discharge Monitoring Reports (DMR) submitted by permittees. The question of veracity for these self-reported records, creates uncertainties as to the true nature of these discharges. A 1978 General Accounting Office (GAO) study monitored the activities of 165 selected dischargers. GAO found that 55 percent of the permittees failed to comply with one or more discharge limitations, some of them discharging high concentrations of toxic substances. The GAO study also found that 23 percent of the permittees failed to submit one or more DMRs; of that group, 65 percent failed to do so for five or more months. The GAO stated furthermore that EPA's enforcement responses were neither timely nor strong. An average of 400 days elapsed between a violation and the issuance of an administrative order, and 500 days between the violation and a referral to the Justice Department. In a preliminary study of over 4,000 violations of industrial dischargers in EPA's Region II, PIRG found that EPA's overall enforcement effort, including telephone calls and warning letters, was a dismal 13 percent.[78]

Regulation of Landfills

The state's Solid Waste Administration will be responsible for new regulations to upgrade or close about half of the state's 300 or so municipal landfills in order to protect nearby water supplies. These regulations are part of the NPDES permits program (discussed on pp. 59 and 60). The state is tightening up its discharge standards for leaking landfills; those facilities that cannot meet the standards will have to be phased out over the next two years. Most of the landfills are small municipal facilities, some of which will be replaced by a few larger ones. Ultimately only 20-25 such landfills will be in operation, creating a more manageable regulatory state role. The funds to upgrade existing landfills will come from a $6 to $8 per ton "tipping" (or dumping) charge. The rates for New Jersey's landfill users currently range from $2 to $5 per ton, still inexpensive compared to New York's $10 (plus) rate. In the past New Jersey did not check landfill leachate unless an acute problem was identified. Under the new regulations, monitoring will be conducted to check for EPA's 129 priority pollutants.[75]

In order to clean up old chemical dumps, the state is anticipating revenue from the federal "Superfund." New Jersey's own Spill Compensation Fund, created in 1976, has raised $32.8 million through taxes on the state's chemical and petroleum in-industries. By June 30, 1981, this fund had been spent.[76] In early 1981 lack of funds caused cleanup efforts to be interrupted at two of the state's largest and most notorious dumpsites: the Chemical Control Corporation in the City of Elizabeth, in the northern part of the state, and in rural Plumstead Township in the south. Chemical Control's clean up alone has cost the state $24.4 million as of July 2, 1981.[19]

The state is concerned, however, that even these modest efforts may be threatened by a section of the federal Superfund law prohibiting states from taxing chemical companies to set up spill funds that would duplicate the federal effort. It is felt that even the federal fund, by itself, will not be sufficient to cover cleanup costs of extensive pollution that is encountered in a state with a large chemical industry, such as New Jersey.* In a lawsuit filed in federal court in April 1981, the state asked the court to uphold its power to tax the oil and chemical industry to pay for cleaning up certain spills. Three corporations — Exxon, B. F. Goodrich, and Union Carbide -- have also filed suit in federal court, claiming that the dual federal and state funds amount to "double taxation." Their action seeks a court ruling declaring the New Jersey fund invalid and requiring the state to refund $750,000 in payments made by the companies since December 1980 when the federal fund was instituted[76a]

In another move to provide funds to clean up the state's 300 or more toxic waste dumps, estimated to cost $1 billion, New Jersey voters in 1981 approved a $100 million Hazardous Discharge Bond Act. This was sponsored by state Assemblyman Raymond Lesniak who also initiated New Jersey's lawsuit against the federal government in the Superfund case.[76b] Lesniak's district includes the city of Elizabeth, the site of Chemical Control Corporation, one of the largest chemical dump sites in the state and nation. A fire here in 1980 destroyed part of the remains of the 60,000 drum chemical repository.

Comprehensive legislation to control the siting of new hazardous waste disposal facilities is embodied in the Major Hazardous Waste Facilities Siting Act of 1981.[76c] One of the innovative features of this law, which establishes a commission with broad authority, is that all new major facilities are to be above ground, accessible to inspection and designed to allow 99.9 percent extraction of material. Although exemptions are provided for technological or economic impracticality, this feature should help to protect ground water supplies now being contaminated by toxic landfill wastes.

The Manifest System

Not only was New Jersey ahead of the federal government in setting up a Spill Compensation Fund, it was also ahead in setting up a "manifest" system under which hand-to-hand records are kept of the movement of all hazardous waste from the point of generation to the point of disposal. New Jersey's system was created in 1978, two years before the RCRA regulations of 1980 required all states to keep such records. The national system will ultimately assist in tracking movements between as well as within states.

Unfortunately, manifest forms can be and are falsified or avoided altogether. One disturbing indication of the disregard for the state's laws by the companies which haul hazardous waste from generators to disposal sites is the fact that only 9 of the 340 firms with hazardous waste transportation permits from the DEP have filed as required with the Board of Public Utilities (BPU). This requirement was designed in part to prevent companies from suddenly going bankrupt, leaving the state to cope with large stocks of toxic wastes. Because of personnel limitations, the state has been unable to enforce this law adequately.[15b]

Water Supply Master Plan

In response to long-time water supply and management problems, the state in the mid-1970's embarked on the formulation of a water supply master plan. The plan is expected to be implemented in 1982. Consultants to the state have made several preliminary recommendations on the plan. These include:

1) creation of a system in which the existing water purveyors continue to play a major role in water supply, but with a "regulatory and managerial umbrella overseen by state government";[95]

2) increased efforts to tighten the relationships of parallel, interdepartmental planning and regulatory programs, and to establish an intergovernmental working partnership with the water purveyors and the public health profession. In recognition of resource limitations, the state would continue to set policy and monitor progress but would leave actual implementation to lower levels of government; [95a] *

3) levy of a water diversion fee to make water supply administration self-sustaining, "a long standing principle in water utility economics and regulation;"[95b]

4) development of some form of systematic rates review to assure the system's ability to be maintained and operated effectively, "thereby guaranteeing fair and equitable rates and a safe supply of water."[95c]

5) placement of increasing emphasis within the DWR upon potable water quality regulation including better coordination of water supply watershed plans and water quality basin plans, e.g., "208" plans;

6) for systems dependent upon a sole source of supply, planning for interconnections with another system in case of emergencies.[96] (This is critical in cases of contamination of drinking water supplies by toxic substances.)

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*The County Environmental Health Act of 1980 provides for delegation by the state to local health departments of some responsibility for monitoring and enforcing environmental regulations. This would include conducting tests of potable water, surface water and air and inspection of disposal dumps. The law will be implemented in 1982 through a gradual process. While it will provide much needed assistance to the state, especially in view of federal funding cuts, local enforcement is always uneven and will have to be monitored by the state.

In stressing the importance of water quality, the consultants stated that if appropriate steps were not taken, some water sources will have to be abandoned in order to comply with drinking water standards. To avoid this, either raw water sources will have to be cleansed through the state's water quality management program or additional treatment will have to be employed by water purveyors, necessitating significant capital investment and increased consumer rates.

State Regulation of Water Supply Rates

In operating water supplies of its own (the Delaware and Raritan Canal and the Round Valley and Spruce Run Reservoirs), the DEP has set a poor example by charging rates that are too low to cover its operating expenses. Likewise, local governments which operate their own water utilities have been allowed to take on new customers while keeping their rates artifically low. Problems in Newark exemplify the results of this process. The city's water rates are among the lowest in the state, and its water supply system has seriously deteriorated because local officials have not invested funds to maintain it. Municipalities also frequently divert water revenues for other government needs, allowing water system deterioration.

To address these problems and others relating to adequate water supply, several pieces of state legislation were proposed in 1980. One of these, enacted in December, 1981, empowers DEP to order the takeover of small incapable water companies by larger companies or by the municipalities within which they are located.[91] A second measure with far-reaching implications for the state's water supply system, creates an independent State Water Utility, which could issue revenue bonds to construct water supply projects or could take over purveyors which have failed to upgrade their system. This was enacted in October 1981.[92] The third of these legislative offerings is the Water Supply Management Act. This measure, enacted in August 1981, restructures the state's basic water laws to give DEP primary responsibility in an attempt to ensure sound management of the water supply system. The legislation creates a uniform permit system for diverters of surface or ground water, adopts a fee schedule, and modifies the system of grandfather rights and diversion privileges.[93] Under this law, DEP would have authority to require public water supply systems to ensure adequate sources of water, a long-standing, serious management issue which has come to light again in the 1981 period of water shortages.

Resistance to a strong state role in drinking water supply planning, and to this package of legislative proposals, had emanated from several quarters. New Jersey's strong tradition of home rule brought local government enmity to state intervention. Environmentalists, experienced in dealing with the DWR over the past decade, lack confidence in its ability to take on the additional burdens represented in the legislation. They wanted to defer new legislation until the state's water supply master plan had been approved. Environmentalists feared an overemphasis on engineering solutions and construction rather than water conservation and source protection. The most potent opposition, however, has come from water purveyors. As one former DEP official put it:

> "....the state's water supply system is fragmented and inefficient. Over 500 entities -- some public, some private; some local, some regional; some big, some small -- have a hand

> in the delivery of water....As long as the rain fell, and the water flowed, the only proposition all these fragmented water suppliers would agree on is that the state agencies should not encroach on their independence. The big, investor-owned water companies made money. They did not want to be dictated to by the state, which they regarded as a potential competitor, or as lacking the competence to tell them what to do. The municipal utilities wanted to keep rates low to keep taxpayers happy, wanted to transfer whatever money they could from their water sales into the general treasury to keep taxes down, and, with the usual defense of home rule, did not want bureaucrats in Trenton telling us what to do."[94]

The political power of the water purveyors is evidenced by their success in the last 50 years in preventing the creation of a state water authority, embodied in the new legislation. Going back to 1934 when Governor A. Harry Moore first made such an attempt, and again to 1958, the water purveyors have been able to block those legislative proposals that would infringe on their own autonomy. In 1981, with severe water supply problems resulting from low precipitation and with revelations of poor purveyor planning, the political tide had turned to allow legislative redress.

Municipal Action: A Model

While the focus of activity to combat chemical contamination of water in New Jersey is at the state level,* one municipal effort to identify the source and disposition of local hazardous waste, and thus protect water supplies, illustrates that communities can augment state efforts hampered by inadequate budgets, personnel, and the enormous size of the problem. In Princeton (population 25,000), the four-member Health Department conducted an environmental survey of chemical, pretroleum, and nuclear waste in the community. They contacted gasoline stations, automobile dealers and body shops, an automobile rental agency, dry cleaners, Princeton Hospital, Princeton University, and the municipal Public Works Department. They found that about 35,000 gallons of waste oil a year is drained from cars in

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*Page 65 describes the effort in New Jersey to shift responsibility for monitoring and enforcement of some environmental regulations from the state to the local level of government. Such a shift will be assisted by recent moves of the Reagan Administration to have federal programs conducted at the state level in a policy of "New Federalism."

Princeton's 15 service stations. Fourteen of the fifteen stations reported that their waste oil is picked up by an oil recycling company on a regular basis. Dry cleaning businesses reported that they recapture for reuse as much as possible of the expensive chemicals they use. Very little is thrown away. Princeton University annually ships 14,500 pounds of chemical wastes from its laboratories and other facilities to a chemical waste landfill in Alabama, plus 198 drums of radioactive waste to the state of Washington. The hospital's "small amount" of low-level radioactive waste goes into the municipal sewer system, as do the chemicals - 60 to 80 gallons a week -- used in x-ray processing.[28] No environmental hazards were uncovered by the survey.

This conclusion, however, was based solely upon data supplied by the various enterprises contacted. Private households were not surveyed, and one can only guess about the dark room hobbyists with photography chemicals, the leftover paint, the pesticides and herbicides, household cleansers, and so on. Many of these products ultimately find their way into water supplies via public sewers, on-site septic systems, or landfills. The municipal survey was a starting point for further research, especially if some environmental episodes, such as well contamination, should arise. Such episodes have occurred in nearby communities.

3. Water Purveyors in New Jersey

The National Context

Nationally, only about ten percent of the 61,000 community drinking water supply systems serve ninety percent of the total population.[106] A 1970 report by the Department of Health, Education and Welfare (HEW) found that of 969 community water supply systems surveyed nationally, 56 percent had deficiencies in physical facilities, including disinfection capabilities, and in source protection; 77 percent of water treatment plant operators were poorly trained, with 46 percent deficient in chemistry principles related to their assignment; 79 percent of the systems had not been inspected by state or county agencies in the year preceding the survey; 69 percent did not analyze for half of the contaminants in the Public Health Service's 1962 drinking water standards; and 36 percent of 2,600 tapwater samples contained one or more bacteriological or chemical constituents that exceeded the limits of the 1962 standards.[107,108] The report concluded that millions of Americans were drinking water of inferior quality, much of it potentially hazardous. This HEW report formed the original stimulus for the Safe Drinking Water Act in 1970.

The tradition of local control of water supply with only minimal involvement by state government changed with passage of the Safe Drinking Water Act in 1974. However, the water supply industry is inherently conservative, and has changed very little in this century. Recent discoveries of chemical contamination, including that resulting from chlorination itself, have jolted the industry and created a somewhat defensive attitude which has manifested itself in strong opposition to government initiatives to institute regulatory controls. Water engineers commonly believe that no matter how seriously polluted the water source, adequate treatment can overcome the problem.[110] This idea was conceived by the enormous success their predecessors achieved with chlorination in coping with bacterial problems in the early 1900s.

The traditional drinking water treatment process does not, however, serve well for those water sources contaminated with the hundreds -- perhaps thousands -- of complex synthetic organic compounds. This process consists primarily of collection of solids (coagulation), allowing solids to settle (sedimentation), filtration, and disinfection. Some drinking water treatment plants also employ adsorption techniques using powdered activated carbon (PAC) to remove unwanted matter for taste and odor enhancement. About 60 U.S. treatment plants use granular activated carbon (GAC) for taste and odor enhancement. But the new challenges of synthetic organics and THMs place the industry on the threshold of a new, and threatening, era.

New Jersey's Water Supply System

New Jersey has 620 community water supply systems, each serving at least 25 people. In addition, some 2,000 smaller non-community systems have been recorded, and there are an estimated 8,000 to 10,000 small systems for which the state has no records.[111] Sources are dispersed, though interconnected by a complex but still inadequate network. Jurisdiction is fragmented between local authorities and various state agencies such as DEP and the Board of Public Utilities (BPU). The fragmentation and complexity which characterize the drinking water supply and delivery system, together with a tradition of local control over water supply, present formidable management challenges.*

Five types of purveyors provide New Jersey's drinking water supplies: 1) investor-owned private companies, 2) municipally-operated systems, 3) commissions, 4) public authorities, and 5) state-operated systems. The municipal and investor-owned systems are the most significant, both numerically and in the volume of water delivered to consumers. Investor-owned utilities fall into two classes: the larger, established, generally well-managed and well-financed organizations; and the small utilities, many of which are inadequately financed and managed. Most of the small investor-owned systems are a continuing problem nationally, as well as in New Jersey. Commissions provide a vehicle for municipalities to join together to develop and use water resources. Authorities are organized at the municipal or county level, and may consist of one municipality or several. Finally, there are three state-owned water supply operations which sell water wholesale to water purveyors: the Delaware-Raritan Canal and the Spruce Run and Round Valley Reservoirs.

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*In contrast to the U.S. trend of greater fragmentation, in part due to urban sprawl, Europeans have been consolidating their water management agencies. For example, in Great Britain 1,600 separate local agencies were consolidated into 10 Water Authorities, based on watershed areas, to handle the full water cycle, e.g. drinking water treatment, sewage, etc. In West Germany 15,000 waterworks were consolidated to less than half that amount, primarily by formation of public corporations of several municipalities. These have created stronger waterworks capabilities.

Financial structures for these different types of water utilities vary significantly. Because most cities are financially pressed, they often use water utility revenues to meet other urban needs, rather than to upgrade the old water system. As a result, urban municipal water departments often do not operate with the same degree of management independence as the larger and more autonomous investor-owned water utilities or the public commissions and authorities. Although state control of drinking water rates is exercised through the Board of Public Utilities, such control applies only to investor-owned systems and to some municipally-operated systems which sell water to other communities. Commissions and municipal utility authorities (MUAs) are exempt from state rate controls.[110a] Because the five different types of purveyors are subject to different financial requirements, they are unequal in their financial strengths and stability. This is a weakness in the overall water supply system. Legislation, previously described, would help to stabilize the overall system.

To gain detailed information on New Jersey's water supply situation, an interview survey was conducted in late 1980 and early 1981 of the 21 largest community system operators in the state. This group was chosen for several reasons. The water purveyors play a vital role in carrying out the mandates of the Safe Drinking Water Act (SDWA). This stems from their legal responsibility to monitor and report violations in their own operations. In addition, because the SDWA did not provide funds for drinking water treatment projects, as the FWPCA did for waste treatment, there is a weaker governmental presence in drinking water regulation. The strength of the large purveyors is also derived from their position relative to government. This stems in part from the institutional longevity of many of the purveyors, some of which have been in existence for over 100 years and have managers with many years of personal experience. In comparison to the "revolving door" at DEP's Division of Water Resources, where young professionals leave for better paying positions after short tenures, the large water purveyors are citadels of managerial stability. Moreover, the largest purveyors are in the best position to discuss the complex new issue of chemical contamination. Some of them were prominently involved nationally in opposing EPA's 1978 regulations to control SOCs and THMs in drinking water. Thus, their attitudes on this issue were sought. Finally, while the 21 purveyors interviewed represent a small fraction of the total 620 community water suppliers, collectively they serve 60 to 65 percent of New Jersey's residents. Table 12 presents data on the populations served and water used by the purveyors surveyed, and Figure 3 gives their geographical locations.

Individually, the 21 purveyors serve populations ranging from over one million people (Elizabethtown Water Company) down to 37,400 people (East Brunswick Water Department), for a total of approximately four million of the state's seven and a half million residents. Some 60 percent of customers are served through direct sales, the rest via indirect sales from one purveyor to another through water pipe interconnections. The total of the indirect populations served is somewhat difficult to calculate since a great deal of overlap exists in these highly complex water supply arrangements whereby different purveyors supply different communities with varying quantities of water at varying times. Thus, the direct population is of primary importance, with the indirect figures serving as an estimate of the purveyors' total capabilities.

The largest centralized systems with complex interconnections (shown in Figures 4 and 5) rely primarily on surface waters -- rivers and reservoirs -- and are located in the more densely populated northeastern part of the state. The smaller decentralized systems, using ground water from wells, are commonly

Table 12

Twenty-One Largest New Jersey Water Purveyors

Name and Location of Plant (Including County)	Population Served		Water Used	Source	
	Direct	Indirect*	MGD**	%Ground	%Surface
1. Hackensack Water Company Harrington Park (Bergen)	800,000	68,000	100	2	98
2. North Jersey District Water Supply Commission Wanaque (Passaic)	-	750,000	100	-	100
3. Elizabethtown Water Company Bridgewater (Somerset)	429,880	623,570	131	25	75
4. Newark Water Department Little Falls (Passaic)	382,400	220,800	126	-	100
5. Passaic Valley Water Commission Little Falls (Passaic)	287,999	600,000	88	-	100
6. Trenton Water Department Trenton (Mercer)	250,000	-	32.5	-	100
7. Monmouth Consolidated Water Company*** Shrewsbury (Monmouth)	242,800	-	27	2	98
8. Commonwealth Water Company*** Short Hills (Essex)	238,708	64,000	36	100	-
9. Jersey City Water Department Boonton (Morris)	225,000	175,000	66	-	100
10. New Jersey Water Company*** (Haddon District) Haddon Heights (Camden)	223,000	6,250	25	100	-
11. Middlesex Water Company**** Woodbridge (Middlesex)	181,000	41,000	29	20	80

12. Camden City Division of Water Camden (Camden)	71,000	-	25	100	-
13. New Jersey Water Company*** (Delaware Valley District) Palmyra (Burlington)	69,274	-	7	100	-
14. Parsippany-Troy Hills Township Water Department Parsippany (Morris)	65,000	-	5.5	100	-
15. Toms River Water Company Toms River (Ocean)	64,000	-	6.2	100	-
16. Ridgewood Water Department Ridgewood (Bergen)	60,958	10,000	6	100	-
17. Brick Township Municipal Utilities Authority (MUA) Brick Town (Ocean)	57,000	-	3.6	100	-
18. South East Morris County MUA Morristown (Morris)	56,000	72,000	9.2	83	17
19. Old Bridge MUA Old Bridge (Middlesex)	55,000	-	4	100	-
20. Merchantville-Pennsauken Water Commission Merchantville (Camden)	50,000	-	6.8	100	-
21. East Brunswick Water Department East Brunswick (Middlesex)	37,400	-	5	60	40
Totals	3,845,420	2,631,120	838.8		

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*Water sold to outside communities through interconnections

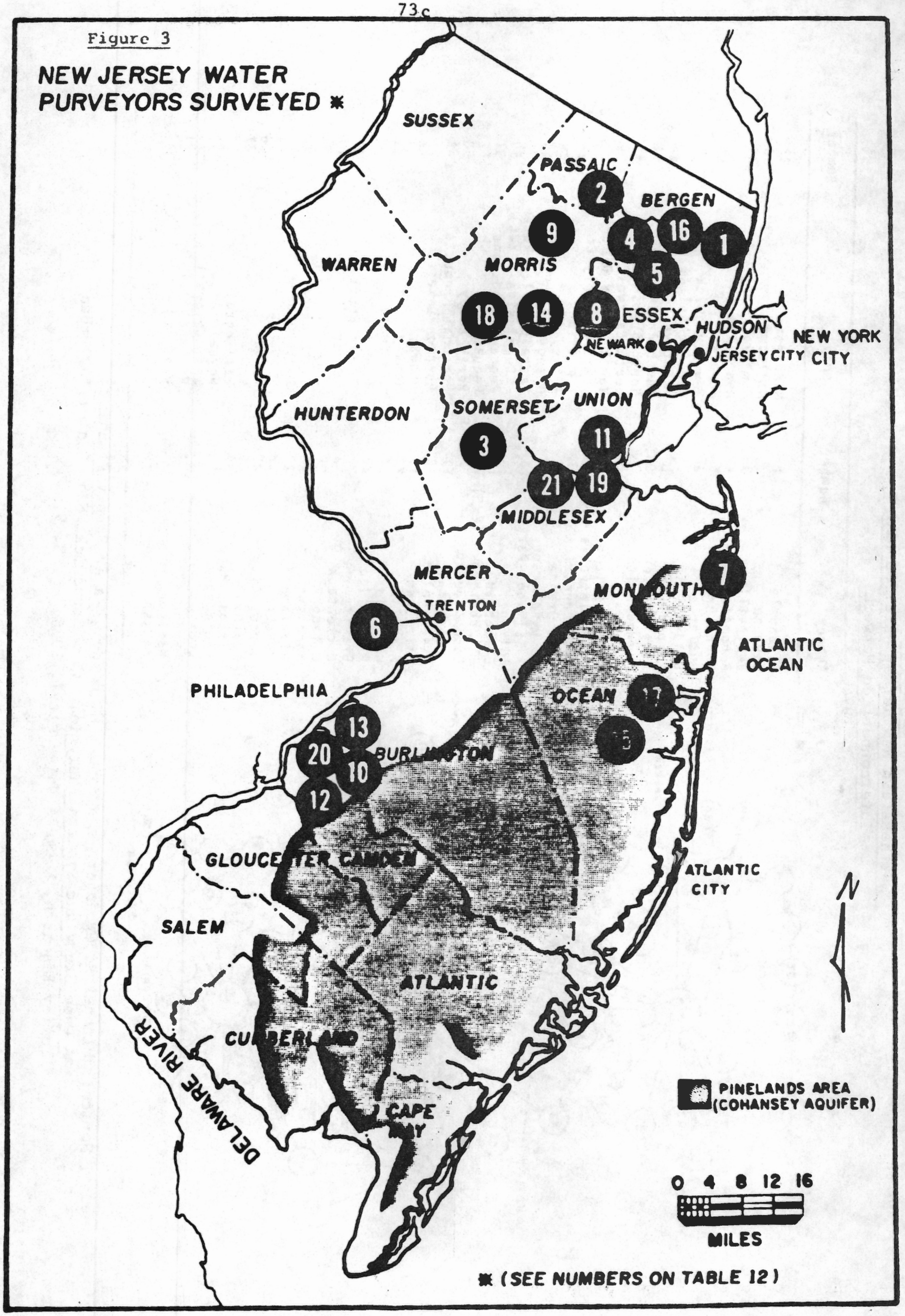
**Million Gallons per day

***Owned by the American Water Works Service Co., a national purveyor

****Unavailable for interview; filled out survey form.

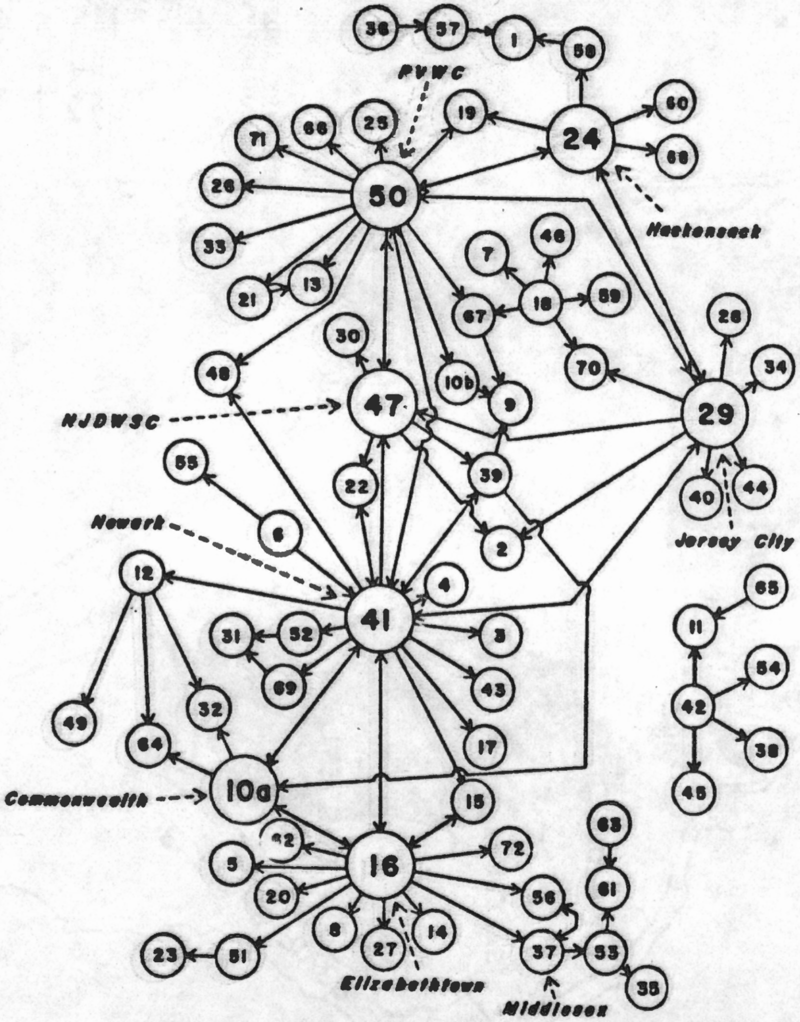
Figure 3

NEW JERSEY WATER PURVEYORS SURVEYED *



* (SEE NUMBERS ON TABLE 12)

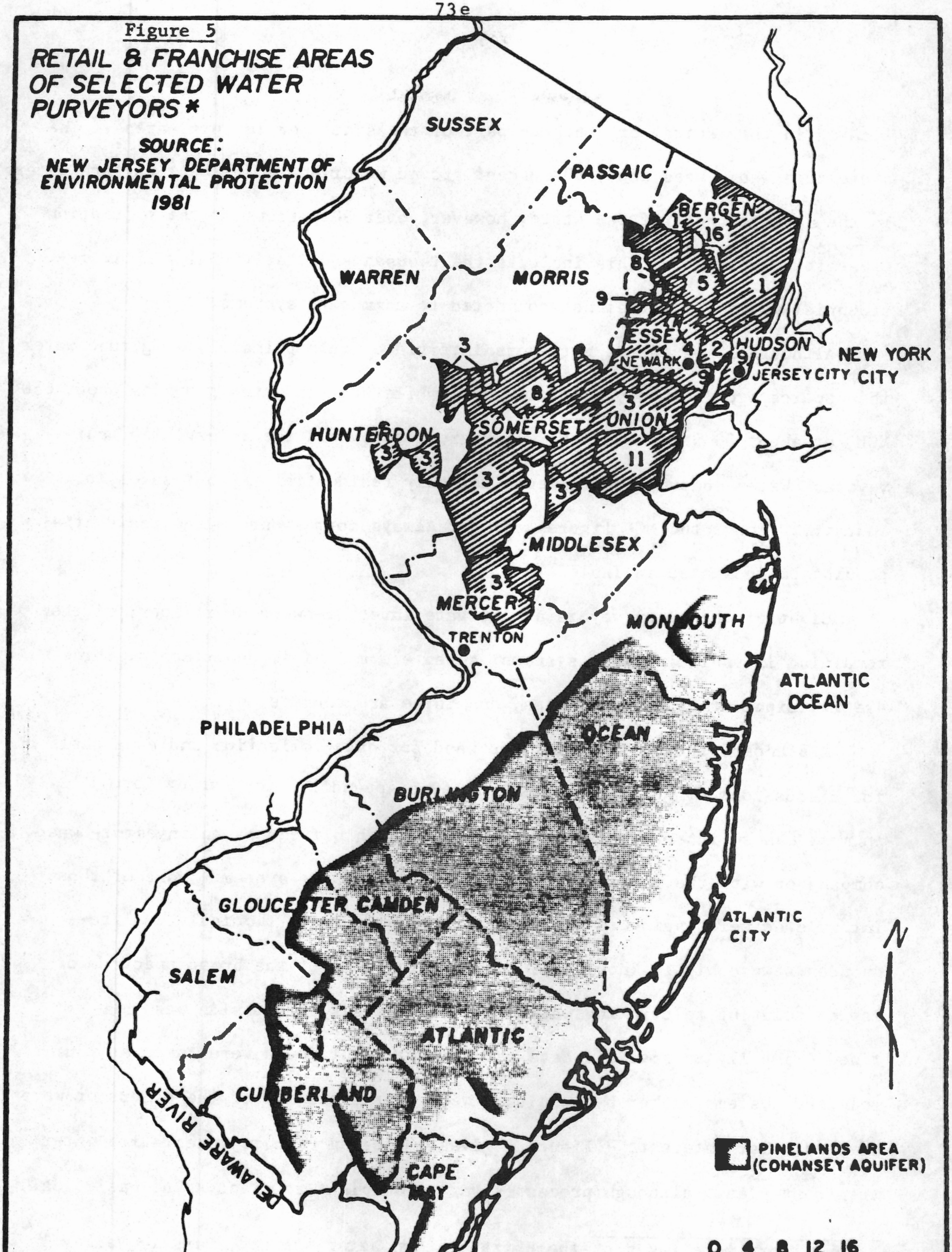
Figure 4
Northeastern New Jersey Water Supply Interconnection Network
1974



Agency	Number	Agency	Number
Allendale	1	Middlesex	37
Bayonne	2	Milltown	38
Belleville	3	Montclair	39
Bloomfield	4	Montville	40
Bound Brook	5	Newark	41
Butler	6	New Brunswick	42
Caldwell	7	N.J. School at Totowa	43
Camp Kilmer	8	North Arlington	44
Cedar Grove	9	North Brunswick	45
Commonwealth: Main	10a	North Caldwell	46
Commonwealth: Little Falls	10b	North Jersey District Water Supply Commission	47
East Brunswick	11	Nutley	48
East Orange	12	Orange	49
East Paterson (Elmwood Park)	13	Passaic Valley Water Commission (PVWC)	50
Edison	14	Peapack-Gladstone	51
Elizabeth	15	Pequannock	52
Elizabethtown (EWC)	16	Perth Amboy	53
Essex County Hospital	17	Personal Products	54
Essex Fells	18	Pompton Lakes	55
Fair Lawn	19	Rahway	56
Franklin	20	Ramsey	57
Garfield	21	Ridgewood	58
Glen Ridge	22	Roseland	59
Gravity	23	Saddle Brook	60
Hackensack	24	Sayreville	61
Haledon	25	Somerville	62
Harrison	26	South Amboy	63
Highland Park	27	South Orange	64
Hoboken	28	Spotswood	65
Jersey City	29	Totowa	66
Kearny	30	Verona	67
Lincoln Park	31	Wallington	68
Livingston	32	Wayne	69
Lodi	33	West Caldwell	70
Lyndhurst	34	West Paterson	71
Madison	35	Winfield	72
Mahwah	36		

Source: Michael R. Greenberg and Robert M. Hordon, Water Supply Planning: A Case Study and Systems Analysis, (New Brunswick, NJ: Center for Urban Policy Research, Rutgers University), 1976, pp. 8, 9.

Figure 5



RETAIL & FRANCHISE AREAS OF SELECTED WATER PURVEYORS*

SOURCE:
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
1981

*(see numbers on Table 12)

located in the central or southern part of the state and in rural areas. The state as a whole uses about 60 percent ground water and 40 percent surface water. In the southern half of the state, however, over 90 percent of the population uses ground water.[112] This includes the thousands of individual on-site residential wells for houses not connected to community systems.

Although 12 of the 21 purveyors interviewed rely primarily on ground water, this source provides only about 150 MGD, while surface water provides about 650 MGD, or about 80 percent of the water provided by all the interviewed purveyors. Water consumption reflects not only residential use but sales to industry. Thus, the MGD figures may not always correspond to the residential population indicated in Table 12.

Eight of the 21 purveyors are private investor-owned operations; of the remaining 13 publicly-owned systems, seven are municipal departments, three are municipal utility authorities, and three are commissions.

A standard interview format was used for data collection and as a basis for discussions of particular issues. (See Appendix B for survey form.) In most cases, interviews were conducted with an officer of an investor-owned company or with the plant manager of the water supply system. Most of those interviewed were engineers by training. In some cases the individual respondents were highly knowledgeable and voluble about the broad spectrum of issues relating to drinking water. In other cases, discussion was confined primarily to specific data gathering. Plant tours were taken at four selected systems either because they were representative of the others or were of particular interest.* Figure 6 gives a diagram of a representative water treatment plant, although processes vary from plant to plant. The basic goal

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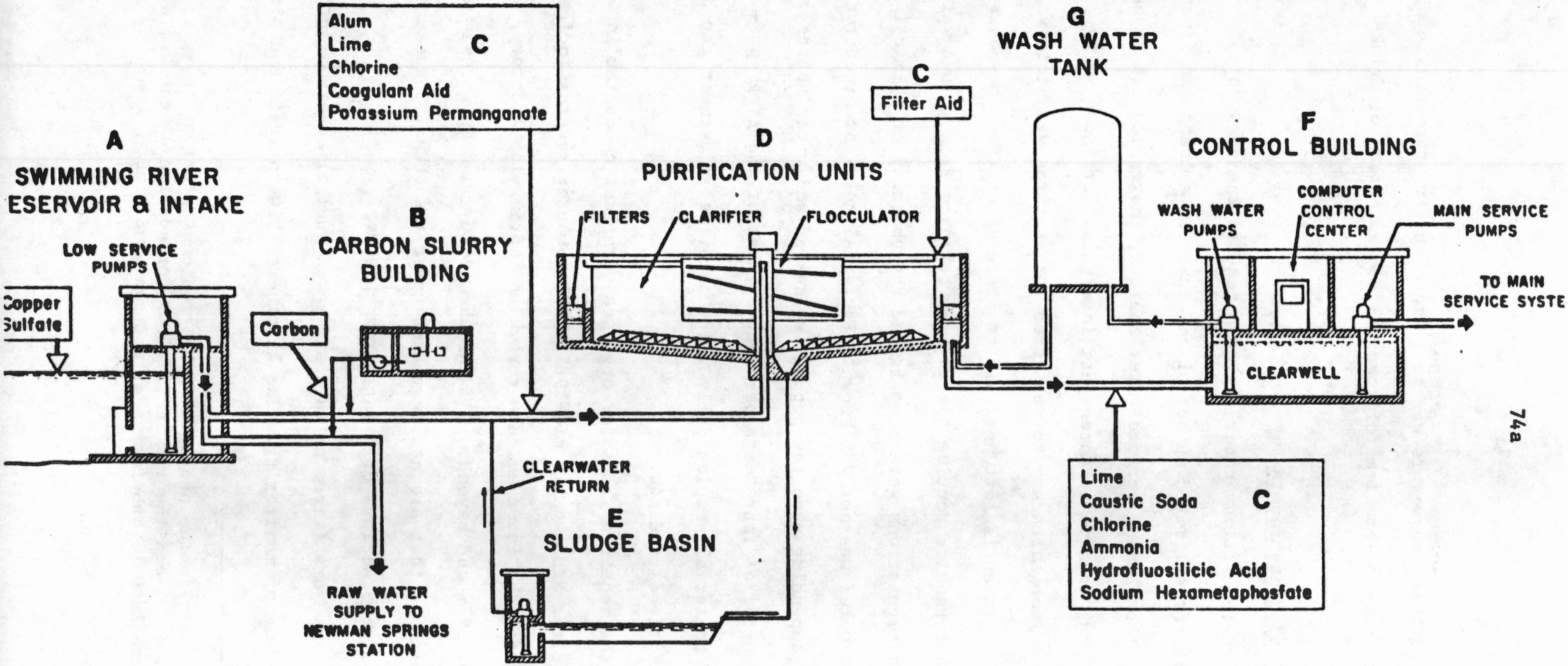
*Plant tours were taken at the Elizabethtown Water Company, Passaic Valley Water Commission, Monmouth Consolidated Water Company, and the Brick Township MUA.

Figure 6

Representative Drinking Water Treatment Plant



SWIMMING RIVER FILTER PLANT

MONMOUTH CONSOLIDATED WATER COMPANY
SHREWSBURY, NEW JERSEY

A. The 2.65 billion gallon Swimming River Reservoir is the source of supply for Swimming River Filter Plant. Copper Sulfate is used to control algae growths which cause tastes and odors.

B. Activated carbon adsorbs taste and odors from water.

C. Chemicals:

Alum—Forms floc which traps impurities and bacteria and settles to the bottom in a low velocity area.

Lime and/or Caustic Soda—For control of alkilinity/acidity balance in water.

Chlorine—For sterilization of water.

Coagulant Aid—Enhances the formation of floc.

Potassium Permanganate—Improves taste and odor quality and aids removal of iron and manganese, if present.

Ammonia—Binds free chlorine residual after treatment to assure its presence throughout the distribution system..

Hydrofluosilicic Acid—For the introduction of fluoride to water to inhibit tooth decay.

Sodium Hexametaphosfate—For stabilizing water quality after treatment.

D. Purification Units—Mixing, flocculation, clarification, and filtration are accomplished here.

E. Sludge resulting from treatment process is held here for drying and removal.

F. Control of all operations is concentrated at this point.

G. Finished water is held in 629,000-gallon tank for the backwashing of filters.

of these interviews with the purveyors was to learn of their procedures, experiences, and attitudes on problems of chemical contamination of drinking water.

Monitoring for Chemical Contaminants

Federal and state regulations under the SDWA require the purveyors to conduct infrequent tests for a limited number of chemical contaminants in finished drinking water.[*] For those using surface water sources, inorganics are to be tested for annually and organics at three-year intervals. For those using ground water sources, inorganics are to be tested for at three-year intervals, whereas testing for organics is left entirely to state discretion. New Jersey and most states do not require routine testing for organics from ground water sources. When these regulations were promulgated the ubiquity of chemical contamination of ground water was not yet known. Bacterial tests are required at varying frequencies depending upon the population served and water source, but are commonly on the order of four tests per month. Most of the large purveyors take several bacterial samples daily since chlorine adjustment can be made on the basis of these findings.

In New Jersey the required tests for organics were last conducted in 1979 and will not be required again until mid-1982. DEP computer records indicate very few violations for the few chemicals for which testing is mandatory, e.g., three violations for 1979 and beyond.[**][112a] This does not include episodes of well closing for chemical contaminants that are not regulated under the SDWA. These cases comprise the state's more serious drinking water episodes.

Ten of the 21 purveyors (three private and seven public) adhere exactly to the prescribed schedule of monitoring. The 11 others (five private and six

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[*] See p. 30.
Finished drinking water is the product of the treatment plant process.

[**] Some tests are taken between the regular periods for additional checks, or because they were late in submission at the mandated time.

public) conduct varying degrees of more frequent testing for different constituents, with no particular pattern emerging. Of the 12 purveyors which use ground water sources primarily, six monitor for some organic compounds on a more or less routine basis. The most frequent testing for chemicals regulated under the SDWA occurs in the Newark (surface water) system: four times a year for inorganics and monthly for organics.

Of the 11 purveyors which test more often than legally required, the one which has the least frequent testing -- the Elizabethown Water Company -- stands out from all 21 for the numbers of chemicals for which it tests. This company tests annually for organics and inorganics in surface water and for inorganics in ground water, but does not test for organics in ground water. Elizabethtown is the only New Jersey purveyor which routinely tests for all of EPA's 129 priority pollutants. This company uses its own modern laboratory, which operates seven days a week with a full time staff of seven. At this point, however, Elizabethtown does not report the results of the more frequent tests and the expanded number of chemicals tested to the state unless there is a request for a report. Much of the information serves as a guide to the company and as a data base which can indicate water quality changes over time. Except for this one company, the concept of monitoring for specific contaminants known to be endemic in the local watershed, regardless of government regulations, does not appear to have been accepted by the large water purveyors, many of which still express skepticism about the health effects of the organic chemicals.

Since 1975, under an EPA Water Supply and Surveillance Program, drinking water tests have been conducted annually on a voluntary basis at EPA's Region II laboratory in Edison, New Jersey for 30 regional water suppliers, including 15 in New Jersey. Of these 15 purveyors, 11 are among the group of 21 interviewed.* These analyses check for the chemicals on EPA's list of

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*Hackensack, North Jersey District, Elizabethtown, Newark, Passaic Valley, Trenton, Monmouth, Commonwealth, Jersey City, Middlesex, Toms River.

129 pollutants. Only MCL "guidelines" can be applied to most of these chemicals because legal standards have not been promulgated. This EPA testing program was established after passage of the SDWA because the water purveyors lacked laboratory capability and because these extensive tests were costly: originally $1,500 to $2,000, now $800 to $1200.* Due to federal budget cutbacks, however, the program may soon be phased out.[112b] In fact, by late 1981 the entire Edison laboratory, which also responds to emergency spills and, in general, lends technical assistance to the DEP, as well as New York state agencies, was threatened with closure due to federal budget cu

Monitoring for THMs commenced nationally in November, 1980 for those suppliers serving populations of 75,000 and over. Of the dozen or so New Jersey purveyors which were scheduled to report by March 1, 1981, only four had done so.** Of those reporting in the first quarter, none exceeded the EPA standard of 100 ppb. In some cases, the purveyors do not clearly understand the methodology (quarterly samples using the average of the four THMs falling under this regulation). Normally notices of violations are sent by DEP six weeks after the due date for MCL reports, in this case in April 1981. By June such notices had not been sent out, partly because of the newness of the rule.[120] In November, 1981 all purveyors serving populations of 10,000 and over commenced THM Monitoring.***

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*Routine analyses for SDWA-mandated chemicals cost about $300.

**Elizabethtown, North Jersey District, Monmouth and Middlesex have reported.

***One interesting state model exists in Connecticut, which is acknowledged by many in the drinking water field to be more progressive in its program than most states. Connecticut's program, administered by its Department of Health Services, is noteworthy in at least three particular areas: 1) Its THM regulation applies to all water utilities regardless of size. Because of the onus on small purveyors in conducting THM monitoring, the state conducts random tests and can take action if concentrations are over 100 ppb. 2) The state standard for water color is more stringent than the national standard as a means of controlling THMs. The rationale is that color is related to levels of natural organics, a precursor to THM formation. 3) Based on state-conducted annual tests for organics in all public ground water supplies, Connecticut adopted a policy of "sharing information with consumers," especially about those commonly-found toxics for which no MCLs exist (e.g., TCE and other industrial solvents) but which exceed the EPA "Suggested No Adverse Response Level (SNARL)." In one such recent case, the state distributed handbills to consumers signed by the Department of Health and the utility involved.[121]

The infrequent and limited scope of the basic testing program (see p. 30) is of concern even under "normal" circumstances, where normal now means an expectation of some contamination, especially in more vulnerable sources. But the testing regime is especially inadequate to detect illegal dumping or accidental spills. When asked about this, most purveyors acknowledged a random approach to means of detecting these kinds of episodes. Some say a large spill would cause a sharp drop in the bacterial count, which they might investigate; or dead fish might offer evidence; or normal watershed surveillance would indicate a problem -- an odor, for example, or film on the water. Such indicators would not, of course, be available for ground water. Accidental spills do occur and fast action can often avert severe contamination. It is the illegal spill or unknown accident which is of greatest concern. Even routine monitoring conducted immediately after an illegal or accidental spill might not yield definitive information on the nature of the spill since such a limited number of chemicals are usually analyzed.*

Alternate Sources of Water

Would alternate sources of water be available should abnormal chemical contamination occur? The larger surface water purveyors usually have the most options. They can sometimes rely on the rapid movement of rivers to flush out the pollution, or upon evaporation of organics exposed to the atmosphere. They also tend to have the best access, through interconnections, to other suppliers.** Nevertheless, alternate external sources are usually limited in the numbers of additional people they can accommodate and in the length of time emergency arrangements can continue. This is especially true during periods of water shortage.

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*In Europe sensitive fish (Trout) are used inside of some drinking water plants to detect any unusual chemical contamination of incoming raw water, a form of continuous monitoring not yet developed with instrumentation.

**Approximately 590 individual interconnections have been identified in the state. About 150 of these are in service for normal transfer of water on a regular basis, with the remainder intended for emergency supply only.[114] However, the condition of these emergency connections and the lack of emergency planning makes this a highly vulnerable link in the water supply chain.

Purveyors using ground water sources usually have very few options available to them. Unless they are connected to another system, obtaining water from an alternate source can take time and be very costly. Alternatively, they can embark on expensive treatment for chemical removal, as was done in Rockaway Township.* Another more immediate alternative is to allow this "sole source" to continue to be used, even with contamination.

Because maximum contaminant levels (MCLs) under the SDWA exist for only a limited number of chemicals, the state in 1980 established "guidelines" to be followed in determining the course of action if organic contamination is found in wells. These guidelines are based on the policy that higher levels of contamination will be tolerated in cases where alternate sources are not available. For example, at levels of 50 to 100 ppb the source can have continued use but additional monitoring is required. For levels of 100 to 200 ppb, the source can still be used but treatment must be provided. If the last option takes time, the contaminated source might be used in the interim. Only when levels are greater than 200 ppb is the source closed for drinking or culinary purposes, with mandatory temporary provision of drinking water to customers from alternate sources.[115] These tolerances are high compared to EPA's proposed criteria for ambient water. For example, the two contaminants which plagued Rockaway Township and Borough, TCE and tetrachloroethylene, both carcinogens, were found at 100 and 500 ppb. EPA's criteria are 2.1 and 0.2 ppb respectively. The EPA criteria serve only as guidelines under the Federal Water Pollution Control Act, whereas MCLs under the Safe Drinking Water Act are legal, enforceable standards.

Some individual cases are instructive: Parsippany-Troy Hills, serving a population of 65,000, has neither internal nor external alternate sources. Although its ground water supply has been described as one with a 30 to 60 foot stratum of clay above the water bearing level, and presumably is better protected than most, breaches (or "windows") in such clay formations are not uncommon.** Brick Township, serving 57,000 people, is also vulnerable, with

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*The case of Rockaway Township is discussed on pp. 48, 49.

**In addition, surface water reaches ground water by various means, not only through such clay strata.

10 wells in an area of one square mile and external sources capable of bridging an emergency of only a few days' duration. Of the large surface sources, the Hackensack Water Company, whose severe water shortage was greatly publicized in the 1980-81 drought, could supply only 20 percent from alternate internal sources and 20 to 30 percent, at most, from external sources for their almost one million customers. Even with these vulnerabilities the large purveyors are often in better condition to meet emergency circumstances than are the 600 smaller community purveyors and the thousands of smaller water suppliers.

Attitudes Toward Use of GAC and Control of THMs

At present, organic chemical contamination is dealt with, if at all, by the wait-and-see method -- monitoring followed, when necessary, by remedy. As we have seen, the weakness of this approach is that both monitoring and remedy are difficult, expensive, unreliable, and sometimes nonexistent -- especially in cases of sudden emergency. Moreover, thresholds for action are necessarily arbitrary and controversial.

The problem seems to cry out for a solution analogous to chlorination -- a preventive technique that removes a broad range of contaminants so that detailed monitoring is not necessary, and so that unexpected contamination episodes are automatically remedied. The closest thing to such a preventive technique is filtration through granulated activated carbon (GAC), a technique commonly used in Europe but used almost not at all in the U.S. for removal of SOC contaminants. In 1978 EPA proposed that GAC be introduced on a large scale in the U.S.*

Each of the interviewed water purveyors was asked about GAC. Almost all were opposed to its use for one or more of three basic reasons:** 1) cost, 2) concerns over technical performance and 3) unproven need based on a lack of absolute proof of health effects. At least two of the purveyors -- the

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*See pp. 23 and 31-34 for a discussion of this issue on the national level.

**It is interesting to note that some environmentalists also have misgivings about GAC, though for very different reasons. They fear that its success would reduce the political pressure to clean up the sources of chemical pollution of water. Clean-up, they feel, is the only real solution to drinking water problems.

Passaic Valley Water Commission and the North Jersey District Water Supply Commission — were prominently involved nationally in opposing EPA's GAC regulation, which currently is being held in abeyance.

Cost of GAC. Table 13 gives cost figures for those five purveyors who provided estimates:

Table 13

Water Purveyor Estimates of GAC Costs

Purveyor	MGD	Capital Costs	Annual Operating Costs
		(millions of dollars)	
Elizabethtown Water Company	131	$50	$9
North Jersey District Water Supply Commission	100	25	7
Passaic Valley Water Commission	88	30	-
Jersey City Water Department	66	10	-
East Brunswick Water Department	5	2.5 - 3	0.5

With a few simple assumptions*, we can reduce the figures given above to the household level. Table 13a gives these results which range from $16.08 to $27.18 per household annually. Other estimates for GAC put the additional cost to customers of plants serving populations of 75,000 to 1,000,000 at $7 to $16 per year for a family of three.[116b]

Table 13a

Yearly GAC Cost Per Household

Elizabethtown Water Company	$18.82
N. Jersey Dist. Water Supply Comm.	17.34
Passaic Valley Water Commission	18.60[a]
Jersey City Water Department	16.08[a]
East Brunswick Water Department	27.18

*Assumptions: GAC plant life = 20 years; real interest rate, 3 percent/yr; average household uses 200 gallons per day. (See also p. 82.)

[a] Operating cost estimated by interpolation using other purveyors' data.

In New Jersey the average annual cost for water supply for a family is $150 (for approximately 80,000 gallons).[*][117] Based on the costs shown in Table 13a GAC could be expected to raise bills on the order of 6 to 10 percent.

There is considerable debate about cost between EPA and the purveyors. EPA estimates the cost of GAC for a 100 mgd plant to be 12.3¢ per 1000 gallons, or about $9 per year for a household using 200 gallons per day.[**][116] This is just about half of the cost estimated by the purveyors for a similar plant.

Although these figures are no more than rough estimates, they are reasonably consistent. Note that East Brunswick is much smaller than the other purveyors. Its higher per household cost, therefore, is consistent with the known economies of scale in GAC.

Instead of GAC one alternative is to use bottled water (although with current regulations, one cannot assume it is better than tap water).[***] The costs of this alternative put GAC costs in perspective. In 1981 bottled water sold in Princeton for 73¢/gallon undelivered and $1/gallon delivered. A family using two gallons per day would pay $536 per year for undelivered water and $730 per year for delivered water, compared to $16 to $27 per year for GAC. The fact that a market for bottled water exists at these prices is itself an interesting commentary on the public concern about contamination of tap water. Such expenditures, and those for home filter devices, contradict claims of public resistance to

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[*] The Passaic Valley Water Commission, whose water source -- the Passaic River -- has 2,500 industrial dischargers and over 100 sewage treatment plants, has among the lowest rates in the state: $60 per year. Passaic Valley has been among the most vociferous objectors to EPA's 1978 proposed regulation for GAC.

[**] The EPA estimates are based on the use of GAC as an adsorber after regular sand filtration. The cost of GAC as a replacement for sand (a much less effective method) in the regular filter is somewhat less, 10.7¢ per 1000 gallons. Because GAC used in the regular sand filter is more labor intensive to operate than the capital intensive GAC used in a post-filter mode and more vulnerable in the inflationary spiral, the percentage difference is less than the capital costs would indicate.[116a]

[***] For the national perspective on bottled water, see p. 11.

increased cost where drinking water quality -- and especially protection -- is concerned.*

Water costs can also be put in perspective by comparing them to other utility costs. For example, New Jersey residents in 1980 paid an average annual household cost of $948 for gas and electricity,[118] more than six times the cost of water supply. Like past energy pricing practices, water unit rates are lower for greater consumption. This has not promoted water conservation and needs rethinking in light of recent water shortages. This comparison is significant also for the parallel public attitudes toward these commodities. Before 1973-74 cheap energy was taken for granted. An abrupt change came with the OPEC oil embargo. In the eastern U.S. abundant and inexpensive water supply has also been taken for granted. This attitude has not, however, taken into account degraded sources and the cost of furnishing drinking water free of toxic substances.

The larger economic question is, who should pay for water pollution -- the consumer, or the polluter? Under the SDWA, costs for control technology are placed directly on the water consumer. Congress intended that the consumer pay for protection and did not provide public funding for water treatment.** In this manner, it was hoped, the consumer would begin to understand the cost of water pollution control. If water prices are kept artifically low and do not reflect the cost of existing conditions, this important incentive for pollution abatement may never be brought to bear.

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*Home filter devices for drinking water range from about $30 to several hundred dollars.

**Congress has provided billions of federal dollars for water pollution abatement through the FWPCA -- solely for surface water, with no funding for ground water.

Public education about water quality and the willingness to pay for better drinking water are inextricably tied. In passing the SDWA, Congress was sensitive to this issue and mandated that public notices be published by those purveyors who violate regulations under the Act. More than 33,000 notices were recorded nationally in 1979. EPA officials acknowledge that this number should be much higher but that some states do not enforce this regulation. Officials at New Jersey's Bureau of Potable Water were unable to give data on the numbers of violation notices. Many water purveyors, especially investor-owned entities, are reluctant to achnowledge water contamination problems. Such an achnowledgement, they fear, casts doubt about the quality of the product they are selling and might lead to costly remedial demands. As noted (p. 77) Connecticut has a more vigorous program of public notification for chemical contamination not limited solely to notices of SDWA violations.*

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*In Europe, water suppliers are actively engaged in public education about water pollution affecting their water supplies. This is accomplished through annual reports and media information.

The purveyors had a much more benign attitude toward remedies for lessening THM formation than toward GAC use. Most agreed that some relatively simple and inexpensive steps could be taken, e.g., changing the point of chlorination to later in the treatment process to decrease contact time with organics in source waters. Of the 21 purveyors surveyed, 14 chlorinate early in the treatment process. Six of these are surface water suppliers, those most likely to have natural organic precursors. Of the seven who introduce chlorine later in the process, three use surface supplies. Some purveyors also suggested that "chemical maneuvering" -- e.g., the relationship between chlorine and pH and other elements -- could be examined more closely to lessen chlorine use. Most were, however, opposed to use of ozone (a gas) as a substitute disinfectant as too expensive and energy intensive, and were concerned about its lack of residual in the distribution system.

Europeans have had practical experience with GAC and ozone to lessen chemical contamination for almost two decades in over 30 operating plants. One underlying difference appears to be the American antiseptic attitude toward bacteria -- represented by high chlorine use -- with greater tolerance for chemicals, and the opposite emphasis in Europe where natural non-chemical treatment methods are preferred. In addition, Europeans feel that since water treatment (with GAC and ozone) represents only 10 to 20 percent of water cost (with the balance for distribution) these technologies are affordable.*

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*This information is based on the author's research visit to Europe in the fall of 1981.[58c]

Watershed Protection

Watershed protection is principally the responsibility of government. Local governments have primary authority in land use decisions and the federal and state governments can control discharges into waterways through NPDES permits. In a densely developed state like New Jersey, watershed protection is a critical issue. Increasingly, water purveyors are becoming aware of chemical contamination through news of well closings and other toxic waste disposal episodes throughout the state and nation.

The following principal sources of contamination were identified by the 21 purveyors as of great concern:

Land disposal of solid wastes	9
Non-point surface runoff	8
Industrial point sources	6
Municipal point sources (sewage plants)	2
Salt from road runoff	2
New development	1

The greatest perceived threat of water quality degradation came from landfills. Two of the groundwater purveyors stated that landfills in their areas in Camden and Burlington Counties were old gravel pits which are directly connected to the acquifer. The purveyor in East Brunswick is concerned about the predilection of government officials to approve new chemical facilities in his area, one already heavily concentrated with such installations. Chagrin was also expressed over the DEP's failure to notify East Brunswick of serious chemical contamination of South Brunswick wells upstream of East Brunswick's source. On this latter point, a similar complaint was heard from Jersey City, as noted below.

While many of the 21 purveyors felt that mechanisms such as "208" areawide water quality planning were helpful in watershed protection, only three are specifically involved in this process.* Another one is informed of all local public meetings and has a liaison person on the municipal planning board. Some of those not directly involved in 208 planning stated that they try to keep abreast of development which may be directly detrimental to the quality of their water sources. Others felt that watershed protection is the primary responsibility of government and that federal and state water pollution laws have been helpful in cleaning up surface water pollution.

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*Section 208 of the Federal Water Pollution Control Act provides funding for areawide planning and local task forces which examine the impact of current and future development on water quality.

Two interesting examples of watershed protection are provided by Jersey City and Newark, the state's largest cities. These cities both have old water sources in rural, though increasingly suburban, areas of the state. The Newark water supply is an example of a "protected watershed," since the purveyor owns all or most of the watershed and can control development there. The Pequannock Watershed, the highest in the state, has been the surface water source for Newark and surrounding suburban communities for over 80 years. When this water supply was developed, chlorination was not in common use and a protected watershed was the major means of assuring safety from contamination. The watershed covers 63.7 square miles of primarily rural land. It has been producing about 75 MGD in recent years. The city owns 86 percent of the watershed and wants to develop about 10 percent of the area to raise revenue for its constricted urban budget.[122] The city also wants relief from the high taxes it pays for this stretch of land. These goals are, however, in conflict with watershed protection and the following impacts have been identified:

1. Nutrient concentrations will increase by nearly 50 percent, causing an increase in the microbiological concentrations of the system.*
2. Toxic substances will be of sufficient concentrations to cause chronic or lethal effects to trout and minnows in the watershed.
3. Metal concentrations (iron and manganese) will exceed federal drinking water standards and will require advanced treatment for removal.
4. Increases in bacterial levels will necessitate extended chlorination for disinfection; use of more chlorine could increase THM formation.
5. Increases in suspended solids will require more efficient filtration processes.[123]

Jersey City took extraordinary measures to protect its supply in the Boonton Reservoir -- up to 1972. In the twenties the city constructed and operated a

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*The development area does not have sewage treatment facilities and septic systems are planned sewage treatment plant in Rockaway, a small community near the river that feeds the Boonton Reservoir. In 1972, the city relinquished operation of the sewage plant although it still contributes funds to the operation. In an ironic sequel to this case, however, the 1980 when Rockaway's municipal drinking water was contaminated with trichloroethylene, the state DEP authorized the community to pump out its wells into tributaries of the Rockaway River -- without informing Jersey City about the move. Protests were lodged by the Major of Jersey City.

In several cases, purveyors have very little control over watershed conditions. The Passaic Valley Water Commission's source -- the Passaic River -- has 2,500 industrial and over 100 sewage plant discharges, creating a 65 percent sewage effluent content in times of low precipitation.* The Elizabethtown Water Company's Dwlaware-Raritan Canal source is highly vulnerable to pesticide and other runoff and to industrial pollution from Trenton.** The Hackensack Water Company serves one million people in its 112 square mile watershed, of which it owns only 10 square miles. Until land use conflicts are better resolved to elevate water supply protection to the primacy it needs to sustain current and future populations, watershed protection will continue to be tenuous.

In another aspect of watershed protection, one national purveyor, with subsidiaries in several states, compared New Jersey's and Connecticut's police powers when an episode occurs threatening water supplies. In Connecticut, the responsible agency can issue a subpoena, if necessary, to gain quick access to property from which the offense is taking place. New Jersey acts more slowly,

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*In an effort to improve this watershed, the Passaic River Coalition, a citizens group, and the City of East Orange, petitioned EPA Administrator Douglas Costle for "sole source" aquifer designation for the Buried Valley Aquifer in the central Passaic River Basin, on which 90 percent of the valley's population depends. 79 Such designation is allowed for critical watersheds under the Safe Drinking Water Act, and was granted for this aquifer in 1980.

**One attempt to protect the Delaware-Raritan Canal in central New Jersey (the drinking water supply for Princeton and many other communities) has been in existence since the mid-1970's when the Delaware-Raritan Canal Commission was given state statutory authority to check municipal development plans for their impact on the state-owned canal. This includes mandatory compliance with storm water detention basin regulations, a mechanism for controlling non-point sources of pollution.

in part because the chain of command in an emergency is not as clearly defined. The offender may be gone by the time action is taken.

In reviewing watershed conditions for the various large purveyors, one observes that several of the old urban areas have water supplies which are superior to those in more wealthy suburbs. This is true of New York City, Jersey City, Newark, and Trenton.* In most cases, their selection of undeveloped rural, upland locations, before the advent of suburbanization, is responsible for this good fortune. So while cities are plagued with financial woes and air pollution, many of them in this region can still offer their residents better drinking water than is available in some suburbs. As noted in the above examples, however, this is a fragile condition which requires watershed vigilance and foresight, especially in a densely developed state like New Jersey.

The hard-pressed fiscal condition of the cities poses serious problems, however. Often urban water delivery systems are old, extensive, and in need of maintenance. This is certainly true in Hoboken, Jersey City, Newark, and Trenton. One incident in Trenton in 1975 is illustrative. The city's mechanical system broke down, leaving its 250,000 consumers without a public water supply for several days. It was discovered that the city had not performed the necessary maintenance because water rates were too low to cover such costs and the city had not applied to the BPU for appropriate rate increases. Such conditions are often tied to political considerations as well as to general financial hardship.

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*Trenton uses the Delaware River well above polluted areas near Camden and Philadelphia and is reputed to have relatively good water quality. The Delaware is supplied by water from reservoirs in upstate New York. Trenton's supply has improved in the last 20 years primarily as a result of federal water pollution controls. Such controls were attributed in part to the exit of several paper companies which discharged into the waterway. During the water shortage of 1980-81 Trenton benefited in water quality and cost because of less use of chemicals such as chlorine, lime and alum. This was attributed to the increased amount of high quality water which was released from New York into the Delaware.

In another issue related to the safety of water delivery systems, the two purveyors interviewed in Ocean County discussed controversies regarding asbestos fibers. Both the Toms River Water Company and the Brick Township MUA use asbestos water pipes, as do many water purveyors throughout the U.S. As a result of a local newspaper story on the dangers of asbestos, the issue became heated in Toms River. Evidence on the health effects of ingesting asbestos fibers in water is not conclusive. When the local newspaper had Toms River's water tested by asbestos experts at Mt. Siani Hospital in New York City, results indicated 200,000 fibers per liter. According to EPA, 30,000 fibers per liter ingested over the course of a lifetime will cause cancer in one person in a million. Statistically, in this case, seven people in one million could contract cancer.[124] Questions over the health effects of asbestos in drinking water were the focal point of a landmark case involving the Reserve Mining Company in Michigan. After 12 years of controversy, Reserve was forced to stop dumping taconite, an asbestos-like mineral fiber, into Lake Superior. The decision was based primarily on health concerns, although medical evidence was uncertain. The court decided on a cautious, preventive approach to public health protection.

III. CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

Passage of the Safe Drinking Water Act (SDWA) in late 1974 gave official recognition to the deficiencies in existing institutional mechanisms to assure safe potable water in the United States. The Act provided for national procedural standards, maximum contaminant levels (MCLs), laboratory certification, public notification of violations, and citizen suits, thereby adopting a preventive and activist approach. Much of this forward momentum, however, has been lost in the Act's implementation. Only a limited number of synthetic organic compounds (SOCs) have been covered by regulation; frequency of monitoring requirements has been constrained; government assistance has been lacking for small water purveyors with insufficinet resources to meet standards; and institutions have been slow to meet the more sophisticated requirements of chemical contaimination — e.g., increased and better trained personnel. In addition, the effectiveness of the act has been temporarily blunted by the water supply industry which has fought implementation of regulations to reduce SOC contamination.

Recognizing that it is probably impossible to obtain sufficient information about human health effects of the myriad toxic chemicals in drinking water to satisfy all questions and doubts on the subject, Europeans have taken several preventive measures. Water purveyors there use granular activated carbon (GAC) filters to reduce SOCs, and use ozone instead of chlorine as a disinfectant, lessening trihalomethane formation. Europeans have been willing to pay for such advanced control technology in exchange for the extra measure of prevention it affords.

One underlying question is "who is to pay?" Under the SDWA, water consumers bear the cost. Control technology should be applied by the polluter at the upstream discharge, instead of at the purveyor's water intake. In this respect, the SDWA's weaknesses must be viewed in the context of the Federal Water Pollution Control Act and a growing body of other laws which influence overall watershed conditions.

When most drinking water treatment plants were built, they had access to relatively clean sources of water. This is no longer the case. With increased land development and greater chemical production each year, source control — especially for chemical contaminants -- is becoming ever more difficult. Moreover, prospects for improvement in the near future do not look bright. Enforcement of discharge limitations on thousands of industrial plants is still grossly inadequate; the effects of primitive disposal of toxic waste still continue; the promulgation of MCLs for meaningful numbers of toxic substances can be kept to a modest pace by legal and political maneuvering; and the political stance prevalent now in Washington is against regulation. Under these circumstances, the quickest and most effective means to protect public health may be to use a technology that removes a broad spectrum of chemical contaminants at the point of drinking water treatment: the fundamental SDWA approach, but with adequate money and pressure to ensure implementation.

An analogy can be made to the use of chlorine, the broad spectrum control mechanism for widely varying bacteria. Just as monitoring is conducted today for only a few bacterial types, e.g., coliform, which indicate possible broader contamination, so surrogate chemicals* may indicate the presence of other compounds. In this manner, a combination of broad spectrum treatment technology for degraded water sources and selective monitoring could offer improved preventive protection.

One critical difference exists between bacterial and chemical contamination, however: the health effects causal relationship. With bacteria this relationship can be more easily established, since people in a confined geographical area are affected rather quickly. With carcinogens, the causal relationship is much more difficult to establish because the time lag for the onset of cancer is very long, sometimes decades.

The purveyors of any consumer commodity are all constrained by the threat of legal action for negligence. Applied to potable water, however, this constraint has not operated well, largely because of the difficulty of establishing the causal relationships between chemicals in drinking water and health effects. As a result, consumer protection from a monopolistic purveyor of drinking water -- a commodity which cannot be avoided -- has been less effective than

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*Such as trichloroethylene (TCE), tetrachloroethylene, carbon tetrachloride, chloroform, trichloroethane, benzene.

for the consumption of other less essential goods and services for which greater choice exists. This condition may change, however, as consumers (and water purveyors) resort to legal action, invoking torts liability where the plantiff can establish a causal connection between chemical contamination in drinking water and injury other than to health, e.g., economic losses for remedial action or decreased property values.

This option comes at a time of increasing consumer awareness of drinking water quality, as evidenced by burgeoning sales of bottled water and home filter devices. Such actions are in keeping with the new emphasis on more healthful lifestyles seen in lowered cigarette smoking rates (down to 33 percent of the population); increased physical activity such as jogging; and in the emergence of health food stores selling higher cost products free of pesticides, chemical preservatives, and food coloring. The perception of a health threat is a potent stimulus to the willingness to pay for improved water quality. Thus, public education may be the factor that is most critical to the eventual effectiveness of the SDWA. The law deliberately emphasizes consumer awareness of local water quality. When people say they can or cannot afford the cost of improved water quality, they are ordering social priorities. Such ordering of priorities can only be rational when a broad spectrum of society is well-informed on the risks, benefits, and options involved.

2. Recommendations

Prevention

Land Use Controls Must be an Integral Part of Water Supply Protection. Implementation of land use controls must be a priority mechanism to protect ground and surface water, especially in critical aquifer recharge areas, in sole source aquifers, and in surface headwaters. National and state plans should identify and preserve upland and ground water sources for future use. Siting criteria for new development must reflect water supply protection priorities. For example, New Jersey's innovative preference in state statute for above-ground storage of toxic wastes should be considered for widespread application.

Prevention is Preferable To Treatment and Should be a Priority. Water purveyors should become more aware of and involved in watershed conditions to learn which pollutants are endemic, and to tailor their monitoring accordingly. Federal and state discharge permit records should yield valuable information in this regard. Watershed knowledge should also apply to ground water sources, such that purveyors become familiar with aquifer flow patterns in relation to known and potential waste producing sources. Initiative -- rather than reaction -- from the purveyors will serve as a stimulus to government to apply more vigorous abatement and enforcement against polluters. Such initiatives should not overlook the available legal tools against recalcitrant polluters and unresponsive government agencies.

Federal and State Water Quality Enforcement Must be Improved. Inadequacies in the enforcement of the NPDES permitting program should be rectified so that all eligible sources come within the program, report effluent contents accurately, and are vigorously brought to compliance by timely government action when necessary.

Gaps in Water Quality Management Should be Addressed. Three particular areas of water quality management need special attention: First, EPA's proposed ground water strategy should be implemented, with non-degradation as its goal. Second, adequate pre-treatment of industrial effluents prior to discharge into sewage systems must be national policy to prevent toxic wastes from contaminating drinking water supplies. And third, non-point sources of pollution must be addressed at the local and state level. Current efforts in this regard under "208" areawide water quality planning should be strengthened.

Polluters Should bear the Cost of Control Technology. Because prevention of drinking water supply contamination should be an overall priority, control technology should be applied at upstream discharge points wherever feasible. In some instances this may avoid the cost of expensive controls for toxic chemicals at water supply intakes. In cases where control technology is still required for degraded potable sources, the responsible polluters should bear the cost of such controls at downstream drinking water treatment plants.

The Burden of Proof Should be on the Polluter. Often in cases of environmental damage the victim must prove harmful effects. This should be reversed so that the polluter bears the burden of proof of lack of harmful effects.

Old Toxic Waste Sites and other Sources Presenting Threats to Water Supplies should be Expeditiously Eliminated. Land use controls and appropriate new siting criteria should avoid future toxic "timebombs," but thousands of existing toxic dumpsites must be cleaned up to protect drinking water supplies. Adequate funding of the federal Super Fund should be effectuated toward this end.

Toxic Waste Source Reduction. Toxic waste source reduction should include manufacturing process changes, with an emphasis on use of more benign chemicals; industrial waste exchanges; recycling; resource recovery; and better waste treatment technology. Economic incentives and disincentives to industry can encourage these long-range preventive measures.[126] One such mechanism could be a disposal tax based on a product's environmental and public health burden.

A Consumers' Hazardous Waste Index For Public Education. This kind of index would indicate the external costs of certain products. Such an innovation, with a small representative list of a "Dirty Dozen" or so generic products, would serve as a public consciousness-raising device. Products which are less essential but which contain toxic materials difficult to dispose, and those for which more benign substitutes exist, are prime candidates for the list. One example could be septic tank cleaners which use toxic industrial solvents such as TCE, now commonly found in ground water. We must begin to make connections between end use products and toxic waste generation.

Procedural Changes

Current Monitoring Requirements Should be Strengthened. Exclusive reliance on complex, infrequent, and difficult-to-enforce monitoring for toxic chemicals -- many still unidentified -- in water sources whose chemical content can change rapidly does not offer adequate public protection. To decide which supplies require control technology, tests should be conducted for EPA's entire list of 129 priority pollutants. Where necessary, effective control technology should be applied. Monthly monitoring of limited numbers of surrogate chemicals* should be instituted instead of the one- and three-year intervals now required by the SDWA. In addition, monitoring for organics in ground water should be mandated rather than left to the discretion of individual states, most of which do not require such routine tests. (Connecticut has mandated annual state ground water monitoring for all supplies serving 1,000 or more people. Results are reported to the state legislature.) Purveyor monitoring should be augmented by meaningful random sampling by state and county agencies.

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*See p. 93.

Performance Standards, Rather Than Government Specified Control Technology, Should Be Considered. Because local water and treatment plant conditions vary widely, and because technology can change, consideration should be given to instituting performance standards for removal of toxic chemicals rather than government-specified control technology. This concept is generally accepted in Europe for air and water pollution abatement. (However, Europeans have commonly selected granular activated carbon and ozone to remove SOCs and lessen THM formation, respectively.) Control technology for removal of chemicals should be mandated for degraded potable sources, but flexibility in selecting that technology (e.g. GAC, resins, etc.) should be allowed.

Trihalomethane Formation Should be Controlled. THM control can start with simple, low-cost measures such as changing the point of chlorination to later in the treatment process for less contact time with precursor organic matter. If this is not adequate to achieve THM standards other methods should be employed, including use of a disinfectant which does not produce as much THM. In addition, "chemical maneuvering" -- e.g., lowering pH levels -- should be considered to lessen the use of chlorine.

Institutional Mechanisms

Economic Incentives Should be Considered to Upgrade Water Quality. Consideration should be given to innovative economic incentives to upgrade water quality. Such incentives can include the use of "soft" SOC standards. This can be based on a sliding scale whereby drinking water rates are lowered for those suppliers offering inferior water, below a certain standard. Rates would be increased when steps are taken to improve drinking water quality. Such a mechanism would also serve as a unique method to educate consumers about water quality.

Federal Incentives for Strong State Drinking Water Programs Should be Implemented. The disparities in federal support for the FWPCA in the form of sewage treatment plant construction grants, compared to the lack of economic incentives in the SDWA, should be reconsidered in an effort to upgrade state drinking water programs, especially for small water suppliers.

Equity in Water Quality Must be Assured for Customers of Small as well as Large Water Purveyors. The size of the water supplier should not determine the quality of drinking water. Toward that end, measures should be taken to upgrade small water suppliers lacking the resources to meet federal and state standards. Regionalization or takeover by larger, responsible purveyors should be considered where feasible. Otherwise, local and state government should supply assistance in the form of grants, expertise, and so on. Municipal government, which has prime authority in land use decisions, must have assurances in the form of performance bonds or other measures that a land developer who becomes a water purveyor will be financially able to operate the water supply at least according to government requirements.

Intergovernmental Coordination Must be Emphasized. State agencies, which have primacy in carrying out the mandates of the SDWA, must work effectively with municipal and county health officials to augment strained manpower and budgets resulting from additional responsibilities under the act and federal budget cuts.

A National and State Effort to Attract Better Trained People Should be Implemented. In order to carry out the mandates of the SDWA, a more sophisticated institutional framework with better trained personnel is required. In some states this requirement is impeded by Civil Service or other mechanisms which do not permit the best qualified people to be employed, or by salaries which are not competitive with those paid in industry. Institutional barriers should be eliminated and pay scales adjusted to attract the best qualified people to meet the new challenges of assuring safe drinking water across the country.

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Appendix A

PROPOSED FEDERAL CRITERIA FOR "PRIORITY POLLUTANTS" IN DRINKING WATER

In settling a lawsuit brought by the Natural Resources Defense Council, the federal Environmental Protection Agency (EPA) agreed to set drinking water criteria for 65 classes of toxic "priority pollutants", including 129 individual compounds. So far the EPA has proposed criteria for 96 of the 129. In several cases, the proposed criterion was set on the basis of chemical toxicity; in many other cases the criterion was set on the basis of the carcinogenicity (cancer-causing ability) of the chemicals. Except as noted in the table, for carcinogens the EPA proposed three different criteria: a criterion that would permit cancer in one person in 10 million drinking the chemical at the proposed level for a lifetime; a criterion that would permit cancer in one person in a million; and a criterion that would permit cancer in one person in 100,000. The criteria presented below are the middle of the proposed range -- in other words, these criteria would permit cancer in one person in one million. To get the other two criteria for carcinogenic chemicals, divide the tabled value by 10 (to get the one in 10 million criterion), or multiply the tabled value by 10 (to get the one in 100,000 criterion). These data are reproduced from Marshall Sittig, Priority Toxic Pollutants -- Health Impacts and Allowable Limits (Park Ridge, NJ: Noyes Data Corp., 1980).

CHEMICAL	PROPOSED CRITERION (ppb)*	CARCINOGEN?
Acenaphthene	20.0	No
Acenaphthylene -- See Polynuclear aromatic hydrocarbons		No
Acrolein	6.72	No
Acrylonitrile	0.0084	Yes
Aldrin/dieldrin	0.0000045	Yes
Antimony and compounds	145.0	No
Arsenic and compounds	0.002	Yes
Asbestos	30,000 fibers per liter	Yes
BCEE -- See Bis(2-chloroethyl) ether		
BCIE -- See Bis(2-chloroisopropyl) ether		
BCME -- See Bis(chloromethyl) ether		
Benzene	1.5	Yes
Benzidine	0.000167	Yes

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CHEMICAL	PROPOSED CRITERION* (ppb)	CARCINOGEN?
Benzo(a)anthracene -- See Polynuclear aromatic hydrocarbons		No
Benzo(a)pyrene	0.00097	Yes
3,4-Benzofluoranthene -- See Polynuclear aromatic hydrocarbons		No
Benzo(j)fluoranthene -- See Polynuclear aromatic hydrocarbons		Yes
Benzo(k)fluoranthene -- See Polynuclear aromatic hydrocarbons		No
Benzo(ghi)perylene -- See Polynuclear aromatic hydrocarbons		No
Beryllium and compounds	0.0087	Yes
BHC -- See Hexachlorocyclohexane		
Bis(2-chloroethyl) ether	0.042	Yes
Bis(2-chloroisopropyl) ether	1.15	Yes
Bis(chloromethyl) ether	0.000002	Yes
Bromodichloromethane	2.0	No
Bromomethane (methyl bromide)	2.0	No
Cadmium and compounds	10.0**	Yes
Carbon tetrachloride	0.26	Yes
Chlordane	0.00012	Yes
Chloroform	0.21	Yes
Chloromethane (methyl chloride)	2.0	No
2-Chlorophenol	0.3	No
Chromium and compounds	0.0008 (Cr-VI)	Yes
Copper and compounds	1000	No
Cyanides	200	No
DDT and metabolites	0.000098	Yes
Dibenzo(a,h)anthracene (DBA)	0.00043	Yes
Di-n-butyl phthalate	5000	No
Dichlorobenzenes	230	No
Dichlorobenzidine	0.00169	Yes
Dichlorodifluoromethane	3000	No
1-2-Dichloroethane	0.7	Yes
Dichloroethylene	0.13	Yes
Dichloromethane (methylene chloride)	2.0	No
2,4-Dichlorophenol	0.5	No
Dichloropropane/propene	200.0/0.63	No
Dieldrin -- See Aldrin/dieldrin		
Di-2-ethylhexyl phthalate	10000	No
Diethyl phthalate	60000	No

CHEMICAL	PROPOSED CRITERION* (ppb)	CARCINOGEN?
2,4-Dimethylphenol	***	Yes
Dimethyl phthalate	160000	No
4,6-Dinitro-o-cresol	12.8	No
2,3-Dinitrophenol	68.6	No
2,4-Dinitrophenol	68.6	No
2,5-Dinitrophenol	68.6	No
2,6-Dinitrophenol	68.6	No
3,4-Dinitrophenol	68.6	No
3,5-Dinitrophenol	68.6	No
Dinitrotoluenes	0.074	Yes
Dioxin -- See Tetrachlorodibenzo-p-dioxin		
Diphenylhydrazines	0.04	Yes
Endosulfan	100	No
Endrin	1.0	No
Ethylbenzene	1100	No
Fluoranthene	200	No
HCH -- See Hexachlorocyclohexane		
Heptachlor	0.000023	Yes
Hexachlorobenzene	0.000125	Yes
Hexachloroethane	0.79	Yes
Hexachlorobutadiene	0.077	Yes
Hexachlorocyclohexane (BHC)	0.000021	Yes
Hexachlorocyclopentadiene	1.0	No
Indeno(1,2,3-cd)pyrene -- See Polynuclear Aromatic Hydrocarbons		Yes
Isophorone	460	No
Lead and compounds	50	No
Lindane -- See Hexachlorocyclohexane		
Mercury and compounds	0.2	No
Monochlorobenzene	20	No
Naphthalene	143	No
Nickel and compounds	133	No
Nitrobenzene	30	No
N-nitrosodiethylamine	0.00092	Yes
N-Nitrosodimethylamine	0.0026	Yes
N-Nitrosodi-n-butylamine	0.0013	Yes
N-nitrosopyrrolidine	0.011	Yes

CHEMICAL	PROPOSED CRITERION (ppb)*	CARCINOGEN?
Pentachlorobenzene	0.5	No
Pentachlorophenol	140	No
Phenol	3400	No
Polychlorinated biphenyls (PCBs)	0.000026	Yes
Polynuclear aromatic hydrocarbons (PAH) (Total of 6 compounds together)	0.00097	Yes
Selenium and compounds	10	No
Silver and compounds	10	No
Tetrachlorobenzene	17	No
Tetrachlorodibenzo-p-dioxin	0.000000046	Yes
1,1,2,2-Tetrachloroethane	0.18	Yes
Tetrachloroethylene	0.2	Yes
Thallium and compounds	4.0	No
Toluene	12.4	No
Toxaphene	0.000047	Yes
Tribromomethane (bromoform)	2	No
Trichlorobenzene	13	No
1,1,2-Trichloroethane	0.27	Yes
Trichloroethylene	2.1	Yes
Trichlorofluoromethane	32000	No
2,3,4-Trinitrophenol	10	No
2,3,5-Trinitrophenol	10	No
2,3,6-Trinitrophenol	10	No
2,4,5-Trinitrophenol	10	No
2,4,6-Trinitrophenol (picric acid)	10	No
Vinyl chloride	51.7	Yes
Vinylidene chloride -- See Dichloroethylene		
Zinc and compounds	5000	No

* Parts per billion, or micrograms per liter.

** Criterion based on toxicity, not carcinogenicity; for this chemical, it is not appropriate to adjust the criterion to achieve a different level of risk.

*** Data insufficient to set a criterion; contact should be minimized.

Appendix B

10/80 (GLS)

Princeton University

Center for Energy and Environmental Studies

Hazardous Waste Research Project

SURVEY OF WATER MONITORING ACTIVITIES OF LARGE POTABLE WATER SUPPLIERS IN NEW JERSEY

Name of water supply system____________________

Mailing address____________________

County and Municipality where treatment plant(s) is/are located__________

____

____

____

Public ☐ or private ☐ supplier____________________

Person interviewed____________________Position__________

Phone No.__________Date__________Administrator__________

1. a) Total direct population served by supplier__________

   b) Estimated total indirect population served by supplier__________

2. a) Municipalities served (use other sheet if necessary)__________

____

____

   b) Counties, in full or in part, served__________

____

3. a) Area served (square miles)__________

   b) Franchise area (square miles)__________

4. Total annual volume delivered in 1979____________________

5. Sources of water

a) Name of surface source(s)____________________

b) Number of wells____________________

c) Percentage of average surface water use ____________________

d) Percentage of average ground water use____________________

6. List treatment process including chemicals used, i.e., aluminum hydroxide, chlorine, etc. (see attached sheet)

a) Any facility brochure on this process?____________________

b) Was use of Granular Activated Carbon (GAC) considered?____________________

Reason for rejection. Cost?________________Technical reasons?________________

____

7. Chemical contaminants tested for in delivered water:

a) 10 inorganics in National Interim Primary Drinking Water Regulations.

How often? Surface Water________________ Ground Water________________

b) 6 organics in National Interim Primary Drinking Water Regulations.

How often? Surface water________________ Ground Water________________

c) Radiological. How often? Surface Water____________Ground Water____________

d) Has testing for Trihalomethanes (THM) been initiated?____________________

e) Other chemical contaminants:

1) Which ones?____________________

2) How often? Surface Water________________Ground Water________________

3) What criteria of acceptability are used?____________________

4) Is testing for non-regulated chemical contaminants the same at all your divisions? ____________________

5) If not, how does it differ?____________________

8. Are there plans to expand monitoring/treatment for <u>chemical</u> contaminants?________

If so, what is planned?____________________

____

9. If state or federal assistance were available would this facility's monitoring/treatment procedures for <u>chemical</u> contaminants be upgraded?

____

10. a) Could you interconnect to alternate internal water supplies if a chemical contamination threat existed?

____

b) Could you interconnect to alternate external water supplies if a chemical contamination threat existed?

____

11. Test sample locations.

a) raw water intake____________________

b) immediately after treatment____________________

c) consumer supply point____________________

d) other____________________

12. Are your chemical testing laboratories state certified?__________

a) Is this an outside laboratory?____________________

b) Is this an onsite facility laboratory?____________________

c) May we have a sample of a laboratory test report for chemcial contaminants?

____

d) Are laboratory tests available to the public?____________________

13. Annual amount of solid waste (sludge) per ton from treatment process.

____

Water content of sludge per ton____________________

Disposal site for sludge____________________

14. Inspection of water supply by state government. How often?__________

15. Most serious contamination problems here have been from:

a) Non-point surface runoff. Yes__________ No__________

b) Industrial point sources. Yes__________ No__________

c) Municipal point sources. Yes__________ No__________

d) Land disposal of solid waste. Yes__________ No__________

e) Other sources____________________

f) Identify any known potential problems.____________________

16. a) Has "208" Areawide Planning had any appreciable effect in improving the quality of the water from which you draw your supplies?

Yes____________________ No____________________

b) Are you involved in "208" planning issues?____________________

17. a) Latest annual total gross revenue____________________

b) Price per unit to customer____________________

c) Is this a uniform price?____________________

d) How do prices differ?____________________

18. Any other comments, relating primarily to chemical contamination, monitoring and treatment:

Conventional Unit Treatment Processes	Chemicals Used
____ pH Adjustment	____________
____ Prechlorination	____________
____ Coagulation	____________
____ Softening	____________
____ Ammoniation	____________
____ Fluoridation	____________
____ Disinfection	____________
____ Aeration	____________
____ Sedimentation	____________
____ Filtration__Sand__Mixed Media__*GAC__	____________
____ Corrosion Control	____________
____ Taste and Odor	____________
____ Iron Removal	____________
____ Other: Describe ____________	____________
____________	____________
____________	____________

*GAC - granular activated carbon

THE EUROPEAN EXPERIENCE: ISSUES IN WATER QUALITY AND DRINKING WATER TREATMENT

A Report to the German Marshall Fund
of the United States
and the
Institute for European Environmental Policy

January 1982
by

Grace L. Singer

Preface

This report is the result of a two-month visit in the fall of 1981 to four European countries: The Federal Republic of Germany,* The Netherlands, Switzerland and Great Britain. Sponsored by The German Marshall Fund of the United States, the trip was part of a program of international communications for Americans working on environmental policy issues. The program is administered by the Institute for European Environmental Policy in Bonn.

The purpose of my visit was to learn about European policies on water pollution, with an emphasis on the increasing number of toxic industrial chemicals being discovered in ground water as well as surface water. A second, related issue which I pursued pertained to the policies and control technologies for removal of chemical contaminants in the drinking water treatment process. Such technologies are increasingly employed by European waterworks, but have been resisted by the American water supply industry.

Because of the brevity of the visit, the complexity of the subject, and the difficulty of dealing with several countries with varying political structures, laws and traditions, I liken this report to a "snapshot" taken with a wide angle lens. That is, the emphasis is on the breadth of interrelated policies, rather than a narrow focus on any one aspect. This format was useful in making comparisons among the countries visited and with the United States.

Much of the information in the report was gained from extensive interviews with government officials, waterworks operators, environmentalists and water researchers. This was augmented where possible with topical literature from the various countries visited.

I wish to thank the many Europeans whom I interviewed for their hospitality and assistance. My special thanks to Dr. Konrad von Moltke, the Director, and the staff at the Institute for European Environmental Policy and to Marianne Ginsburg of the German Marshall Fund of the U.S. for their support. I wish also to express my deep gratitude for the invaluable assistance of Dr. Frank W. Sinden, of the United States, who served as my German interpreter in the many interviews in Germany and Switzerland, as well as for his interpretion of technical material in several languages.

Grace L. Singer
Center for Energy and Environmental Studies
Princeton University
Princeton, New Jersey 08544

January 1982

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*West Germany

THE EUROPEAN EXPERIENCE: ISSUES IN WATER QUALITY AND DRINKING WATER TREATMENT

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Introduction

In recent years a lengthening list of worrisome substances has been discovered in the drinking water of all industrial countries. The responses to these discoveries on the two sides of the Atlantic have been rather different. This is true on both the political and technical levels. With different traditional attitudes about drinking water quality, Europeans and Americans have favored different treatment methods, and with different political traditions they have developed different laws, standards and enforcement mechanisms. Yet the underlying problems are not very different. Each side has much to learn from the other.

The first section of the report briefly summarizes some European experiences in overall water quality and in drinking water policy and technology that may be useful and stimulating to those Americans and Europeans who are struggling with similar problems. This summary of issues is followed by the chapters on each country visited, giving details of that nation's policies.

This report is in part an outgrowth of a previous study in the United States by the author "....Nor Any Drop to Drink!: Public Policies Toward Chemical Contamination of Drinking Water," (Center for Energy and Environmental Studies, Princeton University, Princeton, New Jersey 08544, September 1981, 110 pp.)

I Summary of Issues

1. Water Quality - Policy Issues

European Economic Community (EEC) Influence

EEC Directives on the environment will bring uniformity of standards to the member countries of western Europe in the 1980's. These will include standards and guidelines on water quality, drinking water treatment, hazardous waste disposal, etc. For example the EEC is developing a "Black List" and a "Grey List" for dangerous substances discharged into the aquatic environment. "Black List" items currently includes mercury and cadmium as well as three pesticides: aldrin, endrin and dieldrin. This list will be greatly expanded and such items will require tight controls. Requirements for pollutants on the "Grey List" will be less restrictive. Under EEC proposals for drinking water, source waters are to be classified and receive varying levels of treatment. Already the Directives are forcing countries to upgrade their regulations, including those for halogenated hydrocarbons in drinking water, one of which is Trihalomethanes (THM). (Ramifications of some EEC policies will be discussed in the sections below.) Even in face of economic recession, there appear to be no moves in Europe to weaken environmental regulation such as are taking place in the U.S. In some cases, less funding is available to conduct programs, but laws and regulations are remaining intact.

Ground Water Protection

Evidence of ground water contamination exists in all industrial countries. In contrast to the U.S., where a proposed ground water protection strategy has been stalled, protection of these sources is moving forward in some European countries. This includes designated protection zones which prohibit certain activities, such as transport of toxic wastes. Traditionally tighter land use controls in Europe have also helped to protect ground water. In addition, there is less reliance on landfilling of hazardous waste and a trend toward greater use of physical/chemical treatment and incineration than exists in the U.S., particularly in Germany and Holland. For example, The Netherlands uses land disposal for 39 percent of its hazardous waste.[1] The comparable figure in the U.S. (and in Great Britain) is 90 percent.[2] While the Europeans have by no means solved their ground water contamination problems, they are moving in the right direction in many cases. (For detailed discussions on this issue see the individual national reports.)

Polluter Charges

In contrast to the U.S. where environmentalists have resisted pollution charges as a "license to pollute," such charges are common in Europe. One of the purposes of the charges is to provide an incentive for pollution abatement. In theory, this appears to be a sensible market mechanism favored by economists. In practice, however, the charges are often too low to induce polluters to reduce their emissions enough to significantly improve overall water quality. Currently, this is true in Germany and Great Britain. Inflation has compounded the problem. In addition, local enforcement is made more difficult by industry threats to close a plant. It is also reported that the incentive is ineffective for municipally owned sewage plants because the fees are simply paid from the right hand to the left hand. Environmentalists in Germany are calling for the use of best available control technology instead of "damage charges."[3] Actually, both could be employed. Regardless of technology, charges could be imposed for pollutants still emitted above a certain standard. (See discussion of this issue in the section on The Federal Republic of Germany.)

River Quality vs. Individual Discharges

In Europe, as elsewhere, two kinds of standards have been established: standards for the water in the river and limits on individual discharges. There has been little success, however, in establishing the link between the two.

Although river water is used for many purposes, its use as drinking water has usually determined the quality standards. This is true, for example, of the EEC's classification of waterways, whose highest category is water that can be treated for drinking entirely by natural processes not requiring chemicals, activated carbon, ozone, etc.

The Dutch have been especially eager to achieve high quality standards in the Rhine, but the Rhine's improvements so far have been in easily abated substances notably in mercury reductions and increases in the dissolved oxygen content. The gains have come largely from the construction of waste water treatment plants. Many of the intractable pollutants, however, especially complex industrial organics, continue to increase.[4]

A difficulty in linking river water standards to individual discharges is the EEC's principal of equal discharge rights for all industries. As an official of the Armsterdam Water Supply stated, "The activities of the EEC in the environmental field cannot be detached from the initially economic premises which constituted the basis for the establishment of the Communties; of prime importance is the reduction or avoidance of a disturbance of economic competive relations. This has led to the belief that there must be equal discharge rights for all industries. And this in turn leads to the drawing up of equal emission standards."[5]

One attempt to link source quality with incentives for individual emitters is made in the American Clean Air Act, which provides for "emission offsets." (In order for a new source to start up, old sources must be abated enough so the overall quality is not degraded and is even improved.) No such policy exists for water quality, however. Under the American Clean Water Act, effluent guidelines are intended to make waterways "fishable and swimmable" once more, but only indirect mechanisms for achieving this are provided.

The economists' theoretical solution to the problem of linking resource standards to individual incentives is very simple, but it has never been put into practice. The allowable load for each pollutant is divided among those who wish to use the public resource (air, water) for disposal. Suppose 1,000 lbs. is to be allowed into the river each year. Then an allowance for each of the 1000 lbs. is put up for bid. In a well functioning market, polluters will pay exactly the economic value of the emissions. If it is cheaper to clean up they will do so. In this way the level of the fees is determined not by political pressure but by the market. It is true that the level of the overall river standard (the 1,000 lbs. in the example) may be subject to political pressure, but this is more easily resisted, because the standard is not as arbitrary as individual discharge limits. The overall standard can be directly linked to the use of the water, for example, for producing drinking water. Some variant of this scheme may be useful in meeting water quality deadlines which seem out of reach under present systems. This model might be especially attractive in the U.S. where a market oriented government is currently in power.

Confidentiality of Discharge Data

A difficult problem for any scheme to improve water quality is monitoring and control. Because of this, American environmentalists have pushed hard for public access to data and public participation in the regulatory process. The attitude in the U.S. has been that once industrial waste is released into the environment it affects the public and the public has a right to know about it. Such data has been used, for example, by the General Accounting Office, an arm of the U.S. Congress, to expose deficiencies in the discharge permit system. [6]

In sharp contrast, discharge data in some European countries, most notably Germany, is highly confidential and is based on consent agreements between industry and government on the ground that the data might reveal trade secrets.[*] Great Britain has attempted to move away from secrecy: An as yet unimplemented water regulation, under the 1974 Control of Pollution Act, would mandate that discharge data be on public record.

The Dutch waterworks and international environmentalists based in Holland, have atempted to pinpoint the sources of industrial pollutants in the Rhine. One project with this purpose, "Rheinaktion," made use of a boat to take data on the principle of the "fliessende Welle" (flowing wave).[7] According to this principle, the boat moves downstream with the current so that it is always floating in the same segment of water. Frequent analysis of the water shows clearly the points at which pollutants are emitted into the river. Data from

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[*] An attempt by the author to obtain a sample list of chemicals and quantities discharged along with the damage charges, but <u>without</u> corporate identification, was not successful.

the project show sharp increases in toxic pollutants opposite large chemical firms along the Rhine. The purpose of the project was to bring polluters into the public spotlight.

For a more detailed discussion of this issue see the sections on The Netherlands (Dutch Water works as Activists) and the section on Great Britain (Laws and Standards).

Monitoring for Toxics

One of the problems water suppliers must be concerned about is sudden, temporary poisoning of the water source by either accidental or illegal spills. Two interesting solutions used in Europe are the following:

1) An international alarm system for the Rhine River. The Dutch, downstream from Swiss, French, German, as well as transient boat discharges into the Rhine, have developed an early warning system with the other countries for this busy waterway. The Dutch are very sensitive to the spill problem because the Rhine constitutes 65 percent of their fresh surface water and is the drinking water source of large populations, including Amsterdam.

2) Another notable means for dealing with dangerous spills is a Dutch invention, the automatic trout test, analogous to the coal mine canary. It is used, for example, in the Zurich waterworks at several different points. Water flows slowly through a large glass tube. A trout, used for its sensitivity to pollutants, swims upstream at just the water velocity so that it remains stationary with respect to the tube. A screen prevents the trout from moving too far upstream and a mild electric shock, administered at a downstream point, discourages the trout from backsliding. If poisons in the water make the trout sick or weak so that it falls back with abnormal persistence, electronic sensors set off flashing alarm lights in the control

room to alert waterworks personnel. The poisoning need not be severe enough to kill the trout, only severe enough to impair its behavior. Zurich uses trout tests for both the raw and finished water.

Laboratory monitoring for toxic chemicals in drinking water differs in two fundamental ways in Europe and in the U.S. For example, in The Netherlands tests are conducted every three months. By contrast, U.S. law mandates monitoring for organics in surface water only every three years and leaves organics testing in ground water entirely to each state's discretion; most have no specific schedules.

The second important difference is in monitoring methods. Europeans use a composite chemical measurement, total organic carbon (TOC), rather than readings of specific chemicals, the practice of U.S. water purveyors. The U.S. relies on "maximum contaminant levels" for individual chemicals. This is a limited control in relation to the hundreds of toxic chemicals of concern and may take many years of standard setting, as well as complicated monitoring.*

Implementation Innovations

The best environmental regulations will not work if they are not well implemented and enforced. Two interesting German innovations deserve further study by Americans and others.

1) An Environmental "caretaker" at industrial plants. German law requires that all large firms designate a qualified employee to be responsible for meeting environmental regulations. In theory this person is responsible

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*Currently, out of 700 chemicals identified in U.S. waters, and 129 "Priority Pollutants" identified by the U.S. Environmental Protection Agency, only 16 have maximum contaminant levels (MCLs) under the Safe Drinking Water Act.

to the community as well as to the corporate employer, and is protected from actions by the company. This is a novel attempt to deal with the crucial "whistleblower" problem.

2) Lawyers and engineers work very closely in assigned pairs to implement and enforce environmental regulations. This is often not accomplished as well as it should be in other countries where the legal and engineering (or technical) disciplines are less formally wedded.

Environmental Activism

As a general rule, public participation in environmental matters is less well developed in Europe than it is in the U.S. One notable exception is Holland where government and environmental organizations work very closely. In fact, citizen groups are partially funded by government. This is because of the ecological pressures in this small lowland nation and a strong historical cooperative relationship between the older nature groups and government.

Currently in Holland, in response to the frustration of inadequate improvement of water quality after decades of international negotiations, Dutch environmentalists are planning an international Water Tribunal for the end of 1982. The Tribunal will bring to "trial" a half dozen or so major polluters primarily of the Rhine River and the North Sea. The principal goal is to publicize the issue and focus on major polluters, an extension of the boat information-gathering activities described above. An international scientific support group is being recruited. Very little use is expected to be made of lawyers, however, since the trial will be conducted outside of the formal legal system. This is because there are no legally binding standards for most of the discharged toxic substances, and often the polluters' activities have been legitimized by confidential consent agreements with government.

Further evidence of citizen agitation for improved water quality is seen in Germany where the recent publication of a book "Wie Krank ist Unser Wasser?" ("How Sich is Our Water?") has stimulated media attention and a debate on the fundamental institutions which regulate water pollution and drinking water treatment.[8]

The American Environmental Impact Statement, in existance for a decade, is still being considered in Europe, currently in Holland. Germany is only now considering a proposal to give the public legal standing in hearings required for new development; currently only the parties directly involved can participate. Another example of public exclusion in Germany is in the regulatory or standard setting process where only industry and government participate. In both of these areas, citizen environmental groups have participated increasingly in the U.S. in recent years, with early involvement in the process a principal goal. (For a more detailed discussion of the environmental movement, see the reports on The Netherlands and Germany.)

Waterworks Involvement in Water Quality

One is impressed by the active role taken by the European waterworks in overall watershed conditions, especially in contrast to the narrower purview of most U.S. water suppliers. This difference has many causes and ramifications for water quality. Some of these are deeply imbedded in different traditions; others are the result of a more progressive European attitude toward drinking water. Some of these factors are:

1) Different institutional mechanisms in the U.S. and Europe. In Europe almost all waterworks are owned and operated by government (municipalities, counties, and public corporations of several government units). This has many

consequences. For example, where ground water protection zones exist, these are often established (and managed) by government planners working closely with the waterworks in sister agencies. In contrast, the U.S. has a great mixture of public and private ownership of the waterworks industry and a much less unified approach. This makes projects requiring cooperation, such as the establishment of ground water protection zones, more difficult to undertake.

2.) Consolidation of waterworks into larger regional units in Europe, and a trend toward fragmentation in the U.S. The most notable example of this exists in Great Britain. Here in 1974, 1,609 separate local government agencies were consolidated under 10 regional Water Authorities.[9] These are based on natural watersheds for management of the full water cycle for the 50 million people of England and Wales. This includes supply, drinking water treatment, sewerage, pollution control, fisheries, recreation and flood control. Another notable example exists in Germany. Here a trend toward consolidation in the formation of public corporations of several municipal governments, has also had important results. In 1969 there were 15,000 separate waterworks in the Federal Republic of Germany. By 1977 these had been whittled down to 7,300,[10] eliminating many small, inadequate operations. In the U.S., the number of drinking water supply systems has grown from some 20,000 in 1963[11] to more than 60,000 in 1981.[12] Because of the lack of adequately trained personnel and resources, small waterworks are often not as well operated as large ones, and this has been a serious problem in the U.S. Such fragmentation also fosters a much narrower approach to water supply, rather than the regional purview essential for watershed protection. This condition is more critical now with recent findings of complex industrial chemicals in water supplies. The need to respond to this problem with mandates under the U.S. Safe Drinking Water Act, will require more substantial waterworks' capability, the direction in Europe.

3.) <u>European waterworks have their own national research organizations</u> responsible for responding to their common needs and problems. Thus, European water suppliers are in closer touch with progressive scientific findings. These are especially important in removing the complex pollutants that are increasingly found in drinking water supplies. In contrast, the American Water Works Association conducts no research and has put inself in an adversarial position to government. This was a significant factor in the 1978 rejection of the U.S. Environmental Protection Agency's proposed regulation for control technology (granular activated carbon) to remove toxic chemicals from drinking water.[13]* It is also a factor in the less stringent U.S. trihalomethane standard. Thus, the European waterworks have worked in concert with their progressive research advisors while the American waterworks have resisted similar moves.

4.) <u>Public education</u> about water pollution and its causes has been a natural outgrowth of the waterworks involvement with water pollution. This broader understanding of watershed conditions has taught European waterworks operators that they cannot rely on treatment alone. This is especially true for the increasing number of complex toxic industrial chemicals being discovered with new, sophisticated monitoring instruments. Because of their dependence on the international Rhine River and their unfavorable location at its mouth, the Dutch waterworks have perhaps been more active than most, and have taken

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*Drinking Water Research has been conducted by the Drinking Water Research Division of the USEPA in Cincinnati. A cutback in funding and the anti-regulatory stance of the Reagan administration may, however, seriously hamper the work of this unit.

extraordinary measures to bring pollution problems to public attention, as discussed earlier. Figure 1 is an example of public education about the sources of pollution by the Thames River Authority whose watershed includes the city of London. Such initiatives could be adopted by U.S. waterworks to enlist public support for improved water conditions. Following the example of the Bell Telephone Company, consumer education messages could be enclosed with monthly bills.

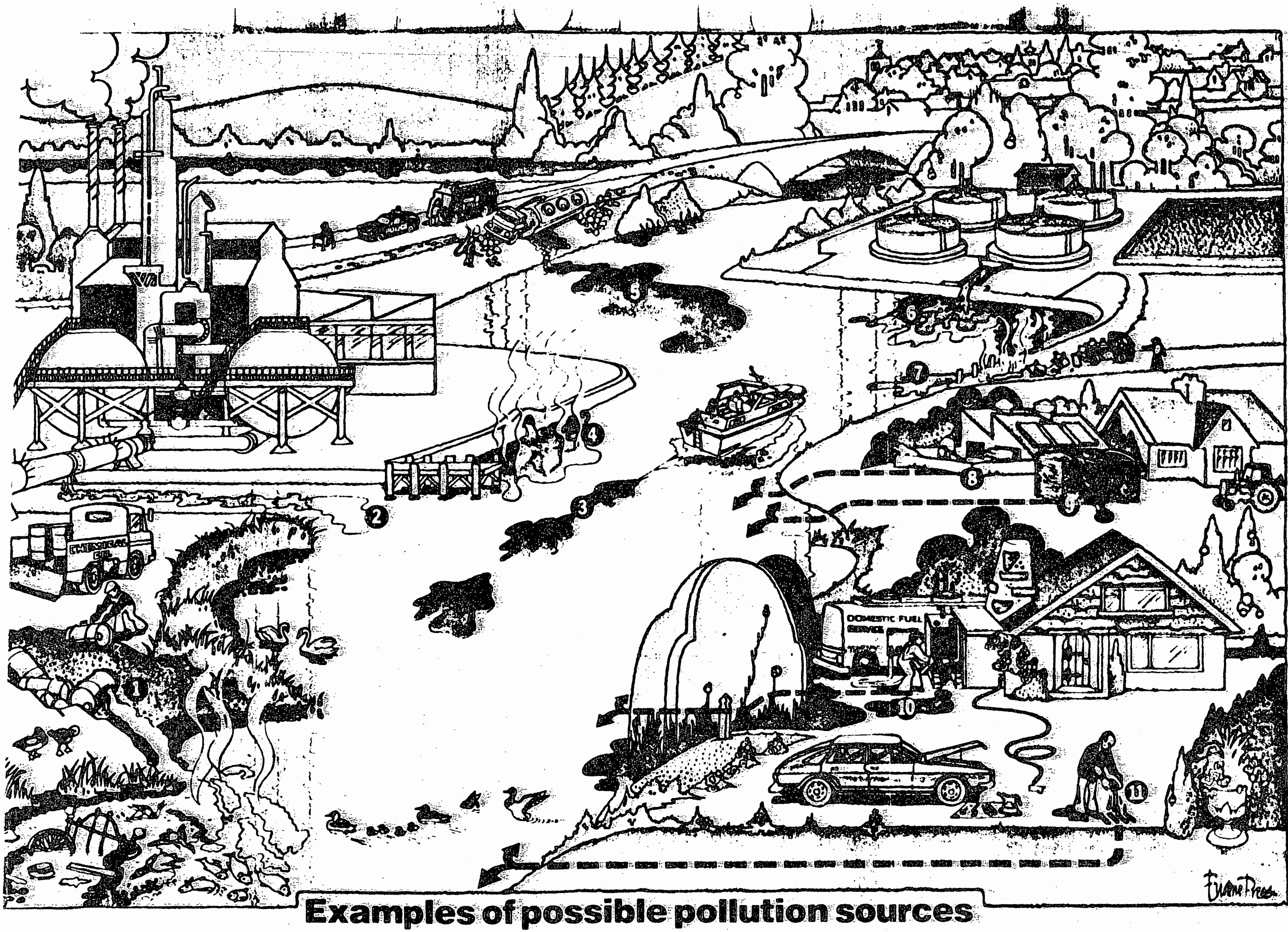
Water Conservation

Another aspect of consumer education and policies can be seen in the lower use of water in most of western Europe, less than 50 gallons (200 liters) per day per person, about half the U.S. consumption. While this conservation ethic is directly tied to the higher cost of water in Europe, averaging about $3.00 per 1,000 gallons (3,785 liters) compared to $1.00 in the U.S., there are specific actions which have brought it about. For example, European toilets are designed to use one third of the flushing water used in the U.S., about 2 gallons (7 liters) compared to about 6 gallons (20 liters).[14] And in Germany, sewage charges are based on water consumption, so that users have an incentive to conserve.

The link between quantity and quality of water supply will become increasingly critical with population growth over the years, and with higher cost of drinking water purification. This pressure can be lessened considerably in the U.S. -- where even water abundant areas periodically experience drought -- by instituting water efficiency measures such as those long used in Europe.

Figure 1

13a



Examples of possible pollution sources

1 Illegal dumping of harmful chemicals. 2 Leakage of chemicals from industrial premises. 3 Illegal oil discharges from launches and ships. 4 Trade effluent discharges containing toxic waste. 5 Oil spillages from road tankers. 6 Poor quality sewage works effluent. 7 Chemical spillages on the highway. 8 Liquid farmyard waste. 9 Liquor from farmyard silage stores. 10 Heating oil spillages and leaks from storage tanks 11 Illegal disposal of car engine oil into drains.

Authority, London, 1981

2. Drinking Water Treatment

Treatment Problems

Traditionally, drinking water has been prepared by two main processes: 1) filtration and 2) disinfection with chlorine. In the past, these processes were considered entirely adequate. In recent years, however, the traditional system has been found to fail in two ways. First, certain toxic industrial chemicals have been found to pass through ordinary filters and enter the final water. Second, the added chlorine has been found to react with commonly occurring organics to form toxic and carcinogenic substances that would not otherwise be in the water.

Europeans have well developed research on drinking water treatment technology, with emphasis on problems of chemical pollutants from industry and from the treatment process itself. Four different centers of drinking water research were identified on this visit: two in Germany (at Karlsruhe and Bremen Universities), one in The Netherlands and one in Great Britain. In current practice, advanced treatment techniques (granular activated carbon, ozone, etc.) are being used in many working plants using different raw waters. This provides an important laboratory for accumulating practical experience. In the U.S., less extensive research on advanced control technology has been conducted by the Environmental Protection Agency, and virtually none by the American Water Works Association. More importantly, the advanced technologies to remove chemical contaminants are not being used in drinking water treatment plants in the U.S., with a resultant gap in practical experience.

Under present conditions of different raw water quality and treatment facilities, no universal system can be devised that is suitable for all plants.

What is needed in the U.S., therefore, is not merely the adoption of advanced technology, but rather the training of a sufficiently large community of scientists, engineers and technicians so that treatment plants can be individually designed (or renovated) to fit particular circumstances. Further, there is a need for people whose expertise extends beyond drinking water treatment to waste water treatment and ecology so that the connections and trade-offs among the three can be rationalized. These links should be reflected not only in the expertise of individuals but in institutions.

Granular Activated Carbon (GAC)

The most notable European innovation is the widespread use of granular activated carbon (GAC) filters. A great deal of research on GAC has been carried out at Germany's Karlsrube University by Professor H. Sontheimer and his colleagues. In fact the spread of GAC filtration in Europe is often credited to the efforts of this group.[15]

Adsorption (especially on activated carbon, but also on resins and other materials) is a basic tool in dealing with chemical contamination, but to be effective it must be carefully integrated with other elements of the treatment system.[16] GAC adsorbs a very wide range of compounds including many of the toxic industrial organics. In fact, GAC filters are so effective that it is tempting to see them as analogous to chlorine; just as chlorine kills a wide variety of organisms in the water, GAC adsorbs a wide variety of chemicals. One example of GAC's effectiveness is in the city of Cologne (Köln). Here, using a total organic carbon (TOC) measurement, a typical reading is 1.3 to 1.4 ppb before GAC filtration, and .06 ppb after filtration.[17] Two of the organic contaminants most commonly found here are trichloroethylene and tetrachloroethylene, both carcinogens. (The proposed U.S. criteria for these are 2.1 ppb and 0.2 ppb respectively.)

GAC was first employed in Europe about 20 years ago in response to taste and odor problems in drinking water. With the development of advanced analytical instruments (gas chromatograph/mass spectrometer) it became possible about 10 years ago to detect trace amounts (parts per billion) of industrial organic chemicals in drinking water, some toxic and carcinogenic. At this point GAC began to be used more intensively so that it would remove even the trace amounts of synthetic organic chemicals. The major difference in this use is the frequency with which the filters are replaced or regenerated. For taste and odor improvements the filters can be used for two to three years before regeneration. For removal of industrial chemicals, regeneration is required every two to three months, with resultant increases in cost.

It is estimated that more than 30 drinking water treatment plants in western Europe are using GAC for chemical removal. In contrast, the use of GAC for removal of toxic chemicals is virtually unknown in the U.S., though it is used in some places for the improvement of taste and odor. The American waterworks industry has resisted GAC use primarily on the basis of cost. When asked about this, European waterworks operators and researchers responded that all drinking water treatment represents only 10 to 20 percent of the total cost of water delivery, with distribution accounting for the balance, so that cost should not be an overriding factor. While GAC is still the subject of research (along with other adsorbents such as resins), and technical problems are receiving continuing attention, there seems to be a consensus in Europe that it is an essential tool for modern water purification.[*] The chemist for the Zurich treatment plant, which is known to be among the most advanced -- if

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[*] There are about 6 GAC units in operation in Great Britain. Here, however, there has been much less focus on organic contaminants than on the Continent. This is explained by British attention to serious problems with nitrates and lead in water. These are primarily the result of agricultural practices and the interaction of acidic waters with lead pipes.

not the most advanced -- plant in the world, summed it up by stating that GAC is one of the most reliable parts of the treatment system.[18]

Disinfection Practices

Trihalomethanes (THM) and Chlorine Use

THM are formed by the interaction of chlorine, used to disinfect drinking water, and natural organic precursors in raw water. At least one THM, chloroform, has been identified as a carcinogen by the National Cancer Institute in the U.S. Eventually, the EEC proposed standard of 1 ppb for all halogenated hydrocarbons, including THMs, will become the western European standard. Even now, however, most European THM standards are more stringent than the U.S. standard (100 ppb), e.g., Germany and Switzerland, 25 ppb, Holland, 1 ppb (proposed), Great Britain, no standard.

A major strategy in reducing THMs is reduction of chlorination. Europeans have never used as much chlorine as Americans. In fact, some European systems use no chlorination at all. Since the discovery of THMs in Holland in 1974 by J.J. Rook, a chemist for the Amsterdam waterworks, the Dutch and indeed, most western Europeans, have taken measures to lessen their use of chlorine even further. (The exception is Great Britain which, like the U.S. has not taken the matter as seriously.) Starting with an already low chlorine use, the Dutch have achieved large further reductions as shown in Table 1.

The Dutch are also considering eliminating the practice of post chlorination (performed at the end of the treatment process to produce a disinfectant residue in the distribution system). Eliminating this step is felt to be possible because of the effectiveness of slow sand filters in removing most bacteria, and because the residue is not effective in combatting the most serious bacterial entrance into the system, e.g., that caused by a ruptured distribution pipe.[*19]

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*Because of the prevalence of plastic water pipes in Holland, ruptures are not uncommon, especially those caused by spilled chemicals from fuel tanks and elsewhere percolating through the ground.

Table 1

Reduction in Chlorine Use in Holland

Chlorine use (metric Tons/year)

	1976	1979	% Reduction
Transport	823.5	332	60%
Breakpoint	636	441.1	31%
Process	18	18	0%
Ferro-oxidation	430	321	25%
Chlorination of finished water:			
Surface	110.5	93	22%
Ground	82	45.4	45%
Total	2108	1250.5	41%

Source: J.C. Kruithof, Het Chlooregebruik in de Jaren, 1976 en 1979, (Rijswijk, The Netherlands, KIWA), April 1981, p. 1

A number of other means for removing THMs and their precursors are being investigated in Europe.[20] So far, none appears to provide a definitive solution to the THM problem.[21] In trying to estimate the total human intake of THMs, researchers are also investigating doses of THMs from sources other than drinking water.[22]

Much is still not known about the toxicology of other substances occurring in drinking water prepared by conventional methods. For example, chlorination can produce many organic chlorine compounds in addition to THMs.[23] According to the Karlsruhe researchers, "Nobody really knows if the substances found with the TOCL (total organic chlorine) method are less harmful than chloroform."[24] Unfortunately the classes of substances that can be tested for do not correspond to toxicity classes.

Alternatives to Chlorination

Both ozone and chlorine dioxide are commonly used in Europe as alternnatives to chlorine. The use of ozone is recommended by the waterworks' researchers in Germany and Holland because of its ability to destroy both bacteria and viruses; (it kills viruses better than chlorine) and its ability to reduce synthetic organic chemicals to a more biodegradable form.[25] Ozone is, however, not a simple substitute for chlorination. Its tendency to break down large organic molecules into smaller ones provides a medium for regrowth of microorganisms. The effect can, however, be turned to advantage if the ozonated water is run through a biological filter, e.g., biological activated carbon.[26]

Because ozone does not produce a bacteria destroying residue in the distribution system, chlorine dioxide, rather than chlorine, is recommended. This preference is attributed to chlorine dioxide's lack of taste and because it does not readily form THMs. One concern about chlorine dioxide is its formation of chlorides. The Zurich waterworks method of handling this problem is indicative of the integrated approach to water treatment practiced in modern European plants:

> "As to the removal of organic substances, ozonization and active charcoal filtration (GAC) yield the best results. Despite the massive reduction of organic substances, mainly humic acid compounds, halogenated hydrocarbons are produced as an undesirable side effect of chlorination. If chlorine is replaced by chlorine dioxide, chloride is released and this is converted to chlorate in the course of treatment, especially by ozonization. This can be prevented by removing chloride by means of active charcoal at the beginning of treatment."[27]

This appears to be one of the most interesting lessons for Americans: The Europeans are taking the THM problem seriously. At the very least, it would appear that American (and British) water purveyors should fundamentally reexamine their chlorination practices to see if they really make sense in light of recent information.

Natural Treatment

There is a general tendency of the Europeans to rely as much as possible on "natural" methods of drinking water purification, including limited chorination. Consistent with this preference is Germany's use of river bank filtration whereby river water is filtered through wells dug in adjacent bank soil. In western Holland, where much of the raw water necessarily comes from the polluted Rhine River, several water works use very slow filtration through the natural dunes that border the sea coast (residence time is several months). Some waterworks (including Amsterdam) use no activated carbon, although the wisdom of this omission is being debated. There is some difference of opinion about the capacity of the dunes to hold pollutants. Some say the time to important breakthroughs is centuries; others are not so sure. Phosphates are already passing through in some places.[28] Environmentalists object to the dune filtration because the percolation ponds, being eutrophied, encourage the growth of species that are not native to the dunes and that crowd out the natural species. (This issue is discussed further in the section on The Netherlands.)

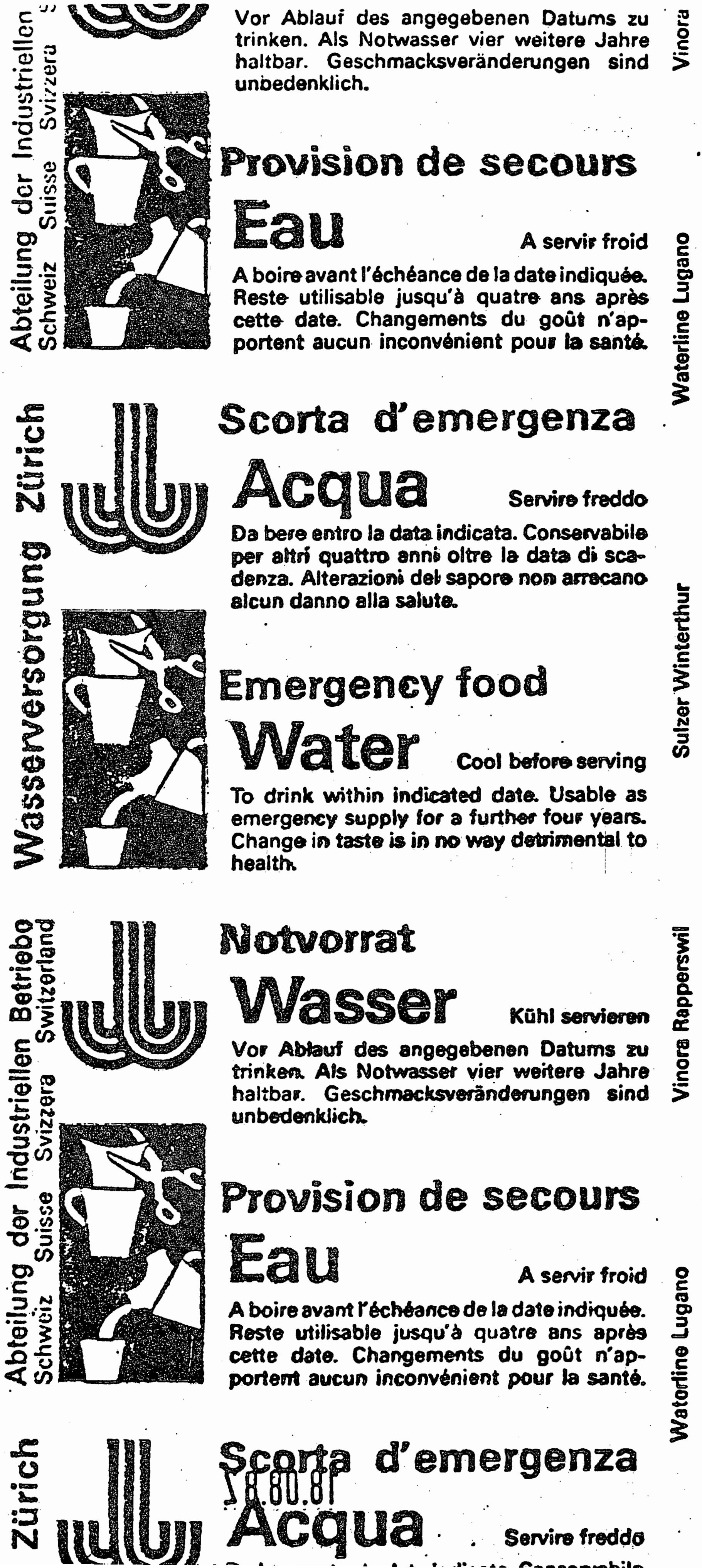
Security Arrangements

Water supplies are vulnerable to disruption or poisoning from crises such as toxic spills, flooding, war, etc. Some sources have better natural protection than others, but all waterworks operators must be concerned about these events. Very few have either the resources or the plans to adequately cope with such occurrences.

One of the most interesting visits of the trip was to the Zurich Wasserversorgung (waterworks), which lives up to its reputation as a "showplace." (See section on Switzerland.) In particular, the security arrangements in Zurich are fascinating. In addition to the fish tests, incorporated into the plant to monitor for accidental toxic spills, as discussed earlier, the Zurich plants include the following security features:

- Ground water pumping is conducted at 60 ft. (18 meters) below the ground surface and since 1974 has been protected against attack - including nuclear - by thick concrete and metal walls. The metal layer is designed to shield the electrical equipment associated with the pumps from the electromagnetic shock which results from a nuclear explosion above the atmosphere.
- Two portable vans are available for emergency use. One van can purify water to a potable standard; the second van packages emergency water supplies for use in individual households. The packages are sealed plastic bags each containing one liter (about a quart) of drinking water. The bags can be stored as an emergency stock for up to five years. (see figure 2)
- Zurich has 900 fountains throughout the city which are fed by gravity flow from springs with no pumping required. The fountains have been kept in operation for their beauty and historical value as well as the alternate pure water supply they afford.

While all of these measures may not be feasible for most waterworks some, such as the use of fish to detect accidental spills, seem highly transferrable. Portable water purification and underground pumping may be suitable for some larger water suppliers serving urban populations.



Vor Ablauf des angegebenen Datums zu trinken. Als Notwasser vier weitere Jahre haltbar. Geschmacksveränderungen sind unbedenklich.

Provision de secours

Eau

A servir froid

A boire avant l'échéance de la date indiquée. Reste utilisable jusqu'à quatre ans après cette date. Changements du goût n'apportent aucun inconvénient pour la santé.

Scorta d'emergenza

Acqua

Servire freddo

Da bere entro la data indicata. Conservabile per altri quattro anni oltre la data di scadenza. Alterazioni del sapore non arrecano alcun danno alla salute.

Emergency food

Water

Cool before serving

To drink within indicated date. Usable as emergency supply for a further four years. Change in taste is in no way detrimental to health.

Notvorrat

Wasser

Kühl servieren

Vor Ablauf des angegebenen Datums zu trinken. Als Notwasser vier weitere Jahre haltbar. Geschmacksveränderungen sind unbedenklich.

Provision de secours

Eau

A servir froid

A boire avant l'échéance de la date indiquée. Reste utilisable jusqu'à quatre ans après cette date. Changements du goût n'apportent aucun inconvénient pour la santé.

Scorta d'emergenza

18.80.81

Acqua

Servire freddo

Figure 2

Source: Emergency Water Supply Package
(1 liter) of Zurich Waterworks, 1981

3. Political and Cultural Differences/Conclusions

Differing institutional mechanisms are apparent in Europe and in the U.S. as exemplified by the specific cases relating to water quality discussed in this section. It is, however, some underlying political and cultural traditions which can perhaps explain many of the policy differences. The U.S. has an open -- and contentious -- political system, allowing much active public participation, while confidentiality and consensus are prevalent in Europe. There is also a much more deferential attitude toward governmental authority in Europe. As a result, relationships with government tend to be more harmonious. One example of this is the difference in action in the regulation for trihalomethanes, resulting from chlorination of drinking water. In the U.S., when a guideline of 100 ppb was announced in 1978 by the U.S. Environmental Protection Agency, a coalition of water purveyors immediately took legal action. In contrast, Europeans have accepted much more stringent standards for THMs e.g., 25 ppb in Germany and Switzerland, and will soon have to comply with the EEC's standard of 1 ppb.

Another interesting difference appears in civil service structure. The European civil service is generally highly trained and compensation is usually equivalent to that in private industry. This is generally not the case in the U.S. where government competes, often unsuccessfully, for well qualified people to conduct increasingly complex environmental programs in a rather contentious setting.

While there are many pros and cons of the European institutions vis a vis those in the U.S., in the area of drinking water the differences are clear.

The Europeans have taken seriously recent findings of chemical contamination resulting both from water pollution and from the treatment process itself. With strong support from their own research institutions, many of the waterworks in western Europe have taken a progressive attitude, rather than the defensive stance adopted by the water supply industry in the U.S. Europeans have decided on a preventive approach to protect public health and are willing to pay the relatively small cost of such protection.

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The Netherlands

Because of its dense population and small coastal geography, environmental pressures and awareness are more pronounced in Holland than in most European countries.* Water quality is a prominent issue, the result of Holland's fresh water shortage; its dependence on the Rhine River for 65 percent of its surface water; its disadvantageous location at the terminus of this polluted international waterway, which first runs through Switzerand, France and Germany; and its ground water levels vulnerably close to the surface.

In Holland, as in Germany, there is a preference for ground water, and the ratio of use is the same: 2/3 ground water, 1/3 surface water, although its largest cities, Amsterdam and Rotterdam, rely on river water. Increasing demand will however cause a heavier dependence on surface sources. Because of the need for increased treatment of polluted water sources such as the Rhine River, the technical ability to cope with this problem is a serious concern in Holland.

Water Use and Conservation

Water use is much less in Holland, 120 liters (about 30 gallons) per person per day, than in most western European countries with daily per capita use of about 200 liters (50 gallons), and in the U.S., with almost 400 liters. One example of water conservation is the amount of water used for toilet flushing. This is 7 liters (about 1 3/4 gallons) in Holland vs. 20 liters in the U.S. Currently the Dutch pay an average water rate of about $2.40 per 1,000 gallons.[1] This compares to the average U.S. rate of $1.00 per 1,000 gallons. The average European rate is $3.00 per 1,000 gallons.

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*Holland's 14 million people are contained in 12,883 square miles. It can be compared to New Jersey, the most densely populated U.S. state, also coastal, which has 7 1/2 million people in 7,836 square miles.[2] Both have about 1,000 people per square mile.

Problems on the Rhine

Since the Rhine River is so critical as a fresh water source, including the drinking water supply for the 1.2 million people of Amsterdam, the nation's largest city, its continuing poor quality is the focus of attention by Dutch officials as well as citizen groups. In Germany, contiguous to Holland, the Rhine is relatively free flowing affording some measure of purification through aeration, although serious pollution problems also exist there. However, the river's flow in Holland is much slower causing eutrophication and less dissipation of pollutants. The Rhine has more than 10 percent of the world's chemical production.[3] Measurements made in 1977 at the German-Dutch border indicate the presence of a number of toxic organic substances which can pass through the drinking water treatment process:

Table 2

	Parts Per Billion (PPB)
3,4 benzofluoranthene*	0.04
1,12 benzoperylene*	0.05
3,4 benzopyrene*	0.02
Bis(dichloropropyl)ether	0.2
Trichlorobiphenyl	0.02
Hexachlorobenzene**	0.04
Triethylphosphate	0.01
Tri(chloroethyl)phosphate	0.2
Tributylphosphate	0.4
Trimethyloxindole	0.01
N-butylbenzenesulfonamide	0.07
Cholinesterase inhibitors	4.6
Dibutylphtalate	1.1
Di(ethylhexyl)phtalate	2.5

Source: C. Poels, O. Snoek, L.J. Huizenga, "Toxic Substances on the Rhine River," Ambio, Vol. 7 No. 5-6, June 20, 1979, p. 222.

*Proposed U.S. criterion, 0.00097 ppb
**Proposed U.S. criterion, 0.000125 ppb

In 1978 the river also contained various inorganic pollutants including the following, with measurements indicated in tons per year: mercury, 20; arsenic, 50; cadmium 110, lead, 1,250.[4] It is estimated that over 1,500 chemicals, many of them toxic, are known to be in the Rhine.[5] In Rotterdam the concern over Rhine water quality was acute enough in 1973 for the city to switch from this drinking water source to the relatively clean Meuse River. Because of geography, this option is not available to Amsterdam.

While some improvements in Rhine water quality were noted by 1975, most notably in higher oxygen content and reduction of mercury concentrations from 5 or 6 ppb to the Dutch standard of 1 ppb (U.S. standard 2 ppb), notable progress has not occurred since then. The success of the mercury reduction is attributed primarily to public awareness of its health effects and the threat of European Economic Community (EEC) legislation.

According to knowledgeable European scientists, U.S. rivers with chemical, petrochemical and paper industries have comparable pollution loads to those in Europe. A major difference, however, is that Europeans must obtain improvement through international cooperation which may involve economic interests in several countries. For example, the French have been particularly resistant to taking measures to adequately limit heavy salt discharges from their potassium mines which have raised the chloride level of the Rhine.

Dutch Waterworks As Activists

In response to the frustration of largely unproductive discussions since the early 1950's under the auspicies of the International Commission for the Protection of the Rhine Against Pollution, the Dutch waterworks dependent on the Rhine have taken a vigorous approach to alleviate the situation. Under the aegis of their activist arm, RIWA, the Dutch have formed their own permanent international organization (IAWR) with other waterworks in Germany and Switzerland.

The principal goals of the Dutch are: 1) that drinking water must take absolute priority over all other uses of water and must be the primary consideration in clean-up measures.* 2) Overall river quality standards as well as individual discharge standards, must serve as guidelines for regulatory measures.** One of the waterworks' maxims is that "effluent dilution is not effluent purification."[6] The counterpart American expression is "the solution to pollution is not dilution."

To enlist public support in their efforts, RIWA is active in communicating pollution problems via annual reports and use of the media. In an effort to obtain and publicize data on specific discharges into the Rhine, information has been gathered by the waterworks and other international groups for a longitudinal profile of the river. This has been accomplished by use of a boat which moves downstream with the speed of the river to collect water samples in the vicinity of industrial outfalls. Such activity is the only means of obtaining this information in most European countries where discharge data is a closely guarded secret between industry and government based on consent agreements. The basis of this confidentiality, in sharp contrast to the open U.S. system of publically available discharge permit figures, is that proprietary data would be revealed to an industrial competitor. The Dutch waterworks contend that there are much more effective ways to obtain information on production processes and that secrecy is inappropriate for toxic discharges into a critical public resource.

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*Historically, such a priority was set for the Thames River which serves as the drinking water supply for London. This is discussed in the section on Great Britain, page GB6.

**Again, in Britain there is an analogy to the emphasis on overall river quality.

While it is true that the Dutch have the advantage (as well as the disadvantage) of being able to point to foreign countries as the principal polluters rather than becoming embroiled in internal political hassels on the issue, their activities are notable. This is especially so when comparing the Dutch activities with the much more languid attitude exhibited by most U.S. waterworks who are not known for drawing attention to water pollution in their watersheds. This contrast is especially striking when viewed against the American waterworks successful 1978 battle with the U.S. Environmental Protection Agency (EPA) to avoid use of control technology commonly used in Europe for removal of chemical contaminants from drinking water. Figure 3 is a vividly illustrated comic strip public education warning about chemical contamination of drinking water published by the Rotterdam Waterwords.

The Environmental Movement

The environmental movement in Holland is the strongest in Europe, partly because of ecological pressures in this small lowland nation and because of a strong historical cooperative relationship between the older nature groups and government. The current relationship includes partial government funding of citizen organizations, unique to the Dutch. Such financial aid is not limited to environmental organizations, but occurs for other groups, e.g., citizens for mental health improvement and agricultural entities, as advocates of the goals of various government ministries.

Environmental groups are generally organized with volunteers at the county level,* with representation to a national coalition. The main coalition, Stichting Natuur en Milieu (SNM), has been in existence since 1972 and functions with a steering committee of 12. SNM works closely with members of Parliament and with government ministries. Its members sit on government advisory committees, and work on legislation and court appeals. Currently SNM is pressing for passage of a law mandating the use of Environmental Impact Statements prior

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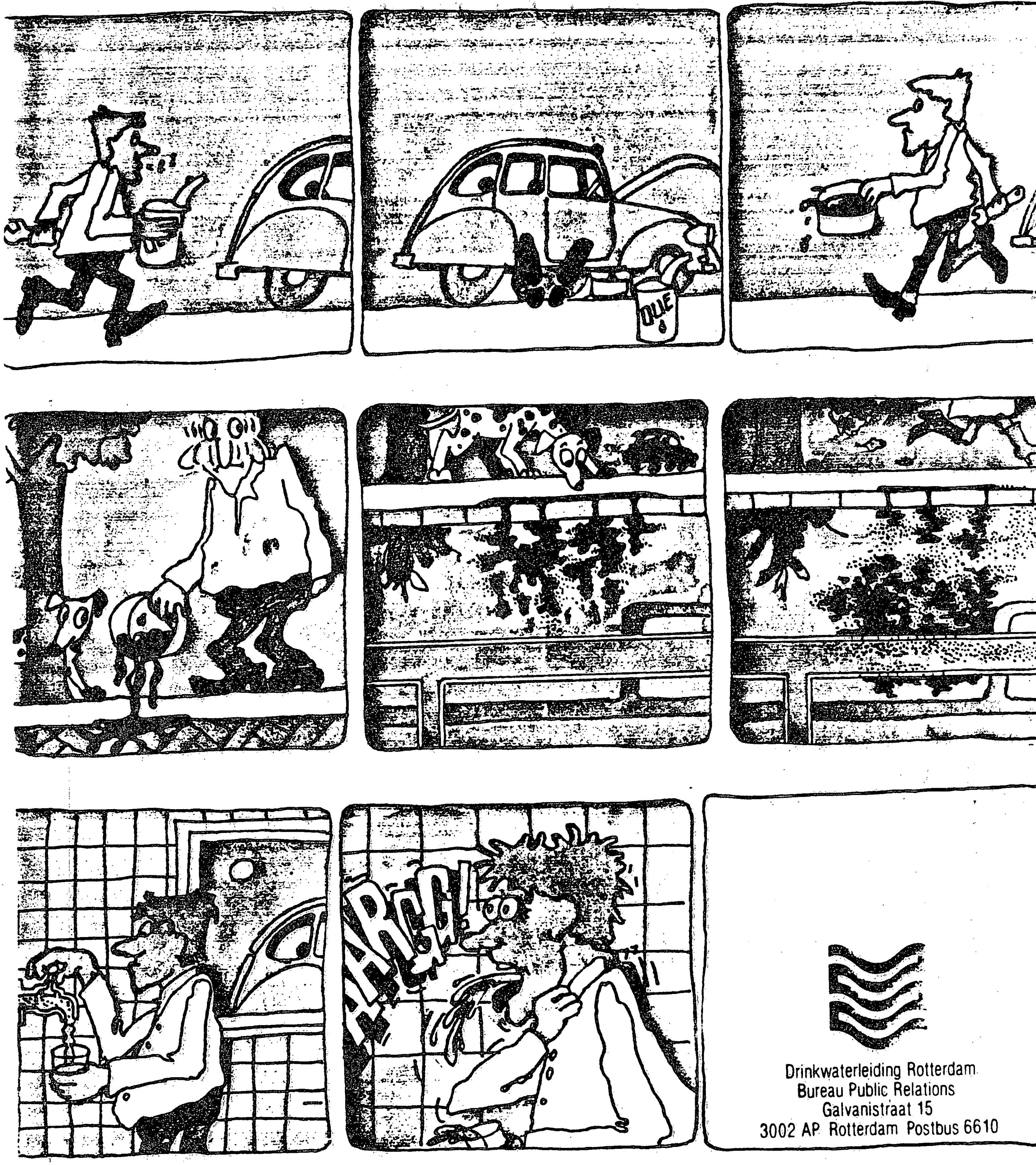
*There are 11 counties - or provinces - in Holland.



Drinkwaterleiding Rotterdam
Bureau Public Relations
Galvanistraat 15
3002 AP Rotterdam Postbus 6610

Figure 3

to development. This is patterned on the U.S. model. The 30 member staff of SNM is predominantly trained in environmental disciplines. For example, the groups' director graduated from an agricultural college and majored in water purification.

The SNM is funded 2/3 by two government agencies (The Ministry of Health and Environmental Protection, and the Ministry of Nature Conservation), with 1/3 coming from members and other fund raising. When asked if such dependence doesn't create conflicts of interest in possible citizen disagreements with government, it was explained that there are often conflicts between environmental protection and economic development among the 16 ministries of government. Many of these agencies represent economic factions and the two ministries charged with environmental and health protection are often at a disadvantage. In this setting, it is considered desirable to have a strong citizen voice in deciding issues which affect the public. In some instances the citizen groups have been at odds with their benefactor agencies. Even so, no threats have been made of funding withdrawal because of the valuable role played by the environmental groups. If such threats were made, however, the groups could have recourse directly with members of Parliament sympathetic to their concerns.

Dutch environmentalists have considered, but rejected, the move in Germany to establish a political party like the Greens to represent primarily environmental interests. They prefer to work with parties in the full political spectrum. This difference is in part a response to the more benevolent atmosphere for environmentalists in the Netherlands than in Germany where such citizen activities are more difficult. Currently, the two issues considered most serious by the environmental groups are nuclear power and chemical waste landfills with resultant ground water contamination.

A principal goal of the environmentalists is to inform the public of threats to health and the environment. In pursuit of this goal, an international group, Rheinaktion, based in Holland operates a boat to obtain water samples at various points along the Rhine near industrial outfalls, much as the Dutch waterworks have done. With information gained in this manner, the environmental groups hope to bring unfavorable attention to polluting businesses and counteract the secrecy of water discharge consents.

The Water Tribunal

Another direct response by environmental groups to the frustration of continuing water pollution, especially of the Rhine River, is the formation in 1981 of an international Water Tribunal to take place at the end of 1982 in Amsterdam or Rotterdam. The tribunal will bring to "trial" a half dozen or so major polluters primarily of the Rhine River and the North Sea. The principal goal is to publicize the issue and focus on major polluters especially of non-biodigradable chlorinated organics, including PCBs. An international scientific support group is being recruited. Very little use is expected to be made of lawyers, since the trial will be conducted outside of the formal legal system. This is because there are no legally binding standards for most of the discharged toxic substances, and often the polluters' activities have been legitimized by confidential consent agreements with government. In the fall of 1981 20 percent of the necessary funds were available to conduct the tribunal. It is expected that Dutch local and national government will provide almost half of the required funding. The tribunal effort is closely coordinated with various environmental groups, 10 of which signed as its original supporters.

Ground Water and Waste Disposal

The focus in Holland has been on surface water contamination because of heavy dependence on the polluted Rhine River as a drinking water source, especially for large cities in western Holland where ground water is brackish. Still, 2/3 of drinking water throughout the country is derived from ground water sources.

Currently there is no ground water protection legislation in Holland, although such a law has been proposed. Attempts have been made to protect ground water in specific parts of Holland's 11 counties, but this has not been successful partly because of the density of population and development. Surprisingly, even with Holland's dependence on ground water, it is still not known where all the aquifer recharge areas are or where these enter the country from Germany and France. Hazardous waste dumping has polluted ground water and wells have been closed as a result. One result of haphazard disposal occurred in the village of Lekkerkert, Holland's Love Canal, where houses were built in 1970-72 on landfill containing toxics such as benzene and toluene. The material under the houses is now being removed and incinerated.

Because of very high ground water levels, Dutch law prohibits landfilling of hazardous waste. However, the lack of adequate alternatives has pushed the government to grant exemptions. In 1979, of 360,000 tons of hazardous waste generated, 39 percent was land disposed.[7*] Dumping of hazardous waste, including nuclear waste, in the North Sea has transferred some of the problem to the international arena. Holland appears to be doing better with domestic waste disposal, with an emphasis on recycling of paper and glass. Almost half the paper used is reprocessed and street bins for glass recycling are common. Thirty-seven percent[**] of domestic waste is disposed of in 11 incinerating plants, with the bulk of the energy released used for electrical generation.[9]

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*In the U.S. it is estimated that 90 percent of industrial waste that is considered hazardous is landfilled.

**The comparable U.S. figure is one percent.[8]

One Dutch innovation allows the government to prohibit the manufacture of items which generate wastes "impossible or very difficult to dispose of" or which are "not properly stored, treated, processed or destroyed."[10] While this feature is not currently implemented, it is the first such legal expression known and allows citizen pressure for environmental protection.

Drinking Water Filtration in Coastal Dunes

The Dutch are increasingly concerned with the need to improve the chemical treatment of drinking water from degraded sources such as the Rhine River. They seek to emphasize natural purification such as slow sand filtration and removal of iron and manganese by aeration and filtration instead of by chemicals. Although health is a major factor in this goal, cost is another concern. One of the Dutch goals for the Rhine River is to have its quality sufficiently improved so that it is classified under EEC rules as A-1. EEC policy stipulates that rivers in this classification are suitable for the preparation of drinking water by natural methods only, whereas lower quality classifications require more treatment, including use of chemicals, to remove contaminants.[11]

In line with the interest in natural purification, is a unique use of coastal sand dunes in Holland to filter surface water. The practice of extracting fresh water which overlies the salt water strata from the coastal dunes used as a reservoir for rain water, has existed for almost 100 years. Since 1956 the city of Amsterdam has filtered pretreated Rhine River water through a dune area of 40 hectares (about 100 acres). The Dutch claim that dune filtration is more effective in removing toxic substances than river bank filtration used in Germany because of the slower water velocity through the dunes. With increasing use, there is however concern over saturation and break through of contaminants with resultant ground water degradation. Environmental groups are raising the issue of protection of the unique dunes ecology and one group - Stichting Duinbehoud - is devoted solely to this problem. Some of the unanswered questions here are: Are the dunes an adequate substitute for use of granular activated carbon in removing toxic organic chemicals? Does use of the dunes for drinking water purification help save the area from development as government officials claim, or does it destroy the local ecology by depositing chlorinated organics, nitrates and salts and by substituting a wet biota for the naturally dry biota, a concern of the environmental groups? Answers to these questions are currently being debated in Holland.

Reduced Chlorination

Another prominent factor in drinking water treatment in Holland is the policy toward use of chlorine for disinfection. In 1974 a chemist for the Amsterday Waterworks, J.J. Rook, announced his discovery of the formation of trihalomethanes (THMs) including chloroform, a carcinogen. The discovery of THMs, the result of chlorine interaction with natural organic material in water, was simultaneously announced in the U.S. by the Environmental Protection Agency. This finding caused a revolution among the waterworks in Holland and other parts of Europe in drinking water disinfection practices. In Holland alone, from 1976 to 1979 use of chlorine dropped from 2,100 to 1,250 tons per year, a 41 percent reduction.[12] This has led to intensified use of ozone (which also promotes toxic chemical breakdown) and chlorine dioxide, and a much lower tolerance for chlorine doses than are permitted in the U.S. For example, the average post chlorine and chlorine dioxide* use in Europe is 0.3 ppm, with less residue at the tap, or point of use. This compares to the permitted U.S. use of 3.0 ppm chlorine with a goal of 1.0 ppm concentration at the tap. Consideration is being given in Holland to eliminating post chlorination because of the effectiveness of slow sand filters in removing most bacteria. Chlorination is generally not applied to ground water in Europe whereas it generally is in the U.S. Thus, the same discovery of THMs in Europe and in

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*Post chlorination is performed at the end of the treatment process to produce a disinfectant residue not afforded by ozone use alone.

the U.S. has been acted upon differently.[13] The Dutch goal is to reduce maximum concentrations in drinking water of chlorinated organics, including THMs, to 1 ppb, the proposed national standard in Holland as well as that of the EEC. This compares to standards in Germany and Switzerland of 25 ppb and in the U.S. of 100 ppb. Because of its lowered chlorine use and advanced treatment methods, the low Dutch THM standard is felt to be readily attainable.*

Monitoring

Monitoring to determine drinking water contamination concentrations is performed much more frequently in Holland than in the U.S. for both organics and inorganics. These are checked every three months, in contrast to every year or every three years in the U.S. For sudden releases of larger amounts of chemical contaminants which occur with accidental or illegal spills, the Dutch rely on two methods. First and most important is an international alarm system for the Rhine River. The Dutch, downstream from Swiss, French and German discharges into the Rhine, use an early warning alarm system developed with Germany and Switzerland for spills and other mishaps on this busy commercial waterway. The second method involves the use of observed fish at critical points in raw water, e.g., where the Rhine River enters Holland.**

Research

Unlike the American Water Works Association, which represents U.S. water suppliers, the European water works conduct their own extensive research on

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*In the U.S., a coalition of waterworks have taken legal action on EPA's THM regulation and the matter is currently before the courts. At this point the regulation involves only monitoring for THMs with a maximum average standard of 100 ppb of four measurements per year.

**The observed fish method, developed in Holland, is an integral part of the Zurich drinking water treatment process.

all aspects of drinking water. The research arm of the Netherlands Waterworks Association (VEWIN), is the Netherlands Waterworks Testing and Research Institute (KIWA). Their research program currently includes:

- granular activated carbon types and alternative adsorbing agents;
- prevention of THM formation during chlorination by ion-exchange, activated carbon filtration and ozonization;
- the possibility of omitting breakpoint chlorination and process chlorination;
- the side effects of chlorination and ozonization;
- protection, monitoring and treatment of polluted ground water;
- toxicological quality of surface water, ground water and treated drinking water;
- testing of various materials used in the treatment and distribution of drinking water.*[14]

Following the example of the European waterworks, the American Water Works Association is exhibiting interest in establishing a research capability and has been visiting with the European waterworks and their research operatives, notably those in Holland and Germany.** Such an exchange could stimulate American water suppliers to become more active in advocating pollution abatement at the source as well as lessening their resistance to use of activated carbon, ozone and other technologies to improve drinking water quality.

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*The predominant use of PVC and polyethelene pipes in Holland is a source of concern. Aside from the possible leaching of plastics into drinking water under normal circumstances, some of these pipes have ruptured as a result of chemical spills, especially under gasoline stations with chronic leaks. In Amsterdam, where lead pipes are used, the concern is to maintain an adequate alkaline (hard) water balance to avoid lead contamination which occurs with acidic water.

**Drinking water research has been conducted by the Drinking Water Research Division of the USEPA in Cincinnati. A cutback in funding may, however, seriously hamper the work of this unit.

The Federal Republic of Germany (FRG)
(West Germany)

Institutional Comparisons with the U.S.

Consolidation of the German waterworks industry is a key factor in the progressiveness of their operation. In 1969 there were 15,000 separate waterworks in the FRG. These had been whittled down to 7,300 by 1977 primarily by consolidation of municipal waterworks. These statistics are especially interesting because they show a trend in western Europe which is counter to that in the U.S., where the number of waterworks grew from 20,000 in 1963 to more than 60,000 in 1981 as development spread to outlying areas. This is significant because more advanced drinking water treatment and monitoring -- especially for removal of toxic chemicals -- is possible at larger treatment facilities with better trained personnel and better equipment than at small facilities. The proliferation of small facilities is a troublesome issue in the U.S.

In the FRG, as in the U.S., national water laws are administered at the state (Laender) level and, as in the U.S., there are varying levels of control in the FRG's 11 states. Implementation is a key factor, and the FRG has the advantage of a civil service that compensates government workers as well as industry does for equivalent positions. This is a continual problem in the U.S. where government competes, often unsuccessfully, with industry to keep well qualified people to conduct increasingly complex environmental programs. One innovative system in the FRG is the use of lawyers and engineers working very closely in pairs to implement and enforce water regulations. This is often not accomplished as well as it should be in the U.S. where the legal and engineering disciplines are usually less formally wedded.

Public participation in environmental regulation is less well accepted in Germany than it is in the U.S. and in Holland. For example, in the public hearing process required for new development, only those parties directly involved may participate. This might include the developer-applicant and the land owner of the property in question. (There is, however, a proposal to give the public legal standing in such hearings.) Another example of public exclusion is in the regulation or standard setting process where only industry and government participate. In both of these areas, citizen environmental groups have participated increasingly in the U.S. in recent years, with involvement early in the process a principal goal. Generally the attitude in the FRG is less receptive to environmental citizen activism than it is in Holland where government works closely with, and helps to fund, citizen groups. Partly in response to this atmosphere in the FRG, the Greens political party was formed in the 1970's. By 1981 it had captured 5 percent of the seats in the German Parliament. The original focus of the party was on environmental improvement but this has broadened in recent years to include other political issues.

Ground Water Protection

The discovery in the FRG about 10 years ago of toxic organic hydrocarbons in drinking water was made possible with new analytical instruments, the mass spectrometer and gas chromatograph. These instruments first indicated surface water contamination and, in the last six or seven years, ground water pollution primarily from industrial activity.* Ground water pollution is widespread, and because it is the source of 2/3 of the FRG's drinking water, these findings are of increasing concern. One example of contamination occurred in the city of Karlsruhe, the location of the university which contains the research arm of the German waterworks. Here one half of the ground water beneath the city is condemned because of toxic chemical contamination from a dry cleaning storage tank. In Dusseldorf, one of the four ground water facilities has been closed because of chemical contamination. The principal sources of discovered contamination in the FRG are the metals industry (50 percent) and dry cleaning operations (20 percent).[1] Very little ground water monitoring is being conducted, however, and much more is necessary to know the dimensions of the problem. In an attempt to locate old World War II landfills which may be leaching toxic substances into ground water, local people are being interviewed for clues.

While Europeans, like Americans, have not paid sufficient attention to developing policies which would establish alternatives to toxic industrial waste landfilling, the FRG (and the Netherlands) have achieved more than the U.S. in instituting alternatives such as physical/chemical treatment and incineration. However, because of the economics of landfilling vs. incineration, landfills are still the predominant disposal method for domestic waste, also a source of ground water pollution. For example, for the city of Bonn, population 150,000, the construction cost of an incinerator was DM 120 million (about $50 million) compared to the cost of a landfill, DM 16 million (about $6 million).

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*Surface water pollution, especially relating to the Rhine River, is discussed in the section on the Netherlands, which has felt the greatest impact.

In an attempt to avoid urban sprawl and future water contamination, the FRG (and most European countries) use land use controls which are generally much more stringent than those in the U.S. For example, landscape protection areas comprise about 50 percent of the FRG and in these areas building variances are required.*[2]

Specific ground water protection regulations include the use of three protection zones in concentric circles. Zone 1, the smallest circle, covers the actual water withdrawal area. Zone 2, the middle circle, covers a 50-day flow area, based on the assumption that it takes that time for bacteria to become harmless.[5] Zone 3 includes the boundaries of the watershed. Regulation is most stringent for zone 1, least stringent for zone 3. While specific regulations vary from state to state, and with the geological features of the area, these are examples of some restrictions: In zone 2, and even in zone 3, trucks carrying chemicals of a certain type and volume can be prohibited on the roads. Chemicals are coded according to their hazard and the codes are displayed on the trucks. Trucks carrying larger quantities of the more hazardous chemicals, e.g., 1,000 liters (about 275 gallons) or more, may be prohibited in some zones.

Planning for future protection zones is still taking place. However, it is becoming more difficult because of conflicts with development and the desire of local governments for new ratables. This has slowed down implementation in many areas. For example, in the state of North Rhine-Westphalia, in the industrial heartland of the FRG, including the city of Köln (Cologne), it is estimated that 120 protection areas would be required to adequately protect ground water. Currently 38 such areas have been created and the rate is

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*The Federal Republic of Germany is about half the size of Texas. It has a population of 60 million.

now four new areas formed per year.[4] At this rate it will take 20 years just to designate protection zones. However, the public is becoming more aware of the problem and may be more supportive of controls. It is interesting to note that the guidelines for the protection zones are formulated by state government working with the local waterworks. This is representative of a much greater involvement by European waterworks in watershed protection than exists in the U.S.

Industrial use of high quality ground water has become an issue in the FRG. This has come about because of "grandfather" laws which permit such use, even when it competes for use as drinking water. Both the waterworks and environmentalists have spoken out against this practice. In contrast to this tradition, the Swiss limit industrial use of ground water to bacterially contaminated sources near habitation. This is true even though the Swiss depend primarily on surface water and the Germans depend on ground water for 2/3 of their supply. In at least one German city, however, innovative measures have been taken to preserve high quality ground water for drinking. In Köln a separate water supply was developed using Rhine River water of inferior quality for industrial purposes only.[5]

Damage Charges for Industrial Polluters

Based on highly confidential effluent discharge consent agreements between industry and government, a system of charges based on "damage units" (Schadeinheiten) is used in the FRG. The damage units are based on the type and quantity of effluent emitted.* This system, embodied in a national water

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*Standards for most of the organic toxic chemicals now being discovered in surface and ground water have not yet been formulated. An attempt by the author to obtain a sample list of chemicals and quantities discharged along with the damage charges, but without corporate identification, was not successful. The issue of confidentiality is discussed more fully in the sections on the Netherlands p. NL-4, and on Great Britain p. GB-3.

law (Abwasserabgabengesetz), has failed to achieve adequate quality improvement. Originally, the charges were to be high enough to serve as an incentive to quicker clean up. However, in parlimentary debates the charges were lowered, making them less effective. Other problems include difficult local implementation in face of industry threats of plant closings if the charges are pressed. It is also reported that the incentive is ineffective for municipally owned sewage plants, many of which accept industrial effluents, because the fees are simply paid from the left hand to the right hand. Such a situation existed in the city of Bremen which preferred to pay its damage charge to the state of Bremen (no net burden on taxes) rather than to raise the money necessary to upgrade its sewerage operation.[6]

Critics of this system claim that the low penalties, based on data from industry, and varying state implementation have created weak controls. Some have argued that the charges have become a license to pollute and that they should be eliminated in favor of a national mandate for use of best available control technology by industry for pollution abatement.[7] This has been the prevailing thought in the U.S. where environmentalists have traditionally resisted a payment system similar to that in Germany.

German law provides for both civil and criminal penalties for water pollution violators. However, in actual implementation, it is very difficult to pinpoint criminal charges and no one in the FRG has ever gone to prison for violating water pollution regulations. The upper limit of DM 500,000 (about $200,000 in 1981) for a civil violation is rarely, if ever, levied.

One innovative German requirement which appears to be effective is that all larger industrial plants have a qualified person responsible for meeting environmental regulations. In theory this person is responsible to the community as well as to his corporate employer, and is protected from actions by the company.

As a result of increased regulation during the 1970's, certain environmentally burdensome products are becoming less profitable and may eventually be phased out. The internalization of once external (or societal) costs, e.g., use of the air and water for cheap disposal, is taking place at corporations like the international Bayer Company, one of the three largest chemical firms in Europe.* Its major facility, located on the Rhine River, has 40,000 employees and operates 365 days a year, 24 hours a day. It produces 6,000 chemicals, 60,000 by-products, mostly unwanted, and 46 compounds which must be controlled.[8] While the company points with pride to its advanced waste treatment facilities, environmentalists in Germany and Holland cite it as a major polluter which should be made to do better. According to one source, the chemical industry is "by far the worst water polluter" in Germany with only 20 percent of its effluents cleaned up before discharges to waterways.[9]

Granular Activated Carbon

In recent years, the use of granular activated carbon (GAC) filters has increased greatly in the FRG and elsewhere in western Europe as a result of pioneering research and promotion by Professor H. Sontheimer and his colleagues at Karlsruhe University.** GAC was first employed in Europe about 20 years ago in response to taste and odor problems in drinking water. With the development of advanced analytical instruments it became possible about 10 years ago to detect parts per billion of synthetic organic chemicals in drinking water, some of which are toxic and carcinogenic. It was at this point that

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*German revenue, DM 12 billion (about $5 billion in 1981).

**More than 30 drinking water treatment facilities in Europe now use GAC to remove toxic chemicals. About 20 of these are in the FRG.

GAC began to be used differently, principally to remove synthetic organics. The major difference in this use is the frequency with which the GAC filters are regenerated. For taste and odor improvement the filters can be used for two to three years before regeneration. For removal of industrial chemicals regeneration must be much more frequent. Karlsruhe researchers recommend regeneration no less than every three months. Bremen University's drinking water group recommends a shorter period, every four to six weeks. Legal standards for regeneration do not exist in Europe and each individual water treatment plant must work out its own timetable. For example, the Köln waterworks regenerates its GAC filters every 12 to 14 months. It does, however, claim to get good removal of organics using a total organic carbon (TOC) measurement. A typical TOC reading here before GAC use is 1.3 to 1.4 ppb and .06 ppb after.[*10] The capacity to remove chemicals is directly related to the loading of the filter and this can vary somewhat depending upon the raw water source. One argument put forth at Karlsruhe in defense of the lack of standards is that if they existed some waterworks would improve just up to the standard and do no better.[11] This, of course, does not take into account that some waterworks, especially small ones, may not meet a minimal standard on their own.

In response to the concerns raised by water suppliers in the U.S. who have resisted the use of GAC, researchers at Karlsruhe, answered this visitor's queries as follows:[12]

Problem: GAC filters can desorb releasing concentrated toxic substances. Response: With ordinary care and monitoring this should not occur. Large desorptions are not common. Problem: Bacterial growth on GAC filters

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[*] Two of the most common organics found are trichloroethylene and tetrachloroethylene. The proposed U.S. critera for these are 2.1 ppb and 0.2 ppb respectively.

is harmful. Response: Biological growth on filters helps in synthetic organic chemical removal. No known pathogens result from this growth. Problem: The chemicals and concentrations in European waters are different (and higher) from those in the U.S. Thus GAC may not be needed in the U.S. Response: Similar industries in Europe and the U.S. will cause similar water contamination. It is unlikely that the differences are large. Problem: GAC costs too much. Response: The cost of all treatment is a small part of the total price of water delivery, about 10 to 20 percent in Europe. GAC is well worth its cost.

Research is going forward on other chemical removal technologies, e.g., resins, as alternatives to GAC. In the meantime, the consensus is that while GAC may not be the perfect solution to all problems, it is an interim solution until water quality is sufficiently improved or until a better control technology is developed. It should not, however, be used as a substitute for water pollution abatement. Older, natural methods, such as slow sand filtration and river bank filtration are receiving renewed appreciation for their ability to remove some chemical contaminants.

Disinfection Alternatives

The use of ozone is recommended at Karlsruhe because of its ability to destroy both bacteria and viruses; (it kills viruses better than chlorine) and to reduce sythetic organic chemicals to a more biodegradable form. Because ozone does not produce a bacteria-destroying residue in the distribution system, an additional disinfectant may be needed in the finished water. Chlorine dioxide, rather than chlorine, is recommended for this purpose. The preference for chlorine dioxide is attributed to its lack of taste and because it does not readily form trihalomethanes (THMs), including chloroform, a carcinogen. Both of these are drawbacks to chlorine use. One drawback of chlorine dioxide is its formation of chlorides.* When asked about the energy-intensiveness and toxicity of ozone, concerns raised by water suppliers in the U.S., the response at Karlsruhe was that ozone is a very small percentage of the cost of water treatment (smaller than GAC) so that cost should not be a barrier, all things considered. The toxicity of ozone, it was stated, is readily removed by storage in pipes for one half hour and has not presented any problems.[13]

In the FRG, and in western Europe generally, chlorine is used much less than it is in the U.S. For example, the maximum chlorine limits in Germany and other European countries is 0.3 ppm, with less residue than that at the tap, or point of use, e.g., .08. The U.S. permits 3.0 ppm chlorine with a general goal of 1.0 ppm at the tap. Many waterworks in Germany do not prechlorinate** their water because of good filtration achieved with the activated carbon. At least two large waterworks in the FRG do not use either ozone or chlorine. These are in Hamburg (population, 2.2 million) and Munich (population, 1 million). These facilities do, however, monitor their water very frequently.[14]

Because of much reduced chlorine use, the German waterworks appear to have no difficulty in meeting the national THM standard of 25 ppb. This standard is less stringent than the proposed European Economic Community (EEC) and Dutch standard of 1 ppb, but stronger than the U.S. standard of 100 ppb. That occurrences in the U.S. can affect European decisions in this area, is illustrated by the debate which ensued during the THM regulation in the FRG. The U.S. standard was used as an argument for keeping the German standard at 25 ppb rather than at a lower level. It will eventually have to be lowered under the current EEC proposals.

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*See the section on Switzerland, p. SW-4, for the Zurich waterwork's method of reducing chlorides.

**Prechlorination is disinfection early in the treatment process creating a longer contact time with precursor organics in raw water and allowing greater formation of THMs.

Agitation for Improvement

While the official German waterworks research group is based at Karlsruhe University, and much research has been conducted there under the supervision of Professor H. Sontheimer on activated carbon filtration, ozonization, river bank filtration, as well as other drinking water treatment, the emergence of a new drinking water research group at the University of Bremen is of interest. Here in the Department of Biology/Chemistry, under the supervision of Dr. W. Thiemann, a less establishment-oriented group has been conducting research on drinking water and speaking out on the issues.[15] The group first became involved as a result of contamination of Bremen's water supply, the Weser River, from salt discharges in East Germany. It succeeded in having the city's source switched to ground water. It was, however, the publication in 1981 of a book, "Wie Krank ist Unser Wasser?" ("How Sick is our Water") by members of this group, Ewe Lahl and Barbara Zeschmar, that focused attention on the broader policy issue beyond technology.[16] Following are some of the recommendations in the book:

- reduction of toxic chemicals in water by use of best available control technology instead of allowing industry to "buy itself the freedom" to pollute via damage charges (based on confidential agreements with government);
- stronger laws against water pollution with adequate financial penalties (to serve as an incentive to clean up);
- development of an overall national plan for ground water protection for siting of new development, rather than just local regulation;
- priority use of ground water as drinking water rather than for industrial use (as is now encouraged by law).

The book and a comprehensive article in the popular magazine Der Spiegel,[17] sed on some of the information generated in Bremen, have helped to bring ublic attention to water quality issues. In the FRG, as elsewhere, this is a critical step to improvement.

Switzerland

In Switzerland, a visit was made to the Zurich city waterworks, described as a showplace because it employs perhaps the most advanced drinking water purification system in the world. Indeed, one is impressed with the fact that even though the city enjoys the benefit of excellent alpine sources, it has still taken extraordinary measures to safeguard its drinking water from chemical and other contamination.

The city of Zurich (population 400,000) is situated at the downstream end of the long, narrow Lake of Zurich at the point where the River Limmat flows out. The lake provides 70 percent of the city's drinking water, the other 30 percent being groundwater. Until recent times the lake water was crystal clear and quite pure. But with burgeoning development in the 1950's and 60's, the lake became significantly polluted by sewage from the many small towns along the shores (present aggregate population 100,000).[1] Drastic improvement of the sewage plants, including phosphate removal to prevent algae growth, has considerably improved the lake water in recent years, so that while it is not pristine, it is much better than most of the surface water available to the millions who live elsewhere in the Rhine basin. There is no significant polluting industry upstream of Zurich.

Drinking Water Treatment

Zurich's Lengg plant, built in 1960 and enlarged in 1975, is probably the world's most modern drinking water treatment facility.* It processes only lake water. Until 1969 the plant used only the simple purification methods of slow and rapid sand filtration. But problems of taste and odor and especially an accidental spill of phenol in the lake in 1967 raised the public's consciousness about the vulnerability of its water. Under the vigorous direction

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*Zurich's three water treatment plants employ a total of 290 people.

of Maarten Schalekamp, a new waterwork director who hailed from Holland at the other polluted end of the Rhine, the Lengg plant was expanded to include the following processes:

- prechlorination (to kill mussel larve which pass through filters)
- fast sand filtration (a mechanical process)
- ozonization (1.5 ppm) for chemical breakdown and disinfection
- granular activated carbon filtration to remove organics
- slow sand filtration (a biological process)
- chlorine dioxide (.04 ppm) for disinfection residue in the distribution system.

One important innovation in the treatment process is the use of fish, analogously to canaries in coal mines, to give early warning of contamination. The fish test is elegantly automated: A sample stream of the water to be tested flows continuously through a glass tube about six inches in diameter. The fish swims upstream inside the tube, constrained on the upstream side by a screen and on the downstream side by automatically administered electric impulses that encourage the fish to swim faster. If the fish is weakened by pollution so that it falls back frequently, in spite of the electric impulses, automatic sensors cause alarm lights to flash in the waterworks' control room. Fish tests run continuously on both the input and output sides of the plant. (On the output side the fish must be artificially fed, on the input side, they fend for themselves.) The output test is considered to be an important safeguard against accidental overloads of treatment chemicals, such as aluminum sulphate (used for flocculation). In Switzerland the fish used are trout, which are especially sensitive to contamination. It was said that less sensitive species such as carp are sometimes used elsewhere, presumably because the raw water will not support trout.

By prohibiting the use of plastic pipe, the Swiss have avoided a number of problems encountered by the Dutch, who used plastic pipe extensively in their distribution systems. Among these are leaching of contaminants from the plastic into the water and dissolving of the pipe by solvents percolating through the soil from accidental spills and leaking fuel tanks.

Granular Activated Carbon (GAC)

To remove waterborne chemical contaminants 12 GAC filter beds of Dutch anthracite coal are used. Regeneration of the GAC to purge the accumulated chemicals is conducted in one bed at a time in an on-site fluidized bed kiln heated to 800°C (1,472°F). The kiln produces 200 pounds of regenerated carbon per hour, with a loss of about 10 percent of the original material. As in Germany and in other countries which use GAC, the Swiss do not have standards for frequency of GAC regeneration. In Zurich it is felt that the GAC can be regenerated every one to three years because of the good raw water quality. (In Germany, it is recommended that regeneration occur at least every three months). This is important because regeneration can be costly.

In discussing the concerns expressed by waterworks officials in the U.S. who have resisted GAC use, the chemist in charge of the Zurich water treatment laboratory stated that GAC is one of the most reliable parts of the treatment system.[2]

Monitoring

In Zurich monthly tests are conducted for organic and inorganic chemicals, although Swiss law does not currently require such monitoring. The method used to conduct tests for organics is to heat the GAC and weigh how much is driven off the filter. This yields a composite of organic chemical content rather than measurements of specific chemicals. At Karlsruhe University, where the

German waterworks research is conducted, they prefer to analyze the water coming through the GAC rather than the GAC contents itself. At Karlsruhe there is, however, a preference for use of a total organic carbon (TOC) reading as an "elite parameter" to indicate the presence of organic water contaminants, somewhat the Swiss method. The significance of these total or composite organic readings can be seen in a comparison with the preference in the U.S. to promulgate standards ("Maximum Contaminant Levels") for individual chemicals, a limited control in relation to the hundreds of toxic chemicals of concern, and a method which may take many years of standard setting as well as complicated monitoring.

Disinfection Alternatives

Since 1957 ozone has been used in Switzerland as a disinfectant, primarily because of objections to the taste of chlorine. After the 1967 phenol spill in Lake Zurich, ozonization was employed at the Lengg treatment plant because of its ability to promote chemical breakdown as well as disinfection. In order to lessen the formation of THMs, including chloroform, very little chlorine is used. Instead, chlorine dioxide is used at the end of the treatment process to produce a residual disinfectant in the distribution system, not possible with ozone use alone. The Swiss have found chlorine dioxide to be a more effective disinfectant than chlorine, but use it primarily because it produces less THMs and will help meet the Swiss national THM standard of 25 ppb, the same as the German standard, and considerably lower than the U.S. standard of 100 ppb. In an explanation of the prevailing thought on this subject, Zurich's waterworks Director Schalekamp wrote:

> "As to the removal of organic substances, ozonization and active charcoal filtration (GAC) yield the best results. Despite the massive reduction of organic substances, mainly humic acid compounds, halogenated hydrocarbons are produced as an undesirable side effect of chlorination. If chlorine is replace by chlorine

dioxide, chloride is released and this is converted to chlorate in the course of treatment, especially by ozonization. This can be prevented by removing chloride by means of active charcoal at the beginning of the treatment.[3]

The maximum chlorine or chlorine dioxide use allowed by Swiss law is 1.5 ppm (in Germany 0.3 ppm; in the U.S. 3.0 ppm). One of the drawbacks of ozone is its energy-intensiveness. To control energy use in general, the Zurich Waterworks pumps water into reservoirs at night when energy costs are lower.*

Ground Water Protection

The Swiss require ground water (and spring water) protection zones in which development may not occur within 180 ft. (55 meters) of wells. In well areas with close proximity to highways, Zurich's Hardhof ground water facility has built three large retention basins where water runoff is treated by slow sand filters covered with a layer of GAC 10 centimeters (about 4 inches thick). The GAC also removes much of the chlorine dioxide used to eliminate reservoir algae. In addition, well heads are mounded to allow water runoff.

Industrial use of ground water is generally limited to bacterially contaminated sources near habitation. This is in contrast to the practice in West Germany where "grandfather" laws allow industrial use of pure ground water in competition with use for drinking water.

Security Arrangements

One of the most interesting aspects of the Zurich visit was the demonstration of security arrangements in the event of war, accidental toxic spills, deliberate contamination, floods, etc. That the Swiss are highly security conscious is illustrated by the extraordinary measures taken to protect Zurich's

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*The Swiss produce 80 percent of their energy from hydropower and 20 percent from nuclear power.

water supply system, beyond the actions discussed above. These measures include the following:

- Ground water pumping is conducted at 60 ft. (18 meters) below the ground surface and since 1974 has been protected against attack - including nuclear - by thick concrete and metal walls. The metal layer is designed to shield the electrical equipment associated with the pumps from the electromagnetic shock which results from a nuclear explosion above the atmosphere.
- Two portable vans are available for emergency use. One van can purify water to a potable standard; the second van packages emergency water supplies for use in individual households. The packages are sealed plastic bags each containing one liter (about a quart) of drinking water. The bags can be stored as an emergency stock for up to five years.
- Zurich has 900 fountains throughout the city which are fed by gravity flow from springs with no pumping required. The fountains have been kept in operation for their beauty and historical value as well as the alternate pure water supply they afford.

Water Use and Cost

Per capita water use in Switzerland is comparable to that in the U.S., almost 100 gallons (400 liters) per day per person, and is almost double the consumption in most European countries. One wonders about the cost of the advanced treatment network in Zurich. Water here is priced to cover all costs of the waterworks, which are an integral part of Zurich's municipal government. Industry pays the same unit rates as do households, and thus has the same financial incentive to conserve. This differs from the practice in many countries, including the U.S., in which industrial users are charged less than households, and thus have weaker incentives to conserve. For their deluxe system, the people of Zurich pay an average of $1.50 per thousand gallons* compared to the average western European price of $3.00 and the U.S. price (without advanced control technology) of $1.00 plus. The lower Swiss price

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*One franc per cubic meter.

may be due in part to better source quality, which requires less GAC filter regeneration, as well as to other factors. Water rate increases are decided in public referenda (as opposed to Public Utility Commission decisions prevalent in the U.S.). In Zurich the public has supported improvements to its water system in 95 percent of the proposals in recent years.

The overriding philosophy in Zurich - which can serve as a model to other communities - is that since treatment represents a small part (20 percent) of the total cost of water supply (80 percent for distribution and all other costs), the city can afford to have high quality standards and employ preventive measures for public health protection.

Great Britain

The most notable feature of water management in Great Britain is the passage in 1973 of The Water Act enabling the formation in 1974 of 10 regional Water Authorities to manage the full water cycle for the 50 million people of England and Wales.

The Water Authorities

The Water Authorities, whose jurisdictions are natural watersheds (see Figure 4), deal with all aspects of water management including: supply, drinking water treatment, sewerage, pollution, fisheries, recreation and flood control. Integrated water management represents a major reformation in England and Wales, which previously had highly segregated functions for water supply and water pollution control and had generally followed the fragmented approach to water management prevalent in most countries, including the United States.* The regional approach is especially effective in Great Britain with its island geography and relatively short rivers contained within its own national boundaries, a quite different situation from the international rivers on the Continent, e.g., the Rhine which runs through four European countries.

The ten regional authorities took over complete ownership of the facilities of 1,609 separate local agencies. This change took place simultaneously with a national reduction of local government units from 1424 to 456 for more efficient operation.[1]

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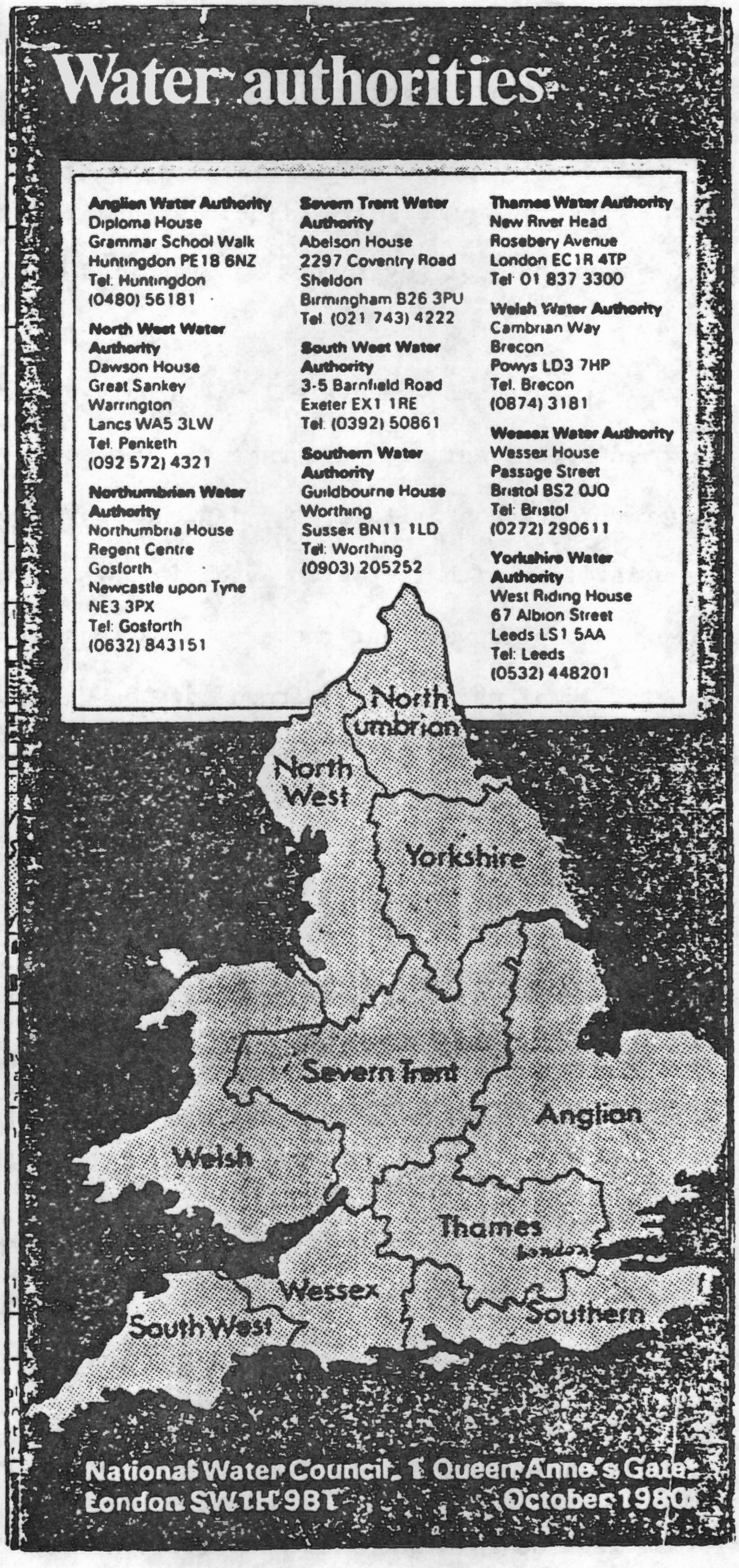
*In the U.S., the number of drinking water supply systems alone has grown from some 20,000 in 1963 to more than 60,000 in 1981. This is the result of development in once rural or suburban areas and is counter to the trend of consolidation not only in Britain, but in other European countries such as Germany and the Netherlands. In the U.S. this has resulted in many small water suppliers who cannot meet regulations for adequate monitoring or treatment of drinking water.



Water authorities

Anglian Water Authority
Diploma House
Grammar School Walk
Huntingdon PE18 6NZ
Tel. Huntingdon
(0480) 56181

North West Water Authority
Dawson House
Great Sankey
Warrington
Lancs WA5 3LW
Tel. Penketh
(092 572) 4321

Northumbrian Water Authority
Northumbria House
Regent Centre
Gosforth
Newcastle upon Tyne
NE3 3PX
Tel: Gosforth
(0632) 843151

Severn Trent Water Authority
Abelson House
2297 Coventry Road
Sheldon
Birmingham B26 3PU
Tel (021 743) 4222

South West Water Authority
3-5 Barnfield Road
Exeter EX1 1RE
Tel. (0392) 50861

Southern Water Authority
Guildbourne House
Worthing
Sussex BN11 1LD
Tel: Worthing
(0903) 205252

Thames Water Authority
New River Head
Rosebery Avenue
London EC1R 4TP
Tel 01 837 3300

Welsh Water Authority
Cambrian Way
Brecon
Powys LD3 7HP
Tel. Brecon
(0874) 3181

Wessex Water Authority
Wessex House
Passage Street
Bristol BS2 0JQ
Tel: Bristol
(0272) 290611

Yorkshire Water Authority
West Riding House
67 Albion Street
Leeds LS1 5AA
Tel: Leeds
(0532) 448201

National Water Council, 1 Queen Anne's Gate
London SW1H 9BT
October 1980

Figure 4

Authorities are composed of appointed and elected officials. For example, the Chairman and 16 other members of the Thames River Authority, which includes the city of London, are appointed by the national Secretary of State for Environment; the other 36 members are officials appointed by local elected government. In this manner local government has retained some decision-making power.

The Authorities are autonomous and are limited only by available funds which must be approved by the national government. Due to the current economic recession and budget cutbacks in Britain, the national government is more involved in setting priorities with the Water Authorities. Between the regional Authorities and the national government there is a National Water Council consisting of 20 members, 10 of which are Chairmen of the Water Authorities. Currently the Council is a coordinating and advisory body but it may become a supra water authority with more power.

Because the Water Authorities are both polluters (as operators of sewerage facilities) and pollution control agencies, a conflict of interest is inherent in their mandate. It was explained that the functions of the sewerage facilities and that of pollution control are kept separate. Also, because the members of the Authorities represent local as well as national government, they can insist that the Authorities conform to Discharge Consents. Since Discharge Consents, i.e., discharge permits, including those for sewerage, are issued by the Authorities, this is a sensitive area which requires general public as well as government vigilance. In line with this, and as a result of media criticism that the Authorities are not as accountable as the local agencies were, the Monopolies' Commission, which investigates entities such as utilities, recommended that the Water Authorities be reduced in membership for efficiency, but that they have Consumer Councils consisting of citizens from various segments of society.

Laws and Standards

The 1974 Control of Pollution Act pertaining to water pollution has not yet been implemented, a fact that is causing concern in various quarters. Such implementation would extend protection to coastal and ground waters. A key innovation of the Act is its requirement that Discharge Consents and the results of water testing be made public. Currently Water Authorities may publish this data but only with the agreement of the discharger. Some Water Authorities do publish this information and list the industries who have refused to agree to public disclosure.[2] The law will also require the Water Authorities to publicly disclose their own sewage discharges. This is significant since 70 percent of all industrial effluents in Britain are channeled through the Water Authorities' sewerage plants. Confidentiality of discharges is an important issue in Europe where protection of the proprietary rights of industry has priority over the public's right to know how public waterways, including drinking water sources, are used. In the United States such information is available to interested members of the public. It has been used, for example, by the General Accounting Office, an arm of the U.S. Congress, to expose deficiences in the discharge permit system.*

Implementation of the 1974 law for water protection has been delayed ostensibly because of the economic recession in Britain, but pressure is building for implementation. Currently, financial penalties for violations of water laws are not a sufficient incentive to pollution abatement because they have not kept pace with inflation and they are difficult to enforce, although the accompanying publicity can be damaging to a company.

The British do not have their own uniform national drinking water standards and are guided only by the World Health Organization (WHO) recommendations of 1970

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*For a discussion of the actions of the Dutch Waterworks to counteract the secrecy of discharges into the Rhine River see p. NL-4.

which pertain primarily to inorganics (but does not include a standard for highly toxic mercury). They will however adopt the drinking water standards in the European Economic Community (EEC) Directive of 1980 expected to be effective in 1985.* The British also rely on a general maxim that potable water be "wholesome." There is however no legal definition of "wholesome" and each Water Authority decides how to meet this amorphous goal. The lack of standards for synthetic organic chemicals (SOCs) coupled with a minimum of monitoring for toxic substances in drinking water has led to an informal reliance on observed fish kills, an uncertain determinant of chronic, low level contamination, although it may indicate large illegal or accidental spills after the fact.

Lobbying for environmental laws and standards is much more low key in Britain than it is in the United States and in the Netherlands. A prime reason for this is the governmental structure whereby department ministers (including the Minister of the Environment) are also members of Parliament, having access to the legislative machinery of the administration. While the economic recession has caused less money to be available for program implementation, there have been no moves to weaken existing environmental legislation, even under the Conservative Thatcher government. This is in sharp contrast to the steps taken in the U.S. by the Reagan administration. In general, there appears to be a greater acceptance on the part of industry in Britain of government control of pollution and less lobbying against regulation. This is partly attributed to the historically less contentious relations between government and industry than exists in the United States, where much landmark environmental legislation has been enacted in the last decade.

Water Use and Cost

Water use in Britain is categorized by upland-surface water, lowland-surface water, and ground water, with each supplying one third of the nation's

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*EEC environmental directives generally will bring national standards to Great Britain, where decentralized government has prevailed.

total source (or 2/3 surface and 1/3 ground water). Upland water is original source water which can contain agricultural wastes; lowland water is reused water further down the course and usually contains industrial wastes. It has been used only for the last 50 years because of population and industrial growth. Water use in Britain is 200 liters (50 gallons) per person per day,* about half the use in the U.S. and Switzerland, but typical for other European countries. The average water cost is about the same as that in the U.S., about $1.00 per 1,000 gallons or $100 per year, much lower than the average Continental cost of $3.00 per 1,000 gallons, although the British cost is based on the ratable value of a house, complicating comparisons. Like the U.S., Britain has not gone to the common use of control technology (granular activated carbon filtration and ozone) to remove toxic chemicals in drinking water and lessen the formation of trihalomethanes caused by the use of chlorine for disinfection. This does not however account for the major price difference since distribution is the principal cost, e.g., in Zurich about 80 percent, with treatment only about 20 percent.

Surface Water

Surface water comprises 2/3 of the total drinking water supply in Great Britain compared to 1/2 percent in the U.S. and 1/3 in West Germany and Holland. It is, thus, an especially important factor in water management here. The emphasis in Britain is on overall river quality with effluent criteria to meet these goals. This approach differs from that in West Germany and in Holland, for example, which focus on individual discharges rather than overall river quality. This is partly because of the international nature of many Continental water courses. While it is accepted on the Continent that effluent standards

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*Only four liters of this is used for human consumption.

are intended to control river pollution, the view is also held that effluent standards should be uniformly fixed, that is all effluents should meet the same standards regardless of river conditions. The declared intention of the EEC in pursuing this idea is to ensure that the burden of purification costs is the same for all EEC countries.

In Britain, with 70 percent of industry discharging effluents into sewerage plants controlled by the Water Authorities, greater government control is possible than with direct discharges to water courses.* Industries pay for the conveyance and treatment of their effluent in proportion to its volume and strength thereby creating a financial incentive to reduce the pollution load. Inspectors collect industrial effluent samples to ensure that harmful substances do not enter the system. Pretreatment of industrial wastes is generally required for chemical operations discharging into sewerage systems.

Land use planning in the siting of new development is considered a major determinant of effluent control. Such planning is generally more stringent in Britain and the rest of Europe because of space constraints than it is in the U.S. with its vast lands and cowboy philosophy. One notable example of such tight controls exists in the area of the Thames River, the drinking water source for 12 million people, including London. For more than 100 years all discharges and other activity affecting the fresh water Thames were controlled by the Thames Conservency, the predecessor of the current Thames River Authority.[4] Over this period, and long before such controls existed elsewhere, the activities of farmers, industry, sewerage authorities and waterworks were regulated in order to preserve the quality of the Thames as a drinking water source. The

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*In Britain 95 percent of household are connected to public sewers. It is estimated that the figures for other countries are: Holland, 88 percent; West Germany 80 percent, U.S. 75 percent.[3]

fresh water Thames thus has relatively little heavy industry. Such industrial development was however permitted downstream from water intakes in the tidal Thames before it empties to the North Sea, and here pollution has been a serious problem. For example, on the Thames and in England generally, petrochemical refineries are not sited inland but are located instead in nonpotable downstream, salt water estuary areas.

The improvement of river quality in Britain in recent years is largely attributed to the closing of coal gasification plants (with the availability of gas and oil from the North Sea) which placed phenols and other chemicals in waterways. In the U.S., which is planning to develop coal gasification, this will be one of the hazards to try to avoid. One goal for the Thames, as well as some other British rivers which formerly supported salmon, a species which cannot live in polluted waters, is to improve water quality sufficiently to develop salmon fisheries.

Britain has four general classifications of rivers from A1 to A4 according to quality. Most rivers are in the A1 and A2 groups. Where A3 rivers are used for drinking water, a program is in progress of moving drinking water intakes upstream of pollution sources. This program is facilitated by the existence of regional water agencies which deal with an entire watershed, rather than fragmented control by many small local government and private entities.

The two water quality problems considered most serious in Britain are nitrates and lead. Intensive agriculture in this small country is the principal source of nitrates in water. This has heightened as increasing amounts of land have gone from the control of farmer/owners to large real estate holdings including banks, with tenant farmers. Without a long-term interest in the area, increased yields are sought through greater use of fertilizers and pesticides with less soil erosion control. Britain uses a nitrate water standard of 50 ppm as a warning of a problem, and 100 ppm* as an allowable upper limit. Some wells with over 100 ppm nitrate have had to be abandoned. Concern has been expressed that the EEC has supported the interests of the large real estate holdings to the detriment of small farmers thus, perhaps unwittingly, fostering an intensification of the nitrate problem.

The lead problem stems from the predominant use of lead water pipes until 1960, and the prevalence in Britain of acidic waters which cause the leaching of lead. Action has been taken in some cases to treat water to reduce its acidity.

Because of the focus on these two contaminants with known deleterious health effects, the British have not paid much attention to synthetic organic chemicals and trihalomethanes in drinking water, although this appears to be changing.

Ground Water Protection

One reason for greater attention to synthetic organic chemicals is the increasing evidence of ground water pollution primarily with trichloroethylene (TCE), a carcinogen, suspected of emanating from unauthorized sludge disposal of dry cleaning operations, and with nitrates from agriculture.

Aquifer protection programs are conducted independently by the Water Authorities. A national program for such protection will not be possible until implementation of the 1974 Control of Pollution Act, extending coverage to ground water. One regional program is that of the Severn-Trent Water Authority, in the midlands area including the city of Birmingham, the second largest in Britain. Its drinking water source is 40 percent ground water. The program establishes

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*The equivalent U.S. standard is 10 ppm.

a four-zone structure of control for siting new development, depending on the degree of aquifer protection required. Zone One encompasses a radius of about 1 kilometer (approximately 1/2 mile) which can be increased or decreased according to geological circumstances. This zone is to receive maximum protection because of its proximity to a drinking water source and its vulnerability. Areas overlain by significant thicknesses of low permeability strata can however be exempt from strict protection. Such a low permeable strata can be clay or what the British call chalk, a finely powdered, relatively unfissured layer of limestone. In Zone One the "authority will usually object in principle to all development proposals which, either individually or in combination with other similar developments, would result in, or would be likely to result in, pollution of ground water or derogation of a ground water source."[5] Such development includes:

- Waste disposal sites, excluding incinerators and transfers, provided adequate protective measures were agreed upon;
- Residential development which cannot be connected to a public sewer;
- Industrial development which involves the use or handling of toxic or potentially polluting material unless adequate protective measures are agreed upon;
- Intensive agriculture;
- Sewage or industrial effluent treatment;
- Discharge of surface water runoff.

While there is a great deal of leeway provided in the wording of the prohibitions to allow, for example, the handling of toxic materials rather than an outright ban in this most protected zone, the plan does permit a determined Water Authority to wield a powerful tool in the difficult area of land use control.

An overall concern about ground water protection in Britain is the increasing number of domestic waste landfills in an acceleration of siting decentralization. Disposal of chemicals classified as dangerous wastes can only be conducted at a few sites operated at the county level of government.[*] However, Britain's heavy reliance on landfilling and overall approach to toxic waste disposal is not as progressive as it is in some other European countries, notably West Germany and Holland. A three year study in 1978 of 20 landfill sites in Britain concludes: "sensible landfill is realistic, and an ultracautious appoach to landfill of hazardous and other types of wastes is unjustified."[6] Currently ninety percent of all "notifiable" (hazardous) waste in Britain is landfilled, compared, for example, to 39 percent in Holland.[**][7]

<u>Drinking Water Treatment</u>

Unlike West Germany, Switzerland and the Netherlands, where granular activated carbon (GAC) and ozone are commonly used to remove toxic chemicals and to lessen the formation of trihalomethanes (THMs) resulting from chlorination, Britain has not employed these methods to any significant extent. Nor has it made the reductions in the use of chlorine achieved on the Continent, especially in Holland, where the waterworks operators are concerned about the formation of THMs, notably chloroform, a carcinogen. Although Britain uses more chlorine than many other European countries, it appears to use less than the U.S. which has a reputation in Europe for heavy chlorination. Some comparisons of acceptable limits of chlorine at the tap, or point of use are: U.S.: 1.0 ppm; Britain: .2 ppm; West Germany: .08 ppm; Holland: slight trace.[9] Because of their use

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[*] There are 50 counties in Great Britain.

[**] Great Britain and the U.S. have in common this 90 percent rate. In the U.S. it is estimated that 90 percent of industrial waste that is considered hazardous is landfilled.[8]

of relatively high amounts of chlorine in Britain, it is feared by government officials that they will be unable to meet the proposed EEC (and Dutch) standard for THM of 1 ppb (currently 25 ppb in West Germany and Switzerland and 100 ppb in the U.S.). Britain does not now have its own THM standard but in summer, when algae blooms which increase the natural precursors of THMs are common, readings often reach 300 to 400 ppb THM.[10]

Only a handful (about six) GAC units to remove toxic chemicals are in operation in Britain, as opposed to about 30 on the western Continent. For example, the Severn-Trent Water Authority has one such unit (out of its 300 drinking water treatment facilities) because of the close proximity to a chemical plant. Continuing problems here, however, have forced the Water Authority to move its drinking water intake to a more favorable location at a cost of almost $4 million.[11]

Research is however proceeding on the use of GAC and ozone in combination with slow sand filtration, the predominant drinking water treatment in Britain. The nation's Water Research Centre addresses all phases of the water cycle managed by the Water Authorities, including drinking water treatment. Because of the British economic recession, the Centre's staff has been reduced from 522 in 1980 to 475 in 1981, with environmental protection research bearing the brunt of the reduction.[12]

Because Britain is devoid of national standards for raw water quality and for treated drinking water, and because very limited monitoring is conducted here. control technology, such as GAC to remove toxic chemicals from drinking water supplies may be essential for vulnerable or degraded water supplies. In addition, because of the predominant use of surface water which contains the natural organic precursors of THMs, a reexamination of disinfection practices is desirable.

Appendix A

Interviews and Contacts

The Federal Republic of Germany

1. Max Bauer, Dipl.-Ing.
Ministerialrat im
Bundesministerium des Innern
53 Bonn 7 Postfach
Tel. 681-3448
(Interior Ministry)

2. Herr Ewald, Engineer
Amt für Stadtentwasserung der Stadt Köln
Hohe Strasse 68-82 Room 505
(Cologne sewage treatment)

3. Dr. Gässler, Director
Institute für gewerbliche Wasserwirtschaft und Luftreinhaltung
Bund der Deutschen Ingenieure
Oberländer Ufer
500 Köln
(water and air research for industry)

4. Dr. Martin Jekel
Dr. Wolfgang Kühn
Engler-Bunte Institut
Karlsruhe University
Wasserchemie
Richard Willstatter-Allee 5
7500 Karlsruhe 1
(research arm of German waterworks)

5. Michael Kromarek (Esq.),
Regierungsdirektor
Regierungspräsident Köln
Untersachsenhausen 6/Tunisstr. 27
5000 Köln
Tel. 0221-16 33 34 94

6. Uwe Lahl and Barbara Zeschmar
Dept. of Biology/Chemistry
University of Bremen
Leobener Str.
D-2800 Bremen 33
Tel. 0421-218 2372
550 430 (home)
(researchers and citizen activists)

7. Klaus Lindner, Dipl.-Ing.
Gas-, Elektrizitäts-und Wasserwerke,
Köln (GEW)
Parkgürtel 24
5000 Köln 30
Tel. (0221) 178 29 90

8. Dr. Frank Andreas Schendel, Esq.
Herr Feuer (?)Environmental Engineer
Bayer AG
5090 Leverkusen, Bayerwerk
Tel. (02 14) 308 19 65

9. A Staatsfeld, statistician
Bundesverband der deutschen
Gas-und Wasserwirtschaft (BGW)
Euskirchener Strasse 80
5300 Bonn
Tel. 0228-61 10 01
(Gas and Water Association)

10. Wolfram Such, Dipl.-Ing. Baudirektor
Wahnbacktalsperrenverband
5205 Augustin 1 - Niederpleis
Mulldorfer Str.
Tel. 02241 28553
(drinking water process-phosphate
removal)

11. Professor W. Thiemann
Department of Biology/Chemistry
University of Bremen
Leobener Str.
D-2800 Bremen 33
Tel. 0421-218 2372

The Netherlands

1. S. Bos
Ministerie Van Volksgezondheid
en Miueuhygiene
Dokter Renerstraat 12
NL-2260 AK Leidschendam
Tel. 0031-70-20 92 60
(Ministry of Health and Environment)

2. Dr. A. Gravaland, Chief Engineer
Amsterdam Municipal Waterworks
P. O. Box 8169
Amsterdam
Tel. 020-5802 555

3. Gurry Huizenga, Senior Engineer
Amsterdam Municipal Waterworks
P. O. Box 8169
Amsterdam
Tel. 020-5802 555

4. Dr. J. C. Kruithof
KIWA, N.V.
P. O. Box 1072
3430 BB Nieuwegeing
Tel. 03402-35394-140
(research arm of Dutch waterworks)

5. J. Lieffering
Vereniging van Exploitanten van
Waterleidingsbedrijven in Nederland
(VEWIN)
Sir Winston Churchill Laan 273
Rijswijk (near the Hague)
Tel. 070-90 27 20
(Dutch Waterworks Association)

6. Jurjen Keuning
Stichting Natuur en Milieu (SNM)
Donkerstraat 17
Utrecht
Tel. 33 13 28
(coalition of citizen environmental
groups)

7. Ton Roelofzen
Stichting Duinbehoud
Rapenburg 48
Leiden
Tel. 071-130798 (home)
071-131800 (office-Albert Saliman)

8. Jan van der Sluis
Stichting Watertribunaal
Damrak 37
Amsterdam
Tel. 24 35 44

(Switzerland (Zürich)

1. Frank Nägeli, Dipl. Ing. ETH,
Vizedirektor
Wasserversorgung Zürich
Hardhof 9 Postfach
8023 Zurich
Tel. 01/435 21 11

(Also saw Dr. C. Walenda, head of
the Zürich waterworks laboratory)
(same address as Nägeli)

Great Britain

1. Dr. T. V. Arden, Director, Administration
Water Research Centre
1 Queen Anne's Gate
London SW1H 9BL
Tel. 01 222 0494

2. Nigel Haigh/Trudy Weber
European Environmental Policy Programme
10 Percy Street
London WIP ODR
Tel. 01-580 9796/9797

3. Allen McDaniel, Chemical Treatment Laboratory
Thames River Authority
Rosebery Avenue
London EC1

4. David Renshaw, Asst. Secretary
Water Quality Division
Department of Environment
43 Marsham Street
Romney House
London SW1
Tel. 212-3744
(the bulk of the above interview was with Albert Goodman, chemist. Peter Hicks, Administrative Principal, Water Quality was also present.)

5. Dr. David Walker
National Water Council
1 Queen Anne's Gate
London SW1
Tel. 930-3100

6. Dr. Brian Waters
Severn-Trent Water Authority
Ariel House
2138 Coventry Road
Birmingham B26 3YT

GROUNDWATER QUALITY IN NEW JERSEY

An Investigation of Toxic Contaminants

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by

Robert K. Tucker, Ph.D.

Office of Cancer and Toxic Substances Research

Brendan Byrne
Governor

Jerry Fitzgerald English
Commissioner

Thomas A. Burke, M.P.H.
Director, OCTSR

Alden McLellan Ph.D.
Assistant Commissioner
for Science and Research

PREFACE

Groundwater constitutes more than ninety-seven percent of the fresh water on this planet. Nationwide, groundwater use is increasing at a rate of 25% every ten years. In New Jersey, sixty percent of our drinking water is from underground sources; in the southern half of the state, more than ninety percent of the population receives its drinking supply from groundwater. Groundwater remains by far the largest unexploited reserve source of drinking water in the State, and these reserves provide a potentially invaluable resource for future generations of New Jersey citizens. Future economic development in the State may depend on the careful protection of these resources.

Many people assume that groundwater, water obtained from springs and wells, is purer and safer than drinking water from surface supplies. The designation "spring water" is a selling point for bottled waters available at the supermarket, and considerable numbers of New Jerseyans will travel quite some distance to fill containers at springs in preference to water from their taps. Not only the general public but also professionals in the field of environmental protection and water quality have, in the past, believed groundwater to be the safest and purest source of public supply. This assumption has led to more extensive testing programs for surface water under such federal legislation as the Water Pollution Control Act and the Safe Drinking Water Act (PL 93-523) and greater concern for and regulation of surface than of groundwater pollution by state as well as federal agencies. Bacterial contamination tends to be greatly attenuated by passage through soil, perhaps leading to past assumptions of groundwater safety. But within the past several years, throughout the nation, more and more examples of groundwater contamination by chemicals have come to light. New Jersey with its very high density of chemical and related industrial development has been particularly subject to the irresponsible, haphazard, and sometimes criminal disposal of chemical wastes.

Recent widely publicized instances of toxic contamination of wells in New Jersey and in other states across the nation show how vulnerable groundwater can be to chemical pollution. While we must not slacken efforts to make surface water "fishable and swimmable", it is imperative that we also move quickly to protect groundwater. There is a critical reason why this is so. Once contamination of groundwater occurs, the pollution is exceptionally persistent and extraordinarily difficult and expensive, if not impossible, to clean up. The study described in this report is a step toward clarifying the extent to which New Jerseyans need be concerned about chemical contamination of their groundwater aquifers.

For the past three years the Office of Cancer and Toxic Substances Research, NJDEP, has been conducting a statewide study of groundwater quality. This report summarizes results for 1118 samples from 670 wells throughout New Jersey. DEP's Division of Water Resources, Areawide Planning Agencies and local boards of health, have assisted by suggesting sites for the study. Collection and analysis of samples has been carried out, under contract to DEP, by the Cook College Department of Environmental Science, Rutgers, the State University. Computerization and statistical analysis of the data has been handled at Rutgers in the Livingston College Department of Geography and Urban Development. We have been assisted in follow up of problem areas by elements of the Division of Water Resources, particularly by Enforcement, the Bureau of Groundwater Management, and the Bureau of Potable Water, and by the State Department of Health. This study represents a pioneering effort to assess groundwater for toxic chemicals, particularly halogenated organic compounds, on a statewide basis. In 1980 the US EPA announced the beginning of a national study to test groundwater quality.

In addition to a summary of the results from the first two years of our groundwater study, this report reviews information from the scientific literature on two important aspects of chemicals in groundwater - their environmental sources, fates, and behavior and their expected health implications.

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SUMMARY

In 1975, Governor Brendan Byrne issued Executive Order 40 directing a concerted effort be made to investigate factors related to the high incidence of cancer in New Jersey. As a result of this executive order, DEP's Office of Cancer and Toxic Substances Research was created. One of this office's primary tasks has been to determine environmental concentrations of chemicals suspected of leading to an increased risk of cancer in humans. As part of this effort, we now have an extensive data-base on some chemicals occurring in groundwater aquifers of the state. This report summarizes the data from the first two years of our groundwater study and discusses sources and behavior of chemicals in groundwater and some of the implications for human health. We looked for fifty chemicals, in three different groups, in well water samples from throughout the state. These three chemical groups are halogenated volatile organics, chlorinated pesticides and related compounds, and metals. This report summarizes data from 1118 samples taken from 670 wells. Although this is a significant sample size it is a small portion of the more than 16,000 potable wells in the state.

One or more of eight volatile organic compounds were found at concentrations above ten parts per billion in 16.6% of the wells tested. These eight chemicals include five (carbon tetrachloride, chloroform, dichloroethane, tetrachloroethylene, and trichloroethylene) for which evidence from animal tests establishes them as capable of causing cancer and three others (trichloroethane, and the di-and tri-chlorobenzenes) chemically similar to known carcinogens, but for which there is no reliable evidence that they cause cancer. In 3.1% of the wells in our study, concentrations of one or more of these eight chemicals exceeded one hundred parts per billion, a clearly unacceptable level.

In the report we present a hypothesis, based on plotting the data, that low level concentrations of volatile organics may occur in wells subject to wide spread contamination by a variety of mechanisms including aerial transport and recharge from surface waters. In contrast, higher levels of contamination occur in a population of wells subject to direct and relatively nearby discharge of pollutants into the ground. For most of the compounds in question the breakpoint of concentration between the two groups of wells occurs at about ten parts per billion. It will be worth while to test this hypothesis with further directed investigation.

Chlorinated pesticides and related compounds, when detected in this study, were usually at very low concentrations. Thirty-one wells had concentrations exceeding standards, but in most of these cases the excess was slight or not confirmed upon resampling. Three drinking water wells with unacceptable levels of these chemicals were removed from service. Because these chemicals are extremely persistent, because they tend to build up in fatty tissue and become concentrated in organisms including humans, and because most of them are known to cause cancer in animals, even low levels of chemicals in this group are cause for some concern. One reflection of this concern is that these compounds have been banned or their use severely restricted.

With exceptions in a few specific instances, metals appear to present a less serious health problem than do the organic compounds in the state's groundwaters. During the first two years of this study, three potable wells and nine

wells not used for drinking purposes were found to have confirmed metal contamination. Lead, found over standard in thirteen wells, was the most frequent serious problem, followed in order by chromium and cadmium. One case of extensive arsenic contamination of a well was discovered.

Movement of water through underground aquifers is generally quite slow, usually measured in feet per year. On the one hand this means that individual cases of groundwater contamination will be localized and that there is time to deal with such cases in an orderly manner once they are discovered. On the other hand, such slow movement mitigates against the contaminant being flushed away and the problem solving itself. Moreover, because many contaminants tend to be retained by solid aquifer material, they tend to move even more slowly than the bulk flow of groundwater itself. This appears the case for metals which undergo ion-exchange reactions and for pesticides which adsorb onto clay particles. The movement of the lower molecular weight volatile organics is less restricted and these chemicals thus spread more easily from a source of contamination. The relative ease of movement, resistence to breakdown, widespread use, and potential cancer causing effects combine to make the halogenated volatile, organic compounds the greatest threat to New Jersey's groundwaters.

It is not possible at present to determine the actual degree of cancer risk to humans from ingestion of chemicals in drinking water. Estimates of risk have been made by extrapolating from animal data, but such estimates are subject to uncertain assumptions and statistical error. There is general agreement in the scientific community that compounds shown to cause cancer in animals present a cancer risk to people. It is also agreed that for such compounds there is no threshold level below which risk is absent.

Of the 670 wells included in this report, thirty-one were found contaminated to a serious degree. Of these polluted wells, twenty were used for industrial or monitoring purposes and eleven had been used for drinking water. The contaminated drinking water wells have been removed from service. Although more than 95% of the wells tested in this study can be considered acceptable for potable use, this is no cause for complacency. Even though the results of this study show that most wells in New Jersey are safe, the fact that 3.1% of the wells had volatile organic contamination above 100 parts per billion, that 16.6% of the wells showed some volatile organic contamination greater thatn 10 parts per billion, that standards for metals were exceeded, if only temporarily, in 29 wells, and that 31 wells had at least transitory problems with low levels of pesticides, serves to confirm the vulnerability of groundwater to contamination. It is imperative that everything possible be done to prevent or minimize entry of toxic chemicals into groundwater.

I. RESULTS

Introduction

This report summarizes the first two years of our groundwater investigation, a study which is still in progress. Initially our effort was a general survey to evaluate the extent of the problem and to determine "background" concentration of contaminants. We are now focusing on problem areas with more intensive investigations of particular instances of contamination. Following this summary report, we plan to make available the data in more detail; we are now in the process of preparing it to be accessible by computer. To date we have been severely hampered by lack of computer facilities within DEP. Much of the almost one year delay in issuing this summary report can be attributed to problems with computerization of the data.

During the first part of the study, wells sampled were divided about equally into three groups: industrial and monitoring, public supply, and domestic. As the study progressed, wells contributing to potable use were emphasized. After the initial sampling at sites chosen by the Area Wide Planning groups ("208 groups"), additional sampling was carried out in areas where high values were found. During the second year, fifteen wells were selected for monthly sampling and thirty-five wells were sampled seasonally. Repeated sampling of these wells gives us a better idea of the variability to expect in groundwater quality. Variability, or difference in concentration from sample to sample of the same well, was greater than we expected before we began the study. Previous studies of more conventional pollutants, usually measured in the parts per million range, led us to believe that contaminant levels would be relatively steady. One part of the variability is due to the range expected as a result of sampling and laboratory analysis. Inherent in any sampling and measurement process are various inaccuracies and possible errors. Precision and accuracy are two different but related concepts used in dealing with analytical variability. Precision refers to the compactness or close agreement of a group of repeated measurements; accuracy refers to how closely the measured value agrees with the true or actual value. Precision is determined by repeated analyses of aliquots (partial samples) of the same original sample. Precision for the analyses in this study, even when dealing with concentrations of a few parts per billion (ppb) or less, is usually better than ± 20%. Accuracy of environmental chemical analysis is much more difficult to determine than precision. This is so for a number of reasons, the most important being the question of what constitutes the "true value". Comparison with reference samples and rigid adherence to proper techniques have been used to increase the accuracy of analysis. Subsequent data reports will provide a detailed analysis of well variability and also of analytical precision and accuracy.

Approximately fifty chemical elements or compounds were tested for in the water samples. These chemicals are listed in Table 1 along with the lower limit of sensitivity for the analytical method. This sensitivity limit, designated the "Minimum Reportable Concentration" or MRC, is the lowest concentration at which the chemical can be reliably detected in the sample. The safe drinking water standards, for those compounds for which such standards have been designated, are also listed in Table 1. The metals were determined by atomic absorption spectrometry, and the organic compounds analyzed by gas chromatography with an electron capture detector. The volatile organic compounds were extracted into pentane prior to chromatography whereas the pesticides and related chemicals were extracted by steam distillation. The analyses were subject to a rigid quality assurance program to ensure validity of the data with duplicate analysis and confirmation by mass spectrometry. When accuracy was determined by comparison of analysis to theoretical concentration of specially prepared samples furnished by the U.S. Environmental Protection Agency, the chemists carrying out this study have performed well (Rutgers, 1978).

Summaries of our findings for each of the three groups of chemicals are given in the following sections and in the accompanying tables and figures.

Table 1. Chemicals Included in this Study

Group 1 - Metals	Minimum Reportable Concentration (MRC) ug/l (ppb)	EPA Standard for Drinking Water ug/l (ppb)
Arsenic	1	50
Beryllium	1	-
Cadminum	1	10
Chromium	1	50
Copper	1	1000[a]
Lead	1	50
Nickel	5	-
Selenium	2	10
Zinc	5	5000[a]
Group 2 - Pesticides and Related Compounds		
PCBs	0.06	-
Arochlor 1016	0.06	-
Arochlor 1242	0.06	-
Arochlor 1248	0.01	-
Arochlor 1254	0.01	-
α-BHC	0.01	-
β-BHC	0.01	-
Lindane (γ-BHC)	0.01	4
Heptachlor	0.01	0.1
Heptachlor epoxide	0.01	0.1
Aldrin	0.01	-
Dieldrin	0.01	-
Chlordane	0.01	-
Toxaphene	0.06	5
Methoxychlor	0.08	100
Mirex	0.02	-
Endrin	0.01	0.2
o,p-DDT	0.04	-
p,p′-DDT	0.04	-
o,p-DDE	0.01	-
p,p′-DDD	0.02	-

Table 1. Chemicals Included in this Study (Continued)

	Minimum Reportable Concentration (MRC) ug/l (ppb)	EPA Standard for Drinking Water ug/l (ppb)
Group 3 - Low molecular weight halogenated organics		
Methylene chloride	90	
Methyl chloride	6.0	
Methyl bromide	1.0	
Chloroform	0.8	*
Bromoform	1.0	*
Trichloroethylene	0.3	
1,1,2,2-Tetrachloroethane	0.3	
1,1,2-Trichloroethane	1.0	
Dibromochloromethane	0.1	*
Trifluoromethane	0.5	*
Carbon tetrachloride	0.1	
1,2-Dibromoethane	0.1	
1,2-Dichloroethane	1.6	
1,1,1-Trichloroethane	2.0	
Vinyl chloride	0.5	
Tetrachloroethylene	0.1	
o-Dichlorobenzene	2.2	
m-Dichlorobenzene	1.3	
p-Dichlorobenzene	1.3	
Trichlorobenzene	2.0	
Diiodomethane	0.3	
Dichlorobromomethane	0.5	*

*Trihalomethanes: The EPA drinking water standard is 100 ppb for total trihalomethanes

a: secondary standards

Volatile Organic Compounds

Of the three groups of chemicals investigated in this study, the volatile organic compounds present the most serious threat for groundwater contamination. The eight chlorinated organic chemicals listed in Table 2 were found at levels above 10 parts per billion (ug/liter) in 16.6% of the wells tested and occurred in 3.1% of the wells at concentrations exceeding 100 parts per billion. Follow-up investigations and analysis confirmed consistent contamination with one or more of these volatile organic compounds above 100 ppb in ten wells used for potable water. These were removed from service.

Table 3 lists other volatile halogenated compounds for which samples were routinely analysed but which were found less often or which occurred only at low concentrations. Group A lists compounds not found in any sample at a concentration exceeding 10 parts per billion while group B contains five compounds which in one or a few samples exceeded 10 ppb but which did not exceed 50 ppb. The compounds in Table 3 were detected relatively rarely, the only one occurring in more than 5% of the samples was one of the trihalomethanes, dichlorobromomethane, which was detected 7% of the time. As will be discussed later in this report, the trihalomethanes, may be formed in the chlorination treatment process of water.

Table 4 presents detection limits and percent detection frequency for the eight volatile organic compounds previously listed in Table 2 and which present the most serious groundwater problems. Frequency of detection ranges up to 26.8% for carbon tetrachloride. The frequency of occurrence reported for each of the volatile organic compounds is obviously dependent on the Minimum Reportable Concentration (abbreviated: MRC), which may differ for each chemical. This detection or lower analytical sensitivity limit ranges between 0.1 and 2.2 ppb for the eight compounds listed in Tables 2 and 4. The lower the detection limit, the more likely that greater numbers of samples will be found to contain that particular compound, and thus this should be kept in mind when comparing the percent detection of one chemical with another.

Table 2. Volatile Organic Compounds with Widespread Occurrence in Groundwater

Chemical	No. of Samples > 10 ppb	No. of Wells > 10 ppb	No. of Wells > 100 ppb
Carbon tetrachloride	6	5	2
Chloroform	24	24	3
1,2-Dichloroethane	22	18	0
Tetrachloroethylene	16	16	2
1,1,1-Trichloroethane	83	65	5
Trichloroethylene	52	27	12
Dichlorobenzene	8	8	2
Trichlorobenzene	4	4	1
	215	167	25
Actual no. of wells*		111	21

*Numbers of wells are less than the totals in the columns because some wells have more than one contaminant.

Table 3. Volatile Organic Compounds Found Rarely or at Low Levels in Groundwater

A. Rare and/or concentrations less than 10 parts per billion:

	Samples % > MRC	Maximum Concentration, ppb
Fluoroform	0.8	3.5
Methyl chloride	0	N.D.
Methyl bromide	0.3	7.4
Vinyl chloride	0.4	9.5
Dibromochloromethane	4.8	2.4
1,1,2,2-Tetrachloroethane	2.1	2.7
Diiodomethane	1.4	2.0

B. Not found at a concentration greater than 50 parts per billion

	Samples % > MRC	Number > 10 ppb	Maximum Concentration, ppb
Bromoform	1.5	1	34.3
1,1,2-Trichloroethane	2.0	1	31.1
Dichlorobromomethane	7.0	1	43.0
Dibromomethane	0.5	2	44.9
1,2-Dibromoethane	3.6	4	48.8

Table 4. Frequency of Detection of the Eight Common Volatile Organic Compounds

Chemical	MRC, ppb	% Samples > MRC
Carbon tetrachloride	0.1	26.8
Chloroform	0.8	14.5
1,2-Dichloroethane	1.6	5.8
Tetrachloroethylene	0.1	22.7
1,1,1-Trichloroethane	2.0	21.0
Trichloroethylene	0.3	26.4
Dichlorobenzene	2.2	4.8
Trichlorobenzene	2.0	1.5

Without detracting from the seriousness of the threat that the volatile compounds pose to groundwater, it should be pointed out that the majority of wells in this study do not contain detectable levels of these halogenated chemicals, and that only a small percentage of the wells have high amounts. In analyzing the data, it became clear that concentrations of a particular contaminant in the samples did not represent a normal statistical distribution. Thus it is not appropriate to calculate average values, or means, for concentrations of a contaminant, nor do median values (all less than detection limits) provide useful information. Graphic methods, however, may indicate trends in the data. The following method was tried for each of the major contaminants. Samples were listed in order of increasing concentration of the contaminant and the percentage determined of samples below given concentrations of the chemical. When the cummulative percent of samples vs. concentration is graphed on regular (cartesian) coordinates, as shown in Figure 1 for chloroform, it is readily apparent that a few samples at the upper end of the frequency distribution are highly contaminated, while most of the samples have concentrations below detection limits. Because of this skewed frequency distribution, presentation of the data on semilogarithmic graphs is more revealing. Semi-log plots for the eight common chlorinated organic chemicals are presented in Figures 2 through 9. Please note that the abscissa (horizontal axis) shows only the upper end of the frequency distribution and that the scale has been expanded in Figures 8 and 9. In Figure 2, for chloroform, two distinct regression lines may be drawn through the data points, with approximately the upper 4% of the samples lying along a line of much steeper slope. The two lines meet at a concentration of about 5 parts per billion; this may represent an approximate break point in the data dividing a population of more directly contaminated wells from the maximum value of a more diffuse "background" concentration. It must be understood that "background" levels are also the result of human activity; these compounds do not occur naturally at levels we can detect. Because of the volatility and widespread use of the halogenated solvents, however, low levels may partially result from atmospheric distribution, recharge from surface waters, or some other indirect mechanism. On the other hand, high levels of contamination, represented by data lying along the steeper slope, are more likely to result from direct discharge of the chemicals into the ground relatively near the sampled well. This hypothesis, that the two regression lines represent different populations of wells,

Figure 1.

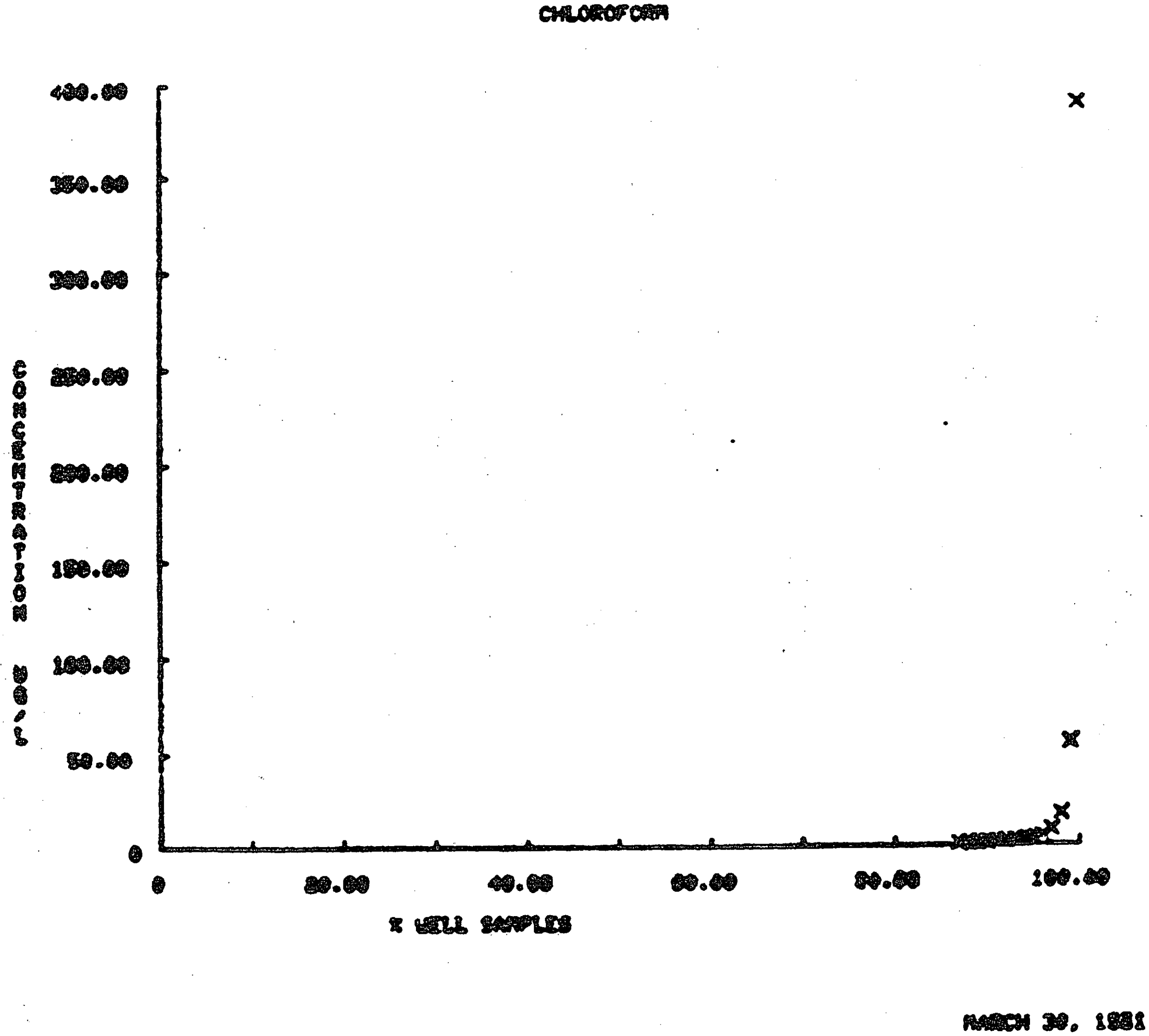
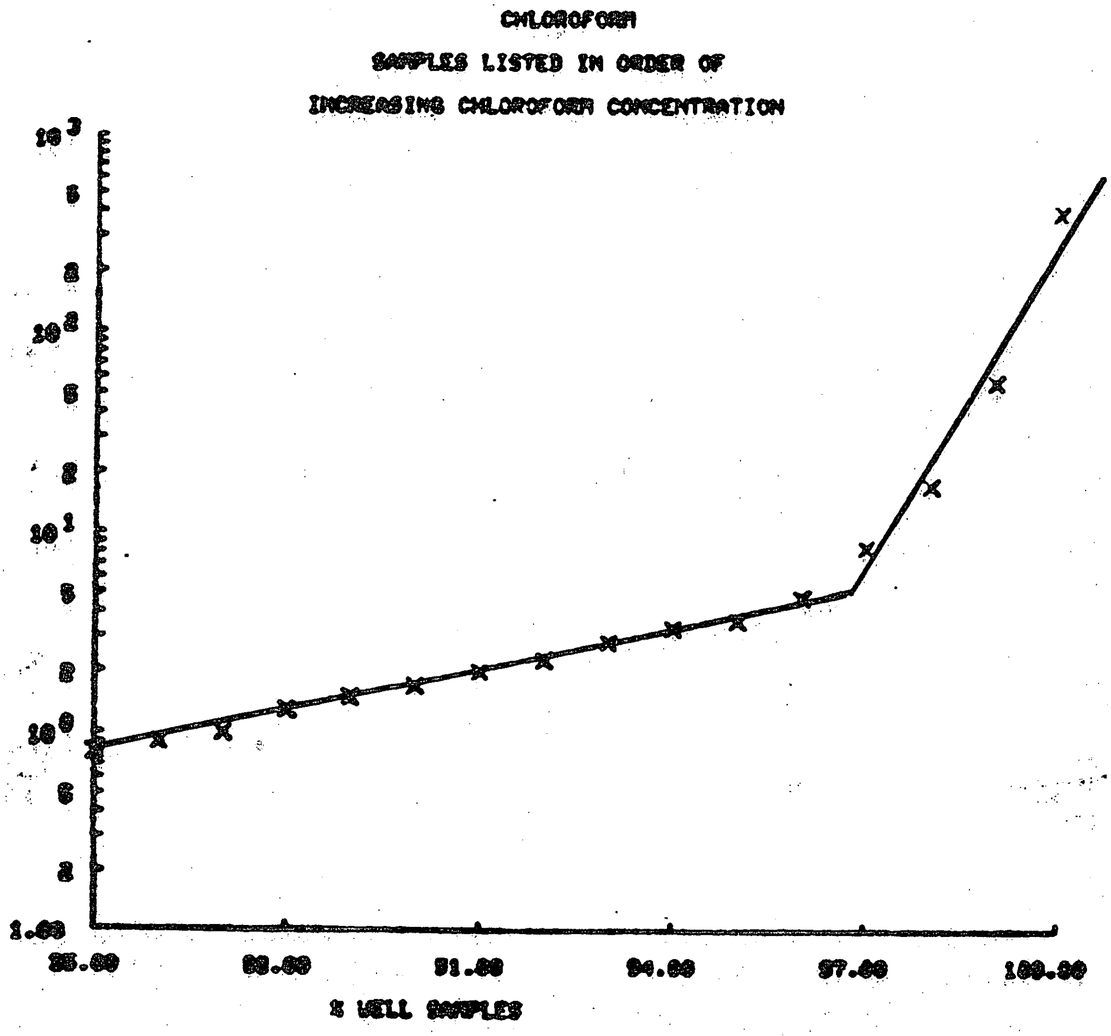

CHLOROFORM
CONCENTRATION UG/L
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0
0
20.00
40.00
60.00
80.00
100.00
% WELL SAMPLES
MARCH 30, 1981

Figure 2.



MARCH 31, 1981

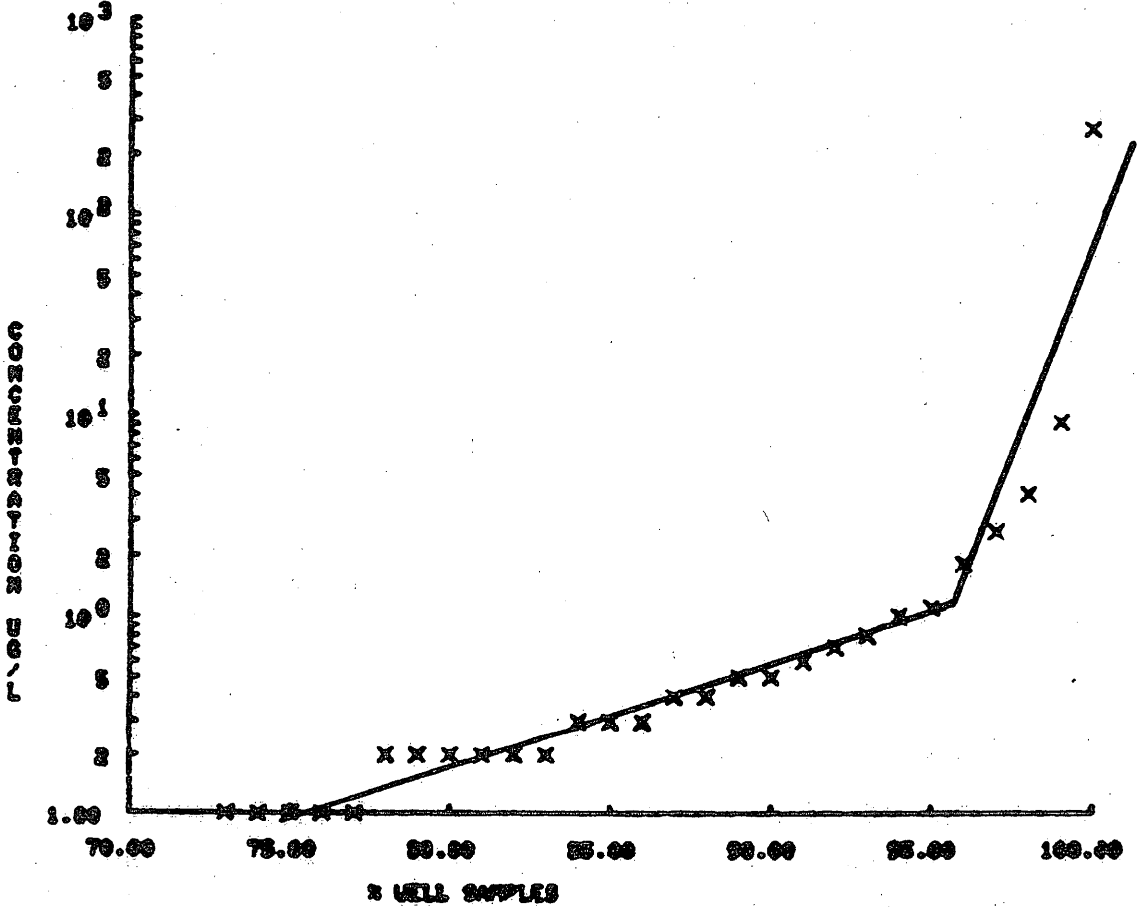
needs further testing by detailed investigations of specific sources of pollutants. It can be seen in each of the other graphs that lines of two different slopes also fit the data, more or less accurately, for the other seven compounds. Except for 1,1,1-trichloroethane where the break point falls at about 25 ppb, the break points for the other chemicals fall below 10 ppb. Carbon tetrachloride, shown in Figure 3, is not detected (above the MRC of 0.1 ppb) in 74% of the samples; approximately 99% of the samples have concentrations below 5 ppb and the final 1% of the samples range between 5 and 360 ppb. Figure 4 shows data for 1,2-dichloroethane; the upper 3% of wells have concentrations greater than 6 ppb. This compound is detected in about 6% of the samples and the maximum concentration found was less than 40 ppb. Data for tetrachloroethylene is graphed in Figure 5. About 4% of the samples have concentrations between 8 ppb (the aproximate break point) and 90 ppb shown as the maximum. Figure 6 depicts data for 1,1,1-trichloroethane, one of the most ubiquitous of the volatile organic compounds measured. Above a detection limit of 2.0 ppb, 21% of samples contained this chemical, and the high break point (approximately 25 ppb) for the regression lines in the figure, further illustrates its wide spread occurrence. The final 4% of the most contaminated samples then range from 25 to more than 600 ppb. Trichloroethylene, shown in Figure 7, also occurs with unfortunately high frequency in New Jersey wells. This chemical was detected in more than 26% of the samples. About 10% of the samples lie along the line of steeper slope which ranges from about 3 ppb to over 600 ppb. Various isomers of chlorinated benzenes are represented in Figures 8 and 9. Dichlorobenzene, consisting of ortho, para, and meta isomers, occurs above 10 ppb in 8 samples. More than 8,000 ppb was found in one sample. The para-isomer was most commonly found, however the ortho isomer occurred in the highest concentration. Trichlorobenzene was found in 4 samples above 10 ppb with the maximum concentration approximately 450 ppb.

These eight common chlorinated organic compounds occurred in a significant number of samples and occasionally at high concentrations. They are among the more mobile chemicals in groundwater as discussed in the section on chemical movement in aquifers. And because of their potential health effects these chemicals present the most serious cause for concern regarding contamination of New Jersey's groundwater.

Pesticides and Related Compounds

Pesticides and their breakdown products, and related chlorinated compounds such as polychlorinated biphenyls (PCBs) and benzene hexachloride isomers (BHC) were detected in a significant number of well samples but usually only in very small amounts. Table 5 summarizes results for this group. Occasionally initial samples had concentrations slightly in excess of drinking water standards; this was especially true for heptachlor and heptachlor epoxide which have stringent standards of 0.1 ppb. Samples subsequently taken usually showed concentrations below the standard, and thus the problems seemed either intermittent or transitory. Of 1118 samples included in this study, 39 exceeded either the 0.1 ppb standard for heptachlor or heptachlor epoxide or 1 ppb for any other of these compounds. Some wells are represented by more than one sample and some wells had multiple contaminants, so that these 39 excess values actually occurred in 31 wells. Of the 31 wells, 28 were potable (18 public supply, and 10 domestic). Resampling and followup studies confirmed values above the standard or above 1 ppb for only three of these potable wells however; two of these were public supply wells also contaminated with volatile organic compounds. The third well was a domestic well adjacent to a man-

Figure 3.



CARBON TETRACHLORIDE

SAMPLES LISTED IN ORDER OF INCREASING

CARBON TETRACHLORIDE CONCENTRATION

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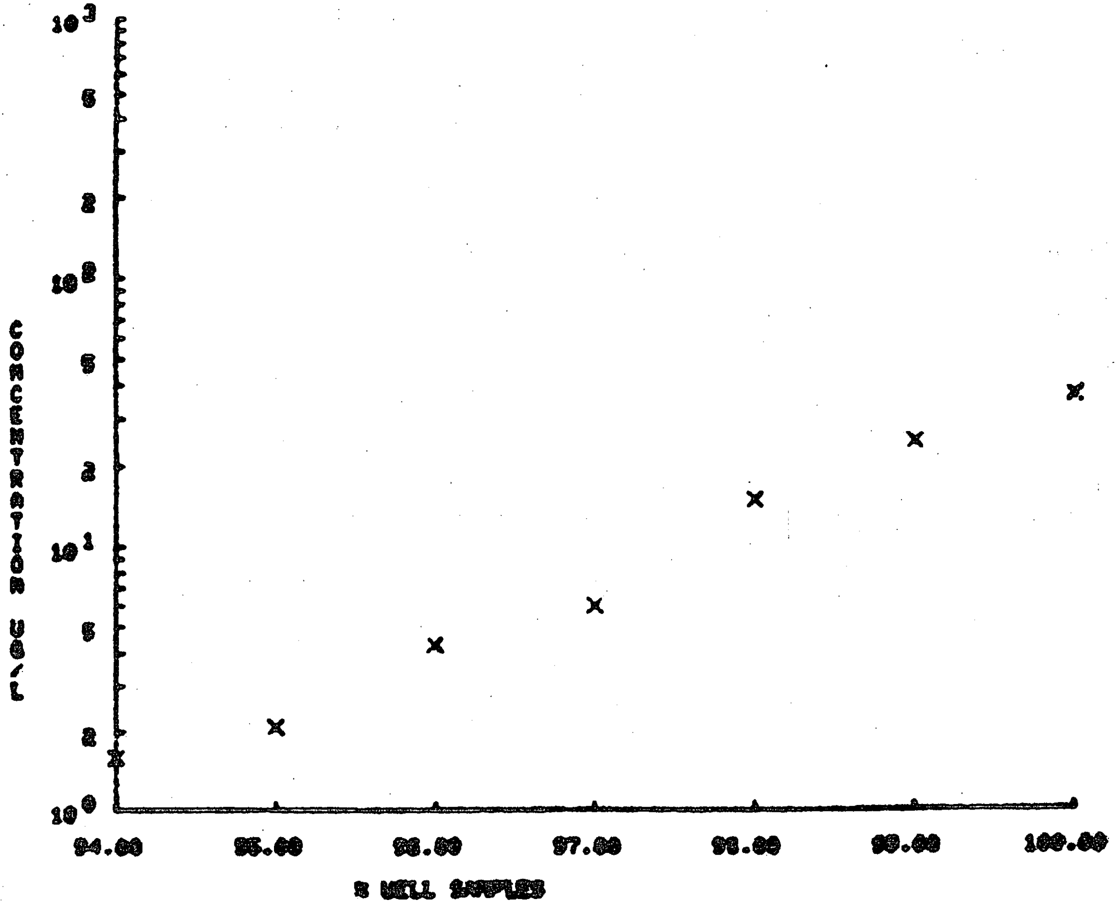
Figure 4.

1,2-DICHLOROETHANE

SAMPLES LISTED IN ORDER OF

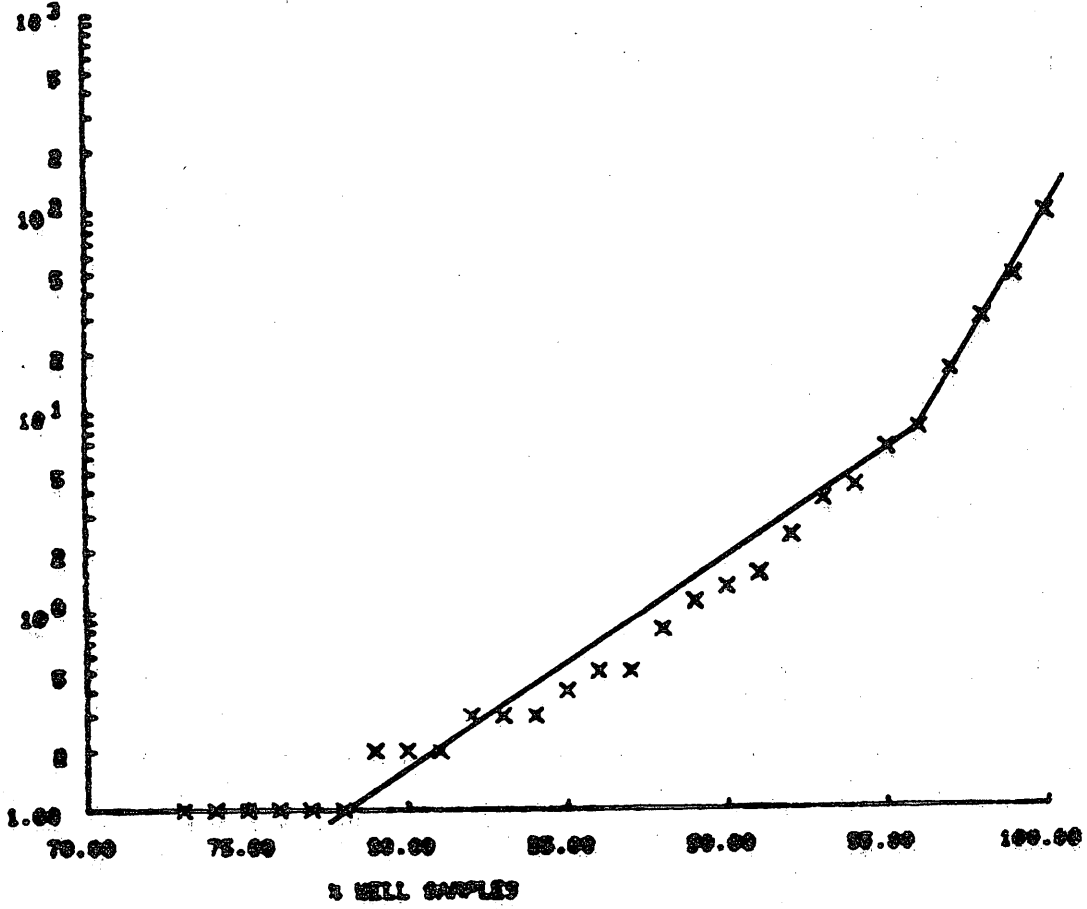
INCREASING 1,2-DICHLOROETHANE CONCENTRATION



MARCH 30, 1981

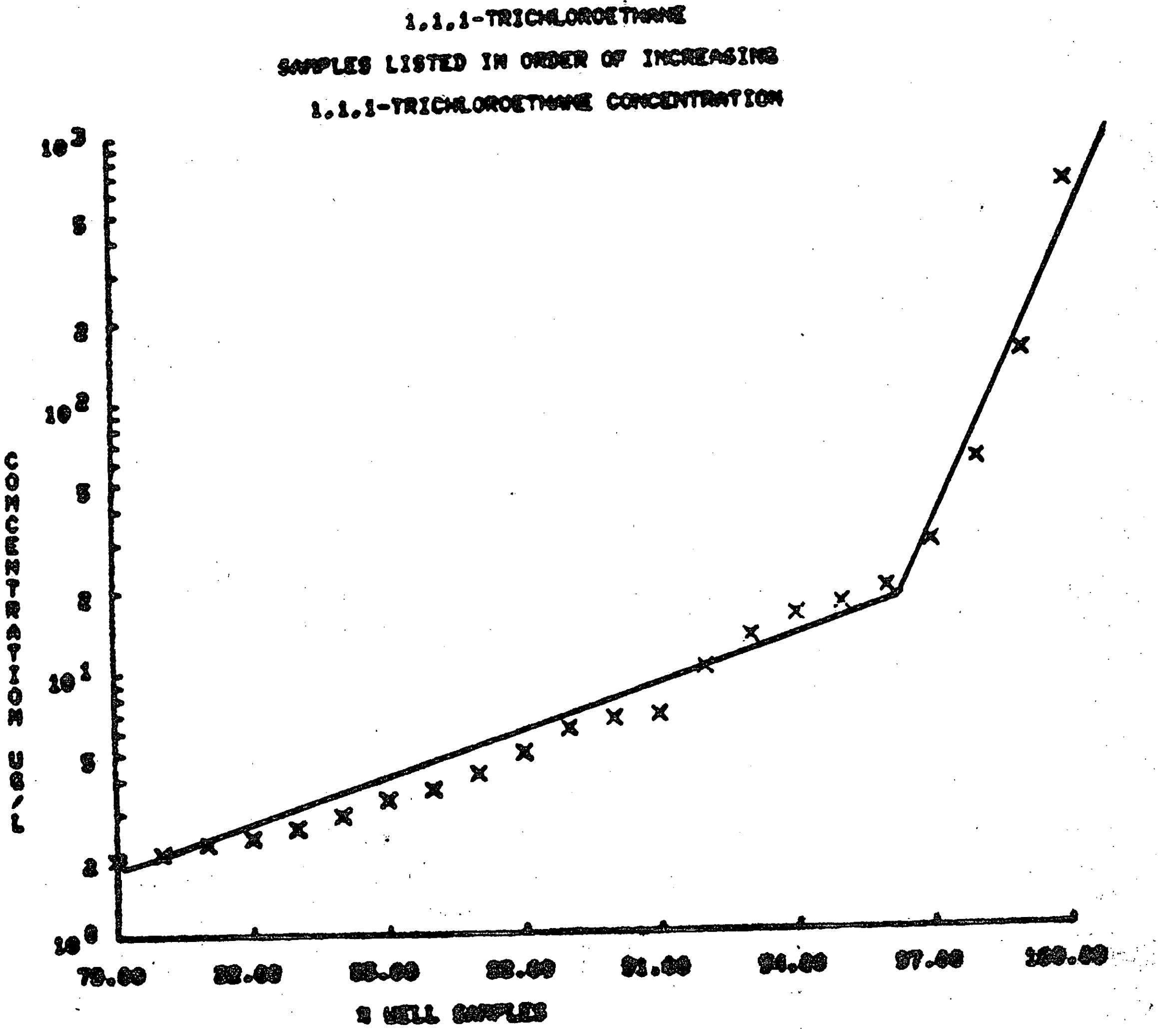
Figure 5.

1,1,2,2-TETRACHLOROETHYLENE
SAMPLES LISTED IN ORDER OF INCREASING
1,1,2,2-TETRACHLOROETHYLENE CONCENTRATION



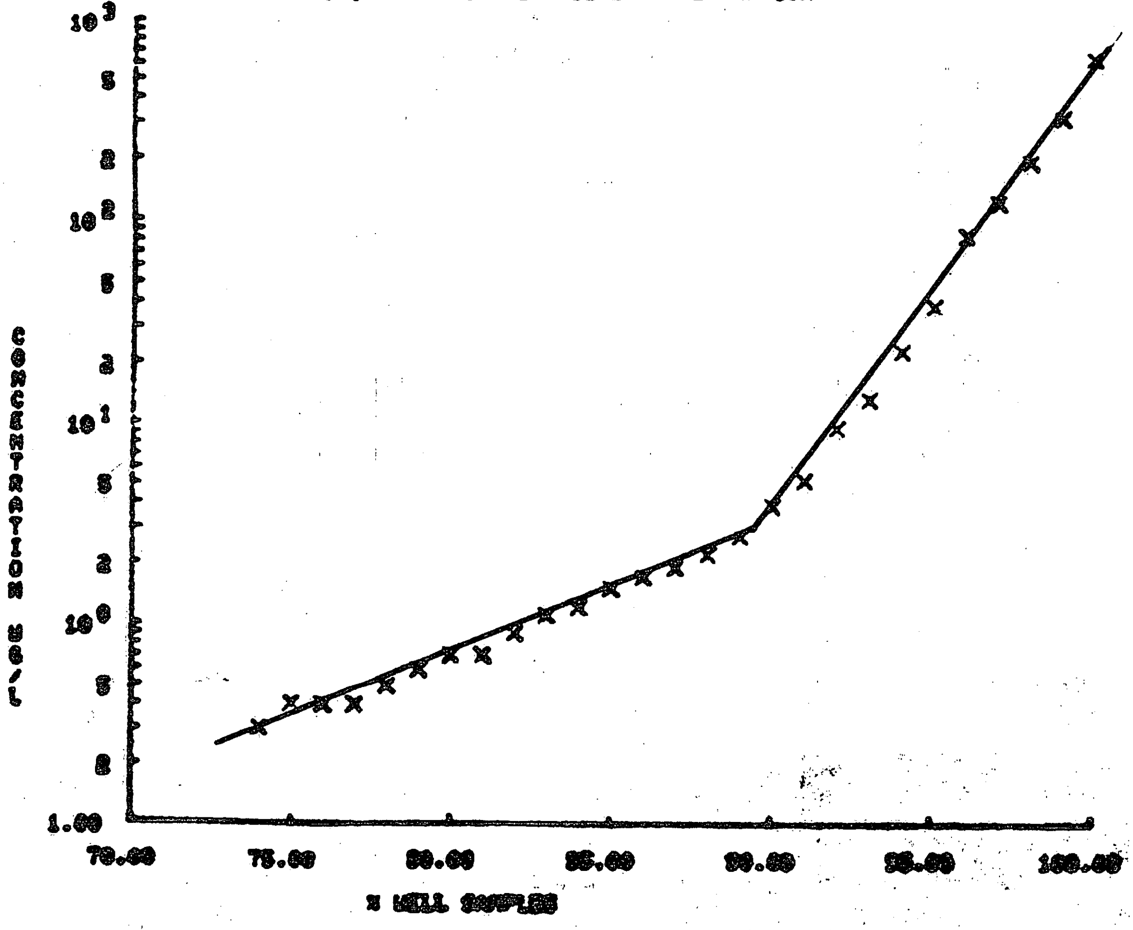
MARCH 31, 1981

Figure 6.



MARCH 31, 1981

Figure 7.

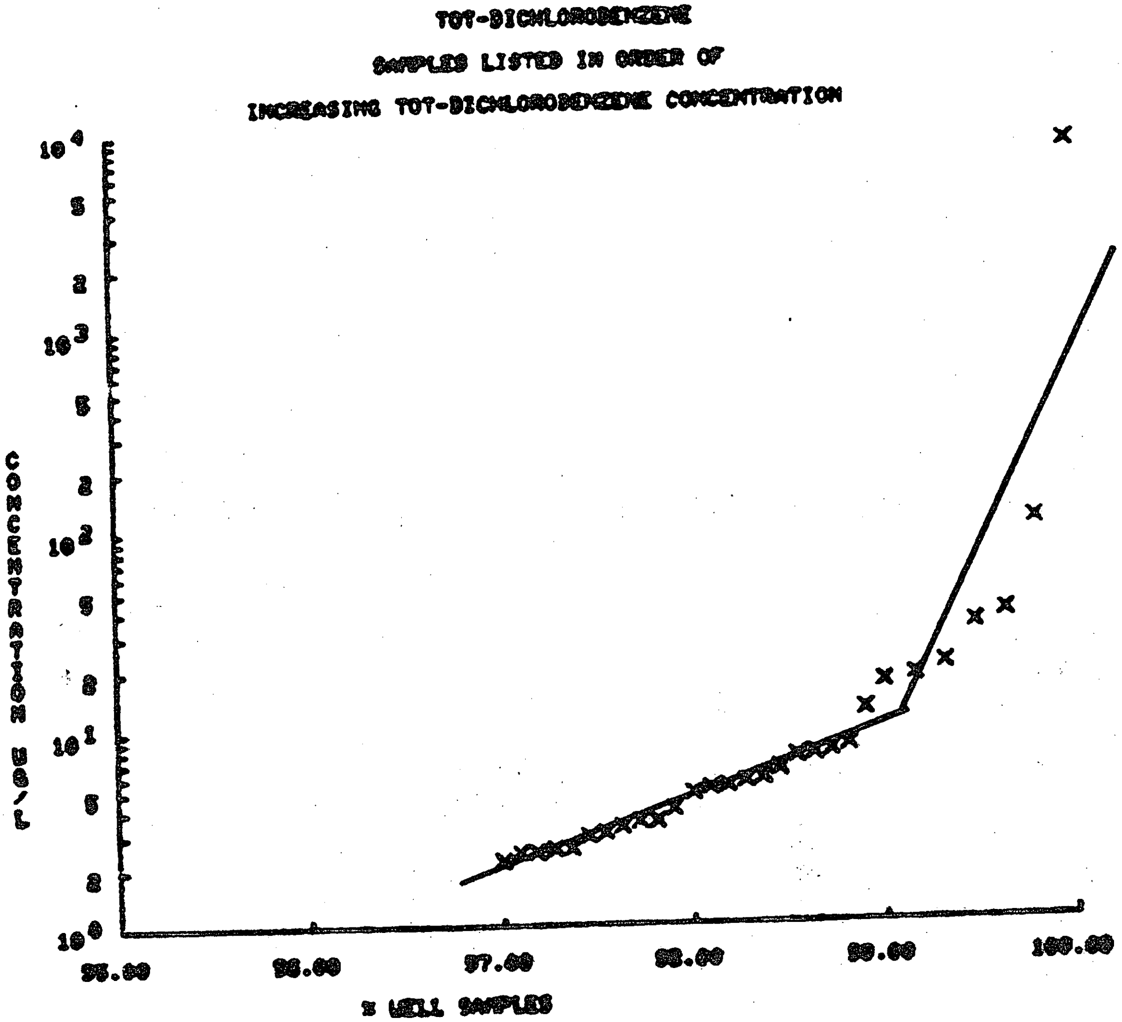

1,1,2-TRICHLOROETHYLENE

SAMPLES LISTED IN ORDER OF INCREASING

1,1,2-TRICHLOROETHYLENE CONCENTRATION

MARCH 31, 1983

Figure 8.



TOT-DICHLOROBENZENE

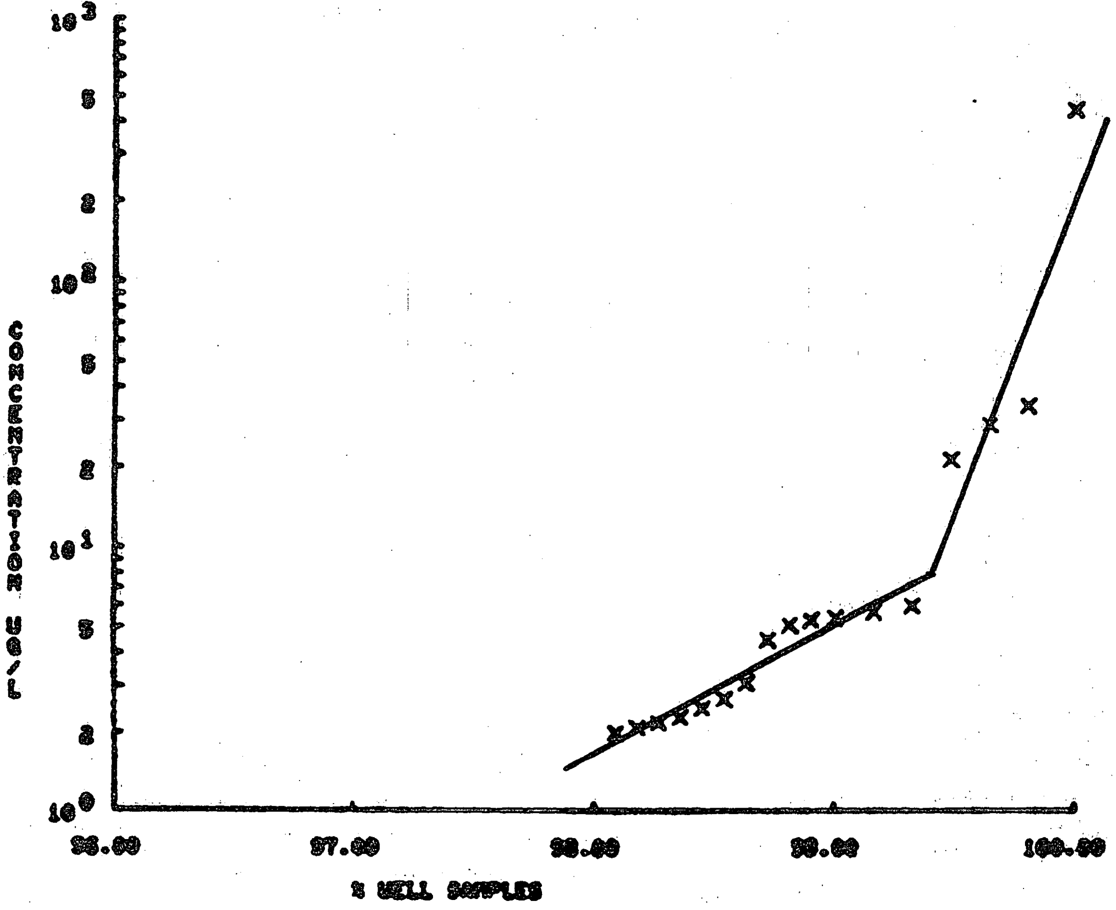
SAMPLES LISTED IN ORDER OF

INCREASING TOT-DICHLOROBENZENE CONCENTRATION

MARCH 30, 1981

Figure 9.

1,2,4-TRICHLOROBENZENE
SAMPLES LISTED IN ORDER OF INCREASING
1,2,4-TRICHLOROBENZENE CONCENTRATION



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ufacturing site where chemical use has occurred. These three wells were taken out of service.

The compound in this group detected most frequently is β-BHC, not itself a pesticide, but related to lindane which is the γ(Gamma) isomer of BHC. This chlorinated chemical was detected in 43.5% of samples tested. DDE, the most resistant of the breakdown products of DDT, was the next most commonly found compound of this group, occurring in 12.3% of the samples. Although concentrations of chemicals in this group tended to be very low, it is disturbing that they should occur at all in groundwater samples. These compounds are extremely resistant to degradation and they have a great propensity to concentrate in fatty tissues of organisms, including humans. Because of the environmental and health dangers of these chemicals, their use has been either banned or severely restricted. Even so, it can be expected that analysis will continue to detect trace amounts for some time to come. A case in point is DDT; this substance although banned since 1973, continues to be found in environmental samples.

Table 5. Pesticides and Related Compounds

Chemical	% Samples > MRC	No. of Wells > std	No. of Wells > 1 ppb
PCBs			
Arochlor 1016	3.4	-	1
Arochlor 1242	7.5	-	2
Arochlor 1248	2.9	-	1
Arochlor 1254	2.2	-	0
α-BHC	1.7	-	0
β-BHC	43.5	-	6
γ-BHC (Lindane)	3.8	0	0
Heptachlor	8.5	21	2
Heptachlor epoxide	3.4	5	0
Aldrin	2.9	3	3
Dieldrin	3.3	0	0
Chlordane	6.5	0	0
o,p′ DDE	12.3	0	0
o,p′ DDT	2.0	0	0
p,p′ DDD	2.7	0	0
p,p′ DDT	2.1	0	0
Endrin	3.5	0	0
Mirex	0.5	0	0
Methoxychlor	0		
Toxaphane	0		

Metals

Metals occur naturally in groundwater, so it is to be expected that they were detected in wells in this study. The percent of samples in which a particular metal was detected ranged from 0.8 percent for beryllium to 84 per cent for copper as shown in Table 6.

High concentrations of a particular metal are likely to be a result of pollution caused by human activity, although natural occurence may occasionally explain the high value. Consistently high values of zinc, for example, in the Voorhes State Park well may indicate naturally occurring zinc deposits in that area.

Table 6 Metals

	% Samples > MRC	Number of Wells > Standard
Arsenic	23.0	1
Beryllium	0.7	-
Cadmium	2.4	4
Chromium	41.6	9
Copper	84.0	7*
Lead	48.8	13
Nickel	23.7	-
Selenium	4.1	0
Zinc	78.6	5*
	Total	39
	Actual No. of Wells	29

*Standards for copper and zinc are secondary, for esthetic rather than health related reasons.

Out of 1118 samples of well water analyzed in this study, there were forty-seven occurrences of metal concentrations exceeding the drinking water standard. In sixteen of these instances a secondary standard, set for esthetic purposes, was exceeded and in the other thirty-one instances a primary health-based standard was violated. Secondary esthetic standards may be set when excess levels could cause taste or odor, interfere with use of soap, or otherwise cause problems not related to toxicity. Because some wells were sampled more than once and because multiple contamination occurred in some wells, the forty-seven occurrences of metal contamination above standards actually represent twenty-nine wells. Our study has found that if a well is contaminated, it is not unusual for more than one contaminant to occur. Twenty-nine wells, then, showed some evidence of contamination by metals; of these, twenty-two violated primary standards and the other seven exceeded secondary standards for copper or zinc. Of these twenty-two wells, twelve were industrial or monitoring wells and ten were used for potable water. Follow-up analysis and investigation confirmed problems with metals in three of the potable wells, two for public supply and one domestic. These three wells were removed from potable use. Another potable well had variable values near the standard and is being closely monitored. Of the twelve non-potable wells, nine were confirmed to be significantly contaminated with metals.

A domestic well contaminated by arsenic was the most serious problem with metals that was demonstrated in the groundwater study. The pollution of this well was already recognized, the water was being used for irrigation only, and our sampling merely confirmed the problem. This well was also heavily contaminated with organics. A firm manufacturing arsenical pesticides on the property adjacent to that containing the domestic well is clearly responsible for destroying the utility of this water source.

Cadmium was observed to occur above the drinking water standard of 10 ppb in three wells. One of these three was an industrial well used for process cooling water, and also provided drinking water for employees of the plant. Upon subsequent investigation and repeat sampling, concentrations of cadmium in this well were below the standard. Because of the serious health risk represented by cadmium continued monitoring of this well is necessary. The other two wells contaminated with cadmium were monitoring wells at an industrial site in Salem county; these two wells also showed other contaminants.

During this study eight wells were found to exceed the drinking water standard for chromium; however no confirmed level above the 50 ppb standard occurred in wells used for potable purposes. Past studies of ground- and surface waters have shown chromium to be widely occurring but with concentrations that are low and variable. For example, a study by Durum and Haffty (1961) gave a range of 0.7 - 84 ppb chromium in U.S. rivers. Kopp and Kroner (1967) reported a range of 1-112 ppb with a mean of 9.7 ppb.

Nickel was detected in 24 percent of the groundwater samples in this study, the maximum concentration being 600 ppb. Most detected levels were far below this value. The usual range of ingested nickel for American adults is 300-600 ug/day, however actual amounts can vary considerably (NAS, 1977). Nickel is not readily absorbed from the gastrointestinal tract, so very little ingested nickel actually enters the body. Nickel may be a required trace nutrient, but the evidence for this is still not complete.

Of the metals tested, lead occurred above the safe drinking water standard in the largest number of wells, thirteen. In only one case, however, did lead contamination seem to be a problem in a drinking water well and here subsequent analysis showed lower results, below 50 ppb. This well needs continued monitoring because of the variability of results and the potential toxicity of lead.

Estimates of natural concentrations of lead in surface waters are on the order of 1-10 ppb (Kubota et al. 1974). Kopp and Kroner (1967) reported mean values of 33.9 ppb in delivered drinking water compared to a mean of 23 ppb in untreated waer. This difference may be due to lead coming from the plumbing system. Lead in old water pipes or in solder used in piping may, in fact, represent a significant source of the metal in some areas.

Problem Wells

Of the 670 wells included in this report, thirty-one were found contaminated to a serious degree. Table 7 presents a summary of wells in which confirmed contamination occured. Five wells had contamination in more than one category, thus totals when added accross do not sum to the number of wells actually affected. Twenty polluted wells were used for industrial or monitoring purposes and eleven had been used for drinking water before this study uncovered problems and the wells were removed from potable use. The thirty-one wells are 4.6% of the wells tested; the fact that more than 95% of the wells tested in this study are considered acceptable by current drinking water standards should not be cause for complacency. Even though most wells in New Jersey are safe, the fact that 111 of the 670 wells (16.6%) showed some volatile organic contamination greater than 10 ppb, that standards for metals were exceeded, if only temporarily, in 29 wells and that 31 wells showed at least transitory problems with low levels of pesticides, serves to demonstrate the vulnerability of groundwater to contamination. Furthermore, this study was conducted to determine "background" levels of pollutants. We did not try to find specifically contaminated areas. Many investigations have been conducted meanwhile by the Department of Environmental Protection into specific cases of groundwater contamination by toxic substances. These widely publicized cases in addition to the results of this study demonstrate how easily groundwater may be contaminated. The magnitude of the threat to public health and the exceptional cost and difficulty of cleanup, if cleanup is even possible, mandate that everything possible be done to prevent or minimize groundwater contamination <u>prior</u> to its occurrence.

Table 7. Summary of High Wells

	Volatile Organics	Pesticides	Metals	# of Wells
Potable Wells with confirmed contamination				
Public	9	2	2	9
Domestic	1	1	1	2
Industrial or Monitoring Wells with High Levels	8	3	9	20
TOTALS	18	6	12	31

II. SOURCES AND BEHAVIOR OF CONTAMINANTS

Introduction

Our modern technological age has seen a tremendous increase in the availability of natural chemicals mined and extracted and an overwhelming production of synthetic chemicals. Inadvertently, and sometimes intentionally, large amounts of these chemicals have contaminated our environment. Nationwide, chemical sales reached a record 146 billion dollars in 1979, with New Jersey setting the pace in virtually all areas of the chemical industry. In New Jersey, in 1979, chemical sales increased 15.4% over the 1978 sales figures, an increase one and one half times better than the overall rate of increase in the U.S. Gross National Product. Actual amounts of synthetic organic chemicals produced are staggering. In 1979, nationwide production of benzene reached a record level of 1.7 billion gallons, 16.3% greater than the previous year (Chemical Week, 1980). Of course, production alone does not indicate the amounts entering the environment; most chemials are used as intermediates in making other chemicals or manufactured products. The exponential increase in the availability of chemicals since World War II has, however, compounded the problems of environmental contamination.

Metals, of course, occur naturally in groundwater. But high levels often represent pollution brought about by man's activities. Arsenic, mercury, and selenium, for example, have been used in pesticides. Such use now is less than it used to be. Copper, in particular, has been used as a biocide, to prevent fouling in pipes and on boat hulls, and to inhibit algal build-up in lakes and ponds.

Synthetic organics in the environment, particularly the halogenated organics with which we are concerned in this groundwater study, result almost entirely from human activity. There is evidence that minute amounts of some of the halogenated organics may be formed naturally, but by far the major contribution to pollution is anthropogenic (Siuda, 1980).

Volatile Organics

The low molecular weight halogenated organics appear to be the most troublesome of the three groups of chemicals covered in this study. Some of these compounds appear to be widespread at low levels in the state's groundwater and in addition to occur in fairly high concentration in a small percentage of groundwater samples. High level contamination obviously results from a nearby source. Industrial lagoons, landfills, leaking underground tanks, illegal dumping, and inadvertent spills have all been implicated in these types of contamination episodes. For very low levels of contamination, on the other hand, more complicated explanations may be required in addition to the specific sources cited above. These additional considerations include aerial transport of volatile organics with washout by rain to the ground and subsequent percolation to aquifers, entering the groundwater from contaminated surface waters in the aquifer recharge process, and widespread consumer use and disposal of these solvents, as for example in laundry products and septic tank cleaners. By such mechanism these compounds may enter the groundwater in relatively small amounts, but over wide geographic areas.

Chloroform, one of the trihalomethanes, has wide use in the chemical industry. It is an intermediate in the production of other chemicals, particularly mixed halogenated hydrocarbons such as the Freons^R. It is used as an industrial solvent, as a fungicide and fumigant, and as an extractant for naturally occurring substances. Considerable use of chloroform occurs in the manufacture of refrigerants and fire fighting agents. Until recently chloroform was used in ways providing direct human exposure - as an anesthetic and in a wide range of cosmetics and toiletries as well as pharmaceutical preparations. Since 1976, when the carcinogenicity of chloroform was established, such direct human exposure has been restricted. Industrial production of chloroform in 1973 in the United States exceeded 250 million pounds (NAS, 1977), and by 1978 its manufacture had risen to 355 million pounds. This production in the U.S. is estimated to constitute approximately one-half the world manufacture of chloroform (U.S. EPA, 1980). More disturbing than the production figures alone is the estimate that about 2% of that produced is released to the atmosphere as evaporative loss. Thus in 1978 in the U.S. some seven million pounds escaped to the air from manufacturing. From this source alone, it becomes clear that chloroform is ubiquitous in the atmosphere. Measurements in New Jersey have shown air concentrations up to 31 parts per billion at a site in Rutherford (Harkov, 1980). Pearson and McConnell (1975) have suggested that the presence of chloroform and other halogenated compounds in surface waters remote from any waste discharge could occur due to absorption of these chemicals from the atmosphere by water droplets and return to the earth during precipitation. Concentrations up to 0.2 parts per billion have been measured in rainwater (U.S. EPA 1980). Aerial transport, while responsible for very low concentrations, can play a role in the wider distribution of the volatile organic compounds.

For chloroform and the other trihalomethanes, however, a more important role in distribution comes as a result of chlorination. The use of chlorine to treat drinking water as well as sewage has played a vital role in protecting public health. Far more lives have been saved as a result of protecting against water-borne bacterial disease than could be at risk from trihalomethane formation. Since the turn of the century, life expectancy in the United States has risen dramatically. Disinfection, to prevent communicable disease, has been a significant factor in the longer average life span. Cholera has been eliminated as an epidemic disease and typhoid fever changed from being one of the leading causes of death to a disease of minor significance. Two factors responsible for virtual elimination of water-borne disease have been filtration and chlorination of drinking water (Greenberg 1980). Chlorination of sewage, too, has been important in disease control. One very great advantage of chlorine as a drinking water disinfectant, is that a bactericidal residual is maintained after treatment, affording protection against disease contamination in the water distribution system. Any alternative disinfectant must maintan this residual effect for ensured safety (Greenberg, 1980). Clearly, no one now proposes to abandon chlorination without equally effective and safe disinfection alternatives. Much research is now taking place, however, to determine ways to improve procedures to minimize the formation of trihalomethane and other halogenated organic compounds without sacrificing safety against disease (Jolley, et al., 1980). A study of chlorination practices at sewage treatment plants in the Passaic River basin indicated that considerably more chlorine than necessary for optimum disinfection was being used (Jolley, et al., 1980). All too often, as with drugs or vitamins, people think that if a little helps more should be better; just as this is not necessarily true in the personal health situation, neither does it apply to "environmental health".

The role of chlorination in producing halogenated organic compounds has now been well established (Rook, 1974; 1980). Although introduction of some compounds may result simply because they are contaminants of the chlorine used, most result from chemical reactions after chlorine addition has taken place. Reaction occurs with such naturally occurring organic components as humic and fulvic acids orginating from plant material, and with organics resulting from algal growth. Surface waters ordinarily are much richer in naturally occurring organic material than groundwater. Sewage, of course, contains a wide range of organic compounds. In addition to disinfection for health reasons, chlorination is used to bleach industrial effluents and as a preventive measure against biological fouling in power plants and for other industrial sites. Chloroform is one of the most readily formed chemicals as a result of chlorination. Other trihalomethanes, dichlorobromomethane, chlorodibromomethane, and bromoform, also are formed in lesser amounts. In marine and estuarine waters, greater amounts of brominated compounds are apparently favored. Other halogenated compounds in addition to the trihalomethanes also result from chlorination, many not yet identified (Jolley, et al., 1980). The discussion of chlorination and the compounds resulting therefrom may seem more relevant to surface water or to drinking water derived from surface supplies than to groundwater. The point to keep in mind, however, is that groundwater aquifers may be recharged from surface water under some conditions; low level concentrations of chloroform and other halogenated organics thus may be transported underground. Furthermore, chlorination contributes to ambient air concentrations of chloroform, and thus to its wide distribution as discussed previously (Barcelona, 1979). While aerial transport of chloroform, whether from manufacturing or chlorination, and recharge from chlorinated surface waters might explain widespread distribution of chloroform, the concentrations in groundwater as a result of these sources are likely to be quite low, probably close to the lower limits of detection in our study. Higher concentrations, and particularly those above the break-point on the frequency distribution as explained in the results section, undoubtedly occur from direct discharge into the ground.

Apparently, 1,1,1-trichloroethane is one of the least toxic of the chlorinated hydrocarbon solvents, and no evidence now exists that it is carcinogenic. It is however, particularly widespread in the environment. During this study, it was found to be the most prevalent of the organic compounds measured in New Jersey wells. Approximately 70% of the trichloroethane manufactured is used for cleaning and degreasing metal. In 1973 world wide production of this chemical amounted to 900 billion pounds. It is estimated that 92% of trichloroethane produced is ultimately released into the atmosphere (U.S.EPA, 1980). Trichloroethane is not easily degraded; breakdown in the atmosphere is slow, and meanwhile rainout to the ground and to surface waters can occur. This is one route whereby trichloroethane can enter groundwater. Su and Goldberg (1976) have reported that surveys worldwide show trichloroethane to be particularly ubiquitous; it has been measured in finished drinking water, in surface waters, rainwater, seawater, marine sediments, marine organisms, and in surface snow in Alaska. These observations illustrate that atmospheric transport is significant in the worldwide distribution of trichloroethane.

One of the first major groundwater pollution incidents uncovered as a result of this study was the contamination of the South Brunswick public supply well by trichloroethane. Direct discharge into the ground resulting from a leaking underground storage tank caused high concentrations of the chemical in the supply well necessitating its being taken out of service. An extensive and excellently conducted study has been carried out on this specific case under the supervision of DEP's Bureau of Groundwater Management (Geraghty and Miller, 1979).

Trichloroethylene, another solvent used primarily as a metal degreasing agent also shows up in a significant number of cases in New Jersey groundwater. Unfortunately this chemical has been demonstrated to be carcinogenic in tests with mice. Trichloroethylene is used in the synthesis of other compounds, as a heat exchange medium, a fumigant, and as a solvent. Vapor degreasing of fabricated metal parts constitutes an estimated 90% of use. U.S. production of trichloroethylene, commonly referred to as TCE, was over 450 million pounds in 1973. TCE may also be formed in very small amounts during the chlorination process; an EPA survey of water supplies nationwide showed values of 0.1 to 0.5 parts per billion.

Tetrachloroethylene, also commonly called perchloroethylene or PCE, is another degreasing solvent predominantly used in cleaning. PCE also is used as a heat-transfer medium and as a chemical intermediate, but by far the largest percentage is used in dry-cleaning of textiles. In 1973 worldwide production of PCE exceecded 1.6 billion pounds, with more than 1 billion lbs. used as a cleaning solvent. An estimated 85% of that produced ended up being released to the atmosphere, almost half within the United States. Thus, for that one year alone, release to the air in the U.S. of this carcinogenic chemical was estimated at 616 million lbs.! Levels of PCE in New York City air have been measured at 9.8 ppb (mean 4.5 ppb) and in Bayonne at 8.2 ppb (mean 1.6 ppb).

The three primary degreasing solvents, trichloroethane, TCE, and PCE are used extensively in New Jersey. An EPA study released in 1979 indicated that there were over 900,000 plants nationwide using these solvents in degreasing; of these 59,000 operated in New Jersey. In our state close to 38,000,000 pounds of these solvents were released into the air in 1974 (Hoogheem, et al., 1979). While the primary environmental fate of all three compounds is photo-oxidation in the troposphere, washout from the atmosphere can occur resulting in widespread low level contamination. It is possible that this route contributes to some of the groundwater contamination by these compounds found in the present study. The widespread use of these compounds also increases the likelihood of direct discharge to the ground by leaking tanks, spills, and careless disposal. The use of these compounds and other chlorinated solvents as septic tank degreasers may also contribute to levels of these chemicals in aquifers.

Also ubiquitous in the environment and only very slowly degraded, carbon tetrachloride, another carcinogen, is manufactured in very large amounts. World production in 1973 was 2.1 billion lbs., with most of this (1.8 billion lbs.) being used as an intermediate in the synthesis of other chemicals, especially fluorocarbons. An estimated 44 million lbs. of carbon tetrachloride evaporated to the atmosphere in the United States in 1973. Very large amounts of carbon tetrachloride may also be found in the atmosphere from the breakdown of tetrachloroethylene; an estimated worldwide formation of 80 million lbs. via this route occurred in 1973. Carbon tetrachloride is more resistant to degradation than many of the other volatile halogenated organics; significant amounts reach the stratosphere where breakdown by photolysis occurs with phosgene as initial product. Again, washout may account for some low level contamination of groundwater.

The substance 1,2-dichloroethane also known as ethylene dichloride is produced in tremendous amounts; U.S. production in 1973 exceeded 9 billion lbs. Dichloroethane is used as a chemical intermediate, especially in the manufacture of vinyl chloride and tetraethyl lead. It is also used as an insecticidal fumigant, in tobacco flavoring, as a constituent of paint, varnish, and finish removers, as a metal degreaser, in soap and scouring compounds, in wetting and penetrating agents, and in ore flotation. The widespread use of this carcinogenic compound, with attendant chances for release to the environment, account for its showing up as a groundwater contaminant.

Dichlorobenzenes, consisting of ortho, para, and meta isomers, serve as intermediates in insecticide production and in the manufacture of phenol and various dyes. They are used as engine cleaners, as heat transfer media such as in cooling magnetic coils, and as solvents for resins and lacquers. Familiar consumer use includes moth repellents and air deodorants; para-dichlorobenzene is a common constitutent of urinal blocks. Trichlorobenzene, which also can exist as several isomers, serves as a solvent for oil-soluble dyes, as a degreasing solvent, dielectric fluid, as an additive in lubricants and as an insecticide. The chlorinated benzenes are very resistant to degradation; they are apparently somewhat more likely to accumulate in fatty tissue of organisms than the one and two carbon halogenated compounds measured in this study.

Pesticides and Related Compounds

PCB, the commonly used abreviation for polychlorinated biphenyl, designates a group of many related molecules and isomers. Depending on how many chlorine atoms and the position of attachment to the two connected phenyl rings, more than 150 variations (isomers) are possible. Molecules with the same composition but different structure are known as isomers. Technical grade mixtures, known in the U.S. by their trade name, Arochlor^{R}, are numbered in a system indicating by the last two digits, the average percentage chlorination. Arochlor 1254, for example, is a mixture of isomers with an average of 54% of the available bonding places on the molecule occupied by chlorine atoms. Behavior in the environment and toxicological potency can differ among the isomers. PCBs are sparingly soluble in water, but the solubilities generally are greater for the less chlorinated isomers. After introduction to the enviroment of an Arochlor mixture, subsequent analysis may show patterns of isomers different from the original composition because of the unequal behavior; this is similar to the weathering behavior of petroleum oils which alters their composition. More highly chlorinated PCB isomers have lower vapor pressures and water solubilities and are chemically more stable and more persistent in the environment. The lower chlorinated isomers may be more easily transported (Tatsukawa, 1976). However, even for the more highly chlorinated PCBs, laboratory experiments have shown rapid volatilization from water. These results were contrary to what might originally have been expected based on solubility and vapor pressure data. Considerable theoretical and laboratory work have shown the PCBs and other highly chlorinated organic compounds to have high fugacity (chemical activity) contributing to volatization (Mackay & Leinonen, 1975). This work has led to one relatively simple procedure, the measurement of an octanol-water partition coefficient, which correlates well with environmental behavior and seems especially predictive of bioconcentration factors. The octanol-water partition coefficient can be roughly equated to lipid solubility. The Arochlors have been used especially as heat transfer agents and as insulating dielectrics in such electrical appliances as transformers and condensers. Their great stability even at high temperatures and their non-flammability contribute to these uses. These compounds have also been used in non-carbon copy paper, paints, and lubricants. Before use of PCBs was restricted, very large amounts had been manufactured. In contrast to pesticides, for which the amount liberated into the environment is essentially equal to that produced, it is estimated that only 20 to 30% of the total production has been introduced into the environment. Although this sounds advantageous, there is cause for concern. Whereas banning of a pesticide means a virtual cessation of any new introduction into the environment after a short time lag, much PCB remains potentially available for accidental release. Restriction meant no new use, but all of the compound in already existing equipment will only slowly be phased out. Because of their volatility and stability PCBs have been transported atmospherically until now everything in the environment is contaminated. Air, water, soil, plants, birds, fish, man --- whatever has been tested is likely to show residues of PCBs. Concentration factors for PCB, that is the tendency to accumulate in organisms, are among the highest for man-made organics (Tatsukawa, 1976). The Hudson River and its estuarine system show heavy PCB contamination because of massive discharges by a General Electric Co. plant into the river above Ft. Edward, New York. The Office of Cancer and Toxic Substances Research is currently monitoring PCB levels in organisms from the New Jersey section of the Hudson River system. Fatty fish, especially stripped bass, have been found with concentrations of PCBs above the FDA action level.

Aldrin, dieldrin, endrin, chlordane, heptachlor, and heptachlor epoxide are a group of related pesticides known as cyclodienes. These compounds have been used principally as preemergence soil insecticides for the control of corn rootworms, wireworms, cutworms, and related plant pests; as seed treatments; as soil poisons for ant and termite control; and for the control of the boll weevil and bollworms on cotton. An estimated 600 million pounds of these highly chlorinated cyclic organic compounds have been dispersed into the soil, air, water, and food of the United States during the thirty years from their discovery and development in the mid 1940s to the mid 1970s when most uses were restricted (NAS, 1977). Dieldrin is the epoxide of aldrin, and is more stable in the environment as are the other epoxides in relation to their parent compounds. Thus in addition to being applied directly, dieldrin and heptachlor epoxide result from applications of aldrin and heptachlor respectively. Oxychlordane is the epoxide of chlordane; this breakdown product has been found extensively through the U.S. (Suprock et al., 1980). Heptachlor, in addition to being applied in its own right is a constituent in technical grades of chlordane; thus chlordane (several isomers), oxychlordane, heptachlor, and heptachlor epoxide can all be detected where chlordane has been applied (NAS, 1977). The EPA banned aldrin and dieldrin on October 1, 1974 and registrations for use of chlordane and heptachlor on agricultural crops were suspended April 1, 1976. Chlordane continues in use for termite control and although restricted is still available to consumers. According to the New Jersey Conservation Foundation, apporoximately 40 pounds of chlordane are used for long term termite proofing in the basements and foundations of new homes in New Jersey. Reapplications occur commonly when houses change ownership. The cyclodiene compounds and their epoxides are extremely persistent in the environment (a property which originally made them attractive as insecticides). Significant amounts will continue to be measured years after use has stopped. From a study of dieldrin in Iowa following decrease and then cessation of use, it was estimated that this compound is decreasing in the environment at a rate of about 15% per year (Schnoor, 1981). In a nationwide survey of soil samples from military installations, residues of one or more products attribuable to chlordane were measured in 403 out of 1258 samples (Suprock, et al., 1980). Extensive sampling of U.S. rivers showed the cyclodienes virtually everywhere at low concentrations (Breidenbach, et al., 1967). These pesticides, in the parts per trillion level, may occur in drinking water even after treatment. Over the past 15 years, suggested drinking water standards for the cyclodienes have been continuously revised downward (NAS, 1977). In addition to our measurements of chemicals in waters of the state, our office has been testing aquatic organisms for pesticides. Levels of chlordane above of the FDA guidelines have been found in fish and invertebrate animals from the Camden area necessitating placing restrictions on fishing (Suchow, et al., 1980).

Before being banned for all except emergency use in 1973, DDT was one of the most extensively used of the chlorinated pesticides. U.S. production, in its heyday, was 176 million pounds per year and it was registered for use on as many as 334 agricultural commodities. An estimated 4.4 billion pounds has been used worldwide, about 80% in agriculture and much of the rest for control of insect-borne diseases such as malaria and typhus. DDT and compounds resulting from chemical changes in the parent compound, DDD and DDE, are exceptionally stable in the environment and like the other chlorinated pesticides have an exceptional tendency to accumulate in organisms, especially in fatty tissue. The overall bioconcentration factor from water to fish may exceed three million (NAS, 1977). DDT is found in milk samples including human milk. Measurements of DDT in human milk samples in the U.S. ranged from 0.04 to 0.16 ppm with an average of 0.078 ppm (Curley and Kimbrough, 1969).

Lindane is the gamma (Greek letter γ) isomer of benzene hexachloride. Benzene hexachloride, or BHC, is more properly designated as hexachlorocyclohexane, but its trivial name, BHC, is customary. The spacial arrangements of the six chlorine atoms on the hexane ring give rise to different isomers, the other most commonly found forms being designated α (alpha) and β (beta). Technical grade BHC is a combination of isomers manufactured by photochlorination of benzene. Lindane, containing at least 99% of the γ isomer, is prepared from technical BHC by selective crystallization. Lindane is relatively more soluble and less persistent in the environment than many of the other chlorinated insecticides (NAS, 1977); a Japanese study predicted significant residues of BHC remaining in 1985, however, even though use is now banned in Japan (Yamoto, et al., 1980).

Metals

The group of inorganic elements tested for in this study has sometimes been commonly referred to as metals; technically, arsenic and selenium are non-metals and should be treated separately, especially in a discussion of groundwater where their behavior and mobility may differ from the others, the so-called "heavy metals." All of the elements may occur in groundwater as a result of natural processes, but human activities may bring about considerably increased concentrations of these chemicals. Average concentrations and frequency of occurrence measured in U.S. surface waters are shown in Table 8 for these inorganic elements.

One important source of increased levels of heavy metals in drinking water may be plumbing or other direct contact of metallic components with the water. For groundwater sampling carried out in this study, measured metal levels may not represent true aquifer levels. Even though sampling protocol required flushing of the system before taking, the sample, metal contamination undoubtedly occurred in some cases. Copper and zinc are most likely to be contributed from the well installation, piping, holding tanks etc. but lead also may occur from solder or other components containing this metal with which the water comes in contact (NAS, 1977).

Table 8. Frequency of Detection and Average Concentrations of Dissolved Metals in Surface Waters of the United States*

Metal	Frequency of Detection, %	Average Concentration ug/liter (ppb)
Beryllium	5.4	0.19
Cadmium	2.5	9.5
Chromium	24.5	9.7
Copper	74.4	15
Lead	19.3	23
Nickel	16.2	19
Zinc	76.5	64

*Based on a study by the U.S. Dept. of the Interior of 1577 samples analyzed between 1962 and 1967 (Kopp & Kroner, 1967).

Because of its wide use, arsenic presents considerable potential as an environmental contaminant. This element and its compounds have been widely used as insecticides and herbicides, in alloying metals, in pigments, and in chemical warfare agents (Ferguson & Gavis, 1972). Arsenic is a byproduct of copper smelting, a process which has released large amounts of arsenic into the environment. One large copper smelter in Washington State, for example, was found to emit stack dust containing 300 tons of arsenic per year into the atmosphere (Crecelius and Carpenter, 1974). Occasionally, high concentrations of arsenic have been found to occur naturally in groundwater springs and wells in areas subject to volcanic activity. Water in wells in Lassen County, California, near a recently active volcano contained concentrations ranging up to 1400 ppb (Goldsmith et al., 1972).

In one instance a level of 13,700 ppb arsenic was found in a hot springs. Usually, however, natural concentrations of arsenic in surface and groundwater are quite low, although this element has a wide distribution. The average concentration of arsenic in the earth's crust is about 2 parts per million (Fleischer, 1973). Median concentrations of arsenic in river waters in the United States are generally below 10 ppb and the scattered data for groundwater concentrations throughout the U.S., according to the National Academy of Sciences Report (1977), indicate low levels, often below the limit of detection and perhaps averaging around 1 ppb. The generally low levels and the mean near 1 ppb agree closely with our findings in the present study. The average arsenic content in drinking water is considerably below that ingested from other sources. The daily intake in the U.S. of arsenic from food has been calculated to be 0.14 to 0.33 mg (Duggan and Lipscomb 1969). Wine, yeast, and meat and shellfish are significant sources of arsenic. Shrimp, in particular, may contain up to 170 parts per million arsenic. Thus water, even if it contained the maximum permitted level, would supply less than half the arsenic people ingest. Human activity can certainly contribute to higher than normal arsenic concentrations in drinking water. In an instance in Minnesota, a well unknowingly drilled within a buried disposal area for an asenical grasshopper pesticide exposed those consuming the water to levels as high as 21,000 ppb. Thirteen people became ill as a result of this exposure. Natural levels of arsenic in groundwater occasionally resulting from natural processes such as vulcanism can lead to toxic exposure. The population of Antofagasta, Chile, were exposed to toxic levels in their water from a volcanic area. In New Jersey, which is fortunately not blessed with volcanos, natural high levels of arsenic would not be expected; pollutant levels, when they occur are the result of human activity. The very high arsenic concentration in one well in Cumberland County, measured in this study, is such an example.

The environmental chemistry of arsenic is complicated; arsenic can exist in four valence states dependent on redox potential, pH, and other factors and can occur in chemical complexes and compounds, both organic and inorganic. At typical groundwater pH ranges, arsenic forms the stable solids As_2O_5 and As_2O_3 (arsenic pentoxide and arsenic trioxide). These solid compounds have solubilities high enough that the dissolved forms can exist at concentrations well above the permissible concentration in drinking water. If oxidizing conditions are present, soluble H_3AsO_4, $H_2AsO_4^-$, $HAsO_4^{2-}$ and AsO_4^{3-} occur. Under mildly reducing conditions the predominant species are H_3AsO_3, $H_2AsO_3^-$, and $HAsO_3^{2-}$. If stronger reducing conditions and the presence of sulfur occur, insoluble sulfides are formed which tend to limit availability of arsenic to concentrations below the safe drinking water level. Under oxidizing conditions, however, dissolved concentrations can exceed the safe limit. The fact that the dominant dissolved species are uncharged or negatively charged (anions) suggests that adsorption and ion exchange may provide little retardation to transport with bulk groundwater flow (Freeze and Cherry, 1979). This transport behavior contrasts with that of the heavy metals and increases the environmental hazard potential associated with arsenic.

Manufacture of electronic equipment such as rectifiers, photocells, and xerography copiers uses selenium and this element, or its compounds such as selenium dioxide, sodium selenite, sodium selenate, and iron selenate, are also used in making steel, in pigments, glass, and ceramics. Industrial selenium is most commonly obtained as a byproduct of copper refining. Natural levels of selenium may vary widely depending on the geology of the areas, but for the most part this element is rare. Average surface water levels in the U.S. are about 0.2 ug/l. In fact, it is likely that concentrations in water, are insufficient to provide required amounts of this micronutrient, if water were the only source (Cannon, 1974). The concentrations of selenium measured in New Jersey groundwater are very low; this element appears to present no hazard from a toxicological point of view.

Beryllium has been reported only in very low concentrations in surface and groundwaters; the maximum observed concentration noted in the National Academy summary of data in the literature was only 1.22 ug/liter. One reason for its low concentration in water is that its carbonate and hydroxide are virtually insoluble (McKee and Wolf, 1963). Beryllium discharge to groundwater is rapidly adsorbed by clay in the soil and thus immobilized (NAS, 1977). Beryllium does find considerable industrial use, especially to make special alloys in metallurgy, in electrodes for neon signs, in the manufacture of x-ray diffraction tubes, in nuclear reactors, and in rocket and missile fuels. The detection limit, or lower sensitivity for beryllium in the present study was 1.0 ppb, and thus not particularly relevant for expected drinking water concentrations. In any event, we found beryllium in less than one percent of our groundwater samples and in no case in a drinking water well at a level to cause concern. For two additional reasons, beryllium is not thought to be a particular problem in well water. First, it has little tendency to travel even if discharged to groundwater because it is rapidly adsorbed by clay in the soil. Second, even if consumed, absorption of beryllium from the digestive tract is minuscule (about 0.006% of that ingested) and excretion is relatively rapid (Browning, 1961).

Friberg and his coworkers have written excellent comprehensive reviews of environmental and health related aspects of cadmium (Friberg, et al. 1971, 1975). Cadmium occurs widely in the natural environment but at very low concentrations, natural levels found in surface waters are usually less than 1 ppb. For the population in general, most experts agree that intake of cadmium in food considerably exceeds that contributed by drinking water (NAS, 1977). Estimates (Friberg, et al., 1975) are that dietary intakes by adults approximate 50 ug per day (range 40-190 ug/day) of cadmium. Uptake by crops from contaminated soil can be a significant source of cadmium. Cadmium is significant contaminant of sewage sludge, as has been shown in the New York-New Jersey metropolitan areas (Sandy Hook Lab, 1972). Proposals for land application of sewage effluent and of sludge for agricultural purposes necessitate careful monitoring of cadmium in food from those areas. Environmental contamination by cadmium has been extensive; this metal presents a serious health problem worldwide (Friberg et al., 1971). Industrially, cadmium is chiefly used in electroplating, in pigments, and as a plasticizer in the manufacture of polyvinylchloride. Instances of groundwater contamination from electroplating operations have led to concentrations as high as 3200 ug/liter (Lieber, 1954). Average natural levels in water rarely exceed the health standard of 10 ug/liter (Durum, 1974). One of the most serious contamination episodes with cadmium led to the outbreak of Itai-Itai (ouch-ouch) disease in a population along the Jintsu River in Japan. Exposure occurred both through drinking water and eating rice grown in contaminated water (Friberg, et al. 1971). The solubility of cadmium is dependent on carbonate content and pH of water. It is least soluble at slightly alkaline pH values of 8-9 and becomes increasingly soluble under more acid conditions.

Concentrations of chromium have been reported to range from 0.7 to 84 ug/liter in U.S. rivers (Durum et al., 1971). Chromium can exist in water in several oxidation states, most commonly trivalent chromium (Cr III) or hexavalent chromium (Cr VI). Trivalent chromium, as a cation, is only sparingly soluble under ordinary conditions, although increased solubility occurs under strongly acid conditions. In the hexavalent state, as the chromate anion (CrO_4^-), much greater solubility occurs, thus high concentrations can result. Natural chromates are rare; CrO_4 in water usually indicates industrial pollution (USGS, 1959). The anionic form, as chromate, would be expected to have greater mobility in groundwater than heavy metal cations usually possess. This has been confirmed in several New Jersey pollution incidents (Kasabach, 1980).

Copper is extremely common, both as a naturally occurring element and because of its extensive industrial use. This metal is a required trace element; human intake through food is estimated to be 2 to 5 mg/day. Except in rare instances copper in water represents a small fraction of the actual human intake. Although copper is thus not likely to cause human health concern at levels found in groundwater, this metal can be toxic to aquatic animals, particularly to larval stages of some invertebrates (Waldhauer et al., 1978). Concentrations of copper in surface waters therefore are certainly of environmental significance.

For the average American, lead in drinking water is a minor component of total lead exposure, constituting about one-tenth or less of that ordinarily obtained from the diet. Dietary lead ingestion is probably 100 to 300 micrograms per day with absorption from the gut of 5 to 10 percent of the ingested amount (Tepper and Levin, 1975). Children, however, may absorb a considerably greater percentage of ingested lead - as much as 40-50 percent in 2-3 years old (Alexander, et al., 1973). Lead intake from air may be 4 to 5 times higher than the average from water. Total human lead exposure is however estimated now to be far above that prevailing in prehistoric times - the levels that could be considered "natural". Lead pollution can be traced back at least 5000 years to the development of techniques for smelting and recovery of silver. About 400 times more lead was produced as a byproduct, than the silver recovered. This byproduct found uses also, and its early production by man marks the beginning of worldwide industrial lead contamination. During that early period, world lead production averaged 160 tons per year. With the introduction of silver coinage in the Greek age yearly production increased to about 10,000 tons and at the height of the Roman period, 2000 years ago, lead production rose to approximately 80,000 tons per year. Lead production declined during the middle ages, but with the onset of the industrial revolution, production increased dramatically. Today worldwide lead production stands at about 3 million tons per year. As much as 300,000 tons annually may be admitted to the air as long lived industrial lead aerosols (Settle and Patterson, 1980; Schell and Barns, 1974). Lead has been spread throughout the earth by atmospheric transport of aerosols from smelting and other activities. Analysis of core samples of polar ice or of sediments provide a record of lead buildup going back thousands of years. With the introduction of leaded gasoline in the 1920's, massive increases of atmospheric lead occurred. An analysis of lead in sediment cores of Lake Washington for example, shows a 16 fold increase over the last 60 years, mostly as a result of this transport, transfer to the lake, followed by deposition in the sediments (Schell and Barns, 1974). "Natural" levels of lead can no longer be measured in the environment, even at remote locations, but must be estimated by extrapolating backward. These estimates give disquieting results. Oceanic surface waters down through the thermocline, approximately 500 meters thick, may contain ten times more lead than in prehistoric times. Lead is so ubiquitous as a pollutant that, according to some investigators, most chemical analysis of environmental samples has been compromised by contamination problems. Careful calculations of dietary intake show that modern ingestion of lead may be one hundred times greater than that taking place before the rise of civilization (Settle and Patterson, 1980). Although drinking water is usually a secondary source of lead, occasional higher than ordinary levels occur as a result of local pollution or as a contribution from the water distribution system. Lead pipes are no longer intentionally used in drinking water systems but solders and other components may contribute; a study of tap water compared to the raw water source suggested an approximate 40 to 50% increase picked up from the plumbing system (Kopp and Kroner, 1967). In natural water, lead concentration is usually no greater than that allowed by the solubility of lead carbonate. Lead is likely to be adsorbed by minerals in sediments and soils, so that its mobility is limited in groundwater (USGS, 1959).

Most of the nickel in surface and groundwater originates from man's activities; natural levels are quite low, probably averaging 5 ug/liter or less. As with copper, human ingestion of nickel is much greater with food than from water (NAS, 1977).

Zinc is an essential micronutrient in human and animal nutrition. This metal is exceptionally common both as a naturally occurring element and as a result of human activity. Zinc is commonly applied in fertilizers; some of the approximately 22,000 tons applied each year undoubtedly finds its way into rivers and streams and is leached to groundwater. Although zinc is quite common in water, diet is a more important source of this element. From a health standpoint zinc deficiency in some areas of the world is a greater cause for concern than is ingestion of any likely levels in water. Some studies suggest that zinc is protective against lead toxicity (NAS, 1977).

Behavior of Chemicals in Groundwater

Neither the high molecular weight PCBs and pesticide type chemicals nor the metals appear to have much mobility in soil or groundwater. Both tend to get bound to soil particles and are therefore held back, traveling much more slowly than the groundwater itself. The higher molecular weight chlorinated organic compounds apparently have a great affinity for already bound organic material on small soil particles and thus they get adsorbed. The metals, on the other hand, form stable complexes with other minerals, or act in an ion-exchange system, tending to be bound by electrostatic charge while releasing other ions such as sodium. These processes of retardation of constituents are complex; in many respects, however, they resemble processes of chromatography. Chromatographic techniques, which have been developed as separation processes in chemistry and biochemistry, have been intensively studied both theoretically and in the laboratory over the last several decades. Thus they offer insights into the behavior of chemicals in groundwater. Adsorption chromatography is the process most applicable to the behavior of the organics whereas ion-exchange chromatography may help us understand how metals behave.

Before it is possible to understand the behavior of constituent chemicals in groundwater however, one must determine the movement of the groundwater itself.

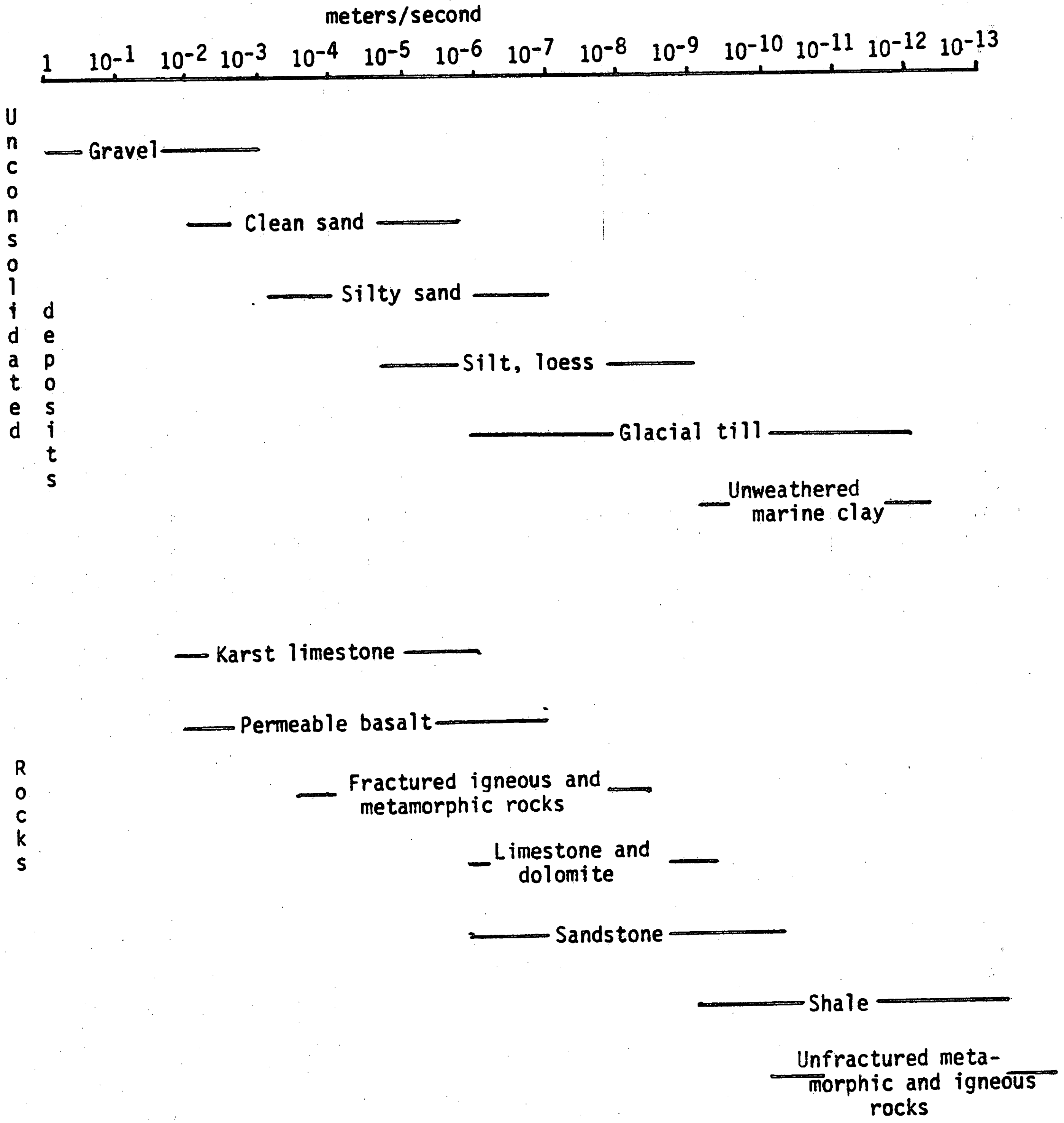
At times in the past, groundwater and surface water may have been regarded and regulated as two separate resources; it should be recognized that they are integral phases of a single hydrological cycle (McGuinness, 1963). This hydrologic cycle consists of the endless circulation of water between ocean, atmosphere, and land. Water precipitated to earth may run over land as in a stream or river or it may infiltrate into the soil. In both instances evaporation contantly takes place as well as exchange between surface and groundwater. At any one time an estimated 97% of all fresh water on earth exists as groundwater (Helweg, 1978). Once in the ground, turnover or exchange of the water may be very slow; residence times in the tens, hundreds or thousands of years are not uncommon (Freeze and Cherry, 1979). Underground reservoirs, called aquifers, consist of the soil particles (sand, gravel, clay, rock, etc.) saturated with liquid water. Movement of groundwater in aquifers composed of unconsolidated sediments, such as exist in southern New Jersey, is more easily determined and predicted than the movement occuring in fractured rock aquifers found in the northern part of our state (Kasabach, 1980). Quantitative mathematical models have been formulated to predict and describe groundwater flow. Generally these follow from Henry Darcy's original formulation, outlined in 1856, that velocity of flow is proportional to the hydraulic gradient (pressure head per unit of distance) with a constant of proportionality dependent on hydraulic conductivity and porosity of the aquifer system. This "constant" thus differs depending on whether the soil matrix is clay, sand, gravel, etc. Actual application of hydrological theory to determination of real groundwater movement is rather more complex than the simplified indication above. Numerous pumping tests using monitoring wells must be made to estimate aquifer hydraulic conductivity and porosity. In the real world, aquifers are heterogeneous and porosity and conductivity are not constant. With wells sometimes far apart, it is of course necessary to make sure that they tap the same aquifer in order that pressure measurements (hydraulic head) may be used to determine hydraulic gradients. In spite of problems and complications, modeling of groundwater movement in unconsolidated sediments has become relatively feasible, and models of the Raritan-Magothy-Potomac and of the Farrington aquifer systems have been recently published (Luzier, 1980; Farlekas, 1979). One such model has been used in a management simulation of aquifer supplementation from the Delaware River (Harbaugh, et al., 1980).

Hydraulic conductivity, the constant of proportionality in Darcy's law is influenced by the porosity of the aquifer medium through which water flow takes place. Porosity is a measure of the connectedness of the tiny pore spaces in the soil. Hydraulic conductivity is also a function of the fluid itself, its viscosity, density, etc., so this must be taken into account when underground movement of other fluids such as oil or gas is considered. Differences in temperature and salinity of water can change its viscosity and density and thus its hydraulic conductivity. This level of sophistication in the mathematical treatment of groundwater movement however gets beyond the scope of this report. In any event, one very important point is that aquifer characteristics of underground formations can vary tremendously, and that even in a relatively porous aquifer the soil materials and conditions may differ greatly from place to place within a small distance. Thus, in the real world, conditions within an aquifer are most likely heterogeneous. Hydraulic conductivity varies over an extremely wide range depending on geologic material. Figure 10 presents ranges of values for hydraulic conductivity in various types of geological material. Depending on the material, this parameter can take on values over 13 orders of magnitude. A range this great is exhibited by only very few physical parameters. In practical terms it can be very useful simply to have an order-of-magnitude knowledge of the hydraulic conductivity of the aquifer (or of the barrier material) with which we are concerned.

If hydraulic conductivity is the same in all directions of measurement, the formation is "isotropic"; if it varies with direction the formation is "anisotropic". Just as aquifer porosity is not necessarily homogeneous, hydraulic conditivity may not be isotropic when measured in different directions from a point in the aquifer. Conditions of aquifer heterogeneity and anisotropy can make determinations of actual groundwater flow very difficult. Simple mathematical models cannot be easily adjusted to complex natural conditions, and assumptions based on field data must be used with great care. Ordinarily, for example, water levels from well data can be used to plot lines of equal hydraulic potential and the assumption is made that groundwater flow will occur at right angles to such equipotential lines. Under anisotropic conditions, however, flowlines and equipotential lines may not be orthogonal (mutually perpendicular) (Freeze and Cherry, 1979). Despite these difficulties, relatively successful mathematical models, or descriptions, are being formulated for large, aquifer systems such as those of the New Jersey coastal plain. Even when simplifying assumptions can be used, these models depend on massive amounts of field data derived from well drilling logs, well level measurements, pumping tests, etc., and require sophisticated computer analysis. These models, while valuable on a regional basis, may miss localized anomalous conditions (Walton, 1979).

Movement of groundwater in fractured rock aquifers, such as those occurring in the northern part of our state, is considerably more difficult to determine than for unconsolidated formations. Theoretically, Darcy's law and all the analytical developments derived therefrom still apply (Snow, 1969), although complications can result, such as non-linear and turbulent flow in rock fractures of wide aperture (Sharp and Maini, 1972) and changes in hydraulic conductivity in fractured rock of low porosity as a result of expansions and contractions of fracture aperture under stress (Biot, 1955). A much more serious problem for understanding flow in many fractured rock aquifers including New Jersey's, is that the geology where they occur is so complex that it is difficult to determine the extent or spacial distribution underground of the formation. In addition, heterogeneity and anisotropy, even if they could be measured are so complex as to render most current mathematical modeling approaches impotent (Wolfe, 1977). As a result, determination of sources of pollutants by tracing back groundwater flow when they occur in these types of aquifers is very difficult (Kasabach, 1980). In most northern New Jersey aquifers, rates of water movement are not well known.

Figure 10. Hydraulic Conductivity - ranges for various materials



Because of modeling studies and the much better understood conditions in aquifers composed of unconsolidated sediment, rates of movement of water in these latter formations are more predictable.

Pumping of wells creates "cones of depression", a decreases in the hydraulic pressure near the well. As can be deduced from Darcy's law, this change in hydraulic gradient influences groundwater flow. Shallow aquifers, especially water table aquifers lacking an overlying confining layer, also are subject to other hydraulic gradient changes. As natural environmental conditions or changes in pumping rates vary there can occur reversals from areas of net groundwater recharge to net discharge or vice versa. Farlekas (1979) notes such a change near Sayerville in 1959 for the Farrington aquifer. Groundwater recharge from rivers may be considerable when influenced by pumping of nearby wells such as occurs in the vicinity of Camden (Kasabach, 1980). When no precipitation and runoff are occuring river flow is maintained by groundwater discharge.

As part of the interconnected hydrologic cycle, aquifers may be subject to constant variations; water levels and the velocity of groundwater flow change over time. Velocities within sand and gravel aquifers, the unconsolidated type occurring in southern New Jersey, have been determined for some areas. Average groundwater velocities in the Potomac-Raritan-Magothy aquifer system near Clayton, in Gloucester County, have been measured or calculated to be between 12 and 31 feet per year. Nearer the Delaware River where heavy pumping takes place, velocities may average 300 ft. per year. Increased use of the aquifer which will draw down water levels, increasing hydraulic gradients near zones of pumping, could double or triple these average velocities of groundwater movement by the year 2000 (Luzier, 1980). Average rates of flow in the Farrington aquifer range between 100 and 2000 feet per year, although the velocity is considerably greater within a few hundred feet of a large capacity pumping well (Geraghty and Miller, 1979). Movement of groundwater, as can be gauged from these average figures, is relatively slow, at least in the unconsolidated aquifer. In other aquifer types movement may be faster. Thompson and Hays (1979) traced Freon-11 up to 46 miles from a point source in a Texas limestone aquifer. Although the time of dumping was unknown, it must postdate the availability of the chemical in 1931; even the earliest possible introduction would indicate a minimum water velocity rate approaching a mile per year. Just as it is important to know how fast groundwater moves in a given situation, we also want to know its direction. Preliminary methods of aquifer mapping and exploration have included seismic refraction (study of sound transmitance underground) and electrical resistivity measurements. Electrical resistivity studies have also been used to map extent of underground pollution (Saunders, 1980). In an electrical resistivity survey, an electric current is passed into the ground through a pair of current electrodes and the voltage drop is measured with another pair of electrodes spaced and moved according to whether lateral or depth profiling is being carried out. In lateral profiling, the electrodes are leap-frogged down a survey line with the distance between them kept constant to provide areal coverage at a given depth of penetration underground. In this mode, aquifer limits may be defined or geographical variations in groundwater salinity or pollution mapped. In depth profiling a series of readings at a single station using different electrode spacings is carried out in order, for example, to determine thickness of sand and gravel aquifers overlying bedrock, or to locate the saltwater-freshwater interface in coastal aquifers. Information gained by surface geophysical methods such as seismic and electrical resistivity measurements must be treated as preliminary; this information must be confirmed and calibrated by test drilling. Resistivity measurement, by itself, has proven insufficiently accurate in some studies (van't Woudt, et al., 1979), but the method can be very helpful in providing data that lead to a more intelligent selection of test-well drilling, thus minimizing the amount of drilling necessary to define plumes of contaminated groundwater (Freeze and Cherry, 1979). Although much of our information on aquifer extent is a result of painstaking analysis of the geological record from well core data (Wolfe, 1977), newer methods have included use of tracer techniques. Such techniques may take advantage of naturally occurring isotopes (both stable and radio-active), and of accidentally or intentionally introduced tracer substances (Rogers, 1978). Measurements of tritium, ^3H, first introduced by atmospheric atomic testing in the 1950's, have been used to estimate turnover times of water in aquifers. Freon-11, CCl_3F, an exceptionally stable entirely man-made material first produced in 1931, has also been used in studies of groundwater age (Thompson and Hayes, 1979).

In determination of aquifer extent we must also keep in mind the third dimension - depth. In some locations, different aquifers may occur at various depths with relatively impermeable layers (aquacludes) between them. The coastal plain of New Jersey is characterized by such a layered system. But total separation between aquifers is often incomplete. Farlekas (1979) cites an example, for the Farrington aquifer, of a geological mechanism leading to incomplete separation. Near Sayerville, at some past time the Raritan River eroded the overlying Woodbridge clay and a more porous material was substituted. This same process may lead to the opposite effect as where the ancestral Raritan River eroded through the Farrington aquifer and the formation was replaced with relatively impermeable river mud disrupting the continuity of the aquifer. The hydraulic connection between parts of the Farrington north and south of the Raritan River is thus now restricted (Barksdale, 1937). This type of mechanism or some other with similar consequences may explain discontinuities in the clay layer separating the Farrington aquifer from the overlying Old Bridge aquifer in the Dayton area of South Brunswick Township. Here, massive contamination of the shallow Old Bridge aquifer also contaminated the deeper aquifer. An estimated 2.6 million gallons per day movement of water recharges the underlying Farrington through the "holes" or "windows" in the separating clay layer (Geraghty and Miller, 1979).

Understanding the movement of groundwater is only the first step in following the flow and behavior of pollutant chemicals entering the ground. Some organics, less dense than water, may travel on top of a water table aquifer; oils, gasoline, and other materials have moved through the ground in this manner (Geraghty and Miller, 1978). When pollutants enter surface water, mixing occurs and the pollutant concentration becomes diluted; pollutants may also evaporate, oxidize, or be attacked by aerobic bacteria. In the confines of an underground aquifer mixing is very slow, contaminants tend to move as a plume with concentration decreasing only slowly. Prevailing lack of oxygen and of aerobic organisms further inhibit breakdown. Diffusion, the process by which molecules spread out with a net movement away from their most concentrated zone, occurs at a rate much slower than the usual bulk flow of groundwater itself. Hydraulic dispersion of the constituents, brought about as a result of bulk flow, is the more usual mechanism by which a gradual decrease in contaminant concentration occurs. Dispersion can be accounted for by drag exerted on molecules in pore channels, by differences in fluid velocities in different pore channels and by differences in path lengths of pore channels; these microscopic processes bring about the spreading of constituents, with longitudinal dispersion (in the direction of travel) normally much stronger than transverse dispersion (lateral or perpendicular to the direction of travel). Dispersion accounts for the slow decrease in concentration of solutes which do not interact strongly with the medium through which the groundwater flows. These solutes are sometimes designated "conservative", and include such ions as chloride, Cl^- (Freeze and Cherry, 1979). Where interactions with the matrix (the material of the aquifer) occur, such as adsorption or ion exchange reactions, movement of contaminants may be held up relative to the average velocity of the water itself.

Organics

Organic substances in groundwater are subject to considerations of solubility and adsorption. Organic material already in the soil may adsorb compounds moving through. Laboratory studies have indicated that the octanol-water partition coefficient, a measure of the lipid solubility of an organic compound, can help predict the extent of adsorption of compounds in soils. The chlorinated pesticides investigated in this study are among those compounds which have high lipid affinity and apparently little mobility in groundwater (Ellgehausen, et al., 1980). These compounds, because of the way they were used, though, are extremely widespread throughout the environment, and are further spread by surface waters as a result of storm runoff, remobilization of sediments, and other disturbances. Braun and Frank (1980) found that soil erosion should be regarded as a major factor in the transport of insecticides into water systems; in their study, over 50% of the total organochlorine insecticides were transported in the January to April period corresponding to spring thaws, low ground cover, and high amounts of suspended sediment in surface waters. Because many storm sewer and sanitary sewer systems are interconnected, pesticides may enter treatment plants. But a disturbing finding in regard to pesticide transport is that most sewage treatment processes do little to remove these compounds; they thus end up in effluent discharged into rivers for further transport (Saleh et al., 1980). The widespread transport of the pesticide compounds in air and surface waters helps explain their wide geographical occurrence in groundwater at very low levels, even through groundwater mobility is low for these compounds.

The low molecular weight compounds, the so-called "volatile organics", on the other hand may travel readily through aquifers. Freon-11, CCl_3F, is apparently one such compound which is poorly adsorbed in soil and thus able to be transported great distances in aquifers (Thompson and Hays, 1979). Paul Roberts and his colleagues at Stanford University in California are conducting a program of experiments using treated water for aquifer recharge which is providing a great deal of needed information on the mobility of organics in groundwater (Roberts, et al, 1980, Reinhard, et al., 1979, Roberts, et al., 1978). Initial findings have demonstrated that the movement of chlorinated hydrocarbons is retarded in varying degrees. Estimated values of the retardation factor (a measure of the ratio of the velocity of the water flow to the velocity of the contaminant in the aquifer they studied were: chloroform, 3; 1,1,1-trichloroethane, 6; and chlorobenzene, 35 to 40.

Their techniques are also being used to help distinguish between adsorption and biodegradation as mechanisms for reduction of groundwater contaminant concentrations. Although some of the compounds they tested, such as napthalene showed evidence for biodegradation (Roberts, et al., 1980), many of the chlorinated compounds were highly refractory, passing through a biologically active aquifer with little degradation (Rittman, 1979). The relatively rapid mobility (in groundwater movement terms) and the ability to resist breakdown may help explain why the volatile halogenated compounds seem to cause the most serious problems of those chemicals tested, for New Jersey's groundwaters.

Metals

Movement of heavy metals in groundwater is subject to several complicating factors. Concentrations of the metals tend to be limited because of their low solubility and their adsorption on clay minerals or organic matter. Characteristically most trace metals in water have a tendency to form hydrolyzed species and to form complexed species by combining with anions such as HCO_3^-, CO_3^{2-}, SO_4^{2-}, Cl^-, F^-, and NO_3^-, or to form complexes with organic compounds. In order to predict mobility of metals it is necessary to know the concentrations of these various complexes, but most chemical analysis usually only provides total concentration. Since formation of complexes, and other chemical behavior, is very much dependent on oxidation-reduction (redox potential) conditions of the enviroment, as well as the on pH (acid-base conditions), these conditions are important in solubility and mobility considerations. In anaerobic groundwater, the relative insolubility of sulfide complexes usually limits trace metals to extremely low concentrations. Such metals as cadmium and lead may be kept at low levels in non-acidic conditions by the relative insolubilities of their carbonates. In addition to solubility constraints, mobility of metals may be strongly influenced by adsorption processes. Usually water that percolates through soils in depleted of its heavy metals in a relatively short time (Williams et al., 1974). Ion exchange is a factor in reducing mobility of metals. Ion exchange mostly takes place on colloidal size particle because these have a large electric charge relative to their surface area. Most clay minerals, such as the common aluminosilicates, consist largely of colloidal size particles; even apparently clean sands and gravels usually have significant contents of colloidal particles intermixed. The ion-exchange process consists of trading ions for other ions already attracted to the clay particles, such that the net electrical balance remains neutral. Divalent ions normally have stronger adsorption affinities than monovalent ions such as Na^+, so that it is usual that the heavy metal ions become bound (Freeze and Cherry, 1979). If pH or redox conditions are altered as a result of human activities, adsorption conditions may change considerably, with previously bound metals released and their mobility altered.

III. IMPLICATIONS FOR HUMAN HEALTH

Introduction

Determining the extent of risk involved in environmental exposure to chemical contaminants, such as those found in groundwater in New Jersey during the present study, is very difficult. In evaluating health effects of chemicals found in drinking water it is important to distinguish between acute toxicity and long term effects. By acute toxicity, we mean direct effects occuring immediately or relatively soon after exposure. Acute toxicity is synonynous with the concept of poisoning; symptoms may range, for example, from skin irritation, nausea, organ damage to death. It is highly unlikely that levels of chemicals usually found in potable wells would cause acute toxic effects. But low level or chronic effects with long term consequences such as genetic mutations which may cause birth defects and cancer cannot be ruled out, even though occurrence attributable to such exposure will likely be rare.

One contribution to the recognition of an environmental role in carcinogenesis was brought about by noting large changes in the incidence of some types of tumors in human populations which has migrated to different areas. Thus possible genetic factors could be sorted out from factors linked to environment. In the 1950's, John Higginson, founding director of the World Health Organization's International Agency for Research on Cancer (IARC), compared the incidence of certain types of cancer in such migrant populations and concluded that two-thirds or more of all cancers had an environmental cause and therefore were theoretically preventable (Maugh, 1979). The term "environment" must be taken in the sense of exogenous or extrinsic all outside influences impinging on the individual. Environmental factors thus include smoking, diet, and other behavioral and "life-style" factors in addition to chemical pollutant exposure.

Cancer is not a single disease, but many diseases. Complex and multiple causes may be responsible for some cancers. Despite decades of effort and billions of dollars spent, there is still much to be learned about how uncontrolled cell growth is triggered. Currently there is considerable disagreement about the extent to which chemical contamination contributes to cancer incidence and mortality. For human populations, we have more reliable data on cancers caused by exposure to varying doses of ionizing radiation, such as gamma rays or x-rays, than to chemical exposure. Yet the radiation data, for risk at low levels of exposure, is difficult to interpret; here too, there is disagreement concerning the risk. By comparison, the difficulties with estimating low level exposure risk from chemicals is made even more difficult by lack of quantitative information on actual past exposure. Estimating risks, at low levels of exposure, whether by chemicals or radiation, is hampered by two difficulties. First, precise direct estimation of small risks requires impracticably large samples. Second, precise estimates of low-dose risks based largely on high-dose data, for which the sample size requirements are more easily satisfied, must depend heavily on assumptions about the shape of the dose-response curve.

It had been thought that except for a few kinds of cancer such as lung cancer, for which cigarette smoking may be largely responsible, cancer rates were holding steady. But recent very disturbing news from the National Cancer Institute, based on data from the last decade indicates significant increases in cancer incidence. NCI found that over the period 1969 to 1976, cancer in white males increased by 9 percent and went up by 14 percent in white females (Pollack and Horm 1980); less than half of this increase is due to smoking (Schneiderman, 1980). If industrial chemical contaminants are a factor in this increase, Davis and Magee (1980) indicate that this would be consistent with the long latency period for overt occurrence of cancer after exposure. There has been a vast increase in production, and potential exposure to organic chemicals since the 1960s. For example, production of tetrachloroethylene, shown to be carcinogenic in animal tests, has increased by more than five times from 1960 to 1980, from about 250 million gallons to over 1.4 billion gallons. Total synthetic chemical production has increased exponentially, doubling approximately every seven to eight years since the end of World War II. Total production of synthetic organic chemicals is now over 175 billion pounds per year in the United States. Also disturbing is a recent study by Enstrom (1979) indicating that lung cancer mortality among non-smokers has risen significantly since 1935. This, of course, does not constitute proof of cause -- Davis and Magee (1979) caution "it is too soon to reach any conclusions about the magnitude of the cancer risk to the general population posed by industrial chemicals". Despite the complexity of cancer causation, the difficulty of determining risk, and the multiple factors involved, it is clear that some cancers are caused by environmental exposure to synthetic chemicals. Diethylstilbestrol, vinyl chloride, bischloromethylether, some analine dyes, benzene, and polycyclic aromatic hydrocarbons are some of the chemicals implicated in causing human cancer. Because of the uncertainties in defining precisely the risks, industry has often been reluctant to assume responsibility for any risk at all. Most chemicals are safe if handled correctly. Only a small percentage of the more than 70,000 chemicals used in commercial quantities have been implicated as carcinogenic risks even though tests have favored suspected compounds. But testing is far from adequate or comprehensive, and thus fairness dictates that the burden of proof be on those who would declare chemicals safe and not on the general population who must suffer the consequences, perhaps delayed 20 to 30 years, of mistakes in assessing risk.

Given that we know that cancer risks are real, but that precise quantitative risk determination may not be possible, the congressional intent of the Safe Drinking Water Act of 1974, (PL 93-523) is clearly justified. This act "requires the Administrator of the EPA to prescribe national primary drinking water regulations for contaminants which may adversely affect the public health." ..."because of the essentially preventive purpose of the legislation, the vast number of contaminants which may need to be regulated, and the limited amount of knowledge presently available on the health effects of various contaminants in drinking water, the committee did not intend to require conclusive proof that any contaminant will cause adverse health effects as a condition for regulation of a suspect contaminant."

Ways of Measuring Health Defects

In order to determine carcinogenic risk, we must rely on three general types of scientific studies. Evidence of risk is provided by epidemiological methods, animal bioassays, and short term laboratory tests with bacteria and mammalian cells.

Epidemiology

Epidemiology, the study of disease in populations, provides some of the earliest evidence for the association of cancer with environmental agents. In 1775

Percivall Pott pointed out the likelihood that the occurrence of cancer of the scrotum in chimney sweeps resulted from soot to which these young boys were constantly and intimately exposed. It has been epidemiological evidence which has implicated asbestos, arsenic, and benzene as human carcinogens. But epidemiology can most easily analyze acute effects in humans, effects such as infectious diseases that occur shortly after the causal event. Latency periods of 20-30 years and complex chains of causality make epidemiological studies of carcinogenesis extraordinarily difficult. Perhaps this is one reason why some who would minimize chemical hazards favor epidemiologic evidence in human populations as the only relevant proof of carcinogenic risk. Among the many difficulties in trying to relate population data of cancer incidence or cancer mortality to exposure to chemicals in drinking water are included the following:

a) There is often a long period of time after exposure before any evidence of cancer is apparent - this latency period may be up to thirty years or more.

b) People may move around considerably during this period, so that it is very difficult to correlate place of exposure with disease incidence. In addition people may commute some distance to work, and thus consume large percentages of water in geographical jurisdictions different from their place of residence. Use of bottled water and consumption of soft drinks introduces further uncertainly in the amount of exposure to water from within the jurisdiction of residence.

c) It is very difficult to find closely matching controls for scientific studies. Since epidemiological methods depend on comparison of populations or in cohort studies on comparison with matched individuals, these controls should be matched as closely as possible except for the suspected exposure variable.

d) So called "confounding factors" confuse interpretation of results. These are contributing factors to cancer, such as cigarette smoking which obscure the contribution of the cause (i.e. chemicals in drinking water) being investigated.

e) Dose data may be unreliable - since exposure over long periods of time is the relevant factor, how can we know what past exposure has been - what is the variability of such exposure? The present study indicates that variation of concentrations of chemicals in a single well can be considerable month to month or season to season.

f) Statistical variation within the epidemiological study may obscure the results.

Despite the difficulties, epidemiological studies have the advantage of determining health effects to human populations under actual conditions of exposure. In a number of instances it has been epidemiological evidence that has first alerted us to the risk of cancer from environmental agents (Schneiderman, 1978).

Mapping of cancer mortality data, on a county by county basis, for the whole United States, by Mason and his colleagues at the National Cancer Institute (1975) provided a tremendous impetus for further epidemiological studies. It was a result of this cancer atlas, and the evidence for higher than average cancer rates in New Jersey, that contributed to bringing our program, the Office of Cancer and Toxic Substances Research, into existence within the New Jersey DEP. Among epidemiological studies encouraged by or initiated as a result of the availability of county by county cancer statistics are those specifically addressing drinking water as an environmental factor. Initially these epidemiological studies tested the assumption that drinking water derived from surface supplies was likely to present a greater cancer risk than groundwater. Several of these studies show positive associations between water source and cancer (Schneiderman 1978). However, these associations tend to be weak and beset with statistical uncertainties.

In view of the findings of the present study, in which it can be seen that groundwater is not immune from contamination, epidemiological studies in which associations can be made directly with measured water quality are to be preferred. Cantor et al. (1977) demonstrate one such approach. In their investigation, data on trihalomethane and other organic chemical concentrations from surveys conducted by the Environmental Protection Agency were used in a multiple regression analysis with mortality rates for cancer sites from the NCI data. From these studies, it was tentatively concluded that bladder and large intestine cancer appears to be correlated with something in water, possibly with chloroform or other trihalomethanes. These quantitative studies are limited by the absence of data on exposure in past time periods and with inability to control for possible confounding factors. These studies are currently being refined with more careful gathering of quantitative data and the use of case-control design to minimize confounding factors. NJ DEP's Office of Cancer and Toxic Substances Research is participating in such studies in cooperation with the National Cancer Institute.

Animal Tests

Animal tests under controlled laboratory conditions provide a particularly valuable method for the determination of the carcinogenicity of suspected chemicals. Obviously, one cannot experiment with exposure to human subjects; human epidemiology involves after-the-fact, inadvertent or accidental exposure of a population. The agreement between animal data and human exposure studies is extraordinarily good for what constitutes a carcinogenic chemical. With the exception of arsenic, more than 82 chemicals for which there is some evidence of human carcinogenicity also cause cancer in test animals. Of course, one cannot do the correlation the other way around, by testing animal carcinogens on humans, but at least six chemicals: 4-aminobiphenyl, diethylstilbestrol, mustard gas, vinyl chloride, aflatoxin, and bischloromethylether - were shown to cause cancer in animals before epidemiological evidence confirmed their carcinogenic potential in humans. Clearly, if a chemical causes cancer in another animal species, it should be considered a human carcinogen. There is much less agreement on further interpretation of the animal results, particularly regarding mathematical extrapolation of risk vesus dose or amount of exposure to the chemical in question. Low doses of a suspected chemical, concentrations approaching likely environmental exposure, would require hundreds of thousands of animals for a single test in order to achieve statistical validity. This is clearly an impractical undertaking. Consequently tests are carried out at high concentrations. One group of animals receives the maximum tolerated dose, an amount just below that which would cause acute or overt toxic effects. Another group receives a fraction, usually one-half or one-tenth, of the chemical received by the high dose group. In order to estimate risk at low levels of exposure, the accepted procedure is to extrapolate, assuming that the risk is linearly related to the dose. Extrapolation based on the linear model is one of the more conservative approaches, but support of this model is not universal among scientists knowledgable in the field.

Despite the difficulties in interpreting results, animals tests still remain the definitive method for testing chemicals for carcinogenicity. But proper animal tests are expensive to conduct, more than a quarter of a million dollars for each chemical, and facilities adequate to carry them out are limited. Only one to two hundred tests per year are possible. New chemicals being developed for commercial use each year number in the thousands and there is still a tremendous backlog of presently used chemicals that has never been properly tested. Screening tests are desperately needed.

Short Term Testing

Because of the length of time, the amount of effort and the uncertainty involved in epidemiological studies and mammalian exposure tests, there has been a constant search for reliable inexpensive short term tests. Although much remains to be learned about how cancer is actually brought about, damage to the genetic material (mutations) within cells appears to play an important role in many, perhaps most, cancers. Thus, reliable ways to measure the potential for damage to DNA by various chemicals are a tremendous advantage in screening for possible carcinogens. One of the most successful tests for mutagenic activity is that developed by Bruce Ames at the University of California. Correlation of mutagenic potential in bacteria with ability to cause cancer in animals is high, close to ninety percent (Ames, 1979).

The short term tests have particular advantages of speed and cost, but no test detects all possible carcinogens. Scientists now recommend a battery of short term tests since one test may detect effects the others do not. Long term tests of exposure in animals will continue to be necessary for validation and epidemiological studies needed to compare results of exposure to human populations.

Determining Risk

Threshold

Whatever method we use for determining whether a chemical presents a chronic risk to human health, we are still faced with the question of quantity. How big a dose (or more appropriately, how small a dose) of that chemical can do someone harm? It may seem like common sense to assume that if we reduce the amount enough, a small exposure won't hurt us. Classical toxicology, the study of acute poisonous effects, supports the notion of a threshold - a concentration of the toxin below which no observable adverse effects occur. Physiologically, thresholds may occur because defense mechanisms in the body are able to overcome low levels of the toxin. For example, metabolic detoxification in the liver or excretion may occur before sufficient levels of the toxic substance build up to cause acute effects. But the concept of threshold dose is not appropriate for chemical carcinogenesis. Because cancer can result from a single transformed cell, and perhaps because under the right circumstances a single molecule of a carcinogenic chemical can cause significant damage to a part of the genetic material within a cell, there may be no lower limit below which risk does not occur.

Let us consider some situations with which we may be familiar in order to understand the concept of threshold. If one were to plot on a graph the numbers of auto accidents versus fatalities, no threshold would be apparent since even a single accident could be fatal. On the other hand, a graph of fatalities versus speed at which crashes occurred will likely show some threshold speed below which no deaths occurred. Anyone who has tried to start a old car with an almost dead battery on a cold morning recognizes that sound of the slow turnover of the engine that's not enough to start - the battery is providing energy below the necessary threshold.

Why the emphasis on threshold? This concept has been a major source of controversy in the study of environmental cancer. The question of whether or not a threshold exists is important in understanding the risk of chemical carcinogens, particularly at the low doses involved in environmental exposure. Unfortunately it may not be possible to settle completely the question of threshold. Computer simulation studies have shown it to be extremely unlikely to be able to distinguish between a linear dose-response curve and a highly nonlinear curve with a threshold even in a large-scale experiment involving several thousand animals per dose level. For example, "By changing the outcomes for only 11 (eleven) animals out of 8000 in a set of data," according to one investigator, "it is possible to change the dose-response curve from linear to highly non-linear. That small number is well within the limits of both experimental variability and human error. It thus seems that statistical analysis of standard animal carcinogenicity experiments does not now, and probably never will, resolve the threshold question." (Guess & Crump, 1976).

The National Academy of Sciences reviewed the controversy about extrapolating to low dose levels and concluded from these arguments that, despite all the complexities of chemical carcinogenesis, thresholds in the dose-response relationships did not appear to exist for direct-acting carcinogens. If they do exist, they are unlikely to be detected and, hence, impossible to use. This means that there can be no totally "safe" exposure to a particular carcinogen, nor can the term "margin of safety" have any meaning. Any dose of a carcinogen must be considered to be associated with a risk, and even if that risk is vanishingly small, it must be estimated. (NAS, 1977)

Risk-Benefit Analysis

If no threshold exists, this means there is no "safe level" for a compound shown to be carcinogenic. Clearly, however, the risk decreases as the exposure gets less. Can we expect zero risk; that is, can we eliminate exposure to environmental cancer causing agents? If not zero risk, what level of risk is acceptable? Acceptable to whom and by whose choice? To minimize risk, what must be done? What effort will be required and what will it cost? Who makes the decisions on the course to follow? These questions go to the heart of current controversy about cancer causing chemicals in the environment; unfortunately there are no easy answers. One suggested approach is to undertake a formal risk-benefit analysis, even to express the results in terms of cost, a financial balance sheet. The United States Supreme Court recently upheld a lower court's decision requiring such cost analysis for occupational regulations lowering the exposure standard for benzene, a known human carcinogen. The risk-benefit analysis if done rigorously has the advantage of setting out explicitly all the factors which must be considered. One danger, however, is that the quantitative analysis will be taken as more certain than it really is - numbers have a tendency to mask the underlying unknowns. David Bazalon (1979), Senior Circuit Judge, United States Court of Appeals for the District of Columbia, has pointed out: "The growing use of analytic tools such as cost-benefit analysis magnifies the chance that unrecognized value judgments will creep into apparently objective assessments." And Arthur

Upton, the director of the National Cancer Institute, has warned that misuse of risk quantification could lead to public health castastrophies if regulatory officials make the mistake of minimizing cancer risks on the basis of estimates that fail to reflect the underlying uncertainties in the mathematical analysis. These uncertainties include possibly large statistical ranges, the appropriateness of the extrapolation model, whether data from one species of animal is valid for another, and numerous questions of experimental method in carrying out the biological studies from which the data come. For example: "A given exposure to a carcinogen may cause a very low incidence of tumors in one species, whereas the identical exposure may cause a very high incidence in another species. An estimated risk of 4.2 cancers per 220 million people, as calculated by extrapolation from mouse or rat data, might turn out in reality to be as low as no human cancer, or as high as 420,000 cancers. Although the occurence of very large errors should be rare, each such error could be a catastrophe. One would not know such errors had occurred until many years after human exposure."

Zero risk is apparently not a practical reality. Some naturally occurring chemicals are now known to cause cancer; other environmental agents including sunlight have been implicated as contributing to the cancer burden. Synthetic chemicals, some of them carcinogenic, have become widespread at trace levels in our surroundings. The food we eat presents some risk and it is now becoming clear that it would be literally impossible to eliminate all carcinogens from our diet (Hutt, 1978). In the present study, small amounts of trichloroethylene or carbon tetrachloride, or some other chemical shown to be carcinogenic in animal studies, may show up in someone's private well. Switching to a public water supply may not be the logical alternative, however, because of the common occurence of chloroform or other trihalomethanes in chlorinated drinking water. Bottled water, available in the supermarket, may also have minute traces of risk-associated chemicals. Thus all the alternatives may have some risk, however slight.

The actual degree of risk to human populations for exposure to low concentrations of cancer causing chemicals, is not accurately known. The risk can only be approximated, within statistical limits, and, in fact, because of the uncertainties already mentioned, the approximations could possibly be in error by several orders of magnitude. By the same token, benefits, many of them intangible, are notoriously difficult to quantify. This does not mean that risk-benefit analysis should not be carried out. It may be worthwhile just to have all the risks and benefits clearly stated. Also, the analysis may provide at least a relative ranking of risks of various chemicals. But because of the uncertainties, results, particularly quantitative values from the method, must be treated with great skepticism. Moreover, we must be aware of other difficulties with risk-benefit analysis. Individual and societal evaluations of risk are quite different (Starr and Whipple, 1980). Perception of risk or benefit may, in fact, differ considerably from that actually measured. A case in point involves airplane and auto travel. More people express a fear of flying than fear to go by car, yet statistically air travel is considerably safer. To quote David Bazalon again: "The question then is not whether we will have risk at all but how much risk, and from what source. Perhaps even more important, the question is who shall decide." (Bazalon, 1979). Although the scientific community, the regulatory agencies, industry and others knowledgable may be expected to provide, as best they can, the information and judgements about risks and benefits from chemicals, their's is not the role to finally decide acceptable risk. That role is a societial responsibility.

Health Effects of Chemicals Analyzed in this Study

Volatile Organic Compounds

The organic compounds listed in Table 2, are commonly referred to as volatile halogenated organics. Except for the chlorinated benzenes, they consist of one or two carbon atoms with various combinations of halogen atoms (chlorine, bromine, iodine) attached. Although the volatile halogenated organics have acute toxic effects if direct or high level exposure to them occurs, the threshold levels for acute health effects are far above those concentrations found in potable wells, or, in fact, likely to be encountered in drinking water.

For the volatile organic compounds measured in this study, acute health effects from amounts found in water are not the real issue. The more serious questions concern the chronic effects - the long term health consequences. The weight of the scientific evidence points to a role in human cancer risk from exposure to these chemicals. Some of them are now known to cause cancer in animals and at least one, vinyl chloride, has been implicated in liver and brain cancers in workers occupationally exposed (Rawls, 1980). Fortunately, vinyl chloride was not picked up as a significant contaminant during this study. Chloroform, carbon tetrachloride, dichloroethane, trichloroethylene, and tetrachloroethylene have demonstrated carcinogenic potential in animal studies and these compounds do occur in some New Jersey wells. The dichloro- and trichlorobenzenes and also 1,1,1-trichloroethane have not so far been shown to be carcinogenic; such negative results should still be viewed cautiously however, pending further testing.

Confirmation of suspicions that chloroform might cause cancer came with release, in 1976, of data from the National Cancer Institute's long-term feeding study with rodents. Ingestion of chloroform resulted in hepatocellular carcinoma in male and female mice, kidney epithelial tumors in male rats and benign thyroid tumors in female rats, (NCI, 1976). Carbon tetrachloride has caused hepatomas in mice, hamsters, and rats. Testing of trichloroethylene in mice caused both males and females to develop hepatocellular carcinoma. In 1978, experimental evidence also implicated tetrachloroethylene as carcinogenic and more recently dichloroethylene has been added to the list of cancer causing compounds. The Federal Environmental Protection Agency has recently released estimations of risk from ingestion of certain chemicals in drinking water. For those organic compounds included in this groundwater study the estimates are given in Appendix A.

Pesticides and Related Compounds

Polychlorinated biphenyls (PCB's), dieldrin, aldrin, chlordane, heptachlor, lindane and other BHC isomers, and DDT have all been shown to be carcinogenic in tests with animals. Concentrations of these compounds, when detected, were generally very low (usualy less than 1 part per billion) in the well samples but nevertheless cause for concern. In contrast to the volatile chlorinated organic compounds, which are fairly readily excreted, the pesticides and PCBs tend to build up in fatty tissue in the body. These chemicals are not easily broken down, but instead highly persistent in the environment and in the body. Thus, because of their persistence, their tendency to bioaccumulate, and because they increase cancer risks, these compounds represent serious potential threats to public health and are cause for concern when found in groundwater even in small amounts. The recognition of the danger they pose has led to outright bans or severe restrictions on their use. DDT was banned for use in the United States in 1973, yet residues of DDT and its metabolites continue to be measured in the environment and are expected to continue to be found for many years. Aldrin and its epoxide, dieldrin, were banned in 1974, heptachlor in 1976 and chlordane suspended for all agricultural uses and restricted to use for termites only, in 1976. In 1977 PCB use was severely restricted. Because of the past patterns of use of these compounds and the fact that they do not break down easily, they are present everywhere in the environment in trace amounts. Curley and Kimbrough (1969) measured DDT residues in human milk ranging from 40 to 156 ppb with an average of 78 ppb. Measurements of PCBs in milk of nursing women have shown concentrations as high as 10,600 ppb with a mean of 1800 ppb for all samples (USDHEW, 1976). In a study of over 1400 bioassays of human fatty tissue, during the years 1970 through 1974, yearly average concentrations of dieldrin ranged between 100-290 ppb, Heptachlor epoxide between 100 to 170 ppb, and oxychlordane was 140 ppb. The average concentration of DDT in human fatty tisue tested was over 11,600 ppb in 1970 with a gradual decrease to 7,800 ppb in 1974 (NAS, 1975). Clearly, the banning or severe use restriction of these compounds is justified. Public health concerns also mandate our continued sampling and analysis for these chemicals in the environment of New Jersey.

Metals

Arsenic is a well known and ancient poison. The more common acute toxic effects, however, occur at levels considerably greater than any concentrations we have found in groundwater. Arsenic is relatively rapidly excreted and thus would not have a tendency to build up in the body (Peoples, 1964). Chronic effects of long term exposure to arsenic, on the other hand, are clearly of concern at levels of arsenic shown to occur both naturally and as a result of pollution. Studies in Taiwan of people exposed to arsenic at a concentration in the range of 500 parts per billion from artesian wells that have been in use for almost fifty years have shown considerably higher prevalence rates for skin cancer (Tsang et al. 1968). Other groups exposed to high concentrations of arsenic in drinking water have also been reported to have increased incidences of skin cancer (Bergoglio, 1964; Zaldivar, 1974). The National Academy of Sciences Committee studying the safety of drinking water has stated that much remains to be learned about the role of arsenic in carcinogenesis and has recommended additional studies. Unfortunately good animal models for human effects are lacking. The committee warns that it is possible that the current interim standard (50 ppb) may not provide an adequate margin of safety.

Beryllium may be a particular occupational hazard when the means and route of exposure are beryllium dust to the lungs. Beryllium is apparently not translocated to the lung from other parts of the body. The National Academy of Sciences drinking water panel was concluded that beryllium is relatively harmless when ingested in food and water, except at very large continuing doses and that it does not present a hazard in drinking water (NAS, 1977).

Contamination by cadmium of an area in Japan leading to a disease they named Itai-Itai (ouch-ouch) was painful testimony to the seriousness of cadmium toxicity (Friberg, et al., 1971). Although evidence of human carcinogenicity is not substantial, cadmium has been shown to be an animal carcinogen and also to cause birth defects in rats (Chernoff, 1973). Results from this study of groundwater do not implicate cadmium as a serious threat currently in well water in New Jersey. The health risks that cadmium poses, however, mandate continued vigilance.

The health effects of chromium present a complex picture with questions still unanswered. The toxicity appears to depend on the valence (oxidation state) of the metal; transformations from trivalent to hexavalent chromium can occur both in the environment and in the body. There is considerable agreement that trivalent chromium is a required dietary trace cofactor. On the other hand, evidence exists that hexavalent chromium may cause cancer when inhaled in high amounts likely to occur under occupational conditions. Non-occupational exposure, and particularly that which occurs through ingestion of the metal at concentrations which normally occur in food and water, does not seem to present a significant hazard (NAS, 1977).

The National Academy committee did not consider nickel to be of concern in drinking water, because of its low toxicity when ingested and because food contains considerably more nickel than is likely to occur in water. The committee concluded there is no present need to establish nationwide limits for nickel in drinking water nor is there a pressing need for further research about nickel in drinking water (NAS, 1977).

Because of extensive worldwide contamination with lead, health effects studies in animals and even chemical analysis of trace levels of this metal are extraordinarily difficult (Settle and Patterson, 1980). Interference in the biosynthesis of heme, the component in red blood cells responsible for oxygen transport, is one problem thought to be caused by lead at only modest increases above typical levels (Zielhuis, 1975). There is some concern that lead exposure, particularly in children, may lead to neurological deficits, such as slowing of transmission of messages along nerves. Lead is suspected of increasing risks of mental retardation (Beattie, et al.,1975). Although eating of lead-containing paint chips, available more commonly in deteriorating neighborhoods, has long been thought to be a major source of exposure to young children, other sources such as lead recovery operations are also available and can present health problems. In view of other possible sources of environmental exposure to lead, the National Academy of Sciences committee on Safe Drinking Water has commented that the present standard of 50 ppb lead in water may not provide a sufficient margin of safety, particularly for fetuses and young children (NAS, 1977). The Office of Cancer and Toxic Substances Research is undertaking a detailed study of exposure to lead in one of New Jersey's older cities. Clearly, much more needs to be known concerning the health risks posed by lead exposure.

Data from the present study show that copper and zinc concentrations occasionally exceed the interim secondary drinking water standards. Secondary standards are set for esthetic purposes rather than for the health related reasons involved in primary standards. The standard for zinc, a secondary one, is 5,000 ppb. However, no adverse health effects are thought to occur below 40,000 ppb. Thus, even for the highest concentration found in this study, zinc is not a health risk in New Jersey groundwater. Copper also did not occur above a concentration (about 5000 ug/l) thought to be any risk to human health.

Selenium was not found to occur above the safe drinking water standard. This element, while toxic at higher concentrations, is known to be a required trace element in human nutrition. Copper and zinc, also required, serve as cofactors in a number of enzyme reactions in the human body.

APPENDIX A - Risk estimates for organic carcinogens

The U.S. Environmental Protection Agency has published estimates of cancer risk, based on extrapolations from animal data, for those chemicals in our study which have been determined to be carcinogenic. The detailed methodology for these estimates is given in the Federal Register Nov. 28, 1980, pages 79351-79353. The risk estimates are given in terms of the concentration of the chemical in water (in micrograms per liter, or parts per billion) which if consumed daily over a 70 year life span would lead to an increased risk of one incidence of cancer per 100,000 people.

Chemical	Concentration for 1 in 100,000 cancer risk-ppb
Trichloroethylene	27
Vinyl chloride	20
Tetrachloroethylene	8
Carbon tetrachloride	4
Chloroform and other trihalomethanes	1.9
Lindane (γ-BHC)	0.19
β-BHC	0.16
α-BHC	0.092
Toxaphene	0.0071
Chlordane	0.0046
Heptachlor	0.0028
PCB	0.00079
Aldrin	0.00074
Dieldrin	0.00071
DDT and metabolites	0.00024

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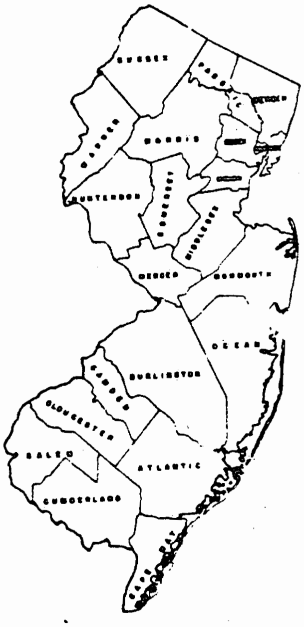
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

GROUND WATER POLLUTION INDEX



1975 TO JUNE 1981

DIVISION OF WATER RESOURCES

WATER QUALITY MANAGEMENT ELEMENT
BUREAU OF GROUND-WATER MANAGEMENT

GLOSSARY

FORMATION ABBREVIATIONS:

Tbh = Beacon Hill Gravel
Tch = Cohansey Sand
Tkw = Kirkwood Sand
Tsr = Shark River Marl
Tmq = Manasquan Marl
Tvt = Vincentown Sand
Tht = Hornerstown Marl
Krb = Red Bank and Tinton Sands
Kns = Navesink
Kmw = Mount Laurel and Wenonah Sands
Kmt = Marshalltown Formation
Ket = Englishtown Sand
Kwb = Woodbury Clay
Kmv = Merchantville Clay
Kmr = Magothy and Raritan Formations
Trb = Brunswick Formation
Trl = Lockatong Formation
Trs = Stockton Formation
Dsk = Skunnemunk Conglomerate
Dbp = Bellevale Sandstone and Pequanac Shale
Kmo = Marcellus Shale and Onondaga Limestone
Dkn = Kanouse Sandstone
Des = Esopus Grit
Dob = Oriskany and Becraft Limestones
Dnc = New Scotland, Stormville and Coeymans Formations
Sbd = Late Silurian Formations
Shf = High Falls Formation
Ssg = Shawangunk Conglomerate
Sd = Decker Limestone and Longwood Shale
Sgp = Green Pond Conglomerate
Omb = Martinsburg Shale
Oms = Manhattan Schist
Ojb = Jacksonburg Limestone
Cok = Kittatinny Limestone
Oe = Epler Formation
Or = Richenback Dolomite
Ca = Allentown Formation
Cl = Leithsville Formation
Ch = Hardyston Sandstone
Fl = Franklin Limestone
Trbs= Basalt Flows
Trdb= Diabase
sp = Serpentine
ns = Nephelite Syenite
bb = Basic Volcanic Breccia
gr = Granite
gb = Gabbro
gn = Gneiss
lgn = Losee Gneiss
bgn = Byram Gneiss
wgn = Wissahickon Mica Gneiss
pgn = Pochuck Gneiss
Fnd = Formation not determined
Qs = Quaternary Sands

FORMATION ABBREVIATIONS:

Qm = Moraine
Qtm = Terminal Moraines of the last (Wisconsin) glacial epoch
Qrm = Recessional Moraine (Wisconsin)
Qsd = Stratified Drift (Wisconsin)
Qed = Early Drift (Wisconsin)
Qbs = Beach Sand and Gravel
Qcm = Cape May Formation
Qrd = River Drift
Qps = Pennsauken Formation
Qbt = Bridgeton
Qal = Alluvium
msk = Skarn
Rec = Recent
pC = Pre-Cambrian

TECHNICAL ABBREVIATIONS:

Ag = Silver
Al = Aluminum
As = Arsenic
Ba = Barium
BOD = Biological Oxygen Demand
Ca = Calcium
Cd = Cadmium
Cl = Chloride
CN = Cyanide
COD = Chemical Oxygen Demand
Cr = Chromium
Cr^{+6} = Chromium (hexavalent)
Cu = Copper
DO = Dissolved Oxygen
F = Flouride
Fe = Iron
Hg = Mercury
K = Potassium
Mg = Magnesium
mg/l = milligrams per liter
Mn = Manganese
Na = Sodium
NJPDES = New Jersey Pollutant Discharge Elimination System
Ni = Nickel
NO_3 = Nitrate
Pb = Lead
PBB = Polybrominated biphenyl
PCB = Polychlorinated biphenyl
ppm = parts per million
Se = Selenium
Si = Silica
SO_4 = Sulfate
TCE = Trichloroethylene
TDS = Total Dissolved Solids
Zn = Zinc

Accidental (A)

A-1	Gulf, Port Monmouth, Monmouth Co., Approximately 3500 gallons of gasoline in ground water. Recovered 2000 gallons from tank area and 1000 gallons from production well. Cleanup finished on 11/8/76. Case closed.	7/76 Qs/Rec/Ket
A-2	Exxon, Millville, Cumberland Co., Approximately 8000 gallons of gasoline was reported to be in the groundwater. Recovered 10,500 gallons. Public supply well 500 ft. away was closed and Exxon used bacterial activation to remove remaining gas. Case closed.	Spring '76: Qbt/Tch
A-3	Arco, Duck Island, Trenton, Mercer Co., Approximately 2500 gallons of ARCO supreme was spilled due to overfill from pipeline. Cleanup was by excavation of 250 cubic yds. of soil. Several monitor wells were installed. Area is underlain by peat. Case closed	11/76 Qs/Rec/Kmr
A-4	Dover Sewer Authority, Lavalette, Dover Twp., Ocean Co., Approximately 3000 gallons of diesel oil was spilled into the ground water. Well at site removed several hundred gallons, and flooding was used to remove the rest. Case closed	11/76 Rec/Qcm/Tch
A-5	Wanaque-Midvale School, Passaic Co., Unknown amount of fuel oil leaked from underground tank and appeared in stream approximately 200 ft. away. Investigation and cleanup is still continuing in spring 1980 due to renewed leakage. Large volume oil involved. 10/80 Recovery system installed. 5/81 System functioning as anticipated, seepage to brook has ceased. Approximately 50,000 gallons of fuel oil recovered.	Spring '76 Qm/Qs/pC
A-6	Ingersol Rand, Philipsburg, Warren Co., Approximately 45,000 gallons of fuel oil lost in 1945. Oil was then found in a new well on the site, 500-800 ft. from spill site; No recovery. New well fouled.	Fall '75 Or/Cavernous Ls.
A-7	Old Deal Rd., Eatontown, Monmouth Co., Well contaminated with organic chemicals, TCE. Investigation revealed people contaminated their own well. Used a 1 lb can of "spray and wash" per week for 52 weeks. Well closed. Home connected to public water supply. Case closed.	Fall '76 Tvt
A-8	West Shore Lake Hopatcong, Sussex Co., Wells contaminated on Adelphi drive. High TDS, Si, Mn, Fe, Cl. Pollution source suspected to be septic systems and iron smelting slag.	2/76 pC gneiss
A-9	Agway, Flemington Junction, Hunterdon Co., Area of many petroleum product spills. Four wells are contaminated; deepest are 170 feet. No cleanup underway.	2/77

A-10 Hess Oil, Lakewood, Ocean Co., 3/77

Leaking tank; gasoline showing up in telephone manhole (Exxon-1000 gallons by 3/21/77). Borings by Exxon indicate traces of gasoline around Exxon station and to the Southeast. Borings both up and down gradient of the Hess station indicate Hess is the source of the gasoline. 18,000± gallons of gas removed. Case closed. Tkw

A-11 South Orange Water Department, South Orange, Essex Co., 3/77

Gasoline in ground water. There were 26 possible sources and the entire South Well Field had a gasoline taste and odor. Well field shut down. All sources pressure tested and some wells drilled. Most severely contaminated wells pumped to waste for 2 1/2 years. Well field returned to service in July 1979. A second gasoline incident occurred in the same well field in early 1981. Problem abated in two months time. Trb

A-12 Hess Oil, Middletown, Monmouth Co., 3/77

Hess gasoline station on Rt. 35. 4400 gallons of gasoline unaccounted for over a two day period. Recovered 7100 gallons by recovery wells. Case closed. Kmv

A-13 Private wells, Manahawkin, Ocean Co., 4/77

Oil, grease, and volatile organics found in wells. It appears as though any leaks or spills in the area of Meenan Oil Co. or Forte Oil storage would flow towards the dewatering wells and thus across the private wells having the contamination problems. The dewatering operation has been stopped and the water quality has gradually improved. Problem appeared to be caused by excessive lowering ground water level. Wells were ordered closed on or after 5/5/77. Qcm/Tch

A-14 Rubin Home, Franklin Twp., Somerset Co., 5/76

A domestic well was contaminated with what appears to be sewage plus hydrocarbons(gasoline?). Well should be abandoned since they have city water. Case closed. Trb

A-15 Maschio's Restaurant, Lyndhurst, Bergen Co., 6/77

Contaminated well used by Maschio's for air conditioning. Gasoline or diesel fuel present in well. Trb

A-16 Mrs. Horman, Arrighi Drive, Warren Twp., Somerset Co.,

Contaminated domestic well with a strong odor, presumably fuel oil. There were three possible sources; 1) home fuel tank 2) 1000 gallon fuel oil spill in 1976 3) buried gas tank 500 ft. away. Trbs

A-17 Harding Twp., Morris Co., 9/77

2-6,000 gallons leaked from a Sunoco (Mohawk Oil Co.) gas station on Rte. 202. Four domestic wells contain significant amounts of gasoline. Recovery effort underway as of 10/11/77 from two recovery wells. Recovery totalled several 100 gallons. A 500 foot well was drilled for the most affected supplies. Case settled out of court. All monitor wells (except one) are clean as of 5/81. Case inactive.

Trb

A-18 Mt. Arlington wells, Morris Co., 7/77

Contamination of several private wells by a gasoline spill at Exxon station in 1970. Station now owned by Getty. Well at Neighborhood Inn started to pump gas in July 1977. Exxon has performed borings. In 1978-1979 Exxon replaced wells and these subsequently became contaminated. Exxon is to hook-up the homes to a central water system in 1980.

gr/gn

A-19 Amoco, Neptune Twp., Monmouth Co., Spring' 77

Located on Rte. 33 and Rte. 35, this station may have lost between 15-30,000 gallons. There was recovery from 6 holes and a 12 x 24 well. Case is now closed.

Tkw

A-20 Arco, Hammonton, Atlantic Co., 6/78

Approximately 2000 gallons of gasoline were leaked and 1200 +300 gallons were recovered from the ground. Ditch recovery method was used and continued until Fall '78. Recovery system has been removed and case is closed.

Tch

A-21 Amoco, Leonia, Bergen Co., 8/78

Approximately 8000 gallons of gasoline leaked and 700+200 gallons were recovered. Recovery was continued and leaking tank was removed. Gasoline periodically appears in storm and sanitary sewers. Explosimeter investigation of Leonia's sewer system was performed in summer of 1979. No problem. Case closed.

Trdb/Trs

A-22 Amoco, Morristown, Morris Co., 8/78

Approximately 3000 gallons of gasoline leaked and 225 gallons were recovered from ground by sump method. Recovery was terminated in fall of '78. Case closed.

Qtm

A-23 Min Wax, Clifton, Passaic Co., 7/78

2650 gallons of mineral spirits were lost via delivery into the wrong pipe. Approximately 300 gallons recovered and contaminated soil removed to the Edgeboro Landfill. Case closed even though 2300 gal not recovered.

Trb

A-24 Coastal Oil Co., Passaic, Passaic Co., 8/78

Unknown amount of #2 fuel oil lost; some into the Passaic River and some into the ground. Recovery wells (2") installed along bulkhead and inside tank dike. Very modest recovery and sheen into River cut off by repairing bulkhead. Seepage has dissipated and case closed. Qal/Trb

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A-25 Shell, Rte. 4; Paramus, Bergen Co., 8/78

Unknown amount of gasoline. Leakage occurred below ground into tributary of Passaic River. Recovery and absorption along bank. Old tanks removed and replaced with a 10,000 gallon fiberglass tank. Recovery totalled few hundred gallons. Case closed. Trb

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A-26 Shell, Rte. 17; Paramus, Bergen Co., 8/78

Supposedly 1300 gallons of gasoline lost, but evidently a false alarm. No leaks observed, and tanks were replaced with no gasoline loss. Closed. Trb

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A-27 Coastal Services, Paulsboro, Gloucester Co., 8/78

Unknown amount of oil/chemicals in groundwater. Lagoons seem to be primary cause of contamination. Groundwater decontamination is underway. Rec/Kmr

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A-28 Air Products Corp., S. Brunswick, Middlesex Co., 9/78

A loss of several thousand gallons of vinyl acetate into surface drainage ponds due to reactor failure. This was pumped into nearby sewer. Soil samples indicate no penetration of spill, therefore no groundwater threat. Case closed. Qps & Kmr

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A-29 Hillsborough Twp. (Stein residence), Somerset Co., 10/77

The contaminated well contained several organic chemicals (possibly gasoline components). Kent-Moore testing of adjacent airport tanks, but no clear case against airport. Well driller donated new well to homeowner, cased to 50 feet. Inconclusive investigation. Airport wells being monitored. Case essentially closed. Trb

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A-30 Hexcel Corp., Sayreville, Middlesex Somerset Co., 6/77

Loss of unknown quantity of PBB's into shallow aquifer. Monitor wells installed with a recovery trench in October 1978. Collapse of dewatering trench due to the high ground water level. Therefore, a well header system was installed. As of early 1979 system was largely clogged. Another trench scheme installed in latter 1979 and ground-water decontamination continues discharging 1,1 dichloroethane (EDC) into adjacent sewer. 5/81 Treatment still not on line, pumping going on. Kmr

A-31	GATX, Carteret, Middlesex Co., Black liquid leaching into the Arthur Kill river. There will be no followup until more data is received.	9/78	Trb/Kmr
A-32	Getty Oil pipeline, Bound Brook, Middlesex Co., Approximately 16,000 gallons of #2 fuel oil leaked into Bound Brook, to Green Brook, then to the Raritan River. Problem is confined to surface water due to broken pipe under the culvert. As a precaution the Elizabeth Town well was closed. No ground water problem, hence case closed.	9/78	Trb
A-33	Shell, Hawthorne, Passaic Co., Gasoline fumes in basement and storm sewer. Some gasoline was spilled into sewer, but no immediate ground water problem. Case closed.	9/78	Trb
A-34	Phillips Oil Co., Hackensack, Bergen Co., Approximately 10,000 gallons of #2 oil has leaked from the bottom of a 2 million gallon tank. Most of the oil was contained and removed from the dike area. Wells have been located. Wells monitored for a period of 1 month, no product was observed. Case closed.	9/78	Qal
A-35	R.P. Profiles, Howell Twp., Monmouth Co., Here 150 gallons of Acetone and 260 gallons of resin were lost in a fire and explosion. The wash-down water went into a septic tank or dry well. No acetone odor detected and according to Ray English (Howell Twp. Health Officer) there is no problem.	9/78	Tkw
A-36	Exxon (Walters), Ridge Rd. Lyndhurst, Bergen Co., Approximately 3561 gallons of unleaded gasoline leaked due to a break in the lines and possibly leached from tanks.	9/78	Trb
A-37	Jacks Texaco, Audubon, Camden Co., A reported 1000 gallons was lost from a leaking line. Two 4" wells were installed and within the first 2-3 weeks 1200 gallons were recovered. As of 12/15/78 5000 gallons were recovered. Recovery operation is in the process of being terminated and case closed.	9/78	Ket
A-38	Deans Oil Co., Mahwah, Bergen Co., Unknown amount of gasoline discovered through sewer excavation explosion. Recovery trench installed and few tens of gallons recovered. No further gas detected. Presumed minor loss. Case closed.	9/78	Trb
A-39	Fuel Oil; Oaklyn, Camden Co., Fuel oil is seeping into several basements during periods of rain. Oil seems to be backing up in the sewer line then into the houses. Cause of spill unknown.	10/78	Tmv

A-40	Municipal Well Contamination, South Brunswick, Middlesex Co., Well #11 with 600 ppb trichloroethane on 12/19/77. Well shut down and a massive State and consultant program to pin-point sources, using pump test, sampling, tens of monitoring wells initiated. Several probable sources. Consultants report of May 1979 agree essentially with Department analysis. IBM sited as principal source of organics. Consent agreement signed in May 1980. As of 6/81, both IBM and Mideast decontaminating successfully. IBM is pumping well #11 to volatalize the organic contaminants.	12/77	Kmr
A-41	City Service, Edison, Middlesex Co., Gasoline spill occurred from a leaking 12,000 gallon fiberglass tank. An estimated 13,000 gallons were lost and a well recovery of 9,600 gallons has taken place. Plume delineated with observation wells and use of resistivity data. No groundwater contamination resulted. Case closed.	10/78	Qtm
A-42	Getty Pipeline Break, Martinsville, Somerset Co., Contaminated domestic well. Pipeline broke on Shanok property. Potential sources are most likely to be pipeline break, but there is a slim possibility of a buried heating oil tank leak.	10/78	Trb
A-43	Blue Star Exxon, Scotch Plains, Union Co., Gasoline spill of 9000 gallons. Five observation wells were drilled and no product was found. Determined to be a paper loss. Case closed.	11/78	Trb
A-44	Mobil station, Haddon Twp., Camden Co., An unknown amount of gasoline was spilled here. Recovery is continuing and has consisted of a ditch recovery with a dewatering sump and an on-site gravity separator.	12/78	Kwb
A-45	Hoboken, Hudson Co., Leak from a heating oil tank has developed. Fuel oil (#2) is leaking into a basement. Source has since been detected and eliminated.	9/78	Fill
A-46	Texaco, Pompton Lakes, Passaic Co., 1500 gallons of gasoline has spilled from a leaking tank. Recovery has continued with the use of a combination dewatering and skimmer well. A total of 500 gallons was recovered. Recovery well has been grout sealed. Case closed.	10/78	Qsd
A-47	Brooklyn Mt. Rd., Hopatcong, Sussex Co., Fuel oil contamination of a domestic well. Investigation has indicated source of oil probably is owner's oil burner.	12/78	gn
A-48	Northwood, Lake Hopatcong, Morris Co., Fuel oil contamination of a domestic well. Cause could be neighbor's fuel line or it may be his own fuel tank. As of 5/81 no clean-up has taken place due to excessive cost that would be incurred by homeowner.	2/78	gn

A-49 Texaco, West Long Branch, Monmouth Co., 10/78
Several thousand gallons of gasoline lost due to leaking underground tanks. Recovery wells installed and have begun to recover gasoline. Case closed. Tvt

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A-50 Mobil Oil, Paulsboro, Gloucester Co., 12/78
Approximately 900 acres of soil and the ground water has been contaminated by oil from this refinery. A major ground water recovery system was installed and operation started in fall of 1980. Kmr

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A-51 Atlantic City, Atlantic Co., 2/78
A series of fuel oil contamination problems due to leaking home fuel oil storage tanks. Case closed. Qbs

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A-52 "Power Test" Gasoline Station, Greenbrook, Middlesex Co., 10/76
Undetermined amount gasoline leaked into the ground approximately 11 feet below grade. Adjacent nursery well contaminated with gasoline. Backhoe holes were dug and a well installed in bedrock for recovery. Power test has since paid for new well for nursery. Case closed. Monitor well secured and there has been no gasoline evident in the new, potable well as of January 1979. No problem reported as of 5/81. Trb

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A53 Jersey City (corner of Paterson Plank Rd. & N.Y. Ave.) Hudson Co. 12/78
Adjacent Exxon and Getty stations leaking unknown volume of gasoline. Fumes detected in basements of nearby row houses which forced evacuation. Recovery wells located at each station and a trench behind row houses worked well for recovery and quick dissipation of fumes. Several 100 gallons recovered and case closed in 1979. Trb

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A-54 Kraemar's Sunoco, Toms River, Ocean Co., 12/18/78
Approximately 7000 gallons of unleaded gasoline leaked into groundwater on November 16, 1978. This spill was reported to the State on December 18, 1978. Several observation wells and one recovery well have been installed. Cleanup began on March 1, 1978. Tch

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A-55 Mobil Station, Stockholm, Sussex Co., 2/79
An underground gasoline tank is leaking into a marshy area located on Route 33. No investigation has begun as of March 11, 1978. Trb

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A-56 Arlington Warehouse, Newark, Essex Co., 1/79
Warehouse fire left a large amount of contaminated water in basement which was leaking into subsurface. Site cleaned up by the office of Hazardous Materials Control. Ground water evaluation completed as of June 1979. Recovery system for groundwater installed in basement but not used. Monitor wells remain. Clean up costs exceed $1 million. Basement filled in and case closed 1980. Monitor wells to be sealed after final sampling. Trb

A-57 Ashland Chemical, Newark, Essex Co., 3/79

Approximately 2500 gallons of #4 fuel oil has leaked into the ground. This spill has lead to the discovery of oil and solvents in Ashlands storm sewer system. In five days 5000 gallons were recovered. A second recovery system installed as of May 1979 for solvents. No real recovery effort as of May 1980. Groundwater decontamination system partly installed in 6/81.

Recent/Trb

A-58 Texaco Gasoline Station, Willingboro, Burlington Co., 3/79

There is a cracked elbow in the gasoline distribution lines. Extremely shallow water table has resulted in gasoline appearing at surface on adjacent Seven-Eleven store parking lot.

Observation wells have been installed to determine extent of the subsurface gasoline contamination. Tanks were tested by Texaco Engineers and were determined competent. To date the amount of product lost is unknown. A gravel packed trench with dewatering well has been installed for recovery. No product was recovered and gasoline declined to undetectable limit in observation wells, case closed.

Ket

A-59 Penn Gasoline Station, Belvidere, Warren Co., 3/79

Number 2 fuel oil entering Pequest River one mile upstream from its confluence with the Delaware River.

A collection sump was installed with sorbent materials and flow to the river has been eliminated. Exact source still being investigated.

Source determined to be spillage from unknown diesel vehicle into storm sewer.

Oil cleared up and cased closed.

fill/Qal

A-60 Highway Dept., Mount Holly, Burlington Co., 4/79

Approximately 6000 gal. of regular gasoline in Wenonah sands. Explosive reading in nearby office. Migrating in several directions. County has removed about 1500 gallons but very poor cooperation from County Freeholders. By mid-May 7 observation wells were installed and the estimate of gas in the ground is at least 110,000 gallons. A Large diameter double pump system recovery well was installed 6/79. Approximately 60,000 gallons has been recovered. 5/81 recovery is continuing.

Kmw

A-61 Lopez Residence, Budd Lake, Morris Co., 4/79

Approximately 500 to 1000 gallons of fuel oil lost from domestic tank. Nearby home well has fuel oil odor. Tank has been removed and recovery effort unsuccessful. A replacement water well will be installed.

Qsd

A-62 Lafayette DOT Maintenance Yard, Lafayette, Sussex Co. 5/79

4000 gal. gasoline and 4000 gallons of fuel oil lost into glacial valley fill over dolomite. Monitor wells and large diameter recovery well installed as of May 1979. Cause was faulty tank installation. Spills not reported immediately by DOT. Essentially no recovery and case closed late 1979.

Qrm

A-63 Getty Service Station, Hillside, Union Co. 3/79

Unknown amount of gasoline lost to groundwater resulting in fumes in nearby homes and temporary evacuation. Recovery wells installed and recovery rate excellent. Approximately 9000 gallons recovered as of 1 May 1979. Duration of recovery unknown. Station closed as of April 1980.

Trb

A-64 Mount Freedom Domestic Well, Mt. Freedom, Morris Co. 5/79

Private home had gasoline-contaminated well. Lost 500 gallons from on-site storage. Replacement well drilled, and this had gas within few weeks. Had carbon filter on supply. In court with driller (D&F). Department located a third well across foliation and cased to 100 feet. Drilled and on line as of May 1980.

gn

A-65 American Cyanamid Spill, Bound Brook, Somerset Co. 3/79

About 80,000 gallons of analine spilled from ruptured pipeline onto ground. Most of the contaminated soil removed and a recovery trench and sump installed. Most of the spill recovered with contaminated groundwater treated in Cyanamid's on-site carbon treatment plant. Progress report due in April 1980; none as of June 1980. Recovery is still underway as of 6/81. Levels of product are much lower. All discharges go to carbon filter system for treatment.

Trb

A-66 Chiarella Residence, Lake Hopatcong, Sussex Co., 8/79

Fuel oil pollution of 95 foot well. 9.46 feet of fuel oil product in well. Owner's tank and lines are in good condition. 5/81 No recovery or clean-up is underway due to cost that would be incurred by homeowner.

gn

A-67 Bocskor Residence, Lake Hopotcong Prospect Point, Sussex Co., 7/79

Fuel oil pollution of two wells. 0.45 feet of fuel oil product in Bocskor well. 10 feet to bedrock. Recommended drum separator on Bocskor well. No recovery initiated due to cost that would be incurred by homeowner.

bgn

A-68 Haar, Alpine Drive Lake Hapotcong, Morris Co., 7/79

Three wells possibly contaminated by septic tank effluent. One well has a fuel oil odor. No known source. Contex Oil across the street. Contex Oil investigated Spring 1980; tanks found to be tight. No further investigation due to cost involved.

bgn

A-69 N25 Housing Project, Trenton, Mercer Co., 8/79

Fuel oil flowing from beneath building into abandoned sewer. Four observation wells drilled. 0.25 feet of fuel oil product in well # 2. Recovery of approximately 4000 gallons of fuel oil was obtained from sewer. No recovery wells were requested.

Fill

A-70 Bi-lo Station, Milleville, Cumberland Co., 6/79
2000 gallons of gasoline lost on the site. Two (2) wells and a separator were installed. Tch

A-71 Temple Har Sinai Site, Ewing Township, Mercer Co., 5/79
Fuel oil leaked from storage tanks that were previously buried at site. It contaminated local ponds. Ponds were cleaned up. Further investigation revealed product movement through subsurface. Heavy rains brought more product to the surface. The surface material was then cleaned up. All buried fuel tanks were to be removed. Bedrock varies from 2 to 15 feet below surface. Ground water depth varies. Trl

A-72 Exxon Station, West Orange, Essex Co., 8/79
Suspected leak in one tank due to presence of water in tank. Two monitoring wells installed which have not shown evidence of product. Ground water at approximately 5.7 feet in the excavated tank pit. No evidence of product when tank was removed on September 24, 1979. Bottom of excavation separated from bedrock by several feet of clay. Trbs

A-73 West End Ave., Lake Hopatcong, Sussex Co., 9/79
Unknown contaminant in two private wells. 3 ppm oil and grease. Resampling and analysis for hydrocarbons was suggested. gn

A-74 East Brunswick, Middlesex Co., 9/79
Fuel oil in two private wells at depths of 160 and 260 feet. 3 ppm hydrocarbons. Kmr

A-75 Texaco Station, Old Bridge, Middlesex Co., 8/79
1500 gallons of regular gasoline lost into coarse sand and gravel. Aerial extent of gasoline has been delineated with explosimeter. Sump pump recommended on site. Qps

A-76 Bloomfield Ave., Clifton, Passaic Co. 9/79
Gasoline in a sewer and an excavation. This site is adjacent to a Chevron Station which may be the source. Lines at the Chevron station are to be tested. Trb

A-77 Exxon Route 17, Hasbrouk Heights, Bergen Co., 9/79
Various losses since 1969. Gasoline present in septic tank and stream. Three slam bar holes exhibited explosive readings. Monitor wells were requested. Recovery effort successful. Overburden and Trb

A-78 Tenneco, Fords, Middlesex Co., 8/79

Approximately 10,000 gallons of formaldehyde leaked from an above ground storage tank and flowed overland into an unlined impoundment. It was subsequently pumped at a controlled rate to the Middlesex County Sewer System. Monitor wells of 3-4 inch diameter were installed at the request of Groundwater Section. Water samples have been taken from the drilled wells to determine the degree of groundwater contamination by the formaldehyde spill. The monitor wells have been designed to also serve as an abatement system in the event that formaldehyde concentrations are high, however formaldehyde analyses were less than background. Kmr

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A-79 Dupont, Parlin, Middelsex Co., 8/79

Approximately 10,000 gallons of acetone leaked from underground supply line. An observation well was drilled at the source of the acetone. A heavy acetone odor was present to a depth of 20 feet. No water was encountered when the well was drilled. Well was removed (10/79) and area was asphalted to prevent infiltration and migration of acetone. Case closed. Kmr

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A-80 Tenneco, Carlstadt, Bergen Co., 9/79

Approximately 2,000 gallons of varsol lost from a buried tank of unknown volume. The water table is at the surface, causing varsol to be trapped against the base of an asphalt pavement. The tank will be filled in. Case closed. Fnd, Meadowland Muck

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A-81 Gulf Station East Orange, Essex Co., 8/79

Gulf engineer suspected leak because of the presence of a hole in the tank. Two wells were put in; fumes were in the well closest to the street corner. Trb

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A-82 Nutley Municipal, Essex Co., 8/79

An unknown amount of #2 fuel oil leaked for an unspecified time. Recovery well with separator system was installed. Qal/Trb

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A-83 NJIT, Newark, Essex Co., 10/79

Approximately 4-5000 gallons of heating oil lost at NJIT campus. Fill over weathered Triassic Brunswick. Monitor wells installed. Less than 1000 gallons recovered. All recovery and monitor wells now sealed. Case considered closed. Fill/Trb

A-85 Midwest Emery Freight, Jersey City, Hudson Co., Fuel tank leak, oil seeping into Hackensack River. Cutoff trench installed and monitor wells to be drilled. Recovery operations still on-going as of 6/81.	10/79	silty sand
A-86 Getty Station, Willingboro, Burlington Co., Station showed a loss of 200-1000 gallons in three tanks with holes. The tanks are sitting on silty clay. Monitor wells will be installed. No product detected.	10/79	Qps
A-87 Amoco & Citgo Stations, Salem Co. Vineland Gasoline in Bell Telephone cable, no tanks appear to be leaking. It is recommended that monitor wells be drilled.	10/79	Tch
A-88 Exxon, Garden State Parkway, Bloomfield, Essex Co., Gasoline seeping into stream. Handex Company conducting clean-up operation. Monitor wells and recovery wells recommended.	10/79	glacial till
A-89 Exxon, Garden State Parkway, Montvale, Bergen Co., Gasoline leaking beneath station. Handex Company conducting clean-up operation. Monitor and recovery wells recommended. Several monitor wells installed.	10/79	Trb
A-90 Dover Christian Nursing Home, Dover, Morris Co., Gasoline vapors in basement of nursing home. An independent station is located 40 ft. away and failed pressure tests. Approximately 2500 gallons were recovered by a well installed between the station and nursing home. Gasoline vapors in the nursing home basement have subsided. Additional monitor wells are requested. As of 5/81 odors ceased, no further work has been done. No product remains on water table. Case considered closed.	10/79	Qsd
A-91 Exxon Station, Johnsonburg, Warren Co., Three wells contaminated by gasoline from an Exxon station. Loss from gas station unknown but 300 gallons were recovered. Monitor wells were installed. It is recommended that deeper wells be installed.	10/79	overburden and Ca
A-92 Carlucci-Vacaro Drive, Budd Lake, Morris Co., There is a yellow viscous fluid in the well. The fluid appears to be a lubricant from the pump however this needs to be confirmed. New pump installed, problem resolved.	11/79	bgn
A-93 Methodist Church, Boonton Twp., Morris Co., The Church has a shallow well with an occasional fuel oil odor. In December 1978 there was a surface spill at the rear of the building. All other wells in the area are acceptable. Boring a deeper well is recommended.	12/79	sand & gravel to 90 ft.

A-94 Foot Hill Rd., Bridgewater Twp., Somerset Co., 8/79

Private well of Staikaponlos family is contaminated with petroleum product, identified as gasoline by Towney Labs; all other wells in the area are reported clean. clayey overburden/Trb

A-95 Exxon Station, Fairlawn, Bergen Co., 12/79

Loss of 600 gallons of gasoline due to a line leak. Six monitor wells were installed, recovery of gasoline is accomplished by periodic pumping of a recovery well. An undetermined amount of product was recovered. Recovery operations ceased 5/81. silty sand/Trb

A-96 Texaco, Cresskill, Bergen Co., 12/79

Loss of 2000-3000 gallons of gasoline. There were 14 monitor wells installed and a recovery well that is 24 inches in diameter and 20 feet deep. An additional trench may be required in the adjacent yard. Case is currently inactive. silty sand (glacial)

A-97 Dunn Walke Farm, Bedminster, Somerset Co., 1/80

Fuel oil leaking into storm sewer on private farm and discharging into a nearby stream. The tank was replaced but the loss is unknown. Three monitor wells were requested. Trb

A-98 Lynhurst, Essex Co., 1/80

Gasoline odor in a home adjacent to a 72 inch diameter sewer. Tanks in two nearby stations Kent-Moore tested as acceptable. The well at a Getty station showed no product. There was only a problem in one home. No product found in sewer, source unknown. silt (Passaic R. floodplain)

A-99 Highland Park, Middlesex Co., 2/80

Gasoline odor in sanitary sewer system. Four buildings were evacuated. A local Datsun dealer lost 2000 gallons, but is not the source of the odor. A local Mobil and Texaco station are suspected. Wells are requested near these stations. Trb

A-100 Conrail yard, Hoboken, Hudson Co., 2/7/80

Fuel oil seeping into canal, probably due to a concentration of tank leaks, line leaks and spillage over the past 50 years. Fourteen initial monitor wells recommended along with cutoff tunnels near the canal. Wells installed 4/80. Only two had product accumulation. Conrail plans to seal off sewer line and install recovery well in summer of 81 to recover lost product. Fill

A-101 Edgewater Terminal, Edgewater, Bergen Co., 2/80

Seepage of oil into Hudson River from storage tanks.

A-102	Exxon, Margate, Atlantic Co., Approximately 2,000 gallons of gas were lost from a leaking fuel line. Line was repaired and over 2000 gallons were recovered. Case closed.	8/79	Qcm
A-103	Shell, Margate, Atlantic Co., Several hundred gallons of gas were lost from a leaking storage tank. A recovery system was set up and 250 gallons were recovered. Case closed.	8/79	Qcm
A-104	N.J. Bell, Shrewsbury, Monmouth Co., Reported loss of approximately 500 gallons of gas from two 10,000 gallon storage tanks. The tanks were removed and three monitor wells were installed. No gas was found in any well. Water depth is 30' and the gas may be held up in the soil. Case closed.	2/80	Krb
A-105	Candlewood Exxon, Howell Township, Monmouth Co., Approximately 200 gallons of gas was lost from leak in a discharge line. The line was repaired and four monitor wells were installed. Explosimeter readings and well information found no trace of gas in the ground. Case closed.	3/80	Tch
A-106	Emil's Gulf, Hazlet, Monmouth Co., An unknown amount of gas was lost from a leaking storage tank. The tank was removed and three monitor wells were installed. The wells showed no gas accumulation in the ground. Case closed.	3/80	Ket
A-107	Hulses Rd. Abandoned Gas Station, Howell Twp., Monmouth Co. Five storage tanks were removed during demolition of an abandoned gas station, with an unknown amount of gas left in the ground. Recommended installation of six monitor wells to determine the amount and extent of gas under the site. Six monitor wells installed. Eight inches of gasoline found in one well. Recommended recovery system.	3/80	Tkw
A-108	Exxon, Morganville, Monmouth Co., An on-site well has been contaminated, possibly because of spillage from an adjacent 12,000 gallon above ground storage tank owned by the Jamesbury Fuel Oil Co. Four monitor wells were recommended to determine the amount of oil in the ground. Wells were installed, and no product found. The storage tank was removed. Recommended removal of contaminated soil around tank area.	3/80	Ket
A-109	Chevron, Hazlet, Monmouth Co., Fuel oil has been seeping into an adjacent creek from an unknown source. The on-site 3000 gallon fuel tank was tested and found to contain no leaks. Two monitor wells have been installed, and at least two more will be put in. It was concluded that gas source was spillage when tanks were being filled. Not enough product to warrant recovery. Case closed.	4/80	Kwb

A-110 Rocky Hill Municipal Well, Borough of Rocky Hill, Somerset Co., '79

Municipal Supply well contaminated with trichloroethylene. Several possible sources are under investigation. 8/80 source determined to be industrial site on Crescent Ave. through hydrogeologic studies. Well is pumping to waste. By 2/81 contaminant levels were consistently low. Residents permitted to drink water with constant monitoring. Trb

A-111 West Amwell Elementary School, West Amwell Hunterdon Co., '80

School well contaminated with organics, principally trichloroethylene, area underlain by Brunswick Shale and Diabase intrusions. 12/80 source determined to be an industry adjacent to the school. Industrial waste was removed in fall of '80. Decontamination system proposed for summer 81. Dumping area to be capped. Trb

A-112 Lakeland Regional High School, Lakeland Passaic Co., '76

Fuel oil spill in 1976, estimated loss 400,000 gallons, oil leaching into stream south of school. OHSC opened spill fund June 1980, recovery program being instituted. Area underlain by pre-cambrian gneiss and cover of stratified drift. Qsd/pgn

A-113 Ianero home, Middlesex Boro, Middlesex Co., 11/79

High concentration barium and chlorides in well. Suspected cause is a municipal salt stockpile nearby. 5/81 chlorides found to be caused by salt pile, resampling showed normal barium levels. Salt pile removed. Case closed. Trb

A-114 Fairlawn Public Wells, Fairlawn, Bergen Co., late '78

Several municipal wells contaminated with organics. All City wells shut down. Industrial survey completed but not certain if source(s) stopped. Purging program recommended in June 1980. Qsd/Trb

A-115 Exxon Refinery (Bayway), Linden, Union Co. '79

Minor hydrocarbon seepage into the Arthur Kill. Monitor wells proceeding inland from Kill have uncovered considerable product on water table. Recovery system designed and will be installed summer 1980. Seepage declined in October of 1980. Coast Guard no longer involved. Exxon proposing to removal oil saturated soil to a sludge farm on their refinery. fill/Trb

A-116	Exxon Station, Boonton, Morris Co. Inventory loss of 5000 gallons. Odors in five buildings. Eight observation wells in, recovery underway from 24" well. Chevron Station in opposite corner requested to test tanks, owner refused. Recovery as of 4/25/80 was 500 gallons. Water table at 18'. Exxon has installed total of 16 wells. Chevron Station across the street is also suspect. Chevron installed 2 wells on 4/81. Total of 800 gallons recovered to date.	2/80 Qsd/sandy clay
A-118	Mobil Station, Wanaque, Passaic Co. Unknown gasoline loss, moving a down sand and gravel valley, odors in five homes. Odors started in Jan 1980 and subsided. Requested 11 monitoring wells but met with opposition from distributor. Dealer hired consultant but cleanup to this point has been inadequate. Gasoline has moved 100 yards from source. Still waiting monitoring wells as of 4/28/80. No further work done. Case to be closed.	2/80 Qsd
A-119	Texaco Station, Oakland, Bergen Co. Weekend loss of 3000 gallons. No prior inventory loss. No product in stream adjacent to tanks. One monitor well was drilled and found free of product.	3/80 Qsd
A-120	Gasoline odors in homes, Nutley, Essex Co. Three homes with slight gasoline odors. All sewer lines free of product. Nearby, Amoco, Gulf, and Texaco tested tanks, found to be sound. Affected homes are surrounded by other homes free of odors.	3/80
A-121	Shell Station, Newark, Essex Co. Loss of 600 gallons and strong odors in sewer lines. Eight monitor wells installed. Installed trench parallel to affected sewer line. Case still open.	3/80 silt & clay/Trb
A-122	Mobil Station, Freehold, Monmouth Co. Odors in nearby Bell Telephone cable prompted investigation of this station by OHSC. Odor problems in a hotel two blocks away. Eight tanks removed from site. Observation wells installed. All wells were free of product or odor. Recovery of 1000 gallons of gasoline and other oils claimed by spill contractor. Two monitor wells recommended adjacent to Bell Telephone cables. No further recovery recommended.	4/80 Krb

A-123	Exxon Station, Bernardsville, Somerset Co. Inventory loss of 72 gallons. Four monitor wells installed. All wells free of product. Case closed.	4/80 Qm
A-124	Orange Exxon, Newark, Essex Co. Inventory loss. Three monitor wells installed and tanks removed. One well clean, other two are dry. Requested that wells be deepened. Case still open.	4/80 Silt and clay/Trb
A-125	Alert, West Orange, Essex Co. Inventory loss, tanks removed, no product in excavation. Case closed.	4/80 Trbs
A-126	Exxon, Orange, Essex Co. Inventory loss, four monitor wells installed. Requested recovery during tank excavation. Water table at 6'.	4/80 Silt and clay/Trb
A-127	Mobil Station, Palasades Park, Bergen Co. Unknown loss, odor in building behind station and down hill. Recovery trench dug between station and affected home. Recommended three monitor wells and an additional trench.	4/80 fill/Trdb
A-128	Abraham and Strauss, Paramus Park Mall, Paramus, Bergen Co. Loss of 200-800 gallons of fuel oil adjacent to building. About 800 gallons recovered from around building. Recommended two wells.	4/80 Fill
A-129	Rhone-Poulenc, New Brunswick, Middlesex Co., Loss of 6500 gallons of methacrolein diacetate from below-ground pipe. Highly toxic chemical. Five monitor wells installed and recovery underway as of late June 1980. Little free chemical located. High concentrations found in one well. Decontamination to sewer system approved 8/80. Levels in well still high and overall recovery slow. Body of spill never delineated. Consultants report due June '81. The site is also under scrutiny due to organics entering local stream. Currently investigating.	6/80 Trb

A-130 Arco Station, State & Atlantic, Hackensack, Bergen Co., 3/81
Undetermined amount of gasoline leaked from corroded tank. All tanks replaced at station. Three monitor wells and three borings to water table completed. Spill appears to be small. Recovery operations underway. Qsd/Trb

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A-131 Dave's Texaco, Somerville, Somerset Co. 3/81
Corroded tank resulted in loss of approximately 300 gallons of gasoline. Six monitor wells installed. All tanks at station replaced with fiberglass tanks. A leaking 500 gallon waste oil holding tank was also replaced. Oil contaminated soil removed to a hazardous landfill. Case closed. Trb

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A-132 Exxon Hamilton & Highland, Franklin Twp., Middlesex Co. 7/80
496 gallons of no lead gasoline leaked from a faulty pump valve into ground. Gasoline has migrated along Hamilton Avenue and has entered a catch basin. From the catch basin it has travelled into a sump hole in a barber shop. No indication of ground water pollution. Recommended soil removal, aeration. 5/81 Exxon still has not put borings in. Trb

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A-133 Tonys Mobil, Ewing Twp., Mercer Co., 12/80
Unknown amount of gasoline lost from tank leak. Recovered 7.5 gallons from monitoring wells. Qps/Trs

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A-134 Hamco, Mahwah, Bergen Co. 8/80
Waste oil-water separator discharging into septic system. Monitor wells installed. Oil in sediments but not in well. Awaiting sampling. Qsd

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A-135 Getty Station, North Branch, Bridgewater Twp., Somerset Co. 3/81
Gasoline spill from corroded, in-ground tank. All tanks at the station were replaced. A recovery trench and monitor wells are still in place. The amount of product lost appears to be small. Recovery attempts are continuing. Trb

A-136	Hasbrook Heights Dept. Public Works, Bergen Co. Unknown amount of gasoline lost from leaking tank. Spill discovered during sewer line excavation (approx. 75' away). Inspection of tank excavation revealed emulsified product indicating old spill. Absorbents used in excavation as well as centrifugal pump. About 10 gallons recovered. Recommended three wells.	11/80 Valley fill/Trb
A-137	Well Contamination, West Windsor Five wells (Logan Dr. and Harrison St.) contaminated, highest concentration 2.7 ppm. gasoline. Suspected are Sunoco Station & a 14" pipeline which broke in 1979 under the Millstone River. Kent-Moore test at station was negative. Pressure test of line negative. Affected homes receiving water from tank trucks. Recent analyses show no problem. Case inactive.	11/80 Qps/Trs
A-138	Texaco, Bayonne, Hudson Co. Unknown quantity of aviation fuel has leaked from a storage tank into ground. Decontamination operations have been started. 5/81 Case considered closed.	9/80 overburden/Trb
A-139	Mobil and Arco, Ewingville Inspection of tank excavation at Mobil revealed possible tank leaks and overfill. Weathered bedrock (6" below tanks) had strong gasoline odor. Arco also had leaking tank. Several local wells contaminated with hydrocarbons but no connection between spill and wells has been proven. Wells drilled 25 and 30 feet did not encounter water. Mobil and Arco are being pressed to drill at least one well to water. Wells at Mobil had a problem with hydrocarbons of unknown type and quantity.	12/80 Trs
A-140	Hartz Mountain, Secaucus, Bergen Co. Fuel oil found in sewers and tidal creek started investigation. Leaking fuel line found near building. Trench and subsequent recovery wells recovered 5000 gallons. Eight observation wells installed. Additional recovery wells will be located. Site located over old landfill in Meadowlands. 5/81 6000 gallons recovered.	12/80 Valley fill/Trb

A-141	Mancus Residence, Elmer, Salem Co. Homeowner detected petroleum hydrocarbon taste and smell in drinking water from private well. Possible sources of contamination include a nearby Texaco Station or nearby domestic fuel oil tank. Case under investigation.	4/81	Qbt/Tch
A-142	Young Residence, Tewksbury, Hunterdon Co. Chlordane found in well after exterminator sprayed around home. Well replaced, water lines still show residual contamination. 5/81 old well will be resampled regularly. New well appears to be clean.	9/80	pC
A-143	Coe Residence, Rumson, Monmouth Co. Leaking fuel oil tank at private residence. The tank was removed and replaced. Five borings to the water table indicated no product in measurable amounts. Case closed.	3/81	Qcm/Krb
A-144	Shell Station, Ratzer Rd. and Hamburg Tpk., Wayne, Essex Co., Undetermined amount of gasoline spilled from corroded tank. Amount of loss not reported. Five monitor wells installed. Recovery system set up. Active case.	3/81	Trbs
A-145	NJ Turnpike Authority Bldg., East Brunswick Twp., Middlesec Co. A spill occurred due to an underground gasoline tank failure. Inventory loss was 800 gallons. Actual loss was greater. Monitoring wells were installed 1/81. Turnpike Authority hired a consultant to do additional exploratory work and design recovery system. Recovery system installed 4/81 and functioning as anticipated.	10/80	Fill/Kmr
A-146	Liberty State Park, Hudson City, Hudson Co., Sheen emanating from bulkhead into the Hudson River led NJDEP to suspect an accumulation of petroleum hydrocarbons on the water table. Four monitor wells were recommended.	3/81	Fill/Organic Silt

A-147 Anheuser-Busch, East Brunswick, Middlesex Co. 2/81

Explosion in test well drilled at Anheuser Busch in search of new production well caused NJDEP to determine that petroleum hydrocarbons were on the water table. Suspected source is Gulf Station across street. Gulf was advised on 3/81 that an observation well should be drilled and their tanks tested. Qcm/Kmr

A-148 Masonville, Walton home, Burlington City, Burlington Co., 6/80

Private well contaminated with gasoline. Suspected source is buried tank on adjacent property. Tank tested and found to be tight. No other known sources located. 5/81 municipal water lines will be installed. Tch

A-149 Reed's Sod Farm , Lawrence Twp., Mercer Co., 4/81

Sod farm reported to have spilled pesticides at tractor loading pad. Over 50 ppm chlordane and 7 ppm DDT detected in the soil next to the loading pad. Selected wells will be sampled for a pesticide scan. Qsd/Trs

A-150 Jenny Realty Co., Edison Apartment Complex, Edison, Middlesex Co., 2/80

Leaking in-ground fuel tank ruptured, discharging an unknown volume of heating oil into a nearby stream. Approximately 1000 gallons of product has been recovered. Additional wells installed 12/80. No product on water table. Case still open. Qps/Trb

A-151 Jerry Jones Mack, Rockaway Township, Morris Co. 10/80

Oil spill. Over 50 yd^3 of oil contaminated soil removed from spill area and taken to an approved out of state landfill. Water sampling showed slight water degradation adjacent to spill. Resampling of wells necessary. Qsd

A-152 Shell Station, Rockaway Township, Morris Co., 7/80

Gasoline leakage from underground tanks resulted in the installation of monitor wells. Ground water sampling here indicates severe degradation of unconfined aquifer. No floating product observed at wells. Additional wells installed 3/81 to 4/81. Ground water sampling necessary. Qtm

A-153 Shell Station, Lake Hiawatha, Morris Co. 10/80

Gasoline spillage of over 3000 gallons. Monitor and recovery wells installed with little recovery realized. Spill cleanup contractor is monitoring and alternate recovery methods necessary. Gasoline plume appears almost stagnant and close to station. Overburden/Trb

A-154 Bordentown Junction, Bordentown, Burlington Co. 4/81

Spill of Diesel fuel resulted from line leak near pumping stations. Fuel migrated through fill to surface water bodies and control implemented with absorbent booms. Site underlain by a tight clay. Monitoring continues with backhoe pits. Kwb

A-155 Rockaway Twp. Well Field, Morris Co. 12/79

Aquifer contaminated by various organic compounds. Partial ground water monitoring system implemented. Monitoring shows two or more contaminant plumes. No source has been found for the chemicals. Investigation proceeding. Water supply from wells is undergoing carbon filtration as of 10/80. Qtm/Qsd

A-156 Steve's Getty, Dover, Morris Co. 4/81

Health Dept. found seepage pit behind station. Analyses of liquids determined fluids mostly oils, greases and water. Pit disconnected and filled as recommended by NJDEP. Wastes manifested and hauled to reclaimer. No further action necessary. Qsd

A-157 Exxon Station, Palymra, Burlington Co. 8/80

Gasoline spillage of unknown amount resulted from underground tank leakage, twenty (20) monitor wells installed including three (3) recovery systems. Over 1000 gallons of gasoline recovered. Groundwater cleanup continuing. Qps

A-158 Schiavano Residence, Woodbridge, Middlesex Co. 2/81

Residence's cellar sump receiving gasoline and gasoline vapors. Gas stations nearby, tested and no leak indicated. Municipality will hire cleanup contractor for interception of gasoline before the house. Qtm

A-159 Chancellor Texaco, Irvington, Essex Co. 3/81

Gasoline spillage from underground storage tanks reported to be 700 gallons. Monitor and recovery systems installed and currently in operation. Gasoline recovered to date is 1380 gallons via trench method. Gasoline contaminated soils excavated (70-80 yd^3) and transported via manifest to appropriate out of state depository. overburden/Trb

A-160 New Jersey Natural Gas, Dover, Morris Co. 4/81

Shallow water table at site is contaminated with organic chemicals. A coal gasification plant previously occupied the site. Old lagoons were suspected of receiving waste discharges. Oil tank farms are located on adjacent properties. Municipal Well #4 has been closed due to contamination. Case is under investigation. Qsd

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A-161 Rozman's Residence, Hopatcong, Morris Co. 3/81

Residence's trout spring effected by fuel oil. Neighbor's upgradient underground tank leaked 550 gallons one month earlier. Recovery on-going at spring and cleanup with oil water separator. Overburden/Pt

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A-162 Rockaway Borough Municipal Well(s), Morris Co. 9/81

Ground water resource affected by organic chemicals. Sampling of nearby wells indicated contamination may be local. Industrial survey conducted by Borough's Health Dept. indicated no active source. Carbon adsorption units scheduled for installation June 1981. Investigation continuing. Qtm/Qsd

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A-163 Dover Well (Hooey Street), Morris Co. 12/80

Water quality degraded by presence of organic chemicals causing well shut down. Industrial survey revealed no active user and discharger of contaminant. Implementing sampling and aquifer testing program at well. Ground water sampling at other Dover wells indicates the contamination is near the well. Investigation continuing. Qtm/Qsd

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A-164 Exxon Station, Bridgeville, Warren Co. 10/80

Leakage of 1200 gallons of gasoline from underground tank occurred. Eight (8) observation wells and one (1) recovery well were installed. Gasoline recovery, to date, has been minimal because of geologic conditions at site. Gasoline appears trapped in the unsaturated zone 15-20' below the surface, monitoring continuing. Qtm

Illegal Dumping (D)

D-1 "Reich Property", Dover Twp., Ocean Co., '74

Industrial chemicals dumped on the Reich Property. These 55 gallon drums were from the Union Carbide plant at Bound Brook and dumped by N. Fernicola. Hundreds of wells were contaminated in Pleasant Plains area. Tch

D-2 Beachwood Plaza, Berkeley Twp., Ocean Co., 9/74

Various chemicals dumped behind Beachwood Plaza. Affect of contamination unknown but will be investigated upon arrival of instrumentation. At this site up to 15,000 drums containing chemicals such as sodium, etc., were dumped. Qcm/Tch

D-3 Pemberton, Burlington Co., 9/75

Some 1500 chemical drums have been dumped here. The liquid chemicals are present on the ground surface and will affect the quality of recharge water percolating down into the Cohansey sand which this dump overlies. Located in the Pine Barrens. Drums were removed in '76 and the case was considered closed. Modified monitoring wells installed and samples taken. Case may be reopened. Tch

D-4 Jackson Twp., Ocean Co., 5/76

Dumping of various chemicals and drums on the Walter Powers property. Phenols reported in wells, case closed. Tch

D-5 Jackson Twp., Ocean Co., Spring '77

Chemical drum dump of Union Carbide. Sambol construction owns the property. Drums have been removed to Dover by Sambol. Union Carbide has removed all drums from Dover and Jackson for disposal. Several drums spilled on the ground, case closed. Tch

D-6 Winslow Twp. (King of Prussia), Camden Co., 1/75

This liquid waste disposal site has several unlined lagoons and discarded drums of chemical waste. It has been found that observation wells show a high concentration of Cr and organics. Surface evidence of damage caused by the operation is in the form of a large number of dead trees around the perimeter of the site in the groundwater flow direction. Site was to be closed and dumping ceased. Tch

D-7	Independence Twp., Warren Co., Approximately 200 drums of Soy oil, etc. from a candy manufacturer (name not given) was stored and spilled in a gravel pit in the Pequest Area. Case closed.	'77	Qs
D-8	Keyport, Monmouth Co., 2000 drums of chemicals were reported to have been dumped here.	'76	Kmw/Kmv
D-9	Barrier Chemical, Vernon Twp., Sussex Co., At this site deliberate dumping of various chemical wastes on abandoned plant site. High amounts of trichloroethylene and benzene. Observation wells have been installed.	6/78	Ca
D-10	Berless Bearing, Livingston, Essex Co., Disposal of cutting oil into unlined pits behind the plant. Borings done and all oil-soaked soil removed along with the liquid. Fuel oil tanks pulled and replaced. Investigation sparked by odd analyses of the nearby Livingston city well. Case closed late 1978.	8/78	Trb
D-11	Runyon Well Field, Old Bridge, Middlesex Co., Deliberate disposal of 7000 gallons of PCB along road near well field for Perth Amboy. Consultant's report shows clean up effort by Department highly effective. Little PCB in ground water. Further recovery is impractical.	'76	Kmr
D-12	Elmwood Park, Berkley Twp., Bergen Co., Stored containers of zinc chloride were deliberately punctured and spilled behind a Motorcycle Shop. At the site 12" of soil was then excavated and removed to landfill. The total spill was approximately 800 gallons and it has been suggested that an additional 18"-24" of soil should be excavated. Additional soil has been removed and excavation area filled with clean material. Case closed.	8/78	Saprolite/Trb
D-13	Bog Creek Farm, Howell Twp., Monmouth Co., Dumping of paint and chemical wastes has been practiced on dead animals to keep dogs away. Wastes seep into a stream. Five monitor wells installed and sampled to delineate contaminated area.	12/78	Tch
D-14	Lone Pine Landfill, Freehold Twp., Monmouth Co., This landfill is illegally taking in chemical wastes. In June of '78 there was an explosion at the site in question due to the chemicals that were dumped there. In late 1980 recommendations on a closure plan were sent to the Solid Waste Adm. Monitor well data indicate contamination of two aquifers.	6/78	Tvt

D-15 Dairy Pak, Morris Plains, Morris Co., 10/78

Approximately 10,000 gallons of ink and solvents were dumped on property. In the cleanup approximately 300 cubic yards of soil were removed and taken to an appropriate land disposal site. Spill site was then capped with impermeable material to eliminate further leaching of residual contaminants adsorbed into the soil. Case closed. Qtm

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D-16 Manzo Construction-Burnt Fly bog, Marlboro, Monmouth Co., 11/78

Illegal dumping of petroleum products into 3 unlined lagoons. Surface water contamination is present and dead trees have been sighted around lagoons in down gradient groundwater flow direction. Several hundred drums and four unlined lagoons were observed. Many of these drums contained toxic chemicals along with various petroleum waste products. Several drums were broken and leaking. Subsurface contamination was evident after seven holes were augered to a depth of 18 inches.

The odor of this oil and chemical-saturated sand was nauseating. Six monitor wells installed and sampled. Soil and water samples taken throughout site. Case is presently in litigation. Ket

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D-17 A & O Polymer, Sparta, Sussex Co. 12/78

Land disposal of Ketone resin products for twelve years. On Dec. 19, 1978 there was a surface spill from within the plant and discharged into the Wallkill River.

Several wells have been found to be contaminated by assorted organic compounds. Water line has been installed to service local residents with contaminated wells.

Investigation of exact source of chemicals is continuing. Installation of monitoring wells is planned to help delineate the extent of the subsurface contamination. Qsd/Ca

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D-18 Franklin Lakes, Bergen Co., 3/79

Possible ground-water contamination by tetrachloroethylene. Source of illegal dumping has been confirmed to be Arlo cleaners on Franklin Avenue.

Cleaning compounds have been dumped into a pond on his property. Concentrations of tetrachloroethylene in these dumped wastes have been found to equal 22,000 ppb.

Investigation is on-going. Trb,pC,Qsd

D-19 K. Wickham, Jackson Township, Ocean Co., 3/79

Septic truck caught dumping by Jackson Township police on March 1, 1979. K. Wickham owned truck and property adjacent to Jackson Landfill. Truck contained septic wastes, benzene, toluene, xylene, butyl benzene and three unknown organic compounds. Tch

D-20 Little Silver Cleaners, Little Silver, Monmouth Co. 1/80

Company is suspected of dumping solvents behind building. Adjacent pond has been contaminated. There will be further sampling of the pond. Five underground leaking storage tanks were excavated. The tanks contained cleaning solvents. The tanks were removed with 80 cubic yards of contaminated soil. Krb

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D-21 Motel Dennis, Hamilton Twp., Atlantic Co. 3/81

Unknown number of drums dumped behind Motel Dennis about 8 years ago. Plume is moving 40 to 100 ft. per year in a southwest direction. Additional hydrogeologic work must be done to determine the boundaries of the plume and recommend development limitations surrounding the site. Contamination concentration of 100 ppm, organic chemicals. Qbt/Tch

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D-22 Borough of Caldwell Sewage Treatment Plant, Essex Co. 12/80

The Borough was cited by our Department for the dumping of non-composted sludge behind their plant. Downgradient groundwater samples showed increased levels of heavy metals and nutrients.

The Borough has been directed to remove all non-composted sludge. Qsd/Trb

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D-23 Naval Air Engineering Center, Ocean Co., Lakehurst 11/80

Disposal of various solvents, compounds at various sites used at the station over the years. Navy drilling at selected locations as data and information dictate. NJDEP providing technical assistance. Aviation fuel site clean; further drilling/sampling underway or planned. Tch

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D-24 Williams Property, Sigtown Road, Cape May, N.J. 10/29/79

During September 1979 approximately 200 drums of organics were dumped by Ted Williams on his property. Eleven monitor wells were installed in January 1980 and a geophysical survey was run. The local geology was determined and the plume was delineated. The contaminated soil was piled up on site. Proposals were requested for cleanup by DHM. To date (Aug. 1981) no cleanup undertaken. Qcm

Industrial (I)

I-1	Magnesium Elektron, Kingswood Twp., Hunterdon Co., At this site there is an unlined lagoon filled with waste from their zirconium industry. Surrounding area wells have been found to be contaminated by high amounts of TDS, sulfates, Na, Cl, ammonia, etc. No file.	Summer '76 Trl
I-2	X-Cell Co., Belvidere, Warren Co., Acetone in an unlined lagoon. Monitor wells to be installed. Contamination of large ground water supply.	9/76 Qs
I-3	Hoffman LaRoche, Belvidere, Warren Co., Contamination of a large ground-water supply due to unlined lagoons. Investigation showed the contamination due to a sewer line break. Periodic water quality data is being submitted for evaluation. Review of data with recommendations requested in 6/81.	7/75 Qs/Omb
I-4	Northern Fine Chemical, Franklin, Sussex Co., Chemical Company and the town of Franklin discharge into a sump. Part of the sump waste goes out through a pipe to a river and part into the ground. A new well 260' deep was contaminated by the sump which is directly up gradient from a well. Company is no longer in operation.	9/75 Fl
I-5	Cellate, Franklin, Sussex Co., Company dumped its waste down a mine shaft. This large volume of waste flowed underground through an old storm sewer to a river. Dye was traced in 1975. Company closed and left area in Nov. 1976.	6/75 gn/msk
I-6	Metaltec., Franklin, Sussex Co., Waste cutting oil was being dumped into an unlined lagoon. Groundwater was found to have a high COD content. TCE is principal contaminant. Two private wells and the Borough well have been closed. Lawsuits and administrative action pending against the company.	Fall '76 Qs/msk/Fl
I-7	Lucas Paints, Gibbstown, Gloucester Co., Paint waste that was dumped into a lagoon has contaminated the groundwater according to well analyses. Sludge disposal area is also contaminating groundwater. The sludge was removed in 1980 and the wells replaced in the Spring of 1981.	Spring '75 Tkw
I-8	Chemed., Howell Twp., Monmouth Co., Silver stripping company discharged into an unlined lagoon and four wells were contaminated. Soil was removed here from 3'-8' deep, wells were closed and interim drinking water was brought in. After being sued by Howell Twp. for $4000 and once by D.E.P. for $1,250, Chemed closed its plant.	10/76 Tch/Tvt

I-9 Rollins Environmental Service, Logan Twp., Gloucester Co., 4/70

This chemical waste treatment facility with its many unlined and lined lagoons has a severe ground-water pollution problem. Numerous monitoring wells have been installed to delineate the extent of contamination. A system of abatement wells has been installed to remove and treat contaminated ground water. Kmv

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I-10 Dupont-Chambers works, Deepwater, Salem Co., '70

Severe ground water contamination has occurred here. Recovery wells have been installed and groundwater has been treated. Investigation continues; awaiting yearly report and new monitor well study. Qcm/Kmr

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I-11 Shield Alloy, Newfield, Gloucester Co., 5/75

Contamination of a Borough well with Cr and chemical leachate from an existing lagoon. Stream also contaminated. Town well and private wells have been closed. A decontamination system has been installed. 5/81, levels of Cr greatly reduced, re-evaluation of decontamination is pending. Tch

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I-12 Pine Wall Nursing Home, Ocean Co., 9/76

Ground-water contamination by large volumes of sewage from septic field. The wells at 40 and 90 feet deep were contaminated. Tch

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I-13 IRC, Sayerville, Middlesex Co., Spring '75

Metal reclaiming Co. has contaminated groundwater. The pH of the water was 1 or less. Kmr

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I-14 Exxon, Constable Hook, Hudson Co., 9/74

Oil found in the groundwater from refinery complex that continually discharged oil from tanks and pipelines. Exxon was then required to collect and retain for disposal all contaminated surface water on property, treat all contaminated surface runoff, and develop a system which will contain and remove all of the subsurface contamination. Qs/Rec

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I-15 Shell Oil, Sewaren, Middlesex Co., '73

Gas leaking from pipes, tanks etc. over the last 50 years. In 1975 1.5 million gallons of gas were recovered by recovery wells. They are presently executing on a decontamination program. Qs

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I-16 Madison Industry, Madison Twp., Middlesex Co., '72

Zinc by-products stored on the ground. Perth Amboy Public Supply Wells in the Old Bridge Sand aquifer have been contaminated. This firm and adjacent CPS are due for trial 29 May 1979. This case is still in court as of 1981. Kob

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I-17 Plessey, Frenchtown, Hunterdon Co., 10/75

Metal plating wastes were discharged into overburden near the Delaware River. Ag, Zn, Ni, Cu, and CN in discharge. Ground discharge abandoned in favor of a treatment facility and surface discharge to the River. Approval issued in 7/81. Enforcement activity complete. Case closed. Qal

I-18 CPS, Madison Twp., Middlesex Co., '73

Organic chemicals in the groundwater above Perth Amboy, Runyon well field. In court at present, and only 3 monitor wells have been installed. This firm and adjacent CPS are in trial. No decision. Case is still in court as of 1981. Kob

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I-19 Bridgeport Rental, Logan Twp., Gloucester Co., '76

Waste oil storage in an old gravel pit has contaminated the groundwater. Oil leaches into an adjacent marsh and the Delaware river. First discovered in 1969 and still a problem. Many wells in area show low level organic contamination. Dike rehabilitation complete 6/81. Site awaiting study and clean up under Superfund. Qcm/Kmr

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I-20 NL Industries, Pedricktown, Salem Co., '76

Lead contamination of wells from 1975-1976. Enforcement action and cleanup ordered. Consultants report and renewed activity in 1980. Enforcement pressing for decontamination as of 6/81. Kmr

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I-21 Sparta Sand and Gravel, Sparta, Sussex Co., '75

Salt storage has contaminated with Cl, the aquifer that is the major water resource for the region. The operators are installing pads and have covered the piles. Case closed. Qs

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I-22 Phelps Dodge, South Brunswick, Middlesex Co., 6/75

Unlined lagoons received 500,000 gallons of waste liquid per day. Plant was closed down in '74 but lagoons remain. Possibility that groundwater in area is contaminated. Monitor wells installed as of May 1979. Under investigation. Poorly designed monitoring wells hampered sampling attempts. Wells redesigned 5/80. Sampling for metals/organics imminent as of 6/81. Qps/Kmr

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I-23 BASF, South Brunswick, Middlesex Co., 12/75

Styrene waste discharged into unlined lagoons. Possible contamination of groundwater from unlined lagoons. Preliminary evaluation completed, monitor wells drilled and consultants report in as of April 1980. Claim no ground water drainage. No apparent organic problem. Enforcement alternatives under discussion in June 1981. Qps/Kmr

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I-24 Certain Teed, Winslow Twp., Camden Co., '73

Phenols in groundwater from waste lagoons. There were at least five domestic wells contaminated. Lagoons were excavated and filled in. In 1978 further complaints received from home owners and company has been ordered to drill deep wells for affected homes. Tch

I-25	Johns-Manville, Winslow Twp., Camden Co., Phenols were found in observation wells from a leaking pond. Study was done by A.W. Martin & Associates which discovered contamination in '75. New lined ponds being constructed.	'76 Tch
I-26	Biocraft Industries, Waldwick, Bergen Co., Small drug manufacturer. Leaks were found in subsurface tanks and lines holding organics. Tanks repaired; monitoring wells installed and a withdrawal program begun in '75. High amounts of organics found in the Quaternary deposits. Bedrock wells nearby. Decontamination proposed but no Consent Agreement by June 1980. Consent Agreement signed after long negotiations. Decontamination slated to start up in 6/81.	'75 Trb
I-27	Accurate Forming, Hamburg, Sussex Co., Spillage from storage area entered the Walkill River. Facility was required to line lagoons by Bureau of Oil and Hazardous Materials Control in 1975. Chromic acid lagoons are lined with 3 mil PVC and it has deteriorated. Investigation is continuing. Four monitor wells installed and sampled. Results show contamination.	late 1975 Qsd/Cl
I-28	Allied Chemical, Morristown, Morris Co., Carbon Tetrachloride and chloroform found in supply well. Consultant has installed monitor wells and conducted study. Well being pumped to waste. Concentration has stabilized at 20 ppb. Report due mid-1980. Revised containment scheme proposed in early 1981 and approved. Drilling of revised well scheme to begin in 1981.	12/76 Qtm/Trb
I-29	Fluid Chemical, Lakewood Twp., Ocean Co., Cosmetic waste liquids and sludges were discharged on the ground surface and into the surrounding ground water over a five year period of operation.	3/7/76 Tch/Qcm
I-30	Vineland Chemical, Vineland, Cumberland Co., Arsenic wastes stored on the surface with effluent disposal in percolation ponds. Arsenic found in surrounding wells, in the adjacent marsh, and in the nearby Blackwater Branch. Enforcement action. Treatment system installed in 1980. Improvised decontamination of ground water underway. Significant site clean-up has taken place. Consent Agreement signed after prolonged negotiations in 1981. Four additional monitor wells installed in 5/81. Changes in the treatment system requested by our Department.	'73 Tch
I-31	Oxford, White Twp., Warren Co., A high concentration of iron is found in this well due to runoff from the abandoned Washington mine.	'73 pC
I-32	Mine Hill, Morris Co., Methane was reported in a well due to dumping of garbage and other material in the Byram or Milem Mine.	'71 pC

I-33 International Wire Products Inc., Wyckoff, Passaic Co., '76
International's effluent has high metals, flouride, sodium and chloride. From discharging to the ground, the ground-water quality from selected wells, including their own supply, indicates elevated concentrations in sodium, chloride, flouride, and Ni. No sewer system available. Consultants report submitted early 1981 recommending further drilling. Drilling started 6/81. Backhoe work uncovered several unsuspected seepage pits filled with organic solvents in 5/81. Investigation underway. Qsd/Trb

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I-34 Ventron, Woodridge, Bergen Co., '74
Mercury has been found in the ground up to a depth of at least 3 feet. Also such contaminants as Cd, Zn, As, Cr, and Pb have been found. This 30 acre site is estimated to contain about 200,000 pounds of Hg, mostly under new warehouse. Currently in litigation with five defendents; Judge Lester presiding(1978). Q(Hackensack Meadows)

I-35 Albion, Winslow Twp., Camden Co., '76
Organics have been found in at least two wells in this development. There is no obvious source, but a homeowner may possibly be introducing organics via septic tank disposal. Inactive Tch

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I-36 Monroe Twp., Gloucester Co., 11/76
Mercury found in two public supply wells. Source has not been determined. Tch

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I-37 Fairfield, Essex Co., 4/76
High level organic contamination present in private and public suply wells. Main suspects are Caldwell Trucking (septage hauler) which operated lagoons, and General Hose Co. which has leaking solvent tanks. Homes have gradually gone to municipal water. Qsd/Trb

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I-38 Fisher Scientific Co., Bridgewater Twp., Somerset Co., 8/76
Organics leaked from a railroad cut behind plant. Seepage from the outcrop is very slow but had access to the Raritan River. Directed to make design and procedural changes at plant. Case closed. Trb

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I-39 Cooper Chemical, Washington Twp., Morris Co., 4/76
Iodine contamination of several springs about one-half mile from this Silver Iodide handling plant. Home owner has received new well from Cooper Chemical. The entire waste effluent system needs to be redesigned and engineered to reduce the amount of discharge to the environment. Case closed. pC

I-40 Ionac, Pemberton Twp., Burlington Co., 2/77

Monitor wells confirm groundwater contamination from unlined lagoons. Lagoons now abandoned. Ionac manufactures ion exchange resins, polymers and organics. Waste has access to the Rancocas Creek. Treatment system on line in early 1980 and consultant investigation to begin to deal w/lagoon sludges. Consultant report submitted 10/80. As of 5/81 site plan being formulated.

Qcm/Kns

I-41 Tri-County Vegetable, Rosenhayne, Cumberland Co., 1/77

Spray irrigation of food processing wastes (peeling operation). High NO_3 content found in an on-site well and in the surrounding area wells. Monitor wells located 1979; not installed as of June 1980.

Tch

I-42 Thatcher Glass, Wharton, Morris County, Summer '76

This plant's effluent is discharged through an old sewer line and migrates into the glacial deposits in this area. There has been a complaint of oil/grease in a nearby potable well.

Glacial

I-43 Swepco Tube, Clifton, Passaic Co., 9/77

Contamination of groundwater by hydrofluoric acid from pickling area. Four monitoring wells installed and manganese, flouride, nitrate, and iron found. Swepco has failed to institute a program of pumping groundwater into its treatment system and is still polluting as of 12/7/78. Case inactive.

Trb

I-44 Polyrez Company, Woodbury, Gloucester Co., 10/77

At Polyrez there is a leachate spring in the filled area behind plant that has an organic odor and a low flow. PVC collection pipe was installed and the flow is to be collected for removal. Under investigation. Leachate still escaping from fill. Consultant hired. Monitor wells installed and sampled. In planning stage for decontamination program.

Kmw

I-45 Yates Industries, Bordentown, Burlington Co., 10/77

A recent case where an assessment of the impact on the groundwater from old copper sludge lagoons and copper scrap is being made. Monitor well location recommendations have been made. Remedial program is in effect. The groundwater report was prepared by Environmental Engineering, Inc. Ground water decontamination continues through recovery wells and treatment plant. Ground water cut-off trench planned for summer 1981. Contamination due to heavy metals Cr, Cu, Zn.

Kmv

I-46 Riverside Metals, Riverside, Burlington Co., 8/77

Impact on the groundwater and recommendations pertaining to the unlined lagoons, filled with copper sludge, which are about 50' from the Rancocas Creek are now being assessed. Copper sludge removed as of 6/78.

Qcm/Kmr

I-47 American Cyanamid, Bound Brook, Somerset Co., 9/77

Old industrial plant with many lagoons; organic wastes are reaching overburden and shale. A possible threat to the off-site municipal wells and others. Seven monitor wells in rock and consultants report due mid-1980. Consent Agreement, including clean-up work and monitoring of wells prepared in 6/81.

Trb

I-48 Camden Municipal Wells, Camden, Camden Co., 7/78

Organics have been found in three city wells. Many possible sources have been sited and the most obvious possibilities are being evaluated, although there is little likelihood of isolating the source(s). Monitoring of the suspected wells is now being carried out weekly.

Kmr

I-49 Kearny Power and Light, Kearny, Hudson Co.,

Mercury found in soil near the Passaic River from an old abandoned heating and generation system. There is the possibility of no ground-water movement due to a bulkhead and very fine soils. Draft of a Consent Agreement in June 1980. Ground water shows 1-3 ppm mercury. Monitoring on-going.

Qal/Qsd/Trb

I-50 Reichhold Chemical Inc., Carteret, Middlesex Co., 12/78

Surface discharge high in phenols, chloroform, oils, and grease is present which may enter the groundwater. Monitor wells have been installed. High phenol concentrations found in one monitor well. Monitor well with high phenols is pumping the waste into the sanitary sewer system. As of 5/81 NJDEP is continuing periodic sampling of monitor wells. Company has cleaned up their operation.

Trb

I-51 Great Adventure, Jackson Twp., Ocean Co., 5/77

Monitoring the changes in the groundwater from spray irrigation and liming at Safari Park is taking place. Monthly analyses of the 12 monitor wells indicate change in groundwater quality. Expansion of spray field in 1980 season. Further expansion of sprayed areas set for 1981. Additional monitor wells planned.

Tch

I-52 Culligan Co., Lebanon, Hunterdon Co., '77

Runoff from piles of regenerating salt and high chloride wash water in septic system has polluted groundwater in the Brunswick Formation. At least four homes have been affected.

Trb

I-53 Mahwah Well Field, Bergen Co., 7/79

Ground-water contamination by volatile organics. Old station well is presently pumping to waste. West Well field wells #1 and #4 have high concentrations of trichloroethylene.

Cooperation between NJDEP and Rockland County Department of Health has been helpful in locating additional potential sources for organic contaminants. Most recent analysis of Mahwah wells showed no presence of organic chemicals.

Qsd/Trb

I-54 Fairlawn Well Field, Bergen Co., 1/79

Three out of seventeen wells are contaminated by volatile organics, such as trichloroethylene, trichloroethane, and tetrachloroethylene. Sampling has continued since 1/79. Well is located in the center of an industrial park. Case relatively inactive-Fairlawn buying water. Recommendations made to pump affected wells to purge aquifer. Consultant is evaluating problem as of 6/81.

Trb

I-55 Hawthorne Well, Passaic Co., 1/79

One well out of 22 in Hawthorne's Well Field is contaminated by volatile organics, such as trichoroethylene, trichoroethane, and tetrachloroethylene. Sampling was done in January of 1979.

Two possible sources include Inmont Corporation and an old mercury processing plant now operated by Calgon Inc. Drilling program proposed at Calgon May 1979. Enforcement pressing for further evaluation and clean-up with regular monitoring schedule as of 6/81.

Trb

I-56 Perry Industries, Hainesport, Burlington Co., 4/79

Unlined lagoon disposing of cleaning materials for metal reprocessing. Lagoon near Rancocas Creek. Monitor wells and sampling proposed.

Kmw

I-57 L.E. Carpenter and Co., Wharton, Morris Co. 5/79

Filter bed contains reddish-orange liquids. Chemical storage tanks once buried, have been bouyed to the surface by high water table. Public water supply wells (4) are located downstream .5 to 1 mile.

Wehran Engineering submitted a sludge removal and ground water monitoring program for the facility. four monitor wells have been installed at the site. Sediments at rear of property are extremely permeable, boulders, gravel and coarse sand. NJDEP is pressing for sludge removal, additional drilling, solvent removal and decontamination as of 6/81. This is a prolonged case.

Qtm/Qsd

I-58 Kauffman-Minteer, Inc., Jobstown, Burlington Co. 5/79
Possible ground-water pollution from a 100' x 500' unlined storage lagoon containing plasticizers, detergents, lube oil, and waxes from tank truck wastewater. Two monitor wells installed, sampled. Kns

I-59 International Flavors and Fragrances, Union Beach, Monmouth Co., 4/79
The groundwater has been contaminated (COD, volatile organics) from spills or leaks in some of the 20,000 55 gallon storage drums on the property. IFF has been fined $25,000, and ordered to install 9 monitor wells. Case is under litigation. Kwb

I-60 New Jersey Water Company, Washington, Warren Co., 4/79
Trichloroethylene at levels of over 100 ppb have been found in Well No. 4 and tetrachloroethylene at levels of over 100 ppb in Well No. 3. Investigation has been started to determine the source. Analyses of all wells in the area indicates that only the two water company wells have significant contamination. Cok

I-61 Apex Plating, Franklin Township, Warren Co. 12/78
Ground disposal of plating waste has lead to contamination of three wells. The cadmium plating operation was taken out of service as soon as the problem was found. Company in process of developing a treatment system. Cok

I-62 Ashland Chemical, Fords, Middlesex Co. 4/79
Chemical plant on meadow mat over Raritan-Magothy. Foul unlined lagoons, and a chemical spill. Organics on water table. Monitor wells will be drilled to cover the property. On 5/81 monitoring wells were installed and sampled. High concentrations of organics were found. Decontamination system required. Kmr

I-63 Tenneco Chemicals, Fords, Middlesex Co. 4/79
Chemical plant on meadow mat over Raritan-Magothy Formation. Monitor wells installed by consultants to cover the property and evaluate extent of ground-water impact. Report in preparation May 1979. Sampling of wells confirmed presence of organics on the water table. Currently awaiting next phase of report. Kmr

I-64 Republic Wire Co., Rahway, Union Co. 5/79
Low-pH pond behind plant, overflowing septic tank and on-site spills. Considerable local publicity. Monitor well locations recommended. Matter in court as of 6/81. Trb

I-65 CBS Records, Pittman, Gloucester Co. 1/79

Plating effluent into unlined lagoons behind very large record-manufacturing plant. Poor housekeeping. Monitor wells located January 1979. Moderate organic contamination of ground water. Solid Waste Adm. evaluating sludge lagoon. Tch

I-66 Metasol (Calgon), Hawthorne, Passaic Co. 2/79

Related to Hawthorne municipal well investigation (I-55). Property is near three municipal wells. Organics and mercury on ground. Program recommended in May 1979 to take soil samples, install monitor wells and sample the aquifer. Mercury and organics confirmed in overburden and bedrock. Additional work recommended by Department in 5/81. Sampling of new wells scheduled for 6/81. Trb

I-67 ARC Co., Boonton, Morris Co. 5/79

A lagoon on the site is unlined and receives wastes from the electronic operations part of the plant. A considerable amount of heavy metals and organic compounds render the untreated effluent quite toxic. Although there is no indication of any wells being contaminated, it is logical to assume ground-water degradation. Monitor wells have been installed by More-Trench. Wells will be sampled to determine the impact of past disposal into the unlined lagoons and to monitor future discharges as part of their discharge permit. Company directed by NJDEP to determine the extent and degree of aquifer contamination caused by their past/present discharges. Report due Fall 1981. pC gneiss

I-68 RFL Inc., Boonton, Morris Co. 5/79

A lagoon on the site is unlined and receives untreated production waste. Effluent contains toxic metals and organic compounds. While no evidence of water supply contamination is present, some contamination may be expected. It was recommended that 3 monitor wells be installed to determine movement and quality. Wells were installed by More-Trench at same time as ARC to determine the impact of past disposal into the lagoons and to monitor future discharges as part of their discharge permit. Ground water monitoring implemented 7/80. Aerator installed in lagoon to improve effluent quality. Company is reporting on water quality to DEP. NJPDES Permit and Treatment works approved being applied for. pC gneiss

I-69 Colloid Chemical, Hanover, Morris Co., 11/79

Phenol in cooling water discharge seeping into Whippany River as a result of poor housekeeping and surface spillage. Monitor wells, a cutoff wall, and sampling are recommended. Shallow monitor wells installed. Deep wells and sampling are necessary and planned. Administrative Consent Order sent 12/80. Qm/Qsd

I-70 Harvest Pickle Co., East Vineland, Atlantic Co., 11/79

Complaint from neighbor that Harvest Pickle Co., located on Post Rd., had been dumping brine on the gravel. The dumping of brine resulted in high chlorides in the ground water and contamination of the neighbor's well. Three monitor wells installed 7/80. On-site monitoring is ongoing. Company installed concrete pad and small holding tank.

Qbt/Tch

I-71 Plumsted Twp., Ocean Co. 2/80

A large number of drums dumped ± 20 years ago at five localities was brought to the attention of NJDEP. An investigation on 2/27/80 revealed dumping of both drums and liquids. The materials observed seem to be a rubber and caulking type waste. Monitor wells requested. At location #5 (Goose Farm) extensive clean-up and ground water decontamination took place. Clean-up temporarily stopped in spring '81 when funds ran out.

Tvt, Tkw, Tch

I-72 BP, Paulsboro, Gloucester Co., 6/79

Site contaminated with various petroleum products. Eleven monitor wells have been installed to determine extent and composition of the various petroleum products under the site. Awaiting results of sampling. Consultant preparing decontamination program.

KmL

I-73 Winner Chemical, Paulsboro, Gloucester Co. 8/79

Various oils, etc. are handled at the site. Ground-water contamination from an unlined lagoon and tank farm. Two monitor wells have been installed. The company will clean up lagoon and farm, and set up a ground-water recovery system. A total of five monitor wells installed to date and sampled. Contaminated sludge will be removed. Decontamination program is planned.

Kmr

I-74 Homasote Co., Ewing Township, Mercer Co. 7/79

The company has an unlined wastewater lagoon. One monitor well has been installed to determine possible ground water pollution. Awaiting results. Sample results show no lagoon leaks. Case closed.

Trs

I-75 Texaco, Westville, Gloucester Co. 10/79

There are two unlined separator sludge lagoons on-site causing possible groundwater pollution. Nine monitor wells requested to determine extent of any ground water pollution.

Kmr

I-76 Inland Chemical, Newark, Essex Co. 12/79

There is possible ground water pollution from drum spillage and tank and line leaks. Inland recovers various chemicals. Recommended installation of five monitor wells.

Trb

I-77 Landis Sewage Authority, Vineland, Cumberland Co. 11/79

The authority has 40 acres of unlined settling ponds for sewage sludge. Stream samples were taken to determine extent of surface/ground water contamination.

Tch

I-78 Monitor Devices, Wall, Monmouth Co. 3/80

Untreated wastewater from the company's plating business has been dumped on the ground for three years. Recommended the installation of three monitor wells to determine extent and nature of ground-water pollution. Three monitor wells installed and sampled. Analyses show heavy metals and organic contamination. NJDEP recommended implementing a decontamination program.

Tch

I-79 Comtron, Inc., Manalapan, Monmouth Co. 6/79

Untreated wastewater has been discharged onto the ground for approx. 15 years. Comtron cleans copper, aluminum, and brass pipes, and plates metals.

Recommended installation of three monitor wells to determine extent and composition of pollution. Three monitor wells installed and sampled. Results show low levels of contamination.

Kns

I-80 Elastomers, Ltd., Keyport, Monmouth Co. 3/80

Latex from the plant's wastewater discharge has been dropped on the ground adjacent to a "percolation" lagoon. The company has agreed to remove the latex and to design a new treatment system. Latex has been removed. Awaiting installation of monitor wells.

Kwb

I-81 Airtron-Litton, Morris Plains, Morris Co. '77

Unlined wastewater disposal lagoons. Sampled two abandoned supply wells on property downgradient of the lagoons and came up with extremely high levels of TCE. Also sampled Mennen Co. well across Hanover Blvd. from Airtron and detected high concentrations of TCE. Buried Valley aquifer appears to be affected on a greater than local scale. Dairy Pack, located directly north of Mennen Co. should also be investigated as a potential source. Sludges in Airtron lagoons have been sampled and found to contain high levels of TCE and the company has been ordered to remove all sludge immediately. Consultant now beginning investigation of site. Area-wide sampling will be initiated. Extent of ground water contamination has yet to be determined.

Qtm/Qsd

I-82 Albert Steel and Drum, Newark, Essex Co., '80

Abandoned solvent recovery site. Assorted drums, laboratory packs and mercury packs found disposed on and beneath the site. The City of Newark now owns the property and has set aside as part of a agreement with NJDEP 200,000 ± for investigating the site. No further work has been done as of 5/81.

Pleistocene

I-83 Trov Chemical, Newark, Essex Co., '80

Numerous illegal discharges into a small creek as well as soil contamination by organics and high levels of mercury.
Status: NJDEP is pursuing a Consent Agreement with the company which is about to change hands. 5/81, the company has changed owners. Clean-up is underway. NJDEP is recommending installation of monitor wells.

Pleistocene

I-84 Dupont, Fabric Division, Parlin, Middlesex Co., '79

Investigated abandoned disposal lagoons. Recently had four monitor wells installed to determine impact of past discharges. All wells are completed in the Old Bridge Sand. Wells have been sampled and indicate low level organic contamination. Resampling is essential to the investigation. The monitor wells at Duponts landfill were also sampled. A problem exists with these wells as they need to be re-developed or deepened. Investigation is continuing. Dupont is reluctant to deepen or re-develop wells. Kmr

I-85 Hatco Chemical, Fords, Woodbridge, Essex Co., '79

Sloppy housekeeping, lagoon disposal of assorted chemicals. Site is situated on the Woodbridge clay overlying the Farrington Sand. The company has aquired the services of Weston as groundwater consultants. Investigation is continuing. Department will ask company to install monitor wells summer 1981. Kmr

I-86 Abex, Mahwah, Bergen Co., '79

Disposal of wash water into unlined lagoons. Discharge contains silica from iron molding process and high iron. Sampling of discharge into the lagoons and monitor well adjacent to the South Lagoon indicate no problem exists. Company will be required as part of their groundwater discharge permit to monitor the well adjacent to the south lagoon and the discharge into the north lagoon on a quarterly basis. Case closed. Qsd

I-87 Ford, Mahwah, Bergen Co., 2/79

Disposal of sludges into unlined lagoons over the last 29 years. Ford is not cooperating with NJDEP. They refuse to install monitor wells. Case will be going to a hearing. Plant is being abandoned by Ford. Sludge removed. Consent Agreement involving monitor wells near signature in 6/81. Qsd

I-88 Pioneer Metals, Franklinville, Gloucester Co., 4/79

Plating operation disposed of wash down wastewater and dip water into a swamp adjacent to their property. They have two 30 ft. wells to supply both process and potable water. These wells have been sampled and contain high levels of hexavalent chromium. Domestic wells across the road and a local high school well down gradient have been sampled. No metals were detected above background. Investigation continues. Tch

I-89 Reichhold Chemical Inc., Carteret, Middlesex Co., 12/78

"See I-50"

I-90 Tenneco Chemicals, Fords, Middlesex Co. 4/79
"See I-63"

I-91 Hummell Chemical Co; South Plainfield, Middlesex Co., 4/80
Chemical plant processing large number of elements and organics. Hearing held in May 1980. Threat of ground water contamination from spills and housekeeping. Pressing for monitor wells as of June 1980. Monitor wells installed May 1981. Sampling slated for 6/81. Qsd/Trb

I-92 Chevron (Ortho Division), South Plainfield, Middlesex Co., 6/80
Pesticide plant next to Hummell Chemical. Long standing poor housekeeping and probable "backyard" disposal of chemicals. Monitor wells installed in 1979 by consultant. Consultant's report due approx. July 1980. Some pesticide damage, decontamination system probable. Qsd/Trb

I-93 Kearney Industries, Piscataway, Middlesex Co., 4/80
Phenol wastewater discharged to ground and later to septic tank system. Now going to sewer. Monitor wells may be recommended. Monitor wells ordered and Administrative hearing held 3/81. No ruling as of 6/81. Trb

I-94 Monsanto, Bridgeport, Gloucester Co. 3/80
Anonymous information that on-site drilling has found serious ground-water pollution. Consultant is executing the program. Follow-up by NJDEP requested in May 1980. Consultants report submitted for review early 1981. Additional data requested 5/81. Kmr

I-95 Cel - Rex, Nutley, Essex Co., 4/80
Rare metal (Au, Ag etc) reclamation, processing operation. Adjacent condominium excavation uncovered contamination traceable to the firm. Department requested monitor wells and a consultant in June 1980. Site near Passaic River. Drilling in late 1980. Report received 4/81. Additional sampling and water level data requested 5/81. Preliminary decontamination design called for. Qsd/Trb

I-96 Amerchol Coporation, Edison Twp., Middlesex Co., 10/79
Suspected ground-water contamination from unlined waste lagoons containing high concentration of organic solvents. Area underlain by Brunswick Shale, very little overburden. Three monitor wells requested in June 1980. Sampling early 1981 showed low level organic contamination. Resampling Summer 81. Trb

I-97 Okonite Cable Company, North Brunswick Twp., Middlesex Co., 6/80

Suspected ground water contamination from waste lagoons and oil spills on-site. Overburden is glacial sand and gravel, underlain by the Raritan-Magothy Formation and the Brunswick Shale. Initial field visit June 1980. Lagoon is lined with concrete. Contaminated soil has been removed. Monitor wells have been requested. Kmr/Trb

I-98 Nascolite, Millville, Cumberland Co. 1/80

The company was cited for the discharge of organic compounds in their waste-water discharges into an unlined ditch. A Consent Order is being prepared for installation of monitor wells and removal of contaminated soil. Tch

I-99 Electronic Parts Speciality, Lumberton Twp., Burlington Co. 4/81

Wastewater discharge from the plant's electroplating operations are diverted into an unlined discharge pond. This case is currently under investigation. Kmw

I-100 Scholler Bros., Hamilton Twp., Atlantic Co., Spring '78

Company has many spillages and an unlined lagoon containing organics. Three wells located in '78 and installed incorrectly. Sampled showed ground water contamination. DEP asked that six additional wells be drilled. Company installed them 12/80. Tch

I-101 Essex Chemical, Paulsboro, Gloucester Co., 3/80

Company has a 12 acre 25' high waste gypsum pile. Three monitor wells indicate groundwater contamination. A perimeter dike is to be installed to channel surface runoff to a treatment plant, then to Mantua Creek. Kmr

I-102 W.A. Cleary & Co. Franklin, Somerset Co., 12/80

Company has one unlined lagoon containing pesticides, herbicides and tree dye wastes. Wells on property and private wells in area sampled 5/81 to see if ground water contamination has occurred. If results are positive observation wells will be installed. Company plans to line lagoon summer 1981. Trb

I-103 Spencer-Kellogg, Edgewater, Bergen Co., 2/80

Company located along Hudson River. Oil seeping out from end of pier. They manufacture vegetable oil products. Monitor wells located and installed. Consultant hired to evaluate problem. Consultants report showed that oil was hydrocarbon based and the source was adjoining property. Spencer-Kellogg directed to upgrade their storm sewer & oil water separator. Wells must be monitored occasionally. Fill

I-104 Bel-Ray Co., Wall Twp., Monmouth Co. 6/80

Company produces lubricants. Cooling water, floor washdown wastewater, and surface runoff flow to an unlined lagoon. Recommended installation of four monitor wells around lagoon to determine whether there is any leakage. Tkw

I-105 Lectro Products, Manalapan, Monmouth Co. 11/80

Sheet metal company discharged untreated wastewater onto ground behind plant for 22 years. Three monitor wells installed, sampled. Awaiting results. Kmw

I-106 Lilly Industrial Coating, Paulsboro, Gloucester Co. 2/81

Organic chemical spill from tank storage farm in 1974. Shallow private wells were contaminated, and replaced by deeper wells. Organic leachate still seeping into adjacent Mantua Creek. Three monitor wells installed in 1974. Ket

I-107 Chemical Leaman Tank Lines, Bridgeport, Gloucester Co., 11/80

Several local wells contaminated with organics leading to investigation of C.L., a tanker storage and cleaning facility. Cleaning wastes, now collected in a tank, were discharged to an unlined lagoon until 1977. This system still allows for discharge to soil. Leaking tankers drip chemicals onto unpaved parking yard. Shallow water table has strong chemical odor. Consultant work reveals first two aquifers severely degraded with volatile organics. Deep wells will be drilled 6-81. Approximately 12 wells show some contamination. Kmr

I-108 Blue Spruce, Bound Brook, Middlesex Co. 10/80

Pesticide facility has operated with very poor housekeeping. Both solid and liquid waste has contaminated the soil and water table aquifer. Site near Raritan River with confluence of Middle Brook. Effect on bedrock aquifer undetermined. Qsd/Trb

I-109 American Cyanamid, Woodbridge, Middlesex Co., 8/80

Leaking lagoon. Received sludge high in N and some wax. Surrounding fill very impermeable. Native ground is a swamp (tidal), decomposing vegetation, and clay-sand. No significant contamination. Case closed. Trb

I-110 Dowell Industries, Mt. Holly, Burlington Co., 2/81

Firm uses caustic or acid solution to clean boilers or water treatment facilities. Waste discharged to lagoon. Lagoon lining had several small rips. Tank truck washing facility also operated. Kmw

I-111 Struthers-Dunn, Mantua, Gloucester Co. 11/79
Plating waste was discharged to unlined lagoon. Monitor wells had shown objectionable levels of CN, Cr, Phenols. Recent analyses have shown problem has subsided. Periodic monitoring required for 2 more years. Tch

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I-112 AMF-Maarck, S. Brunswick, Middlesex Co., 11/80
Plant discharged TCE and methylene chloride into septic tank. Well on site is contaminated (120 ppb). Solvents now stored in holding tank.

Wells being installed 5/81 to investigate extent of problem. Qps/Trs

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I-113 Aerosystems Technology, Franklin, Sussex Co. 2/81
New plant on old Cellate property operated by owner of Metaltec Corp. Cooling water discharge contains phenols, organics. Springs on property show TCE. Extent and causes of problem not known. Qt/fl

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I-114 Sutton Well, Clinton, Hunterdon Co. 7/80
4450 ppm Cl found in Sutton well. Source is H.C.R.D. salt stockpile which was left uncovered for several years. Resistivity survey delineates source and plume. 5/81, County has provided or will provide water to homes from High Bridge Water Co. Qal/pC

I-115 Allyn Manufacturing, Whiting, Ocean Co., 10/80
Firm dyes and paints dried plants for store displays. Discharge dye containing methylene chloride to an unlined seepage ditch. Painting done on unprotected ground. Wells on property (80') are clean. Recommend five shallow monitor wells and soil testing. Tch

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I-116 Pavonia Engine Yard, CONRAIL, Camden Co., 8/80
Fuel oil spill caused by overfilling of tank in unlined, diked tank farm. Many thousands of gallons lost. Problem is perpetual. In addition, facility housekeeping is atrocious; many spillages throughout yard.

Ten monitoring wells installed, 7/80. Additional wells and recovery system requested since every well contained measureable product. Recovery system installed, not functioning adequately 12/80. 5/81, Conrail has not provided funds for additional observation wells or to upgrade recovery system. Qcm/Kmr

I-117 Metallurgical Industries, Inc., Tinton Falls, Monmouth Co. 3/81

Company has been discharging untreated wastewater ("neutralized" acids) behind its plant since 1967. Requested installation of three monitor wells. Tvt

I-118 Elmwood Pk., Bergen Co. 11/80

Grant Chemical and Laplace Chemical both have had serious housekeeping problems. Predecessor to Grant purportedly discharged chemical waste onto ground. Soil between the two firms has strong chemical odor and high levels of COD, metals, SO_4, low pH. One local well contaminated with organics. Laplace Chem. Discharge and soil from three sites sampled for volatile organics. Trb

I-119 Engineering Labs., Oakland, Bergen Co. 11/80

Plastics grinding firm discharges plastic waste and cooling water to unlined lagoons. Site located along Ramapo Border Fault which is "open" in this area. Sampling has shown high COD in ground water. Company required to file for appropriate permits. Qg/Trb

I-120 Princeton Polychrome Press, West Windsor, Mercer Co., 2/81

Chemical spillage and unlined wastewater lagoon. Local private wells have been sampled, no problem was found. Qps/Trs

I-121 Diamond Shamrock, S. Kearny, Hudson Co. 12/80

Very old chrome smelting plant on Hackensack River. Wastes dumped on site and used as fill and aggregate at other sites. Chromate discharging to river and drainage channels. Large amount of Cr waste buried with alumina hydrate, and lime. This slab is breaking down leaching Cr to ground water. Recommended that D.S. hire a consultant to investigate degree and extent of ground water contamination. Qsd/Trb

I-122 Conrail-Meadows Yard, Kearny, Hudson County 3/81

Poor housekeeping, surface spillage and storage of old solvent drums has led to suspect a possible ground water problem. Site inspection scheduled for 6/81. organic silt

I-123 Bell Labs, Hanover Twp., Essex Co. 2/81

Facility utilized sand filter and sludge drying beds which received high concentrations of organics and metals. Company has installed monitor wells. Qsd

I-124 Simmons Olds, Toyota, Ramsey, Bergen Co., 5/81

Illegal discharge of waste oil, transmission fluid, mineral spirits and solvents to an unlined seepage pit led NJDEP to suspect possible ground water contamination. Monitoring wells have been recommended to determine the extent of the problem. Qsd/Trb

I-125 Picattiny Arsenal, Rockaway Twp., Morris Co., 12/80

Ground water monitoring system implemented to define water quality at suspected pollution sources here. Sampling conducted in May 1981 and results forthcoming. Qsd, bgn, Sgp

I-126 Radiation Technology, Rockaway Twp., Morris Co., 4/81

Industry finishes wood products using cobalt radiation to bind a plastic protective coating. Organic chemicals detected in potable/process wells here. Awaiting results of state's testing to begin investigation of source(s). pC

I-127 Middlesex Sampling Center, Middlesex, Middlesex Co., 6/80

Government (Federal) investigating facility previously used as a uranium sampling center for Manhattan project. Consultant prepared report which NJDEP is reviewing. Trb

I-128 Mobil Testing Farm, Hopewell, Mercer Co., 3/80

Facility tests herbicides. Monitor wells and water quality monitoring system in operation. Rutgers Universty sampling and analyzing water quality of both surface and ground water. Trb

I-129 Imperial Oil, Morganville, Monmouth Co. 5/81

Company blends viscosity enhancing agents into lubricating oils. Industrial activities conducted here for over 100 years by many firms. Many pollution sources observed on-site. Illegal dumping of PCB's has occurred at several locations adjacent to Imperial Oil. Assessment of extent and degree of soil, surface water, and ground water contamination is necessary. Ket

I-130 Cosden Oil & Chemical Company, Washington Twp., Mercer Co., 5/81

Wastewater containing with an "oil sheen" and possibly containing heat transfer oil, mineral oil, fuel oil, and styrene monomers is being discharged via a pipe to a grassy area. Firm has been notified that this activity must have a permit. The site will be visited in the near future to locate monitoring wells. Kmv

I-131 Public Service Elec. & Gas Co., Mercer Generating Sta., Mercer Co., 5/81

Rain and runoff percolating thru a coal stockpile is elevating the TDS and SO_4 levels in the groundwater flowing below the pile. (Levels exceed ground water standards.) PSEG claims that the Delaware is not affected hence there is no problem. Groundwater monitoring has started to create a data base so that appropriate action (lining the stockpile) can be taken. Kmr

I-132 Linden Chlorine, Linden, Union Co. '80

Mercury-brine sludge is possible source of ground water contamination. Sludge is being dumped into unlined lagoon. Consultant has been hired to install wells and investigate problem. Wells will go in summer 1981. Trb

I-133 Revlon Co., Edison, Middlesex Co. 8/80

High amounts of organics, 200 ppb, in Amerchol's production well (across st.) led to investigation of this site. Samples from seepage pit yielded numerous organics in high concentrations. Site visit scheduled 11/80 to resample since company's analyses differed. Wells requested based on sample analyses, April '81. Awaiting response. Trb

I-134 Chem. Sol, Piscataway, Middlesex Co. 2/80

Abandoned chemical site with suspected contamination by organics caused by dumping. Water and soil sampled on site 2/80. High level of organics in water and high PCB's in soil. On 10/80 Consultant drilled eight monitor wells. These and 300 ft. old production well were sampled. Analyses confirmed presence of gross contamination. Awaiting consultants report which will contain proposals for decontamination and further investigation. Trb

I-135 Solvents Recovery Service, Linden, Union Co. 8/80

Suspected ground water contamination due to spillage of organics in unlined tank farms and elsewhere on-site. Poor housekeeping. Consultant hired to do hydrogeologic investigation. Wells installed 2/81. Sample analyses document presence of contamination. NJDEP will seek decontamination in the near future. Company may be reluctant. Till/Trb

I-136 CP Chemicals, Inc., Sewaren, Middlesex Co., 7/80

Ground water contamination caused by discharge into unlined lagoons and dumping throughout site. Constituents include cyanide, arsenic, copper, zinc and lead. Consent Order signed in early '81 calling for subsurface investigation. Monitoring wells installed fall 1980, sampled 5/81. Awaiting results of analyses. Expect to find contamination and will seek decontamination in the future. fill/organic silt/till

I-137 Koppers, Kearny, Essex Co., 10/80

Company left large amount of tar-like residue on the premises. Some hydrocarbons have been observed leaching into the Hackensack River. Investigation pending. All types of contamination (pesticides, organics, metals) present. Proposal for entombment of worst area. drift/Trb

I-138 Denzer and Schaeffer, Bayville, Ocean Co. 9/80

Silver reclaiming operation discharged caustic solution onto the ground. Also septic tank receiving acid solution (pH 1) and discharging into ground. Company has hired consultant for septics. Private wells may be threatened. Administrative Order sent requiring monitor wells 5/81. Qcm/Tch

I-139 Fasco, Phillipsburg, Warren Co., 10/80

Metal Plating company allowed a solution containing high concentrations of Zinc, Tin, and Cadmium to percolate into permeable sand & gravels. 5/81 drilled 45' boring, no water. Soil samples show elevated levels of cyanide to 10 feet. Negotiations for soil removal underway. Qg

I-140 U.O.P., Johnson, East Rutherford, Bergen Co. 1/80

Shallow monitor wells reveal severe contamination present in the water table aquifer. Six (6) old process wells, located in a lower artesian aquifer are being prepared for sampling and sealing. Based upon this sampling, determinations will proceed regarding the deep aquifer water quality. Company is required to assess the extent and magnitude of the water table contamination. Investigation continuing. Recent/Qsd

I-141 Johanson Mfg. Co., Boonton Twp. Morris Co. 8/80

Unlined lagoon receives treated wastes from electronics plant. Monitor wells installed 10/80 and ground water degradation found near lagoon. NJDEP will meet shortly with company to direct them to ascertain the extent and degree of aquifer contamination caused by their discharges. Case continuing. Qsd

I-142 BFI, Pedricktown, Salem Co. 10/80

Industrial cleaning facility maintained a waste lagoon. Sloppy housekeeping characterizes the site. Preliminary pollution assessment completed 3/81, concluded that the waste lagoon (inactive) had the greatest impact on ground water quality. Assessment indicated that the contamination may have moved 100' from the site. Contaminants include organic solvents, metals and to a lesser extent several inorganics. Investigation continuing. Qcm/Kmr

I-143 Conrail Facility, Raritan Boro, Somerset Co. 3/81

Unlicensed landfills and storage of old solvent drums has alerted NJDEP to the possibility of a potential ground water problem. Site inspection scheduled for 6/81 to determine need for monitoring wells, etc. Trb

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I-144 Lake Intervale, Morris Co. 1/79

Private lake surrounded by homes. Deepening of lake uncovered chemical seepage of benzene and toluene. Investigation of nearby industries initiated. Improvised air-stripping scheme implemented to deal with seepage during excavation operation. Sampling of soil removed also done. Excavation work completed in very early 1981 (investigation of nearby industries [Norda, Synthatron] continuing) Qsd/Trb

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I-145 Marisol Inc., Middlesex Twp., Middlesex Co., 1/79

Liquid waste reclaimer found to have high levels of organics in production well. Monitor wells ordered drilled and four wells installed 2/81. Sampling scheduled and consultants report due. Trb

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I-146 Reagent Chemical, Middlesex Twp., Middlesex Co., 5/79

Third owner of this industrial site. Discharges of hazardous wastes by former occupants. Auger work has confirmed buried wastes, including arsenic. Four monitor wells installed early 1981. Will be sampled. (cases I-145 and I-147 nearby) Trb

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I-147 Inmont Chemical, Middlesex,Middlesex Co., '79

Near to Marisol plant (I-145). Site inspections, meetings held 1979-80 to discuss deficiencies and ground water evaluation program. Monitor wells installed early 1981. Sample results and consultants report outstanding as of June 1981. Trb

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I-148 Air Products, Middlesex, Middlesex Co. 5/79

Plant in area highlighted by Marisol matter (I-145). Discharge of lab waste to septic tank and evidence of spillages. Improvised decontamination for organic seepage, terminated in early 1981. Soil borings and analyses confirmed organics in the overburden. Consultant report submitted in 3/81. Meeting held 5/81 requesting decontamination of shallow aquifer. Trb

I-149 Inmont Chemical, Lodi, Bergen Co. NJDEP was notified of below-ground storage failure. Requested to review consultants proposal and implement it. Program agreed to and drilling began on 6/3/81. Sampling and soil borings scheduled.	4/81	Trb
I-150 Stauffer Chemical, Edison, Middlesex Co. Handle and store variety of organic chemicals. Monitor wells installed 1979 showing organics in ground water. Interceptor decontamination system installed on site with sewer discharge. Upgraded, scaled up system for ground water and runoff collection under design 6/81.	'79	Trb
I-151 Parker Andrews Ind., S. Bruns., Middlesex Co. One of several possible sources investigated as part of S. Brunswick Well No. 11 problem. Some organics in ground water in four monitor wells installed at plant. Water levels and subsequent report show migration away from Well No. 1. Periodic monitoring requested; in-plant changes made.	1/78	Kmr
I-152 Norda, Boonton, Morris Co. Old flavor & fragrances plant with below ground storage, septic tanks. Chemical seepage at nearby Lake Intervale brought NJDEP to the site. Consultants report submitted 4/81. Further work including monitor wells requested 6/81.	6/81	Qsd
I-153 Taylor Forge, Branchberg Twp., Somerset Co. Metal processor found to have unlined lagoons and organics in their production well. One nearby domestic well also affected. Lagoons will be discontinued, domestic well replaced and production well used to confine organic migration. Solvent handling improved.	12/78	Trb
I-154 Allied Chemical, Metuchen, Middlesex Co. Cooling water discharge to dry well. Monitor wells and consultants report show some ground water contamination. Company is applying for Treatment Works Approval (TWA) and tie-into sewer.	'77	Kmr/Trb
I-155 Vineland Foods, Norma, Salem Co. Chicken processing plant with spray irrigation of wastewater. Several consultants reports prepared and monitor wells installed. Treatment works approval near completion for continued spray, with sampling & monitoring program.	'75	Tch

I-156 Hunt Wesson, Bridgeton, Cumberland Co. 9/76
Vegetable processing plant with spray irrigation of effluent. Long-term spray site with some impact on ground water. Consultants reports and monitor wells provided. Approval recommended with regular monitoring and reports. Tch

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I-157 United Poultry, Vineland, Cumberland Co. 3/77
Chicken processing plant with spray irrigation of effluent. Several reports and phases of drilling for subsurface evaluation. Dissolved air floatation (DAF) equipment installed for upgraded treatment; sewer line to be constructed for reduced effluent loadings as per Consent Order. Tch

Sanitary Landfills (S)

S-1 Fenimore Landfill, Roxbury Twp., Morris Co., 2/75

When visited on 2/75 the operation was described as one of the worst landfill sites. Many violations were in progress, but the worst of the violations was the fact that they were accepting chemical drums on and in the landfill. Sampling in '75 showed degradation of Drakes Brook. As of 4/25/77 the disposal site was ordered to cease its operation and submit plans for proper closure.

Qs/Qm/gr/gn

S-2 Ottilio Dump, Newark, Essex Co., '75

Continual dumping of chemicals and drums into pits that have been excavated to the water table. Area was to be filled in and further dumping prevented. Wastewater from landfill bleeds into a tributary of the Passaic River.

Trb

S-3 Price Trucking, Doughty Mill, Atlantic Co., '72

This landfill, which has accepted many millions of gallons of chemicals, has contaminated groundwater in the surrounding area. Atlantic City Well Field is located nearby. Closed by state in 1976. EPA is taking legal actions against owners. This office has performed well analyses and geophysical studies. Atlantic City MUA has hired a consultant to study the impact of this landfill on their well field.

Tch

S-4 Helen Kramer Landfill, Mantua Twp., Gloucester Co., 8/75

This landfill has accepted chemicals and oil which in turn have contaminated the groundwater. The oil is bleeding out into a creek through 200 ft. of virgin ground. Kramer has proposed a leachate interceptor pipe to trap leachate.

Kmw

S-5 Dover Twp. (SLF), Ocean Co., 9/75

The landfill received chemical drums at one time and buried them in the Cohansey aquifer. This burying of drums (some containing sodium) may or may not be responsible for the ground-water pollution in Pleasant Plains. Four monitor wells have been drilled and more will be put in.

Tch

S-6 Toms River Chemical, Toms River, Ocean Co., '72

Groundwater is contaminated in area surrounding TRC's landfill and lagoons. PCB related compounds have been detected in observation wells on both sides of the Toms River. No water supplies are in danger at present. Geophysical studies have taken place and are continuing.

Tch

S-7 Hayden Chemical, Manchester Twp., Ocean Co., 4/73

They have been discharging penicillin wastes into a lagoon. Analyses of wells indicate PCB-type compounds and organics. Over the years millions of gallons of liquid have been discharged into the ground. Site closed.

Tch

S-8	Lakewood Twp. SLF, Lakewood Twp., Ocean Co., It has been reported by the fire warden that several thousand drums have been buried here. No analyses on the groundwater have been taken. Late 1980-81, samples were obtained from surrounding homes. No contamination was found. Monitor wells are planned around the landfill.	'72	Tch
S-9	Lakewood Twp.-Prospect Rd., Ocean Co., A small number of drums have been disposed of on this site.	'73	Tch
S-10	Ocean Landfill Corp., Manchester Twp., Ocean Co., Thousands of drums along with millions of gallons of liquids have been dumped here. Thus far there has been no analyses on or around landfill site.	'72	Tch
S-11	Wantage Twp., Sussex Co., Landfill leachate flows into a cave and resurges at a spring one-half mile away. In 1976 landfill was ordered closed.	'75	Oe
S-12	Baker Chemical, Harmony Twp., Warren Co., Arsenic contamination of groundwater from sludge and chemical lagoons.	'76	Qs/Ca
S-13	Baker Chemical, Lopatcong Twp., Warren Co., In the landfill there has been a disposal of chemical containers with some liquid and solid wastes. It should be known that a large capacity public supply well approximately 500' away from the site showed organic chemicals.	'76	Qs/Cl
S-14	Kin Buc, Edison, Middlesex Co., Chemical dump site filled with drums of liquid chemicals. Millions of gallons were dumped per week. Site is now closed.	'75	Qp/Kmr/Trb
S-15	Princeton Disposal, South Brunswick, Middlesex Co., Chemical drums and liquids were disposed of on this site. There is a serious ground-water contamination problem here, but it seems that Princeton Disposal blames it on the Spillatore site which is across the street. EPA sponsored drilling underway spring '81	'75	Qs/Tr
S-16	L&D, Mt. Holly, Burlington Co., Here there is leachate contamination of domestic wells. Recovery and treatment of groundwater ordered.	'74	Kmw
S-17	JIS, South Brunswick, Middlesex Co., Organic chemical contamination of domestic well due to disposal of chemical wastes in landfill. Leachate plume moving toward Monroe Township's private wells about a mile away. Case before appelate court as of 1979. Consultant has been hired, additional monitor wells installed. Landfill closed by Court in 1980. Legal action continuing.	'76	Qps/Kmr

S-18 Sparta Township Landfill, Sparta, Sussex Co., '76
This landfill has received large amounts of septage. There have been spills into the Paulins Kill. Geophysical mapping of the area indicates severe ground-water contamination with the landfill as a likely source. Qsd/Cok

S-19 Nick Lipari Landfill, Mantua Township, Gloucester Co., '75
This landfill is closed, but did accept chemicals from Rohm & Haas. Organic chemicals are in the monitor wells and flow into the Chestnut Branch. Still in litigation as of 12/78. Qp/Tkw

S-20 Jackson Township Landfill, Jackson Township, Ocean Co., 11/78
Ground water is polluted with at least 41 different organic chemicals which are felt to have originated from the dumping of liquids at this landfill over a period of six years. Landfill is currently closed to liquids and NJDEP has been intimately involved in delineating a zone of contamination using monitor wells and geophysical methods. Tch

S-21 Monroe Township Landfill, Middlesex Co., 7/79
Private wells contaminated with organic chemicals from a closed landfill. Chemicals were received and drum disposal in nearby woods has occurred. The full extent of damage has not been determined as of 7/79. Important aquifers are affected. A full investigation will be underway in early July involving sampling, resistivity, refraction seismology and drilling. Rigorous boring program and sampling completed 1979-1980. The result was a comprehensive closure plan. A temporary collection system on-line during evaluation period. Construction of cut-off walls underway Spring 1981. Additional monitor wells recommended. Kmr

S-22 Fazzio Landfill, Bellmawr Twp., Camden Co. 1/81
Landfill is closed. Leachate is seeping into adjacent Big Timber Creek and Beaver Creek. Closure plan includes capping of landfill and installing a slurry trench around south and west perimeter. Have requested installation of six monitor wells. Kwb

S-23 Waste Disposal Inc. Landfill, Howell Twp, Monmouth Co. 10/80
Leachate, high in volatile organics, was leaching into Muddy Ford Brook, adjacent to the west. Six on-site monitor wells indicate organic contamination. Consultant has proposed relocation of stream, capping (part of) the landfill, installing a cut-off wall, and instituting ground-water recovery and treatment of leachate. Tkw

S-24 Absecon Landfill, Absecon, Atlantic Co., 9/80
Residents near landfill complained of a "waste problem" in their wells. Potable Water sampled four of these wells. None were polluted. The water problem appeared to be the relatively high background iron content in the ground water. Case closed. Tch

S-25 Harrison Ave. Landfill, Camden City, Camden Co. 6/80

Landfill (now closed) accepted chemicals. Several city wells on and near the landfill have been closed due to contamination. N.J. Water Co. Well Field is one mile east (downgradient). Seven monitor wells were installed on-site and sampled. City has been required to submit an acceptable closure plan to the Solid Waste Administration. Kmr

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S-26 Gloucester Environmental Management Services, Inc. (G.E.M.S.) Landfill, Gloucester Twp., Camden Co., 6/80

A full scale geophysical investigation and organic chemical analysis of surface and ground water was undertaken upon discovery of several leachate seeps eminating from the landfill. Due to the large size (60 + acres) and lengthy time of chemical dumping at the landfill (30 + years), seventeen private wells were sampled. Organic chemical contaminants up to 44 ppb were discovered 3/4 mile downgradient. The landfill is closed and the case is in litigation. Tkw

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S-27 Lower Township Landfill, Rio Grande, Cape May Co., 6/80

Abandoned landfill, formerly inadequately monitored by two (2) shallow wells, located less than 1/2 mile from 325 million gallon per month well field. Sampling scheduled but aborted because monitor well could not be found. Pressing SCA Services to install proper monitor system and water quality testing program. Qcm

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Septic Tanks-(ST)

ST-1 Barry Lakes, Vernon Twp., Sussex Co., 4/78

Possible ground-water pollution from malfunctioning septic systems which are located in glacial, clayey soils, and discharged to fractured gneisses. Hepatitis outbreaks in the last three years may possibly be water borne. Bowe & Walsh, Inc. recommend sewering this area in their 201 plan. Eight residents have sued Vernon Township, et al to fix or replace malfunctioning septic systems. NJDEP has joined suit against builder as an individual and as a corporation. Alternate septic systems were designed for seven residents but will cost more than $10,000 each. Primary issue at this time (February 1980) is to alleviate immediate problem of malfunctioning septic systems without expending large sums of money because area will be sewered within two or three years. Lawsuit still pending in Sussex County Court. Presently attempting to provide community septic system to alleviate problems. Numerous violations of Chapter 199 Standards. pC

ST-2 Fleck and Ayoub, Warren Glen, Warren Co., 6/78

Two septic systems have been overflowing for a period of a year. After a thorough investigation, alternative system was then designed for the two residences. Cok

ST-3 Berkeley Heights, Union Co., 3/78
A problem of an overflowing septic system. A thorough geologic investigation prompted installation of sewers. Trbs

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ST-4 Barton's Lake, Shamong Twp., Burlington Co., 5/81
74 unit subdivision has 33% septic malfunction, 65% of wells are polluted with $N-NO_3$. Case under study by NJDEP.
Tch

JF:T:R42:A1-29:B1-28

[illegible]

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10007

January 31, 1980

Mr. George Czurlanis
2-8 Jefferson Lane
Tuckerton, N.J. 08087

Dear Mr. Czurlanis:

I was recently contacted by Mr. Beronja of our Industry Assistance Office in Washington concerning your previous request for all correspondence and reports generated by this office on the water quality at Little Egg Harbor, New Jersey.

As I explained during our telephone conversation on January 11, you are entitled to review our files at any time under the Freedom of Information Act but if you require copies an official request in writing should be made. As I did not receive a written request from you I assumed you no longer desired the information or was successful in obtaining it elsewhere.

In order to avoid further delays I am transmitting to you at this time all correspondence pertaining to this water supply even though an official written request was not received.

Let me make some comments regarding the information provided. EPA has not set a standard for asbestos in drinking water. Available data from either animal tests or human epidemiology studies are not definitive enough at this time to determine whether ingesting asbestos fibers in drinking water is a health hazard. There is no appreciable increase in either calcium hardness or pH as the water passes through the distribution system which would be expected if the pipe was deteriorating. Therefore in an effort to diagnose the problem more fully, additional samples were collected on January 14. These samples will be analyzed for asbestos as well as wet chemistry. Results have not been received as of this writing but are expected within the next two weeks at which time copies will be provided.

I trust the information provided in this transmittal will meet your needs. Your interest in water supply is most appreciated.

Sincerely yours

R. Williams

Robert R. Williams, P.E., Chief
Public Water Supervision Program
Section

w/Siease

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10007

January 16, 1980

Mr. Ron Williams
Bureau of Potable Water
New Jersey Department of
Environmental Protection
P.O. Box 2809
Trenton, N.J. 08625

Dear Mr. Williams:

Transmitted herewith are results of the asbestos analyses performed on drinking water samples collected at Little Egg Harbor, New Jersey on November 1, 1979.

	Asbestos Concentration (in Millions of Fibers per Liter)	
	Amphibole	Chrysotile
Holly Lake Plant (Raw-water)	BDL (1.0)*	NSS (4.0)**
Pineland Regional H.S. (Custodian Room)	8	270
42 Revolutionary Road	NSS (0.25)	1.8

/ mile

130 Patient Lots

*BDL - Below Detectable Limits of 1 x 10^6 fibers per liter.
**NSS - Not Statistically Significant - Although some asbestos fibers were found in the sample during analysis, the counting statistics where not good enough to consider the value as an accurate concentration.

A high concentration of asbestos fibers was found in the Pineland Regional H.S. sample. The chrysotile fibers examined in the sample averaged 1.4 micrometers in length, 0.033 micrometers in width, and had a mean aspect ration (length/width) of 42.5. Fibers as long as 8 micrometers long were found.

As you know, EPA has not set a standard for asbestos in drinking water. Available data from either animal tests or human epidemiology studies are not definitive enough at this time to determine whether ingesting asbestos fibers in drinking water is a health hazard.

At the same time the samples were collected for asbestos analyses, additional samples were collected for inorganic chemical analyses. The results of these samples are as follows:

Sample Site	pH	Calcium Hardness(1)	Alkalinity	Managanese	Iron	A.I.(2)
Holly Lake Plant-Raw	6.62	8.0 mg/l	11.0 mg/l	6.0 ug/l	60 ug/l	8.6
✓ Holly Lake Plant-Finished	8.22	6.5	35.0	29.0	1,200	10.6
✓ Holly Lake Sales Office	8.85	7.5	37.5	6.0	50	11.3
✓ 42 Revolutionary Road	8.66	7.5	39.0	4.0	50	11.1
✓ Pineland Regional H.S.	8.84	8.0	40.0	6.0	180	11.3

(1) mg/l as $CaCO_3$

(2) AI = Agressive Index

Using this data a corresponding aggressive index (AI) was calculated for each sample. Generally, AI's less than 10 are considered aggressive, between 10 and 12 moderately aggressive, and greater than 12 non-aggressive. When an aggressive water passes through asbestos cement pipe there is a possibility that the pipe's integrity can be adversely affected due to dissolving of the pipe's cement. Once this cement is dissolved the asbestos fibers can then be released. Usually, dissolving of the pipe's cement is accompanied by significant increases in calcium hardness and pH resulting in increased aggressive indexes. Evaluation of the above chemical data does not indicate that this phenomenon is occurring. While the raw water is aggressive (AI = 8.6), the water leaving the well site is significantly less aggressive (AI = 10.6). Furthermore, there is no appreciable increase in either calcium hardness or pH from plant delivered to the furthermost point of the distribution system at the high school.

On this basis we feel that the extremely high asbestos level found is not the result of deterioration of the A/C pipe resulting from aggressive water. The fibers could be the result of recent construction in the area. If drilling and tapping of the pipe was not performed under controlled conditions and the pipe flushed completely asbestos levels of the magnitude found could occur. Fibers released during these operations could build up within the distribution system at places of low flow such as deadends and then be released sporatically during high flow conditions such as flushing. The High School is one such deadend. If the system was flushed and a sample taken from an adjacent tap, without extensive flushing of that tap (10 minutes) it is possible that a residual buildup of fibers may have been collected in the sample, resulting in the very high count. It is therefore our recommendation to resample at the school. Mr. Jaime Referente of this office will coordinate this effort with Mr. Taj Kahn of your staff. In addition, we are requesting that samples for pH, alkalinity, calcium hardness and carbon dioxide analyses be collected at the same 5 sites as the November 1, 1979 sampling. This will provide us with the necessary data to confirm that aggressive water is not attacking the A/C pipe.

If you have any questions, please feel free to call.

Sincerely yours,

Robert Williams, Chief
Public Water Supervision
Program Section

October 1, 1979

Mr. Ronald Williams
Bureau of Potable Water
New Jersey Department of
Environmental Protection
P.O. Box 2809
Trenton, New Jersey 08625

Dear Mr. Williams:

The following are the results of the asbestos analysis performed on drinking water samples taken from Little Egg Harbor, New Jersey on August 23, 1979.

Sample	Asbestos Concentration (in Millions of fibers per liter) Amphibole (minerals)	Chrysotile
Holly Lake Well, Grt. Bay Blvd.	BDL*	BDL*
Pine~~tree~~ Lands Regional H.S. (Custodail Closet)	NSS0.2**	1.2
Laboratory Filtered Distilled	BDL	BDL

*BDL - Below detectable limits of 500,000 fibers/liter.

**NSS - Not Statistically Significant - 2 amphibole fibers were found in sample during analysis. Although present, the counting statistics are poor for this value of amphibole asbestos.

A statistically significant concentration of chrysotile asbestos fibers was found in the Pinetree Regional H.S. samples. The level of 1.2 million fibers per liter is not as high as found in some other asbestos cement pipe systems. Over 500 million fibers perlliter were found in one system in South Carolina. Various water supplies in Florida, Kentucky, Pennsylvania and South Carolina have been shown to contain significant concentrations of fibers.

Based on the latest chemical analysis of Little Egg Harbor's water supply (August, 1978) an aggressive index (AI) of 10.7 was calculated for the finished water and 8.4 for the raw water. While an AI of 10.7 is considered moderately aggressive, an AI and 8.4 is very aggressive. When a very aggressive water is transmitted through asbestos cement pipe, there is a strong likelihood that the pipe's cement will be dissolved. This is usually evidenced by an increase inthe water's pH and calcium hardness. Once the cement is dissolved the asbestos fibers bonding is lost and the fibers can be released into the water. This dissolving of the cement can usually be controlled through pH adjustment using line treatment or introducing iron or zinc into the water prior to distribution. The addition of iron or zinc results in a protective coating on the pipe's surface. The fibers found in the sample collected at the high school could be the result of such deterioration of the pipe. This condition can easily be verified by profiling the parameters of pH, alkalinity, hardness, and AI through the distribution system from the well to the high school.

Another factor to be considered is construction in the area. Drilling and tapping of asbestos cement pipe, if not performed under controlled conditions using a flushing device on the tapping tool, can cause a major release of fibers into the water. In light of this, it is imperative that the school's system be flushed on a regular basis, particularly if any tapping of the main is anticipated. This would prevent the accumulation of fibers at deadends and eliminate the possibility of "false positive" counts when additional water samples are collected.

The Environmental Protection Agency has not as yet set a standard for asbestos in drinking water. Available data from either animal test or human epidemiology studies are not definitive enough at this time to determine whether ingesting asbestos fibers inddrinking water at a level of 1.2 million fibers per liter is a hazard to health.

In order to completely access the potential for leaching asbestos fibers within Little Egg Harbor's distribution system, it will be necessary to profile of chemical parameters including the AI's through the distribution system as well as collect additional samples for asbestos analysis. We have made arrangements with our laboratory, in Cincinnati for the analysis of three additional samples but will require the cooperation of the water supply to provide the analysis for the chemical parameters. Therefore, we would like to coordinate this effort through your office as soon as possible. If you have any questions, please feel free to call.

Sincerely yours,

Robert R. Williams, P.E.
Senior Sanitary Engineer
Water Supply Branch

Princeton University SCHOOL OF ENGINEERING/APPLIED SCIENCE
CENTER FOR ENERGY AND ENVIRONMENTAL STUDIES
THE ENGINEERING QUADRANGLE
PRINCETON, NEW JERSEY 08544

February 16, 1982

Ms. Marian Mlay, Deputy Director
Office of Drinking Water (WH-550)
Environmental Protection Agency
Washington, DC 20460

Dear Ms. Mlay:

As one who has studied and written on the issue of chemical contamination of drinking water, I would like to comment on some proposals before EPA as amendments to the Safe Drinking Water Act:

Preventive Approach of the Safe Drinking Water Act

Because many toxic chemicals in drinking water remain unidentified and because maximum contaminant levels exist for only a very limited number of chemicals (compared to the 700 chemicals identified in water and EPA's list of 129 Priority Pollutants), it is essential that the preventive mandate of the act be retained. This mandate is embodied in the words of the Act: "may have any adverse effect on the health of persons." Such a preventive approach should include the use of best available control technology for degraded drinking water sources. Criteria for judging such a threat could be based on tests for the 129 Priority Pollutants of a raw water source used for drinking water.

I have recently returned from a study-trip to Europe on the subject of chemical contamination of drinking water and have learned that control technology (granular activated carbon,ozone) is feasible and effectively used to improve water quality. The Europeans have decided on a preventive approach for public health protection. The per capita cost of such protection makes it feasible. In my 1981 case study in New Jersey, such costs (based on water purveyor estimates) ranged from $16 to $27 annually per household for a 66 MGD plant to a 5 MGD plant, respectively.

Cost/Benefit Analysis

The proposed requirement for a formal cost/benefit analysis is a means of undercutting the effectiveness of the Act. It is very difficult, if not impossible, to compute the benefits to the public without putting a price tag on life or on life with more or less illness. We cannot be certain how much ill health and death are prevented because of the long time-lag (often decades) between initial contact with a carcinogen and the onset of cancer. Yet, the cost of drinking water treatment can be easily quantified and used as the basis for avoiding regulation. Thus, cost/benefit analysis is different in the area of public health protection than it is in other fields where more quantifiable benefits exist. A cost criterion based on a per capita, or per household basis, is a more logical means of computing. This is at the consumer level where such costs are ultimately paid.

I have selected only two principal areas of the Act to comment on because of the brevity of the comment period, which is regretful. In such an important area of legislation dealing with the most basic necessity of life, the public should be allowed adequate comment time. Other areas of concern include sole source aquifer designation, variances, and public participation via the National Drinking Water Advisory Council. These and other features of the Act (e.g., number of toxics regulated, more frequent and better monitoring) should be strengthened, rather than weakened. The public is now more aware of drinking water contamination, even of once pristine ground water, and will expect its government to take the necessary precautions to protect public health. This is evidenced by recent public opinion polls which show overwhelming support for environmental and health protection.

Enclosed are excerpts from my draft report (introduction, conclusions and recommendations) " . . . Nor Any Drop to Drink!: Public Policies Toward Chemical Contamination of Drinking Water." Enclosed also is the report (the summary of issues only) from my fall 1981 European study-trip, "The European Experience: Issues in Water Quality and Drinking Water Treatment." Both reports are undergoing final revision, thus only the excerpts are enclosed at this time.

I would appreciate being placed on your mailing list for future notices of hearings, requests for testimony, etc., relating to the Safe Drinking Water Act, and drinking water generally.

Sincerely,

Grace L Singer

Grace L. Singer
Research Staff Member

GLS:es

Enc. a/s

Telephone: (609) 452-5468

PROPOSED FEDERAL CRITERIA FOR "PRIORITY POLLUTANTS" IN DRINKING WATER

In settling a lawsuit brought by the **Natural Resources Defense Council**, the federal Environmental Protection Agency (EPA) agreed to set drinking water criteria for 65 classes of toxic "priority pollutants", including 129 individual compounds. So far the EPA has proposed criteria for 96 of the 129. In several cases, the proposed criterion was set on the basis of chemical toxicity; in many other cases the criterion was set on the basis of the carcinogenicity (cancer-causing ability) of the chemicals. Except as noted in the table, for carcinogens the EPA proposed three different criteria: a criterion that would permit cancer in one person in 10 million drinking the chemical at the proposed level for a lifetime; a criterion that would permit cancer in one person in a million; and a criterion that would permit cancer in one person in 100,000. The criteria presented below are the middle of the proposed range -- in other words, these criteria would permit cancer in one person in one million. To get the other two criteria for carcinogenic chemicals, divide the tabled value by 10 (to get the one in 10 million criterion), or multiply the tabled value by 10 (to get the one in 100,000 criterion). These data are reproduced from Marshall Sittig, **Priority Toxic Pollutants -- Health Impacts and Allowable Limits** (Park Ridge, NJ: Noyes Data Corp., 1980).

CHEMICAL	PROPOSED CRITERION (ppb)*	CARCINOGEN?
Acenaphthene	20.0	No
Acenaphthylene -- See Polynuclear aromatic hydrocarbons		No
Acrolein	6.72	No
Acrylonitrile	0.0084	Yes
Aldrin/dieldrin	0.0000045	Yes
Antimony and compounds	145.0	No
Arsenic and compounds	0.002	Yes
Asbestos	30,000 fibers per liter	Yes
BCEE -- See Bis(2-chloroethyl) ether		
BCIE -- See Bis(2-chloroisopropyl) ether		
BCME -- See Bis(chloromethyl) ether		
Benzene	1.5	Yes
Benzidine	0.000167	Yes

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29 Pine Knoll Drive, Lawrenceville, NJ 08648

CHEMICAL	PROPOSED CRITERION* (ppb)	CARCINOGEN
Benzo(a)anthracene	-- See Polynuclear aromatic hydrocarbons	No
Benzo(a)pyrene	0.00097	Ye
3,4-Benzofluoranthene	-- See Polynuclear aromatic hydrocarbons	No
Benzo(j)fluoranthene	-- See Polynuclear aromatic hydrocarbons	Ye
Benzo(k)fluoranthene	-- See Polynuclear aromatic hydrocarbons	No
Benzo(ghi)perylene	-- See Polynuclear aromatic hydrocarbons	No
Beryllium and compounds	0.0087	Ye
BHC -- See Hexachlorocyclohexane		
Bis(2-chloroethyl) ether	0.042	Ye
Bis(2-chloroisopropyl) ether	1.15	Ye
Bis(chloromethyl) ether	0.000002	Ye
Bromodichloromethane	2.0	No
Bromomethane (methyl bromide)	2.0	No
Cadmium and compounds	10.0**	Ye
Carbon tetrachloride	0.26	Ye
Chlordane	0.00012	Ye
Chloroform	0.21	Ye
Chloromethane (methyl chloride)	2.0	No
2-Chlorophenol	0.3	No
Chromium and compounds	0.0008 (Cr-VI)	Ye
Copper and compounds	1000	No
Cyanides	200	No
DDT and metabolites	0.000098	Y
Dibenzo(a,h)anthracene (DBA)	0.00043	Y
Di-n-butyl phthalate	5000	N
Dichlorobenzenes	230	N
Dichlorobenzidine	0.00169	Y
Dichlorodifluoromethane	3000	N
1-2-Dichloroethane	0.7	Y
Dichloroethylene	0.13	Y
Dichloromethane (methylene chloride)	2.0	N
2,4-Dichlorophenol	0.5	N
Dichloropropane/propene	200.0/0.63	N
Dieldrin -- See Aldrin/dieldrin		
Di-2-ethylhexyl phthalate	10000	N
Diethyl phthalate	60000	N

CHEMICAL	PROPOSED CRITERION* (ppb)	CARCINOGEN?
2,4-Dimethylphenol	***	Yes
Dimethyl phthalate	160000	No
4,6-Dinitro-o-cresol	12.8	No
2,3-Dinitrophenol	68.6	No
2,4-Dinitrophenol	68.6	No
2,5-Dinitrophenol	68.6	No
2,6-Dinitrophenol	68.6	No
3,4-Dinitrophenol	68.6	No
3,5-Dinitrophenol	68.6	No
Dinitrotoluenes	0.074	Yes
Dioxin -- See Tetrachlorodibenzo-p-dioxin		
Diphenylhydrazines	0.04	Yes
Endosulfan	100	No
Endrin	1.0	No
Ethylbenzene	1100	No
Fluoranthene	200	No
HCH -- See Hexachlorocyclohexane		
Heptachlor	0.000023	Yes
Hexachlorobenzene	0.000125	Yes
Hexachloroethane	0.79	Yes
Hexachlorobutadiene	0.077	Yes
Hexachlorocyclohexane (BHC)	0.000021	Yes
Hexachlorocyclopentadiene	1.0	No
Indeno(1,2,3-cd)pyrene -- See Polynuclear Aromatic Hydrocarbons		Yes
Isophorone	460	No
Lead and compounds	50	No
Lindane -- See Hexachlorocyclohexane		
Mercury and compounds	0.2	No
Monochlorobenzene	20	No
Naphthalene	143	No
Nickel and compounds	133	No
Nitrobenzene	30	No
N-nitrosodiethylamine	0.00092	Yes
N-Nitrosodimethylamine	0.0026	Yes
N-Nitrosodi-n-butylamine	0.0013	Yes
N-nitrosopyrrolidine	0.011	Yes

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CHEMICAL	PROPOSED CRITERION (ppb)*	CARCINOGEN?
Pentachlorobenzene	0.5	No
Pentachlorophenol	140	No
Phenol	3400	No
Polychlorinated biphenyls (PCBs)	0.000026	Yes
Polynuclear aromatic hydrocarbons (PAH) (Total of 6 compounds together)	0.00097	Yes
Selenium and compounds	10	No
Silver and compounds	10	No
Tetrachlorobenzene	17	No
Tetrachlorodibenzo-p-dioxin	0.000000046	Yes
1,1,2,2-Tetrachloroethane	0.18	Yes
Tetrachloroethylene	0.2	Yes
Thallium and compounds	4.0	No
Toluene	12.4	No
Toxaphene	0.000047	Yes
Tribromomethane (bromoform)	2	No
Trichlorobenzene	13	No
1,1,2-Trichloroethane	0.27	Yes
Trichloroethylene	2.1	Yes
Trichlorofluoromethane	32000	No
2,3,4-Trinitrophenol	10	No
2,3,5-Trinitrophenol	10	No
2,3,6-Trinitrophenol	10	No
2,4,5-Trinitrophenol	10	No
2,4,6-Trinitrophenol (picric acid)	10	No
Vinyl chloride	51.7	Yes
Vinylidene chloride -- See Dichloroethylene		
Zinc and compounds	5000	No

* Parts per billion, or micrograms per liter.

** Criterion based on toxicity, not carcinogenicity; for this chemical, it is not appropriate to adjust the criterion to achieve a different level of risk.

*** Data insufficient to set a criterion; contact should be minimized.

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