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BRIEFING PAPER ON THE ECONOMIC IMPACT OF THE SAFE DRINKING WATER ACT AMENDMENTS OF 1986

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Introduction

Congress in 1986 amended the Safe Drinking Water Act (SDWA) to strengthen protection of the nation's drinking water. The NARUC Water Committee, recognizing that the SDWA might impose substantial costs on water utilities regulated by state public utility commissions, asked The National Regulatory Research Institute (NRRI) to assess the state of knowledge of the economic impact of the SDWA. The Water Committee was concerned that little is known about the costs of the SDWA and that those cost estimates that are available may be low. This briefing paper, which is based on a thorough review of existing literature on the cost of complying with the SDWA, suggests that the Water Committee is correct.

The U.S. Environmental Protection Agency (EPA) has estimated that the annual cost of compliance with new drinking water standards for volatile organic chemicals (VOCs) will be $24 million, or $18,000 on average for each water system affected (EPA, 1985, V-7). VOCs are only one of several groups of contaminants to be removed from drinking water under the SDWA. Recent EPA figures estimate the total annual cost at $471 million to meet surface water filtration and disinfection standards, another SDWA requirement (EPA, 1987, I-1). Further treatment (at more cost) is likely to be needed to meet SDWA standards for synthetic organic chemicals (SOCs), inorganic chemicals (IOCs), and radionuclides.

Estimates of the impact of the SDWA on water rates vary widely. EPA suggests that water bills will go up by 20 percent at most for water systems that must treat VOCs to comply with the SDWA. An NRRI review of the literature suggests water bill increases from 37 percent to well over 100 percent are possible for various treatment improvements, especially for small water systems. One earlier study estimated bill increases of 700 percent for small systems for turbidity control (SMC-Martin, 1981).

The studies summarized throughout this paper indicate that compliance cost estimates made by EPA in Washington are conservative compared with estimates by EPA's own Water Engineering Research Laboratory. To date, standards for the 83 contaminants under the SDWA have not been finalized and cost estimates for technologies to treat most of these are far from being determined by EPA. The few studies that are available on treatment costs for a wide range of contaminants are not easily comparable. Thus, the ultimate financial impact of the SDWA is by no means defined at this time.

State regulatory commissions do not question the importance of supplying safe drinking water to utility ratepayers. Nor do they question the conclusions of health experts that over time doses of inordinate amounts of the 83 substances can lead to some cases of illness and death. EPA suggests, for example, that nationwide possibly 42 cancer cases a year would be prevented through the VOC regulations. Commission interest comes from their mandate under state law to identify, examine, and allocate the cost of providing potable water to ratepayers. As the cost of conforming to the SDWA standards appears to be significant, state commissions are concerned about the impact of these costs on rates. Further, state commissions have the responsibility to ensure that only prudently incurred costs are allowed to be recovered from ratepayers and, therefore, have acted to independently conduct research through the NRRI so as to provide state commissions with the information they need to monitor SDWA compliance costs of jurisdictional water utilities. Appropriate expenditures to meet SDWA requirements can be expected to be approved by the commissions.

The SDWA explicitly requires that cost be taken into consideration in setting the enforceable limits on the 83 contaminants, the "maximum contaminant levels" (MCLs). Each MCL is to be set in the light of the best available treatment technology (BAT) "affordable for a large public water system" (132 Congressional Record 6287, 1986). For many small systems, the best available treatment technology may not be affordable. The SDWA also provides for variances and exemptions under certain circumstances, with renewable exemptions for the smallest systems. Since most of the water utilities regulated by the commissions are small, a majority of commission-regulated water utilities could be eligible for exemptions. Thus the SDWA provides opportunities to tailor requirements for installation of new treatment facilities to the financial impact on individual systems, particularly small ones. The concern of state regulatory commissions is that this clear intention of the SDWA be carried out.

This paper will briefly review the history of the 1986 Amendments to the SDWA, note the nature of the health risks associated with the contaminants, and highlight estimated costs of compliance with the SDWA as these estimates have appeared in the literature. In preparing this paper we have talked with numerous state and federal experts. Since commissions primarily regulate investor-owned water utilities, the emphasis in this paper is on the impact on those systems, which tend to be small, rather than on municipal ones.

This paper represents the first of a two-part effort by the NRRI in 1987 to provide the NARUC Water Committee with background information to help in the preparation of comments to EPA on proposed regulations under the SDWA and to inform member commissions of the implications of the Amendments. In the second paper the NRRI will use existing data and models to predict the effect of the SDWA on commission-regulated public water systems.

Background

Regulatory commissions in 45 states are charged by statute with regulation of water utilities. The state regulatory commissions are required by law to assure that water utilities under their jurisdiction provide safe, adequate, and reliable service at reasonable rates, while assuring that allowable operating costs are covered and a fair rate of return is earned for investors. Most commissions regulate only investor-owned water utilities, although about a dozen regulate municipal ones as well.

In a recent study the NRRI estimated the number of investor-owned water utilities under commission jurisdiction at 3,197; 2,927 of these (93 percent) had annual revenues of $250,000 or less (Mann, Dreese & Tucker, 1986, 17).[1] A utility with annual revenues of $250,000 would have approximately 1,000 service connections to provide water to about 3,300 people. The EPA counts as small any public water supply serving 3,300

[1] 39 commissions out of 46 that regulate water utilities responded to the survey. States that did not participate in the survey were Indiana, Mississippi, New Hampshire, Oregon, Texas, Washington, and West Virginia.

people or less. The NRRI survey found that 2,004 of the commission-regulated water utilities (62.7 percent) had revenues of $100,000 or less, probably corresponding to somewhat fewer than 500 service connections. One typical connection uses about 120,000 gallons of water a year, although this varies considerably among regions of the United States.

The EPA classifies water systems as "community" or "non-community." There are an estimated 60,000 community water systems in the United States and possibly 160,000 non-community water systems. A community water system is defined under the SDWA as a public water system that serves at least 15 service connections used by year-round residents. A non-community water system is any other public water system. The Small Business Administration estimates that of the 60,000 community systems about 58,500 are small in that they serve 50,000 people or less (50 Federal Register 46927). Less than 100 of these 58,500 "small" systems are considered to have modern treatment facilities. Most lie outside regulatory commission jurisdiction since they are owned by government or quasi-government entities (for example, cities, counties, or water districts) or by non-profit entities such as cooperatives or home-owners' associations.

A large proportion of the small water systems under commission jurisdiction are financially troubled, as documented in several previous NRRI studies (Lawton and Davis, 1983; Davis et al, 1984; Mann, Dreese, & Tucker, 1986). There are many financially viable, well-managed small water companies, but deficient capital, unskilled management, slipshod accounting and bookkeeping, unreliable operations and maintenance, poor customer services, and substandard water quality are common. Treatment techniques are very basic, usually no more sophisticated than chlorination. Economies of scale associated with utilities having a monopoly in a given territory are absent, due to the small customer base.

EPA is well aware of the problems of the small water system. But it appears that the primary focus of the EPA in implementing the SDWA Amendments of 1986 is on the large, municipally owned water systems that serve the majority of the nation's population. The attention of most commissions is drawn to the privately owned, relatively small water system. This diversity of focus must be remembered throughout this report since it is a major factor in our assessment of the burden of the new regulations on commission-regulated water systems.

History and Major Requirements of the SDWA

The SDWA Amendments of 1986 (PL 99-339) are an attempt by Congress to strengthen a law that, in the opinion of many legislators, was never effectively implemented by the EPA or enforced by the states. The SDWA was originally passed in 1974 (PL 93-523), but by 1986 final standards for only 23 contaminants had been promulgated by EPA under the Act (132 Congressional Record 6285, 1986). A widespread perception of administrative footdragging and a belief that chemical contamination of drinking water sources was dangerous and increasing led to passage of the 1986 Amendments.

The 1986 SDWA Amendments received broad-based bipartisan support in both houses of Congress. The House and Senate each passed their versions of the Amendments by voice vote. The final version of the bill (S 124) was passed 94-0 in the Senate and 382-21 in the House. In discussing the need for the Amendments, legislators cited specific incidents of chemical contamination of drinking water in Massachusetts, Florida, California, New York, Michigan, Ohio, Minnesota, Colorado, Washington, New Jersey, and Maine.

The debate in Congress reflects public concern about water quality, as shown in a recent Wall Street Journal/NBC News poll. Sixty-one percent of those surveyed said there should be more governmental regulation of the environment while only six percent said there should be less (McGinley, 1987).

Private water companies are very much aware of the need to preserve high quality drinking water. In the 1985 Annual Report of the American Water Works Company it is noted that:

> For many years, the water utility industry has focused its efforts on extending service to expanding areas on the periphery of existing systems. The emphasis now has shifted to preserving water quality. This new initiative is made necessary by the contamination of our nation's underground aquifers and surface waters from indiscriminant industrial waste disposal and agricultural runoff. Continued vigilance and substantial capital investment will be required in the next decade to protect the public from this contamination. (American Water Works Company, Inc., 1985, 2)

The essential thrust of that portion of the Amendments which deals with public water systems is to require EPA to set standards according to a strict schedule. The maximum contaminant level goals (MCLGs), which are unenforceable goals based solely on levels at which there is no harm to human health, are to be published by the EPA along with the practical and enforceable levels (the MCLs). MCLs and MCLGs for the nine VOCs were to be promulgated by June 19, 1987; for 40 more contaminants by June 19, 1988; and for the remaining 34 by June 19, 1989. The deadline for the regulation setting criteria for filtration of surface water systems is Dec. 19, 1987. The EPA is combining filtration and disinfection regulations into one set of rules for surface water treatment.

The MCLs are to be set as close to the MCLGs as is "feasible," with costs taken into consideration. The key provisions of the Amendments dealing with feasibility and costs read as follows:

> (4) Each maximum contaminant level goal established under this subsection shall be set at the level at which no known or anticipated adverse effects on the health of persons occur and which allows an adequate margin of safety. Each national primary drinking water regulation [MCL] for which a maximum contaminant level goal is established under this subsection shall specify a maximum level for such contaminant which is as close to the maximum contaminant level goal as feasible.
>
> (5) For purposes of this subsection, the term 'feasible' means feasible with the use of the best technology, treatment techniques and other means which the Administrator finds, after examination for efficacy under field conditions and not solely under laboratory conditions, are available (taking cost into consideration). For the purpose of paragraph (4), granular activated carbon is feasible for the control of synthetic organic chemicals, and any technology, treatment technique, or other means found to be the best available for the control of synthetic organic chemicals must be at least as effective in controlling synthetic organic chemicals as granular activated carbon." (SDWA Amendments of 1986, Sec. 101(b), 100 Stat. 643, 1986)

It is in the interpretation of the sections of the SDWA quoted above and the guidelines used by EPA where considerable discussion and some controversy have arisen. It is the interpretation of these two key parts of the Amendments that raises significant questions for commission regulated companies.

Regulation of a number of the contaminants to be limited under the SDWA Amendments is not new. Some of the contaminants for which MCLs are to be proposed under the strengthened SDWA were regulated under federal legislation even before 1970 when the EPA was created. The major contaminants added under the SDWA 1986 Amendments are the VOCs, trihalomethanes (THMs), and some organic chemicals and pesticides (SOCs).[2] For some contaminants only new MCL parameters have been established. Proposed MCLs for IOCs, microbials, radionuclides, and some pesticides are similar to those promulgated under previous legislation and which are currently being enforced in some states (Ohio EPA, 1981). What is substantially different with the new Amendments is the intent of Congress that the EPA vigorously enforce the old standards and the new ones with litigation and penalties. In the past litigation and severe penalties were the exception and voluntary compliance was heavily relied upon by the states. In some states enforcement was negligible.

The SDWA allows variances and exemptions from MCLs for some systems. Variances can be granted by the states to systems which cannot meet MCLs despite the application of the best available technology, taking costs into consideration. The statute provides that the EPA administrator's finding of best available technology may vary depending on the number of persons served by the system or for other physical conditions related to engineering feasibility and costs of compliance with maximum contaminant levels" (SDWA of 1986, Sec. 1415, 100 Stat. 643, 1986). Variances thus apply to physical constraints to meeting MCLs. They may only be issued by the states if no unreasonable health risk will result. The provisions for variances "make clear that large public water systems can be equipped to use technologies

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[2] Volatile organic chemicals (VOCs) are produced for use in chemical manufacturing and occur primarily in solvents. They get into water supplies through leakages and spills and are estimated to exist in about 15 percent of groundwater wells. Technically, the VOCs to be regulated are low-molecular weight volatile chlorinated hydrocarbons used mostly for degreasing, and benzene, which is a feedstock in some chemical manufacturing processes and a derivative of gasoline distillation.

that would not be available to small water systems" (H.R. Rep. No. 168, 99th Cong., 1st Sess. 28, 1985).

Claims relating strictly to economic barriers to compliance can be considered for exemptions, rather than variances. Exemptions may be issued for no more than three years for a system that cannot meet a standard within that time because (1) the needed capital improvements cannot be completed within the three years, (2) the system needs financial assistance and has entered into an agreement to obtain it, or (3) the system has entered into an agreement to become part of a regional water system (SDWA of 1986, Sec. 1416, 100 Stat. 643, 1986).

For very small water systems, the amended SDWA provides renewable exemptions, a departure from the old law. Systems with less than 500 service connections and which need financial assistance for the necessary improvements may renew an exemption for "one or more additional two-year periods if the system establishes that it is taking all practical steps" towards financing capital improvements or becoming part of a regional water system (SDWA of 1986, Sec. 1416, 100 Stat. 643, 1986).

Contaminants and Their Health Effects

The primary health risk associated with water contaminants historically was the spread of infectious diseases. For example, the average death rate in major cities due to typhoid was 66 per 100,000 persons before filtration was adopted and fell to 19 per 100,000 after filtration was adopted in these cities. Chlorination typically came later and reduced the typhoid death rate another 50 percent in many cities (Clark, 1985).

While there is still concern about waterborne outbreaks of disease, the more recent concern has been with cancer. There are many chemicals which are cancer-causing but most of these are not waterborne. Estimates about the carcinogenic effect of contaminants differ substantially among experts (50 Federal Register, 1985). In testing before 1980, water sources for seven cities showed as many as 150 to 500 specific organic contaminants. Consumer activist Ralph Nader reports that the mountain stream which is the main source of Seattle's water supply contains 450 organic contaminants (Nader, 1987). Nader argues that 160 substances found in water are known to be carcinogenic, mutagenic, tumor promoters, or toxic. Some scientific experts argue that many of the so-called carcinogens occur in such small amounts that they do not require a massive treatment program.[3]

Most scientists would argue that "the dose makes the poison," and many agree with Bruce Ames when he notes that "it is likely that a high percentage of all of the chemicals in the world, both man-made and natural, will be classified as carcinogens, when tested at the maximum tolerated dose" (Ames, 1987, 20). Ames further notes that "most of the carcinogens we are worried about in pollution may in fact, be harmless at low levels... The key issue is understanding the mechanism by which carcinogens cause cancer" (Ibid, 21). With specific reference to waterborne tetrachloroethylene (TCE), one of the VOCs for which MCLs have been determined by EPA, Ames concludes that:

> ... amounts of pollution that humans are ingesting from pesticide residues or pollution are trivial relative to the background of natural and traditional (e.g. from cooking food) carcinogens. For example, the possible carcinogenic hazard of drinking the TCE-contaminated well water in the 35 wells shut down by EPA in Silicon Valley is even less than that from the chloroform in ordinary chlorinated tap water, and is thousands of times less than the possible carcinogenic hazard of drinking an equal volume of beer (alcohol is a carcinogen) and 10 times less than the hazard of eating a daily peanut butter sandwich (peanut butter contains traces of aflatoxin, a mold carcinogen). These latter hazards are themselves trivial. (Ames, 1987, 20)

"Adverse effect on the health of persons" qualifies a contaminant for inclusion on the list of contaminants to be regulated under the SDWA. Justification for inclusion of each of the 83 contaminants on the list is contained in a variety of publications but mostly in the Federal Register and in Health Assessment Reports of the EPA. Some of the controversy over the Amendments centers around the nature of these health assessments.

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[3] EPA has developed standards for only 126 toxic pollutants, and there are 30,000 chemicals in commercial use. EPA suspects at least 1,000 of these to be toxic or carcinogenic (Chemical Week, 1986, 22). The International Agency for Research on Cancer (IARC) had evaluated the carcinogenic potential of 585 chemicals by 1985 (50 Federal Register 46947, 1985).

A health assessment must be completed by EPA for each of the 83 contaminants to be regulated. To date, 58 of these are available. Those for the nine volatile organic chemicals (VOCs) are the most thorough and apparently have the widest agreement among toxicologists and cancer researchers. The remaining 74 contaminants for which MCLs are being set are more controversial simply because many of them have not had extensive human testing. The presumptive evidence on many of these is sufficient to establish that they have an adverse effect on the health of persons.

In the SDWA legislation, Congress prohibited the EPA from using a risk-based approach in setting MCLs (EPA, 1985, IV-9). But in responding to Executive Order 12291, which requires a benefit-cost analysis of all new federal regulations (not only EPA regulations), EPA relies almost exclusively on cancer case prevention as the measure of benefits for VOC removal. It is estimated that treatment for the nine VOCs would prevent at most 42 cancer cases in the United States annually. Interestingly, almost all of these would occur from the removal of vinyl chloride alone. The prevention attributable to small systems is minimal, as shown in Table 1.

TABLE 1

ESTIMATED TOTAL NUMBER OF CANCER CASES AVOIDED PER YEAR FROM VOC TREATMENT BY SIZE OF WATER SYSTEM

System Size (population)	EPA Highest Estimated Cancer Cases Avoided Per Year	EPA Lowest Estimated Cancer Cases Avoided Per Year
25-500 Customers	1	1
501-3300	3	2
3301-50K	20	18
>50K	18	16
Total U.S. Cases Avoided	42	37

Source: EPA, 1985, IV-12

The numbers in Table 1 are based on EPA's assumption that contaminant levels for VOCs are 1.0 microgram per liter of water (1.0 ug/l). This is the proposed MCL for vinyl chloride. The MCL for most VOCs is 5.0

micrograms per liter (5.0 ug/l) or higher. For example, the proposed MCL for 1,1,1-trichloroethane is 200 micrograms per liter (200 ug/l). The higher allowed levels of contaminants would of course reduce the cancer avoidance numbers in Table 1.

To put EPA's estimated rates of cancer cases in perspective it should be noted that "400,000 Americans die each year from smoking and 100,000 die from alcohol, a carcinogen" (Ames, 1987, 22). Moreover, water's contribution of the 83 contaminants to humans is assumed by EPA to be 20 percent. The rest comes from air, direct contact, workplace, food processing, and other sources.

Treatment Techniques

There is, unfortunately, a great amount of confusion with respect to appropriate treatment techniques and their costs for all 83 contaminants. The great majority of published studies on the costs of the SDWA are hypothetical and not based on actual field experience of water utilities. Technologies and cost projections for all 83 contaminants, based on actual testing in the field, are non-existent or extremely minimal and preliminary. In other words, the fundamental criterion of the SDWA for imposing new treatment requirements, that the treatments be proven feasible under real world conditions, has not been met for most means of removing the contaminants covered by the Act.[4]

While the cost estimates for VOC removal are fairly simple and straightforward, the proposed MCLs for other organics and inorganics will require more complex treatments. For example, a public water system, such as a small investor-owned system which currently does not filter its water, has a menu of treatment choices it can install, ranging from conventional treatment using sand for filtration to more advanced techniques using GAC, ion exchange, and/or other techniques. Its final choice of treatment

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[4] EPA states that five treatment facilities using granular activated carbon for removing VOCs are being operated in the United States today. Operating data from these systems were not available to us as this report was being prepared (50 Federal Register 46915, 1985).

techniques will be determined by the contaminants occurring in its system on a regular basis. To a large degree each water system will be unique with respect to its choices, and thus its costs.

Although granular activated carbon (GAC) is a broad spectrum treatment technology and even favored in the 1986 Amendments, there is no single treatment technique which will remove all of the contaminants proposed under the SDWA. There are some contaminants for which a preferred treatment technique has yet to be developed. And many of the latest and preferred techniques from a technological point of view have not been costed out by EPA. The "best available treatment" for each contaminant is yet to be determined by EPA, but a recent summary of current research is attached as Appendix A, Probable Treatment Technologies and Their Costs.

Compliance Cost Estimates Derived From Published Sources

The NRRI review of the literature on costs of compliance with the SDWA found that research in this area has been quite limited. Most of the existing published studies have been conducted by EPA, either in Washington or by Robert Clark at EPA's Water Engineering Research Laboratory in Cincinnati.

The primary document on economic impact published thus far by EPA's Office of Drinking Water in Washington is entitled Economic Impact Analysis of Proposed Regulations to Control Volatile Synthetic Organic Chemicals (VOCs) in Drinking Water, referred to here as "EPA, 1985." EPA has also circulated preliminary, brief, and unpublished tables on costs of surface water treatment entitled "Briefing on Surface Water Treatment Regulation," and referred to here as "EPA, 1987." A full economic analysis of surface water treatment costs has not been published by EPA. Nor have documents on the economic impact of regulations on contaminants other than VOCs been published by EPA. EPA also contracted with Policy Planning and Evaluation, Inc. for two studies, one dealing with elasticity of water demand and the other with ratemaking treatment of water quality expenditures. Both are referenced in this briefing paper.

Clark has published a number of studies on various treatment technologies. The eight studies by Clark that dealt most clearly with economic data on water treatment technologies are referenced here. A major study on the impact of the SDWA on small firms was conducted in 1981 (before the current amendments) by SMC-Martin. The SMC-Martin study focused on small water utilities in Pennsylvania. A recent study by Camp, Dresser, and McKee (1987) estimated treatment costs for all probable technologies to remove 60 different contaminants covered by the SDWA. Treatment cost estimates from this study are given in Appendix A.

To our knowledge, no important study on the costs of complying with the SDWA has been overlooked in this literature review. We conducted a computer search of all major periodical indices at the beginning of this study. We contacted the American Water Works Association and the National Association of Water Companies. Neither has conducted independent research on the costs of the SDWA. The AWWA Research Foundation is, however, currently beginning a research project on monitoring costs. We also contacted numerous government officials and consultants working in the area of drinking water.

EPA officials in Washington and Cincinnati were helpful in our review of relevant data and studies. Ongoing studies by EPA or its consultants were not available to us for this report, although we have been informed by EPA and one of its consultants that results of the ongoing studies of treatment technologies and costs would be available soon.

Because much of the information we now have on the economic impact of the SDWA is limited to the costs of the removal of VOCs, this report tends to highlight these costs. It should be emphasized again that VOC removal is not the only requirement of the SDWA. Many of the water systems throughout the United States will be required to filter and disinfect their surface water as a first requirement of the SDWA. It was estimated in the briefing paper circulated informally by the EPA in the spring of 1987 that approximately 2,882 community water systems which do not now filter their water will need new filtration facilities and approximately 2,280 systems must upgrade their filtration systems to meet the new standards (EPA, 1987).

There are about 11,202 surface water systems in the U.S. and 48,458 underground systems. EPA estimates that approximately 6,000 community water systems have one or more VOCs exceeding .5 ug/l. Of those systems needing to remove VOCs under the proposed MCLs, 80 percent (4,889) will be small systems serving less than 3,300 persons (EPA, 1985, V-10). EPA cost estimates for removal of VOCs are contained in Table 2.

TABLE 2

EPA COST ESTIMATES OF VOC REMOVAL* (1983)
(in dollars)

	System Size (in Population)					
	25-500	501-3,300	3,301-50,000	50,000+	Average	Total
Total Annual Cost	$4,100,000.00	$6,200,000.00	$9,900,000.00	$3,500,000.00		$23,700,000
Per System Cost	4,800.00	20,800.00	58,700.00	239,900.00	$17,600.00	
Annual Cost Per Family	90.74	41.07	11.55	3.09	10.84	
Dollars/1,000 Gallons	.54	.29	.07	.02	.06	

Source: EPA, 1985, various tables.
*Based on MCL = 5 ug/l

It is not clear in EPA's document analyzing the costs of VOC removal which treatment technique was used to generate these specific numbers but the costs appear to be quite small. For investor-owned systems with less than 500 customers the cost per 1,000 gallons is 54 cents and the cost per customer per year is $90.74.

The statistical analysis used by EPA in its VOC assessment to generate these projections is subject to many questions which we cannot answer without reviewing EPA's working papers. To estimate the annual compliance cost the EPA used a "social rate of interest." Presumably this is the inflation-adjusted, "risk-free" rate used in financial theory. EPA also used the average of the inflation-adjusted municipal and corporate bond rates. These relatively low rates naturally generate relatively low annualized costs and would not reflect the actual capital costs of investor-owned utilities.

Some of the very important input data which EPA used in its study were generated from a panel of experts who "considered, for each VOC, system size, influent level and MCL, the relative unit cost and effectiveness of each available control measure. The panel participants also applied their practical experience in estimating the frequency with which each treatment would be chosen. Their probability estimates were entered in the remaining portion of the PTm (Policy Testing Model) decision tree matrix" (EPA, 1985, V-5). The probabilities of systems of a given size and with given influent concentrations selecting particular compliance measures for given MCLs are presented in the EPA study (Exhibit B-1). The cost equations that are built into the model, however, are not.

Nobody has studied the economic impact of proposed EPA regulations as extensively as Clark and his associates at the EPA's Water Engineering Research Laboratory. They have estimated the incremental costs for many treatment technologies. Unfortunately, most of Clark's estimates are hypothetical, although some are derived from a mathematical and statistical model developed by EPA. The model is based on some actual treatment cost experiences and experiments from a variety of water systems throughout the United States. Clark and his associates have looked extensively at granular activated carbon (GAC) and most other techniques for treating VOCs, turbidity, inorganic contaminants, and some SOCs. His studies and other relevant cost estimates are summarized in Table 3.

Clark's studies use a great variety of system sizes, treatment techniques, cost equations, original plant and retrofit plant processes, and incremental and average cost effects. It is difficult to adequately summarize the great wealth of detail he has presented in his many studies. It is also difficult to compare his studies with each other or with studies by other researchers. We hope that the summaries given below and throughout the rest of this section of the paper do not misrepresent his results by oversimplification.

TABLE 3

ILLUSTRATIVE INCREMENTAL COST ESTIMATES FOR TREATING CONTAMINATED WATER WITH GAC OR EQUIVALENT TECHNOLOGY

Reference	Method of Analysis	Type of Water Supply	Contaminant Being Treated	Cost in Cents/1,000 gallons by System Size: Small Systems	Large Systems
1. Clark, 1987	Model	Surface	SOCs	89.7	18.9
2. EPA, 1987	Survey	Surface	Turbidity	156.5	21.0
3. EPA, 1985	Model	Ground	VOCs	41.5**	4.0
4. Clark, 1985	Model	Surface	SOCs	40.5	19.6
5. Clark, 1984	Model	Ground	VOCs	91.8	39.0
6. Clark, 1982	Model	Surface	Turbidity	N.A.	10.4
7. Clark, 1980	Model	Surface	Organics	51.5	12.3
8. Clark, 1980	Field	Surface	Inorganics	103.0	14.8
9. Clark, 1979	Model	Surface	SOCs; THMs	23.0	10.0
10. Clark, 1979	Model	Surface	SOCs; THMs	N.A.	11.0
Average				63.1	16.1

Sources: Published studies listed in bibliography.
*The studies cover a wide range of system sizes. The smallest system processes less than 1/ million gallons per day. The largest is New York City at 1 1/2 billion gallons per day.
**Average of 2 smallest systems; the smallest system cost is 54 cents/1,000 gallons.
N.A. - Not available

Most of Clark's research attempted to deal with costs of removing contaminants under rules that were proposed before the 1986 Amendments were passed by Congress. The studies are generalized models as noted above and illustrated by the data in Table 3. His cost for VOC removal for small systems is 91.8 cents/1,000 gallons using GAC; while EPA estimated the cost at 41.5 cents/1,000 gallons for small systems. We are not certain of the technology assumed by EPA nor the system size EPA used. They are nevertheless the only comparable studies for VOC treatment. Obviously, the differences in cost estimates are quite large for small and large systems.

With respect to the new standards on surface water contaminants Clark's recent studies are the only ones available. In his most recent study (1987) Clark uses a 1978-79 EPA mathematical model and updates it with some field scale data to project the cost of treating a variety of SOCs with GAC. Using this model he generates GAC costs for various carbon usage rates (.0572 to 1.2 lbs./1,000 gallons) and carbon service lives (35 to 730 days) for separate SOCs. For the smallest plant size (.25 mgd), using the lowest service days (35) and the most pounds/1,000 gallons (1.2 lbs.) the incremental cost to the utility would be 238 cents/1,000 gallons treated. At the other extreme, for a 100 mgd plant with the same usage and days of service the cost would be 50 cents/1,000 gallons.

For very low usage rates (.0572 lbs./1,000 gallons) and high service lives (730 days) the comparable costs are 84 cents and 12 cents per thousand gallons. Small system costs range from five to seven times higher than the largest system costs, illustrating the enormous economies of scale involved in water delivery. Table 3 shows his averages only.

In the same study Clark estimates the capital cost of a GAC system to be $2,053,140. This is fairly close to the actual capital cost he uses for comparison, which was $1,900,000 (Clark, 1987, 24).

In his 1984 study Clark used his model to estimate the cost of a GAC system which would remove 80 percent of most organics as required under the regulations (at that time), although he based this hypothetical study on removal of alcohol and chloroform as representative of other organics.

His data suggested that 80 percent removal would reduce the cancer death rate by 2.6/100,000 persons per year. The cost estimates are for a 10 mgd and 100 mgd plant using sedimentation, filtration, chlorination, and post-GAC filtration. The annual cost would be 40.5 cents/1,000 gallons for the small plant and 19.6 cents/1,000 gallons for the large plant.

These summaries are indicative of the kind of research that Clark and his associates have been doing. The Water Engineering Research Laboratory is responsible for evaluating the types of technologies that might be feasible for meeting MCLs.

It is abundantly clear that Clark's estimated costs for meeting the EPA proposed standards are substantially higher in many ways than estimates made by the Washington EPA study. Even as early as 1980 Clark estimated that retrofitting for GAC technology to meet organic and THM requirements would raise treatment costs by 22 percent over current costs (Clark, 1979); and in the 1980 study referenced in Table 3 he estimated the average increase in cost for six actual plants to be 97 cents/1,000 gallons depending on the inorganic problem the system experienced (Clark, 1980).

The average of the estimates for small systems in Table 3 is 63.1 cents/1,000 gallons treated, which is almost 50 percent higher than the Washington EPA estimate for VOC removal. Admittedly, the costs are not easily comparable, but they suggest that application of the newest regulations would be expensive to small systems. For example, a system with 1,000 customers (households) would deliver about 100 million gallons per year at an incremental annual cost of treatment of $54,000 (at 54 cents/1,000 gallons which is EPA's VOC estimate for the smallest system). This is a significant annual increment in operating costs for most small systems using the very low estimate of the EPA. For the typical customer the annual bill would be increased by $54.

Simply looking at the incremental cost per 1,000 gallons does not give a complete picture of the costs of VOC removal to water systems. The up-front investment costs for new technologies are substantial and the monitoring costs under the proposed regulations could be very high. Some of the estimated capital costs for the new technologies are listed in Table 4.

The estimates in Table 4 are interpretations of complex and differing estimates from these sources. If anything they are conservative. In Camp, Dresser, and McKee's Study for the New Jersey EPA (study 3 in Table 4) "probable" capital cost estimates for a 1 mgd plant ranged between $250,000 and $3,500,000 (Appendix A). Few small systems could afford capital costs

TABLE 4

ESTIMATED CAPITAL COSTS FOR NEW TREATMENT FACILITIES

Reference	Type of Data Used	Type of Technology	Purpose of Application	Capital Costs by System Size* Small	Large
1. Clark, 1987	Actual	GAC	Remove SOCs		$ 2,053,000
2. EPA, 1987	Estimated Average Cost	N.A.	Filtration for 15 large cities		153,000,000
3. Camp, 1987	Estimated	All probable technologies	Remove 60 different individual contaminants	$250,000-$3,500,000	
4. Lee, 1983	Estimated	GAC	Meet all state/ federal mandated requirements		535,000
5. Clark, 1981	Field and Estimated	Sand filtration package plants	Remove contaminants listed under old EPA interim standards	1,120,000	
6. SMC-Martin, 1981	Estimated	Conventional plant	Meet 1979 turbidity standards	126,000	
7. Clark, 1980	Actual and Estimated	Various	Remove inorganics	317,000	
8. Clark, 1980	Estimated	Retrofitting using GAC	Remove SOCs under interim EPA standards	1,500,000	24,000,000

Source: Published studies listed in bibliography.
*Sizes range from very small systems (less than 1/2 mgd) to large systems (New York City).
N.A. = Not available.

of this magnitude without substantial increases in rate base and consequent increases in water rates.

Since capital costs are amortized over 20 or more years, the annualized increase in costs of meeting the new standards would be more representative of the impact of the SDWA on small systems. Table 5 summarizes the annual increase in total costs that systems would face under the new requirements. Again, many of these estimates are based on hypothetical or interim standards proposed before 1986. Because more contaminants must be removed and new parameters may be established for some previously regulated contaminants, future costs will likely be higher. For example, capital costs of $250,000 amortized over 20 years at eight percent would be $25,463 annually. Operating costs would need to be added to these capital costs.

TABLE 5

ESTIMATED INCREASE IN ANNUAL CAPITAL AND OPERATING COSTS TO MEET SDWA REQUIREMENTS

Reference	Type of Data	Contaminant Treated	Annual Total Cost by System Size	
			Small	Large
1. Clark, 1987	Estimated	SOCs		$2,260,000
2. EPA, 1985	Estimated	VOCs	$12,600*	239,900
3. Lee, 1983	Estimated	Organics, THMs		120,000
4. SMC, 1981	Estimated	1979 MCL standards	23,000	
5. Clark, 1980	Estimated	Inorganics	79,000	

Source: Published studies listed in bibliography.
*Sizes range from very small to large systems.
**Average of two smallest systems.

The EPA estimate is quite low compared with the others in Table 5. Moreover, EPA does not provide separate costs for capital and operating expenses but lumps them together, making comparisons of annual capital costs impossible (EPA, 1985, V-3). The increased annual cost for compliance listed in Table 4 does not include monitoring costs, which are listed in Table 7.

A number of researchers have provided current costs of water supply treatment and some of these can be compared with projected incremental treatment costs taken from Table 3. These comparisons are shown in Table 6.

TABLE 6

COMPARISON OF CURRENT AND PROJECTED COSTS OF WATER SUPPLY NEEDED TO MEET SDWA REQUIREMENTS (cents/1,000 gallons)

	System Size Based on Population					
	Small (< 3300 persons)			Large (> 3300 persons)		
Reference	Current Supply Cost	Projected Increase in Supply Cost	Percent Change	Current Supply Cost	Projected Increase in Supply Cost	Percent Change
1. EPA, 1987	153.5	156.0*	102.0%	59.8	21.0*	36.5%
2. EPA, 1985	233.5	41.5	18.0	89.0	4.0	4.4
3. NAWC, 1985**	194.0	63.1***	33.0	167.0	16.1***	10.0

Source: Published studies and calculations by authors.
*Cost for filtration only.
**These member water systems are really quite large since only member companies with annual revenues over $1 million are listed in this report.
***Average of projections in Table 3.

It is interesting to note that the EPA (1985) shows the highest current water supply costs and lowest projected costs for small systems of the studies referenced in Table 6. It should be remembered that EPA treatment is for VOC contaminants, and we do not know the cost estimates that were used for particular treatment technologies. But in its cost-benefit analysis used to justify the new proposed regulations under Executive Order 12291 the EPA used costs for packed tower aeration and achieved a substantial net benefit/cost ratio under the new proposals. Packed tower aeration for removal of VOCs is the preferred treatment for VOCs on the basis of cost. The cost of packed tower aeration is only a fourth (25 percent) of that for GAC (Clark, 1984). It follows that if the EPA (1985) estimate in Table 6 was based on packed tower aeration, if GAC were used instead there could be a 72 percent increase per/1,000 gallons for small systems and an 18 percent increase for large systems (4 x 18 percent and 4 x 4.4 percent).

Monitoring Costs Under Proposed SDWA Standards

A final cost to be incurred by water utilities under the SDWA is the cost of monitoring (see Table 7). Under the SDWA there are no exemptions for meeting monitoring requirements. Systems must monitor for the 83 contaminants for which MCLs are set as well as for unregulated contaminants. The original EPA proposal called for one sample per entry point to the system per quarter for one year for groundwater and similar samples for surface waters for each source to the system. The regulations have been somewhat modified and require all systems to monitor for eight VOCs once within four years based on population served. Where VOCs are found in the water supply, repeat monitoring could be required quarterly for up to one year. Unregulated organics would need to be monitored once every five years. This is to be phased in first by the utilities serving the largest population. Repeat monitoring is mandated if levels are high. States have some discretion over the monitoring for unregulated organics (Ohio EPA, 1987).

There is, of course, ongoing sampling for organics now under regulation, and for inorganics, radionuclides, and microbials. New monitoring requirements are to be promulgated for these at the same time the new MCLs are established in 1988 and 1989. Moreover, beginning in 1991, the names of 25 additional contaminants and their MCLs must be promulgated along with their monitoring schedules.

The new monitoring requirements will add significantly to current monitoring costs. Until the full set of MCLs and monitoring schedules is promulgated and enforced it is difficult to project these costs for an individual water system. However, based on current laboratory testing costs for water systems, the costs shown in Table 7 would be conservative estimates. These costs are subject to many provisos such as number of samples, availability of qualified laboratories, resampling frequencies, and number of contaminants found. They are suggestive of what small systems will need to do under the SDWA, but they will be spread over a five-year period for most systems unless a system has a serious contaminant problem.

Since water sampling and monitoring on the scale required by the SDWA has not yet occurred, actual cost estimates could very likely be in error.

TABLE 7

ESTIMATED MONITORING AND SAMPLING COSTS UNDER SDWA
1986 AMENDMENTS FOR A TYPICAL WATER SYSTEM
(cost for single sample)

Contaminant	Cost per Sample
VOCs	$ 180
Organics (SOCs)	200
Inorganics (nitrate and fluoride)	130
Radionuclides	14
(Repeat sampling $100 each for radium 226 and 228)	
Trihalomethanes (THMs)	100
Pesticides and higher molecular weight SOCs*	2,000
Estimated Total Monitoring Cost	$ 2,544

Source: Ohio EPA estimates, by telephone 5/6/87; and U.S. EPA estimates verbally from Dr. Joseph Cotruvo, 3/19/87.
*50 Federal Register 46922, 1985.

Impact of the SDWA on Water Rates and Water Bills

Estimates in the literature of the impact of SDWA compliance costs on water rates range far and wide and are subject to tremendous standard deviations and prediction errors. Water supply costs will rise. These costs will be absorbed in the very short run by water utilities and ultimately charged to water users. Impacts on water bills and rates which are presented in Table 8 are those appearing in the literature and estimates

TABLE 8

PROJECTED INCREASES IN WATER BILLS UNDER THE SDWA

Reference	ANNUAL WATER BILLS Current Bill	Projected Increase	Percent Change
1. EPA, 1987	$267.00[1]	$156.00[2]	58.8%
2. EPA, 1985			
<500 population	N.A.	90.74	Est. of no more
501-3300	N.A.	41.07	than 20%[5]
>50,000	N.A.	3.09	
3. Dreese, 1985 Cincinnati, OH	68.00	35.00[3]	51.0
4. Lee, 1983	200.00	73.55[4]	37.0
5. SMC-Martin, 1981			
<100 population	100.00	774.00	774.0
500-1000	100.00	115.00	115.0

Source: Published studies and unpublished reports.
[1] Average revenue per customer listed in NAWC, 1985, 2. Since these include revenues from large systems serving large industrial users and small systems serving residential customers it is likely that this number is high compared with annual bills for residential customers only.
[2] Estimate for 1,058 small systems needing new filtration equipment (EPA, 1987, I-2).
[3] The EPA's Water Engineering Research Laboratory estimates Cincinnati's cost for GAC installation will be 35 cents/1,000 gallons.
[4] Increase caused by all mandated programs, not only SDWA.
[5] Estimate made in 50 Federal Register 46972, 1985.
N.A. = Not available

made by author Richard Dreese. The percentage increase ranges from a low of 20 percent by EPA to possibly 77.4 percent, an estimate made in 1980 by SMC-Martin.

In reviewing the potential impact on small systems in Pennsylvania if the interim EPA standards of 1979 were implemented, SMC-Martin used a current water bill of $100 per customer. SMC-Martin estimated the increased cost per customer for turbidity control (for small customers) to be $774 per year, which is an increase of 774 percent (SMC-Martin, 1981, 27). It is unlikely that these revisions in bills will be willingly absorbed by consumers.

One EPA assumption that bears questioning is that the compliance costs of the new regulations will be passed forward to users automatically. It is stated in the proposed rulemaking discussion that:

> EPA is also aware that a number of small systems have already installed these technologies and found them to be affordable. Because these technologies are affordable by small systems, economies of scale would also make them affordable to large size systems. <u>The increased cost is expected to be passed on to the consumer either as a water rate increase or as a tax increase</u> (50 <u>Federal Register</u> 46914, 1985; underlining added).

The ability to pass along costs of compliance with the SDWA differs from company to company and among the states. It is certainly presumptuous to suggest that these costs will be immediately absorbed by consumers with no lag, no extensive hearings, no expert witnesses, no staff reports, and on a dollar for dollar basis. If, for example, a water utility built extensive treatment facilities for a projected future demand that did not materialize, a commission might disallow some or all of the cost of the excess treatment capacity.

<u>Costs of SDWA Compliance for Small Water Systems</u>

The actual rate increases due to SDWA requirements for small water systems are unknown, but it is known that many of these systems currently have operating losses and a number are being forced to abandon their systems (Mann, Dreese, Tucker, 1986). SMC-Martin, in its study of estimated compliance costs for small systems in Pennsylvania under the 1979 proposed SDWA standards concluded that two-thirds (66 percent) of small Pennsylvania systems were operating at average losses of approximately $1,900 per year (SMC-Martin, 1981, 10). For many reasons small investor-owned systems are reluctant to seek rate increases even though commissions throughout the United States have provided simplified and rapid filing and hearing procedures for them. Implementation of the new regulations could have a serious financial impact and add to the small system problem that already burdens customers and commissions. Many of the water utilities under commission jurisdiction are likely to seek exemptions from SDWA requirements.

At this time no detailed impact analysis on small investor-owned systems is being presented since EPA has yet to publish final MCLs or recent cost estimates for each technique. Nevertheless, the impact on small systems and their customers could be substantial, notwithstanding the statement by the EPA that "a number of small systems have already installed these technologies [GAC or packed tower aeration] and found them to be affordable" (50 Federal Register 46914, 1985).

Compliance Problems Unique to Investor-Owned Systems

There are at least two compliance problems faced by investor-owned water systems that do not affect municipal systems:

1. They must undergo commission scrutiny and rate hearings to recover costs of compliance. Many municipal systems have tariff flexibility outside legislative approval requirements and may pass forward SDWA compliance costs without a comprehensive rate case.

2. To the extent that investor-owned systems must pay state and federal income taxes and usually have capital costs higher than municipal systems, their increased revenue requirements are likely to be higher than for municipal systems for an equal increase in compliance costs.

Because of these differential cost impacts, investor-owned systems will have economic impacts which are not mentioned in any of the EPA economic analyses nor in those published by other experts. Moreover, even in the EPA commissioned study Ratemaking Treatment of Water Quality Expenditures by Public and Private Systems (Policy Planning & Evaluation, Inc., 1986, II-19) it is stated that only 61 percent of revenue increases are granted to investor-owned water systems by regulatory commissions (a percentage that approximates commission awards in the electric and gas utility sectors).

And there is a widely recognized reluctance or inability on the part of small investor-owned systems to apply for rate increases (SMC-Martin, 1981). Commissions of course do allow companies to recover all costs that are prudent and legitimate.

<u>The Standard of Affordability of Treatment</u>

Cost projections for complying with the SDWA seem on the face of it to be substantial, yet the actual impact on commission-regulated water utilities depends on the definition and application of the concept of "affordability." The idea of affordability comes into play in two ways. The first is in setting across-the-board standards for BAT. Congress made very clear that EPA "selects and applies that technology which can be afforded by the largest public water systems to spread the cost of the treatment technology over a large number of consumers" (132 <u>Congressional Record</u> 6287, 1986). Variances and exemptions come into play when treatment is not "affordable." It is conceivable that EPA will find there is no affordable BAT for small systems for some contaminants. The concept of affordability also comes into play in applying SDWA requirements to particular water systems. Here "affordability" may be grounds for requesting a variance or exemption.

The "affordability" criterion that EPA has been considering would allow an increase in water bills equivalent to one percent of median family income or a total annual water bill of two percent of median family income. The median family income used to estimate affordability is between $25,000 and $27,500 per year, based on census data showing a median income for all U.S. families in 1984 of $26,433 (<u>Statistical Abstract of the United States 1986</u>, 106 ed. U.S. Department of Commerce, Bureau of the Census, Table 751, 450). Thus, EPA is estimating that households can afford a total annual water bill of about $550 a year or an increase of $250-$275 a year.

At best, the concept of "affordability" is a tricky one. What is "affordable" to one person may not be to another. Preferences for a commodity at alternative prices differ. Everybody needs drinking water, but demand for drinking water with a small amount of carcinogens may vary considerably. Some people may be willing to take more risk than others.

The use of a percentage of median income as a base-line for computing "affordability" seems particularly arbitrary. Ratepayers and commissions aren't used to thinking in terms of a percentage of income in paying for or designing water bills. They think in terms of what they are already paying. An annual water bill of $550 would be a several-fold increase or more in many areas of the country. One can predict this would be perceived as unreasonable. An increase in telephone bills totaling $31.20 a year to finance fixed costs related to access to the long-distance network was recently considered by many regulators a danger to "universal service" because it could not be afforded by low-income families. How much more important is the universal service of providing life-sustaining, potable water?

In estimating "rate shock" it may be preferable to think in terms of percentage increases in water bills rather than dollar increases. It could be that EPA's possibly conservative estimate of actual annual increases of $90.74 per customer for removal of VOCs could be perceived as "rate shock," since such increases would amount to 20-50 percent for many customers.

Median income varies from locality to locality. Annual water bills are already higher and median incomes lower for many communities with small water systems. Such communities may be able to argue for exemptions based on their relative poverty.

One danger in assessing the affordability of treatment techniques is that estimates to clean up one set of contaminants may be only the beginning. Total costs to meet all standards may be much higher. Any attempt by EPA to assess affordability should take into account total costs of meeting all requirements, not just those for VOCs or surface water treatment.

The idea of affordability is being considered by EPA as it applies to customers. It is possible that a treatment technique may be affordable to customers but not to an investor-owned water company. "Affordability" in this case applies to the ability to secure financing for capital improvements. Many small investor-owned water utilities are already capital-poor. They have no taxing authority, and rate increases are not automatic.

The emphasis in this discussion has been on how "unaffordable" it may be to comply with SDWA requirements. It is in fact possible that commission-regulated water systems faced with the presence of contaminated drinking water will be willing to pay more than predicted to clean it up. Instead of asking for an exemption based on low median income or other factors, ratepayers may call for the treatment to be installed even at a high relative cost. In decrying the costs of the SDWA it should not be forgotten that consumers have expressed a strong concern with the quality of their drinking water. In the final analysis water is a public utility, and people may have higher quality standards for water than for other liquids or foods, even if the other things they choose to eat or drink are more likely to cause cancer.

A number of other important economic considerations are necessarily involved when utilities attempt to increase rates substantially or frequently. The OPEC embargo of the early 1970s was a traumatic experience for regulators, utilities and customers. What we learned is that demand elasticity is important. EPA has recently researched this topic in a study by Policy Planning & Evaluation, Inc. (1986). The study found that existing estimates on price elasticity of water differ. The EPA-sponsored literature review does not report disaggregated elasticity coefficients at various price ranges or for subsectors of the water market. Thus, we cannot be overly confident about what actual customer adjustments to higher rates will be, particularly for small systems.

Summary and Conclusions

The 1986 Amendments to the SDWA will significantly affect public water systems under the jurisdiction of state regulatory commissions. Vigorous enforcement by EPA could push some of them into bankruptcy or abandonment of their systems, eventualities which already occur with these systems throughout the United States.

The commission-regulated water system looking for a simple solution to its water problem is going to face considerable uncertainty. There are no simple solutions because available technologies have generally not been tested extensively on small systems. Some systems will not know which options they have without considerable effort and cost of evaluating their uncertain alternatives. Water systems will need to perform engineering studies simply to apply for variances or exemptions. Given the poor quality of bookkeeping records for many small systems, management time and costs for these systems will be high. There are potential legal costs and employee training costs involved in meeting and keeping to the SDWA standards. Many of the potential "hidden" costs to small systems are documented in a recent article (Karaganis, 1987).

The projected costs of compliance with the new standards vary widely depending on the treatment techniques used, the contaminant regulated, and other factors. No cost estimates have been made based totally on field experiences for VOC or SOC removal. Cost estimates have largely been based on mathematical models for a variety of contaminant removal technologies using older standards, but practically none has been done under the new proposed standards.

Further research on the impact on small investor owned systems should be done, but this cannot be completed until final MCLs, based on the best available treatment technologies and costs, are published by EPA for VOC removal. Final MCLs, EPA regulations on BATs, and EPA cost estimates for removal of other contaminants are not scheduled to be available until 1988 and 1989.

The incremental capital and annual operating cost estimates of compliance range from several thousand dollars to millions of dollars per utility, and the projected water rate and water bill impacts vary greatly. It can be generally concluded that the EPA cost estimates are low compared with other published estimates. Specific estimates on various impacts are as follows:

- Only two cost estimates for VOC treatment were found; and the EPA estimate of 41.5 cents/1,000 gallons is low compared with Clark's estimate of 91.8 cents/1,000 gallons.

- Our research found hypothetical estimates for SOC and filtration treatment as high as 156 cents/1,000 gallons for small systems, an increase of 100 percent for some systems.

- Capital cost estimates for new facilities and equipment range from a few thousand to several millions of dollars; EPA does not make a capital cost estimate but lumps annual capital and operating expenses together, making comparisons difficult. Minimum annual capital costs for small systems could be about $25,463 ($250,000 amortized at 8 percent for 20 years).

- Water rates and bills could rise between 20 percent (the EPA maximum estimate for VOC removal) and 774 percent (the SMC-Martin estimate for turbidity control for small systems).
- Monitoring and sampling could cost small firms about $2,500 but these costs may prove higher when the actual MCLs are finalized by EPA.

It is clear from our research that additional documentation and analysis of the costs of the SDWA to small water systems will likely justify their applications for variances and exemptions from the regulations. The language in the legislative history of the 1986 Amendments to the SDWA indicates that Congress and the EPA were well aware of their plight.

The next effort of the NRRI in considering the cost implications of the SDWA will be to use existing information to try to form an independent assessment of the impact of the SDWA on small, commission-regulated water utilities. When this is done (by September 1987) we will be in a position to evaluate the existing state of knowledge, given the literature review in this briefing paper and the follow-on economic analysis using existing data and models. If it appears to be useful to NARUC, the NRRI could then pursue more detailed documentation of the difficult financial position that commission-regulated water utilities may face under the SDWA. A strong effort to collect cost data for utilities under commission jurisdiction may be needed. Such data are now available for other types of utilities. Or further research may be needed on the availability and costs of actual treatment techniques.

Regardless of further effort by the NARUC Water Committee to provide timely input into the development of EPA regulations on the SDWA or NRRI efforts to support the Committee with relevant research, it is clear that NARUC member commissions may need to consider how best to deal with the implications of the SDWA for their states. Commissions may want to monitor the development and analysis of data relating to the SDWA by relevant agencies. They may want to contact the state agencies designated to enforce the SDWA to inform them of commission concerns and perhaps coordinate responses to SDWA requirements. Commissions might consider the need to hold hearings, set rules, and even develop appropriate legislation to address SDWA requirements. And they may wish to decide generically how to deal with "rate shock" caused by the SDWA, whether through public education, phase-in of higher rates, or other means.

APPENDIX A

PROBABLE TREATMENT TECHNOLOGIES AND THEIR COSTS

This appendix shows treatment technology processes applicable to 60 contaminants and their capital costs for a 1 mgd plant. The source of the appendix is a report prepared by Camp, Dresser, and McKee for a Workshop in Response to Organic Chemicals in Public Water Supplies conducted for the New Jersey Department of Environmental Protection on March 19, 1987.

TREATMENT TECHNOLOGY
- PROCESSES -

CONTAMINANT		PROBABLE TREATMENT TECHNOLOGY	CAPITAL COST FOR 1MGD.
1.	Benzene	A. Air Stripping	$250,000 - $350,000
		B. GAC Adsorption	$450,000 - $550,000
2.	Vinyl Chloride	A. Air Stripping	$250,000 - $350,000
		B. GAC Adsorption	$450,000 - $550,000
3.	Carbon Tetrachloride	A. Air Stripping	$250,000 - $350,000
		B. GAC Adsorption	$450,000 - $550,000
4.	1,2-Dichloroethane	A. Air Stripping	$250,000 - $350,000
		B. GAC Adsorption	$450,000 - $550,000
5.	Turbidity	A. Direct Filtration	$1,000,000
		B. Conventional Treatment	$2,250,000
6.	Trichloroethylene	A. Air Stripping	$250,000 - $350,000
		B. GAC Adsorption	$450,000 - $550,000
7.	1,1-dichloroethylene	A. Air Stripping	$250,000 - $350,000
		B. GAC Adsorption	$450,000 - $550,000
8.	1,1,1-trichloroethane	A. Air Stripping	$250,000 - $350,000
		B. GAC Adsorption	$450,000 - $550,000
9.	p-dichlorobenzene	A. Air Stripping	$250,000 - $350,000
		B. GAC Adsorption	$450,000 - $550,000
10.	Acrylamide	A. GAC Adsorption	$450,000 - $550,000
		B. Air Stripping	$200,000 - $300,000
11.	Alachlor	A. GAC Adsorption	$450,000 - $550,000
		B. Air Stripping	$200,000 - $300,000
12.	Aldicarb	A. GAC Adsorption	$450,000 - $550,000
		B. Air Stripping	$400,000 - $500,000
13.	Carbofuran	A. Steam Stripping	$700,000 - $1,000,000
		B. GAC Adsorption	$600,000 - $700,000

PARAMETER	PROBABLE TREATMENT TECHNOLOGY	CAPITAL COST FOR ONE 1 MGD.
14. Chlordane	A. GAC Adsorption	$450,000 - $550,000
15. Cis-1,2-dichloro-ethylene	A. Air Stripping	$250,000 - $350,000
	B. GAC Adsorption	$450,000 - $550,000
16. DBCP	A. GAC Adsorption	$500,000 - $700,000
17. 1,2-dichloropropane	A. Air Stripping	$250,000 - $350,000
	B. GAC Adsorption	$450,000 - $550,000
18. o-dichlorobenzene	A. Air Stripping	$250,000 - $350,000
	B. GAC Adsorption	$450,000 - $550,000
19. 2,4-D	A. GAC Adsorption	$450,000 - $550,000
20. EDB	A. GAC Adsorption	$600,000 - $800,000
	B. Air Stripping	$300,000 - $450,000
	C. Steam Stripping	$700,000 - $1,000,000
21. Epichlorohydrin	A. GAC Adsorption	$600,000 - $800,000
22. Ethylbenzene	A. Air Stripping	$250,000 - $350,000
	B. GAC Adsorption	$450,000 - $550,000
23. Heptachlor	A. GAC Adsorption	$450,000 - $550,000
24. Heptachlor Epoxide	A. GAC Adsorption	$450,000 - $550,000
25. Lindane	A. GAC Adsorption	$450,000 - $550,000
26. Methoxychlor	A. GAC Adsorption	$450,000 - $550,000
27. Monochlorobenzene	A. Air Stripping	$250,000 - $350,000
	B. GAC Adsorption	$450,000 - $550,000
28. Pentachlorophenol	A. GAC Adsoprtion	$450,000 - $550,000
29. Styrene	A. Steam Stripping	$700,000 - $1,000,000
30. Toluene	A. Air Stripping	$250,000 - $350,000
31. 2,4,5-TP	A. GAC Adsorption	$450,000 - $600,000

PARAMETER	PROBABLE TREATMENT TECHNOLOGY	CAPITAL COST FOR ONE 1MGD.
32. Toxaphene	A. GAC Adsorption	$450,000 - $600,000
33. trans-1,2-dichloro-ethylene	A. Air Stripping	$250,000 - $350,000
33A. Xylene	A. Air Stripping	$250,000 - $350,000
34. Arsenic	A. Ferric Sulfate Coagulation	$2,000,000 - $2,500,000
	B. Alum Coagulation	$2,000,000 - $2,500,000
	C. Excess Lime Softening	$2,250,000 - $2,750,000
35. Asbestos	A. Direct Filtration	$1,000,000
	B. Conventional Treatment	$2,250,000
36. Barium	A. Lime Softening	$2,250,000 - $2,750,000
	B. Ion Exchange	$500,000 - $800,000
37. Cadmium	A. Ferric Sulfate Coagulation	$2,000,000 - $2,500,000
	B. Lime Softening	$2,250,000 - $2,750,000
	C. Excess Lime	$2,250,000 - $2,750,000
38. Chromium(+3)	A. Ferric Sulfate Coagulation	$2,000,000 - $2,500,000
	B. Alum Coagulation	$2,000,000 - $2,500,000
	C. Excess Lime Softening	$2,250,000 - $2,750,000
38A. Chromium(+6)	A. Ferrous Sulgate Coagulation	$2,250,000 - $2,500,000
39. Copper	A. Conventional Treatment	$2,250,000
	B. Ion Exchange	$500,000 - $800,000
40. Lead	A. Ferric Sulfate Coagulation	$2,000,000 - $2,500,000
	B. Alum Coagulation	$2,000,000 - $2,500,000
	C. Lime Softening	$2,250,000 - $2,750,000
	D. Excess Lime Softening	$2,250,000 - $2,750,000
41. Mercury (Inorganic)	A. Ferric Sulfate Coagulation	$2,000,000 - $2,250,000
41A. Mercury (Organic)	A. GAC Adsorption	$600,000 - $1,000,000

PARAMETER	PROBABLE TREATMENT TECHNOLOGY	CAPITAL COST FOR ONE 1 MGD.
42. Nitrate	A. Ion Exchange	$500,000 - $800,000
43. Nitrate	A. Ion Exchange	$500,000 - $800,000
44. Selenium(+4)	A. Ferric Sulfate Coagulation	$2,000,000 - $2,250,000
	B. Ion Exchange	$500,000 - $800,000
	C. Reverse Osmosis	$2,500,000 - $3,500,000
44A. Selenium(+6)	A. Ion Exchange	$500,000 - $800,000
	B. Reverse Osmosis	$2,500,000 - $3,500,000
45. Silver	A. Ferric sulfate Coagulation	$2,000,000 - $2,250,000
	B. Alum Coagulation	$2,250,000
	C. Lime Softening	$2,250,000 - $2,750,000
	D. Excess Lime Softening	$2,250,000 - $2,750,000
46. Fluoride	A. Ion Exchange with activated Alumina or bone char	$550,000 - $700,000
47. Radium	A. Lime - Soda softening	$2,500,000 - $3,500,000
	B. Reverse Osmosis	$2,500,000 - $3,500,000
	C. Ion Exchange	$900,000 - $1,100,000
48. Beta/photon emitters	A. Lime-Soda Softening	$2,500,000 - $3,000,000
	B. Ion Exchange	$700,000 - $800,000
	C. Reverse Osmosis	$2,500,000 - $3,500,000
49. Coliform Bacteria	A. Disinfection	$25,000 - $75,000
50. Trihalomethanes	A. Alternate disinfectant	-
	B. Non-THM producing disinfectant and GAC	Site specific
	C. Precursor Removal	-
51. Radon	A. Aeration	$400,000 - $1,000,000
	B. Ion Exchange	$400,000 - $600,000
52. Corrosivity	A. Chemical Addition	$20,000 - $100,000
53. Sodium	A. Membrane Filtration	$2,500,000 - $3,500,000
	B. Distillation	$3,000,000 - $3,500,000

PARAMETER	PROBABLE TREATMENT TECHNOLOGY	CAPITAL COST FOR ONE 1MGD.
54. Color	A. Conventional Treatment	$2,250,000
55. Odor	A. GAC Adsorption	$500,000 - $650,000
	B. PAC Adsorption	$50,000 - $150,000
	C. Chemical Oxidation	$20,000 - $100,000
56. Chloride	A. Membrane Filtration	$2,250,000 - $3,500,000
	B. Distillation	$3,000,000 - $3,500,000
57. Iron/Manganese	A. Manganese Greensand	$700,000 - $1,000,000
	B. Oxidation Filtration	$700,000 - $1,000,000
	C. Diatomacesus Earth Filtration	$600,000 - $900,000
58. Sulfate	A. Membrane Filtration	$2,500,000 - $3,500,000
59. Viruses	A. High Dose/Long Contact Chlorination	$20,000 - $100,000
60. Giardia Lamblia	A. Filtration	$1,000,000

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