Regulatory Impact
Analysis
for the
Interim Enhanced
l Surface Water Treatment Rule

PREPARED FOR:

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Executive Summary

ES.1 Protection of Public Health

The primary mission of the Environmental Protection Agency (EPA) is to safeguard human health and the environment This document addresses the expected impacts—both improvements to public health and the costs to industry and consumers—of one EPA regulation that will make water safer to drink

One of the most difficult challenges facing water systems is reducing the health risk caused by disease-causing microbial contaminants (i.e., bacteria, protozoa, and viruses). Many water systems treat their water with a chemical disinfectant to prevent diseases from microbial contaminants. Disinfection, however, may pose risks of its own. Disinfectants and their byproducts have been associated with potential health risks that include cancer and reproductive and developmental effects. EPA has identified ways to significantly lessen the potential risks associated with microbial contaminants without increasing the use and potential risks posed by disinfectants at reasonable costs. To implement these changes, EPA is publishing a final Interim Enhanced Surface Water Treatment Rule (IESWTR) that contains the new requirements for water systems and this Regulatory Impact Analysis (RIA), which documents the costs and benefits of the rule.

The primary goal of the IESWTR is to improve public health by increasing the level of protection from exposure to *Cryptosporidium* and other pathogens in drinking water supplies. The Safe Drinking Water Act (SDWA) requires the setting of drinking water standards at contaminant levels designed to avoid adverse effects on health while allowing for a margin of safety. The rule is expected to reduce the level of *Cryptosporidium* and other pathogen contamination in finished drinking water supplies through improvements in filtration at water systems. The rule is also expected to provide a larger margin of safety, particularly by reducing the likelihood of the occurrence of *Cryptosporidium* outbreaks.

In the classic paradigm of public health decision-making, it is necessary to decide upon a prudent course of action despite confounding factors. The decision process consists of weighing available evidence to gain as much insight as possible into expected or possible health outcomes while also weighing the costs and technological realities of available responses. At one end of the spectrum, a "No Action" option might be justified when the balance of health evidence suggests low exposure, low probability, and low severity while the response technologies imply high costs and limited effectiveness. At the opposite extreme, urgent and forceful action might be warranted when the health evidence suggests high exposure, high probability, and high severity while the response technologies have modest costs and good effectiveness. Based on the risk assessment presented in this RIA, EPA believes that there is sufficient exposure, probability, and severity on the health side to warrant a public health decision to accept the cost and technology impacts of the IESWTR in order to obtain the projected exposure reduction. Highlights of this balancing analysis are summarized in the following discussion.

ES.2 Exposure

Exposure to *Cryptosporidium* is potentially quite large The presence of *Cryptosporidium* in surface water sources is common, as oocysts have been found in wastewater, pristine surface water, surface water receiving agricultural runoff, water for recreational use, and drinking water The over-139 million people in the U S served by utilities covered by the major provisions of the IESWTR are potentially at risk from exposure to *Cryptosporidium* and other microbial contaminants.

ES.3 Health Hazards

In 1990, EPA's Science Advisory Board (SAB), an independent panel of experts established by Congress, cited drinking water contamination as one of the most important environmental risks and indicated that disease-causing microbial contaminants (i.e., bacteria, protozoa and viruses) are probably the greatest remaining health risk management challenge for drinking water suppliers (EPA/SAB, 1990) Information on the number of waterborne disease outbreaks from the U.S. Centers for Disease Control (CDC) underscores this concern. CDC indicates that, between 1980 and 1996, 401 waterborne disease outbreaks were reported, with over 750,000 associated cases of disease. During this period, a number of agents were implicated as the cause, including protozoa, viruses and bacteria, as well as several chemicals. Most of the cases (but not outbreaks) were associated with surface water, and specifically with a single outbreak of cryptosporidiosis in Milwaukee (over 400,000 cases) (MacKenzie, et al., 1994)

It is important to note that for a number of reasons, the CDC reports may substantially understate the actual number of waterborne disease outbreaks and cases in the U.S. First, few States have an active outbreak surveillance program. Second, disease outbreaks are often not recognized in a community or, if recognized, are not traced to the drinking water source. Third, a large number of people experiencing gastrointestinal illness (predominantly diarrhea) do not seek medical attention. Fourth, physicians may often not have a broad enough community-wide basis of information to attribute gastrointestinal illness to any specific origin such as a drinking water source. Finally, an unknown but probably significant portion of waterborne disease is endemic (i.e., not associated with an outbreak), and thus is even more difficult to recognize.

Waterborne disease is usually acute (i.e., sudden onset and typically lasting a short time in healthy people). Some pathogens (e.g., *Giardia*, *Cryptosporidium*) may cause extended illness, sometimes lasting months or longer, in otherwise healthy individuals. Most waterborne pathogens cause gastrointestinal illness, with diarrhea, abdominal discomfort, nausea, vomiting, and/or other symptoms. Other waterborne pathogens cause, or at least are associated with, more serious disorders such as hepatitis, gastric cancer, peptic ulcers, myocarditis, swollen lymph glands, meningitis, encephalitis, and a myriad of other diseases.

Gastrointestinal illness may be chronic in vulnerable populations (e.g., immunocompromised individuals). The severity and duration of illness is often greater in immunocompromised persons than in healthy individuals and may be fatal among this population. For instance, a follow-up study of the 1993 Milwaukee waterborne disease outbreak reported that at least 50 *Cryptosporidium*-associated deaths occurred among the severely immunocompromised (Hoxie, et al., 1997). Immunocompromised persons include infants, pregnant women, the elderly, and especially those with severely weakened immune systems (e.g., AIDS patients, those receiving treatment for certain types of cancer, organ-transplant recipients and people on immunosuppressant drugs) (Gerba et al., 1996).

With specific reference to cryptosporidiosis, the disease is caused by ingestion of environmentally resistant *Cryptosporidium* oocysts that are readily carried by the waterborne route Both human and other animals may excrete these oocysts Transmission of this disease often occurs through ingestion of the infective oocysts from contaminated water or food, but may also result from direct or indirect contact with infected persons or animals (Casemore and Jackson, 1983, Cordell and Addiss, 1994) Symptoms of cryptosporidiosis include typical gastrointestinal symptoms (Current, et al , 1983), and as noted above, these may persist for several days to several months.

While cryptosporidiosis is generally a self-limiting disease with a complete recovery in otherwise healthy persons, it can be very serious in immunosuppressed persons EPA has a particular concern regarding drinking water exposure to *Cryptosporidium*, especially in severely immunocompromised persons, because there is no effective therapeutic drug to cure the disease. There have been a number of waterborne disease outbreaks caused by *Cryptosporidium* in the U. S , United Kingdom and many other countries (Rose, 1997). There appears to be an immune response to *Cryptosporidium*, but it is not known if this results in protection (Fayer and Ungar, 1986).

One of the key regulations EPA has developed and implemented to counter pathogens in drinking water is the Surface Water Treatment Rule (SWTR). Among its provisions, the rule requires that a surface water system have sufficient treatment to reduce the source water concentration of *Giardia* and viruses by at least 99.9 percent (3 log) and 99.99 percent (4 log), respectively. A shortcoming of the SWTR is that the rule does not specifically control for the protozoan *Cryptosporidium*. The first report of a recognized outbreak caused by *Cryptosporidium* was published during the development of the SWTR (D'Antonio, et al., 1985). A particular public health challenge is that simply increasing existing disinfection levels above those most commonly practiced in the United States today does not appear to be an effective strategy for controlling *Cryptosporidium*, because the oocyst is especially resistant to disinfection.

In terms of occurrence, *Cryptosporidium* is common in the environment. Runoff from unprotected watersheds allows transport of these microorganisms to water bodies used as intake sites for drinking water treatment plants. One of the particular challenges of *Cryptosporidium* is its resistance to disinfection practices used at water treatment plants. Today's rule addresses the concern of passage of *Cryptosporidium* through physical removal processes during water treatment. It also strengthens the effectiveness and reliability of physical removal for particulate matter and microorganisms in general, thereby reducing the likelihood of the disinfection barrier being over-challenged. Waterborne disease outbreaks have been associated with a high level of particles passing through a water treatment plant (Fox, et al., 1996). This presents a significant public health concern. Hence, there is a need to optimize treatment reliability and to enhance physical removal efficiencies to minimize the *Cryptosporidium* levels in finished water. This rule, with tightened turbidity performance criteria and required individual filter monitoring, is formulated to address these public health concerns.

ES.4 Risk Assessment and Uncertainty

As with other microbial contaminants, there are two ways to characterize the risk posed by cryptosporidiosis: 1) endemic risk of illness resulting from everyday low-level exposure to the small percentage of oocysts that might pass through treatment processes without being inactivated; and 2) epidemic risk of illness resulting from large numbers of viable oocysts that pass through treatment processes during some sort of non-routine failure or upset of the treatment plant. The extent of current information, knowledge, and uncertainty falls in an uneven pattern across these two approaches to analysis

Endemic analysis requires knowledge of the occurrence of oocysts in raw water, the efficacy of treatment processes in reducing concentrations of viable oocysts, and the dose-response relationship applicable to humans Enough is known about each of these variables to perform risk assessment, but each factor contributes variability to the result The existence of endemic risk has been investigated at an individual water system level with epidemiological studies and some corroboration of the risk assessment methodology has been established, but there are still broad uncertainty bounds associated with these attempts at calibration.

Epidemic disease incidence is often reported to the CDC, but the reporting system is believed to be affected by under-reporting. There is no reliable means of projecting the total incidence of outbreaks from these data. In addition, there is no simple way to predict the likelihood of future outbreaks that may be caused by uncommon combinations of natural and human events.

This RIA presents a quantitative risk assessment only for endemic incidence of cryptosporidiosis. In this analysis, there is uncertainty associated with several key points, requiring assumptions and sensitivity analyses to quantify risk. The result is a broad range of answers. Assuming a baseline 2.5 log removal of *Cryptosporidium* for current treatment, this RIA estimates an expected value (mean) of 1,503,000 cryptosporidiosis endemic infections per year resulting in 643,000 illnesses from exposure to drinking water supplies in the water systems that will require changes under the rule. The 90 percent confidence range of this estimate extends from a low of 8,000 to a high of 1,241,000 illnesses per year. Under the comparison assumption of a 3.0 log removal, this RIA estimates an average of 208,500 illnesses, with a 90 percent confidence range of 2,500 to 384,500.

ES.5 Benefits of the IESWTR

According to the risk assessment performed for this RIA, the IESWTR is estimated to reduce the mean annual number of illnesses caused by *Cryptosporidium* in water systems improving filtration by 110,000 to 463,000 cases depending on which of the six scenarios describing baseline removal (2.5 and 3.0 log) and improved *Cryptosporidium* removal (low-, mid-, and high-improved) is assumed. Based on these values, the mean estimated annual benefits of reducing the illness ranges from $0.263 billion to $1.240 billion per year. This calculation is based on a valuation of $2,000 per incidence of cryptosporidiosis prevented, which is the mean of a distribution of values ascribed to health damages avoided.

The risk assessment also indicated that the rule could result in a mean reduction of 14 to 64 fatalities each year, depending on varied baseline and removal assumptions. Using a mean value of $5.6 million per statistical life saved, reducing these fatalities could produce benefits in the range of $0.085 billion to $0.363 billion.

In addition, benefits would accrue from the implementation of the rule in the form of reduced risk of outbreaks and consequent epidemic illness, enhanced aesthetic water quality, avoided costs of averting behavior, and reduced risk from other pathogens, such as *Giardia lamblia*. Benefits for these categories were not quantified for this analysis.

ES.6 Compliance Costs and Treatment Effectiveness

The total annual cost of the IESWTR is estimated at $307 million (Exhibit ES 1) using a 7 percent cost of capital [1] Utilities incur 95 percent of this annual cost ($291 million), and States incur the remaining 5 percent (about $16 million) The rule elements that most significantly influence the total cost of the IESWTR include the cost to build and maintain new or advanced treatment facilities and the cost to monitor the performance of systems. EPA estimates that the total capital cost nationwide would be $759 million Total capital costs are those costs associated with the purchase of equipment or systems that will meet the treatment requirements The largest capital expenditures are associated with installing individual filter turbidimeters and making hydraulic improvements to account for recycle flow in process control decisions. These costs are typically one-time investments. To make the costs comparable with implementation costs that occur each year, these capital or treatment costs are multiplied by a factor that "annualizes" the total, thus allowing all rule costs incurred in a year to be summed. To operate and maintain this capital investment will require about $106 million annually. The annual treatment costs (annualized capital costs and operating and maintenance (O&M) costs) are $192 million (at a 7 percent cost of capital). The cost to monitor the performance of systems in terms of turbidity is the other major cost of the rule. Turbidity monitoring is projected to cost utilities about $96 million annually.

The remaining costs ($19 million annually, about 6 percent of the total) include some other costs to utilities and all of the costs to States. Utilities will also provide reports and respond when filter performance falls below expectations ($0.20 million annually); establish disinfection benchmarks ($2.80 million annually); and incur one-time start-up costs for monitoring turbidity and haloacetic acid (HAA5) benchmarking monitoring ($0.65 million annualized).

Annual State costs are projected at $15 million. Almost all of this cost (96 percent) is for activities relating to three requirements: turbidity monitoring, sanitary surveys, and disinfection benchmarking. The remaining 4 percent of State costs are to start up various parts of the program and to implement the exception reporting process. Detailed tables for treatment costs, utility costs, and state costs at the 3, 7, and 10 percent cost of capital rates may be found in Appendices A through E.

Average annual cost per system (large surface water systems that filter using rapid granular filtration) are displayed in Exhibit ES.3. Because each system will implement one or more treatment techniques depending on its current water quality characteristics, all affected systems will incur different annual costs under the IESWTR. Additionally, while 691 systems will have to modify their treatment techniques to meet the turbidity requirements, 1,381 large surface water systems will have to monitor for turbidity and report turbidity exceptions. Thus, 691 systems will incur both treatment and monitoring costs, and 690 systems will incur only monitoring costs. It is important to note that the cost estimates used for this exhibit are the *average cost* per system. Within any one size category, systems may use different treatment techniques with widely varying costs in many different combinations to treat their water. The average cost per system gives a good approximation of the most likely costs these systems are expected to incur under the rule. Under this IESWTR, approximately 50 percent of systems are expected to face an

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[1] Estimated costs are annualized using a range of rates for the cost of capital over 20 years. The 1994 proposed rule used a 10 percent cost of capital to annualize. To assist the M-DBP Committee in comparing revised costs, this 10 percent rate is currently used where appropriate and for comparison. The Office of Management and Budget (OMB) recommends that 7 percent be used to annualize capital costs. To reflect this recommendation, costs based at the 7 percent rate are discussed and used throughout this RIA. In addition, a 3 percent cost of capital, which is used as a sensitivity analysis, is presented in Exhibit 1 1 and in Appendices B and E

average annual cost of less than $130,000 The highest annual average cost is $3 million, estimated for 4 systems in the largest population size category

ES.7 National Benefits Comparisons

Given the benefits and costs summarized in Exhibits ES 1 and ES 2, the IESWTR results in positive net benefits, assuming a mean number of illnesses avoided, under all three improved removal scenarios (low, mid, and high) assuming that current treatment achieves a removal of 2 5 logs, taking into account *only* the cost of endemic illnesses avoided. Using a current treatment removal assumption of 3 0 logs, net benefits are positive under the high and mid improved removal scenario, but are negative under the low improved removal assumption using only the cost of endemic illnesses avoided. When the value of endemic mortalities prevented is added into the benefits, however, all scenarios have positive net benefits at the mean.

Thus, the monetized net benefits are positive across the range of current treatment assumptions, improved log removal scenarios, and cost of capital rates at the mean. The benefits due to the endemic illnesses avoided may be slightly overstated because the mortalities were not netted out of the number of illnesses. This value is minimal and would not be captured at the level of significance of the analysis. Several categories of benefits, including reducing the risk of outbreaks, reducing exposure to other pathogens such as *Giardia*, and avoiding the cost of averting behavior have not been quantified for this analysis, but could represent substantial additional economic value. In addition, the estimates for avoided costs of endemic illness do not include the value for pain and suffering or the risk premium.

These results indicate that the rule is consistent with the SDWA's focus on avoiding adverse health impacts while allowing for a margin of safety, with reasonable assurance that the benefits of the rule will outweigh the costs.

ES.8 Household Cost Comparisons

Another intuitive measure of the cost-effectiveness and public health benefit of the IESWTR is provided by computation of the household cost of compliance (Exhibits ES.3). A large number (92 percent) of households will face a *maximum* increase in cost of $12 per year ($1 per month). In other words, 60 million households will incur no more than a $1 increase in their monthly costs. Five million households (7 percent) will face an increase in cost of between $12 and $60 per year ($1-$5 per month). The highest cost faced by 23,000 households is approximately $100 per year ($8 per month).

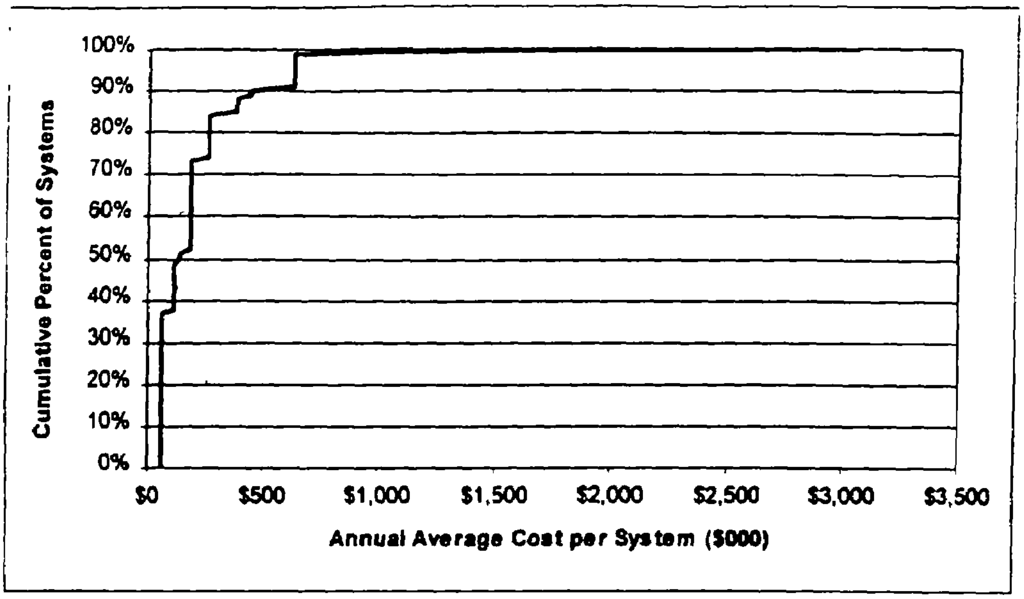
Taking the $1 per month figure as a measure of implied public health benefit at the household level, it is useful to ask what benefits can be identified that could balance a $1 per month expenditure. First, it is entirely possible that there is much more than a dollar-a-month's worth of tangible health benefit based on reduced risk of cryptosporidiosis alone. Second, the broad exposure to microbial pathogens and the myriad possible health effects involved offer the possibility that there are significant additional health benefits of a tangible nature. Finally, however, the preventive weighing and balancing of public health protection provides also a margin of safety—a hedge against uncertainties. Recent survey research conducted in the drinking water field provides compelling empirical evidence that the number one priority of water system customers is the safety of their water. Although definitive economic research has not been performed to investigate the extent of household willingness-to-pay for such a margin of safety, there is very strong evidence from conventional customer survey research implying a demand for this benefit.

ES.9 Conclusion

In the final analysis, the various benefit/cost comparisons developed in this RIA are quite useful in assisting the balancing and weighing analyses that must be performed to support public health decision-making. Based on a careful weighing of the projected costs against the potential quantified and non-quantified benefits, EPA has determined that the benefits of the rule justify its costs.

Exhibit ES.3

Cumulative Distribution of Annual Average Cost per System of the IESWTR



Cumulative Distribution of Annual Cost per Household of the IESWTR

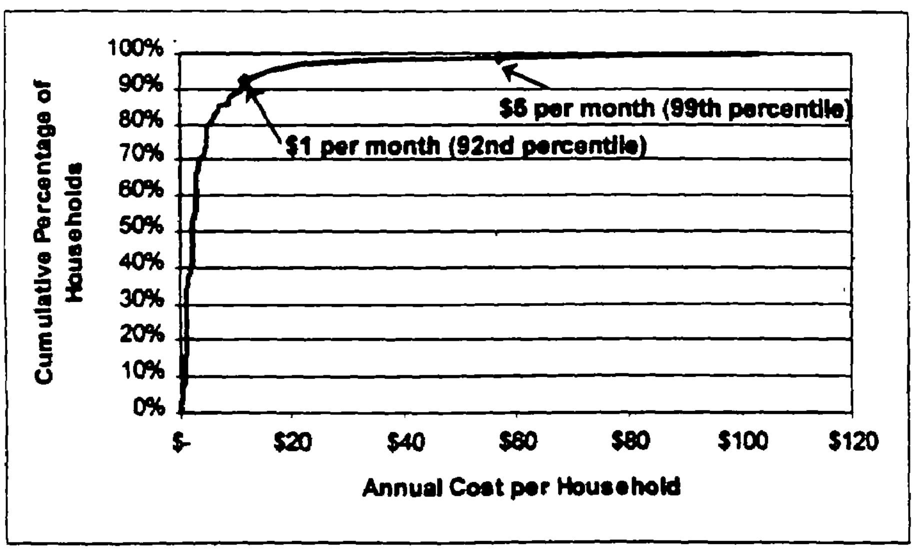


Exhibit ES.4
Characteristics of Surface Water Systems that Use Filtration

System Size (population served)	Number of Systems	Number of Plants	Number of Systems to Modify Treatment	Number of Systems to Monitor Only	Number of Households
< 10K	4,880	4,880	0	4,880	4,122,000
10K-25K	594	594	303	291	4,553,000
25K-50K	316	316	161	155	5,767,000
50K-75K	124	124	63	61	3,983,000
75K-100K	52	104	27	25	2,467,000
100K-500K	259	518	122	137	25,524,000
500K-1M	26	52	11	15	12,414,000
>1M	10	20	4	6	10,515,000
Total	**6,261**	**6,608**	**691**	**5,570**	**69,345,000**

1: Introduction

1.1 Introduction

This document analyzes the impacts of the final Interim Enhanced Surface Water Treatment Rule (IESWTR). Executive Order 12866, *Regulatory Planning and Review*, requires EPA to estimate the costs and benefits of the IESWTR in a *regulatory impact analysis* (RIA) and to submit the analysis in conjunction with publishing the final rule.

The IESWTR applies to public drinking water systems using surface water or ground water under the direct influence of surface water (GWUDI) as a source, using rapid granular filtration as a treatment technology, and serving 10,000 or more persons, with the exception of a provision that States perform a sanitary survey for all surface and GWUDI systems. It builds on the 1989 Surface Water Treatment Rule (SWTR) and will improve control of microbial pathogens such as *Cryptosporidium* as well as assure there will be no significant increase in microbial risk for those systems that may need to change their disinfection practices in order to meet new disinfection byproduct (DBP) standards under the Stage 1 Disinfectants/Disinfection Byproducts Rule (Stage 1 DBPR).

This RIA provides background on the rule, summarizes the key components, discusses alternatives to the rule, and estimates costs and benefits to the public and State governments. This chapter summarizes the technical and regulatory issues associated with the rule. It explains the nature of microbial contamination, reviews the potential health effects of exposure to microbial pathogens, details how the final IESWTR will address the health effects, and then summarizes the estimated costs and benefits of rule implementation. In addition, this section includes a statement addressing the potential disproportionate impact of the rule on low-income or minority communities.

Subsequent chapters are intended to meet the requirements of the Executive Order by responding to specific analytical questions. Chapter 2 reviews alternative approaches considered as the rule was being developed. Chapter 3 presents utility data and discusses the changes systems would have to make as a result of the rule; this approach will establish a baseline for use in the following three chapters. Chapter 4 examines the rule's potential benefits through the development of a risk assessment. Chapter 5 presents an estimate of the costs to implement the rule. Chapter 6 provides a comparison of estimated costs and benefits and summarizes the results of this RIA. Chapter 7 examines the economic rationale for regulating microbial contaminants.

The IESWTR will be followed by additional rules to improve microbial protection for public water systems that use surface water and address risk-risk trade-offs with disinfection byproducts. These include

1) The Long-Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR), which will primarily address public water systems serving fewer than 10,000 people, to be promulgated in November 2000;

2) The Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), which will be promulgated simultaneously with the Stage 2 DBPR in May 2002, and,

3) The Filter Backwash Recycling Rule, to be promulgated in August 2000.

1.2 Public Health Concerns Addressed by the IESWTR

In 1990, EPA's Science Advisory Board (SAB), an independent panel of experts established by Congress, cited drinking water contamination as one of the most important environmental risks and indicated that disease-causing microbial contaminants (i.e., bacteria, protozoa and viruses) are probably the greatest remaining health risk management challenge for drinking water suppliers (EPA/SAB, 1990). Information on the number of waterborne disease outbreaks from the U.S. Centers for Disease Control (CDC) underscores this concern. CDC indicates that, between 1980 and 1996, 401 waterborne disease outbreaks were reported, with over 750,000 associated cases of disease. During this period, a number of agents were implicated as the cause, including protozoa, viruses and bacteria, as well as several chemicals. Most of the cases (but not outbreaks) were associated with surface water, and specifically with a single outbreak of cryptospondiosis in Milwaukee (over 400,000 cases) (MacKenzie, et al., 1994).

It is important to note that for a number of reasons, the CDC reports may substantially understate the actual number of waterborne disease outbreaks and cases in the U.S. First, few States have an active outbreak surveillance program. Second, disease outbreaks are often not recognized in a community or, if recognized, are not traced to the drinking water source. Third, a large number of people experiencing gastrointestinal illness (predominantly diarrhea) do not seek medical attention. Fourth, physicians may often not have a broad enough community-wide basis of information to attribute gastrointestinal illness to any specific origin such as a drinking water source. Finally, an unknown but probably significant portion of waterborne disease is endemic (i.e., not associated with an outbreak), and thus is even more difficult to recognize.

Waterborne disease is usually acute (i.e., sudden onset and typically lasting a short time in healthy people). Some pathogens (e.g., *Giardia*, *Cryptosporidium*) may cause extended illness, sometimes lasting months or longer, in otherwise healthy individuals. Most waterborne pathogens cause gastrointestinal illness, with diarrhea, abdominal discomfort, nausea, vomiting, and/or other symptoms. Other waterborne pathogens cause, or at least are associated with, more serious disorders such as hepatitis, gastric cancer, peptic ulcers, myocarditis, swollen lymph glands, meningitis, encephalitis, and a myriad of other diseases.

Gastrointestinal illness may be chronic in vulnerable populations (e.g., immunocompromised individuals). The severity and duration of illness is often greater in immunocompromised persons than in healthy individuals and may be fatal among this population. For instance, a follow-up study of the 1993 Milwaukee waterborne disease outbreak reported that at least 50 *Cryptosporidium*-associated deaths occurred among the severely immunocompromised (Hoxie, et al., 1997). Immunocompromised persons include infants, pregnant women, the elderly, and especially those with severely weakened immune systems (e.g., AIDS patients, those receiving treatment for certain types of cancer, organ-transplant recipients and people on immunosuppressant drugs) (Gerba et al., 1996).

With specific reference to cryptosporidiosis, the disease is caused by ingestion of environmentally resistant *Cryptosporidium* oocysts that are readily carried by the waterborne route. Both human and other animals may excrete these oocysts. Transmission of this disease often occurs through ingestion of the infective oocysts from contaminated water or food, but may also result from direct or indirect contact with infected persons or animals (Casemore and Jackson, 1983, Cordell and Addiss, 1994) Symptoms of cryptosporidiosis include typical gastrointestinal symptoms (Current, et al., 1983), and as noted above, these may persist for several days to several months

While cryptosporidiosis is generally a self-limiting disease with a complete recovery in otherwise healthy persons, it can be very serious in immunosuppressed persons. EPA has a particular concern regarding drinking water exposure to *Cryptosporidium*, especially in severely immunocompromised persons, because there is no effective therapeutic drug to cure the disease. There have been a number of waterborne disease outbreaks caused by *Cryptosporidium* in the U. S, United Kingdom and many other countries (Rose, 1997). There appears to be an immune response to *Cryptosporidium*, but it is not known if this results in protection (Fayer and Ungar, 1986).

One of the key regulations EPA has developed and implemented to counter pathogens in drinking water is the Surface Water Treatment Rule (SWTR). Among its provisions, the rule requires that a surface water system have sufficient treatment to reduce the source water concentration of *Giardia* and viruses by at least 99.9 percent (3 log) and 99.99 percent (4 log), respectively. A shortcoming of the SWTR is that the rule does not specifically control for the protozoan *Cryptosporidium*. The first report of a recognized outbreak caused by *Cryptosporidium* was published during the development of the SWTR (D'Antonio, et al., 1985). A particular public health challenge is that simply increasing existing disinfection levels above those most commonly practiced in the United States today does not appear to be an effective strategy for controlling *Cryptosporidium*, because the oocyst is especially resistant to disinfection.

In addition to these microbial issues, there is another potentially confounding public health concern. The disinfectants used to control pathogens may produce toxic or carcinogenic disinfection byproducts (DBPs) when they react with organic chemicals in the source water. An important question facing water supply professionals is how to minimize the risk from both microbial pathogens and DBPs simultaneously.

At the time the SWTR was promulgated, EPA had limited data concerning *Giardia* and *Cryptosporidium* occurrence in source waters and treatment efficiencies. The 3-log removal/inactivation of *Giardia lamblia* and 4-log removal/inactivation of enteric viruses required by the SWTR were developed to provide protection from most pathogens in source waters. However, additional data have become available since promulgation of the SWTR concerning source water occurrence and treatment efficiencies for *Giardia*, as well as for *Cryptosporidium* (LeChevallier, et al., 1991 a,b). A major concern is that if systems currently provide four or more logs of removal/inactivation for *Giardia*, such systems might reduce existing levels of disinfection to more easily meet the new DBP regulations, and thus only marginally meet the three-log removal/inactivation requirement for *Giardia lamblia* specified in the current SWTR. Depending upon source water *Giardia* concentrations, such treatment changes could lead to significant increases in microbial risk (Regli, et al., 1993; Grubbs, et al., 1992; EPA, 1994). As discussed below, the disinfection benchmarking required under today's rule is specifically designed as a process by which a utility and the State, working together, assure that there will be no significant reduction in microbial protection as the result of modifying disinfection practices in order to meet maximum contaminant level goals (MCLs) for Total Trihalomethanes (TTHM) and five Haloacetic Acids (HAA5) under the Stage 1 DBPR.

1.3 Regulatory History

The primary responsibility for regulating the quality of drinking water lies with EPA. The Safe Drinking Water Act (SDWA) establishes this responsibility and defines the mechanisms at the Agency's disposal to protect public health EPA sets water quality standards by identifying which contaminants should be regulated, and establishes levels of contaminant reduction to be attained by utilities.

To regulate a contaminant, EPA first establishes a maximum contaminant level goal (MCLG) that establishes the contaminant level at which no known or anticipated adverse health effects occur. MCLGs are unenforceable health goals. EPA then sets an enforceable maximum contaminant level (MCL) as close as technologically possible to the MCLG. If it is not feasible to measure the contaminant, a treatment technique is specified.

For utilities, compliance with a regulation means not exceeding the MCL. However, when MCLs are not economically or technologically feasible, an approved treatment technique can be used. A treatment technique requirement is a regulatory approach that specifies a technology that reduces exposure to contaminants to the extent feasible.

As described earlier, one of the key regulations EPA has developed and implemented to counter pathogens in drinking water is the 1989 SWTR. Among its provisions, the rule requires that a utility have sufficient treatment to reduce the source water concentration of *Giardia lamblia* and viruses by at least 99 9 percent and 99.99 percent, respectively. The SWTR has several shortcomings, including not specifically controlling for the protozoan *Cryptosporidium*. Also, the disinfectants used to control pathogens may either be toxic or carcinogenic directly, or produce toxic or carcinogenic DBPs when they react with organic chemicals in the source water. An important question facing water supply professionals is how to minimize the risk from both microbial pathogens and DBPs simultaneously.

To address the complex issues associated with regulating microbial pathogens, EPA launched a rule-making process in 1992 and convened a Regulatory Negotiation (RegNeg) Advisory Committee under the Federal Advisory Committee Act (FACA), representing a range of stakeholders affected by possible regulation. The RegNeg Committee met repeatedly over a period of 10 months and arrived at a consensus proposal for taking progressive steps toward addressing both DBPs and microbial pathogens. The 1992 consensus-building process resulted in the three following regulatory proposals—

1) A staged approach to regulation of DBPs (referred to as the Stage 1 and Stage 2 DBPRs) incorporating MCLs, MRDLs, and treatment technique requirements;

2) A companion Interim Enhanced Surface Water Treatment Rule (IESWTR) designed to improve control of microbial pathogens and prevent inadvertent reductions in microbial safety as a result of DBP control efforts, and;

3) An Information Collection Rule (ICR) to collect information necessary to reduce many key uncertainties prior to subsequent negotiations regarding the Stage 2 rule requirements.

Congress amended the SDWA in 1996 and affirmed the strategy developed by the RegNeg Committee. Congress also established a series of new statutory deadlines for the rules. Under the new amendments, the IESWTR and the Stage 1 DBPR must both be promulgated by November 1998. The Filter Backwash Recycle Rule and the Long Term 1 Enhanced Surface Water Treatment Rule (LT1) are required to be promulgated by August 2000 and November 2000, respectively EPA must promulgate the Stage 2 DBPR by May 2002 In addition, the Agency will promulgate a Final Ground Water Rule by November 2000 and a Long Term 2 ESWTR (LT2) to accompany the Stage 2 DBPR by May 2002

In 1997, a similar FACA process was implemented with the Microbial-Disinfectants/Disinfection Byproducts (M-DBP) Advisory Committee. The M-DBP Committee convened to collect, share, and analyze new information available since 1994, review previous assumptions made during the RegNeg process, as well as build consensus on the regulatory implications of this new information. The Committee made recommendations to EPA including the following. performing benchmarking to provide a methodology and process by which a utility and the State, working together, assure that there will be no significant reduction in microbial protection as the result of modifying disinfection practices in order to meet MCLs for Total Trihalomethanes (TTHMs) and 5 haloacetic acids (HAA5); turbidity; *Cryptosporidium* MCLG; *Cryptosporidium* removal requirements; and sanitary surveys.

1.4 Summary of the Rule

The IESWTR is intended to improve control of pathogens such as *Cryptosporidium* as well as assure no significant increase in microbial risk as systems act to meet the new DBP MCLs under the Stage 1 DBPR. With the exception of a requirement that States conduct a sanitary survey for all surface water and GWUDI systems, the IESWTR applies only to public drinking water systems, using surface water or GWUDI as a source and serving 10,000 or more people.

Major features of the rule include an MCLG of zero for *Cryptosporidium*, limitations on turbidity, a disinfection benchmark and, sanitary survey provisions. In addition, the rule adds *Cryptosporidium* to the definition of GWUDI and to watershed control requirements for unfiltered systems, as well as requiring that newly constructed finished water reservoirs be covered.

Cryptosporidium

The rule sets the MCLG for *Cryptosporidium* at zero. All surface water systems that serve 10,000 or more people and are required to filter under the SWTR must remove at least 99 percent of influent *Cryptosporidium* (referred to as achieving 2 log removal). Systems that use rapid granular filtration (direct filtration or conventional filtration treatment) and meet the turbidity requirements contained in the IESWTR (described below) are assumed to achieve at least a 2 log removal of *Cryptosporidium*. Systems that use slow sand filtration and diatomaceous earth filtration and meet the turbidity performance requirements contained in the 1989 SWTR also are assumed to achieve at least a 2 log removal of *Cryptosporidium*. Systems may demonstrate that they achieve higher levels of physical removal, and States have the option of determining whether certain systems do not meet the 2 log removal requirement even though the systems are in compliance with the revised, more stringent, combined effluent turbidity provisions in the final IESWTR.

Turbidity Requirements

For all surface water and GWUDI systems that use conventional treatment or direct filtration, serve 10,000 or more people, and are required to filter under the SWTR—

- The turbidity level of a system's combined filtered effluent (CFE) at each plant must be less than or equal to 0 3 nephelometric turbidity units (NTUs) in at least 95 percent of the measurements taken each month, and,

- The turbidity level of a system's CFE at each plant must at no time exceed 1 NTU

For both the maximum and the 95[th] percentile requirements, compliance is determined based on measurements of the CFE at 4-hour intervals.

Individual Filter Requirements

All surface water systems that use rapid granular filtration and that serve 10,000 or more people conduct continuous monitoring of turbidity for each individual filter and must provide monthly exception reports to the State as part of the existing CFE reporting process. Exceptions to be reported include the following: 1) any individual filter with a turbidity level greater than 1.0 NTU based on 2 consecutive measurements 15 minutes apart; and 2) any individual filter with a turbidity level greater than 0 5 NTU at the end of the first 4 hours of filter operation (i.e., after backwashing or cleaning) based on 2 consecutive measurements 15 minutes apart. Systems must develop a filter profile if there is no apparent reason for abnormal filter performance.

If an individual filter has turbidity levels greater than 1.0 NTU based on 2 consecutive measurements 15 minutes apart at any time in each of 3 consecutive months, the system shall conduct a self-assessment of the filter. If an individual filter has turbidity levels greater than 2.0 NTU based on 2 consecutive measurements 15 minutes apart at any time in each of 2 consecutive months, the system shall arrange for the conduct of a Comprehensive Performance Evaluation (CPE) by the State or a third party approved by the State.

Disinfection Benchmarking

Disinfection benchmarking allows a plant to chart or plot its daily levels of *Giardia* inactivation on a graph which, when viewed on a seasonal or annual basis, represents a "profile" of the plant's inactivation performance. The system can use the profile to evaluate the effects of possible changes in disinfection practice on microbial protection. This approach makes it possible for a plant that is considering changing its disinfection practices to meet DBP MCLs to evaluate whether the particular change under consideration will result in a lower level of inactivation than the benchmark. Comparison with the benchmark provides the necessary tool to allow plants, taking source water quality into consideration, to project or measure the possible impacts of potential changes in disinfection. Only certain systems would be required to develop a profile and keep it on file for State review during sanitary surveys (i.e., systems with TTHM/HAA5 levels exceeding 80 percent of Stage 1 DBPR MCLs). Only a subset of those required to develop a profile (i.e., those intending to make significant changes in their disinfection practice) would be required to submit their profile and analysis to the State for review.

Sanitary Surveys

The IESWTR requires States to conduct sanitary surveys of all surface water systems (including GWUDI systems). Under the IESWTR a sanitary survey is defined as an on-site review of the water source (identifying sources of contamination using results of source water assessments where available), facilities, equipment operation, maintenance, and monitoring compliance of a system to evaluate the adequacy of the system, its sources and operations, and the distribution of safe drinking water Included in the IESWTR requirements is the concept that components of a sanitary survey may be completed as part of a staged or phased State review process within the established frequency interval set forth below Finally, in order to meet the IESWTR requirements, a sanitary survey must address each of the eight elements in the December 1995 EPA/State Guidance on Sanitary Surveys

This rule provides that sanitary surveys must be conducted for all surface water systems (including GWUDI systems) no less frequently than every 3 years for community systems and no less frequently than every 5 years for noncommunity systems. Any sanitary survey conducted after December 1995 that addresses the eight sanitary survey components of the 1995 EPA/State guidance may be counted or "grandfathered" for purposes of completing the first round of surveys. This approach also provides that for community systems having outstanding performance based on prior sanitary surveys as determined by the State, successive surveys may be conducted no less than every 5 years.

In addition, as part of follow-up activity for sanitary surveys, systems must respond to deficiencies outlined in a State sanitary survey report within 45 days, indicating how and on what schedule the system will address significant deficiencies noted in the survey. Finally, States must have the appropriate rules or other authority to assure that facilities take the steps necessary to address significant deficiencies identified in the survey report that are within the control of the utility and its governing body.

Other Requirements

New provisions under the IESWTR include extending watershed control requirements for unfiltered systems serving 10,000 or more people to include the control of *Cryptosporidium*. This builds on the existing requirements for *Giardia lamblia* and viruses. *Cryptosporidium* are included in the watershed control provisions wherever *Giardia lamblia* is mentioned. The watershed control program minimizes the potential for source water contamination and includes a characterization of the watershed hydrology characteristics, land ownership, and activities that may have an adverse effect on source water quality. Monitoring for unfiltered systems is not required but will be considered under future microbial rules.

EPA believes that an effective watershed protection program will help to improve source water quality because existing guidance already references the need to guard against pathogenic protozoa, including *Cryptosporidium* specifically. EPA is proceeding on the presumption that existing watershed programs already consider, and State reviews have evaluated, the adequacy of watershed provisions to assure that raw drinking water supplies are adequately protected against *Cryptosporidium* contamination. To the extent this is not the case, however, EPA expects that unfiltered systems and States in their annual review will reassess their program with regard to this concern and take whatever steps are necessary to ensure that potential vulnerability to *Cryptosporidium* contamination is considered and adequately addressed.

With the IESWTR, EPA includes *Cryptosporidium* in the definition of GWUDI systems. Systems using these ground water sources that are considered vulnerable to *Cryptosporidium* contamination would be subject to the provisions of the SWTR. EPA believes that current GWUDI guidance is adequate and, based on presently available data, additional changes are not needed to accommodate this provision.

Also included in the IESWTR is a requirement that systems cover finished water reservoirs and storage tanks Finished water reservoirs that are open to the atmosphere may be subject to some of the environmental factors that surface water is subject to, depending on site-specific characteristics and the extent of protection provided.

1.5 Environmental Justice

Executive Order 12898 established a presidential policy for incorporating environmental justice into Federal agency missions by directing agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.

First, national drinking water regulations apply uniformly to utilities. Although not all utilities have to modify treatment or operations to reach a particular standard, all must comply with the water quality standards as promulgated. Thus, the treatment performance level is consistent across all populations served by surface water systems serving 10,000 or more people. A complementary regulation is under development that will address similar issues for systems serving fewer than 10,000 people.

In addition, concerns of affected communities, including sensitive subpopulations, were included in the IESWTR through the RegNeg and M-DBP processes undertaken to craft the regulation. Both committees were chartered under the FACA and included a broad cross-section of regulators, the regulated communities, industry, and consumers. Extensive discussion on setting levels that provided the maximum protection feasible took place, and the final consensus on recommendations to EPA for the IESWTR considered issues of affordability, equity, and safety.

Finally, the Agency held a stakeholder meeting March 12, 1998 to specifically address environmental justice issues. The main objectives of the meeting were to solicit ideas from environmental justice stakeholders on issues surrounding proposed drinking water efforts to increase environmental justice representation in the regulatory process.

1.6 Unfunded Mandates Reform Act Analysis

Title II of the Unfunded Mandates Reform Act (UMRA) of 1995, P.L. 104-4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and tribal governments and the private sector. Under UMRA section 202, EPA must prepare a written statement including a benefit/cost analysis, for proposed and final rules with Federal mandates that may result in expenditures to State, local, and tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year.

Because EPA believes that this rule may result in expenditures of $100 million or more for State, local, and tribal governments, in the aggregate, or the private sector in one year, it has prepared *Unfunded Mandates Reform Act Analysis for the Interim Enhanced Surface Water Treatment Rule* to accompany this RIA. This document reviews the benefit/cost analysis, estimates potential disproportionate budgetary effects, and summarizes State, local, and tribal government input. The analysis identifies the selected regulatory option as the least costly, most cost-effective, and least burdensome that accomplishes the objectives of the IESWTR.

1.7 Regulatory Flexibility Analysis

A Regulatory Flexibility Analysis was not prepared for this analysis or rule, since the rule only applies to systems serving 10,000 or more people EPA has defined small systems under the Regulatory Flexibility Act (RFA) as utilities that serve fewer than 10,000 people This latter set of systems will be addressed as part of the upcoming LT1 Rule. An RFA will be developed as part of that rule. Although the sanitary survey requirement in the IESWTR applies to all systems, regardless of size, costs are incurred by States and are not considered under the RFA.

2: Consideration of Regulatory Alternatives

2.1 Chronological Review of Regulatory Options Considered

2.1.1 Alternative Development Process

As discussed in Chapter 1, the 1994 Interim Enhanced Surface Water Treatment Rule (IESWTR) proposal was developed as the result of a Federal Advisory Committee Act (FACA)-chartered Microbial Disinfectants/Disinfection Byproducts (M-DBP) regulatory negotiation in 1992 and 1993. In response to expedited regulatory deadlines established by Congress under the 1996 Safe Drinking Water Act (SDWA), a FACA committee was rechartered in 1997 to develop recommendations on key IESWTR issues based on new information obtained since the 1994 proposal. As Committee members reviewed data, regulatory scenarios were forwarded to the Technologies Working Group (TWG) for detailed analysis and cost estimation. Consensus recommendations were developed over the course of the Committee's deliberations.

The M-DBP Committee and TWG used a modified "Delphi" expert process in developing consensus approaches. A "Delphi" analytical process uses teams or groups of experts to reach independent understandings of technical problems. A modification to this process was used by the M-DBP Committee in their deliberations. In general, the TWG provided guidance on the specific regulatory alternatives. Analysts then prepared the cost estimates based on agreed upon assumptions and provided the estimates to the TWG and Committee for review and feedback. Often, the cost estimates provoked discussion and debate, with the TWG and Committee members asking for further research and refinements of the estimates, before reaching a consensus on the recommended approach.

At each phase of the M-DBP Committee process, the Committee reviewed the findings and analysis of the TWG and further refined the approach. As a result, a variety of alternatives were discussed and costed in a series of meetings from March to July, 1997. At the first meeting in March 1997, the Committee discussed turbidity and the use of a disinfection benchmark. The meeting in April focused on turbidity monitoring; this discussion continued in May with added review of the role of sanitary surveys, the retention of the predisinfection credit, and a physical removal credit for *Cryptosporidium*. June and July M-DBP Committee meetings focused on coming to a conclusion on these issues and capturing consensus language in an Agreement-in-Principle.

The IESWTR was proposed to improve control of pathogens such as *Cryptosporidium*, with the objective of maintaining protection from microbial pathogens while systems act to meet the new disinfection byproducts (DBPs) maximum contaminant levels (MCLs) under the Stage 1 DBPR.

Because *Cryptosporidium* is particularly resistant to inactivation using chlorine, physical removal by filtration is extremely important in controlling this organism. Current filtration requirements under the Surface Water Treatment Rule (SWTR) mandate achieving a 0.5 Nephelometric Turbidity Unit (NTU) for combined filter effluent (CFE) in 95 percent of monthly samples, with levels never exceeding 5 NTU. To improve filtration performance, the M-DBP Committee assessed the tightening of these turbidity performance criteria and monitoring individual filtration performance.

An underlying assumption in the rule is that improved turbidity performance levels can be achieved primarily by changes in operation and administrative practices Costly new treatment technologies, in general, are not necessary The alternative development process did consider the use of membranes, or nanofiltration technology, if the 95[th] percentile performance levels were set at 0.1 NTU. This RIA, however, assumes a 0 3 NTU for CFE for in 95 percent of monthly samples, with levels never exceeding 1 NTU, as described in the next section

2.2. Summary of Regulatory Alternatives Considered

2.2.1 Turbidity Treatment

Based on a review of new data, the M-DBP Committee considered tightened turbidity standards for CFE at three levels: 0.1, 0.2, and 0.3 NTU. In general, the M-DBP Committee agreed that plants would typically target their operations to achieve 0.2 NTU to ensure that they would consistently meet a 0.3 NTU standard. Similarly, plants that expect to meet a 0.2 NTU limit 95 percent of the time would typically target their operations to achieve 0.1 NTU. At this initial stage of discussion, maximum turbidity levels (currently set at 5 NTU) were assumed between 1.0 and 2.0 NTU. A mix of operational improvements to comply with each level of CFE turbidity were varied at each level. The mix of improvements selected by utilities primarily determines the costs of compliance.

Defining the types of operational improvements and the number of systems required to modify filtration activities, and what those activities might be, are important parts of a regulatory discussion on changing limits. As turbidity limits become increasingly rigorous, a larger number of surface water systems would need to modify their filter operations. With current filtration technologies, the difference in compliance between 0.2 NTU and 0.3 NTU are those of degree. In general, more systems would be required to modify operational practices, and apply improvements in greater percentages, at 0.2 NTU compliance than at 0.3 NTU compliance.

Moving to the most stringent 0.1 NTU level, however, represents a shift in filtration operations that differs substantively from the other two possible turbidity limits. In addition, while turbidity measurement has long been recognized as a means for evaluating treatment performance for removal of particulate matter (which includes microorganisms), issues remain pertinent as to the accuracy and precision of the measurements (i.e., turbidimeters with different designs, variations in calibration, and measurement procedures). A major concern expressed by participants among the M-DBP Committee is the ability to reliably measure low turbidity levels. The TWG assumed that if systems operated to achieve a turbidity limit of less than 0.2 NTU 95 percent of the time (as an operating goal to consistently meet a 0.3 NTU limit), this would provide an adequate margin of safety from variability in treatment performance and turbidity measurement error. However, the TWG believed strongly that at 0.1 NTU and below measurement variability became a much more significant issue of technical feasibility. Therefore, compliance strategies at the 0.1 NTU limit represent a greater commitment of resources because of this technology shift and issues related to turbidimeter accuracy precision at very low turbidity levels.

The M-DBP Committee explored two compliance options for the 0.1 NTU limit. One compliance option includes the use of a barrier technology, such as a membrane filter, that could effectively reduce turbidity levels to 0.1 NTU. Over 95 percent of all surface water systems using rapid granular filtration and serving populations of 10,000 or more would need to make this technological upgrade.

Ozone was evaluated as a second compliance option, to serve as a primary treatment choice as an alternative to systems being required to achieve the 0 1 NTU limit It was assumed that 85 percent of systems would use ozone treatment technologies, and 10 percent of systems would need to use a barrier technology, such as a filter membrane. Five percent of systems are assumed to not need additional technologies beyond those required for a 0 1 NTU or 0 2 NTU limit

The M-DBP Committee discussed lowering the maximum CFE below 5 NTU. Technical analysis during previous discussions on the rule had assumed a fixed maximum CFE level of between 1.0 and 2.0 NTU for the previous options Three options for maximum CFE levels (2.0 NTU, 1 NTU, and 1.0 NTU) were analyzed and were the subject of cost modeling. The actual values represented by these proposed CFE levels were the subject of some discussion. While the 2.0 and 1.0 maximum levels refer to those specific values, the 1 NTU maximum is best understood as representing values less than 1.5 NTU, due to significant figures.

The data available to the TWG demonstrated that 80 to 90 percent of systems already achieve 1.0 NTU, and the cost analysis revealed that the primary issue is compliance with CFE turbidity. The Committee agreed as part of this discussion that CFE turbidities of 0.3 NTU were achievable by systems with current filtration technologies and focused their deliberations on this level.

2.2.1 Turbidity Monitoring

Concurrent with the discussion on CFE turbidity levels, the M-DBP Committee reviewed individual filter monitoring requirements as implemented in several States. Individual filter monitoring is intended to supplement CFE monitoring by providing a method to identify problems with individual filter operations that might otherwise be masked in CFE turbidity levels.

The State of California has individual filter monitoring requirements. Filter readings are taken at least once every 15 minutes, and exceedances are reported to the State in monthly reporting forms. Filter ripening, the period immediately after cleaning the filter and the start of a filter run, is monitored to ensure that turbidity levels, commonly elevated during ripening, lower to normal levels within 4 hours.

Under the approach considered by the Committee, California served as a point of departure for discussions on possible configurations for monitoring provisions. The M-DBP Committee made the following recommendations regarding individual filter effluent turbidity levels:

- Individual filter turbidimeters continuously record turbidity levels with exceedance reporting to the State;
- Different types of exceedances would compel different responses;
- Any exceedance of 1.0 NTU from any filter would be reported in an end-of-the-month exceedance report;
- If there is no apparent reason for the abnormal filter performance, the system shall conduct a filter assessment;
- If readings of 1.0 NTU are recorded in three consecutive months for any filter, an assessment of that filter by the utility is conducted;

- If readings of 2 0 NTU are recorded in two consecutive months, a State or third-party Comprehensive Performance Evaluation (CPE) would be conducted: and,

- In all cases, exceedance readings are based on two consecutive filter readings, 15 minutes apart, to provide for instrument error

2.2.3 Disinfection Benchmarking

One of the underlying premises of the M-DBP Committee deliberations was that existing microbial protection must not be significantly reduced as a result of utilities taking the necessary steps to comply with provisions of the Stage 1 DBPR. A key recommendation from the Committee was that EPA include a provision for disinfection benchmarking in the IESWTR. Benchmarking will allow systems to more precisely identify current levels of disinfection inactivation (i.e., disinfection profiles) and evaluate potential changes that may possibly occur as the result of changes in disinfection practices to meet new DBP MCLs.

Only certain utilities would be required to develop a disinfection profile and keep it on file for State review during sanitary surveys (i.e., systems with TTHM/HAA5 levels exceeding 80 percent of the Stage 1 DBPR MCLs). Of these systems, only a subset would be required to submit the profile to the State as part of a package submitted for review (i.e., if the system is intending to make significant changes to its disinfection practice).

In general, utilities that meet the criteria for preparing a profile may either create the profile by conducting new daily monitoring or by using "grandfathered" data. A disinfection profile consists of a compilation of daily *Giardia lamblia* log inactivation measurements computed over the period of a year. If new data are required, systems must begin a 1-year monitoring effort, to start no later than 15 months after IESWTR promulgation. Profiles can span 1 to 3 years depending upon the information currently available. The State will review disinfection profiles as part of its sanitary survey.

2.2.4 Sanitary Surveys

Sanitary surveys are used as a preventive tool to identify water system deficiencies that could pose a threat to public health. The July 1994 Federal Register proposed that all systems that use surface water, or groundwater under the influence of surface water, have a periodic sanitary survey regardless of whether they filter. Prior to the IESWTR, the only sanitary survey requirements at the Federal level have been those specified in the 1989 Total Coliform Rule. Beyond requiring sanitary surveys for systems collecting less than 5 total coliform samples each month and specifying frequency, the Total Coliform Rule does not specify what must be addressed in a sanitary survey or how such a survey should be conducted. The SWTR does not specifically require water systems to undergo a sanitary survey; however, unfiltered water systems, as one criteria to remain unfiltered, have an annual on-site inspection to assess the system's watershed control program and disinfection treatment process.

Since the publication of the proposed IESWTR in 1994, EPA and the States have issued joint guidance on sanitary surveys. The guidance outlines the following elements as integral components of a comprehensive sanitary survey: source; treatment; distribution system; finished water storage; pumps/pump facilities and controls; monitoring, reporting, and data verification; water systems management and operations; and operators compliance with State requirements. The M-DBP Committee recommended that surveys must be conducted for all surface water systems (including ground water under the influence of surface water) no less frequently than every three years for community systems and no less frequently than every five years for noncommunity systems Any sanitary survey conducted after December 1995 that addresses the eight sanitary survey components of the guidance document may be counted or "grandfathered" for purposes of completing the first round of surveys

2.3 Cost and Benefit Analyses Conducted

National compliance costs and projected benefits were estimated for all elements of the IESWTR with cost implications. These benefit and cost projections follow in Chapters 4 and 5

The largest and most complex national compliance cost estimates are associated with compliance under the strengthened turbidity treatment provisions. Compliance cost estimates were based on the following:

- Determining the number of utilities currently meeting the requirement;
- Identifying filtration improvement activities for those that do not currently meet the requirement;
- Assessing the number of systems that would engage in improved operational practices and how often those practices would be implemented; and,
- Determining unit costs of improved operational practices.

Comparative analyses of options were developed during the M-DBP Committee technical discussions. Each stage of the rule development was accompanied by a comparison in cost among the alternatives. As the approach was refined, final sets of assumptions and models were reviewed until the national compliance cost estimates presented in this RIA were established.

For cost estimates for both turbidity monitoring and disinfection benchmarking, the M-DBP Committee identified the activities associated with each recommendation and then obtained unit costs for the activities to estimate total costs. A discussion of system and treatment baselines, including source data, follows in Chapter 3. Chapter 5 details the manner in which the cost estimates were generated, and provides a summary of total costs.

3: Baseline Analysis

3.1 Industry Profile

Data on utilities and their capacity to achieve treatment levels were analyzed to develop the national compliance cost model. Data inputs include the total number of systems to which the provisions would apply, households and populations served by these systems, average and maximum system flow rates, and applicable costs of capital, operations and maintenance, and labor. Utilities are characterized as to whether they are able to achieve compliance with the recommended provisions, and if not, which practices they will need to modify in order to comply.

3.1.1 Total Number of Systems

The rule includes treatment provisions for surface water systems serving populations of 10,000 or more. Systems serving less than 10,000 people will be covered in the Long-Term 1 Enhanced Surface Water Treatment Rule (LT1).

The number of systems is derived from preliminary data collected as a result of the 1996 Information Collection Rule (ICR) data collection effort and from the EPA's Safe Drinking Water Information System (SDWIS). SDWIS includes a registry of water systems, self-reported violations of water quality regulations, and numbers of significantly non-compliant water systems, among other data. Unfiltered systems and systems that include softening plants are not included in the total number of systems.

Preliminary information collected through the ICR provides a more recent and accurate picture of system numbers and characteristics. Under the ICR, data are available for systems that serve populations of 100,000 or more. For systems serving less than 100,000, the analysis uses the SDWIS database. In combination, the two data sources provide a reasonable accounting of water systems.

Analysis using these two data sources identified 1,381 surface water systems meeting the turbidity treatment criteria established for the rule (i.e., serving 10,000 or more and using rapid granular filtration). This estimate of the number of surface water systems closely matches system estimates used in the 1994 analysis of the proposed IESWTR, which identified 1,363 systems, a difference of slightly more than 1 percent. Differences in the number of systems between 1994 and 1997 are explained by the great variability inherent in the databases. The number of systems as reported in SDWIS changes frequently, even daily, and reflects, among a number of factors, changing ownership and the continuous establishment and dissolution of systems.

Although the turbidity and disinfection benchmarking requirements are applicable only to systems that serve 10,000 or more people, the sanitary survey provisions in the rule will apply to all systems, including those serving fewer than 10,000 people. Of these smaller systems, 5,165 surface water systems were identified and used in the cost estimation procedures for sanitary surveys.

Number of Plants per System Size

To develop costs for turbidity requirements, the analysis included the total number of plants serving populations of 10,000 or more (Exhibit 3 1) The total number of systems under 10,000 was used to calculate the costs associated with sanitary surveys. For smaller systems (those serving less than 75,000 people), the Technologies Working Group (TWG) assumed 1 plant per system For systems serving more than 75,000 people, 2 plants per system were assumed. A total number of 1,728 plants was used for the analysis.

Exhibit 3.1 Systems and Plants using Rapid Granular Filtration per Size of Population Served

Population Served	Number of Systems	Average Number of Plants per System	Total Number of Plants
10,000-25,000	594	1	594
25,000-50,000	316	1	316
50,000-75,000	124	1	124
75,000-100,000	52	2	104
100,000-500,000	259	2	518
500,000-1,000,000	26	2	52
>1,000,000	10	2	20
Total	**1,381**		**1,728**

* In general, the IESWTR does not apply to systems in this size category However, the sanitary survey provisions do apply to systems serving under 10,000 people

3.1.2 Treatment Characteristics in Systems Serving 10,000 or More People

Once the universe of surface water systems and plants was established, the current treatment characteristics were profiled to determine the methods utilities are using to meet the current standards and how utilities will have to modify their practices to comply with the IESWTR.

Four databases that summarize the historical turbidity of various filtration plants were evaluated to assess the national impact of modifying turbidity limits. The databases depicted turbidity information from the American Water Works Service Company (AWWSCo), two multi-state surveys, and a survey of plants participating in the Partnership for Safe Water program. Only turbidity data from plants serving 10,000 or more people were used. The analyses also included only plants that meet the current 95th percentile turbidity standard, 0.5 NTU, and the current maximum turbidity standard, 5 NTU, in all months. Each of the databases was analyzed to assess the current performance of plants with respect to the number of months in which selected 95th percentile and maximum turbidity levels were exceeded.

The AWWSCo database included annual data for plants operated by the company in 10 states. EPA analyzed composite filtered effluent turbidity data obtained from the AWWSCo plants.

The multi-state survey data, which were divided into two databases (State 1 and State 2), included turbidity data from 86 plants in 11 states. The plants in the State 1 database were expected to provide a more representative sample of typical plant performance among the plants for which data were available The State 2 database increased regional representation that reflects geographic variations that may not have been captured in the State 1 database

The last database included in the turbidity analysis was from plants participating in the Partnership for Safe Water, a joint venture of several public and private organizations, including the American Water Works Association and EPA, among others. At the time of analysis, the Partnership membership included 199 utilities serving approximately 80 million people. The data used were derived from the Partnership's 1997 report

These databases provide baseline data to determine the number of systems and plants that would be expected to modify their treatment practices in order to comply with the turbidity treatment requirements of the rule The analysis primarily used data from the State 2 and Partnership for Safe Water databases, as their data were considered more complete and provided a better cross-section of utilities

Each data set contains a subset of systems that do not presently comply with the IESWTR The State 2 database provides a broad geographical distribution of the nation's systems. The Partnership database is more representative of larger, more professionally managed systems. The analysis captured these differences by assuming that the State 2 database most accurately reflects the status of systems serving populations below 100,000 people, and that the Partnership database accurately reflects systems serving populations above 500,000 people. For those systems serving between 100,000 and 500,000 people, an average of the two databases was used. It was not possible to merge the data from the three databases, as methods of collection, population studied, and data compatibility differed.

The data indicated that, in general, as the turbidity limits became more stringent, fewer systems were able to meet the limits with their current operational practices. For each of the alternatives discussed during the regulation development process, different compliance figures were used.

Systems presently unable to comply with the recommended turbidity limits are described as "occurrence" systems. The percentages of occurrence systems for each system size category determine the total number of systems for which the national costs of compliance were calculated.

3.2 Cost Analysis

3.2.1 System Population Size Categories and Total Population

System population characteristics are important to this analysis in several ways. First, all utilities are categorized by the size of the population served. For this RIA, only systems serving 10,000 or more people were included (except in the case of sanitary surveys). These systems are divided into the seven size categories used throughout the analysis and consistent with industry definitions of system size categories

Household costs, however, did not use population data. Instead, for each system size category, average flow in millions of gallons per day (MGD) was converted to an annual flow and then divided by a number representing annual household use. The result was multiplied by the number of systems in the size category to provide the total number of households for each size category For further explanation of the derivation of household costs, refer to Appendix F.

3.2.2 Average System Flow Rates

Average system flow rates are integrated into the national compliance cost model in determining household costs Average and maximum system flows, expressed in millions of gallons per day (MGD), were developed separately from the cost model but are key components in generating unit costs (EPA, July 1998b)

The 1991 Water Industry Database (WIDB) contains a higher value for the largest (greater than 1 million) system size category (350 MGD versus 270 MGD) than the data sources used for the bulk of the cost estimation under this analysis This higher flow rate is calculated and displayed in the cost appendices, where appropriate

3.2.3 Cost of Capital

A cost of capital rate of 7 percent was used to calculate the unit costs for the national compliance cost model. This rate represents the standard social discount rate preferred by the Office of Management and Budget (OMB) for benefit/cost analyses of government programs and regulations.

In addition to the 7 percent rate, unit costs were generated using both a 10 percent and 3 percent rate and evaluated using the national cost model. The 10 percent cost of capital rate provides a link to the 1994 IESWTR cost analyses and is assumed to be a reasonable estimate of the cost to utilities to finance capital purchases that may be required under the recommended provisions.

The exhibits of cost estimates presented in Chapter 5 reflect the 7 percent rate. The 10 and 3 percent rates are presented in the cost summary exhibit (Exhibit 5.1) for purposes of comparison. Costs presented in the RIA are expressed in 1998 constant dollars.

3.2.4 Unit Costs

Unit cost estimates are an integral part of the calculation of national compliance costs for the turbidity treatment feature of the rule. Both capital and operating and maintenance costs for each treatment activity have been estimated (EPA, July 1998b). Unit costs were calculated at 3, 7, and 10 percent costs of capital. Unit costs estimates, including revised flows, are included in Appendices B through D.

3.2.5 Costs of Labor

Labor rates in the national compliance cost model are used primarily to estimate costs to utilities and States of the turbidity monitoring and disinfection benchmarking elements of the rule. Both of these elements include a detailed cost model. Labor rates for these cost models were developed through the TWG process detailed elsewhere and through a limited survey of plant and system operators conducted by the American Water Works Association (AWWA)

Labor rates are calculated for three categories: management, technical, and clerical. Management are those individuals with overall responsibility for the functioning of a plant or system. Technical engineers are those individuals who operate a plant and would be expected to perform most of the functions described in the labor burden and cost model. Clerical staff are those individuals primarily involved in administrative office functions.

A labor load rate, representing fringe payments, indirect costs, and general and administrative costs, was multiplied by the direct labor rate This rate was originally estimated at 150 percent of the direct labor rate (1 5 load), though current Department of Labor statistics indicate that a lower, 140 percent, rate (1 4 load) is more accurate The 1 4 load rate was used in the final calculations

3.3 Benefit Analysis

Estimating the benefits of reducing exposure to *Cryptosporidium* requires performing a risk assessment to determine the number of illnesses reduced by the rule and then assigning a value to those reductions Risk assessments require information on health effects, toxicity, and exposure Benefits analysis requires information on the value of reducing health and other potential damages. Data to estimate the benefits associated with reducing health damages (cost-of-illnesses avoided) were derived from previous survey research on the costs for a giardiasis outbreak (Harrington, et al , 1985 and 1989).

3.3.1 Health Effects and Toxicity

Several sources were used to assess the health effects and hazards posed by *Cryptosporidium* in drinking water. Data from the Center for Disease Control (CDC) provided the number of reported outbreaks and resulting cases of cryptosporidiosis (Center for Disease Control, 1996). Other publications provided information on symptoms and the incidence of hospitalization and fatalities for the Milwaukee outbreak (Mackenzie, et al , 1994). Information on the toxicity, dose-response relationship, and ingestion assumptions were derived from recent peer-reviewed articles (see Chapter 4). These sources described recent studies on the infection and illness in human volunteers subjected to controlled exposure to oocysts of *Cryptosporidium* to arrive at an estimate of the risk and toxicity of *Cryptosporidium*.

The analysis described in Chapter 4 on the characterization of national finished water *Cryptosporidium* distribution was used to assess the population exposure to *Cryptosporidium* in finished water supplies (EPA, July 1998a).

4: Benefits Analysis

4.1 Introduction

The health benefit derived from the promulgation of a drinking water standard is typically thought to be represented by the health damages that will be avoided as a result of compliance with the standard This is, however, an incomplete concept The complete concept of the economic benefit of improved drinking water standards consists of the total value of benefits to the consumer. These benefits include reducing the probability of suffering health damage and other losses of utility captured in the consumer's "willingness-to-pay (WTP)" for the change (Freeman, 1979). To the extent possible, the analysis presented in this chapter focuses on quantifying and valuing the WTP to avoid health damages, using out-of-pocket costs only as a substitute measure if the more complete value is not available

The economic benefits of the Interim Enhanced Surface Water Treatment Rule (IESWTR) derive from the increased level of protection to public health. Reducing turbidity is indicative of a more efficient filtration process (Rose, 1997). As the efficacy of the filtration process improves, a reduction in waterborne pathogens, particularly *Cryptosporidium*, is likely to be achieved (EPA, November 3, 1997). In this analysis, the benefits of improved filtration are assumed to be entirely due to the decreased probability of cryptosporidiosis, the infection caused by *Cryptosporidium*, and the avoidance of resulting health costs. Exposure to other pathogenic protozoa, such as *Giardia*, or other waterborne bacterial or viral pathogens, are almost certainly reduced by the recommended turbidity provisions but are not quantified. Also, reduction in waterborne disease outbreaks, which involve societal costs other than costs of illness (e g., loss of business due to a boiled water advisory, purchase of bottled water or the action of boiling water) were not included because of difficulties in making such assessments.

Section 4 2 explains the analysis of the economic benefits principally associated with health damages and resulting costs due to cryptosporidiosis avoided under the IESWTR. Section 4.3 discusses, but does not quantify, other economic benefits that may result from the rule, including reduced costs to sensitive subpopulations, reduced or avoided costs of averting behavior, and enhanced aesthetic water quality

4.2 Health Benefits from Reducing Exposure to *Cryptosporidium*

4.2.1 Exposure Assessment

Drinking water supplies can be contaminated by a number of pathogens that have been identified as the cause of waterborne disease outbreaks (Center for Disease Control, 1996). In particular, the contamination of drinking water supplies with the parasite *Cryptosporidium* poses a health risk to the public because the parasite is highly infectious, resistant to inactivation by chlorine, and small in size and consequently difficult to filter (Guerrant, 1997). This analysis of benefits for the IESWTR focuses on the reduction of exposure to *Cryptosporidium* in drinking water supplies through filtration and improved operation and performance of the filtration process.

Cryptosporidiosis is an acute, self-limiting illness lasting 7 to 14 days with symptoms that include diarrhea, abdominal cramping, nausea, vomiting, and fever (Juranek, 1995). Exhibit 4 1 contains information on the symptoms of patients with cryptosporidiosis observed during a major outbreak in Milwaukee.

Exhibit 4.1 Symptoms of 205 Patients with Confirmed Cases of Cryptosporidiosis during the Milwaukee Outbreak			
Symptom	Percent	Mean	Range
Water Diarrhea	93	Duration 12 days	1 - 55 days
Abdominal Cramps	84	N/A	N/A
Weight Loss	75	10 pounds	1 - 40 pounds
Fever	57	100 9°F	99 0° - 104.9°F
Vomiting	48	N/A	N/A

Source Mackenzie et al , 1994

Several subpopulations are more sensitive to cryptosporidiosis, including the young, elderly, malnourished, disease impaired (especially those with diabetes), and a broad category of those with compromised immune systems, such as AIDS patients, those with Lupus or cystic fibrosis, transplant recipients, and those on chemotherapy (Rose, 1997). Symptoms in the immunocompromised subpopulations are much more severe, including debilitating voluminous diarrhea that may be accompanied by severe abdominal cramps, weight loss, malaise, and lowgrade fever (Juranek, 1995). Mortality is a substantial threat to the immunocompromised infected with *Cryptosporidium*:

> The duration and severity of the disease are significant: whereas 1 percent of the immunocompetent population may be hospitalized with very little risk of mortality (< 0 001), *Cryptosporidium* infections are associated with a high rate of mortality in the immunocompromised (50 percent) (Rose, 1997).

There is no effective treatment for cryptosporidiosis (Guerrant, 1997).

According to waterborne disease outbreak data for 1993-1994, the Centers for Disease Control (CDC) estimate that *Cryptosporidium* was responsible for over 400,000 cases of gastrointestinal infection (Exhibit 4.2) (EPA, November 3, 1997). The vast majority of these cases occurred in one outbreak in Milwaukee, Wisconsin, the largest recorded outbreak of waterborne disease in the United States. Of the approximately 800,000 persons served by the water system, it was estimated using standard epidemiological methods for estimating cases of illness that over 400,000 (50 percent) became ill. Of those, 4,000 required hospitalization (approximately 1 percent of those becoming ill), with at least 50 additional cryptosporidiosis-associated deaths among immunocompromised individuals (as reported on death certificates) (Mackenzie, et al., 1994; Hoxie, et al., 1996).

Exhibit 4.2 Waterborne *Cryptosporidium* Outbreaks in the U.S. Associated with Drinking Water by Type of Water Source (1984-1995)			
Date	Location	Water Source	Number of Cases
1984	Braun Station, San Antonio, TX	Well	2,000
1986	Albuquerque, NM	Lake	56
1987	Carrollton, GA	River	13,000
1992	Jackson County, OR	Springs and River	15,000
1991	Reading, PA	Well	551
1993	Milwaukee, WI	Lake	403,000
1993	Yakima, WA	Well	7
1993	Cook County, MN	Lake	27
1993	Las Vegas, NV	Lake	78
1994	Walla Walla, WA	Well	104

Source: Modified from Rose, 1997

The incidence of cryptosporidiosis indicated by the outbreak data presents a dilemma of interpretation. On one hand, the Milwaukee outbreak is an anomaly in its magnitude of incidence relative to the incidence historically reported in other outbreaks. On the other hand, the Milwaukee outbreak was detected late, at about the time when the peak amount of cryptosporidiosis occurred, suggesting that there may be other such incidences that were unrecorded. Only large outbreaks of cryptosporidiosis cases concentrated in a specific location have a chance of being detected and reported. Isolated cases (endemic) are much less likely to be reported. Many, perhaps most, infected individuals may not seek medical treatment for their symptoms. If the infected individuals do seek medical treatment, primary care physicians may not be able to isolate *Cryptosporidium* as the cause of the illness. If diagnosed, physicians may not report the information to the CDC. These compounded impacts could lead to gross under-reporting and under-estimating of cryptosporidiosis cases (Okun, et al., 1997).

In addition, the presence of *Cryptosporidium* in surface water sources is relatively common. Exhibit 4 3 summarizes the level and occurrence, where available, of *Cryptosporidium* in surface water sources and in finished drinking water.

Exhibit 4.3 Summary of Surface Water Monitoring Data for *Cryptosporidium* Oocysts

Sample Source	Number of Samples	Positive Samples (percent)	Range of Oocyst Concentration (Oocysts/L)	Mean (Oocysts/L)	Reference
Stream	19	73 7	0 – 240	1 09	Rose, et al , 1988b
Stream/ River	58	77 6	0.04 – 18	0 94	Ongerth and Stibbs, 1987
Surface Water	111	51 4	0 02 – 1 3		Rose, 1988
Stream/ River	38	73 7	< 0 001 – 44	0 66	LeChevallier, et al , 1991a
Impacted River	11	100	2 – 112	25	Rose, et al., 1988a
Reservoir inlet	10	30	0 007 – 0 024	0.012	Norton and LeChevallier, 1997
Reservoir outlet	10	70	0.017 – 0 31	0 081	Norton and LeChevallier, 1997
Raw Water	85	87	0.07 – 484	2.7	LeChevallier, et al , 1991a
Lake	20	70 7	0 – 22	0 58	Rose, et al., 1988b
Lake/ Reservoir	32	75	1 1 – 8 9	0 91	Ongerth and Stibbs, 1987
River (pristine)	6	NA	0.8 – 5800	1920	Madore, et al., 1987
River/ Lake	262	51.5	0.065 – 65.1	2.4	LeChevallier and Norton, 1995
Lakes/ Rivers	147	20	0.3 – 9.8	2 0	Atherholt, LeChevallier and Norton, 1995
Lakes	179	5.6	0 – 22.4	0.333 (median)	Archer, et al , 1995
Streams	210	6.2	0 – 20 0	0.07 (median)	Archer, et al., 1995
Filtered Water	82	26.8	0.001 – 0.48	0.015	LeChevallier, et al., 1991b
Finished Water (unfiltered)	6	33.3	0.001 – 0.017	0.002	LeChevallier, et al., 1992
Finished Water	262	13.4	0.0029 – 0.57	0.033	LeChevallier and Norton, 1995

Source EPA, June 24, 1998a.

Because *Cryptosporidium* is exceptionally resistant to inactivation using chlorine, physical removal by filtration is extremely important in controlling this organism. Based on the turbidity provisions in the rule, many water systems would be expected to place an increased emphasis on improving overall filtration performance. In addition to improving overall filter performance, the monitoring requirements for individual filters in the proposed rule will improve the performance of individual filters at the water treatment plants.

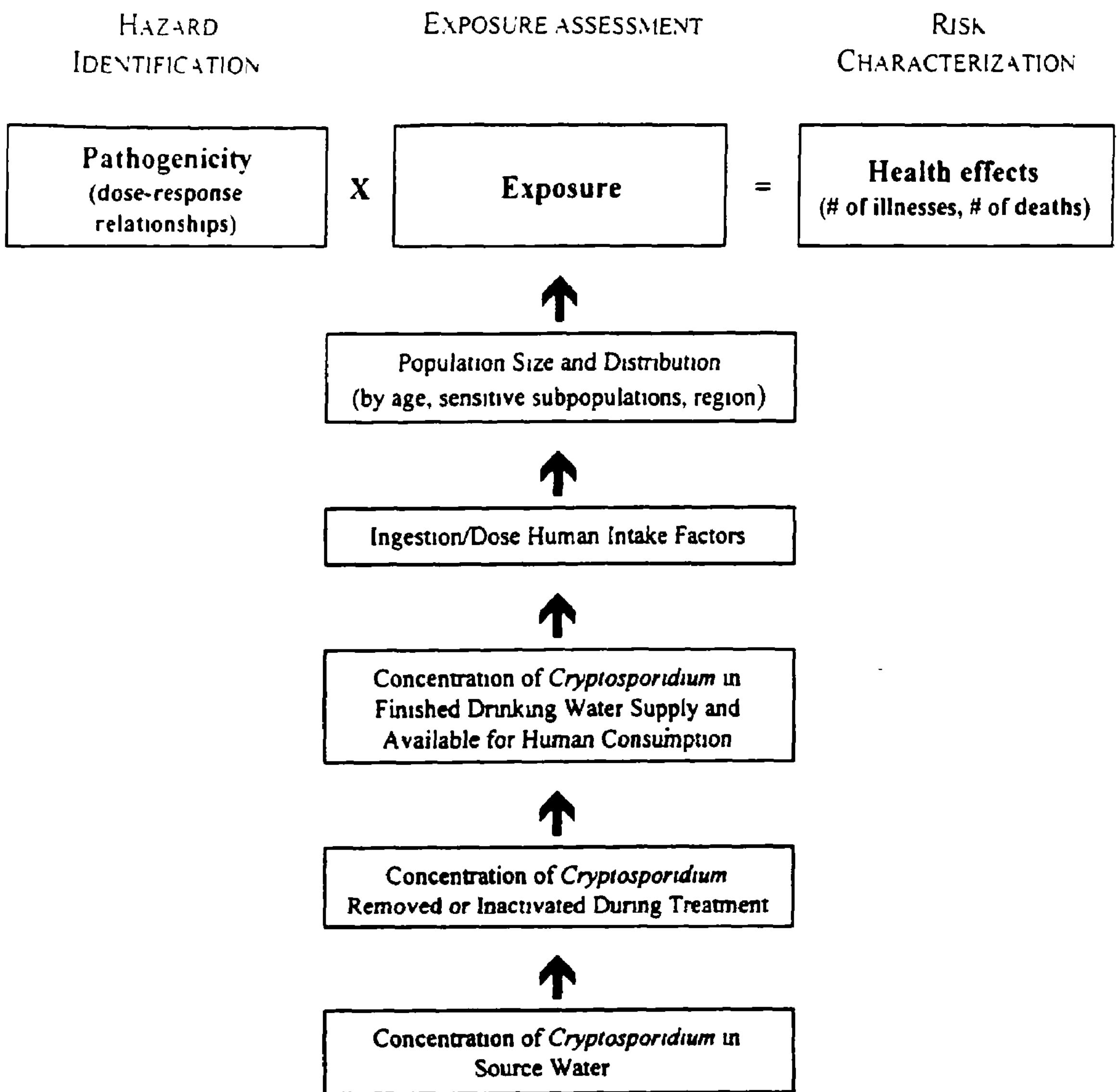
The following benefits analysis is based on the assumption that improved overall filtration performance and tighter control over individual filter operations will lead to fewer *Cryptosporidium* oocysts in finished drinking water supplies This is expected to reduce the incidence of cryptosporidiosis in two ways First, the endemic risk (isolated cases that are not reported) is assumed to be reduced because the improved overall filtration performance will remove a greater portion of oocysts from the finished water supply on a regular basis Second, the risk of outbreaks (large numbers of reported cases) may also be reduced as the enhanced monitoring and tighter control over individual filter operations allow operators to detect and prevent breaches in treatment (EPA, November 3, 1997) The risk assessment described in the next section quantifies the expected reduced endemic risk, with a discussion in Section 4 3 2 of the expected reduced risk of outbreaks

4.2.2 Risk Assessment Methodology

Risk assessment is an analytical tool that can be used to characterize and estimate the potentially adverse health effects associated with exposure to an environmental hazard, in this case *Cryptosporidium* (Rose, 1997) This risk assessment—used to estimate and understand potential benefits—follows a standard methodology employed within EPA and the Federal government (National Research Council, 1983). Risk assessment requires the use of scientific data and, if data are not available, reasonable assumptions, to produce estimates when there is considerable uncertainty about the exact nature, extent, and degree of the risk This risk assessment makes use of ranges and probability distributions to take into account scientific uncertainty.

Risk assessment generally involves three basic steps: identifying the type of health effect and magnitude of danger from the substance in question (hazard identification), estimating the exposure (exposure assessment), and then combining the two to characterize the overall risk (risk characterization) (National Research Council, 1983). There are three possible endpoints to risk characterization: infection, illness (morbidity), and deaths (mortality). This analysis calculates the number of illnesses and the associated number of premature deaths attributable to infection from *Cryptosporidium*. Exhibit 4.4 displays the steps in the risk assessment process for characterizing the endemic risk of morbidity and mortality from *Cryptosporidium* in drinking water.

Exhibit 4.4 Steps in the Risk Assessment Process for *Cryptosporidium*



Source National Research Council, 1983

In order to quantify the health effects due to *Cryptosporidium* in drinking water, the following input variables are necessary:

- The dose-response function (relation of ingestion to infection);
- The viability of oocysts;
- The rate of morbidity (illness) given infection; and
- The ingested dose (concentration of oocysts in finished water x daily ingestion of water).

The following sections describe the assumptions and derivation of these variables used in the risk assessment.

4.2.3 Hazard Identification

A key step in the risk assessment is to characterize the incidence of the health effect in relationship to the dose administered (dose-response relationship). Dose-response information for *Cryptosporidium* is represented by the following general model defining the probability of infection given a dose of *Cryptosporidium* (Haas, et al., 1996).

$$\Pi = 1 - \exp(-d / k)$$

Where Π = probability of infection
d = ingested dose
k = slope parameter (relation of ingestion to infection)

Using data from human ingestion trials of *Cryptosporidium parvum* (*C. parvum*) (DuPont, et al., 1995), the best fit value for k (i.e., the number of infections given ingestion), is estimated at 238.6, with a 95 percent confidence interval of 132.0 to 465.4 (Haas, et al., 1996). These trials were conducted with healthy, medically screened individuals; as a result, the slope parameter k may be different for sensitive subpopulations; i.e., a lower dose may induce a response in sensitive individuals equivalent to what a higher dose induces in healthy individuals.

Not all infections will result in illness and observable symptoms. The proportion of all infections that result in illness is referred to as the morbidity ratio. Based on human ingestion trials, a constant morbidity ratio of 0.39 (i.e., 39 percent of infections result in illness) was estimated, with upper and lower 95 percent confidence limits of 0.62 and 0.19 (Haas, et al., 1996, DuPont, et al., 1995). The human ingestion trials (DuPont, et al., 1995) assume no pre-existing immunity. Recently, however, it was found that after repeated exposure to *C. parvum* the rate of illness was the same as the initial exposure, but the symptoms were less severe and fewer oocysts were shed by re-infected subjects (Okhuysen, et al., 1998).

Different strains of *Cryptosporidium* may produce different dose-response relationships and morbidity ratios. Preliminary results of human ingestion trials indicate that one strain results in approximately the same dose-response relationship as *C. parvum*, while another strain is one log more infectious than *C. parvum* but is encountered less frequently (DuPont, 1997). Until more complete experimental data are available, the dose/response relationship for *C. parvum* will be used as a proxy for all species of *Cryptosporidium*. Additionally, the dose-response relationship and morbidity rate could be different for sensitive subpopulations. The analysis uses a lognormal distribution for the dose-response relationship that runs from a low value of 78 to a high value of 782 (mean of 238.6), a one order of magnitude spread. This distribution should adequately characterize the potential variability of the dose-response relationship across sensitive populations.

Risk Assessment Assumptions:

Dose/Response Relationship $\Pi = 1 - \exp(-d/k)$

k value	mean = 238.6, 5th percentile = 132 0, 95th percentile = 465 4 (data fit to log normal distribution)
Morbidity	mean = 0.39, 5th percentile = 0.19, 95th percentile = 0 62 (assumed triangular distribution)

Source Haas et al., 1996

4.2.4 Baseline Exposure Assessment

Estimating the exposure to *Cryptosporidium* requires four basic pieces of information used to develop two baseline assumptions (described below): the concentration of *Cryptosporidium* in source water; the concentration of *Cryptosporidium* removed or inactivated during treatment; the concentration of *Cryptosporidium* remaining in finished water supplies; and the amount of drinking water consumed on a daily basis.

Exhibit 4.5 displays the national distribution of expected raw (source) and finished water *Cryptosporidium* concentrations. The largest survey of *Cryptosporidium* oocyst occurrence in source water, using currently available methods, is LeChevallier and Norton (1995), which was analyzed by EPA in 1996. The mean concentration at the 69 sites from the eastern and central U.S. seems to be represented by a lognormal distribution. Although limited by the small number of samples per site (one to sixteen samples; most sites were sampled five times), variation within each site appears to be described by the lognormal distribution. The quartiles, 90th, and 95th percentiles for these occurrence data are presented in Exhibit 4.5.

EPA assumes two potential sources of error in the LeChevallier and Norton (1995) data: 1) measurements from the eastern and central U.S. may not be representative of the U.S. as a whole; and 2) the existing analytical method provides poor *Cryptosporidium* recovery. EPA assumes that the magnitude of the error from each source is approximately equal (about 0.5 logs) but opposite in sign. Thus, the two error sources act to reinforce the original distribution derived from the LeChevallier and Norton (1995) data. The poor recovery acts to produce a measured distribution lower than expected, whereas the possibly poorer quality source water sampled by LeChevallier and Norton (than the U.S. as a whole) acts to produce a measured distribution higher than expected. Insufficient data exist to further evaluate these assumptions using quantitative statistical methods.

Assumptions were made about the performance of current treatment in removing or inactivating oocysts to estimate the finished water *Cryptosporidium* concentrations. EPA based these assumptions on historical studies of *Cryptosporidium* and *Giardia lamblia* removal efficiencies by rapid granular filtration as discussed in the IESWTR Notice of Data Availability (EPA, November 3, 1997). In summary, a range of 2 to 6 log removal of *Cryptosporidium* oocysts was observed in several studies conducted over a decade, depending on source water quality and treatment plant efficiency.

Generally removal in a 3 to 6 log removal range is based on pilot plant studies that may be more accurate for measuring oocyst removal since, in general, enough cysts were present in the source water to detect cysts in the finished water Log removal at the low end of the range is primarily based on data from full-scale plants, some of which may not have been well operated during the evaluation period These full-scale data were collected before the Surface Water Treatment Rule (SWTR) became effective and, as such, were collected from full-scale plants some of whose operation may have been deficient as compared with more recent operation Also, removal data indicated for full-scale plants are probably biased to the low side because many of the measurements in the finished water are below detection levels and in such cases finished water values were assumed to equal detection values. Current performance among treatment plants is likely to be better than that reflected in the data sets for full-scale plants that had been collected before the effective date of the SWTR, due to improvements resulting from volunteer partnership programs (i e , the Partnership for Safe Water) that improve treatment efficiency in addition to the SWTR

EPA believes that the SWTR and the Partnership for Safe Water have influenced the removal range of typical plant performance upward from 2.0-2.5 log removal to 2.5-3.0 log removal, recognizing that some plants fall above and below this range. Based on this information, the following two assumptions were made about the performance of current treatment in removing or inactivating oocysts so as to estimate finished water *Cryptosporidium* concentrations. The standard assumption is that current physical removal treatment of oocysts results in a normal distribution mean of 2.5 logs (and a standard deviation of 0 63 logs). Because the finished water oocyst concentration represents the baseline against which improved removal resulting from the rule is compared, variations in the baseline log removal assumption could have considerable impact on the risk assessment. To evaluate the impact of the removal assumptions on the baseline and resulting improvements, an alternative normal distribution mean of 3.0 logs (and a standard deviation of 0.63 logs) was also used to calculate finished water concentrations of *Cryptosporidium* as a sensitivity analysis (Exhibit 4.5).

Exhibit 4.5 Baseline Expected National Source Water and Finished Water *Cryptosporidium* Distributions, Based on Current Treatment (oocysts/100L)

Percentile	Source Water Concentrations	Finished Water Concentrations (oocysts/100L) Assuming Current Removal Equals: 2.5 Logs	3.0 Logs
25	103	0.20	0.07
50	231	0.73	0.23
75	516	2.59	0.82
90	1064	8.10	2.56
95	1641	16 04	5.07
Mean		**4.26**	**1.35**
Standard Deviation		**25.43**	**7.76**

The concentration of oocysts in finished water refers to a count of the total number of oocysts in the water and does not take into account whether the oocysts are viable and potentially infectious. The viability of oocysts after treatment is an area of scientific uncertainty. One study (LeChevallier, Norton, and Lee, 1991) found that one tenth to one third of oocysts in untreated water are viable and potentially infectious based on internal morphological structures To take into account the impact of the lack of specificity for species detection (many of which may not be infectious) and inability of methods to distinguish between a live and dead oocyst, EPA chose the low end of the range for this analysis and assumed that 10 percent of oocysts in finished water are potentially viable and infectious The viability/infectivity is modeled in this analysis as a uniform d -tribution with a mean of 10 percent, a .ow value of 5 percent, and a high value of 15 percent

Risk Assessment Assumptions:

Viability/Infectivity (assumed uniform distribution):

low = 5 percent
average = 10 percent
high = 15 percent

The daily water ingestion of healthy adults was assumed to be lognormally distributed with a mean of 1 948 liters per person and a standard deviation of 0.827 liters. The distribution was truncated, or capped, at three liters per day (Haas and Rose, 1995).

Risk Assessment Assumptions:

Daily ingestion of water:

1.948 liters per person (data fit to a lognormal distribution with standard deviation of 0.827 liters and capped at 3 liters/day)

Source Haas and Rose, 1995

4.2.5 Risk Characterization

The above assumptions and factors were used as inputs to a model that calculates the annual number of infections. The calculations include determining mean daily individual exposure to oocysts from drinking water by multiplying the concentration of oocysts per liter in finished water supplies by the amount of water ingested per day. The daily exposure to risk is then multiplied by the viability/infectivity factor to calculate the number of viable and potentially infectious oocysts. The daily risk of infection for an individual resulting from the exposure to viable oocysts is calculated by applying the dose-response relationship, adjusted for the morbidity rate, to the daily ingestion of viable oocysts. The individual annual risk of infection is calculated by taking the daily risk to the 365th exponent. The individual risk is converted to a total number of infections in the exposed population by multiplying the individual risk by the total population.

$$I = P \times (1 - \exp(-d^{*} V / k))^{365} \times M$$

Where

I = total number of illnesses
P = population exposed
M = morbidity rate
V = viability of oocysts
d = ingested dose (concentration of oocysts in finished water x daily ingestion of water)
k = slope parameter (relation of ingestion to infection)

In summary, EPA used the following assumptions in developing the risk characterization.

- An exponential dose-response function for estimating infection rates with a lognormal distribution (fit from data) and a mean k of 238.6 (Haas, et al., 1996);
- Two liters per person daily water consumption with a lognormal distribution (fit from data) (Haas and Rose, 1995);
- A national surface water lognormal distribution of oocysts modified from data collected by LeChevallier and Norton (EPA, June 24, 1998a);
- An assumed uniform distribution of percentage of oocysts that would be infectious with a mean value of 10 percent (LeChevallier and Norton, 1991); and,
- An estimated 39 percent (assumed triangular distribution) mean value for people who are infected *and* become ill (Haas, et al., 1996, Dupont et al., 1995).

A Monte Carlo simulation was performed to estimate the mean number of infections, as well as the distribution of infections around the mean for each of the assumptions about current treatment performance. The simulation treats each variable (ingestion rate, dose-response, morbidity, and viability) as a probability distribution, rather than as a single point estimate, to attempt to take into account the potential uncertainty of the assumptions. The Monte Carlo technique allows repetitive calculations using values from each distribution according to its probability. The result is a probability distribution of the estimated number of infections and morbidity that allows the characterization of the mean (expected value) and range of the risk. Exhibits 4.6 and 4.7 display the distribution of the estimated number of infections annually as calculated in the Monte Carlo simulation at 50,000 trials. Appendices G and H contain a summary of the resulting distributions for 2.5 and 3.0 log removal, respectively.

Assuming the standard 2.5 log removal performance for current treatment, the model estimates an expected value (mean) of 1,503,000 *Cryptosporidium* infections per year resulting in 643,000 illnesses from exposure to drinking water supplies in the water systems that will require changes under the rule. Estimates, at the 90 percent confidence limit, range from a low of 8,000 to a high of 1,241,000 illnesses per year. The values for the 90 percent confidence limit represent the notion that there is a 10 percent chance that the number of illnesses could be as low or lower than 8,000 or as high or higher than

1,241,000. Under the comparison assumption of a 3.0 log removal, the model estimates an average of 208,500 illnesses, with a 90 percent confidence range of 2,500 to 384,500.

A recently published study (Perz, et al., 1998) performed a risk assessment for *Cryptosporidium*. The study used slightly different input assumptions, but the annual predicted infection risk (infections per person per year) estimated are comparable at the median: 0.0009 from the study compared with 0.0018 at the 2.5 baseline log removal and 0.0006 at the 3.0 baseline log removal derived from the current risk assessment. The current risk assessment results in a much wider spread of values at the 90 percent confidence interval because of a greater use of distributions in the Monte Carlo simulation.

Exhibit 4.6
Frequency Distribution of Annual Illnesses (Morbidity)
Current Treatment Assumption of 2.5 Log *Cryptosporidium* Removal, without IESWTR

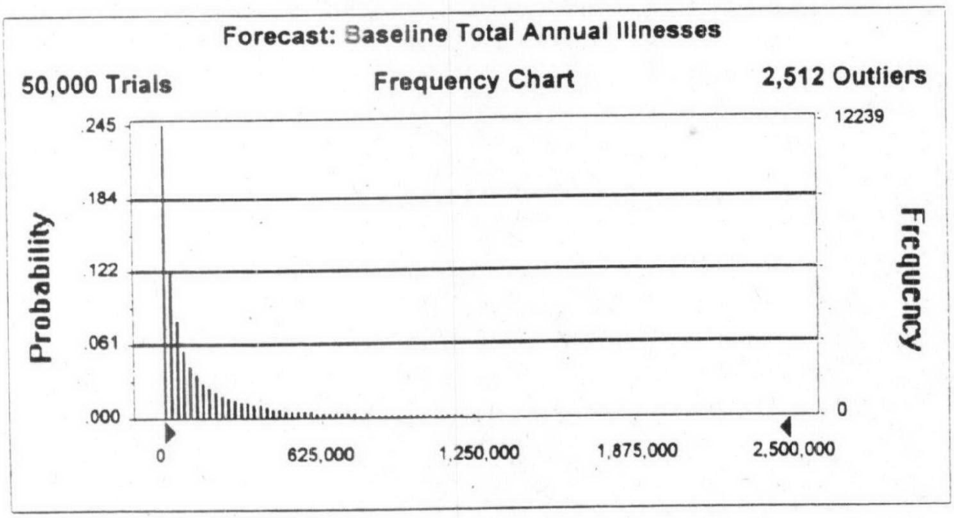
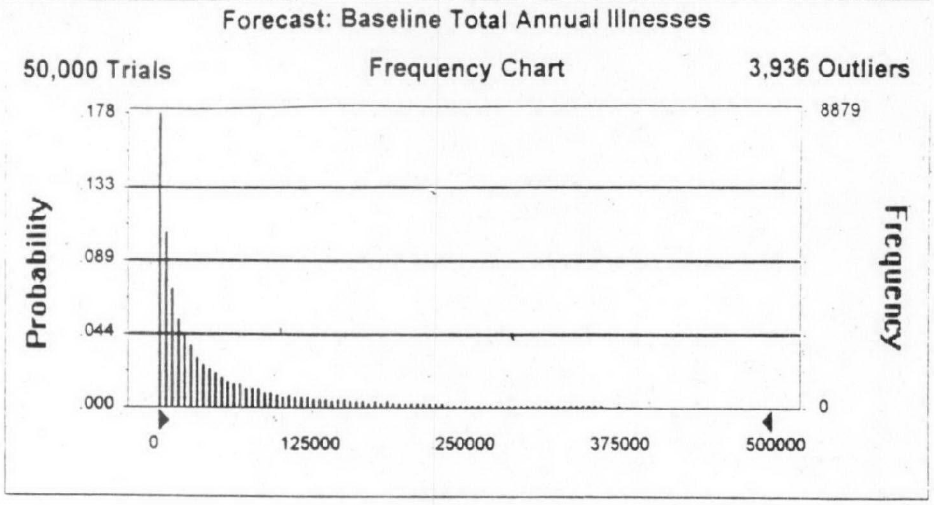


Exhibit 4.7
Frequency Distribution of Annual Illnesses (Morbidity)
Current Treatment Assumption of 3.0 Log *Cryptosporidium* Removal, without IESWTR



4.2.6 Risk Under the IESWTR Provisions

As stated earlier, it is assumed that the turbidity provisions or the rule will result in lower endemic exposure to *Cryptosporidium*, reflecting improvements in overall and individual filter performance (see Section 4.2.4). The following assumptions were made to estimate the additional removal of *Cryptosporidium* resulting from the turbidity provisions.

Exhibit 4.8 gives the total number of systems, population served, and the number of systems expected to need additional removal due to the new treatment standard. The source for the number of systems and the number expected to need additional treatment are described in Chapter 3. The number of systems in the last three columns are based on results from the State 2 database for populations less than 100,000, the Partnership for Safe Water data for populations greater than 500,000, and both the State 2 and the Partnership data for the population category between 100,000 and 500,000. Approximately 50 percent of systems failed to meet the 0.2 NTU standard in at least one month of the year for the State 2 data.

Exhibit 4.8 Expected Number of Systems Requiring Additional Treatment if Monthly Turbidity Standard is Reduced to 0.2 NTU						
System Size (population served)	Number of Systems	Population Served (millions)	Number Expected to Need Additional Treatment	Systems Failing to Meet 0.2 NTU		
				Number Meeting 0.3 NTU	Number Meeting 0.4 NTU	Number Failing to Meet 0.4 NTU
10,000-25,000	594	12 363	303	97	145	62
25,000-50,000	316	15 686	161	52	77	33
50,000-75,000	124	10 202	63	20	30	13
75,000-100,000	52	10 100	27	8.	13	5
100,000-500,000	259	39 951	122	49	47	26
500,000-1,000,000	26	22 675	9	4	2	2
>1 Million	10	28.240	3	2	1	1
Total	**1,381**	**139.217**	**688**	**232**	**315**	**142**

The assumed finished water *Cryptosporidium* distributions that would result from additional log removal with the rule were derived assuming that additional log removal was dependent on current removal, i.e., that sites currently achieving the worst filtered water turbidity performance levels would show the largest improvements or high improved removal assumption (for example, plants now failing to meet a 0.4 NTU limit would show greater removal improvements than plants now meeting a 0.3 NTU limit). The analysis also assumes independence between the distribution of *Cryptosporidium* and turbidity level. Exhibit 4.8 contains the assumptions used to generate data on improved turbidity plant performance as a result of the IESWTR.

Exhibit 4.9 is based on a study by Patania, et al., 1995, and shows the relationship between *C. parvum* and removal efficiencies by rapid granular filtration as discussed in the IESWTR Notice of Data Availability. This study showed that, a filter effluent turbidity of 0.1 NTU or less resulted in the most effective cyst removal (Exhibit 4.9). The improved removal shown under the high removal assumptions in Exhibit 4 10 are based upon this observed level of cyst removal. An incremental decrease in filter effluent turbidity from 0.3 to 0.1 NTU reduced cyst removal by up to one log. This oocyst removal range is the basis for the mid- and low- removal assumptions. Exhibit 4.10 contains the assumptions used to generate the new treatment distribution for a low-, mid-, and high-log removal assumptions.

The resulting improved removal assuming current log removal of 2.5 and 3.0 is displayed in Exhibit 4.11.

Exhibit 4.9

Cumulative Probability Distribution of Aggregate Pilot Plant Data for *C. parvum* Removal

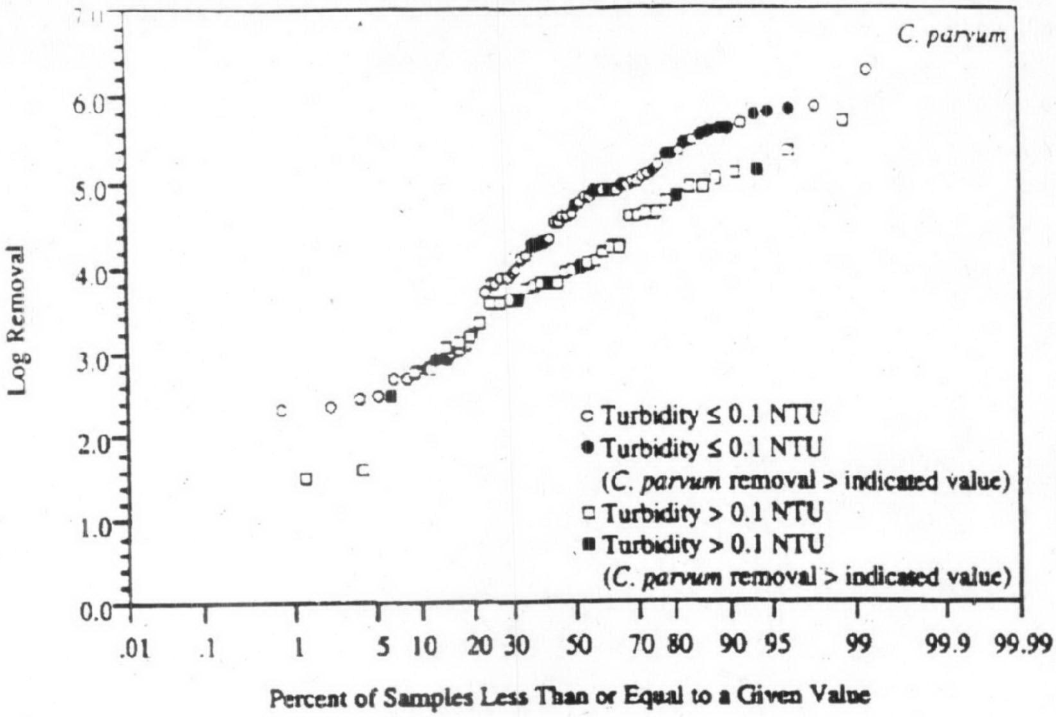


Exhibit 4.10 Improved *Cryptosporidium* Removal Assumptions Additional *Cryptosporidium* Log Removal with IESWTR			
	Low	**Mid**	**High**
Plants now meeting 0.2 NTU Standard	None	None	None
Plants now meeting 0.3 NTU Standard	0.15	0.25	0.3
Plants now meeting 0.4 NTU Standard	0.35	0.5	0.6
Plants now failing to meet 0.4 NTU Standard	0.5	0.75	0.9

Exhibit 4.11 Expected National Source Water and Finished Water *Cryptosporidium* Distributions with Improved Removal					
Assuming Current Log Removal of 2.5					
		Finished Water Concentration (oocysts/100L)			
	Source Water Concentrations (oocysts/100L)	Current Treatment	Improved Removal		
Percentile			Low	Mid	High
25	103	0 20	0 17	0 15	0 14
51	231	0.73	0 52	0 42	0.38
75	516	2 59	1.55	1 17	1 03
90	1064	8.10	4 15	2.94	2.51
95	1641	16.04	7 49	5 11	4 27
	Mean	**4.26**	**1.94**	**1.33**	**1.12**
	Standard Deviation	**24.53**	**6.99**	**4.01**	**3.09**
Assuming Current Log Removal of 3.0					
25	103	0.07	0.05	0.05	0 05
51	231	0.23	0.16	0.13	0 12
75	516	0.82	0 49	0.37	0.33
90	1064	2.56	1.31	0.93	0.79
95	1641	5.07	2.37	1.62	1.35
	Mean	**1.35**	**0.61**	**0.42**	**0.35**
	Standard Deviation	**7.76**	**2.21**	**1.27**	**0.98**

Using the assumption of a 2.5 current log removal and mid-case (from Exhibit 4.11) improvement in removal, the turbidity provisions are estimated to reduce the mean concentration of oocysts from 4.26 oocysts per 100 liters to 1.33 oocysts per 100 liters, a reduction of 69 percent. Using the assumption of a 3.0 current log removal and mid-case improvement in removal, the turbidity provisions are estimated to reduce the mean concentration of oocysts from 1.35 oocysts per 100 liters to 0.42 oocysts per 100 liters, also a reduction of 69 percent.

The improved *Cryptosporidium* log removal values were input to the Monte Carlo model simulation. (See Appendices G and H for distributions.) Exhibit 4.12 summarizes the calculated infections and illnesses reduced (difference between the baseline and improved removal scenarios as modeled in the Monte Carlo simulation) for each of the two current log removal assumptions under low-, mid-, and high-case improved removal scenarios. The mean value presented in the tables represents the statistical expected value of the distribution. The 10th and 90th percentiles implies that there is a 10 percent chance that the estimated value could be as low as the 10th percentile and that there is a 10 percent chance that the estimated value could be as high as the 90th percentile.

Exhibit 4.12 Number of Infections and Illnesses		
	Baseline *Cryptosporidium* Removal Assumption	
	2.5 Logs	3.0 Logs
Current Treatment/Baseline		
Annual Infections—Mean	1,503,000	511,500
Annual Illnesses—Mean	643,000	208,500
Annual Illnesses—10th Percentile	8,000	2,500
Annual Illnesses—90th Percentile	1,241,000	384,500
Low Improved *Cryptosporidium* Removal		
Annual Infections—Mean	743,500	245,000
Annual Illnesses—Mean	304,000	99,000
Annual Illnesses—10th Percentile	7,500	2,400
Annual Illnesses—90th Percentile	635,500	205,000
Illnesses Avoided with Low Improved *Cryptosporidium* Removal Assumption		
Annual Illnesses—Mean	338,000	110,000
Annual Illnesses—10th Percentile	0	0
Annual Illnesses—90th Percentile	1,029,000	322,500
Mid Improved *Cryptosporidium* Removal		
Annual Infections—Mean	521,000	168,000
Annual Illnesses—Mean	210,000	67,000
Annual Illnesses—10th Percentile	6,900	2,200
Annual Illnesses—90th Percentile	456,500	144,000
Illnesses Avoided with Mid Improved *Cryptosporidium* Removal Assumption		
Annual Illnesses—Mean	432,000	141,000
Annual Illnesses—10th Percentile	0	0
Annual Illnesses—90th Percentile	1,074,000	333,000
High Improved *Cryptosporidium* Removal		
Annual Infections—Mean	445,000	140,000
Annual Illnesses—Mean	180,000	56,000
Annual Illnesses—10th Percentile	6,600	2,100
Annual Illnesses—90th Percentile	391,000	123,000
Illnesses Avoided with High Improved *Cryptosporidium* Removal Assumption		
Annual Illnesses—Mean	463,000	152,000
Annual Illnesses—10th Percentile	0	0
Annual Illnesses—90th Percentile	1,080,000	338,000

Note: Mean values derived from Monte Carlo simulation may not precisely match values derived arithmetically.

4.2.7 Benefits from Reducing Endemic Risk from *Cryptosporidium*

The health benefits of the rule can be evaluated in terms of two valuation measures: 1) cost-of-illness (COI) avoided, and 2) willingness-to-pay (WTP) to reduce the probability of suffering an adverse health effect (Freeman, 1979). COI avoided due to adverse health effects includes medical costs, lost income, reduced productivity and averting expenditures These are goods for which there are observable market values and are therefore, easier to quantify than WTP values

The WTP concept goes beyond the expected value of avoided COI, to include the total value of health benefits In principle, WTP for reduced health risk is likely to exceed the market value of avoided cost of illness WTP includes the intuitive notion that illness is, after all, disagreeable and that one would be willing to pay to avoid the pain and suffering associated with an adverse health effect beyond the cost of the illness Since there are no markets for avoided pain and suffering, there are no observable market transactions by which their value can be measured.

Another reason that the WTP for reduced health risk is likely to exceed the expected value of avoided COI springs from risk aversion Essentially, uncertainty about future damages is unsettling, and there seems to be an economic premium attached to these kinds of damages. Because it assumes a neutral attitude towards risk, the use of expected COI (instead of WTP) will tend to understate the economic value of risk reduction.

Expenditures on averting behavior also comprise a part of WTP In the context of reducing endemic *Cryptosporidium* risk, averting behaviors involve the day-to-day, routine activities that consumers undertake with respect to drinking water, including consumption of bottled water or use of individual filtration devices The reasons for undertaking these behaviors are numerous (i.e., taste, odor, reducing exposure to chemical contaminants) with the motivation of reducing specifically the risk from *Cryptosporidium* a minor factor. Expenditures on averting behaviors during outbreaks are discussed in Section 4.3.4.

Information is not available on the direct measurement of either COI or WTP to reduce risk specifically for *Cryptosporidium*. For the purposes of this analysis, estimates for the COI associated with giardiasis will be used as a proxy for the cost of illness of cryptosporidiosis. The costs incurred during an outbreak of waterborne giardiasis in 1983 in Pennsylvania were based on a survey of 370 people who had "confirmed" cases of giardiasis, i.e., a positive stool sample. The study estimated direct medical costs (paid for either by the victim or insurance company) including the costs of doctor visits, emergency room visits, hospital visits, laboratory fees, and medication. The study also estimated other costs, including time costs for medical care, value of work loss days, loss of productivity, and loss of leisure time (Harrington, et al., 1989). The study did not value the "pain, suffering, stress, and anxiety, or any other psychological or resulting physiological consequences of the outbreak." (Harrington et al., 1985).

Exhibit 4.13 contains a summary of the average losses for confirmed cases of giardiasis in 1984 dollars and updated using the Consumer Price Index for all Urban Consumers to a 1998 price level.

The average losses per case of giardiasis reported in the survey are approximately $3,100 at the current price level. The average losses per case of cryptosporidiosis could be less because cryptosporidiosis is self-limiting in immunocompetent subjects, with infections lasting a shorter duration (7 to 14 days) than giardiasis infections (30 days median length-of-illness in sample). To take into account the shorter duration of cryptosporidiosis, the estimates for non-direct medical costs of giardiasis are adjusted by the ratio of the duration of cryptosporidiosis over the duration of giardiasis. The ratio and adjusted costs are estimated using a Monte Carlo simulation to model the distribution of potential duration for each illness. Data from the Milwaukee outbreak indicate that the duration of cryptosporidiosis is lognormally distributed, with a range of 1 to 55 days, a mean of 12 days, and a median of 9 days (Mackenzie, et al., 1994). Data from the Pennsylvania outbreak indicate that the duration of giardiasis is lognormally distributed, with a mean of 41.6 days and a standard deviation of 45 days (Harrington, et al., 1985). The resulting adjusted COI associated with cryptosporidiosis is represented by the distribution shown in Exhibit 4.14 with a mean of $2,000 and a median of $1,400 (90 percent confidence interval $800-$3,800).

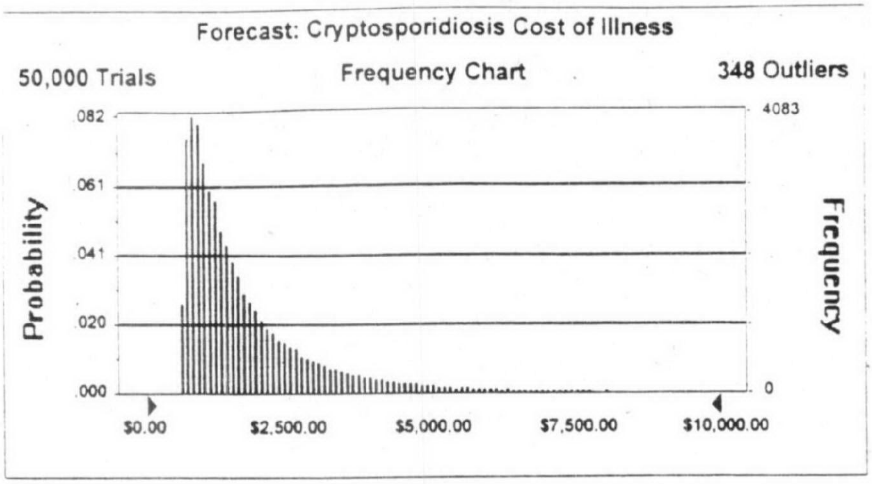
Exhibit 4.13 Losses per Case of Giardiasis by Category			
Loss Category	**Average Losses (1984 $) (Harrington, et al., 1985)**	**CPI Update Factor**	**Average Losses (1998 $)**
Direct Medical Costs:			
Doctor visits	$ 36	2.27	$ 82
Hospital visits	100	2.27	227
Emergency room visits	27	2.27	61
Laboratory tests	63	2.27	143
Medication	28	2.27	64
Subtotal	*$ 254*		*$ 577*
Indirect Medical Costs:			
Time costs for medical care	$ 18	1.58**	$ 28
Value of work loss days	359***	1.58	567
Loss of work productivity	371***	1.58	586
Loss of leisure time	876***	1.58	1,384
Subtotal	*$ 1,624*		*$ 2,565*
Total	**$ 1,878**		**$ 3,142**

* Consumer Price Index, All Urban Consumers, US City Average, Medical Care: 242.0 (June 1998)/106.8 (1984 average)
** Consumer Price Index, All Urban Consumers, US City Average, All Items. 163.0 (June 1998)/103.9 (1984 average)
*** Based on the assumption that the wage rate for the unemployed, homemakers, and retirees equals the wage rate for employed persons in the sample. Use of an alternative assumption or labor rate will result in different indirect costs.

It is important to note that the values in the above distribution reflect the potential COI avoided, not the full WTP to reduce the probability of suffering a cryptosporidiosis infection. The estimates do not take into account the value of avoiding pain and suffering, the economic premium associated with risk aversion, or the costs of averting behaviors. Therefore the full value of the economic benefit to reduce cryptosporidiosis may be higher than the $2,000 COI avoided per case mean estimate. Exhibit 4.15 contains the values of annual illnesses avoided, using the distribution of adjusted COI estimates.

To compare these results against previous studies, one study (Mauskopf and French, 1991) estimated the WTP to avoid foodborne illnesses based on the nature and length of the illness, integrated with the value of a statistical life and indices of self-reported health status to value the losses in quality and length of life. The WTP estimates for illnesses similar to cryptosporidiosis range from $156 to $8,004 for mild to moderate cases of botulism (5 to 21 days of weakness, vomiting, and nausea) and $266 to $2,484 for salmonellosis (3 to 7 days of similar symptoms). Using these estimates, the value for cryptosporidiosis (7 to 14 day duration) could range from $218 ($31.20/day for 7 days) to $5,335 ($381/day for 14 days). The cost of illness estimates (with a mean of $2,000) fall within this range and are a reasonable approximation of the value to avoid health damages associated with cryptosporidiosis, recognizing that some costs (such as averting expenditures) have not been monetized.

Exhibit 4.14
Frequency Distribution of Adjusted Cost of Illness Estimate



4.2.8 Benefits from Reducing Mortalities Due to Endemic Risk from *Cryptosporidium*

Cryptosporidiosis poses a serious risk of death in sensitive subpopulations, such as those with compromised immune systems. Based on data from the Milwaukee outbreak, the fatality rate can be estimated at approximately 0.0125 percent (0.0125 percent of all illnesses would result in a fatality—50 fatalities/400,000 cases) in a mixed population of exposed persons. This figure was derived based on death certificate reporting (50 additional deaths associated with cryptosporidiosis as reported on the death certificate, of which 46 had AIDS as the underlying cause of death) and should be regarded as a minimum estimate (Hoxie, et al., 1996).

The fatality rate from the Milwaukee outbreak may not be reflective of overall mortality rates from low-level endemic exposure. The estimated levels of *Cryptosporidium* in the finished water supplies during the Milwaukee outbreak were much higher than the levels expected in systems complying with the existing SWTR. Thus, the higher level of *Cryptosporidium* in the water supply could have resulted in a higher fatality rate if more significant symptomatic response were associated with infection influenced by higher ingested dosages. However, there is no data yet available to support this hypothesis; data is only available to indicate higher probability of infection resulting from higher ingested dose levels. There is some evidence that the fatality rate among susceptible subpopulations may not be linked to community-wide exposure levels (Rose, 1997). The majority of fatalities identified from the Milwaukee outbreak (46 of 50) were among individuals with AIDS (Hoxie, et al., 1996). In another outbreak in Las Vegas, similar mortality rates were observed in AIDS patients (52.6 percent among AIDS patients in Las Vegas compared with 68 percent among AIDS patients in Milwaukee), although it was hypothesized that the drinking water had been contaminated over an extended period of time with intermittent low levels of oocysts, unlike Milwaukee's massive contamination (Rose, 1997).

Exhibit 4.15 Value of Illnesses Avoided Annually		
	Baseline *Cryptosporidium* Removal Assumption	
	2.5 Logs	3.0 Logs
Illnesses Avoided with Low Improved *Cryptosporidium* Removal Assumption		
Mean	338,000	110,000
10th Percentile	0	0
90th Percentile	1,029,000	322,500
COI Avoided with Low Improved *Cryptosporidium* Removal Assumption		
Mean	$950,469,000	$262,876,000
10th Percentile	$0	$0
90th Percentile	$1,883,000,000	$584,500,000
Illnesses Avoided with Mid Improved *Cryptosporidium* Removal Assumption		
Mean	432,000	141,000
10th Percentile	0	0
90th Percentile	1,074,000	333,000
COI Avoided with Mid Improved *Cryptosporidium* Removal Assumption		
Mean	$1,172,000,000	$327,137,000
10th Percentile	$0	$0
90th Percentile	$1,960,000,000	$607,800,000
Illnesses Avoided with High Improved *Cryptosporidium* Removal Assumption		
Mean	463,000	152,000
10th Percentile	0	0
90th Percentile	1,080,000	338,000
COI Avoided with High Improved *Cryptosporidium* Removal Assumption		
Mean	$1,240,000,000	$358,900,000
10th Percentile	$0	$0
90th Percentile	$1,999,000,000	$619,700,000

The Milwaukee fatality rate might also not be representative of the national fatality rate if there are larger sensitive subpopulations in Milwaukee than nationally. In fact, sensitive subpopulations may be under-represented in Milwaukee. According to Hoxie, et al. (1996), "Indeed, in 1992, just prior to the outbreak, the annual reported AIDS case rate in the Milwaukee metropolitan area ranked 78th among 98 metropolitan areas in the United States with populations 500,000 or more." Thus, the greater presence of sensitive subpopulations in some areas might indicate a greater susceptibility to cryptosporidiosis. At this time, there is no basis for adjusting the Milwaukee outbreak fatality rate to the general population. Assuming the Milwaukee fatality rate of 0.0125 percent, Exhibit 4.16 displays the estimated range of fatalities prevented as modeled in the Monte Carlo simulation.

Exhibit 4.16 Number of Mortalities among Exposed Population		
	Baseline *Cryptosporidium* Removal Assumption	
	2.5 Logs	3.0 Logs
Current Treatment/Baseline		
Annual Mortalities—Mean	87	27
Annual Mortalities—10th Percentile	1	0
Annual Mortalities—90th Percentile	156	48
Low Improved *Cryptosporidium* Removal		
Annual Mortalities—Mean	39	12
Annual Mortalities—10th Percentile	1	0
Annual Mortalities—90th Percentile	80	26
Mortalities Avoided with Low Improved *Cryptosporidium* Removal Assumption		
Annual Mortalities—Mean	**48**	**14**
Annual Mortalities—10th Percentile	**0**	**0**
Annual Mortalities—90th Percentile	**129**	**40**
Mid Improved *Cryptosporidium* Removal		
Annual Mortalities—Mean	27	8
Annual Mortalities—10th Percentile	1	0
Annual Mortalities—90th Percentile	57	18
Mortalities Avoided with Mid Improved *Cryptosporidium* Removal Assumption		
Annual Mortalities—Mean	**60**	**18**
Annual Mortalities—10th Percentile	**0**	**0**
Annual Mortalities—90th Percentile	**135**	**42**
High Improved *Cryptosporidium* Removal		
Annual Mortalities—Mean	23	7
Annual Mortalities—10th Percentile	1	0
Annual Mortalities—90th Percentile	49	15
Mortalities Avoided with High Improved *Cryptosporidium* Removal Assumption		
Annual Mortalities—Mean	**64**	**20**
Annual Mortalities—10th Percentile	**0**	**0**
Annual Mortalities—90th Percentile	**136**	**42**

Studies that assess the value per statistical life (VSL) saved (i.e., reduced risk of premature death) generally have central point estimates between $5 million and $8 million dollars with a range from $2 million to $14 million (Chestnut and Alberini, 1997). A recent EPA study characterized the VSL saved as a lognormal distribution with a mean of $4.8 million with a standard deviation of $3.24 million, truncated at $13.5 million (in 1990 price level), based on 26 individual study estimates (EPA, 1997). Updating the VSL for current price levels results in a distribution with a mean of $5.6 million and a standard deviation of $3.16 million, truncated at $16.87 million ($13.5 X update factor).

Because the fatalities from cryptosporidiosis are expected to occur primarily in sensitive subpopulations, there may be some arguments for adjusting the VSL. The typical valuation methodology used to derive the VSL generally measure the individuals' WTP to reduce the risk of a premature death by a small amount. The small reduction in risk is then spread across a broad population. The mortality risk associated with cryptosporidiosis is different in that a smaller sensitive subpopulation faces a higher baseline risk. The valuation literature is unclear on whether this type of a risk would have a higher or lower WTP although one study found that respondents favored programs that affect smaller populations facing higher baseline risks, assuming the same number of lives are saved (Van Houtven, 1997). A review of existing empirical literature with respect to adjusting the VSL saved by drinking water programs does not, however, provide a strong basis for specific adjustments (up or down) to the VSL (Van Houtven, et al., 1997).

An alternative method for valuing the increased mortality associated with cryptosporidiosis in sensitive subpopulations, the quality-adjusted life years (QALY) method, may be more appropriate than the commonly-used VSL. The QALY method derives an estimate of the number and quality of life years extended and then assigns a value to the additional life years. At the present time, there are several limitations in applying the QALY method, including determining the increased life expectancy among sensitive subpopulations and improved quality of life. In addition, the empirical research to monetize QALYs is ongoing and not sufficiently robust to use at this time (Chestnut and Alberini, 1997).

For the purposes of this RIA, Exhibit 4.17 displays the potential benefits for preventing fatalities using the updated VSL distribution, recognizing the uncertainties inherent in this, or any available valuation methodology.

4.3 Other Benefits

4.3.1 Reducing Health Effects to Sensitive Subpopulations

The health effect of cryptosporidiosis on sensitive subpopulations is much more severe and debilitating than on the general population. The estimated COI avoided calculated earlier probably does not capture the full value of costs to sensitive subpopulations, since health trials were conducted with healthy individuals and symptomatic responses are more severe in sensitive populations. For example, the duration of cryptosporidiosis in those with compromised immune systems is considerably longer than in those with competent immune systems, with more severe symptoms often requiring lengthy hospital stays. In those subpopulations, the COI from cryptosporidiosis would be much larger than $2,000 per case. During the Milwaukee outbreak, 33 AIDS patients with *Cryptosporidium* accounted for 400 hospital days at an additional cost of nearly $760,000 (Rose, 1997). COI due to these hospital days alone is estimated at $23,000 per case ($760,000/33 patients). Although the COI for sensitive populations is expected to be greater than the general population, no attempt was made to quantify these effects for the purposes of this regulatory impact analysis. Also, the cost of averting expenditures could be higher in sensitive subpopulations.

4.3.2 Benefits From Reducing Risk of Outbreaks

Besides reducing the endemic risk of cryptosporidiosis, the turbidity provisions in the rule may also reduce the likelihood of major outbreaks, such as the Milwaukee outbreak, from occurring. The economic value of reducing the risk of outbreaks could be quite high when the magnitude of potential costs is considered. For example, if the $2,000 per cryptosporidiosis infection estimate is applied to the

4.3.3 Enhanced Aesthetic Water Quality

Economic theory suggests that improving the aesthetic quality of drinking water produces benefits separate from improvements in health Consumers, presumably, would be willing to pay to protect the aesthetic quality of drinking water from high turbidity levels. However, the improvements from the rule may not be noticeable to the general public in terms of aesthetic water quality. These benefits are not, therefore, quantified for this analysis.

4.3.4 Avoided Costs of Averting Behavior

During outbreaks or periods of high turbidity, consumers and businesses may use alternative water sources or practice behaviors to reduce risk, such as boiling water. If the rule reduces the need for these averting behaviors, an economic benefit will accrue. During an outbreak of giardiasis, expenditures on averting behaviors, such as hauling in safe water, boiling water, and purchasing bottled water, were estimated at between $1.74 to $5 53 per person per day during the outbreak (Harrington, et al., 1989). If these expenditure figures are applied to the Milwaukee outbreak, total expenditures on averting behavior would lie between $19,448,000 ($1.74 X 14 days X 800,000 persons) to $61,936,000 ($5.53 X 14 days X 800,000 persons). Determining the precise reduction in outbreak risk and resulting benefits due to reduced or avoided averting behavior is not possible given current information, but potential benefits could be substantial.

5: Cost Analysis

5.1 Introduction

This chapter estimates total national costs of complying with the Interim Enhanced Surface Water Treatment Rule (IESWTR) It discusses which elements of the rule incur costs, on what basis those costs are estimated, and how they are aggregated. Chapter 6 compares the cost estimates with potential benefits of the rule

The cost estimation for the IESWTR combines information from existing data sources with technical assumptions based on expertise developed by the Microbial-Disinfectants/Disinfection Byproducts (M-DBP) Advisory Committee and its Technologies Working Group (TWG). These estimates are the result of an iterative process that was continually updated by new data and modified assumptions. Where necessary, a chronology of the decisions that formed a particular estimate is discussed.

5.1.1 How this Chapter is Organized

Each section of this chapter addresses a particular provision of the IESWTR and its estimated cost. First, a summary of the estimated national costs of compliance is presented. Subsequent sections discuss each provision that incurs a cost, assumptions and data elements used in the analysis, how the costs were estimated, and results. The six provisions described include the following—

1) Turbidity treatment;
2) Turbidity monitoring;
3) Exception reporting;
4) Disinfection profiling;
5) Sanitary surveys; and,
6) Covered finished water reservoirs.

The cost of regulating utilities is commonly passed to consumers; therefore, an estimate of annual costs per household of the IESWTR concludes this chapter. Additional documentation on the analyses and cost estimates in this chapter are documented in Appendices A through F.

5.2 Total National Costs of Compliance

Exhibit 5 1 summarizes the estimate of total national costs of compliance for the IESWTR. The exhibit is divided into two major groupings; the first grouping displays the final cost estimates ("Final Rule (1998 $s)") of the IESWTR, the second displays compares this to an earlier estimation developed in 1994 ("1994 Proposal").

The first column of the exhibit displays the total cost of compliance at a 3 percent cost of capital to reflect a sensitivity analysis. The second column contains the total cost of compliance at a 7 percent cost of capital, in keeping with the Office of Management and Budget (OMB) guidance on discounting. The third column presents the total cost using a 10 percent cost of capital to maintain continuity with the rate at which costs were calculated in 1994. The fourth and fifth columns are the total costs of compliance as computed in 1994 The fourth contains costs of the 1994 proposed rule in 1992 dollars. There is some difference in how monitoring and start-up costs for both utilities and States are calculated, based on revised methods of annualizing these costs The fifth column updates the 1994 costs with an inflation factor to 1998 dollars

Differences in cost between the 1994 proposal and the final IESWTR are accounted for primarily by changes in the level of disinfection required and restoration of disinfection credit prior to disinfection byproduct (DBP) precursor removal. This results in fewer systems needing to install additional disinfection contact basins, relative to the costs in the 1994 proposal. The utility treatment options proposed in 1994 totaled $467 million in annualized costs, compared with $209 million (10 percent cost of capital) in 1998, a difference of $258 million

5.2.1 How Costs Were Developed

Cost estimates presented in this chapter are based on available data, assumptions, and decisions developed by EPA and reviewed and confirmed through a modified "Delphi" process. A "Delphi" analytical process uses teams or groups of experts to reach independent understandings of technical problems. A modification to this process was used by the M-DBP Committee in its deliberations. A TWG was formed by the M-DBP Committee early in the rule development process. On any particular topic or question, the members of the TWG shared their knowledge, experience, and judgment. The TWG fully discussed cost estimates and then used its collective judgment to reach consensus on whether the estimate was appropriate for use in the analysis or whether further research was needed. Assumptions or estimates generated through this process were presented to a full meeting of the TWG and further presented to the M-DBP Committee.

5.3 Turbidity Treatment

5.3.1 Overview

The cost of adopting alternative treatment practices to meet the IESWTR's turbidity treatment standards represents the major portion of costs associated with the rule. Turbidity treatment rule provisions were the subject of extensive discussion during the M-DBP Committee deliberations. An understanding of the current configuration of water treatment plants, of how many would be projected to change their treatment practices based on the rule, and of which alternatives would be implemented (if any) is needed to accurately estimate turbidity treatment costs.

5.3.2 Methodology

The baseline of current treatment practices discussed in Chapter 3 served as the basis for discussion on the compliance forecast. The compliance forecast estimates the number of systems required to modify their treatment practices to meet the turbidity requirements and the treatment alternatives they would likely select. Unit costs for each alternative were developed during a companion analysis. The total costs of the turbidity treatment requirement were then calculated by multiplying the estimated number of systems modifying treatment, the treatments they would likely implement, and the unit cost of that treatment.

Exhibit 5.1
Summary of Costs Under the Interim Enhanced Surface Water Treatment Rule ($000s)

	Final Rule (1998 $s)			1994 Proposal	
	3% Cost of Capital	7% Cost of Capital	10% Cost of Capital	10% Cost of Capital 1992 $s	10% Cost of Capital 1998 $s
Utility Costs					
Utility Treatment Capital	$ 758,965	$ 758,965	$ 758,965	$ 3,665,568	$ 4,370,389
Annual Costs					
*Annualized Capital**	*65,999*	*85,611*	*103,437*		
Annual O&M	*105,943*	*105,943*	*105,943*		
Total Treatment	171,942	191,554	209,380	391,702	466,891
Turbidity Monitoring	95,924	95,924	95,924		
Turbidity Exceptions**	195	195	195		
Disinfection Benchmarking	2,841	2,841	2,841		
Subtotal	*270,902*	*290,514*	*308,340*	*$ 391,702*	*$ 466,891*
Annualized One-Time Costs***					
Turbidity Monitoring Start-Up	289	405	504		
HAA Benchmarking	175	246	306		
Subtotal	*464*	*651*	*810*		
Total Annual Utility Costs	**$ 271,366**	**$ 291,165**	**$ 309,150**		
State Costs					
Annual Costs					
Turbidity Monitoring	5,256	5,256	5,256		
Turbidity Exceptions****	409	409	409		
Sanitary Survey	6,979	6,979	6,979	867	1,034
Disinfection Benchmarking	2,789	2,789	2,789		
Subtotal	*15,433*	*15,433*	*15,433*	*$ 867*	*$ 1,034*
Annualized One-Time Costs***					
Turbidity Monitoring Start-Up	27	38	48		
Disinfection Benchmarking Start-Up	22	30	38		
Sanitary Survey Start-Up	39	55	69		
Subtotal	*88*	*123*	*155*		
Total Annual State Costs	**$ 15,521**	**$ 15,556**	**$ 15,588**		
Total Annual Costs	**$ 286,887**	**$ 306,721**	**$ 324,738**	**$ 392,569**	**$ 467,925**

* Capital costs are annualized over 20 years with the exception of turbidimeters and process control modification equipment, which are annualized over 7 years.
** Costs associated with Individual Filter Effluent turbidity requirements for exceptions reporting and Individual Filter Assessments
*** All one-time costs are annualized over 20 years.
**** Costs associated with Reporting Exceptions and Comprehensive Performance Evaluations.

Compliance Forecast

The compliance forecast is the heart of the turbidity treatment cost analysis To forecast utility compliance with the IESWTR, EPA made assumptions regarding which turbidity treatment alternatives might be implemented. Treatment alternatives could be implemented singly or in combination with any number of other alternatives.

The compliance forecast is presented as a list of alternatives, with an estimate of the percentage of total systems that would implement each of the alternatives. Alternatives are generally not exclusive; therefore, the sum of percentages exceeds 100. The total number of systems forecast to modify their treatment process is subdivided into different system size categories (defined by the population served), often with different forecasts for each category.

Estimates of compliance are based on an understanding of current levels of turbidity (as measured in nephelometric treatment units, or NTUs), and the requirements in the rule. Utilities generally measure turbidity in two ways: as the output from an individual filter, and as a combined stream of all individual filter outputs (combined filter effluent—CFE). The IESWTR requires continuous turbidity monitoring at individual filters and requires CFE to be below 0.3 NTU in 95 percent of the monthly measurements, and CFE is not to exceed 1 NTU at any time. The IESWTR also sets levels for monthly exceptions reporting and follow-up activities (see Chapter 1 for discussion of specific activities that are triggered at different individual filter effluent levels).

During the development of the rule, the TWG analyzed different individual and CFE maximum turbidities and reviewed costs associated with each. Analysis originally focused on reducing the existing 0.5 NTU standard to either 0.2 NTU or 0.3 NTU 95th percentiles. In each case, compliance was measured as meeting the limit 95 percent of the time and not exceeding a CFE maximum between 1.0 NTU and 2.0 NTU. In general, plants that expect to meet a 0.3 NTU limit 95 percent of the time, in order to ensure that they would consistently meet this level, would typically target operations to achieve 0.2 NTU. Similarly, plants that expect to meet a 0.2 NTU limit 95 percent of the time would typically target operations to achieve 0.1 NTU. In response to concerns that the 0.2 NTU and 0.3 NTU compliance forecasts did not capture the full potential of turbidity treatment, costs for a more restrictive 0.1 NTU combined turbidity limit were also analyzed.

The number of systems required to take some action varies by the proposed regulatory levels of turbidity (Exhibit 5.2). At 0.3 NTU, 691 out of a possible 1,381 systems (50 percent) were projected to need to modify their treatment to comply. At 0.2 NTU, it was assumed that an additional 404 systems (29 percent) would need to modify treatment to comply. For 0.1 NTU, however, rather than incrementally increasing the overall number of systems, the number for 0.2 NTU (1,095 systems) was used. This assumed that increased protection would be achieved through adoption of membrane technology rather than other treatment practices to reduce turbidity (from 0.2 to 0.1 NTU) and that no additional systems would be affected by the increased requirement.

Exhibit 5.2 Number of Systems Modifying Treatment Practices to Meet Limit				
System Size (population served)	Number of Systems (using rapid granular filtration)	To Meet 0.3 NTU Limit	To Meet 0.2 NTU Limit	To Meet 0.1 NTU Limit
10,000-25,000	594	303	475	475
25,000-50,000	316	161	253	253
50,000-75,000	124	63	99	99
75,000-100,000	52	27	42	42
100,000-500,000	259	122	202	202
500,000-1 Million	26	11	18	18
>1 Million	10	4	7	7
Total	1,381	691	1,095*	1,095*

* 1,095 systems need to modify treatment to meet the 0 2 NTU and the 0 1 NTU standards Due to rounding, the number of systems each of these categories totals 1,096

Treatment Activities

Specific treatment activities to help utilities meet the turbidity treatment requirements were proposed by experts in the technical aspects of treatments and later confirmed by the M-DBP Committee. Treatment activities were grouped in ten categories. As a general rule, it is assumed that activities are not exclusive of one another; rather, they can be combined with other activities to make a "treatment mix." This assumes that systems can implement more than one treatment activity in order to meet the turbidity treatment levels. This precludes an analysis of hundreds of separate treatment scenarios. Descriptions of the treatment activities are included in *Technologies and Costs for the Interim Enhanced Surface Water Treatment Rule* (EPA, July, 1998b).

The compliance forecasts in Appendix A display the percentage of systems implementing a specific treatment activity Appendix A contains all three compliance forecasts discussed during the development of the IESWTR (final level: 0.3 NTU; alternate levels: 0.1 and 0 2 NTU).

In general, costs are estimated by multiplying the compliance forecast for each treatment alternative by the unit cost of the alternative then multiplying the result by the number of systems expected to modify treatment. This is not applied universally, however. Certain variations in the compliance forecast capture situations unique to specific treatment activities. These variations are included in the calculations that generate the total cost of compliance. These variations include the following—

- The four filtration improvements (*filter media addition, filter media replacement without support gravel, filter media and support gravel replacement,* and *filter media, support gravel, and underdrain replacement* (Appendix A-1)) are not intended to be inclusive; instead, they represent four separate activities that do not overlap.

- The percentage provided in the table for *individual filter turbidimeter installation* applies to all utilities for which these regulations are applicable, not just to those systems in need of modifying their treatment to meet the turbidity levels in the rule. This assumes that all systems will be required to install individual filter turbidimeters under the rule, regardless of current performance This accounts for the approximately 20 percent of systems that already have turbidimeters in place

- The first activity under Process Control Testing Modificatic- *(modify/implement turbidimeter monitoring and recording)* applies to all systems for which ..ie rule applies. Eighty percent of all systems are assumed to need Supervisory Control and Data Acquisition (SCADA) systems in order to comply with the IESWTR. In this case, the SCADA system is expected to monitor and record—to monitor system flows in the plant (flowmeters), to monitor and control chemical additions in the plant, and to acquire and record data from turbidimeters.

- The second activity under Process Control Testing Modification *(modify/implement process monitoring (other than turbidity))*, refers only to those systems that have or will implement a SCADA system for turbidity and includes the incremental activity of including a feedback mechanism for other parameters to allow for continuing corrections to the water stream. In the cost model, this percentage applies to those systems that need to modify treatment practices to meet the recommended limits.

Calculating Total Treatment Costs

Units costs for each treatment activity were developed by EPA and are presented in dollars per thousand gallons ($/kgal) of average water flow per day. Total treatment costs were computed for each of the three treatment approaches discussed during the development of the IESWTR (0.1, 0.2, 0.3 NTU). Total treatment costs were calculated using the following conversion calculation.

Unit Cost of Activity Conversion Equation

[Unit Cost of Activity I / ($/kgal)] x
[(1000 Gal/MGD) (Average Flow MGD)] x
(365 Days/Year) x
(Number of Systems Required to Modify Treatment) x
(Percent of Systems Needing a Treatment Activity I)

The total annual cost of treatment is calculated by amortizing the total capital cost at different costs of capital and adding to the annual operation and maintenance (O&M) cost. Cost amortization used three different costs of capital (3, 7, and 10 percent).

5.3.3 Estimated Treatment Costs at 0.1, 0.2, and 0.3 NTU Levels

This analysis was originally developed to support M-DBP Committee deliberations in 1997.The data displayed in Exhibit 5 3 are, therefore, presented at the three levels under discussion at that time: 0.1, 0.2, and 0 3 NTU. The TWG did not set a specific maximum CFE, so a 1.0 NTU to 2.0 NTU maximum CFE was assumed for the purposes of this analysis.

The cost estimates presented to the M-DBP Committee in 1997 show clear distinctions among the different proposed regulatory levels At 0 3 NTU, total annual costs for turbidity treatment were estimated to be $174 million Annual household cost increases were estimated to be $6 35, or $0 53 per household per month At 0 2 NTU, total annual cost increases were estimated to be $317 million, with average annual household costs of $6 62, or $0 55 per household per month. Household cost increases remained somewhat stable between these two alternatives because although costs at 0.2 NTU rose sharply, the total number of households also increased due to the larger number of systems affected. At 0 1 NTU, the total annual cost of treatment was estimated to be $3,213 million, or roughly 10 times that at 0 2 NTU and 20 times the 0 3 NTU scenario Average household cost increases under this scenario equaled $67 17, or $5 60 per household per month

Exhibit 5.3 Cost Estimates for Alternative Combined Filter Effluent (CFE) Turbidity Limits–May 1997 ($000/year)

System Size (population served)	Number of Systems	Maximum 1.0 to 2.0 NTU CFE		
		0.3 NTU*	0.2 NTU**	0.1 NTU***
10,000-25,000	594	$ 41,211	$ 64,640	$ 519,443
25,000-50,000	316	32,782	53,307	493,916
50,000-75,000	124	18,605	27,720	278,044
75,000-100,000	52	11,395	14,326	152,368
100,000-500,000	259	47,370	105,373	1,221,318
500,000-1 Million	26	12,316	29,882	322,177
>1 Million	10	10,074	21,511	225,945
Total	**1,381**	**$ 173,754**	**$ 316,759**	**$ 3,213,211**
Average Annual Household Cost Increase		**$ 6.35**	**$ 6.62**	**$ 67.17**

* The turbidity level of a system's CFE ≤ 0 3 NTU in at least 95% of monthly measurements
** The turbidity level of a system's CFE ≤ 0.2 NTU in at least 95% of monthly measurements
*** The turbidity level of a system's CFE ≤ 0 1 NTU in at least 95% of monthly measurements

Projected compliance activities most significantly affecting cost include changing primary coagulant feed points, filter rate-of-flow controller replacement, individual filter turbidimeter installation, accounting for recycle flow in process control decisions, and process control strategy facilitators.

Additionally, assumptions contained within the compliance forecast for 0.2 NTU and 0.3 NTU differed. Twice as many systems would install coagulant aid polymer feed and filter aid polymer feed capabilities in complying with the 0.2 NTU limit as compared with the 0.3 NTU limit.

The estimated total annual costs for systems to comply with the 0.1 NTU limit differed by almost a factor of 10 from both the 0.2 NTU and 0.3 NTU alternatives. It was assumed that for a system to comply with the 0.1 NTU turbidity limit, 95 percent of systems would need to install membrane technology, an expensive alternative that accounts for most of the cost difference between 0.1 NTU and 0.2 NTU. Differences between the two alternatives are slightly moderated, however, by two other assumptions.

First, the compliance forecast assumes that, in general, moving to more restrictive limits implies that more systems will have to modify turbidity treatment practices This is exhibited in the compliance forecast for the 0 3 NTU and 0 2 NTU limits The 0 1 NTU limit, however, uses the compliance forecast used in the 0 3 NTU analysis, with the exception of membrane technology Systems would not need the additional improvement in turbidity treatment that moving from 0.3 to 0 2 NTU would imply. Therefore, at 0 1 NTU the compliance forecast includes treatment modifications equivalent to those assumed necessary to meet the 0.3 NTU limit. Gains in treatment performance to reach the 0.1 NTU limit are achieved through use of membrane technology

Second, in the compliance forecast for both the 0.2 NTU and 0.3 NTU limits, 80 percent of all systems are anticipated to install individual filter turbidimeters. With the 0.1 NTU option, the use of membrane technology would effectively remove protozoa and other microbial pathogens. Therefore, no individual filter turbidimeters would be needed.

5.3.5 Estimated Treatment Costs at 1, 1.0, 2, and 2.0 NTU CFE Maximums

In addition to establishing the levels of CFE monthly turbidity limits, the M-DBP Committee reviewed the difference in cost at alternative CFE maximums. Prior to this rule-making, limits of CFE turbidity were set at a maximum of 5 NTU When discussing where to set the monthly CFE limits, the M-DBP Committee had assumed that CFE maximums would be between 1.0 and 2.0 NTU. This implied that if systems were modifying their treatment at any time to meet the 3.0 CFE 95 percent of the time and their CFE would not exceed 2.0 NTU at any time.

Three levels for CFE maximum were analyzed. Cost estimates were prepared for 1 NTU (essentially levels that could be rounded to 1, i.e., up to 1.5 NTU), 1.0 NTU, 2 NTU (essentially levels that could be rounded to 2, i.e., up to 2.5 NTU), and 2.0 NTU CFE maximums.

New compliance forecasts and cost estimates for the 1, 1.0, and 2.0 NTU CFE maximum levels were based on analysis conducted by EPA (EPA, June 24, 1998). System data from the Partnership for Safe Water and State 2 databases served as the basis for the analysis (see Chapter 3). The analysis conservatively assumed a 0.8 maximum CFE NTU target to meet a 1.0 maximum CFE NTU. The result indicated that additional costs might be incurred to achieve the more stringent 1.0 and 1 maximum CFE NTUs.

At the 1 maximum CFE NTU level, systems in population size categories below 50,000 were assumed to perform additional treatment activities 20 percent of the time; for all other systems, 10 percent was assumed. The slight difference between the 1.0 and the 1 maximum CFE NTU levels (approximately 3 percent of systems already adopted alternative treatment activities to meet the 0.3 NTU standard) led the M-DBP Committee to review cost estimates only for the 1 NTU CFE maximum level. The 2.0 NTU CFE maximum option, the outer range of maximums assumed under the previous stage of alternative development, was not explored further as costs for this option had been previously estimated.

To account for activities related specifically to meeting a 1.0 NTU maximum, the 0.3 NTU compliance forecast was modified through the modified "Delphi" process and confirmed by the M-DBP Committee. The CFE maximum level did not require new treatment; instead, increases in the percentages of some treatment alternatives were presumed sufficient to meet the limit. In all but one case, these percentages were added to the existing figures. Increases in staff training were assumed to apply to all systems, not only those systems for which treatment changes were to be made.

Annualized treatment costs were estimated (using a 0.3 NTU monthly 95th percentile combined filter effluent turbidity) at 1 and 2.0 NTU CFE maximum levels. Costs at the 1 NTU level were estimated at $203 million, costs for the 2.0 NTU scenario at $199 million (Exhibit 5.4).

Exhibit 5.4 National Cost Estimates for Alternative Maximum Combined Filter Effluent Turbidity Limits—June 1997 (10 Percent Cost of Capital Rate)

Size Category (Population Served)	Number of Systems	Combined Filter Effluent ≤ 0.3 NTU at Least 95% of the Time ($000s)	
		2.0 Max*	1 Max**
10,000-25,000	594	$ 41,211	$ 42,706
25,000-50,000	316	34,388	35,303
50,000-75,000	124	17,973	18,190
75,000-100,000	52	9,309	9,407
100,000-500,000	259	6,7290	67,849
500,000-1 Million	26	17,200	17,287
> 1 Million	10	12,134	12,189
Total	**1,381**	**$ 199,458**	**$ 202,932**

* CFE not to exceed 2.0 NTU at any time
** CFE not to exceed 1 NTU at any time (essentially 1.5 NTU)

5.3.6 Ozone for *Cryptosporidium* Inactivation

The M-DBP Committee conducted additional analysis on the use of ozone as an alternative to systems required to achieve 0.1 NTU. In developing a compliance forecast for this alternative, 85 percent of all systems required to modify treatment were assumed to install an ozone system and contactor. Of this number, 30 percent would use Granular Activated Carbon (GAC)/Biologically Activated Filters (BAF), and 2 percent would use ammonia for bromate control.

Of the remaining 15 percent of systems that would not use ozone treatment, two-thirds (or 10 percent of the total) would install membranes (due to the inability to adequately control for bromate if they were to use ozone). The remaining third of systems (or 5 percent of the total) required to modify treatment were able to use regular process controls to achieve compliance.

The total annual costs for *Cryptosporidium* inactivation through the primary application of ozone are detailed in Exhibit 5.5. These costs were calculated by multiplying the unit costs for each option by the annualized cost equation (shown earlier) and by inserting the appropriate compliance forecast percentage as above

Exhibit 5.5 Cost Estimates for *Cryptosporidium* Inactivation by Ozone							
			Systems Using Ozone (85%)			Systems Not Using Ozone (15%)	
System Size (population served)	Number of Systems	Systems Required to Modify Treatment	Total Systems *	GAC/BAF* *	Ammonia ***	Membranes ****	Regular Process Controls *****
10,000-25,000	594	475	404	121	8	48	24
25,000-50,000	316	253	215	65	4	25	13
50,000-75,000	124	99	84	25	2	10	5
75,000-100,000	52	42	36	11	1	4	2
100,000-500,000	259	202	172	52	3	20	10
500,000-1 M	26	18	15	5	1	2	1
> 1 M	10	7	6	2	-	1	0
Total	**1,381**	**1,095**	**932**	**281**	**19**	**110**	**55**
Annual Est. Cost ($000)			**$ 351,200**	**$ 237,100**	**$ 440**	**$ 1,279,000**	-

* 85% of systems required to modify treatment would have to install an ozone system contactor
** 30% of the plants installing an ozone system contactor would use GAC/BAF
*** 2% of the plants installing an ozone system would use ammonia for bromate control
**** Of the 15% of the systems that would not use ozone treatment, 10% would install membranes
***** Of the total of all systems, 5% are able to use regular process controls to achieve compliance

Calculations were based on ozone unit costs from *Technologies and Costs for the Interim Enhanced Surface Water Treatment Rule* (EPA, July, 1998b) as well as through TWG deliberations (BAF and ammonia) Because the figures for *Cryptosporidium* inactivation were developed with an earlier cost model, subsequent methodological changes in the model have been made that could, if applied, reduce the estimated costs of this option, but the magnitude of this change is not known.

5.3.7 Estimated Cost of Turbidity Treatment

Final estimated costs for turbidity treatment in this RIA differ from those presented to the M-DBP Committee. For ease of comparison to earlier cost estimates, unit costs used by the M-DBP Committee were generated using a 10 percent cost of capital. Later analyses expanded this to include costs of capital of 7 and 3 percent. As explained in Chapter 3, a 7 percent cost of capital is now used to calculate total annualized costs. Final estimates of the cost of turbidity treatment are presented at all costs of capital in Exhibit 5.6.

Exhibit 5.6 Final Annual Cost Estimates for Turbidity Treatment Requirements (0.3 NTU 95th Percentile, 1.0 NTU CFE Maximum) (1998 $000s)				
System Size (population served)	Number of Systems	3 Percent Cost of Capital	7 Percent Cost of Capital	10 Percent Cost of Capital
10,000-25,000	594	$ 33,946	$ 37,624	$ 40,932
25,000-50,000	316	29,316	31,862	35,304
50,000-75,000	124	15,450	17,143	18,564
75,000-100,000	52	7,958	8,861	9,508
100,000-500,000	259	56,895	63,544	69,080
500,000-1 Million	26	16,310	18,381	20,092
> 1 Million	10	10,130	11,641	12,927
Total	**1,381**	**$ 170,005**	**$ 189,056**	**$ 206,407**

5.4 Monitoring Individual Filter Turbidity

5.4.1 Overview

The IESWTR requires that all surface water systems that use rapid granular filtration and serve at least 10,000 people to monitor individual filter turbidimeters for each filter in their system. This section discusses the model used to estimate costs and displays the result of the analysis. Costs for monitoring do not include the capital costs of the turbidimeters. These are included in the previous discussion on turbidity treatment. This section provides separate and aggregated cost estimates to utilities and States.

A generalized turbidity monitoring model was developed to provide a framework for estimating costs associated with the IESWTR. The model assumes the use of turbidimeters for each filter and an on-line SCADA system. Filter readings would be taken at least once every 15 minutes and tabulated. The model assumes that once during each work shift (8 hours) the turbidity data would be converted to a reviewable form and would then be reviewed by a system manager. In cases where the monitoring recorded exceedances, an exception report would be made to the State and, if warranted, an individual filter assessment might occur.

Exceptions reporting to the State is warranted if any of the following occur:

- An individual filter has a turbidity level greater than 1.0 NTU for two consecutive measurements 15 minutes apart; and,
- An individual filter has a turbidity level greater than 0.5 NTU at the end of the first four hours of filter operation after backwash for two consecutive measurements 15 minutes apart.

Requirements for additional triggers are discussed in subsequent sections.

5.4.2 Methodology

Costs of turbidity monitoring include both start-up and annual costs for utilities and States. In each case, the underlying estimation methodology is the same. For both utilities and States, specific activities associated with monitoring were identified, primarily through the use of the modified "Delphi" process and subsequent confirmation by the M-DBP Committee.

Labor Rate Assumptions

Labor rates used to calculate the turbidity monitoring labor burden, are derived from a document summarizing cost estimates put forth by plant operators (Via, 1997). Originally, a 1.5 load rate, or 150 percent of wages, (rate of fringe, overhead, and general and administrative costs used to calculate actual total labor cost) was incorporated into the labor rates to account for the true labor costs. Current Department of Labor statistics indicate that a load rate of 1.4 is more accurate (Bureau of Labor Statistics, 1997). The labor rates in the cost model, therefore, reflect a load of 1.4. Unloaded labor costs ranged from $15.00 per hour for technical engineers to $22.00 per hour for managers. Eighty percent of the monitoring labor burden will be for technical workers and 20 percent of the labor burden will be for managers (EPA, June 24, 1998b).

5.4.3 Estimated Costs to Utilities for Turbidity Monitoring

Overview

Turbidity monitoring is required of all systems covered by the rule and using filtration. This section estimates the costs to those utilities of monitoring and reporting results annually and the costs associated with start-up of turbidity monitoring.

Monitoring and Reporting Costs

Utility monitoring activities at the plant level include data collection, data review, data reporting, and monthly reporting to the State. Burden hours were derived from conference calls with EPA and plant operators and were reviewed during M-DBP Committee deliberations.

The labor burden hours for data collection and review were calculated under the assumption that plants are using on-line monitoring, in the form of a SCADA or other automated data collection system. The data collection process requires that a plant engineer gather and organize turbidimeter readings from the SCADA output and enter them into either a spreadsheet or a log once per 8-hour shift (three times per day). Updating of system software was not included as a cost in the final analysis. Upgrading would occur only if there were an equivalent or greater cost savings from labor reductions due to fewer readings.

After data retrieval, the turbidity data from each turbidimeter will be reviewed by a plant engineer once per 8-hour shift (three times per day) to ensure that the filters are functioning properly and are not displaying erratic or exceptional patterns. A monthly summary data report would be prepared. This task involves the review of daily spreadsheets and the compilation of a summary report. It is assumed to take one employee 8 hours per month to prepare. Recordkeeping is expected to take five hours per month. Recordkeeping entails organizing daily monitoring spreadsheets and monthly summary reports.

Plant-level data will also be reviewed monthly at the system level to ensure that each plant in a system is in compliance with the rule. A system-level manager or technical worker will review the daily monitoring spreadsheets and monthly summary reports that are generated at the plant level. This task is estimated to take about 4 hours per month. Once the plant-level data have been reviewed, the system manager or technical worker will also compile a monthly system summary report. These reports are estimated to take 4 hours each month to prepare.

Start-up Costs

A list of utility start-up activities was derived from "Delphi" discussions with a sample of plant operators. Utility start-up activities include reading and understanding the rule, mobilization and planning, and employee training. System managers would review the rule in order to understand provision and to determine how these standards will affect their operations. It is assumed that each plant will need to complete some mobilization and planning in order to comply with the turbidity provisions. This will require that system managers assess current plant operations and employee schedules in order to implement a strategy for monitoring the turbidity data.

Total Estimated Cost to Utilities for Turbidity Monitoring

Annual costs to utilities for turbidity monitoring are estimated at $96 million (Exhibit 5.7). The total utility labor burden of complying with monitoring and reporting requirements is estimated to be over 4 million hours per year. This equals an average of 3,016 hours per system per year. The national utility start-up and implementation costs are estimated at $4.5 million. This is annualized at 7 percent, with a resulting annual cost of $0.4 million. The labor burden associated with utility start-up and implementation activities is estimated to be over 160,000 hours. Actual burdens and costs will vary from system to system depending on the level of sophistication of the data management systems.

Exhibit 5.7 Utility Turbidity Start-Up and Monitoring Annual Costs

Compliance Activities	Respondents Affected	Unit Costs	CF*	Annual Costs
Utility Start-Up Costs**	1,381 Systems	$ 3,108	0.09439	$ 405,136
Utility Plant Monitoring Costs	1,728 Plants	52,644		90,968,832
Utility System Monitoring Costs	1,381 Systems	3,588		4,955,028
Total Annual Utility Costs for Turbidity Monitoring and Start-Up				**$ 96,328,996**

* The Capitalization Factor (CF) is calculated using the cost of capital (7%), the number of years of capitalization (20 years), and the current value of money ($1).
** Start-up costs are annualized over 20 years with a CF of 0.09439

5.4.4 Estimated Costs to States for Turbidity Monitoring

Overview

The State's responsibility under the rule includes reviewing system data to ensure that all systems in the State are in compliance with the IESWTR. State activities also include reviewing Statewide utility data, recordkeeping, and determining compliance. State activities were identified through a process of interviews with State officials. review of similar regulatory requirements, and confirmation by the M-DBP Committee Annual State costs for review (nationwide) are estimated to be $5 3 million The annual labor burden is estimated to be 182,000 hours, or about 132 hours per system.

Start-Up Costs

One-time State start-up activities include the adoption of the rule and State regulation development. The list of State start-up activities was derived from technical experts and State regulators.

Total Estimated Cost to States for Turbidity Monitoring

Exhibit 5 8 presents the estimated cost of implementing turbidity monitoring. The rule would collectively cost States an estimated total of $407,000 to implement. This is annualized at 7 percent, with a resulting annual cost of $38,000. The national labor burden for the State program start-up is estimated to total 14,000 hours.

Exhibit 5.8 State Turbidity Start-Up and Monitoring Annual Costs

Compliance Activities	Respondents Affected	Unit Costs	CF*	Annual Costs
State Start-Up Costs**	56 Entities	$ 7,268	0.09439	$ 38,417
State System Monitoring Costs	1,381 Systems	3,806		5,256,086
Total Annual State Costs for Turbidity Monitoring and Start-Up				**$ 5,294,503**

* The Capitalization Factor (CF) is calculated using the cost of capital (7%), the number of years of capitalization (20 years), and the current value of money ($1)
** Start-up costs are annualized over 20 years with a CF of 0 09439

5.5 State and Utility Turbidity Exceptions Reporting Costs (Exception Reports, IFAs, and CPEs)

5.5.1 Overview

The turbidity monitoring provisions, *in tandem* with existing CFE monitoring requirements, are designed to provide utilities and States with a means to better assess effluent quality. The IESWTR sets new limits for CFE levels; therefore, exceedance of the individual filter limits would trigger a variety of responses as described below, depending on the limit exceeded.

Exceptions Reporting

A monthly exception report must be filed by each utility for exceedances of the individual filter turbidity limit. Two samples, taken 15 minutes apart, at which a plant exceeds either an individual filter turbidity of 1.0 NTU or, after ripening, an individual filter turbidity of 0.5 NTU after the first four hours of filter operation after backwash, constitute an exception. This precludes any anomalous readings by allowing sufficient time for "bubbles" or other distortions to disperse.

IFAs and CPEs

In addition to the monthly exception report required for each exceedance, additional requirements are triggered when exceedances persist. If a plant reports exceedances of 1 0 NTU at one filter for three consecutive months, an individual filter assessment (IFA) is required. The IFA will be performed by the utility If a plant records exceedances of 2 0 NTU at one filter in two consecutive months, a comprehensive performance evaluation (CPE) is required A State or third party must perform the CPE.

The intent of this rule element is to provide an opportunity for utilities to correct filter problems after being alerted to their presence. Thus, a utility can react to the preliminary readings with the exceptions report and begin corrective actions internally, thus possibly avoiding costs associated with the IFA or the CPE.

5.5.2 Methodology

This analysis assumes exceedance rates for each category and the level of effort and cost to respond to those exceedances based on previous experience and through the use of the modified "Delphi" process. The incidence of individual filter turbidity readings that would trigger an exception report to the State is estimated to occur at 10 percent of all systems each year. Compiling and submitting these reports to the States is estimated to take 8 hours and cost a system $414 per report. The reporting process involves the review of monitoring data spreadsheets and writing the report.

Two percent of all systems are estimated to exceed IFA thresholds of 1.0 NTU individual filter turbidity in 3 consecutive months. At this percentage, approximately 28 IFAs will be conducted each year, at an estimated cost of $5,000 each. This cost assumes that each IFA takes 50 hours to complete at a rate of $100/hour.

One percent of all systems are estimated to exceed CPE thresholds of 2.0 NTU turbidity in two consecutive months. At this percentage, approximately 14 CPEs will be conducted each year at a cost of $25,000 each. This cost is based on the assumption that each State or third party CPE takes 250 hours to complete at a rate of $100 /hour (Exhibit 5.9). For this analysis it is assumed that States will perform the CPEs.

Estimated Cost of Exceptions for States and Utilities

Estimated annual costs for utilities filing exception reports and conducting IFAs total $195,173. States are expected to incur annual costs of $64,000 to review the exception reports and $345,000 to perform CPEs. Cumulative annual costs for exception reports, IFAs, and CPEs total $604,000.

Exhibit 5.9 Utility and State Turbidity Exception Costs			
	Respondents Affected Annually	Cost per Occurrence	Annual Costs
Utility Costs			
Annual Reporting Exceptions	138 Systems	$ 414	$ 57,173
Annual IFAs	28 Systems	5,000	138,000
Total Utility Exception Costs			**$ 195,173**
State Costs			
Annual Reporting Exceptions	138 Systems	$ 461	$ 63,664
Annual CPEs	14 Systems	25,000	345,000
Total State Exception Costs			**$ 408,664**
Total Annual Costs			**$ 603,837**

5.6 Disinfection Profiling and Benchmarking

5.6.1 Overview

This section discusses the cost associated with generating data for and performing a one-time disinfection profile of a utility's microbial backstop/disinfection data—disinfection benchmarking. This profile establishes a benchmark of the utility's disinfection practices, providing regulators with data to support their review of utility activities during a sanitary survey or when the utility changes its disinfection practices. Unlike turbidity monitoring, which must be done by the 1,381 large surface water systems that employ rapid granular filtration, disinfection benchmarking requirements must be met by all 1,395 large surface water systems, a difference of 14 systems.

As described in the rule, a disinfection benchmark consists of a compilation of daily *Giardia lamblia* log inactivations (plus virus inactivations for systems using either chloramines or ozone for primary disinfection), computed over the period of a year, based on daily measurements of operational data (disinfectant residual concentration, contact time, temperature, and where necessary, pH). To establish the disinfection benchmark, the utility will determine the lowest average month (critical period) for each 12-month period and average critical periods to create a benchmark reflecting a lower bound of the utility's current disinfection practice. Those utilities with necessary data to develop benchmarks, using operational data collected prior to promulgation of the rule, may use up to 3 years of that data in developing their benchmarks. The benchmark will be the average of log inactivations of the lowest month each year for the 3-year period. Those utilities that do not have 3 years of relevant operational data will have to begin a 1-year monitoring effort to develop a benchmark. This effort will begin no later than 15 months after the IESWTR is promulgated.

Costs for benchmarking include costs of the 1-year monitoring effort for developing the profile and benchmark, as well as review of the benchmark when considering disinfection changes. The costs are shared by both utilities and States. Where costs were unavailable, assumptions were provided through the modified "Delphi" process.

5.6.2 Methodology

For each State or utility activity identified, estimated burden hours were multiplied by labor rates Labor category subtotals were totaled by activity and activities totaled by major benchmarking processes The labor associated with benchmarking is conducted at the plant l. el, with the cost per system based on the number of plants For this analysis it was assumed that smaller systems had one plant, larger systems had two Again, this analysis includes 1,395 systems to include both filtering and unfiltering systems The percentage of systems requiring benchmarking was determined using data from the 1996 Water Industry Data Base (WIDB), and totals calculated by system size

Data Monitoring

Each system will review data for total trihalomethanes (TTHM) and 5 haloacetic acids (HAA5) to determine whether it must develop a year-long disinfection profile. Much of these data are already available All systems over 10,000 already collect TTHM data for compliance with the 1979 Total Trihalomethane Rule. Systems over 100,000 also collect HAA5 data for the 1996 Information Collection Rule (ICR) To comply with the requirement of reviewing HAA5 data, only systems serving between 10,000 and 100,000 persons are expected to incur costs in collecting new data.

Costs for HAA5 data collection were estimated in the companion Stage 1 Disinfectants/Disinfection Byproducts Rule (Stage1 DBPR) regulatory impact analysis. Those costs are incorporated here. For each collected sample, a 50-minute effort is required, costing $200. For a total of 12 months, this equals $2,400 and 10 hours. Multiplying by the number of systems serving between 10,000 and 100,000 (1,086 systems) generates a cost of $2,606,400. In addition, it is estimated that 11 systems will be required to generate a public notification of failure to monitor for HAA5. Each public notice cost $210 for a total of $2,300. Total start-up costs are $2,608,700. This one-time cost estimate annualizes at a 7 percent rate to $246,000.

Percentage of Systems Needing to Develop a Benchmark

Three industry databases (1996 WIDB, the Partnership for Safe Water database, and the State 2 Survey database) provided the number of plants per system and number of systems per each size category (1,381 total systems). In addition, 14 unfiltered systems were included in this analysis. In determining the number of plants per size category, the number of plants per system was multiplied by the number of systems in each of the population size categories. HAA5 and TTHM figures from the 1996 WIDB were used to estimate the percentage of systems that would prepare a disinfection benchmark under the IESWTR This analysis determined that 29 percent of the systems would need to develop a benchmark. This percentage reflects the number of systems with data showing TTHMs or HAA5 greater than or equal to either 64 μg/L or 48 μg/L—80 percent of the maximum contaminant levels (MCLs) for TTHMs and HAA5, respectively.

Utilities must prepare a disinfection benchmark if they:

- Measure TTHM levels of at least 80 percent of the MCL (64 μg/L) as an annual average; or,
- Measure HAA5 levels of at least 80 percent of the MCL (48 μg/L)as an annual average.

The 1996 WIDB includes annual average TTHM and HAA5 figures from 574 plants (comprising 399 systems). Analysis of the 78 systems in the 1996 WIDB for which TTHM and HAA5 data exist shows that 29 percent had TTHM levels greater than 64 µg/L and/or HAA levels greater than 48 µg/L. Under the rule these systems would conduct a disinfection benchmark (Exhibit 5.10).

TTHM and HAA5 data exist only at the distribution system level and, therefore, only permit an analysis at that level. For example, if there were five plants in a system, the TTHM and HAA5 data for these plants were identical as all five feed into the same distribution system. To avoid double counting, only one set of TTHM and HAA5 data were used as part of the analysis in this example. The absence of plant disinfection byproduct data limited an analysis to the system level.

Exhibit 5.10 TTHM and HAA5 Data from the Water Industry Database (WIDB)

TTHM level (µg/L)	HAA5 level (µg/L)	Number of WIDB Systems*	
		Systems w/ TTHM data only**	Systems w/ both TTHM & HAA5 data***
≥64	≥ 0.048	50 (22%)	22 (29%)
< 64	< 0.048	180 (78%)	56 (71%)
Total		**230 (100%)**	**78 (100%)**

* Systems for which no data exists or for which only zero exist, were omitted from the data set.
** Plants that are categorized only according to TTHMs because HAA5 data are not reported
*** Systems that have either TTHM levels that are ≥ 64 µg/L or HAA5 levels that are ≥ 48 µg/L

Utility Activities

Utility costs associated with benchmarking were divided into four activity components. These are cost per system, cost per plant using paper data, cost per plant using mainframe data, and cost per plant using Personal Computer (PC) data. Each component is made up of activities defined by the TWG, reflecting a plant's method of collecting data. Plants with paper data were assumed to represent half of the number of plants needing a disinfection benchmark, while plants with mainframe data and plants with PC data each represent a quarter. The TWG assumed that all plants currently collect this data in either an electronic or paper format and, therefore, would not incur additional data collection expenses due to microbial profiling.

Average system costs were multiplied by the percent of systems needing a disinfection benchmark and summed by system category. Each plant category was multiplied by the corresponding percentage (the percentage of plants using either paper, mainframe, or PC data), with total plant costs representing the sum of all types by system size category.

State Activities

Each State will review disinfection benchmarks as part of its sanitary survey process. Those utilities that decide to make a significant change in disinfection practice (e.g., move point of disinfection, change the type of disinfectant, change the disinfection process, or make other changes designated as significant by the State) are required to develop a disinfection benchmark and must consult with the State prior to implementing such a change. Supporting materials for such consultation must include a description of the proposed change the disinfection benchmark, and an analysis of how the proposed change will affect the effectiveness of disinfection

State activities considered applicable to the disinfection benchmark process included reading and understanding the rule changes, mobilization and planning, training of State staff, and providing training in protocols for utilities and consultants These activities are complemented by additional tracking of system compliance, review of data received, making regulatory determinations, meeting with utilities, and recordkeeping

Estimates for State start-up and annual costs were totaled State start-up costs are derived by multiplying State start-up costs by the number of States and territories (56). These costs are then annualized at 7 percent. Total annual costs for all States are also derived by multiplying the annual costs per State by 56.

Labor Rate Assumptions

Labor costs and assumptions figure prominently in benchmarking cost estimates. Two classes of labor comprise the work effort: management and technical. Management and technical positions are assumed to divide labor hours at a 1:4 ratio. Clerical hours are incorporated into the cost, but are not part of the burden needed to complete an activity.

Costs of labor were derived from the modified "Delphi" process, and are based on actual labor rates in place in numerous systems (Via, 1997). Unloaded labor costs ranged from $15.00 per hour for technical engineers to $22.00 for managers. Labor rates include a 1 4 load, representing fringe rates, provided by the Bureau of Labor Statistics (BLS).

5.6.3 Estimated Costs of Disinfection Benchmarking

Exhibit 5.11 displays the specific activities and costs pertinent to utilities required to benchmark under the recommended provisions. Provided are the total costs incurred by systems and costs based on current information collection techniques.

Exhibit 5.11 Annual Utility Disinfection Benchmarking Cost Estimates

	Cost per Entity	Number of Entities	Annual Costs
Annual Cost per System	3,987	405	$ 1,616,517
Annual Cost per Plant: Paper Data	3,551	252	894,701
Annual Cost per Plant: Mainframe Data	1,339	126	168,638
Annual Cost per Plant: PC Data	1,283	126	161,582
Total Annual Cost			$ 2,841,438

Exhibit 5 12 displays State costs for reviewing utility disinfection benchmarks. This exhibit illustrates the start-up costs per State, as well as the total annual costs for all States.

Exhibit 5.12 Annual State Disinfection Benchmarking Cost Estimates			
	Cost per State	Number of States & Territories	Total Costs
Start-Up Cost (annualized)	$ 544	56	$ 30,489
Annual Cost	49,795	56	2,788,632
Total Annual Cost	$ 50,341		$ 2,819,121

Labor costs are the primary factor in both State and utility total benchmarking costs. Where labor rates or activity burdens are high, costs are high. This sensitivity to labor rates and burdens increases the need to better understand the ratio between high- and low-burden activities. For example, modifying assumptions on plant processes with high labor burdens (e.g., plants with paper data) could substantially alter the final cost totals.

5.7 Sanitary Surveys

5.7.1 Overview

A sanitary survey is an onsite review of the water source, facilities, equipment, operation, maintenance, and monitoring compliance of a utility. The survey evaluates the adequacy of the system, its sources and operations, and the distribution of safe drinking water. The sanitary survey documents the capabilities of a system to continually provide safe drinking water and identifies any deficiencies.

Elements of the rule, such as disinfection benchmarking, expand existing sanitary survey practices. For example, disinfection benchmarking requirements may entail additional State review during a sanitary survey to assess the results of the disinfection profile for microbial inactivation. In addition, the IESWTR also requires States, as part of the sanitary survey requirement, to work with utilities to overcome or address significant deficiencies.

The IESWTR requires that the State, or third party approved by the State, conduct sanitary surveys for *all* surface water systems (including both filtered and unfiltered systems) no less frequently than every 3 years for community systems and no less frequently than every 5 years for noncommunity systems. Any sanitary survey conducted after December 1995 that addresses the eight elements outlined in the rule (source; treatment; distribution system; finished water storage; pumps, pump facilities, and controls; monitoring, reporting, and data verification; system management and operation, and operator compliance with State requirements) may be considered "grandfathered" for purposes of completing the first round of surveys. This approach also provides that for those community systems determined by the State to have outstanding performance based on prior sanitary surveys, successive sanitary surveys may be conducted no less frequently than once every 5 years.

5.7.2 Methodology

States will perform start-up activities, such as planning and training, to prepare for conducting sanitary surveys. These costs are based on a per-state estimate of the technical and managerial labor hours that will be required. This annualized cost at 7 percent cost of capital is presented in Exhibit 5.14.

Annual sanitary survey costs are a function of plant and system size The larger the plant or system the more extensive the data gathering, data review, and data reporting effort Estimated costs per survey in those systems serving less than 25,000 are roughly similar, larger size categories see progressively higher sanitary survey costs (Exhibit 5 14, see Appendix E-11 for details)

States are expected to conduct sanitary surveys on a rotating basis For this analysis, 80 percent of surveys are assumed to have already been conducted. This analysis assumes that the remaining 20 percent to comply with the rule.

Unlike other elements of the rule, the sanitary surveys need to be conducted for all surface water treatment systems, not just those serving more than 10,000 persons However, this does not trigger the requirement for a regulatory flexibility analysis because the IESWTR requires States to conduct surveys, as reflected in this cost analysis.

Sanitary surveys must also be conducted for systems that do not filter, unlike most of the IESWTR requirements. The impact of surveys for these systems on cost estimates is minor. Unfiltered systems have a smaller treatment process to review but a more extensive source water review. The Surface Water Treatment Rule (SWTR), however, addresses source water review in unfiltered systems, so these costs are not counted in this estimate.

This analysis establishes a list of activities that are typically conducted during a sanitary survey This list is derived from guidance on conducting surveys. Each activity has an estimated cost, computed as the number of hours needed to complete the task by labor category. The total time needed to complete an activity is longer in larger systems than in smaller.

Total sanitary survey costs were computed for each size category for both filtered and unfiltered water systems (6,560 systems), then multiplied by the percentage of plants needing to conduct a survey. It is assumed that there are 5,165 small surface water systems. The baseline number of large systems (1,395) to perform sanitary surveys is different than the baseline number of systems presented in Exhibit 3.1, since insufficient data exist to determine how the 14 unfiltered systems that do not have to modify treatment are categorized by system size. The baseline for this analysis was established from the 1994 Stage 1 DBPR RIA. While the number of systems reported in each size category differs from that presented in the rest of this RIA, it provides a good estimation of the costs States will have to incur to perform sanitary surveys.

5.7.3 Estimated Cost of Sanitary Surveys

Exhibit 5 13 displays the revised baseline estimated for this analysis. Exhibit 5.14 displays the total cost to States per population size category based on this revised baseline. Appendix E-11 includes start-up and annual activities and burdens for each size category, including distinctions between filtered and unfiltered systems (Exhibit 5.14 may not match detail of Appendix E-11 due to independent rounding). The cost estimates in this analysis include all costs of conducting sanitary surveys, not just the incremental effort included in the rule. The costs presented here are, therefore, considered an overestimate of the probable costs.

Exhibit 5.13 Revised Baseline of Systems Based on 1994 Stage 1 DBPR RIA					
System Size (population served)	Total Number of Plants	Number of Plants, Filtered	Filtered Plants to Conduct Survey	Number of Plants, Unfiltered	Unfiltered Plants to Conduct Survey
< 10K	5,165	4,880	976	285	57
10K-25K	569	551	110	18	4
25K-50K	328	322	64	6	2
50K-75K	157	155	31	2	0
75K-100K	108	216	43	0	0
100K-500K	350	344	69	6	1
500K-1M	86	82	17	4	0
> 1M	30	28	6	2	0
Total	6,560	6,578	1,316	323	64

Exhibit 5.14 Total Start-Up and Annual Costs of Sanitary Surveys Based on Revised Baseline of Systems			
Start-Up Costs Annualized at 7% Cost of Capital			$ 55,356
System Size (population served)	Costs for Filtered Plants	Costs for Unfiltered Plants	Total Costs
< 10K	$ 1,464,000	$ 55,575	$ 1,519,575
10K-25K	165,000	3,900	168,900
25K-50K	580,800	9,110	589,910
50K-75K	499,500	0	499,500
75K-100K	1,041,675	0	1,041,675
100K-500K	2,194,200	15,115	2,209,315
500K-1M	669,375	0	669,375
> 1M	280,800	0	280,800
Subtotal	$ 6,895,350	$ 83,700	6,979,050
Total Annual Costs (including annualized costs)			$ 7,034,406

5.8 Covered Finished Water Reservoirs

5.8.1 Overview

The IESWTR requires that systems cover all new finished water reservoirs, holding tanks, or other storage facilities for finished water Finished water reservoirs open to the atmosphere are subject to the same environmental factors as surface waters, depending on site-specific characteristics and the degree of protection provided These include contamination by persons swimming, by disposal of garbage into the reservoir, by microbial and other organisms, and by small mammals, birds, fish, and the growth of algae This contamination is marked by increases in algal cells, bacteria, turbidity, total and fecal coliforms (e.g., E coli), and pathogens.

5.8.2 Methodology

The analysis of costs for covering finished water reservoirs is complicated by the lack of data regarding the construction of reservoirs. The precise number of systems constructing finished water reservoirs is unknown. As the rule requires all systems constructing finished water reservoirs to cover them, its cost impact is only on those who were not originally planning to construct covers. Furthermore, reservoirs are not uniform in size, configuration, or depth, requiring the development of a range of unit costs to capture the variability of the total costs.

To address these factors, several key assumptions were made. To estimate the number of reservoirs being constructed, data on the number of systems serving at least 10,000 people were gathered from a 1987 ASDWA survey and compared with the base number of systems in this analysis, derived from the Safe Drinking Water Information Systems (SDWIS). The difference is the total number of new systems for a 9-year period, which was then extrapolated for the full 20 years used elsewhere in this analysis.

EPA estimates that 10 percent or fewer of newly constructed systems use finished water reservoirs. Although some States require that finished water reservoirs be covered, many systems have already covered their reservoirs as a response to the public health concerns raised by uncovered reservoirs. The actual number of covered finished water reservoirs, however, is difficult to establish. This analysis is based on the estimate that 10 percent of systems use finished water reservoirs, and that all covers for new reservoirs are implemented in response to this rule. EPA believes this to be a conservatively high estimate of the number of finished water reservoirs to be covered specifically in response to the IESWTR provisions.

The calculations for this rule element use a model finished water reservoir, assuming a 25-foot depth and a reservoir storage volume equal to one day of average water flow capacity at each system size category. Cover costs are estimated at $2.00 per square foot.

Estimated Cost of Covered Finished Water Reservoirs

The estimated costs of covered finished water reservoirs at 7 percent cost of capital are presented in Exhibit 5.15

Based on the assumptions above, approximately 73 new systems will build covered finished water reservoirs in the next 20 years. Annualized capital costs are estimated to be $2 million and annual O&M

is estimated to be $0.5 million. Approximately 65 percent of the covered finished water reservoirs are estimated to be built in the two smallest size categories.

Exhibit 5.15
Annual Cost of Covered Finished Water Reservoirs (7 percent cost of capital)

System Size (population served)	Estimated Number of New Plants with Covered Finished Water Reservoirs	Total Annualized Capital Costs	Total Annual O&M	Total Annual Cost
10K-25K	30	$ 146,141	$ 122,618	$ 268,759
25K-50K	17	193,049	87,772	280,821
50K-75K	8	151,209	51,232	202,441
75K-100K	6	150,244	42,501	192,745
100K-500K	9	477,542	105,596	583,138
500K-1M	2	483,162	83,350	566,512
> 1M	1	345,115	56,782	401,897
Total	**73**	**$ 1,946,462**	**$ 549,851**	**$ 2,496,313**

5.9 Household Costs

5.9.1 Overview

Household costs are the translation of the total cost to utilities to their customers. The previous sections estimate total utility costs for the various elements of the IESWTR. This section further refines the analysis of the cost impacts of the rule by expressing utility costs as increases in annual costs to individual households.

5.9.2 Methodology

One estimated cost, turbidity treatment, complicates the calculation of household costs because it is a compilation of activities, each with a different cost to utilities. Two assumptions are made with respect to turbidity treatment, therefore, in this analysis.

The underlying assumption that drives the turbidity treatment portion of the total cost analysis is that compliance forecast activities to meet the rule requirements are more likely to occur together than not. In other words, a utility is more likely to have to implement a group of activities rather than an individual activity.

A second assumption involves an exception to the first assumption. The first four filtration activities (Appendix A) are mutually exclusive and would not be implemented together. Thus, a utility would perform only one of the following

- Filter media addition,
- Filter media entire replacement without support gravel,
- Filter media and support gravel replacement; or
- Filter media, support gravel, and underdrain replacement

The underlying assumption that activities are more likely to occur together than not has implications in the choice of methodology. This assumption precludes the use of a simple average cost per household (calculated by dividing the total turbidity treatment costs for each system size category by the number of households) for several reasons. First, a simple average by size category underestimates the upper bound of household costs. Some systems within each category will be more likely to implement many, if not all, of the activities, thereby resulting in a much higher-than-average household cost for their ratepayers. An alternative methodology is needed to capture the projected distribution of costs across treatment alternatives.

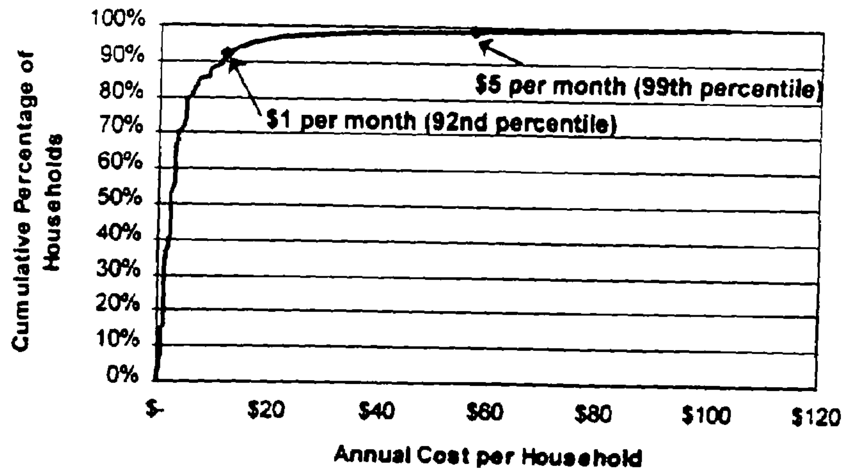
The methodology used for this analysis assumes that a small percentage of systems within each size category will need to implement *all* of the general treatment activities and one of the first four filtration activities to comply. The next increment of systems are assumed to implement ***all but one*** (the least common) of the general treatment activities and one of the first four filtration activities to comply. The process continues dropping out general treatment activities, until a final increment of systems only implements the most common treatment activity. Once the range of activities was estimated, costs of these activities were calculated. These system unit costs were then converted to household costs. The final step repeats this process for each system size. The results are a list of the number of households at a specific cost per household. These results are then graphed to display the cumulative distribution of household costs. Detailed household cost estimates are presented in Appendix F.

5.9.3 Results of Household Cost Analysis

Under the IESWTR, households will face the increases in annual costs displayed in Exhibit 5.16. All households served by large surface water systems will incur additional costs under the IESWTR since all systems are required to perform turbidity monitoring activities. However, as shown in the cumulative distribution of households affected by the rule, a large number (92 percent) of households will face a *maximum* increase in cost of $12 per year ($1 per month). In other words, 60 million households will incur no more than a $1 increase in their monthly costs. Five million households (7 percent) will face an increase in cost of between $12 and $60 per year ($1-$5 per month). The highest cost faced by 23,000 households is approximately $100 per year ($8 per month).

The assumptions and structure of this analysis, in describing the curve, tend to overestimate the highest costs. To be on the upper bound of the curve, a system would have to implement all, or almost all, of the treatment activities. These systems, conversely, might seek less costly alternatives, such as connecting into a larger regional water system. The TWG thought that this was an extreme situation, and the resulting high values may occur only for a small number of households. In addition, even at the upper end the monthly cost per household is less than $10 per month, relatively small in comparison with other common household expenditures

Exhibit 5.16
Cumulative Distribution of Annual Cost per Household of the IESWTR



5.10 Combined Effect of the Stage 1 DBPR and the IESWTR

Because the IESWTR and Stage 1 DBPR were developed *in tandem* to address the risks of disinfection byproducts while not compromising protection against microbial contaminants, it is important to examine the combined effects of both rules as well as those rules expected to be implemented in the next several years.

While the Stage 1 DBPR may impose additional costs to large surface water systems beyond those described in this chapter for the IESWTR, these systems may see greater benefits as well. The anticipated impact of both rules at a 7 percent cost of capital is summarized in Exhibit 5.17.

Exhibit 5.17
Cost Impact of Current and Expected Rule-Makings

System Types	Current and Expected Rules		
	D/DBP Stage 1 ($000)	Interim ESWT ($000)	Other Rule-makings Planned
Small Surface Water	$ 56,804	$ 0	Stage 2 DBPR Long-term ESWTR 1 (LT1)
Large Surface Water	278,321	291,165	Stage 2 DBPR Long-term ESWT 2 (LT2)
Small Ground Water	218,062	0	Stage 2 DBPR Ground Water Disinfection
Large Ground Water	130,651	0	Stage 2 DBPR Ground Water Disinfection
Subtotal	**$ 683,838**	**$ 291,165**	....
States	17,342	15,556	....
Totals	**$ 701,180**	**$ 306,721**	....

6: Net Benefits

This section provides a comparison of the benefit and cost outcomes with benefit/cost principles Chapters 4 and 5 present quantitative summaries of the final benefit and cost impacts of the Interim Enhanced Surface Water Treatment Rule.

The assessment of net benefits is always somewhat problematic due to the relative ease of quantifying compliance treatment costs versus the difficulty of assigning monetary values to the avoidance of health damages and other benefits arising from the regulation. The challenge of assessing net benefits for the IESWTR is compounded by the fact that there are areas of scientific uncertainty regarding the exposure assessment and the risk assessment for *Cryptosporidium*. Areas where important sources of uncertainty enter the benefits assessment include the following.

- Occurrence of *Cryptosporidium* oocysts in source waters;
- Occurrence of *Cryptosporidium* oocysts in finished waters;
- Reduction of *Cryptosporidium* oocysts due to treatment, including filtration and disinfection;
- Viability of *Cryptosporidium* oocysts after treatment;
- Infectivity of *Cryptosporidium*;
- Incidence of infections (including impact of under reporting);
- Characterization of the risk; and,
- Willingness-to-pay to reduce risk and avoid costs.

The benefits analysis attempts to take into account some of these uncertainties by estimating benefits under two different current treatment assumptions and three improved removal assumptions. The benefits analysis also used Monte Carlo simulations to derive a distribution of estimates, rather than a single point estimate.

Exhibit 6.1 summarizes the annual cost of the rule at the 3, 7, and 10 percent costs of capital. Annual utility costs at 7 percent are approximately $291 million and annual State costs are approximately $15 million.

Exhibit 6.2 summarizes the mean expected value of potential annual benefits expected to accrue to the turbidity provisions under the six different scenarios, as well as the range. The range presented in the exhibit represents the 10th and 90th percentiles of the calculated distribution of illnesses. Thus, the actual number of illnesses has a 10 percent probability of being as low or lower than the bottom end of the range presented and as high or higher than the top of the range presented.

Exhibit 6.1
Summary of Costs under the Interim Enhanced Surface Water Treatment Rule ($000s)

	Final Rule (1998 $s)		
	3% Cost of Capital	7% Cost of Capital	10% Cost of Capital
Utility Costs			
Utility Treatment Capital	$ 758,965	$ 758,965	$ 758,965
Annual Costs			
*Annualized Capital**	*65,999*	*85,611*	*103,437*
Annual O&M	*105,943*	*105,943*	*105,943*
Total Treatment	171,942	191,554	209,380
Turbidity Monitoring	95,924	95,924	95,924
Turbidity Exceptions**	195	195	195
Disinfection Benchmarking	2,841	2,841	2,841
Subtotal	*270,902*	*290,514*	*308,340*
Annualized One-Time Costs***			
Turbidity Monitoring Start-Up	289	405	504
HAA Benchmarking	175	246	306
Subtotal	*464*	*651*	*810*
Total Annual Utility Costs	**$ 271,366**	**$ 291,165**	**$ 309,150**
State Costs			
Annual Costs			
Turbidity Monitoring	5,256	5,256	5,256
Turbidity Exceptions****	409	409	409
Sanitary Survey	6,979	6,979	6,979
Disinfection Benchmarking	2,789	2,789	2,789
Subtotal	*15,433*	*15,433*	*15,433*
Annualized One-Time Costs***			
Turbidity Monitoring Start-Up	27	38	48
Disinfection Benchmarking Start-Up	22	30	38
Sanitary Survey Start-Up	39	55	69
Subtotal	*88*	*123*	*155*
Total Annual State Costs	**$ 15,521**	**$ 15,556**	**$ 15,588**
Total Annual Costs	**$ 286,887**	**$ 306,721**	**$ 324,738**

* Capital costs are annualized over 20 years with the exception of turbidimeters and process control modification equipment, which are annualized over 7 years
** Costs associated with Individual Filter Effluent Turbidity Requirements for exceptions reporting and Individual Filter Assessments
*** All one-time costs are annualized over 20 years
**** Costs associated with Reporting Exceptions and Comprehensive Performance Evaluations.

Exhibit 6.2 Summary of Potential Annual Benefits					
		Baseline Assumes...			
		2.5 Log *Cryptosporidium* Removal		3.0 Log *Cryptosporidium* Removal	
		Mean	Range	Mean	Range
Crytposporidiosis Illness Avoided Annually					
LOW	Number of Illnesses Avoided	338,000	0 - 1,029,000	110,000	0 - 322,500
	Cost of Illness Avoided	$0.950 billion	$0 - 1.883 billion	$0.263 billion	$0 - 0.585 billion
MID	Number of Illnesses Avoided	432,000	0 - 1,074,000	141,000	0 - 333,000
	Cost of Illness Avoided	$1.172 billion	$0 - 1.960 billion	$0.327 billion	$0 - 0.608 billion
HIGH	Number of Illnesses Avoided	463,000	0 - 1,080,000	152,000	0 - 338,000
	Cost of Illness Avoided	$1.240 billion	$0 - 1.999 billion	$0.359 billion	$0 - 0.620 billion
Value of Crytposporidiosis Mortalities Avoided Annually					
LOW	Number of Mortalities Avoided	48	0 - 129	14	0 - 40
	Value of Mortalities Avoided	$0.272 billion	$0 - 0.674 billion	$0.085 billion	$0 - 0.209 billion
MID	Number of Mortalities Avoided	60	0 - 135	18	0 - 42
	Value of Mortalities Avoided	$0.341 billion	$0 - 0.706 billion	$0.107 billion	$0 - 0.219 billion
HIGH	Number of Mortalities Avoided	64	0 - 136	20	0 - 42
	Value of Mortalities Avoided	$0.363 billion	$0 - 0.708 billion	$0.115 billion	$0 - 0.221 billion
Reduced Risk of Crytposporidiosis Outbreaks	Cost of Illness Avoided Emergency Expenditures Liability Costs	Benefits not quantified, but could be substantial for large outbreak ($0.800 billion cost of illness avoided for a Milwaukee-level outbreak)			
Reduced Risk from Other Pathogens		Benefits not quantified.			
Enhanced Aesthetic Water Quality		Difference may not be noticeable to consumer			
Averting Behavior		Benefits not quantified, but could be substantial for large outbreak ($0.020 billion to $0.062 billion for a Milwaukee-level outbreak)			

Given the costs summarized in Exhibit 6.1 and the benefits assuming a mean number of illnesses avoided summarized in Exhibit 6.2, the recommended rule results in positive net benefits under all three improved removal scenarios (low, mid, and high) assuming that current treatment achieves a removal of 2.5 logs, taking into account *only* the value of cost of illness (COI) avoided. Using a current treatment removal assumption of 3.0 logs, net benefits are negative under the low improved removal assumption using only the value of COI avoided. When the value of mortalities prevented is added into the benefits, all baseline assumptions and removal scenarios have positive net benefits at the mean.

Thus, the monetized net benefits are positive across the range of current treatment assumptions, improved log removal scenarios, and cost of capital rates. The benefits due to the illnesses avoided may be slightly overstated because the mortalities were not netted out of the number of illnesses. This value is minimal and would not be captured at the level of significance of the analysis. Several categories of benefits, including reducing the risk of outbreaks, reducing exposure to other pathogens such as *Giardia*, and avoiding the cost of averting behavior have not been quantified for this analysis, but could represent substantial additional economic value. In addition, the estimates for avoided COI do not include the value for pain and suffering or the risk premium.

7: The Economic Rationale for Regulation

7.1 Introduction

This section of the RIA discusses the statutory authority on the economic rationale for choosing a regulatory approach to protect public health from drinking water contamination. The economic rationale is provided in response to Executive Order Number 12866, *Regulatory Planning and Review*, which states,

> [E]ach agency shall identify the problem that it intends to address (including, where applicable, the failures of the private markets or public institutions that warrant new agency action) as well as assess the significance of that problem (Sect. 1 b(1)).

In addition, OMB Guidance dated January 11, 1996, states that "in order to establish the need for the proposed action, the analysis should discuss whether the problem constitutes a significant market failure (p 3)." Therefore, the economic rationale laid out in this section should not be interpreted as the Agency's approach to implementing the Safe Drinking Water Act. Instead, it is the Agency's economic analysis, as required by the Executive Order, to support a *regulatory approach* to the public health issue at hand.

7.2 Statutory Authority for Promulgating the Rule

The 1996 reauthorization for the Safe Drinking Water Act (SDWA) mandated new drinking water requirements. EPA's general authority to set Maximum Contaminant Level Goals (MCLGs) and the National Primary Drinking Water Rule (NPDWR) was modified to apply to contaminants that "may have an adverse effect on the health of persons," are "known to occur or there is a substantial likelihood that the contaminant will occur in public water systems with a frequency and at levels of public health concern," and for which "in the sole judgment of the Administrator, regulation of such contaminant presents a meaningful opportunity for health risk reductions for persons served by public water systems" (1996 SDWA, as amended).

The 1996 Amendments also require the promulgation of the Interim Enhanced Surface Water Treatment Rule (IESWTR) and a Stage 1 Disinfectants/Disinfection Byproducts Rule (Stage 1 DBPR) by November 1998. In addition, the 1996 Amendments require EPA to promulgate a Final Enhanced Surface Water Treatment Rule and a Stage 2 DBPR by November 2000 and May 2002, respectively.

7.3 The Economic Rationale for Regulation

In addition to the statutory directive to regulate microbial contaminants, there is also economic rationale for government regulation. The need for government regulation often results from an imperfection in the market's ability to provide safe water at price levels that efficiently satisfy consumer needs. In a perfectly competitive market, market forces guide buyers and sellers to attain the best possible social outcome. A perfectly competitive market occurs when there are many producers of a product selling to many buyers, and both producers and consumers have complete knowledge regarding the products of each firm There must also be no barriers to entry in the industry, and firms in the industry must not have any advantage over potential new producers Several factors in the public water supply industry do not satisfy the requirements for a perfect market and lead to market failures that require regulation.

First, the public water market is a very limited competitive market with monopolistic tendencies. These monopolies tend to exist because it is not economically efficient to have multiple suppliers competing to build multiple systems of pipelines, reservoirs, wells, and other facilities. Instead, a single firm or government entity performs these functions under public control. Under monopolistic conditions, consumers are provided only one level of service with respect to the quality attribute of the product, in this case drinking water quality. If they do not believe the margin of safety in public health protection is adequate, they cannot simply switch to another water utility

Second, there are high information and transaction costs that impede public understanding of the health and safety issues concerning drinking water quality. The type of health risks potentially posed by trace quantities of drinking water contaminants involve analysis and distillation of complex toxicological data and health sciences. EPA is currently in the final stages of developing the Consumer Confidence Report rule that will make water quality information more easily available to consumers. The Consumer Confidence Report rule will require community water systems to mail their customers an annual report on local drinking water quality. However, consumers would still have to analyze this information for its health risk implications. Even if informed consumers are able to engage utilities regarding these health issues, the costs of such engagement-transaction costs (measured in personal time and commitment) present another significant impediment to consumer expression of risk preference.

SDWA regulations are intended to provide a level of protection from exposure to drinking water contaminants that would not otherwise occur in the existing market environment of public water supply. The regulations set minimum performance requirements for all public water supplies in order to protect all consumers from exposure to contaminants. SDWA regulations are not intended to restructure flawed market mechanisms or to establish competition in supply. While these distortions are essential conditions in weighing perceptions of benefits and costs, SDWA regulations do not attempt to correct market imperfection directly. Rather, SDWA standards establish the level of service to be provided in order to better reflect public preferences for safety. The Federal regulations remove the high information and transaction costs by acting on behalf of all consumers in balancing the risk reduction and the social costs of achieving this reduction.

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