REGULATORY IMPACT ANALYSIS FOR THE PROPOSED LONG TERM 1 ENHANCED SURFACE WATER TREATMENT AND FILTER BACKWASH RULE

EPA DOCUMENT NO. 815-R-00-005

FEBRUARY 15, 2000

PREPARED FOR:

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF GROUND WATER AND DRINKING WATER
MR. STEVE POTTS, TASK ORDER PROJECT MANAGER

PREPARED BY:

THE CADMUS GROUP, INC.
1901 NORTH FORT MYER DRIVE
SUITE NO. 1016
ARLINGTON, VA 22209

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
1710 GOODRIDGE DRIVE
MCLEAN, VA 22102-3701

EPA CONTRACT NO. 68-C-99-206, TASK ORDER 021

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1.1 Need for the Proposal

Drinking water contamination is one of the most important environmental risks, and disease-causing microbial contaminants (i.e., bacteria, protozoa, and viruses) are probably the greatest remaining health risk management challenge for drinking water suppliers according to EPA's Science Advisory Board (SAB), an independent panel of experts established by Congress (U.S. EPA/SAB, 1990). The proposed Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Rule (LT1FBR) undertakes the challenge to improve the control of microbial pathogens such as *Cryptosporidium* in public drinking water systems.

Cryptosporidium, which is common in the environment, is transported in watersheds from sources of oocysts (e.g., agricultural runoff and untreated wastewater) to water bodies that serve as drinking water sources. If system treatment operates inefficiently, oocysts may enter finished water at levels that pose health risks. *Cryptosporidium* is of particular concern to EPA as it develops the LT1FBR because—unlike pathogens such as viruses and bacteria—it is difficult to inactivate *Cryptosporidium* oocysts using standard disinfection practices. Therefore, the control of *Cryptosporidium* is dependent on physical removal processes. Other emerging disinfection-resistant pathogens such as *Microsporidia*, *Cyclospora*, and *Toxoplasma* are also a concern for similar reasons.

Cryptosporidiosis is the disease caused by ingesting *Cryptosporidium* oocysts. Dupont, et al. (1995) found that a dose of even a few *C. parvum* oocysts is sufficient to cause infection in healthy adults. Cryptosporidiosis is a common protozoal infection that usually causes 7 to 14 days of diarrhea with possibly a low-grade fever, nausea, and abdominal cramps in individuals with healthy immune systems (Juranek, 1998). There is currently no therapeutic cure for cryptosporidiosis, but the disease is self-limiting in healthy individuals. It does, however, pose serious health and mortality risks for sensitive subpopulations including children, the elderly, pregnant women, and the immunocompromised[1] (Gerba et al., 1996; Fayer and Ungar, 1986; U.S. EPA 1998a), which represents almost 20 percent of the population in the United States (Gerba et al., 1996).

Cryptosporidium oocysts in drinking water treated by small systems pose both an endemic and an epidemic health risk. The nature of endemic risks prevents the resulting illnesses from appearing in databases that track waterborne diseases. Consequently, there are no data to determine the extent of the endemic health impact in the United States. Evidence on epidemic risk, however, suggests that improving small system performance will generate health benefits. Between 1984 and 1994, six of the ten documented epidemics associated with drinking water systems occurred in systems serving fewer

[1]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).

than 10,000 people (Moore et al., 1993; Kramer et al., 1996; Levy et al., 1998; Craun et al., 1996; Craun, 1998).[2]

The two primary methods for treating drinking water for microbial contaminants are chemical disinfection (inactivation) and physical removal. The main goal of LT1FBR, which is discussed in greater detail in Chapter 2, is to improve the physical removal of microbial contaminants through the enhancement of turbidity treatment processes and management of recycle practices. Chemical disinfection is also addressed through a disinfection benchmark provision that maintains microbial protection levels while systems alter disinfection practices to reduce health risks associated with disinfection byproducts.

The strategy of the proposed rule is to enhance turbidity treatment practices at small systems that use filtration and to address risks posed by recycle practices. EPA believes that improved finished water turbidity levels are indicative of improved physical removal and, therefore, reduced risk of *Cryptosporidium*-related illnesses. Recycle practices are of concern because recycle of flows such as filter backwash and thickener supernatant within the treatment process can potentially return a significant number of oocysts to the treatment plant in a short amount of time, particularly if the recycle is returned to the treatment process without prior treatment, equalization, or some other type of hydraulic detention. Should recycle disrupt normal treatment operations or should treatment not function efficiently due to other deficiencies, high concentrations of oocysts may pass through the plant into finished drinking water.

As a result, the proposed rule addresses two requirements of the Safe Drinking Water Act (SDWA) as amended in 1996. Those amendments established a number of regulatory deadlines, including schedules for a Stage 1 and a Stage 2 Disinfection Byproduct Rule, two stages of the Enhanced Surface Water Treatment Rule 1412(b)(2)(C), and a requirement that EPA promulgate regulations to "govern" filter backwash recycling within the treatment process of public utilities (Section 1412(b)(14)). The proposed LT1FBR is the second part of the first stage of the Enhanced Surface Water Treatment Rule. The other part, the Interim Enhanced Surface Water Treatment Rule (IESWTR) promulgated in December 1998, established requirements to improve control of microbial pathogens in public water systems serving 10,000 or more people that use surface water or GWUDI. The LT1FBR extends those requirements to small systems and also addresses the filter backwash recycling requirement.

The proposed LT1FBR applies to public drinking water systems using surface water or ground water under the direct influence of surface water (GWUDI) as a source and serving fewer than 10,000 people, with the exception of a recycle control provision that also applies to large systems (i.e., systems serving 10,000 or more people). LT1FBR builds on the 1989 Surface Water Treatment Rule (SWTR) (54 *FR* 27486, June 19, 1989). It will also protect the public against increases in microbial risk as systems alter their disinfection practices to meet new disinfection byproduct (DBP) standards

[2]The documented outbreaks do not account for all of the epidemic illnesses. The number of identified and reported outbreaks in the Centers for Disease Control database represents a small percentage of actual waterborne disease outbreaks because there are numerous opportunities for the reporting framework to fail to register an outbreak (National Research Council, 1997; Bennett et al., 1987).

promulgated under the Stage 1 Disinfectants/Disinfection Byproducts Rule (Stage 1 DBPR) (63 *FR* 69477, December 16, 1998). Chapters 2 and 3 describe the provisions of the proposed rule in detail; briefly, they are:

- 2-log *Cryptosporidium* removal requirements for systems that are required to filter under the SWTR

- Strengthened combined filter effluent (CFE) turbidity performance standards of 1.0 NTU as a maximum and 0.3 NTU as the 95th percentile monthly, based on continuous monitoring for systems using conventional or direct filtration, and related requirements for systems using other filtration technologies

- Requirements for individual filter turbidity monitoring for plants using conventional or direct filtration

- A disinfection benchmark provision with applicability monitoring, profiling, and benchmarking components to insure that microbial protection is not undercut as facilities take the necessary steps to comply with new disinfection byproduct standards

- Inclusion of *Cryptosporidium* in the definition of GWUDI systems and in the watershed control requirements for unfiltered public water systems

- A requirement that new finished water storage facilities are covered.

- Reporting requirements and recycle practice modifications for systems that practice recycle

1.2 Consideration of Regulatory Alternatives

The public health decision-making process is particularly demanding for this rule because it primarily affects small drinking water systems, which have limited capabilities for investing in new treatment technologies or maintaining complex monitoring regimes compared to large systems. Nevertheless, their customers are entitled to health protection comparable to the protection afforded to large system customers by the IESWTR (63 *FR* 69389, December 16, 1998). Thus, EPA has carefully weighed the feasibility of small system implementation against the public health risks posed by microbial contaminants to customers of small systems throughout the rule development process. EPA incorporated stakeholder inputs from small systems operators, consumers, and States with the substantive elements of the IESWTR to design a proposed rule that provides small system customers with a comparable level of protection while minimizing the costs to small systems.

To reduce the potential burden of the proposed LT1FBR on small systems, EPA developed and evaluated the cost implications of several regulatory alternatives for the following provisions: individual filter monitoring, disinfection benchmark applicability monitoring, disinfection benchmark profiling, and recycle practice. EPA started with the regulatory framework for the IESWTR and worked with stakeholder groups to determine how to make the requirements less burdensome for small systems without compromising the health benefits of the proposed rule.

Chapter 3 discusses the alternatives in detail and describes why EPA selected the preferred alternatives for the proposed rule. Exhibit 1–1 compares the preferred LT1FBR alternatives with their IESWTR counterparts. With the exception of the recycle provision, which is new under the proposed rule, the comparison shows that the preferred LT1FBR alternatives will place less data collection and data analysis burden on small systems.

Exhibit 1–1. Key Differences Between the Preferred Alternatives for the Proposed LT1FBR and the IESWTR Requirements

Provision	Preferred LT1FBR Alternative	IESWTR Requirements
Individual filter monitoringC events requiring an exceptions report[1]	Individual filter turbidity exceeds 1 NTU in two consecutive measurements	Individual filter turbidity exceeds 1 NTU in two consecutive measurements Individual filter turbidity exceeds 0.5 NTU in two consecutive measurements after first 4 hours of filter operation
Disinfection benchmarkC applicability monitoring	Optional TTHM and HAA5 sample at maximum residence point during the month of warmest water temperature Total samples: 1 (optional)	TTHM and HAA5 samples at four locations in each of 4 quarters Total samples: 16
Disinfection benchmarkC profile development	Collect data weekly for 1 year Total profile data points: 52	Collect data daily for 1 year Total profile data points: 365

1. The proposed LT1FBR and the IESWTR have comparable filter self assessment and comprehensive performance evaluation requirements.

1.3 Baseline Analysis

Each provision of the proposed LT1FBR affects a different subset of surface water or GWUDI systems, and Chapter 4 discusses how EPA estimated the number of affected systems by provision. For example, the proposed LT1FBR establishes new combined filter effluent requirements for surface water and GWUDI systems that serve fewer than 10,000 people and filter drinking water, and an individual filter monitoring requirement that applies to the subset of systems using conventional and direct filtration. The LT1FBR also establishes management of recycle flow requirements, which apply to all surface water and GWUDI systems using rapid granular filtration regardless of size.

The methods and sources used to identify the number of systems that are included under each provision are detailed in Chapter 4. Exhibit 1–2 provides the system size categories and the number of systems that may be affected by the provisions of the LT1FBR. The number of systems using filtration that may be affected by one or more of the turbidity provisions was developed from an analysis of current finished water turbidity, and an analysis of the types of filtration employed (e.g., conventional, direct, slow sand, and membranes). The number of systems that will have to perform applicability monitoring and/or develop disinfection profiles and establish a benchmark is based on the type of drinking water system (i.e., community, nontransient noncommunity) and chronic exposure. Estimates of systems that may be regulated under the recycle provision were developed from an analysis of primary water treatment and recycling practices.

Exhibit 1–2. Number of Systems Under LT1FBR Provisions

System Size	Turbidity Provisions	Applicability Monitoring and Disinfection Benchmarking	Recycle Provisions
#100	2,201	1,404	502
101B500	2,031	2,333	670
501B1,000	1,109	1,301	486
1,001B3,300	2,150	2,553	993
3,301B9,999	1,643	1,859	887
10,000B50,000	N/A	N/A	830
50,001B100,000	N/A	N/A	141
100,001B1,000,000[1]	N/A	N/A	127
Total	9,133	9,450	4,636

1. This system estimate does not include seven individual plants that belong to systems serving more than one million people, which were included in the cost analysis because they may be affected by the recycle provisions.

1.4 Benefits of the LT1FBR

Chapter 5 provides EPA's analysis of potential benefits of the proposed rule. According to the risk assessment performed for this RIA, the turbidity provisions in the proposed LT1FBR are estimated to reduce the mean annual number of *Cryptosporidium* illnesses by improving filtration in drinking water treatment plants serving fewer than 10,000 people. The risk assessment predicts that improved filtration will result in mean reductions of 22,800 to 83,600 annual illnesses depending on which of the scenarios describing baseline removal (2.0 or 2.5 log) and improved *Cryptosporidium* removal (low-, mid-, or high-removal) is assumed. Based on these cryptosporidiosis reductions, the mean annual estimated benefits from reducing illnesses are between $53.9 million and $199.5 million per year. This calculation assumes a mean cost of illness of approximately $2,400 per illness.

The LT1FBR risk assessment also predicts a mean annual reduction of 3 to 10 mortalities by improving filtration practices, depending on the baseline removal and improved removal assumptions. These annual mortality reductions produce benefits in the range of $16.2 million to $59.8 million, based on a mean value of $5.7 million per statistical life saved. Exhibit 1–3 summarizes annual benefits accruing from the LT1FBR turbidity provisions.

Exhibit 1–3. Summary of Annual Benefits Associated with Avoided Illnesses and Mortalities for the Turbidity Provisions (January 1999 dollars)

	Daily Drinking Water Ingestion and Baseline *Cryptosporidium* Log-Removal Assumptions ($ millions)	
	Mean = 1.2 Liters per person	
Improved Log-Removal Assumption	**2.0 log**	**2.5 log**
Low Removal		
Avoided Illnesses	$150.3	$53.9
Mortalities	$45.0	$16.2
Total	$195.3	$70.1
Mid Removal		
Avoided Illnesses	$185.3	$66.2
Mortalities	$55.5	$19.9
Total	$240.8	$86.1
High Removal		
Avoided Illnesses	$199.5	$71.1
Mortalities	$59.8	$21.3
Total	$259.4	$92.4

Totals may not equal detail due to rounding.

The calculated turbidity benefits are the lower bound of total benefits accruing from the proposed LT1FBR. Additional nonquantified benefits come from the recycle provisions for small and large drinking water systems, the disinfection benchmark provision, the requirement that all new finished water reservoirs be covered, and the inclusion of *Cryptosporidium* in the definition of GWUDI and the watershed control requirements for small unfiltered systems. These components combine to reduce health effects to sensitive subpopulations, reduce the risk of outbreaks, enhance aesthetic water quality, and minimize expenditures associated with averting behavior, as well as reduce risk from other pathogens (e.g., *Giardia lamblia*). Data were not available to quantify benefits for these categories and provisions; however, qualitative analysis suggests that these benefits will be positive and significant. In particular, the recycle provisions will prevent the accumulation of *Cryptosporidium* within the treatment plant and minimize the risk of oocysts entering finished water by improving filter performance and reducing hydraulic disruptions.

1.5 Costs of the LT1FBR

Chapter 6 summarizes the methods EPA used to analyze costs for the proposed rule. EPA estimates that the annualized cost of the preferred alternatives for the proposed rule will be $87.6 or $97.5 million depending on the discount rate. These estimates include capital costs for turbidity treatment and recycle practice changes and start-up labor costs for monitoring and reporting activities that have been annualized assuming either a 3 percent or a 7 percent discount rate over a 20-year period. They also include annual operating and maintenance costs for turbidity treatment and recycle practice changes and annual labor for turbidity monitoring activities. The labor costs incorporate both system and State burden estimates.

Exhibit 1–4 summarizes costs by provision for the set of preferred alternatives. Costs for the turbidity provisions, which include treatment changes to meet the revised CFE requirements and individual filter monitoring activities, account for 70 or 72 percent of total costs depending on the discount rate assumption. The recycle provisions, which include costs for some systems moving their recycle return location, direct recycle systems conducting a self assessment, and direct filtration reporting their recycle practices account for 23 to 25 percent of total costs.[3] System expenditures for all provisions are approximately 93 percent of total costs; State expenditures make up the remainder.

Exhibit 1–4. Total Annual Costs for Two Combinations of Alternatives (January 1999 dollars)

Compliance Activity	Preferred Alternatives ($ millions)		IESWTR Alternatives ($ millions)	
	3%	7%	3%	7%
Turbidity Provisions	$63.4	$68.6	$116.7	$121.9
Disinfection Benchmarking	$1.3	$1.8	$5.9	$8.3
Covered Finished Storage	$2.5	$2.6	$2.5	$2.6
Recycle Provisions	$20.4	$24.5	$20.4	$24.5
Total Costs	**$87.6**	**$97.5**	**$145.5**	**$157.3**

Detail may not add to total due to independent rounding.

To reduce the potential cost to small systems, EPA developed and evaluated the cost implications of several regulatory alternatives for the following provisions: turbidity monitoring, disinfection benchmark applicability monitoring, disinfection benchmark profiling, and recycle practice. Many of the alternatives reduce the labor burden on small systems relative to what it would be if the proposed rule incorporated the same requirements as the IESWTR. Exhibit 1–4 also reports what the costs would be under alternatives similar to IESWTR requirements. Comparing these costs with the costs of the preferred alternatives shows that the preferred alternatives reduce total costs by approximately 38 to 40 percent, primarily by reducing the labor burdens associated with individual filter monitoring activities.

[3]The recycle cost estimate includes indirect capital and operating and maintenance costs based on EPA's estimates of how many direct recycle and direct filtration systems may be required to alter their recycle practices. This represents the high range of EPA cost estimate for the preferred recycle alternative.

Increased drinking water production costs may be passed on to consumers, including households, in the form of higher fees. EPA estimated the potential impact on households by developing a distribution of costs across all affected systems and converting that distribution to a per-household basis. Approximately 6.6 million households could be affected by the turbidity, disinfection benchmarking, and covered finished water storage provisions. EPA estimates that the mean annual incremental cost per household would be $8.66, and the incremental annual cost would be less than $10 for approximately 86 percent of households and less than $120 (i.e., $10 per month) for 99 percent of households. The recycling provisions could affect approximately 12.9 million households based on EPA's assumptions, and the mean cost per household is $1.79. Annual incremental cost would be less than $10 for about 99 percent of households and less than $120 for 99.9 percent of households.

1.6 Economic Impact Analysis

As part of the rule promulgation process, EPA is required to perform a series of distributional analyses that address the potential regulatory burden placed on entities that are directly or indirectly effected by the rule. The distributional impacts considered were the cost of compliance for State, local, and Tribal governments, and small businesses; the effect of rule implementation on sensitive subpopulations; and the potential for disproportionate impacts on low-income and minority populations. Chapter 7 discusses EPA's economic impact analyses and findings.

A distributional impact analysis was performed as part of the requirements under the Unfunded Mandate Reform Act. The analysis looked at budgetary impacts across system sizes as well as geographically over the United States. Across system sizes, the greatest impact in terms of cost-to-revenue ratios would be on those systems serving 500 or fewer people, although over 70 percent of system costs will accrue to systems serving more than 1,000 people.

For States, budgetary impacts were considered using three different perspectives: annual compliance costs per State; the percentage increase in drinking water program costs per State; and State per capita drinking water program expenditures. The evidence from the three perspectives of budgetary impacts does not suggest that there would be a disproportionate budgetary effect resulting from the rule. There is no evidence of a geographic concentration of higher impact. Nor does any one State consistently show relatively high impacts across all three analyses.

The Regulatory Flexibility Act, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA), requires the EPA to consider the financial impact of LT1FBR on small business entities. EPA conducted an analysis of the budgetary impact of the rule on three different categories of small system ownership: public, private, and non-profit. Using assumptions regarding the costs that systems of various sizes will incur to comply with the LT1FBR rule, EPA was able to generate a hypothetical distribution of per-system costs. EPA compared this cost distribution to financial data to determine how many systems might incur costs in excess of 3 percent or 1 percent of revenue. The results of the analysis suggest that a significant number of small systems will be substantially impacted by the rule. Consequently, EPA prepared an Initial Regulatory Flexibility Analysis, which is included in Chapter 7.

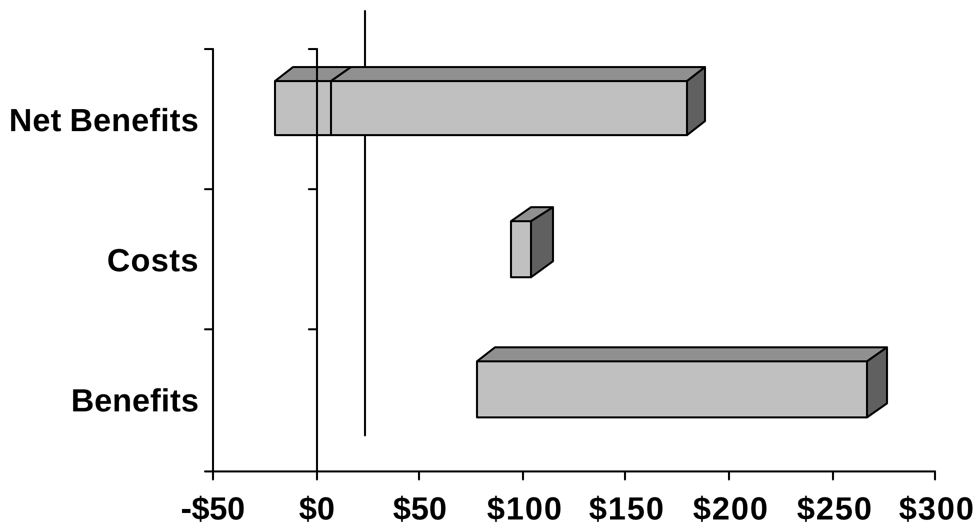
A primary purpose of the proposed LT1FBR is to improve control of microbial pathogens, specifically the protozoan *Cryptosporidium*. Under Executive Order 13045, EPA must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by EPA. Because of the severity of illness and high costs for treatment experienced by sensitive subpopulations—including young children—as a result of *Cryptosporidium* infection, LT1FBR is expected to have a disproportionately positive impact on children.

As required under Executive Order 12898, EPA must identify and address disproportionately high and adverse human health or environmental effects the adoption of LT1FBR may have on minority and low-income populations. The Agency has considered environmental justice-related issues concerning the potential impacts of this action and has consulted with minority and low-income stakeholders. Furthermore, the proposed LT1FBR extends the types of health risk reductions achieved by the 1998 IESWTR to consumers served by small public water systems. Therefore, the minority and impoverished populations served by small systems will realize the health protection benefits currently provided to populations served by larger systems.

1.7 Weighing of Benefits and Costs

For the comparison of benefits and costs in Chapter 8, EPA subtracted the incremental costs of the proposed rule from the incremental benefits to obtain net benefits. Assuming incremental annualized costs can be represented by the costs for the preferred alternatives shown in Exhibit 1–4 ($87.6 million to $97.5 million across discount rates) and incremental benefits can be represented by the range in Exhibit 1–3 (mean values of $70.1 million to $259.4 million across the removal assumptions), net benefits potentially range from a negative value of $27.4 million to positive value of $171.8 million. The low net benefit estimate equals the low benefit minus the high cost estimate. Conversely, the high net benefit estimate is the difference between the high benefit estimate and the low cost estimate. The chart in Exhibit 1–5 compares these ranges, and shows that the range of potential net benefits lies primarily in the positive quadrant. Thus, benefits will most likely exceed costs.

Exhibit 1–5. Comparison of Annual Benefit, Cost, and Net Benefit Ranges (January 1999 dollars, millions)



Although this analysis suggests that monetized net benefits may be as low as negative $27.4 million for the preferred alternatives, total social net benefits are likely to be positive taking the qualitative benefits into consideration. Costs were estimated for most of the provisions of the proposed LT1FBR, but benefits were only estimated for the turbidity provisions; EPA did not quantify benefits associated with three provisions that accounted for approximately one third of total costs: recycle practices, disinfection benchmarking, and covered finished storage. Furthermore, the quantified benefits for the turbidity provisions do not include categories of benefits such as reducing exposure to other pathogens (e.g., *Giardia lamblia*) and avoiding the cost of averting behavior. The nonquantified benefits could represent substantial additional economic value. Overall, EPA expects the rule to provide benefits for more than 18 million households. If the aggregate benefit per household for these nonquantified benefits is at least $1.52 per year, then even the low range of net benefits will be positive.

This RIA provides background on the proposed rule, summarizes the key components, discusses alternatives to the proposed rule, and estimates costs and benefits to the public and State governments.

2. Need for the Proposal

This document analyzes the impact of the proposed Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Rule (LT1FBR). Executive Order 12866, *Regulatory Planning and Review*, requires EPA to estimate the costs and benefits of regulations in a regulatory impact analysis (RIA) and to submit the analysis in conjunction with publishing the proposed rule.

The proposed Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Rule applies to public drinking water systems using surface water or ground water under the direct influence of surface water (GWUDI) as a source and serving fewer than 10,000 people, with the exception of the recycle provisions, which also apply to large systems (systems serving 10,000 or more people). LT1FBR builds on the 1989 Surface Water Treatment Rule (SWTR) (54 FR 27486, June 29, 1989). LT1FBR 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 Stage 1 Disinfectants/Disinfection Byproducts Rule (Stage 1 DBPR) (63 FR 69389, December 16, 1998).

This RIA provides background on the proposed rule, summarizes the key components, discusses alternatives to the proposed rule, and estimates costs and benefits to the public and private sectors. This chapter summarizes the technical and regulatory issues associated with the need for the proposed rule. It explains the nature of surface water treatment for microbial pathogens, identifies the public health concerns addressed by the proposed rule, and summarizes the key components of the proposed rule.

Chapters 3 through 8 are intended to meet the requirements of Executive Order 12866 by responding to specific analytical questions. Chapter 3 reviews alternative approaches considered as the proposed rule was being developed. Chapter 4 presents public water system (PWS) data to establish a baseline of information for use in the following four chapters. Chapter 5 examines the proposed rule's potential benefits, reviewing occurrence data, treatment efficiencies and dose response relationships. Chapter 6 presents an estimate of the costs to implement the proposed rule. Chapter 7 reviews the distribution of the costs and benefits of the proposed rule on various entities and subpopulations. Chapter 8 weighs the overall benefits and costs of the various alternatives considered for the proposed rule.

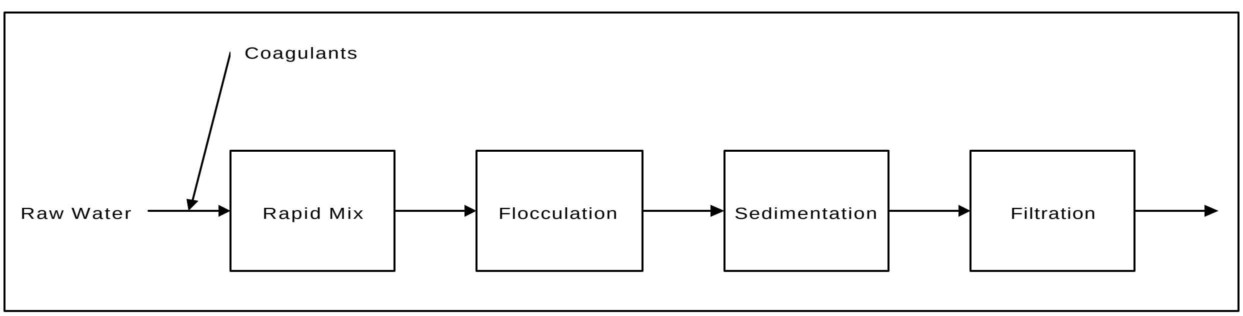
2.1 Description of the Issue

The primary issue of concern being addressed by LT1FBR is improved public health protection through the treatment of drinking water for microbial contaminants. The two primary methods for treating drinking water for microbial contaminants are chemical disinfection (inactivation) and physical removal. Chemical disinfection has been addressed by several other regulations and is not the primary issue being addressed by LT1FBR. The main goal of LT1FBR is to improve the physical removal of microbial contaminants by enhancing filtration and other physical removal processes and management of recycle practices to protect these physical treatment processes.

The types of water treatment plants or unit operations that may be used to physically remove particles include: conventional treatment, direct filtration, package plants, softening, solids contact clarification, slow sand filtration, and diatomaceous earth filtration. LT1FBR does not apply to the latter two types of treatment.

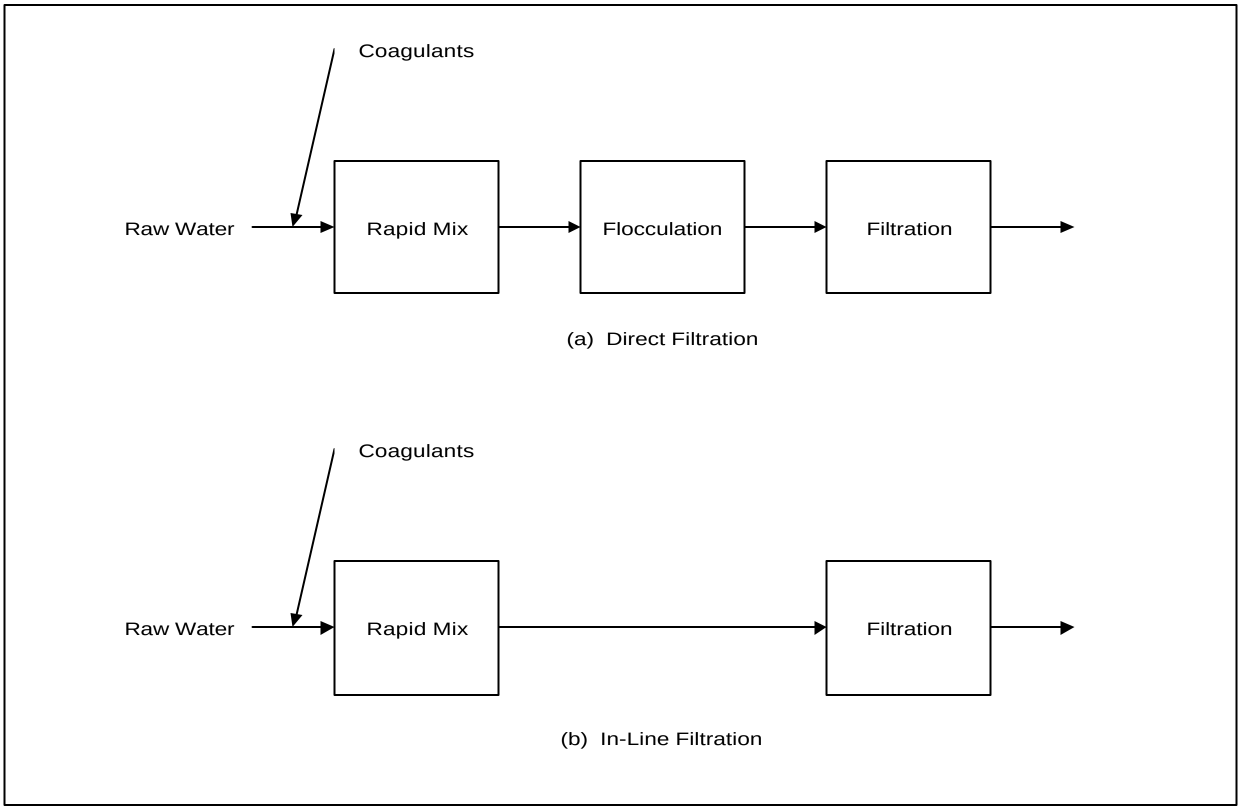
Conventional treatment, the most widely used plant type, consists of chemical coagulation, rapid mix, flocculation, and sedimentation followed by filtration. A general flow schematic for a conventional water treatment plant is presented in Exhibit 2–1. Source water is treated with chemical coagulant(s), such as aluminum sulfate (alum), ferric or ferrous sulfate, ferric chloride, and/or a coagulant aid to destabilize suspended particles and improve sedimentation as the water enters the treatment system. Coagulant aids promote the attachment of suspended particles to the polymers, and coagulate to form a heavy floc that is easily removed in the settling process. The flow is then subjected to rapid mixing that blends the coagulant into the raw water. In the flocculation step, coagulated water is gently stirred to allow particles to collide and combine to form larger particles. This produces a dense and readily settleable floc. The flocculated water flows into a sedimentation basin where the dense floc settles over time leaving clarified water above it. Sedimentation should provide a high level of particulate removal and significantly reduce the turbidity level. This clarified water is filtered to remove particles or turbidity that remains after sedimentation.

Exhibit 2–1. Flow Schematics for Conventional Water Treatment Systems



In the direct filtration process, suspended solids are removed solely through filtration process (AWWA/ASCE, 1998). As depicted in Exhibit 2–2, direct filtration consists of coagulation followed by rapid mixing, flocculation, and filtration. Unlike conventional treatment, the chemically conditioned and flocculated water is applied directly to the filters. No separate sedimentation process is used in direct filtration. A variation of direct filtration, in-line filtration, excludes the flocculation process and instead relies on flocculation to occur in the piping between the rapid mix and the filters. In both direct filtration and in-line filtration, the filters are the only means of suspended solid, particle, and pathogen removal.

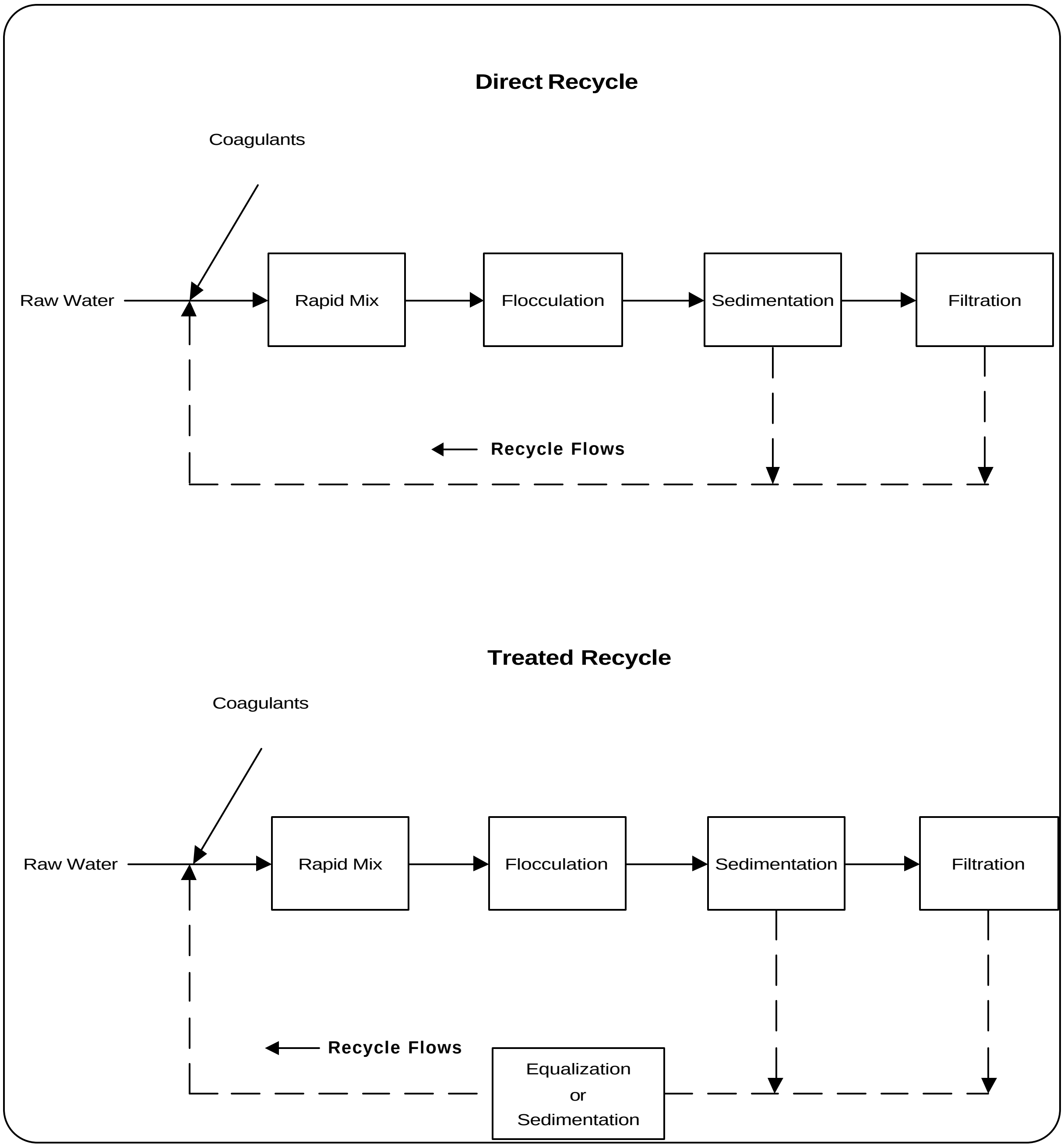
Exhibit 2–2. Flow Schematics for Direct Filtration Systems



Small surface water systems may use several other technologies. Some small surface water systems are package plants. Package plants can be defined as a complete modular treatment plant, designed as a factory assembled, skid mounted unit. A complete modular treatment plant typically consists of chemical coagulation, flocculation, settling and filtration. Most modular systems utilize high rate treatment processes, with shorter detention time than that of custom-engineered conventional treatment plants. Another type treatment used by some systems is the softening plant. Softening plants utilize the same basic treatment process as conventional treatment plants, except that they also remove hardness (calcium and magnesium ions) through precipitation, followed by solids removal. In the contact clarification treatment process, the flocculation and sedimentation (and often the rapid mix) processes are combined in one unit, that being an upflow solids contactor or contact clarifier. In addition, small systems may also utilize microfiltration and bag and cartridge filters to remove turbidity.

In the treatment processes just discussed, pathogenic microorganisms are removed during the sedimentation and/or filtration processes in a water treatment plant. As Exhibit 2–3 shows, recycle streams generated during treatment, such as spent filter backwash water, liquids from dewatering, or thickener supernatant are often concentrated and returned to the treatment train. These recycle streams, therefore, may contain high concentrations of pathogens, including disinfection-resistant *Cryptosporidium* oocysts, in addition to chemicals added during the stages of the treatment process (e.g., oxidants, softeners, coagulants, polymers). If the recycle enters the treatment train after the point of primary coagulation, the recycle can degrade the treatment process, by causing an inappropriate chemical dose, hydraulic surge and potentially overwhelming the plant's multi-barriers with a large concentration of pathogens.

Exhibit 2–3. Flow Schematics for Systems that Recycle



2.2 Public Health Concerns

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 (U.S. EPA/SAB, 1990). Information on the number of waterborne disease outbreaks from the U.S. Centers for Disease Control and Prevention (CDC) underscores this concern. CDC indicates that 401 waterborne disease outbreaks were reported between 1980 and 1996, with over 750,000 associated cases of disease (CDC, 1996).

2.2.1 Contaminants and Their Associated Health Effects

Waterborne disease caused by *Cryptosporidium* is of particular concern to the LT1FBR, as *Cryptosporidium* oocysts are not inactivated with standard disinfection practices (unlike pathogens such as viruses and bacteria), and there is currently no therapeutic cure for cryptosporidiosis (unlike giardiasis). *Cryptosporidium* is not generally inactivated in systems using standard disinfection practices, therefore, the control of *Cryptosporidium* is entirely dependent on physical removal processes. Other emerging disinfection resistant pathogens, such as *microsporidia*, *Cyclospora*, and *Toxoplasma* are also a concern of LT1FBR for similar reasons.

Waterborne disease is usually acute (i.e., sudden onset and typically lasting a short time in healthy people). Some pathogens (e.g., *Giardia* and *Cryptosporidium*) may cause extended illness, lasting weeks or longer in otherwise healthy individuals, and the infection can prove fatal for sensitive populations such as the immunocompromised. 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 many other diseases.

Cryptosporidiosis is caused by ingestion of *Cryptosporidium* oocysts, which are readily carried by the waterborne route. The most common source of oocysts in water is the feces of infected hosts (Walker et al., 1998). Dupont, et al. (1995) found through a human feeding study that a low dose of *C. parvum* is sufficient to cause infection in healthy adults. Infected humans and other animals may excrete *Cryptosporidium* oocysts, which can then be transmitted to others. Transmission of cryptosporidiosis often occurs through ingestion of the infective oocysts from contaminated food or water, but may also result from direct or indirect contact with infected persons or animals (Casemore, 1990; Cordell and Addiss, 1994).

Cryptosporidiosis is a common protozoal infection that usually causes 7–14 days of diarrhea with possibly a low-grade fever, nausea, and abdominal cramps in individuals with healthy immune systems (Juranek, 1998). There appears to be an immune response to *Cryptosporidium*, but it is not known if this results in complete protection (Fayer and Ungar, 1986). When prior exposure or chronic contamination of the water by low levels of oocysts confers short-term immunity to immunocompetent residents in a community (Okhuysen et al., 1998), most cases of symptomatic illness in that community will then occur in newly exposed individuals, such as young children, visitors, and new residents (Frost et al., 1997).

2.2.2 Sensitive Subpopulations

There are a number of sensitive populations that are at greater risk of serious illness (morbidity) or mortality from either epidemic or endemic infection by *Cryptosporidium* pathogens than is the general population (Frost et al., 1997). In sensitive populations, gastrointestinal illness caused by cryptosporidiosis may be chronic. These sensitive populations include children, especially the very young; the elderly; pregnant women; and the immunocompromised. This sensitive segment represents almost 20 percent of the population in the United States (Gerba et al., 1996; Fayer and Ungar, 1986; U.S. EPA 1998b).

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 (Framm and Soave, 1997). Therefore, prevention of infection is critical (Petersen, 1992). 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).

2.2.3 Sources of Contaminants

Cryptosporidium is common in the environment (Rose, 1997, Soave, 1995, LeChevallier et al., 1991a). Runoff from unprotected watersheds allows the transport of these microorganisms from sources of oocysts (e.g., feces of wildlife, untreated wastewater, and agricultural runoff) to water bodies used as intake sites for drinking water treatment plants. If treatment operates inefficiently, oocysts may enter the finished water at levels of public health concern. Increasing disinfection dosages (i.e., chlorine or chloramines) is not an effective strategy for controlling *Cryptosporidium*, because the *Cryptosporidium* oocyst is especially resistant to disinfection practices.

Cryptosporidium oocysts have been detected in wastewater, pristine surface water, surface water receiving agricultural runoff or contaminated by sewage, ground water under the direct influence of surface water (GWUDI), water for recreational use, and drinking water (Rose, 1997; Soave, 1995). Over thirty environmental surveys have reported *Cryptosporidium* source water occurrence data from surface water and GWUDI (presented in Exhibits 2–4 and 2–5), which typically involved the collection of a few water samples from a number of sampling locations having different characteristics (e.g., polluted vs. pristine; lakes or reservoirs vs. rivers).

Each of the studies cited in Exhibits 2–4 and 2–5 presents *Cryptosporidium* source water occurrence information, including: 1) the number of samples collected, 2) the number of samples positive, and 3) both the means and ranges for the concentrations of *Cryptosporidium* detected (where available). However, the recovery and detection for *Cryptosporidium* in water samples using the immunoflourescence assay method is limited. Additionally, the method does not indicate with certainty whether the oocysts detected are viable or infective to humans (Frey et al., 1997). Despite these limitations, the occurrence information generated from these studies is valuable as a measure of the incidence of *Cryptosporidium* in source waters. EPA compiled information on the following source waters: rivers, reservoirs, lakes, streams, raw water intakes, springs, wells under the influence of surface water, and infiltration galleries.

Finally, sedimentation and filtration processes in drinking water treatment plants remove pathogenic microorganisms from the source water. Recycle streams generated during water treatment (e.g., spent filter backwash water, sedimentation basin sludge, or thickener supernatant) are often concentrated and returned to the plant and combined with raw source water entering the plant. Recycle combined with raw water can elevate the influent pathogen concentrations because recycle streams may contain high concentrations of pathogens, including disinfection-resistant *Cryptosporidium* oocysts. High oocyst concentrations challenge the treatment process and increase the risk of pathogen breakthrough to the finished water.

Exhibit 2–4. Surface Water Survey and Monitoring Data for *Cryptosporidium* Oocysts

Sample Source	Number of Samples (n)	Samples Positive for *Cryptosporidium* (percent)[1]	Range of Oocyst conc. (oocysts/L)	Mean (oocysts/L)	Reference
Rivers	25	100	2–112	25.1	Ongerth and Stibbs 1987
River	6	100	2–5,800	1,920(a)	Madore et al. 1987
Reservoirs/Rivers (polluted)	6	100	0.19–3.0	0.99(a)	Rose 1988
Reservoir (pristine)	6	83	0.01–0.13	0.02(a)	Rose 1988
Impacted river	11	100	2–112[2]	25(g)	Rose et al. 1988a[2]
Lake	20	71	0–22	0.58(g)	Rose et al. 1988b[2]
Stream	19	74	0–240	1.09(g)	Rose et al. 1988b[2]
Filtered water	82	27	0.001–0.48	0.015	LeChevallier et al. 1991b
Raw water	85	87	0.07–484	2.7 (g) detectable	LeChevallier et al. 1991c
River (pristine)	59	32	NR	0.29(g)	Rose et al. 1991
River (polluted)	38	74	<0.001–44[2]	0.66(g)	Rose et al. 1991
Lake/reservoir (pristine)	34	53	NR	0.093(g)	Rose et al. 1991
Lake/reservoir (polluted)	24	58	<0.001–3.8[2]	1.03(g)	Rose et al. 1991
River (all samples)	36	97	0.15–0.45 (pristine) 10–63.5 (agricultural)	0.2 (pristine) 18.3 (agricultural)	Hansen and Ongerth 1991
Protected drinking water supply	6	81	0.15–0.42	0.24(g)	Hansen and Ongerth 1991

Exhibit 2–4. Surface Water Survey and Monitoring Data for *Cryptosporidium* Oocysts

Sample Source	Number of Samples (n)	Samples Positive for *Cryptosporidium* (percent)[1]	Range of Oocyst conc. (oocysts/L)	Mean (oocysts/L)	Reference
Pristine river, forestry area	6	100	0.46–6.97	1.62(g)	Hansen and Ongerth 1991
River below rural community in forested area	6	100	0.54–3.6	1.07(g)	Hansen and Ongerth 1991
River below dairy farming agricultural activities	6	100	3.3–63.5	10.72(g)	Hansen and Ongerth 1991
Reservoirs	56	45	NR	NR	Consonery et al. 1992
Streams	33	48	NR	NR	Consonery et al. 1992
Rivers	37	51	NR	NR	Consonery et al. 1992
Finished water (clearwell)	14	14	NR	NR	Consonery et al. 1992
Finished water (filter effluents)	118	26	NR	NR	Consonery et al. 1992
Site 1—River source (high turbidity)	10	100	0.82–71.9	4.8	LeChevallier and Norton 1992
Site 1— Filter effluent	10	70	0.01–0.04	NR	LeChevallier and Norton 1992
Site 2 — River source (moderate turbidity)	10	70	0.42–5.1	2.5	LeChevallier and Norton 1992
Site 2 — Filter effluent	10	10	0.005	NA	LeChevallier and Norton 1992
Site 3 — Reservoir source(low turbidity)	10	70	0.77–8.7	2.5	LeChevallier and Norton 1992
Site 3 — Filter effluent	10	10	0.02	NA	LeChevallier and Norton 1992
Lakes	179	6	0–22.4	0.033 (median)	Archer et al. 1995
Streams	210	6	0–20.0	0.07 (median)	Archer et al. 1995
Finished water	262	13	0.0029–0.57	0.33 (detectable)	LeChevallier and Norton 1995
River/lake	262	52	0.065–65.1	2.4 (detectable)	LeChevallier and Norton 1995
River/lake	147	20	0.3–9.8	2.0	LeChevallier et al. 1995
River 1	15	73	0–22.3	1.88 (a) all samples 0.43 (g) detected	States et al. 1995
River 2	15	80	0–14.7	1.47 (a) all samples 0.61 (g) detected	States et al. 1995
Dairy farm stream	13	77	0–11.1	1.26 (a) all samples 0.55 (g) detected	States et al. 1995

Exhibit 2–4. Surface Water Survey and Monitoring Data for *Cryptosporidium* Oocysts

Sample Source	Number of Samples (n)	Samples Positive for *Cryptosporidium* (percent)[1]	Range of Oocyst conc. (oocysts/L)	Mean (oocysts/L)	Reference
Finished water	1,237	7	NR	NR	Rosen et al. 1996[5]
Reservoir inlets	60	5	0.007–0.24	0.019 (g) 0.016 (median)	LeChevallier et al. 1997b
Reservoir outlets	60	12	0.012–1.07	0.061 (g) 0.6 (median)	LeChevallier et al. 1997b
River (polluted)	72	40	0.2–2.8	0.24 (g)	LeChevallier et al. 1997a
Source water	NR	24	0.01–53.9[3]	7.4 (a)[3] 0.71 (g)[3]	Swertfeger et al. 1997
First flush (storm event)	20	35	0–417	NR	Stewart et al. 1997
Filtered (non -storm event)	87	10	0–4.2	NR	Stewart et al. 1997
Grab (non -storm event)	21	19	0–6.5	NR	Stewart et al. 1997
River 1	24	63	0–14.7	0.58 (g)	States et al. 1997
Stream by dairy farm	22	82	0–23	0.42 (g)	States et al. 1997
River 2 (at plant intake)	24	63	0–22	0.31 (g)	States et al. 1997
Settled water (prefiltration)	24	29	0–0.35	0.12 (g)	States et al. 1997
Finished	24	8 (confirmed) 13 (presumed)	0–0.006	0.005 (g)	States et al. 1997
Reservoirs (unfiltered system)	NR	37–52[4]	0.15–0.43 (maxima)[4]	0.008–0.014[4]	Okun et al. 1997
Raw water intakes	148	25	0.0004–0.18	0.003	Consonery et al. 1997
Finished water	155	2.5	0.0002–0.008	0.002	Consonery et al. 1997
Raw water intakes (rural)	NR	NR	0.4–4	NR	Swiger et al. 1998

1. Rounded to nearest percent.
2. As cited in Lisle and Rose (1995).
3. Based on presumptive oocyst count
4. Combined monitoring results for multiple sites in large urban water supply.
5. As cited in States et al. 1997

(a) = arithmetic average

(g) = geometric average

NR = not reported, NA = not applicable

Exhibit 2–5. U.S. GWUDI Monitoring Data for *Cryptosporidium* Oocysts

Sample Source	Number of Samples (n)	Samples Positive for *Cryptosporidium* Oocysts (percent)	Range of Positive Values (oocysts/L)	Mean (oocysts/L)[1]	Reference
Ground water well	17	(1 sample)	1/1,175 L	NA	Archer et al. 1995
Ground water sources (all categories)	199 sites[2]	11[2]	0.002–0.45d	NR	Hancock et al. 1998
Vertical wells	149 sites[2]	5[2]	NR	NR	Hancock et al. 1998
Springs	35 sites[2]	20[2]	NR	NR	Hancock et al. 1998
Infiltration galleries	4 sites[2]	50[2]	NR	NR	Hancock et al. 1998
Horizontal wells	11 sites[2]	45[2]	NR	NR	Hancock et al. 1998
Ground water sources	18	5.61	0.3	NR	Rose et al. 1991
Spring-fed cistern (Potter Co., PA, Nov. 1991)	1	100	Unknown	NR	Conrad 1997; PADEP 1997
Spring (Spring Twp., Center Co., PA, May 1995)	1	100	0.3	NR	Conrad 1997; PADEP 1997
Vertical well Lemont Well #4 (Center Co., PA, Aug. 1992)	6	66.7	NR	NR	Conrad 1997; PADEP 1997
Vertical well (Boggs Twp. Well #1, Center Co., PA, Apr. 1997)	1	100	0.52	NR	Conrad 1997; PADEP 1997
Vertical well (Boggs Twp. Well #1, Center Co., PA, Apr. 1997)	2	50	0.79	NR	Conrad 1997; PADEP 1997
Vertical well (Douglas Co., OR, Feb. 1996, Feb. 1997)	3	33.3	NR	12	Sebald 1997
Infiltration gallery (Salem, OR, Jan. 1994 through Sept. 1996)	31	35.5	0.3 – 12.7	NR	Salis 1997
Ranney collector (St. Helens, OR, May 1993 through Mar. 1997)	31	3.2	NR	4.5	Salis 1997
Well (Marshfield, MA, June 1997)	1	(one sample)	NR	NA	Smith 1997
Shallow, vertical well (Braymer Well #4, MO, May 1995)	3	33.3	NR	0.3	Ledbetter (undated)

1. Geometric mean reported unless otherwise indicated
2. Data are presented as the percentage of positive sites

NA = not applicable

NR = not reported

The LeChevallier and Norton (1995) study collected the most samples and repeat samples from the largest number of surface water plants nationally. LeChevallier and Norton conducted the study to determine the level of *Cryptosporidium* in surface water supplies and plant effluent water. In total, surface water sources for 72 treatment plants in 15 States and two Canadian provinces were sampled. The generated data set covered a two-year monitoring period (March, 1991 to January, 1993) that was combined with a previous set of data (October, 1988 to June, 1990) collected from most of the same set of systems to create a database containing at least five immunofluorescence assay analyses for 94 percent of the 67 systems sampled. *Cryptosporidium* oocysts were detected in 135 (51.5 percent) of the 262 raw water samples collected between March 1991 and January 1993, while 87 percent of samples were positive during the survey period from October, 1988 to June, 1990. The geometric mean of detectable *Cryptosporidium* was 240 oocysts per 100 liters (L), with a range from 6.5–6510 oocysts/100L.

LeChevallier and Norton (1995) also detected *Cryptosporidium* oocysts in 35 of 262 plant effluent samples (13.4 percent) analyzed between 1991 and 1993. When detected, the oocyst levels averaged 3.3 oocysts/100L (ranging from 0.29 to 57 oocysts/100L). A summary of occurrence data for all samples in filtered effluents for the years 1988 to 1993 showed that 32 of the water treatment plants (45 percent) were consistently negative for *Cryptosporidium*. Forty-four of the plants (62 percent) were positive for *Giardia*, *Cryptosporidium*, or both at one time or another (LeChevallier and Norton, 1995).

The oocyst recoveries and densities reported by LeChevallier and Norton (1995) are comparable to the results of another survey of treated, untreated, protected (pristine) and feces-contaminated (polluted) water supplies (Rose et al., 1991). Six of thirty six samples (17 percent) taken from potable drinking water were positive for *Cryptosporidium*, and concentrations in these waters ranged from .5–1.7 oocysts/100L. In addition, a total of 188 surface water samples were analyzed from rivers, lakes, or springs in 17 States. The average oocyst concentrations ranged from less than 1 to 4,400 oocysts/100L, depending on the type of water analyzed. *Cryptosporidium* oocysts were found in 55 percent of the surface water samples at an average concentration of 43 oocysts/100L.

It should be noted that the Information Collection Rule (ICR) will provide 18 months of *Cryptosporidium* monitoring data for the development of a national source water *Cryptosporidium* occurrence distribution. Although the data collection efforts have been completed (January 2000), the last 6 months of data are still undergoing quality assurance review. EPA's supplementary survey is also providing *Cryptosporidium* and other microbial source water occurrence data; the full set of supplementary survey data will not be available for analysis until July 2000. The Technical Working Group supporting the Federal Advisory Committee involved with LT2ESWTR negotiation has been deliberating over the appropriate data analysis methods to create the national source water distribution for *Cryptosporidium* occurrence. This issue will continue to be discussed during the remainder of the LT2ESWTR Regulatory Negotiation process, scheduled to end in July 2000. It is likely that the data will undergo peer review only after the closure of the Regulatory Negotiation process. Due to the ICR data evaluation and peer review time frame, EPA does not envision being able to utilize these data in the LT1FBR regulatory impact analyses and instead intends to incorporate the data into the impact analysis for the LT2ESWTR.

Despite analytical method limitations, *Cryptosporidium* has been detected in source waters. In general, oocysts are detected more frequently and in higher concentrations in rivers and streams than in lakes and reservoirs (LeChevallier et al., 1991a; Rose et al., 1988a,b). Madore et al. (1987) found high concentrations of oocysts in a river affected by agricultural runoff (5,800 oocysts/L). Such concentrations are especially significant if the contaminant removal process (sedimentation, filtration) of the treatment plant is not operating effectively. Oocysts may pass through to the finished water, as LeChevallier and Norton (1995) also found, and infect drinking water consumers, evident through waterborne disease outbreaks.

2.2.4 Waterborne Disease Outbreaks

The CDC, EPA, and the Council of State and Territorial Epidemiologists have maintained a collaborative surveillance program for collection and periodic reporting of data on waterborne disease outbreaks since 1971. The CDC database and biennial CDC–EPA surveillance summaries include data reported voluntarily by the States on the incidence and prevalence of waterborne illnesses. According to the CDC–EPA database, between 1971 and 1996 a total of 652 outbreaks and 572,829 cases of illnesses were reported (see Exhibit 2–6). The total number of outbreaks reported includes outbreaks resulting from protozoan contamination, virus contamination, bacterial contamination, chemical contamination, and unknown factors.

Exhibit 2–6. Comparison of Outbreaks and Outbreak-related Illnesses from Ground Water and Surface Water for the Period 1971–1996[1]

Water Source	Total Outbreaks[2]	Cases of Illnesses[2]	Outbreaks in CWSs	Outbreaks in NCWSs
Ground	371 (57%)	90,815 (16%)	113	258
Surface	223 (34%)	471,375 (82%)	148	43
Other	58 (9%)	10,639 (2%)	30	19
All Systems[3]	652 (100%)	572,829 (100%)	291	320

1. Modified from Craun and Calderon (1994) and additional 1995–1996 data.
2. Includes outbreaks in CWSs + NCWSs + Private wells.

From 1984 to 1994, there were 19 reported outbreaks of cryptosporidiosis in the United States (Craun, 1998). As mentioned previously, *C. parvum* was not identified as a human pathogen until 1976. Furthermore, Cryptosporidiosis outbreaks were not reported in the United States prior to 1984. Ten of these cryptosporidiosis outbreaks were documented in CWSs, NCWSs, and a private water system (Moore et al., 1993; Kramer et al., 1996; Levy et al., 1998; Craun, 1996; Craun et al., 1998). The remaining nine outbreaks were associated with water-based recreational activities (Craun et al., 1998). The ten cryptosporidiosis outbreaks in drinking water systems are summarized in Exhibit 2–7.

Exhibit 2–7. Cryptosporidiosis Outbreaks in U.S. Drinking Water Systems

Year	Location CWS, NCWS, Private	Cases of Illness (Estimated)	Source Water	Treatment	Suspected Cause
1984	Braun Station, TX, CWS	117 (2,000)	Well	Chlorination	Sewage-contaminated well
1987	Carrollton, GA, CWS	(13,000)	River	Conventional filtration/ chlorination; inadequate backwashing of some filters	Treatment deficiencies
1991	Berks County, PA, NCWS	(551)	Well	Chlorination	Ground water under the influence of surface water.
1992	Medford (Jackson County), OR, CWS	(3,000; combined total for Jackson County and Talent, below)	Spring/River	Chlorination/package filtration plant	Source not identified
1992	Talent, OR, CWS	see Medford, OR	Spring/River	Chlorination/package filtration plant	Treatment deficiencies
1993	Milwaukee, WI, CWS	(403,000)	Lake	Conventional filtration	High source water contamination and treatment deficiencies
1993	Yakima, WA, private	7	Well		Ground water under the influence of surface water
1993	Cook County, MN, NCWS	27	Lake	Filtered, chlorinated	Possible sewage backflow from toilet/septic tank
1994	Clark County, NV, CWS	103; many confirmed for cryptosporidiosis were HIV positve	River/Lake	Prechlorination, filtration and post-filtration chlorination	Source not identified
1994	Walla Walla, WA, CWS	134	Well	None reported	Sewage contamination

Adapted from Craun, et al. (1998)

Six of the ten cryptosporidiosis outbreaks reported in Exhibit 2–7 originated from surface water or possibly GWUDI water supplied by public drinking water systems serving fewer than 10,000 persons. The first outbreak involved 117 known cases and 2,000 estimated cases of illness in Braun Station, Texas in 1984. It was caused by sewage leakage into a ground water well suspected to be under the influence of surface water. A second outbreak in Pennsylvania in 1991 (551 cases of illness) occurred at a well also under the influence of surface water. The third and fourth (multi-episodic) outbreaks took place in Jackson County, Oregon in 1992 (3,000 cases of illness) and were linked to treatment deficiencies in the Talent surface water system. A fifth outbreak (27 cases of illness) in Minnesota, in 1993, occurred at a resort supplied by lake water.

Finally, a sixth outbreak (134 cases of illness) in Washington in 1994, occurred due to sewage-contaminated wells at a CWS.

Three of the ten outbreaks (Carollton, Georgia (1987); Talent, OR (1992); Milwaukee, WI (1993) were caused by water supplied by water treatment plants where process stream recycle was implicated as a possible cause of the outbreak. In total, the nine outbreaks occurring in PWSs caused approximately 419,939 cases of illness. These outbreaks illustrate that when treatment is not operating optimally or when source water is highly contaminated, *Cryptosporidium* may enter the finished drinking water and infect drinking water consumers, ultimately resulting in waterborne disease outbreaks.

The occurrence of outbreaks of waterborne gastrointestinal infections including cryptosporidiosis may be much greater than suggested by reported surveillance data (Craun and Calderon 1996). The CDC database is based on responses to a voluntary and confidential survey that is completed by State and local public health officials.

The U.S. National Research Council strongly suggests that the number of identified and reported outbreaks in the CDC database (both for surface and ground waters) represents a small percentage of actual waterborne disease outbreaks (National Research Council, 1997; Bennett et al., 1987). In practice, most waterborne outbreaks in community water systems are not recognized until a sizable proportion of the population is ill (Perz et al., 1998; Craun, 1996), perhaps one to two percent of the population (Craun, 1996).

In addition, healthy adults with cryptosporidiosis may not suffer severe symptoms from the disease; therefore, infected individuals may not seek medical assistance, and their cases go unreported. Even if infected individuals consult a physician, *Cryptosporidium* is not analyzed by routine diagnostic tests for gastroenteritis and, therefore, tends to be under-reported in the general population (Juranek, 1995; Craun, 1996). Such obstacles to outbreak reporting indicate that the incidence of disease and outbreaks of cryptosporidiosis may be much higher than officially reported by the CDC.

Endemic waterborne disease is a factor that should also be considered. Endemic waterborne disease is defined as any waterborne disease not associated with an outbreak. EPA, however, is not aware of any currently available data for the United States that documents the incidence of waterborne endemic cryptosporidiosis. For example, 14–40 percent of the normal gastrointestinal illness in a community in Quebec was associated with treated drinking water from a surface water source (Payment et al., 1997). Given the lack of endemic waterborne disease occurrence data, combined with the strong possibility that outbreaks are under-reported, it is likely that there are greater instances of cryptosporidiosis and other waterborne diseases than are currently recorded.

2.2.5 Filter Backwash and Other Process Streams: Occurrence and Impact Studies

EPA, in conjunction with the American Water Works Association (AWWA), the American Water Works Service Company (AWWSCo), and Cincinnati Water Works, compiled issue papers on each of the following recycle streams: spent filter backwash water, sedimentation basin solids, combined thickener supernatant, ion-exchange regenerate, membrane concentrate, lagoon decant, mechanical dewatering device concentrate, monofill leachate, sludge drying bed leachate, and small-volume streams (e.g., floor, roof, lab drains) (EE&T, 1999). In addition, EPA compiled the existing *Cryptosporidium* occurrence data and occurrence data on other constituents of the recycle streams with the data presented in AWWA's white papers. Through these efforts, *Cryptosporidium* occurrence data have been found for five types of recycle streams: untreated spent filter backwash water, gravity settled spent filter backwash water, combined gravity thickener supernatant (a combination of spent filter backwash and clarification process solids), gravity thickener supernatant from clarification process solids, and mechanical dewatering device liquids. Nine studies have reported the occurrence of *Cryptosporidium* for these process streams. Each study's scope and results are presented in Exhibit 2–8, and brief narratives on each major study follow the table. Note that the results of the studies, if not presented in the published report as oocysts/100L, have been converted into oocysts/100L.

Exhibit 2–8. *Cryptosporidium* Occurrence in Filter Backwash and Other Recycle Streams

Name/ Location of study	Number of samples	Type of sample	Cyst/oocyst concentration	Number of treatment plants sampled	Reference
Drinking water treatment facilities	2	backflush waters from rapid sand filters	sample 1: 26,000 oocysts/gal (calc. as 686,900 oocysts/100L); sample 2: 92,000 oocysts/gal (calc as 2,430,600 oocysts/100L)	2	Rose et al. 1986
Farmoor water treatment plant, England	not reported	backwash water from rapid sand filter	Over 1,000,000 oocysts/100L in backwash water on 2/19/89 100,000 oocysts/100L in supernatant from settlement tanks during the next few days	1	Colbourne 1989
Potable water supplies in 17 States	not reported	filter backwash from rapid sand filters (10 to 40-L sample vol.)	217 oocysts/100L (geometric mean)	not reported	Rose et al. 1991
Name/Location not reported	not reported	raw water initial backwash water	7 to 108 oocysts/100L detected at levels 57 to 61 times higher than in the raw water	not reported	LeChevallier et al. 1991a

Exhibit 2–8. *Cryptosporidium* Occurrence in Filter Backwash and Other Recycle Streams

Name/ Location of study	Number of samples	Type of sample	Cyst/oocyst concentration	Number of treatment plants sampled	Reference
Bangor Water Treatment Plant (PA)	Round 1: 1 (8-hour composite)	raw water filter backwash supernatant recycle	6 oocysts/100L 902 oocysts/100L 141 oocysts/100L	1	Cornwell and Lee 1993a,b
	Round 2: 1 (8-hour composite)	raw water filter backwash supernatant recycle	140 oocysts/100L 850 oocysts/100L 750 oocysts/100L		
Moshannon Valley Water Treatment Plant	Round 1: 1 (8-hour composite)	spent backwash supernatant recycle raw water sludge	16,613 oocysts/100L 82 oocysts/100L 13 oocysts/100L 2,642 oocysts/100L	1	Cornwell and Lee 1993a,b
	Round 2: 1 (8-hour composite)	raw water supernatant recycle	20 oocysts/100L 420 oocysts/100L		
Plant "C"	11 samples using continuous flow centrifu- gation; 39 samples using cartridge filters	backwash water from rapid sand filters; samples collected from sedimentation basins during sedimentation phase of backwash water at depths of 1, 2, 3, and 3.3 m.	continuous flow: range 1 to 69 oocysts/100L; 8 of 11 samples positive cartridge filters: ranges 0.8 to252/100L; 33 of 39 samples positive	1	Karanis et al. 1996
Pittsburgh Drinking Water Treatment Plant	24 (two years of monthly samples)	filter backwash	328 oocysts/100L (mean); (38 percent occurrence rate) non-detect-13,158 oocysts/100L	1	States et al. 1997
"Plant Number 3"	not reported	raw water spent backwash	140 oocysts/100L 850 oocysts/100L	not reported	Cornwell 1997

Exhibit 2–8. *Cryptosporidium* Occurrence in Filter Backwash and Other Recycle Streams

Name/ Location of study	Number of samples	Type of sample	Cyst/oocyst concentration	Number of treatment plants sampled	Reference
"Plant C" (see Karanis, et al., 1996)	12	raw water	avg. 23.2 oocysts/100L (max. 109 oocysts/100L) in 8 of 12 samples	1	Karanis et al. 1998 (Table 8, p.14)
"Plant A"	50	backwash water from rapid sand filters	avg. 22.1 oocysts/100L (max. 257 oocysts/100L) in 41 of 50 samples		
	1	rapid sand filter (sample taken 10 min. after start of backwashing)	150 oocysts/100L		

The occurrence data available and reported are primarily for raw and recycle stream water. Filtered effluent water was not sampled in most cases, and effluent occurrence would not provide a good proxy for the implications of process stream recycle on the efficacy of the treatment process. There is generally a plant-specific latency period for filter backwash to re-enter the treatment train. If filter backwash does enter the treatment train as a slug load and disrupts the treatment process, its effects would possibly not register in the finished water until several hours after the start of backwashing. In addition, the recovery efficiencies of the IFA detection method complicate measurements in dilute effluent waters. However, the generally large concentrations of oocysts flushed from the filters, sedimentation basins, and other areas of the plant and present in recycle streams can potentially enter the finished water and cause cryptosporidiosis outbreaks, should the treatment plant not operate efficiently or become disrupted due to recycle practice.

As shown in Exhibit 2–8, the concentrations of oocysts in backwash water and other recycle streams are greater than the concentrations generally found in raw water. For example, four studies (Cornwell and Lee, 1993b; States et al., 1997; Rose et al., 1986; and Colbourne, 1989) have reported *Cryptosporidium* oocyst concentrations in filter backwash water exceeding 10,000 oocysts/100L, in some instances by several orders of magnitude. Such concentrations illustrate that the treatment plant has been removing oocysts from the influent water during the sedimentation and/or filtration processes. As expected, the oocysts have concentrated on the filters and/or in the sedimentation basin sludge. Therefore, the recycling of such process streams (e.g., filter backwash, thickener supernatant, sedimentation basin sludge) re-introduces high concentrations of oocysts to the drinking water treatment train. Recycle can potentially return a significant number of oocysts to the treatment plant in a short amount of time, particularly if the recycle is returned to the treatment process without prior treatment, equalization, or some other type of hydraulic detention. Should recycle disrupt normal treatment operations or should treatment not function efficiently due to other deficiencies, high concentrations of oocysts may pass through the plant into finished drinking water. The major recycle stream studies presented in Exhibit 2–8 will be described in further detail below.

Rose, et al.

Rose, et al. (1991) reported the geometric mean of the backwash samples at 217 *Cryptosporidium* oocysts/100L. This was the highest reported average *Cryptosporidium* concentration of any of the water types tested, which included polluted and pristine surface and ground water sources, drinking water sources in addition to backwash water.

LeChevallier, et al.

In the analysis of pathogen concentrations in the raw water and filter backwash water of the water treatment process, LeChevallier et al. (1991c) found very high oocyst levels in backwash water of systems that had low raw water parasite concentrations. *Cryptosporidium* levels in the initial backwash water were 57 to 61 times higher than in the raw water supplies. Raw water samples were found to contain from 7 to 108 oocysts/100L. LeChevallier et al. (1991c) also noted that when *Cryptosporidium* (12 of 13 times) were detected in plant effluent samples, the organisms were also observed in the backwash samples. They conclude that the consistency of these results shows that accumulation of parasites in the treatment filters (and subsequent release in the backwash water) could be related to subsequent penetration of the treatment barriers.

Cornwell and Lee

Cornwell and Lee (1993b) detected *Cryptosporidium* concentrations of over 15,000 *Cryptosporidium* oocysts/100L in the spent filter backwash at an adsorption clarifier plant (Moshannon Valley) and over 800 *Cryptosporidium* oocysts/100L in backwash water from a direct filtration plant (Bangor). The parasite levels in the backwash samples were significantly higher than concentrations found in raw source water, which contained *Cryptosporidium* oocyst concentrations of 6–140 oocysts/100L at the Bangor plant and 13–20 oocysts/100L at Moshannon Valley.

In addition, Cornwell and Lee determined oocyst concentrations for two other recycle streams, combined thickener supernatant and sedimentation basin solids. The supernatant pathogen concentrations was reported at 141 *Cryptosporidium* oocysts/100L at the Bangor plant, and levels were reported at 82 to 420 cysts/100L for the Moshannon plant in Rounds 1 and 2 of sampling, respectively. The sedimentation basin sludge was reported at 2,642 *Cryptosporidium* oocysts/100L in the clarifier sludge from the Moshannon Valley plant.

States, et al.

Cryptosporidium occurred in the raw Allegheny river water supplying the plant with a geometric mean of 31 oocysts/100L in 63 percent of samples collected, and ranged from non-detect to 2,333 oocysts/100L (States et al., 1997). Of the filter backwash samples, a geometric mean of 328 oocysts/100L was found at an occurrence rate of 38 percent of samples, with a range from non-detect to 13,158 oocysts/100L The fact that the mean concentration of *Cryptosporidium* oocysts in backwash water can be substantially higher than the oocyst concentration in untreated river water suggests that recycling untreated filter backwash water can be a significant source of this parasite within the treatment process.

2.2.6 Current Control and Potential for Improvement

Existing turbidity limits were created to remove large parasite cysts such as *Giardia*, and, therefore, must be strengthened to control for the smaller *Cryptosporidium* oocysts passing through the treatment plant removal processes. In addition, degradation in treatment performance caused by improper plant process stream recycle or other treatment deficiencies may harm efforts to control *Giardia lamblia* and emerging pathogens, in addition to *Cryptosporidium*, particularly during periods of heavy precipitation or high runoff.

In spite of filtration and disinfection, *Cryptosporidium* oocysts have been found in filtered drinking water (LeChevallier, et al., 1991a; U.S. EPA, 1993), and many of the individuals affected by waterborne disease outbreaks caused by *Cryptosporidium* were served by filtered surface water supplies (Solo-Gabriele and Neumeister, 1996). It appears that surface water systems that filter and disinfect may still be vulnerable to *Cryptosporidium*, depending on the source water quality and treatment effectiveness. However, today's proposal will ensure that treatment is operating efficiently to control *Cryptosporidium* (see Section IV.A and IV.D). Treatment practices that control *Cryptosporidium* will control other microbiological contaminants of concern (e.g., *Giardia*).

One of the key regulations EPA has developed and implemented to counter pathogens in drinking water is the Surface Water Treatment Rule (SWTR) (54 FR 27486, June 29, 1989). Among the provisions of the rule, the SWTR 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 logs) and 99.99 percent (4 logs), 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).

In 1998, the Agency finalized the IESWTR, designed to enhance the SWTR protections from microbial pathogens, specifically *Cryptosporidium*, for systems serving 10,000 or more persons. The IESWTR provisions included a Maximum Contaminant Level Goal (MCLG) of zero for *Cryptosporidium*. In addition, the IESWTR requires a minimum 2 log (99 percent) removal of *Cryptosporidium*, linked to enhanced combined filter effluent and individual filter turbidity monitoring provisions, although this requirement currently applies only to surface and GWUDI systems serving 10,000 people or more that must filter under the SWTR.

Several provisions of today's proposed rule, the LT1FBR, are designed to address the concerns covered by the IESWTR, improving control of *Cryptosporidium* and other microbial contaminants, for the portion of the public served by smaller PWSs (i.e., serving fewer than 10,000 persons). The LT1FBR also addresses the concern that for all PWSs that practice process stream recycling, *Cryptosporidium* (and other emerging pathogens resistant to standard disinfection practice) are reintroduced to the treatment process of PWSs by the recycle of spent filter backwash water, solids treatment residuals, and other process streams.

Insufficient treatment practices have been cited as the cause of several reported waterborne disease outbreaks (Rose, 1997). Rose (1997) also found that reducing turbidity is indicative of a more efficient filtration process. Therefore, the turbidity and filter monitoring requirements of today's proposed LT1FBR would ensure that the removal process necessary to protect the public from cryptosporidiosis is operating properly, and the recycle stream provisions would ensure that the treatment process is not disrupted or operating inefficiently. The regulatory history that led up to development of the LT1FBR is summarized in the following section.

2.3 Regulatory History and Current Controls

2.3.1 1979 Total Trihalomethane Rule

In November 1979 (44 FR 68624), EPA set an interim MCL for total trihalomethanes (TTHM - the sum of chloroform, bromoform, bromodichloromethane, chlorodibromomethane) of 0.10 mg/l as an annual average.

The interim TTHM standard applies to community water systems using surface water and/or ground water serving at least 10,000 people that add a disinfectant to the drinking water during any part of the treatment process. At their discretion, States may extend coverage to smaller water systems; however, most States have not exercised this option.

2.3.2 Total Coliform Rule

The Total Coliform Rule (TCR) (54 FR 27544, June 19, 1989) applies to all public water systems. The TCR sets compliance with the Maximum Contaminant Level (MCL) for total coliforms (TC) as follows. If a system exceeds the MCL, it must notify the public using mandatory language developed by the EPA. All systems must have a written plan identifying where samples are to be collected.

If a system has a TC-positive sample, it must test that sample for the presence of fecal coliforms or *E. coli*. The system must also collect a set of repeat samples, and analyze for TC (and fecal coliform or *E. coli* within 24 hours of the first TC-positive sample).

The TCR also requires an on-site inspection (referred to as a sanitary survey) every 5 years for each system that collects fewer than five samples per month. This requirement is extended to every 10 years for noncommunity systems using only protected and disinfected ground water.

2.3.3 Surface Water Treatment Rule

Under the Surface Water Treatment Rule (SWTR) (54 FR 27486, June 29, 1989), EPA set maximum contaminant level goals of zero for *Giardia lamblia*, viruses, and *Legionella*; and promulgated regulatory requirements for all PWSs using surface water sources or ground water sources under the direct influence of surface water. The SWTR includes treatment technique requirements for filtered and unfiltered systems that are intended to protect against the adverse health effects of exposure to *Giardia lamblia*, viruses, and *Legionella*, as well as many other pathogenic organisms. Briefly, those requirements include 1) requirements for maintenance of a disinfectant residual in the distribution system; 2) removal and/or inactivation of 3 log (99.9 percent) for *Giardia* and 4 log (99.99 percent) for viruses; 3) combined filter effluent turbidity performance standard of 5 nephelometric turbidity units (NTU) as a maximum and 0.5 NTU at the 95th percentile monthly, based on four-hour monitoring for treatment plants using conventional treatment or direct filtration (with separate standards for other filtration technologies); and 4) watershed protection and other requirements for unfiltered systems.

2.3.4 Information Collection Rule

The Information Collection Rule (ICR), which was promulgated on May 14, 1996 (61 FR 24354) applied to large public water systems serving populations over 100,000; a more limited set of ICR requirements pertain to ground water systems serving between 50,000 and 100,000 people.

The purpose of the ICR was to collect occurrence and treatment information to help evaluate the need for possible changes to the current microbial requirements and existing microbial treatment practices, and to help evaluate the need for future regulation for disinfectants and disinfection byproducts (DBPs). The ICR will provide EPA with additional information on the national occurrence in drinking water of (1) chemical byproducts that form when disinfectants used for microbial control react with naturally occurring compounds already present in source water; and (2) disease-causing microorganisms, including *Cryptosporidium, Giardia*, and viruses. The ICR also provided engineering data on how PWSs currently control for such contaminants. The ICR monthly sampling data will also provide information on the quality of the recycle waters via monthly monitoring (for 18 months) of pH, alkalinity, turbidity, temperature, calcium and total hardness, TOC, UV_{254}, bromide, ammonia, and disinfectant residual (if disinfectant is used). This data will provide some indication of the treatability of the water, the extent to which contaminant concentration effects may occur, and the potential for contribution to DBP formation.

2.3.5 Interim Enhanced Surface Water Treatment Rule

Public water systems serving 10,000 or more people that use surface water or ground water under the direct influence of surface water are required to comply with the IESWTR (63 FR 69477, December 16, 1998) by December 2001. The purposes of the IESWTR are to improve control of microbial pathogens, specifically the protozoan *Cryptosporidium*, and address risk trade-offs between pathogens and disinfection byproducts. Key provisions established by the rule include: a MCLG of zero for *Cryptosporidium*; 2 log *Cryptosporidium* removal requirements for systems that filter; strengthened combined filter effluent turbidity performance standards of 1.0 NTU as a maximum and 0.3 NTU at the 95th percentile monthly, based on four-hour monitoring for treatment plants using conventional treatment or direct filtration; requirements for individual filter turbidity monitoring; disinfection benchmark provisions to assess the level of microbial protection provided as facilities take the necessary steps to comply with new disinfection byproduct standards; inclusion of *Cryptosporidium* in the definition of ground water under the direct influence of surface water and in the watershed control requirements for unfiltered public water systems; requirements for covers on new finished water reservoirs; and sanitary surveys for all surface water systems regardless of size.

2.3.6 Stage 1 Disinfection Byproduct Rule

The Stage 1 DBPR (63 FR 69389, December 16, 1998) applies to all PWSs that are either a community water system (CWS) and nontransient noncommunity water system that treat their water with a chemical disinfectant for either primary or residual treatment. In addition, certain requirements for chlorine dioxide apply to transient noncommunity water systems. The Stage 1 DBPR was published at the same time as the IESWTR (63 FR 69477, December 16, 1998).

The Stage 1 DBPR finalizes maximum residual disinfectant level goals (MRDLGs) for chlorine, chloramines, and chlorine dioxide; MCLGs for four trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane, and bromoform), two haloacetic acids (dichloroacetic acid and trichloroacetic acid), bromate, and chlorite; and NPDWRs for three disinfectants (chlorine, chloramines, and chlorine dioxide), two groups of organic disinfection byproducts TTHMs and HAA5 and two inorganic disinfection byproducts, chlorite and bromate. The NPDWRs consist of maximum residual disinfectant levels (MRDLs) or maximum contaminant levels (MCLs) or treatment techniques for these disinfectants and their byproducts. The NPDWRs also include monitoring, reporting, and public notification requirements for these compounds. The Stage 1 DBPR rule includes the best available technologies (BATs) upon which the MRDLs and MCLs are based. EPA believes the implementation of the Stage 1 DBPR will reduce the levels of disinfectants and disinfection byproducts in drinking water supplies. The Agency believes the rule will provide public health protection for an additional 20 million households that were not previously covered by drinking water rules for disinfection byproducts.

2.3.7 Stakeholder Involvement

EPA has conducted two stakeholder meetings to solicit feedback and information from the regulated community and other concerned stakeholders on issues relating to today's proposed rule. The first meeting was held July 22 and 23, 1998 in Lakewood, Colorado. EPA presented potential regulatory components for the LT1FBR. Breakout sessions with stakeholders were held to generate feedback on the regulatory provisions being considered and to solicit feedback on next steps for rule development and stakeholder involvement. Additionally, information was presented summarizing ongoing research and data gathering activities regrding the recycle of filter backwash. The presentations generated useful discussion and provided substantial feedback to EPA regarding technical issues, stakeholder concerns, and possible regulatory options.

The second stakeholder meeting was held in Dallas, Texas on March 3 and 4, 1999. EPA presented new analysis, summaries of current research, and revised regulatory options and data collected since the July stakeholder meeting. Regional perspectives on turbidity and disinfection benchmarking components were also discussed with presentations from EPA Region VI and the Texas Natural Resources Conservation Commission. Four break-out sessions were extremely useful and generated a wide range of information, issues, and technical input from a diverse group of stakeholders.

2.4 Economic Rationale

2.4.1 Introduction

This section of the RIA discusses the statutory authority and 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 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 market or public institutions that warrant new agency action) as well as assess the significance of that problem (Sect. 1b(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 (SDWA). Rather, 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.

2.4.2 Statutory Authority for Promulgating the Rule

Section 1412(b)(1)(A) of SDWA requires EPA to establish National Primary Drinking Water Regulations for contaminants that may have an adverse public health effect, that are known to occur, or present a substantial likelihood of occurrence in public water systems at a frequency and level of public health concern and that present a meaningful opportunity for health risk reduction for persons served by PWSs.

Section 1412(b)(2)(C) of SDWA states that, "The Administrator shall promulgate an Interim Enhanced Surface Water Treatment Rule, a Final Enhanced Surface Water Treatment Rule, a Stage I Disinfection Byproducts Rule, and a Stage II Disinfection Byproducts Rule..." The above section of the statute gives specific authority to promulgate the LT1FBR. Section 1412(b)(2)(c) is supplemented with an additional provision regarding the recycle of process streams, which states, "The Administrator shall promulgate a regulation to govern the recycling of filter backwash water within the treatment process of a public water system."(1412(b)(14))

EPA is authorized to promulgate a National Primary Drinking Water Regulation "that requires the use of a treatment technique in lieu of establishing a MCL," if the Agency finds that "it is not economically or technologically feasible to ascertain the level of the contaminant." A treatment technique has been selected to control *Cryptosporidium* because it is currently not feasible to measure the concentration of *Cryptosporidium* for regulatory purposes.

2.4.3 The Economic Rationale for Regulation

In addition to the statutory directive to regulate surface water treatment and recycling there is also a strong economic rationale for government regulation. The need for regulation is a direct result of the structure of the market for publically provided drinking water. Economic theory suggests that society's well being is maximized when goods are produced and sold in well functioning competitive markets. A perfectly competitive market is said to exist 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. Two major factors in the public water supply industry do not satisfy the requirements for a competitive market and lead to market failures that require regulation.

First, the public water market has 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 in the same locality. 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. Since water purveyors often operate in such a monopolistic environment they may not respond to the usual market incentive to satisfy their consumers' desire for safety and high drinking water quality.

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 risk potentially posed by trace quantities of drinking water contaminants involve analysis and distillation of complex toxicological data and health sciences. EPA has finalized the development of the Consumer Confidence Report Rule that makes water quality information more easily available to consumers. This Rule requires community water systems to post or 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 systems regarding these health issues, the costs of such engagement-transaction costs (measured in personal time and commitment) present 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 for public water supply. The regulations set minimum performance requirements for all public water supplies in order to protect all consumers from exposures to contaminants. SDWA regulations are not intended to restructure flawed market mechanisms or to establish competition in supply, but rather, to regulate the "product" produced within these markets. In other words, SDWA standards establish the level of service to be provided in order to better reflect public preferences for safety. Also, the Federal regulations remove the high information and transaction costs that would be required for consumers to make informed purchasing decisions by acting on behalf of all consumers in balancing the risk reduction and the social costs of achieving this reduction.

2.5 Summary of the Proposed Rule

EPA is proposing the following requirements to meet the public health protection goals of the LT1FBR, which will provide a level of protection for small systems that is comparable to the IESWTR, and to fulfill the statutory requirements of the SDWA. Exhibit 2–9 shows that the proposed rule includes two sets of provisions—the set of small system provisions that are parallel to the IESWTR requirements (enhanced filtration requirements, disinfection benchmark requirements, and additional requirements), and the set of provisions that address recycle practices. The flow chart in Exhibit 2–10 illustrates how a system using surface water or GWUDI as a source determines which provisions apply to it.

2.5.1 Enhanced Filtration Provisions

The proposed rule established a requirement for 2 log (i.e., 99 percent) removal of *Cryptosporidium* oocysts for surface water and GWUDI systems serving fewer than 10,000 people and filtering their water under the SWTR. This requirement applies between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream either before or at the first customer. Compliance with the combined filter effluent turbidity requirements, described below, insures compliance with the 2 log removal requirement.

There are two turbidity provisions in the proposed LT1FRB. One provision establishes revised combined filter effluent requirements for small systems that use filtration. These requirements differ across filtration technologies. A second provision establishes individual filter monitoring requirements for the subset of systems that use conventional or direct filtration.

For conventional and direct filtration systems, the proposed rule revises the existing combined filter effluent requirement such that the turbidity level of representative samples of a system's combined filter effluent water must be less than or equal to 0.3 nephelometric turbidity units (NTU) in at least 95 percent of the measurements taken each month. The turbidity level of representative samples of a system's filtered water must not exceed 1 NTU at any time.

For systems using membrane filtration (i.e., microfiltration, ultrafiltration, nanofiltration, and reverse osmosis) the proposed rule requires that the turbidity level of representative samples of a system's combined filter effluent water must be less than or equal to 0.3 NTU in at least 95 percent of the measurements taken each month. The turbidity level of representative samples of a system's filtered water must not exceed 1 NTU at any time. EPA included turbidity limits for membrane systems to allow such systems the ability to opt out of a demonstration of their ability to remove *Cryptosporidium*. In lieu of these turbidity limits, a public water system that utilizes membrane filtration may demonstrate (using pilot plant studies or other means) to the State that membrane filtration—in combination with disinfection treatment—consistently achieves 3 log removal and/or inactivation of *Giardia lamblia* cysts, 4 log removal and/or inactivation of viruses, and 2 log removal of *Cryptosporidium* oocysts. For each approval, the State will set turbidity performance requirements that the system must meet at least 95 percent of the time and that the system may not exceed at any time that are consistent with these removal and/or inactivation requirements.

Systems utilizing slow sand or diatomaceous earth filtration must continue to meet the combined filter effluent limits established for these technologies under the SWTR. Namely, the turbidity level of representative samples of a system's filtered water must be less than or equal to 1 NTU in at least 95 percent of the measurements taken each month and the turbidity level of representative samples of a system's filtered water must at no time exceed 5 NTU.

For all alternative filtration technologies (i.e., other than conventional, direct, slow sand, diatomaceous earth, or membrane), public water systems must demonstrate to the State for purposes of approval (using pilot plant studies or other means) that the alternative filtration technology—in combination with disinfection treatment—consistently achieves 3 log removal and/or inactivation of *Giardia lamblia* cysts, 4 log removal and/or inactivation of viruses, and 2 log removal of *Cryptosporidium* oocysts. For each approval, the State will set turbidity performance requirements that the system must meet at least 95 percent of the time and that the system may not exceed at any time at a level that consistently achieves these removal and/or inactivation requirements.

The proposed individual filter monitoring requirement applies to all surface water and GWUDI systems that serve populations fewer than 10,000 and utilize direct or conventional filtration. These systems are required to conduct continuous monitoring (i.e., one turbidity measurement recorded every 15 minutes) for each individual filter. A system must provide an exceptions report to the State as part of the existing combined effluent reporting process if any individual filter turbidity measurement exceeds 1 NTU, unless the system can show that the next reading is less than 1 NTU. Furthermore, if a system is required to submit an exceptions report for the same filter in three consecutive months, the system must conduct a self-assessment of the filter. Finally, if a system is required to submit an exceptions report that contains an accedence of 2 NTU for the same filter in two consecutive months, the system must arrange for a comprehensive performance evaluation to be conducted by the State or a third party approved by the State.

2.5.2 Disinfection Benchmarking Provision

Small systems are already required to comply with the Stage 1 DBPR. The proposed LT1FBR follows the principles set forth in earlier negotiations, i.e., if systems consider making changes to their disinfection practices to comply with Stage 1 DBPR, they cannot undercut their current level of microbial protection. The disinfection benchmarking requirements are designed to ensure that risk from one contaminant is not increased while risk from another contaminant is decreased. The requirements, which apply to all small systems (i.e., serving fewer than 10,000 people) that use surface water or GWUDI as a source and are not a transient noncommunity system, have three components:

- Applicability monitoring to determine which systems have annual average TTHM and HAA5 levels close enough to their respective MCL (i.e., equal to or greater than 80 percent of the MCL) such that they may need to consider altering their disinfection practices to comply with Stage 1 DBPR

- Disinfection profiling to develop a baseline of current microbial inactivation over one year

- Disinfection benchmarking to determine the month with the lowest average level of microbial inactivation from the profile.

All systems subject to the rule must develop a disinfection profile unless they choose to monitor TTHM values and can demonstrate levels less than 80 percent of their respective MCLs. The disinfection profile is developed by measuring four parameters: disinfectant residual, contact time, water temperature, and pH. These values are used to derive the level of microbial inactivation and must be measured on a weekly basis for one year starting in the first week of January 2003.

If a system that is required to develop a disinfection profile decides to make a significant change in disinfection practices it must calculate its disinfection benchmark, which is the lowest level of inactivation achieved over the course of the year, and consult with the State before implementing such a change. Significant changes in disinfection practice are defined as: moving the point of disinfection (other than routine seasonal changes already approved by the State); changing the type of disinfectant; changing the disinfection process; or making other modifications designated as significant by the State. Supporting materials for the consultation with the State must include a description of the proposed change, the disinfection profile and benchmark for *Giardia lamblia* (and, if necessary, viruses for systems using ozone or chloramines), and an analysis of how the proposed change might affect the current level of *Giardia lamblia* inactivation.

Systems serving fewer than 500 persons have the option to request assistance from the State in calculating disinfection benchmark. This option is contingent on the system providing the State with the necessary operational data, and State agreement to perform the profile and benchmark calculations.

In the proposed rule, the applicability monitoring component is optional, which differs from the IESWTR requirements. If a system has TTHM and HAA5 data taken during the month of warmest water temperature (one sample for each to be taken anytime from 1998–2002) and taken at the point of maximum residence time in the distribution system, they may submit this data to the State beginning two years after the publication date. If the data shows that TTHM and HAA5 levels are less than 80 percent of their respective MCLs, the system does not have to develop a disinfection profile. If the data shows that either TTHM or HAA5 levels or both are equal to or greater than 80 percent of the MCLs, the system would be required to develop a disinfection profile in 2003. If a system does not have, or does not gather such TTHM and HAA5 data during the month of warmest water temperature and at the point of maximum residence time in the distribution system as described, then the system would automatically be required to develop a disinfection profile starting the first week of January 2003.

2.5.3 Other LT1 Provisions

The proposed rule also modifies the definition of GWUDI to include C*ryptosporidium* for systems serving fewer than 10,000 persons. Under the SWTR, States were required to determine whether systems using ground water were using ground water under the direct influence of surface water. State determinations were required to be completed by June 29, 1994, for community water systems and by June 29, 1999, for noncommunity water systems. EPA does not believe that it is necessary to make a new determination of GWUDI for this rule based on the addition of *Cryptosporidium* to the definition of GWUDI because the current screening methods appear to adequately address the possibility of *Cryptosporidium* in the ground water.

The proposed rule extends the existing watershed control regulatory requirements for unfiltered systems serving fewer than 10,000 people to include the control of *Cryptosporidium*, which will be included in the watershed control provisions for these systems wherever *Giardia lamblia* is mentioned. Affected public water systems must maintain their watershed control programs to minimize the potential for contamination by *Cryptosporidium* oocysts as well as *Giardia lamblia* and viruses in the water. The State must determine whether the watershed control program is adequate to meet this goal. The adequacy of a program to limit potential contamination by *Giardia lamblia* cysts, *Cryptosporidium* oocysts, and viruses must be based on the comprehensiveness of the watershed review, the effectiveness of the system's program to monitor and control detrimental activities occurring in the watershed, and the extent to which the water system has maximized land ownership and/or controlled land use within the watershed.

The proposed rule also requires surface water and GWUDI systems that serve fewer than 10,000 people to cover all new reservoirs, holding tanks, or other storage facilities for finished water for which construction begins after 60 days after publication of the final rule. This requirement does not apply to existing uncovered finished water reservoirs.

2.5.4 Recycle Provisions

As Exhibit 2–9 shows, there are three recycle provisions in the proposed rule. These provisions apply to large and small systems. The first provision requires all surface water and GWUDI systems that employ rapid granular filtration to return spent filter backwash, thickener supernatant, or liquids from solid/liquid separation processes prior to the point of primary coagulant addition; systems that must move their recycle are required to submit a schematic diagram of proposed changes in the location of returned recycled water to the State. Plants that require an alternative recycle location to maintain optimal finished water quality, plants that are designed to employ recycle flow as an intrinsic component of the treatment process, or plants with unique treatment requirements or processes may apply to the State for a waiver to return recycle flows to an alternative location.

The second provision requires all surface water and GWUDI systems employing rapid granular filtration that practice direct recycle, typically employ 20 or fewer filters to meet production requirements during the highest production month in the 12-month period prior to the LT1FBR compliance date and recycle spent filter backwash or thickener supernatant to the primary treatment process to conduct a self assessment and report the results to the State. The State will determine whether recycle practices need to be changed. Prior to conducting the self assessment, a system must submit a monitoring plan to the State describing how it will monitor recycle flows and source water influent during the month of highest production and determine whether and how frequently it exceeds State-approved capacity. States are required to review the self assessments and report to EPA their determinations regarding whether modifications to recycle practices are necessary and provide a brief summary of the reasons for making those determinations.

The third provision requires that surface water and GWUDI systems with direct filtration and recycling to the main treatment process report their recycling practices to the State. The State is required to determine whether recycle practices must be changed. States are also required to report these determinations to EPA along with brief explanations.

Exhibit 2–9. Summary of How the Proposed LT1FBR is Organized

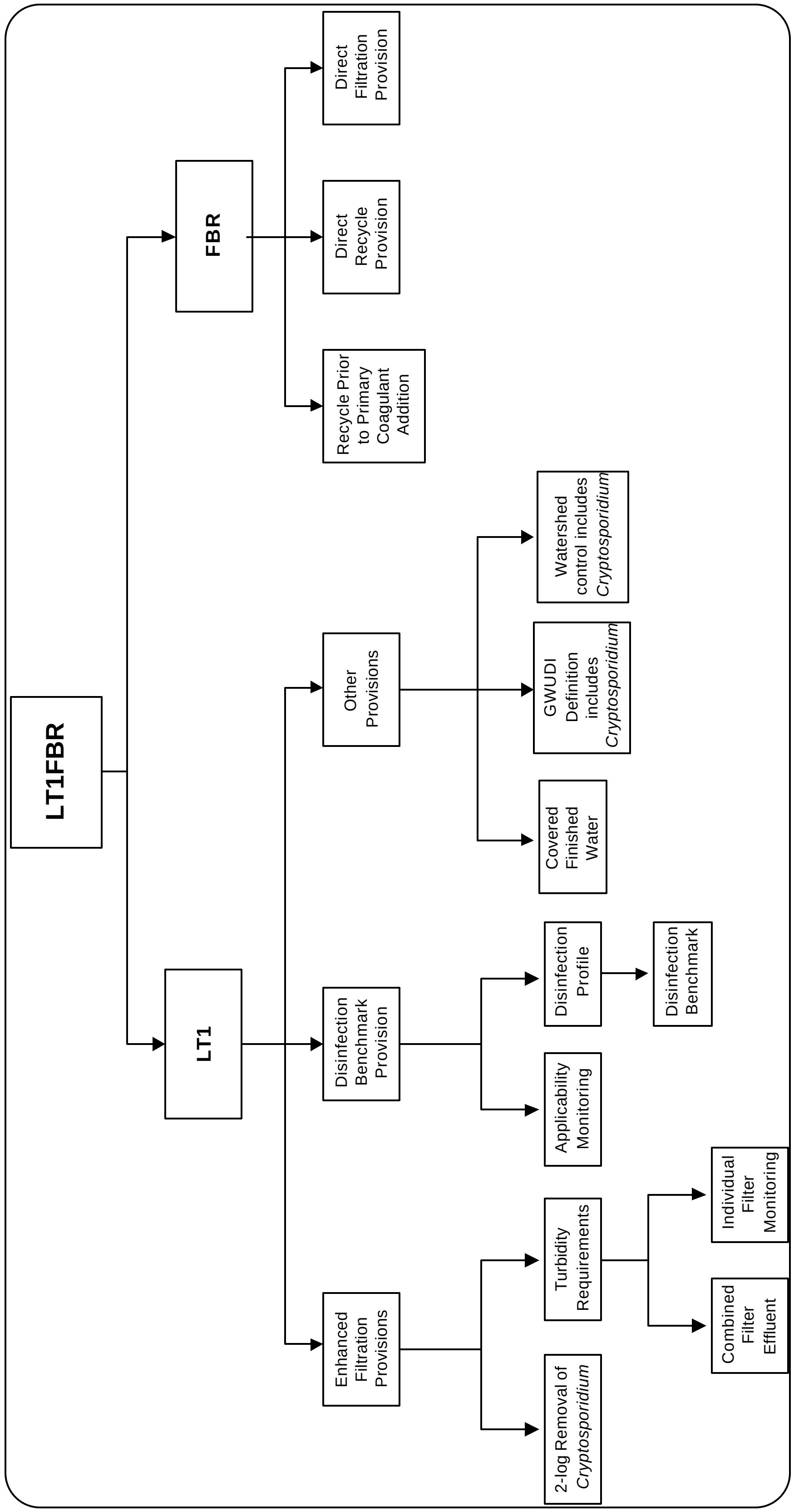
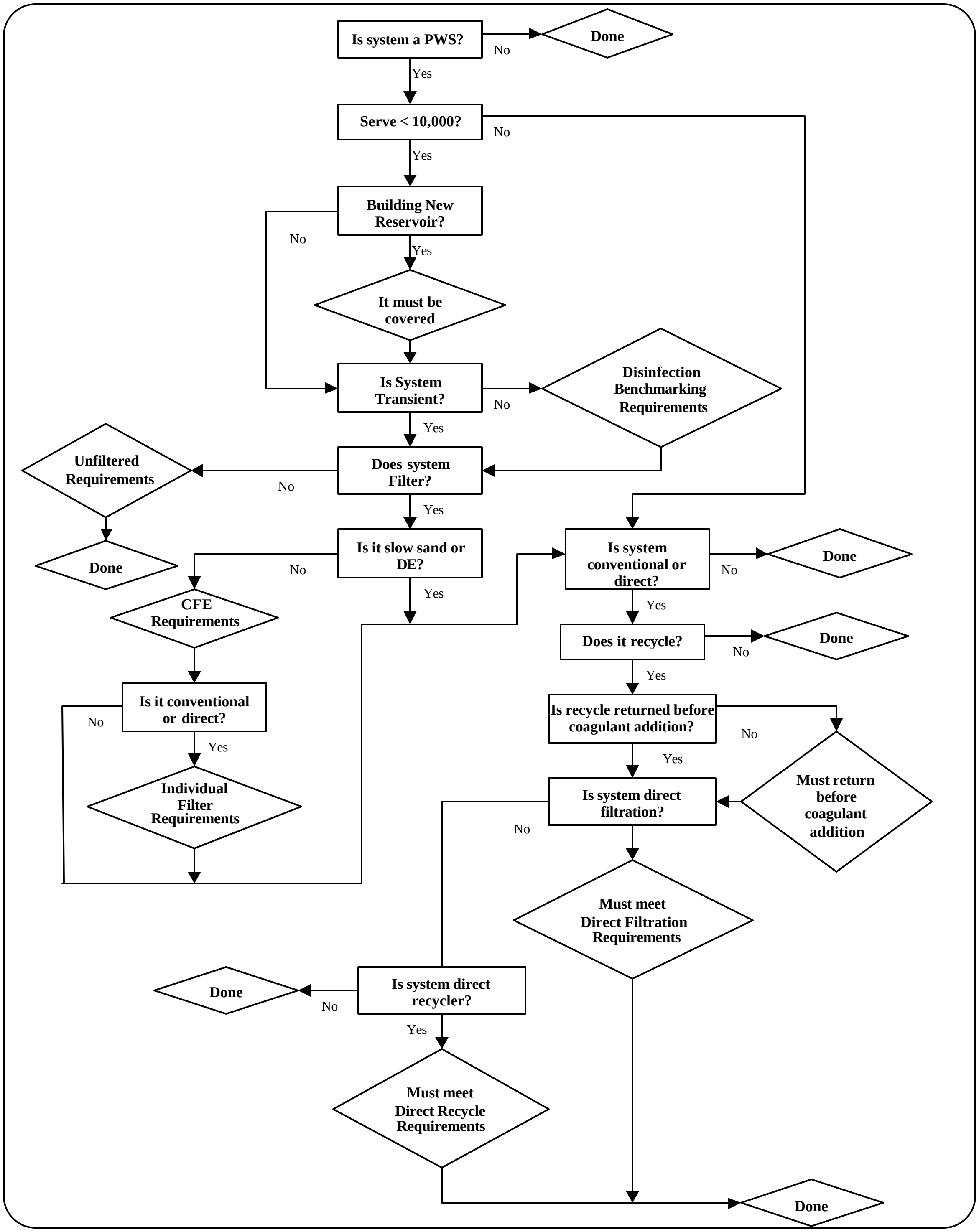


Exhibit 2–10. Illustration of How the Provisions Apply to Different Types of Surface Water or GWUDI Systems



3. Consideration of Regulatory Alternatives

In addition to the proposed rule described in the previous section, EPA considered several alternative regulatory options. EPA started with the regulatory framework for the IESWTR, which applies to systems serving 10,000 or more people, in developing this proposed rule. Then several less burdensome alternatives tailored to small water systems were considered. For the purposes of developing the RIA, EPA considered three different individual filter turbidity alternatives, four applicability monitoring alternatives, and three disinfection profiling alternatives. In addition, four alternatives for the recycle provisions were considered. The remainder of the chapter provides a detailed description of these regulatory alternatives and EPA's rationale for considering them.

3.1 Individual Filter Turbidity Monitoring

The proposed LT1FBR establishes an individual filter turbidity monitoring requirement which applies to all surface water and GWUDI systems using conventional and direct filtration and serving fewer than 10,000 people. In developing this requirement, the Agency evaluated several alternatives in an attempt to reduce the burden faced by small systems while still providing a level of public health protection comparable to the IESWTR. In addition, the Agency wanted the individual filter turbidity monitoring requirement to serve as an early warning tool systems can use to detect and correct problems with filters.

Alternative T1

The first alternative considered by the Agency would require direct and conventional filtration systems serving populations fewer than 10,000 to meet the same requirements as established for systems serving 10,000 or more people in the IESWTR. This alternative would require that systems conduct continuous monitoring of turbidity (one turbidity measurement every 15 minutes) for each individual filter. Based on this monitoring, systems would need to provide an exceptions report to the State as part of the existing combined filter effluent reporting process for any of the following circumstances:

- Any individual filter has a turbidity level greater than 1.0 NTU based on two consecutive measurements taken 15 minutes apart

- Any individual filter has a turbidity level greater than 0.5 NTU at the end of the first 4 hours of filter operation based on two consecutive measurements taken 15 minutes apart

- Any individual filter has turbidity levels greater than l.0 NTU based on two consecutive measurements taken 15 minutes apart at any time in each of 3 consecutive months (the system must, in addition to filing an exceptions report, conduct a self assessment of the filter)

- Any individual filter has turbidity levels greater than 2.0 NTU based on two consecutive measurements taken 15 minutes apart at any time in each of 2 consecutive months (the system must file an exceptions report and must arrange for the conduct of a comprehensive performance evaluation (CPE) by the State or a third party approved by the State).

Under the first two circumstances identified above, a system must produce a filter profile if no obvious reason for the abnormal filter performance can be identified.

Alternative T2

The second alternative considered by the Agency represents a slight modification from the individual filter monitoring requirements for large systems. The 0.5 NTU exceptions report trigger was omitted in an effort to reduce the burden associated with daily data evaluation. Additionally, the filter profile requirement was removed. This alternative still requires that all conventional and direct filtration systems conduct continuous monitoring (one turbidity measurement every 15 minutes) for each individual filter, and the additional requirements are stated as follows.

- A system must provide an exceptions report to the State as part of the existing combined effluent reporting process if any individual filter turbidity measurement exceeds 1.0 NTU, unless the system can show that the next reading is less than 1.0 NTU.

- If a system is required to submit an exceptions report for the same filter in 3 consecutive months, the system must conduct a self assessment of the filter

- If a system is required to submit an exceptions report for the same filter in 2 consecutive months that contains an exceedance of 2.0 NTU by the same filter, the system must arrange for the conduct of a CPE by the State or a third party approved by the State.

Alternative T3

The third alternative considered by the Agency would include new triggers for reporting and follow-up action in an effort to reduce the daily burden associated with data review. This alternative still requires that all conventional and direct filtration systems conduct continuous monitoring (one turbidity measurement every 15 minutes) for each individual filter, and it has three other requirements.

- A system must provide an exceptions report to the State as part of the existing combined effluent reporting process if filter samples exceed 0.5 NTU in at least 5 percent of the measurements taken each month and/or any individual filter measurement exceeded 2.0 NTU (unless the system can show that the following reading was less than 2.0 NTU).

- If a system is required to submit an exceptions report for the same filter in 3 consecutive months the system must conduct a self assessment of the filter.

- If a system is required to submit an exceptions report for the same filter in 2 consecutive months that contains an exceedance of 2.0 NTU by the same filter, the system must arrange for the conduct of a CPE by the State or a third party approved by the State.

For all three alternatives, the requirements for conducting filter self assessments and CPEs are the same. If a CPE is required, the system must arrange for the State or a third party approved by the State to conduct the CPE no later than 30 days following the exceedance. The CPE must be completed and submitted to the State no later than 90 days following the exceedance. If a self assessment is required, it must take place within 14 days of the exceedance and the system must report to the State that the self assessment was conducted. The self assessment must consist of at least the following components:

- Assessment of filter performance
- Development of a filter profile
- Identification and prioritization of factors limiting filter performance
- Assessment of the applicability of corrections
- Preparation of a filter self assessment report.

Exhibit 3–1 summarizes the key differences between the alternatives. It includes EPA's estimate of how frequently a system would need to review turbidity data to comply with the reporting requirements.

Exhibit 3–1. Filter Turbidity Monitoring Alternatives

Key Differences	Alternative T1	Alternative T2	Alternative T3
Minimum frequency with which turbidity data are analyzed	Daily	Weekly	Monthly
Exceptions report trigger based on	> 1 NTU in two consecutive measurements or > 0.5 NTU in two consecutive measurements after first 4 hours of filter operation	> 1 NTU in two consecutive measurements	> 0.5 NTU in at least 5% of measurements in a month or > 2 NTU in two consecutive measurements

In considering the above alternatives, the Agency attempted to reduce the burden faced by small systems. Each of the three alternatives was judged to provide comparable levels of public health protection. All three were also considered useful diagnostic tools for small systems to evaluate the performance of filters and correct problems before follow-up action was necessary. The first alternative was viewed as significantly more challenging to implement and burdensome for smaller systems because of the amount of data review. This evaluation was also expressed by small entity representatives during the Agency's SBREFA process as well as stakeholders at each of the public meetings held to discuss issues related to the proposed rule. Although Alternative T3 reduced the system burden associated with data review, it would institute a very different trigger for small systems than that established for large systems by the IESWTR. This was viewed as problematic by several stakeholders who stressed the importance of maintaining similar requirements in order to limit transactional costs and additional State burden. Therefore, the Agency is proposing Alternative T2 as described above, which allows operators to expend less time evaluating turbidity data. Alternative T2 maintains a comparable level of public health protection as those afforded large systems, reduces much of the burden associated with daily data collection and review, yet still serves as a self-diagnostic tool for operators and provides the mechanism for State follow-up when significant performance problems exist.

3.2 Applicability Monitoring

EPA considered four alternatives for disinfection byproduct (DBP) applicability monitoring and, thereby, which systems would be required to develop a disinfection profile. Although the applicability monitoring alternatives and the profile alternatives (see Section 3.3) are discussed and analyzed separately, EPA considered them in conjunction with one another to select the preferred alternatives because they work together to protect public health. In exploring alternatives for both activities, the Agency focused on reducing the burden on small systems while providing a level of health protection with respect to the risk-risk tradeoff between microbial and DBP contaminants that is comparable to IESWTR.

Alternative A1

The IESWTR required that large systems monitor each quarter for total trihalomethanes (TTHMs) and five haloacetic acids (HAA5)[4] at four points in the distribution system. At least one of those samples must be taken at a point that represents the maximum residence time of the water in the system. The remaining three must be taken at representative locations in the distribution system, taking into account the number of persons served, the different sources of water, and the different treatment methods employed. The results of all analyses per quarter are averaged and reported to the State.

EPA considered applying this alternative to systems serving fewer than 10,000 people and requested input from small system operators and other interested parties, including the public. Based on the feedback EPA received, two other alternatives were developed for consideration.

Alternative A2

EPA considered requiring systems serving fewer than 10,000 people to monitor for TTHM and HAA5 according to the following schedule, which has requirements that differ by system size. Systems serving between 500 and 10,000 would need to collect a sample for TTHM and HAA5 analyses no less than once per quarter per treatment plant operated. Systems serving 500 and fewer would need to collect a sample for TTHM and HAA5 analyses no less than once per year per treatment plant during the month of warmest water temperature. If systems wish to take additional samples, however, they would be permitted to do so. This alternative provides an applicability monitoring frequency that is identical to the DBP monitoring frequency under the Stage 1 DBPR that systems will have to comply with in 2004.

Alternative A3

EPA considered requiring all systems serving fewer than 10,000 people to monitor once per year per system during the month of warmest water temperature.

Under Alternatives A1, A2, and A3, systems may consult with States and elect not to perform TTHM and HAA5 monitoring and proceed directly with the development of a disinfection profile.

During the SBREFA process and during stakeholder meetings, EPA received some positive comments regarding Alternative A3 as the least burdensome approach. Other stakeholders, however, pointed out that Alternative A3 does not allow systems to measure seasonal variation as in Alternative A2 for systems serving populations between 500 and 10,000. Several stakeholders agreed that despite the costs, the information obtained from applicability monitoring would be

[4]This is the sum of the concentrations of mono-, di-, and trichloroacetic acids and mono- and dibromoacetic acids.

useful. EPA agrees that it is valuable to systems to monitor and understand the seasonal variation in TTHM and HAA5 values. Alternative A2 is most consistent with EPA's goal of reducing the burden on small systems, while maintaining comparable levels of public health protection. Consequently, the Agency considered proposing Alternative A2 as part of today's proposed rule.

During subsequent discussions, which included feedback from States, the Agency reconsidered Alternative A2. Due to the statutory provisions in SDWA that require States have 2 years to develop their own regulations as part of their primacy requirements, EPA recognized that requiring applicability monitoring prior to the completion of the 2-year period after promulgation could pose a significant burden on States. In response to these concerns, the Agency developed a new preferred alternative, Alternative A4.

Alternative A4

Applicability monitoring is optional and not a requirement under this alternative; systems do not need to obtain State approval to forego monitoring. If a system has TTHM and HAA5 data taken during the month of warmest water temperature (from 1998–2002) and taken at the point of maximum residence time, it may submit these data to the State 2 years after the rule is published and prior to January 1, 2003. If the data show TTHM and HAA5 levels less than 80 percent of their respective MCLs, the system does not have to develop a disinfection profile. If the data show TTHM or HAA5 levels or both at or greater than 80 percent of their respective MCLs, the system would be required to develop a disinfection profile in 2003. If a system does not have or does not gather TTHM and HAA5 data during the month of warmest water temperature, and at the point of maximum residence time in the distribution system as described above, then the system would automatically be required to develop a disinfection profile starting the first week of January 2003.

Exhibit 3–2 summarizes the sampling requirements across the four alternatives. The combination of fewer sampling periods and fewer samples per period imply a lower system burden for A4 compared to the other alternatives. Furthermore, systems can opt to forego monitoring, which further reduces the potential burden of the proposed rule.

Exhibit 3–2. Applicability Monitoring Alternatives

Key Differences	Alternative A1	Alternative A2	Alternative A3	Alternative A4
Sample collection frequency	Once per quarter for 1 year	501–9,999: no less than once per quarter for 1 year; # 500: no less than once during the month of warmest water temperature	Once during the month of warmest water temperature	Optional: one sample during the month of warmest water temperature prior to January 1, 2003
Sample collection location	At four locations including one at the point of maximum residence time	At the point of maximum residence time	At the point of maximum residence time	At the point of maximum residence time
Total samples	16[1]	501–9,999: 4[1] # 500: 1[1]	1[1]	1[2]

1. Systems may obtain State approval to forego applicability monitoring and begin profiling.
2. Applicability monitoring is optional for Alternative A4; State approval is not required.

3.3 Disinfection Profiling and Benchmarking

EPA considered three alternatives for requiring systems to develop the disinfection profile. These alternatives consider a range of sampling requirements that EPA developed to evaluate the trade-off between less frequent sampling and the robustness of the resulting disinfection profile and benchmark.

Alternative B1

The IESWTR requires systems serving 10,000 or more persons to measure four parameters (disinfectant residual, contact time, water temperature, and pH) and develop a profile of microbial inactivation on a daily basis if they have TTHM or HAA5 levels that equal or exceed 80 percent of their respective MCLs. EPA considered extending this requirement to systems serving fewer than 10,000 persons, and requested input from small system operators and other interested stakeholders. EPA received feedback that this requirement would place a significant burden on the small system operator for at least two reasons:

- Small system operators are not present at the plant every day
- Small systems often have only one operator at a plant who is responsible for all aspects of maintenance, monitoring, and operation.

Recognizing the potential burdens that the profiling procedures placed on small systems, EPA considered two additional alternatives that are evaluated in the RIA.

Alternative B2

EPA considered requiring all systems serving fewer than 10,000 persons to develop a disinfection profile based on weekly parameter measurements for one year. A system with TTHM and HAA5 levels less than 80 percent of their respective MCLs (based on either required or optional monitoring as described above) would not be required to conduct disinfection profiling. This alternative would save the operator time and still provide information on seasonal variation over the period of 1 year.

Alternative B3

EPA considered a daily monitoring requirement only during a 1-month critical monitoring period to be determined by the State. In general, colder temperatures reduce disinfection efficiency. For systems in warmer climates, or climates that do not change very much during the course of the year, the State would identify other critical periods or conditions. This alternative reduces the number of times the operator has to calculate the microbial inactivation.

Initially, EPA considered a fourth alternative of not requiring the disinfection profile at all. After consideration of the feedback of small system operators and other interested stakeholders, EPA believes that there is a strong benefit in the plant operator knowing the level of microbial inactivation, and that this information is essential to ensuring that systems continue to provide adequate microbial protection while they comply with the requirements of the Stage 1 DBPR. Consequently, this alternative was excluded from further analysis. Exhibit 3–3 summarizes the three alternatives that are evaluated in the RIA.

Exhibit 3–3. Disinfection Profiling and Benchmarking Alternatives

Key Differences	**Alternative B1**	**Alternative B2**	**Alternative B3**
Profiling data is collected	Once/day for a year	Once/week for a year	Once/day for a month
Inactivation observations	365	52	30

EPA considered all of the above alternatives and EPA selected Alternative B2 as the preferred alternative for the proposed rule for the following reasons. First, given early implementation concerns, the timing of this alternative appears to be the most appropriate in balancing early implementation issues with the need for systems to prepare for implementation of the Stage 1 DBPR and ensuring adequate and effective microbial protection. Second, it allows systems and States that have been proactive in conducting applicability monitoring to reduce costs for those systems that can demonstrate low TTHM and HAA5 levels. Third, this alternative allows systems and States the opportunity to understand seasonal variability in microbial disinfection. Finally, this alternative takes into account the flexibility needed by the smallest systems while maintaining comparable levels of public health protection with the larger systems.

3.4 Recycle Provisions

EPA considered four alternatives for the recycle provisions. All of the alternatives require select recycle flows to be returned prior to the point of primary coagulant addition. Alternatives R2, R3, and R4 place additional requirements on systems that practice direct recycle or direct filtration, as well as other conventional systems that recycle. Each of these alternatives are discussed in detail in the paragraphs that follow.

Alternative R1

The first alternative considered by the Agency requires that rapid granular filtration plants using surface water or GWUDI as a source return filter backwash, thickener supernatent, and liquids from dewatering processes prior to the point of primary coagulant addition.[5] Plants that require an alternative recycle return location to maintain optimal finished water quality (as indicated by finished water or intra-plant turbidity levels), plants that are designed to employ recycle flow as an intrinsic component of the treatment process, or plants with unique treatment requirements or processes may apply to the State for a waiver to return recycle flows to an alternative location. Softening systems may recycle process solids, but not spent filter backwash, thickener supernatant, or liquids from dewatering processes, at the point of lime addition immediately preceding the softening process to improve treatment efficiency. Contact clarification systems may recycle process solids, but not spent filter backwash, thickener supernatant, or liquids from dewatering processes, directly into the contactor to improve treatment efficiency.

Alternative R2

In addition to requiring plants to return select recycle flows prior to the point of primary coagulant addition, this alternative also requires some direct recycle systems to perform a self assessment of their recycle practice and report the results to the State. The public water systems that would be required to conduct a self assessment are those that meet all of the following criteria:

- Use surface water or GWUDI as a source and employ conventional rapid granular filtration treatment

- Employ 20 or fewer filters to meet production requirements during the highest production month in the 12-month period prior to LT1FBR's compliance date

- Recycle spent filter backwash or thickener supernatant directly to the treatment process (i.e., recycle flow is returned within the treatment process of a PWS without first passing

[5]The recycle provisions apply to individual plants because some large systems have two or more plants treating water, some of which may not recycle flow to the treatment process and, therefore, are not subject to the recycle provisions.

the recycle flow through a treatment process designed to remove solids, a raw water storage reservoir, or some other structure with a volume equal to or greater than the volume of spent filter backwash water produced by one filter backwash event).

The systems that meet all the above criteria are required to develop and submit a recycle self assessment monitoring plan to the State no later than 3 months after the rule's effective date. At a minimum, the monitoring plan must identify the month during which monitoring will be conducted, contain a schematic identifying the location of raw and recycle flow monitoring devices, describe the type of flow monitoring devices to be used, and describe how data from the raw and recycle flow monitoring devices will be simultaneously retrieved and recorded.

Systems are required to submit a self assessment report to the State within 1 month of completing the self assessment monitoring. At a minimum, the report must provide the following information:

- All source and recycle flow measurements taken and the dates they were taken. For all events monitored, report the times the filter backwash recycle event was initiated, the flow measurements taken at three minute intervals, and the time the filter backwash recycle event ended. Report the number of filters in use when the backwash recycle event is monitored.

- All data used and calculations performed to determine whether the system exceeded operating capacity during monitored recycle events and the number of event flow values that exceeded State approved operating capacity.

+

- A plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them, and their final destination in the plant

- A list of all the recycle flows and the frequency at which they are returned to the plant

- Average and maximum backwash flow through the filters and the average and maximum duration of backwash events in minutes, for each monitoring event

- Typical filter run length, number of filter typically employed, and a written summary of how filter run length is determined (e.g., preset run time, headloss, or turbidity level).

Systems are required to submit the self assessment to the State within 3 months of completing the last day of source and recycle flow monitoring.

EPA is proposing that the State review all self assessments submitted by PWSs and report to the Agency the one of the following for each individual plant:

- A finding that modifications to recycle practice are necessary, followed by a brief description of the required change and a summary of the reason(s) the change is required
- A finding that changes to recycle practice are not necessary and a brief description of the reason(s) this determination was made.

Alternative R2 also requires direct filtration plants using surface water and GWUDI that recycle to the treatment process to report certain data that characterize their recycle practice to the State:

- Whether recycle flow treatment or equalization is in place

- The type of treatment provided for the recycle flow

- If equalization, sedimentation, or some type of clarification process is used, the following information should be provided: the physical dimensions of the unit sufficient to allow calculation of its volume, and the type, typical dose, and frequency at which treatment chemicals are used

- The minimum and maximum hydraulic loading the treatment unit experiences

- The maximum backwash rate, duration, typical filter run length, and the number of filters at the plant.

The purpose of this requirement is to allow States to assess whether the existing recycle practice of direct filtration plants addresses the potential risks posed by recycle. The Agency believes that direct filtration plants need to remove oocysts from recycle flow prior to reintroducing it to the treatment process. States are required to report their determination for each system to EPA and provide a brief explanation of the reason(s) for the decision.

Alternative R3

The Agency also considered requiring all recycle plants without existing recycle flow equalization or treatment to install recycle flow equalization. This option would not require a self assessment. Under Alternative R3, systems would also still be required to return select recycle flows prior to the point of primary coagulant addition. Direct filtration plants would have to report data on recycle treatment to the State.

Alternative R4

Finally, the Agency considered requiring conventional filtration plants that recycle within the treatment process to provide sedimentation or more advanced recycle treatment. This option would not require direct recycle systems to perform a self assessment, nor would it require direct filtration plants to report on their recycle practices. Similarly, direct filtration plants would also need to provide sedimentation or more advanced recycle treatment. Under Alternative R4, systems would also still be required to return select recycle flows prior to the point of primary coagulant addition.

Exhibit 3–4. Filter Backwash Alternatives

	Alternative R1	Alternative R2	Alternative R3	Alternative R4
Recycle return location	Prior to primary coagulant addition	Prior to primary coagulant addition	Prior to primary coagulant addition	Prior to primary coagulant addition
Direct recycle systems	No Provision	Report self assessment to State	Equalization for recycle flows	Sedimentation or better for recycle flows*
Direct filtration systems	No Provision	Report recycle practices to State	Report recycle practices to State	Sedimentation or better for recycle flows

* Note: This requirement would apply to all conventional filtration systems that do not provide sedimentation or more advanced treatment for their recycle flows.

EPA considered all of the above alternatives and is proposing Alternative R2. EPA concluded that a national treatment requirement is inappropriate at this time due data deficiencies. However, the Agency believes that the available information supports requiring recycle to be returned prior to the point of primary coagulant. In addition, providing the States with information from the direct recycle self assessments and the direct filtration recycle practices will aid them in targeting recycle treatment in higher risk recycle practices.

4. Baseline Analysis

This chapter discusses the methods used to identify the number of systems and populations affected by each of the rule provisions. Additionally, the sources, the resulting statistics, and any assumptions developed for the analysis are identified. Much of the data used to develop the RIA are provided in the *Occurrence Assessment for the Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Recycle Rule* (U.S. EPA 1999a) and the *Cost and Technology Document for the Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Recycle Rule* (U.S. EPA 1999b). However, additional data and assumptions were needed to complete the economic analysis for this document and are discussed in this chapter.

4.1 Baseline Assumptions

The Agency developed estimates of the number of systems that would be affected by components of the proposed rule by utilizing three primary sources: Safe Drinking Water Information System (SDWIS), Community Water Supply Survey, and Water:\Stats. A brief overview of each of the data sources is provided in the following paragraphs.

<u>Safe Drinking Water Information System (SDWIS)</u>

SDWIS contains information about public water systems including violations of EPA's regulations for safe drinking water. Pertinent information in this database includes system name and identification number, population served, geographic location, type of source water, and type of treatment (if provided). EPA utilized the 1997 State-verified version of SDWIS to develop the total universe of systems that utilize surface water or ground water under direct influence (GWUDI) as sources.

<u>Community Water System Survey (CWSS)</u>

EPA conducted the 1995 Community Water System Survey to obtain data to support its development and evaluation of drinking water regulations. The survey consisted of a stratified random sample of 3,700 water systems nationwide (surface water and ground water). The survey asked 24 operational and 13 financial questions.

<u>Water:\ Stats (WaterStats)</u>

WaterStats is an in-depth database of water system information compiled by the American Water Works Association. The database consists of 898 systems and provides a variety of data including treatment information.

System population characteristics are important to this analysis in several ways. First, all systems are categorized by the size of the population served. For this RIA, only small systems (i.e., serving fewer than 10,000 people) were included for LT1 provisions. Both small and large systems are analyzed for the recycle provisions along with individually analyzing these provisions for systems serving over 1,000,000. Systems are divided into the seven size categories used throughout the analysis; these categories are consistent with industry definitions of system size categories. The size categories are shown in Exhibit 4–1.

Exhibit 4–1. System Population Size Categories and Total Population

System Size	Turbidity Provisions	Recycle Control Provisions
25–100	T	T
101–500	T	T
501–1,000	T	T
1,001–3,300	T	T
3,301–9,999	T	T
10,000–50,000		T
50,001–100,000		T
100,001–1,000,000		T
over 1,000,000		T

Average and system design flow rates are integrated into the national compliance cost model in estimating unit costs, determining treatment developed for compliance forecast or decision trees, and sizing equipment. Average and system design flows, expressed in millions of gallons per day (mgd), were developed separately from the cost model but are key components in generating unit costs (U.S. EPA, 1999b). Flows are used to estimate equipment size, basin dimensions, filter bed and media requirements, and energy costs.

Purchased water systems are included in this analysis even though many of the provisions of the LT1FBR apply only to systems that treat their water. The Agency chose to include these purchased water systems to estimate the total population affected by LT1FBR. Purchased water systems must be included because population served information in SDWIS represents only the direct retail population served by each system. It does not include the total number of people using water treated by a system if the system sells water to other systems. Furthermore, the Agency chose to include purchased water systems in the analysis as a proxy to determine the amount of treatment costs systems selling water to purchased water systems will face. Costs are estimated from water production flow equations based on population served information. Systems that only sell water to other systems may have little or no population served in SDWIS, therefore including the purchased water systems accounted for the production of water sold to other systems.

Noncommunity water systems were assumed to have similar treatment characteristics to community water systems in a given size category. This assumption was made because specific information on treatment technologies utilized by nontransient noncommunity (NTNC) and transient noncommunity (TNC) water systems were not available. In some instances, noncommunity water systems may in fact have less treatment in place than community water systems.

4.2 Industry Profile

Data on systems and their capacity to achieve treatment levels were analyzed to develop the national compliance cost estimate. The scope of this rule is confined to water systems that utilize surface water or GWUDI as sources. This universe consists of 11,593 systems serving fewer than 10,000 persons, and 2,096 systems serving 10,000 or more persons. Exhibit 4–2 provides the number of systems using surface water or GWUDI in each size category for systems serving fewer than 10,000 people. Exhibit 4–3 provides the same information for systems serving more than 10,000 people.

Exhibit 4–2. Systems Utilizing Surface Water or GWUDI Serving Fewer Than 10,000 People

System Type	Population Served					
	<100	101–500	501–1,000	1,001–3,300	3,301–9,999	Total Number of Systems
Community	1,131	2,046	1,198	2,475	1,839	8,689
Noncommunity	1,400	527	98	78	40	2,143
NTNC	273	287	103	78	20	761
Total	2,804	2,860	1,399	2,631	1,899	11,593

Exhibit 4–3. Systems Utilizing Surface Water or GWUDI Serving 10,000 or More People

System Type	Population Served				
	10,000–50,000	50,001–100,000	100,001–1,000,000	> 1,000,000	Total Number of Systems
Community	1,539	269	245	16	2,069
Noncommunity	18	3	0	0	21
NTNC	4	1	1	0	6
Total	1,561	273	246	16	2,096

The rule has three main components—turbidity provisions, disinfection benchmarking provisions, and recycle provisions. The LT1 provisions pertain to surface water and GWUDI systems serving populations fewer than 10,000 that use filtration. The recycle provisions of the rule include all surface water and GWUDI systems that practice rapid granular filtration and recycle filtered water.

Primarily, the number of systems is derived from data collected from SDWIS, the CWSS (U.S. EPA, 1997a), and WaterStats. These primary sources were supplemented with data from the 1996 Information Collection Rule (ICR) and the Water Industry Baseline Handbook (U.S. EPA 1999c).[6]

The 1996 ICR data provided information on the number of systems recycling water and the locations of recycle return. In addition, WaterStats data was augmented by data from a survey performed by the American Water Works Association (AWWA, 1998) and was used to characterize the specific treatment processes used by systems that recycle.

Steps taken to identify the number of systems included for each rule provision are discussed below along with the data used to develop that universe. These data were used to quantify benefits and develop national costs of the rule.

4.3 Number of Systems Under the Turbidity Provisions

To determine the number of systems affected by the turbidity provision, the total number of systems serving less than 10,000 people utilizing surface water and GWUDI was tabulated from SDWIS and reported in the WIBH (U.S. EPA, 1999c). These systems were aggregated by system size and by system type. The WIBH does not provide detailed treatment information for systems. To develop the number of systems that filter and those that use rapid granular filtration (conventional or direct filtration) the WIBH values were multiplied by the percent of systems practicing those filtration techniques as reported in CWSS (U.S. EPA, 1997a).

4.3.1 Estimate of the Number of Systems Subject to 2 log *Cryptosporidium* Removal Requirement

Using the baseline described in Exhibits 4–2 and 4–3, the Agency applied the percentages of surface water and GWUDI systems that filter (as noted in the CWSS) to develop an estimate of the number of systems that filter and serve fewer than 10,000 persons. These percentages range from 78.5 percent for the smallest systems to 86.5 percent and are shown in Appendix I. This resulted in an estimated 9,133 surface water and GWUDI systems that filter and would be subject to the

[6] The Water Industry Baseline Handbook (WIBH) was developed by EPA to support the analyses required under the 1996 SDWA amendments. To complete the analyses required under SDWA, EPA developed the WIBH to serve as a single integrated set of data that defines baseline characteristics or conditions of the regulated community, the customers, and governmental entities.

proposed removal requirement. Exhibit 4–4 provides this estimate broken down by system size and type.

Exhibit 4–4. Estimate of Systems Subject to 2 log *Cryptosporidium* Removal Requirement

System Type	Population Served					
	<100	101–500	501–1,000	1,001–3,300	3,301–9,999	Total Number of Systems
Percent of systems that filter[1]	78.5%	71.0%	79.3%	81.7%	86.5%	
Community	888	1,453	950	2,022	1,591	6,903
Noncommunity	1,099	374	78	64	35	1,649
NTNC	214	204	82	64	17	581
Total	2,201	2,031	1,109	2,150	1,643	9,133

Note: Columns and row might not add to total due to rounding
1. Source: CWSS

4.3.2 Systems Subject to Strengthened CFE Turbidity Standards

Using the estimate of 9,133 systems that filter and serve fewer than 10,000 persons, the Agency used information in the CWSS database to estimate the number of systems that utilized specific types of filtration. The data were segregated based on the type of filtration and the population size of the system. Percentages were derived for each of the following types of filtration:

- Conventional and direct filtration
- Slow sand filtration
- Diatomaceous earth filtration
- Alternative filtration technologies.

The percentages were applied to the estimate of the number of systems that filter for each of the respective system size categories. The percent of filtered systems that are conventional or direct filtration range from 38 percent for the smallest size category to 90 percent for the largest size category. Based on this analysis, the Agency estimates 5,897 conventional and direct filtration systems will be subject to the strengthened combined filter effluent turbidity standards. Exhibit 4–5 provides the number of conventional and direct filtration systems by system size category.

Exhibit 4–5. Estimate of Systems Subject to Strengthened CFE Turbidity Standards for Conventional and Direct Filtration Systems

System Type	Population Served					
	<100	101–500	501–1,000	1,001–3,300	3,301–9,999	Total Number of Systems
Percent of filtration systems that are Conventional or Direct[1]	38.0%	55.0%	73.0%	77.0%	90.0%	
Community	337	799	694	1,557	1,432	4,819
Noncommunity	418	206	57	49	31	760
NTNC	81	112	60	49	16	318
Total	836	1,117	810	1,655	1,478	5,897

Note: Columns and rows might not add to total due to rounding.
1. Source: CWSS.

EPA estimates 1,756 systems utilize slow sand or diatomaceous earth filtration, and must continue to meet turbidity standards set forth in the SWTR. The remaining 1,482 systems are estimated to use alternative filtration technologies and will be required to meet turbidity standards as set forth by the State upon analysis of a 2 log *Cryptosporidium* demonstration conducted by the system.

4.3.3 Estimate of the Number of Systems Subject to Individual Filter Monitoring Requirements

EPA believes that the support and underlying principles regarding the IESWTR individual filter monitoring requirements are also applicable for the LT1FBR. The Agency has estimated that 5,897 conventional and direct filtration systems will be subject to the proposed individual filter turbidity requirements. The Agency has analyzed information regarding turbidity spikes and filter masking and concluded potential improvements in finished water quality justify individual filter monitoring in addition to CFE monitoring.

Monitoring the performance of individual filters within a treatment plant is important to ensuring low turbidity in finished water. Poor performance of one filter—accompanied by potential pathogen breakthrough—can be masked by optimal performance in other filters, such that there is no discernable increase in combined filter effluent turbidity. Individual filters are also susceptible to short turbidity spikes that are be captured by existing four-hour combined filter effluent measurements. To address these shortcomings in large systems, EPA established individual filter monitoring requirements in the IESWTR. The Agency believes it's appropriate and necessary to extend individual filter monitoring requirements to systems serving populations fewer than 10,000.

This provision applies to small surface water and GWUDI systems that use conventional or direct filtration, which are reported above in Exhibit 4–5.

4.4 Systems Affected by Disinfection Benchmarking Provision

The disinfection benchmarking requirement applies to all small water systems utilizing surface water or GWUDI that are community water systems or nontransient noncommunity water systems. Exhibit 4–6 provides the number of systems in each system size category that will be required to comply with the disinfection benchmarking requirement.

Exhibit 4–6. Estimate of Systems Subject to Disinfection Benchmarking Provision

	Population Served					
System Type	**<100**	**101–500**	**501–1,000**	**1,001–3,300**	**3,301–9,999**	**Total Number of Systems**
Community	1,131	2,046	1,198	2,475	1,839	8,689
Noncommunity	0	0	0	0	0	0
NTNC	273	287	103	78	20	761
Total	1,404	2,333	1,301	2,553	1,859	9,450

Columns and rows may not add to totals due to rounding

4.5 Systems Affected by the Recycle Provisions

To determine the systems affected by the recycle provisions, data from the Information Collection Rule and the AWWA Survey (1998) were analyzed. The following section describes those data sources and summarizes their results. Using the results from the analysis of the two data sources, the baseline number of systems that will be affected by the provisions are estimated and presented at the end of this section.

Information Collection Rule

Public water systems subject to the ICR were required to report whether recycle is practiced for sample washwater (i.e., recycle flow) between the washwater treatment plant (if one existed) and the point at which recycle is added to the process train. Sampling of plant recycle flow was required prior to blending with the process train. Systems were also required to measure recycle flow at the time of sampling, the twenty four hour average flow prior to sampling, and report whether treatment of the recycle was provided and, if so, the type of treatment. Reportable treatment types were plain sedimentation, coagulation and sedimentation, filtration, disinfection, or a description of an alternative treatment type. Plants were also required to submit a plant schematic to identify sampling locations. EPA used the sampling schematics and other reported information to compile a database of national recycle practices. The results are summarized below.

4.5.1 Recycle Practice

The Agency developed a database from the ICR sampling schematics and other reported information. Exhibit 4–7 summarizes the plants in the database. Of the 502 plants in the database at the time the analysis was performed, 362 used rapid granular filtration.

Exhibit 4–7. Recycle Practice at ICR Plants

Plant Classification	Number
All ICR Plants	502
Filtration Plants[1]	362
Filtration Plants Recycling[2]	226
Recycle Plants Serving $ 100,000	168
Recycle Plants Serving < 100,000	58
Filtration Plants Treating Recycle	148

These plants are classified as conventional, lime softening, other softening, and direct filtration. The remaining 140 plants in the database do not employ rapid granular filtration capability and generally provide disinfection for ground water. Of the 362 filtration plants in the database, 226 (62.4 percent) reported recycling to the treatment process. Seventy-four percent of the plants that recycle serve populations greater than 100,000 and 26 percent serve populations below 100,000. Exhibit 4–8 shows the distribution of plants by treatment type and Exhibit 4–9 shows the distribution of plants by population served. Exhibit 4–10 shows that 88 percent of ICR recycle plants use surface water. An additional 1 percent use GWUDI and another 1 percent use a combination of ground water and surface water. Therefore, 90 percent of ICR recycle plants use a source water that could contain *Cryptosporidium*.

Exhibit 4–8. ICR Recycle Plants by Treatment Train Type

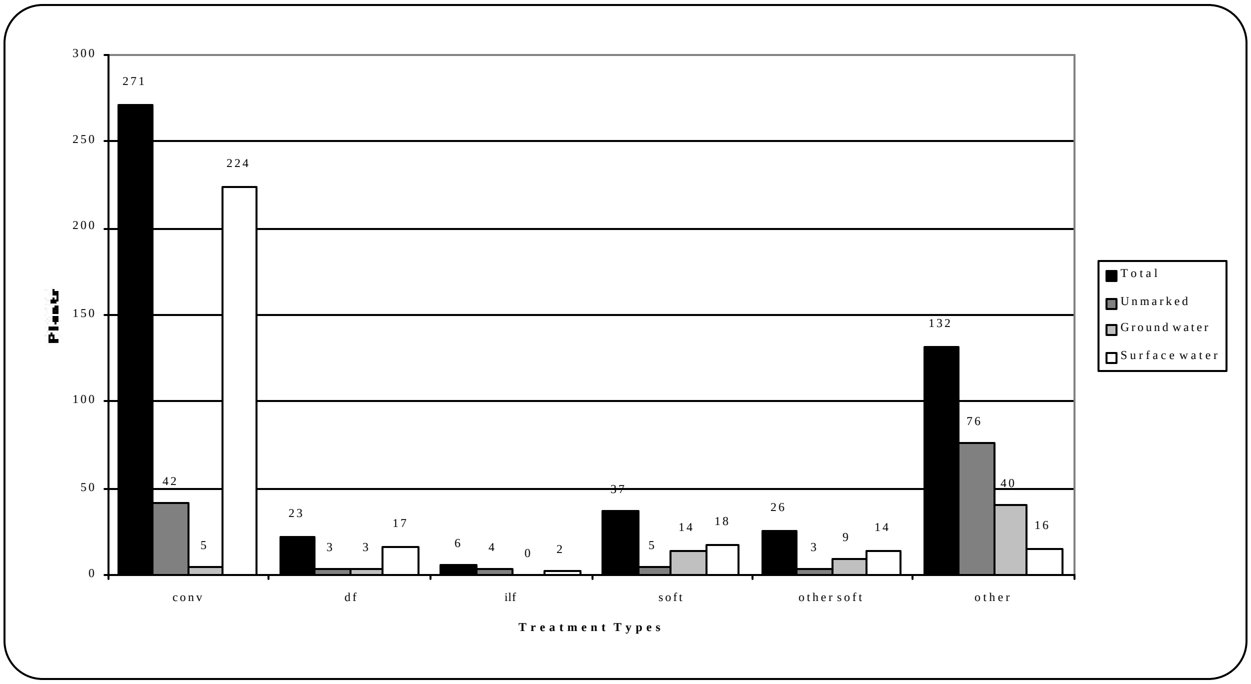


Exhibit 4–9. ICR Recycle Plants by Population Served

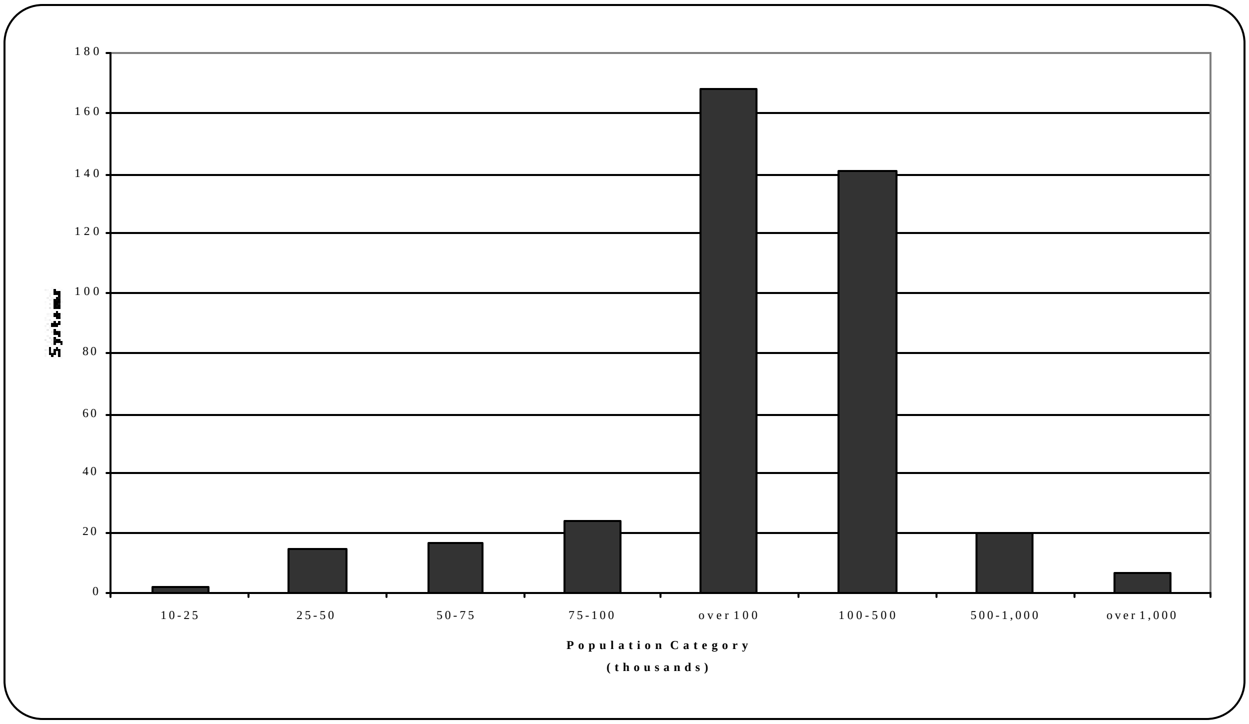


Exhibit 4–10. Source Water Use by ICR Recycle Plants

Source Water Type	Number of Plants	Percent of Recycle Plants
Total Number of Recycle Plants	226	100%
Surface Water	199	88%
Ground Water Under the Direct Influence	3	1%
Ground Water and Surface Water	2	1%
Ground Water Only	22	10%

Exhibit 4–11 shows that 65 percent of ICR recycle plants report providing treatment for the recycle flow. The percentage of plants providing treatment is the same for the subsets of plants serving greater than and less than 100,000 people. Sedimentation is the most widely reported treatment method, as 77 percent of plants providing treatment employ it. The database does not provide information on the solids removal efficiency of the sedimentation units. All direct filtration plants practicing recycle reported providing treatment for the recycle flow.

Exhibit 4–11. Treatment of Recycle at ICR Plants*

ICR Recycling Plants	Number of Plants	Percentage of Recycle Plants
Number of Recycle Plants	226	100%
Practice Recycle Treatment	147	65%
Use Sedimentation	114	77%
Use Sedimentation/Coagulation	14	10%
Use Two or More Treatments	14	10%
Other Treatment	5	3%

* Disinfection not counted as treatment because it does not inactivate *Cryptosporidium*..

Exhibit 4–12 indicates that 75 percent of ICR recycle plants return recycle prior to the point of primary coagulant addition. Fifteen percent return it prior to sedimentation, and ten percent of plants return it prior to filtration. These percentages hold for the subsets of plants serving greater than and less than 100,000 people. The data indicate that introducing recycle prior to rapid mix may be a common practice. EPA believes that introducing recycle flow prior to the point of primary coagulant addition is the best recycle return location because it limits the possibility that residual treatment chemicals in the recycle flow will disrupt treatment chemistry.

Exhibit 4–12. Recycle Return Point

Point of Recycle Return	Number of Plants	Percent of Plants
Number of Recycle Plants	224*	100%
Prior to Point of Primary Coagulant Addition	169	75%
Prior to Sedimentation	34	15%
Prior to Filtration	21	10%

*Recycle return point could not be determined for two plants.

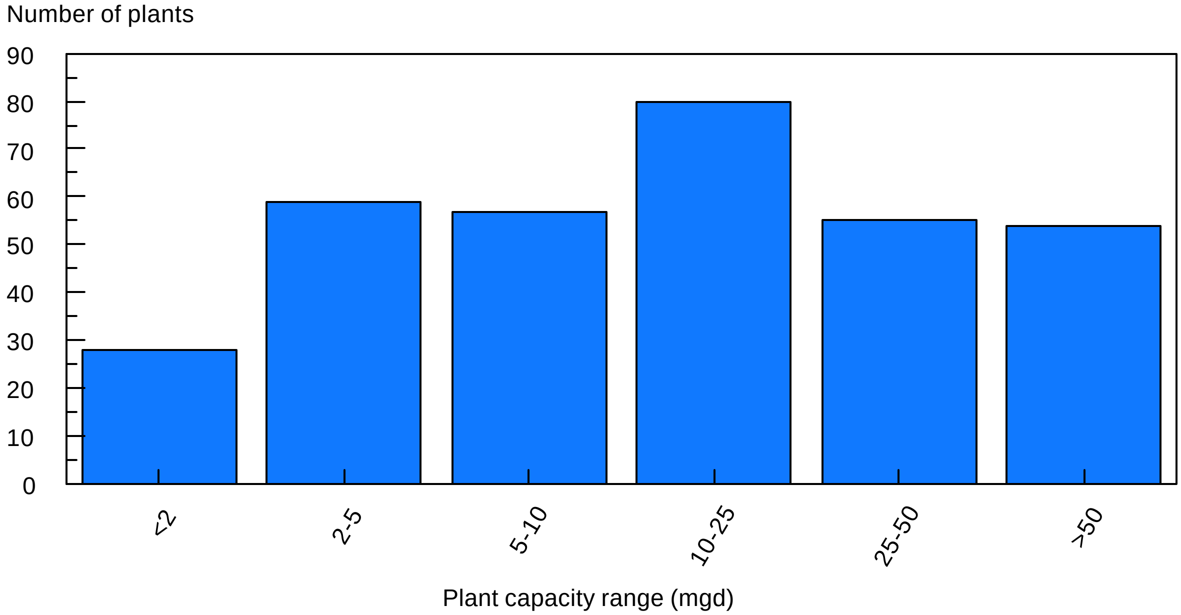
The data provide the following conclusions regarding the recycle practice of ICR plants:

- The recycle of spent filter backwash and other process streams is a common practice
- The great majority of recycle plants in the database use filtration and surface water sources
- A majority of plants in the database that recycle provide treatment for recycle flow
- A large majority of plants in the database that recycle (approximately three out of four) return recycle flows prior to the point of primary coagulant addition.

Recycle FAX Survey

The AWWA sent a FAX survey (AWWA, 1998) to its membership in June 1998 to gather information on recycle practices. Plants were not selected based on source water type, the type of treatment process employed, or any other factor. The survey was sent to the broad membership to increase the number of responses. Responses indicating a plant recycled spent filter backwash or other flows were compiled to create a database. The resulting database included 335 plants. The database does not contain information from respondents who reported recycle was not practiced. Data from some of the FAX survey respondents is also included in the ICR database. Plants in the database are well distributed geographically and represent a broad range of plant sizes as measured by capacity. Exhibit 4–13 shows plant distribution by capacity and Exhibit 4–14 by geographic location. The following discussion of FAX survey data is divided into two sections. The first discusses national recycle practice and the second discusses options for recycle disposal in lieu of returning recycle to the treatment process.

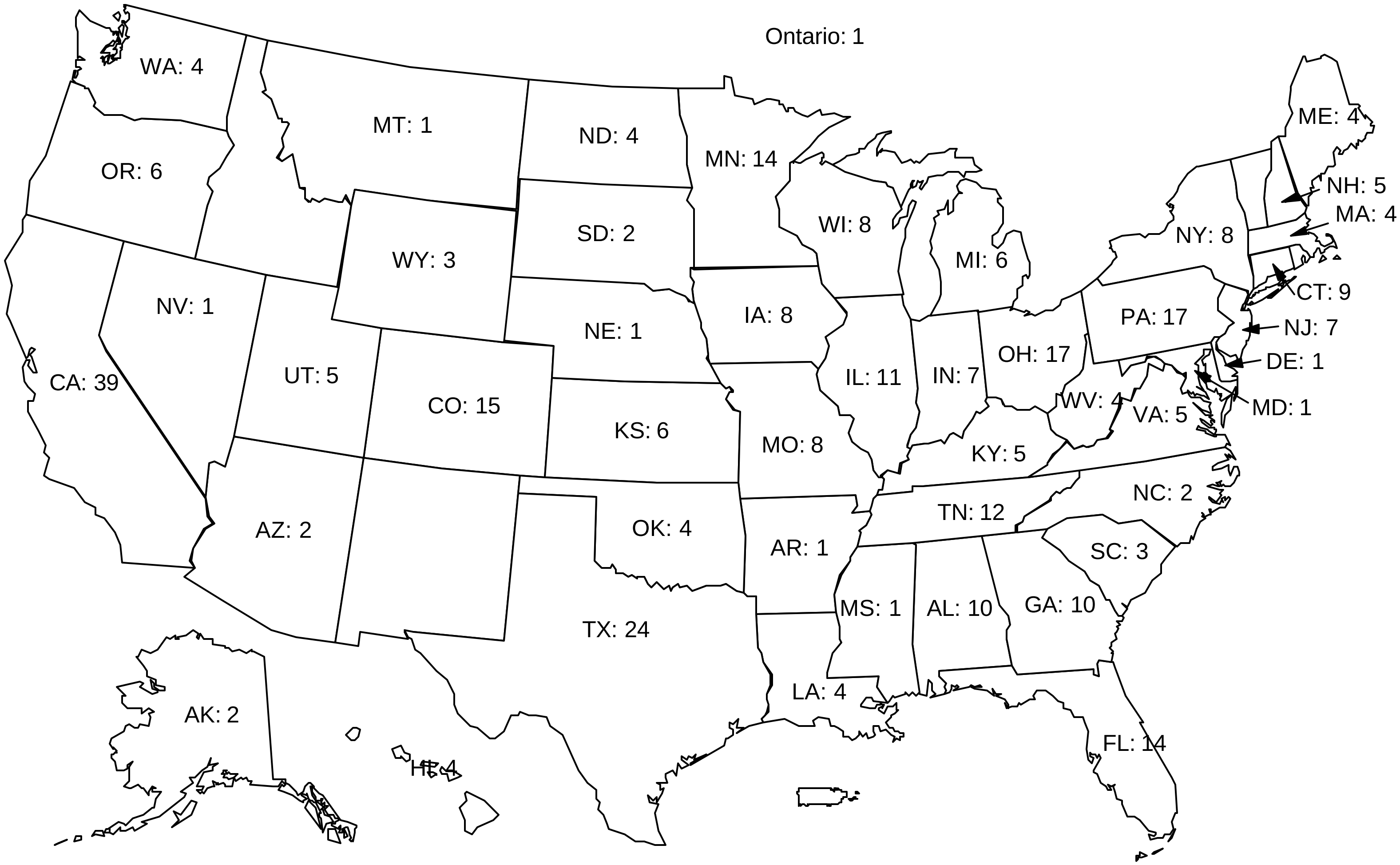
Exhibit 4–13. Distribution of FAX Survey Plants by Plant Capacity



Number of plants bracketed by capacity

Source: Environmental Engineering and Technology, Inc., 1998.

Exhibit 4–14. Number of Plants per State Included in AWWA FAX Survey



Source: Environmental Engineering and Technology, Inc., 1999.

Recycle Practices of FAX Survey Plants

Data summarized in Exhibit 4–15 show that 78 percent of plants in the database rely on a surface water as their source. The percentage of plants using source water influenced by a surface water (which may contain *Cryptosporidium)* could be higher because the data do not report whether wells were pure ground water or GWUDI.

Exhibit 4–15. Source Water Used by FAX Survey Plants

Source Water Type	Percent of Plants
Surface Water	78%
River	27%
Reservoir	28%
Lake	16%
Other	7%
Well*	22%

* Wells sources can be either ground water or ground water under the direct influence of surface water.

Exhibit 4–16 shows that a wide variety of treatment process types are included in the data, with conventional filtration (rapid mix, coagulation, sedimentation, filtration) representing over half of the plants submitting data. Upflow clarification is the second most common treatment process reported. Ten percent of plants in the database use direct filtration. Only 4 percent of plants do not use rapid granular filtration.

Exhibit 4–16. Treatment Trains of FAX Survey Plants

Treatment Process Type	Percent of Plants*
Conventional filtration	51%
Upflow Clarifier	21%
Softening	14%
Direct Filtration	10%
Other	4%

* 96 percent of plant in the database provide filtration.

Exhibit 4–17 indicates that a vast majority of plants recycle prior to the point of primary coagulant addition. Only 6 percent of plants returned recycle in the sedimentation basin or just prior to filtration.

Exhibit 4–17. Recycle Return Point of FAX Survey Plants

Return Point	Percent of Plants
Prior to Point of Primary Coagulant Addition	83%
Pre-sedimentation	11%
Sedimentation basin	4%
Before filtration	2%

Exhibit 4–18 shows that the majority of plants in the database provide some type of treatment for the recycle flow prior to its reintroduction to the treatment process. Approximately 70 percent of plants reported providing treatment, with sedimentation being employed by over half of these plants. Equalization, defined as a treatment technology by the survey, is practiced by 20 percent of plants in the database. Fourteen percent of plants reported using both sedimentation and equalization.

Exhibit 4–18. Recycle Treatment at FAX Survey Plants

Treatment Type	Percent of Plants
No Treatment	30%
Treatment	70%
Sedimentation	54%
Equalization	20%
Sedimentation and Equalization	14%
Lagoon	5%
Others	7%

Exhibit 4–19 summarizes recycle treatment practice and frequency of direct recycle based on population served. The table illustrates that, for plants supplying data, treatment of recycle with sedimentation is provided more frequently as plant service population deceases. Plants serving populations of less than 10,000 direct recycle (23 percent) less frequently than plants serving populations greater than 100,000 (42 percent). The data indicate that a majority of small plants in the database may have installed equalization or sedimentation treatment to protect treatment process integrity from recycle induced hydraulic disruption. All direct filtration plants in the FAX survey provide recycle treatment or equalization.

Exhibit 4–19. Recycle Practice Based on Population Served[1]

Population Served	Recycle Practice Number of Plants	Equalization[2]	Sedimentation[2]	Direct Recycle[2]
< 10,000	43	4 (9%)	29 (67%)	10 (23%)
10,000–50,000	79	8 (10%)	45 (57%)	26 (33%)
50,001–100,000	35	6 (17%)	19 (54%)	10 (29%)
> 100,000	65	23 (35%)	15 (23%)	27 (42%)

1 Based on 222 surface water plants suppling all necessary data to make determination.
2 Number of plants (percent of plants) in category.

FAX survey data support the following conclusions regarding the recycle practice of plants supplying data: 1) the recycle of spent filter backwash and other process streams is a common practice, 2) the majority of recycle plants use surface water as their source and are thereby at risk from *Cryptosporidium*, 3) a large majority of plants providing data recycle prior to the point of primary coagulant addition, and 4) a majority of plants supplying data provide treatment for recycle waters prior to reintroducing them to the treatment plant. The FAX survey provides an informative snapshot of national recycle practices due to the number of recycle plants it includes, the geographic distribution of respondents, and the good representation of plants serving populations of less than 10,000 people.

Options to Recycle

The FAX survey collected information about: 1) whether feasible alternatives to recycle are available (i.e., National Pollutant Discharge Elimination System (NPDES) surface water discharge permit or pretreatment permit for discharge to a Publicly Owned Treatment Work (POTW)), 2) the importance of recycle to optimizing treatment performance and meeting production requirements, and 3) whether recycle flow monitoring had been performed. The related responses are summarized in Exhibit 4–20.

Exhibit 4–20 shows that approximately 20 percent of respondents could not obtain either an NPDES surface water discharge permit or a pretreatment permit for discharge to a POTW. Approximately 85 percent of respondents stated that recycle flow is not important to meet typical demand. Twenty-four percent of all respondents stated that returning recycle to the treatment process is important for optimal operation. “Optimal operation” was not defined by the survey and respondents may have considered not changing current plant operation (e.g., not changing current recycle practice) an aspect of optimal treatment, rather than addressing whether recycle practice is important for the plant to produce the highest quality finished water.

Exhibit 4–20. Options to Recycle as Reported by FAX Survey Plants*

Question	Yes (Percent)	No (Percent)	Unknown (Percent)
Able to obtain NPDES surface discharge permit?	131 (41%)	120 (37%)	70 (22%)
Able to obtain pretreatment permit for POTW discharge?	137 (43%)	136 (42%)	48 (15%)
Can obtain either an NPDES or a POTW discharge permit?	192 (60%)	63 (19.5%)	66 (20.5%)
Is recycle important to meet peak demand?	44 (14%)	257 (80%)	20 (6%)
Is recycle important to meet typical demand?	28 (9%)	272 (85%)	21 (6%)
Is recycle important to optimal operation? (All plants in survey)	75 (24%)	225 (70%)	21 (6%)
Is recycle important to optimal operation?** (softening plants only)	3 (13%)	19 (83%)	1 (4%)

* Number of plants varies from question to question due to different response rates.
**Optimal operation not defined by survey. May include overall plant operation rather than importance of recycle to producing highest possible quality finished water.

Summary of Analysis

The ICR and FAX survey data are complimentary, as the ICR data supplies a wealth of data regarding recycle practices at large capacity plants, while the FAX survey provides data on recycle practices over a range of plant capacities. Taken together, the two data sets provide a good picture of current recycle practice. The data indicate that recycle is a common practice for the plants sampled. Approximately half of the respondents providing data return recycle flow to the treatment process and 70 percent provide some type of recycle treatment. Sedimentation and equalization are the two most commonly employed treatment technologies for plants supplying data. Approximately 80 percent of plants sampled return recycle prior to the point of primary coagulant addition. Examining the recycle practices of plants in the ICR and FAX survey data shows that small plants (i.e., fewer than 10,000 people served) are more than twice as likely as large plants (i.e., greater than 10,000 people served) to provide sedimentation for recycle treatment (58 versus 26 percent).

The FAX survey responses show that approximately half of plants providing data have an option to recycle return, whether it be an NPDES surface water discharge permit or discharge to a POTW. Eighty percent of respondents stated that recycle flow is not important to meet peak demand. Less than a quarter of respondents have monitored pathogen concentrations in recycle return flows and fewer than half have any monitoring data to characterize the quality of the recycle return flows.

The proposed filter backwash recycle provisions apply to both large and small surface water systems. The number of systems is a subset of the rapid granular filtration systems discussed under the turbidity provisions of the LT1FBR and systems regulated under the IESWTR promulgated in December 1998. The total number of conventional and direct filtration systems was multiplied by the percent of systems practicing filtration techniques cited in the CWSS. EPA estimates that 60 percent of these systems recycle filter backwash (Cornwell and Lee, 1994). Exhibit 4–21 provides the total number of systems, those practicing filtration and those recycling filter backwash water.

Data from the ICR and FAX survey indicate that 75 and 83 percent of plants, respectively, return recycle prior to the point of primary coagulant addition. The "point of primary coagulant addition" was defined in both analyses as the return of recycle prior to the rapid mix unit. The FAX survey data indicate that 77 percent of plants serving under 10,000 people recycle prior to the point of primary coagulant addition. It also showed that 83 percent of all plants in the database return recycle there, which suggests that plants serving smaller populations may return recycle prior to the point of primary coagulant addition as frequently as plants serving larger populations.

The number of systems treating recycle flows is derived from the percentages estimated in Exhibit 4–19. The percentages in the FAX survey were used to estimate the number of systems present in Exhibit 4–21 that are direct recycle systems and the number of systems that treat recycle with equalization or sedimentation/clarification.

Twenty-three direct filtration plants that used surface water responded to the FAX survey. In the FAX survey, plants could report whether they provide recycle flow equalization, sedimentation, or some other type of treatment. Of the respondents, 21 reported providing treatment for the recycle flow and two plants reported providing only equalization. In the ICR database, there were 23 direct filtration plants and 14 of them recycled to the treatment process. All fourteen plants provide recycle treatment. It is not possible to determine the level of oocyst removal that FAX survey and ICR plants achieve with available data.

Similar to the methodology used for the turbidity provision, the number of systems identified in the WIBH were multiplied by the percent of systems practicing specific treatment and recycling practice to provide a distribution of systems by size, type, and treatment practice.

Exhibit 4–21 provides the number of systems for each of the treatment and recycle practice and the multiplier used to derive the value. It is important to note specific treatments are subsets of previous developed subsets. For example, systems that practice direct recycle return, equalization of recycle water, or sedimentation of recycled water are a subset of the conventional filtration systems that recycle.

Exhibit 4–21. Summary of the Number of Systems Affected by Recycle Provisions

System Type	Population Categories								
	0–100	101–500	501–1000	1,001–3,300	3.300–9,999	10,000–50,000	50,001–100,000	100,001–1,000,000	Total
Percent of Direct or Conventional filtration systems that recycle	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	
Number of Systems	502	670	486	993	887	830	141	127	4,636
Percent of systems that recycle after rapid mix	23.0%	23.0%	23.0%	23.0%	23.0%	23.0%	23.0%	23.0%	
Number of Systems	115	154	112	228	204	191	32	29	1,066
Percent of conventional systems with direct recycle	23.0%	23.0%	23.0%	23.0%	23.0%	33.0%	29.0%	42.0%	
Number of Systems	107	143	104	212	190	255	38	50	1,099
Percent of conventional systems that equalize recycle flows	9.0%	9.0%	9.0%	9.0%	9.0%	10.0%	17.0%	35.0%	
Number of Systems	42	56	41	83	74	77	22	41	437
Percent of conventional systems that treat recycle flows with sedimentation	68.0%	68.0%	68.0%	68.0%	68.0%	57.0%	54.0%	23.0%	
Number of Systems	317	424	307	628	561	440	71	27	2,775
Direct Filtration Systems that Recycle	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	
Number of Systems	35	47	34	70	62	58	10	9	325

Note: Columns and rows may not add to totals due to rounding

4.6 Contaminant Exposure

The proposed LT1FBR rule will increase the level of protection to public health through reductions in turbidity and waterborne pathogens, particularly *Cryptosporidium*. The LT1FBR turbidity provisions are the small drinking water system companion piece to IESWTR. The proposed provisions are intended to reduce turbidity, which is indicative of a more efficient filtration process (Rose, 1997). The LT1FBR recycling provisions apply to all drinking water systems, large and small, that recycle flows including filter backwash as described in Chapter 3. EPA's data indicates that current spent filter backwash and other recycle streams may introduce *Cryptosporidium* oocysts, in excess of oocysts present in the source water, to the treatment process (U.S. EPA, 1999a). Oocysts added to the treatment process through recycle water may increase the risk of oocysts occurring in finished water supplies, and thereby threaten public health.

Several sources were used to assess the health effects and hazards posed by *Cryptosporidium* in drinking water. Data from the Centers for Disease Control and Prevention (CDC) provided the number of reported outbreaks and resulting cases of cryptosporidiosis (Centers 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 5). 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 6 of the Occurrence Assessment for the LT1FBR (U.S. EPA, 1999a), which includes a characterization of national finished water *Cryptosporidium* distribution, was used to assess the population exposure to *Cryptosporidium* in finished water supplies.

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). The data and any assumptions used to complete the benefits analysis are detailed in Chapter 5.

For each rule component the same methodology used to develop the number of systems was applied to population statistics. Appendix I provides the potential populations used in the risk assessment and benefits analysis in Chapter 5. Each exhibit shows the progression used to develop the exposed populations. Population data were taken from the WIBH (U.S. EPA, 1999d) and further developed using percentages from CWSS (U.S. EPA, 1997a).

5. Benefits Analysis

5.1 Introduction

The health benefits of a drinking water standard come from reducing the probability that consumers will suffer health damages and other losses. The value of the benefits is captured in the consumer's willingness-to-pay (WTP) for the change in drinking water quality (Freeman, 1979). Often, this value is estimated to be the health damages (medical cost and lost productivity) that will be avoided as a result of enforcing the drinking water standard—referred to as 'cost-of-illness' (COI). COI measures, however, are thought to understate total benefits because they do not capture the full value that consumers place on reducing risk and avoiding illness. This chapter describes how avoided health injuries are estimated using a risk assessment approach, and how those injuries are valued using WTP or COI estimates from the economic valuation literature. The proposed Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Rule (LT1FBR) contains turbidity, recycle, and other provisions intended to increase the level of protection to public health through reductions in waterborne pathogens, particularly *Cryptosporidium*. This section of the document discusses the proposed rule's turbidity and recycle provisions and the benefit that may be realized from each provision. Section 5.2 discusses and monetizes the health benefits associated with reducing human exposure to *Cryptosporidium* in regulated drinking water systems through implementation of the proposed LT1FBR turbidity provisions. Sections 5.3 and 5.4 describe qualitative benefits associated with the proposed rule, including benefits from the turbidity provisions, recycle provisions, disinfection benchmark provisions, requirements for covers on new finished water reservoirs, and inclusion of *Cryptosporidium* in the definition of ground water under the direct influence (GWUDI) and in the watershed control requirements for unfiltered public water systems. Section 5.5 concludes the benefits chapter with a summary of calculated annual benefits from the proposed rule and a discussion of how omissions, biases, and uncertainties may affect the results of the benefits analysis.

5.1.1 Expected Benefits from Turbidity Provisions

The proposed LT1FBR turbidity provisions are the small drinking water system companion pieces to IESWTR. These provisions will reduce finished water turbidity, which is indicative of a more efficient filtration process (Rose, 1997). Improved removal of *Cryptosporidium* and other waterborne pathogens is likely to occur as the filtration process improves (U.S. EPA, 1999a), resulting in reduced endemic illnesses and associated health benefits, as well as other non-health related benefits (Exhibit 5–1). The benefits of improved filtration that have been quantified and monetized in this analysis are due to the decreased probability of cryptosporidiosis, the infection caused by *Cryptosporidium.* Reduced exposure to other pathogenic protozoa, such as *Giardia*, or other waterborne bacterial or viral pathogens, are additional benefits of the proposed LT1FBR turbidity provisions that have not been quantified. Furthermore, additional benefits of reduced averting costs (e.g., purchasing bottled water or boiling tap water) associated with improvements in drinking water quality were not quantified because of the difficulties in making such assessments.

Exhibit 5–1. Overview of LT1FBR Benefit Categories and Associated Components

Health Benefits	
Reduced illness (morbidity and mortality)	• Reduced risk of *Cryptosporidium* and other disinfection resistant pathogens occurring in finished water (endemic and outbreak-related)
Non-Health Benefits	
Avoided costs of averting behavior	• Bottled water and point-of-use (POU) devices
Enhanced aesthetic water quality	• Improved perception of drinking water quality
Avoided outbreak responses	• Avoided costs to affected water systems and local governments (provision of alternative water, issuing warnings and alerts, and costs associated with negative publicity) • Time spent on averting behavior during outbreaks, e.g., hauling/boiling water

5.1.2 Expected Benefits from Recycle Provisions

The proposed LT1FBR recycle provisions apply to large and small surface water and GWUDI drinking water systems that recycle treatment process flows within the primary treatment process. Benefits associated with the recycle provisions are similar to the benefits outlined in Exhibit 5–1. EPA's research indicates that spent filter backwash and other recycle streams may introduce additional *Cryptosporidium* oocysts to the treatment process. Since *Cryptosporidium* is not inactivated by standard disinfection practice, any oocysts returned to the treatment process in recycle flow are a threat to enter the finished water and cause disease. Further, hydraulic and chemical treatment disruption caused by recycle flow may lower log removal performance, increasing the public health risk from oocysts in finished water supplies.

The proposed rule contains three recycle provisions. First, all plants must return spent filter backwash, thickener supernatant, and liquids from dewatering prior to the point of primary coagulation addition. This ensures that recycle flows pass through as many physical removal processes as possible to provide maximum opportunity for oocyst removal and maintain the integrity of chemical dosing. Second, plants meeting specific criteria must perform a self assessment to determine the impact of recycle flows on plant operations. Results from the self assessment must be reported to the State. The self assessment and reporting process will identify plants that may challenge oocyst removal performance by exceeding design capacity during recycle events and allow States to require changes to recycle practices to protect public health. Third, direct filtration plants must report their recycle practices to the State, including whether flow equalization or treatment is provided for recycle flow prior to its return to the treatment process. The purpose of this requirement is to ensure that the recycle practice of direct filtration plants is assessed to determine whether existing plant practice addresses the potential risk posed by recycle. The improved recycle practices under the LT1FBR will reduce the public's exposure to *Cryptosporidium* and other waterborne pathogens in drinking water, thus resulting in public health benefits.

5.1.3 Expected Benefits from Other Provisions

The proposed LT1FBR contains three additional provisions that provide positive health benefits to customers of small drinking water systems:

- Disinfection benchmark provisions
- Requirements for covers on new finished water reservoirs
- Inclusion of *Cryptosporidium* in the definition of GWUDI and in the watershed control requirements for unfiltered public water systems.

Disinfection benchmarking provisions ensure continued microbial protection of drinking water while facilities take the necessary steps to comply with new disinfection byproduct standards. The disinfection benchmarking requirements are designed to ensure that there will be no unintended reduction in microbial protection as a result of significant modifications to disinfection practices that may be made to reduce DBPs. The proposed rule requires that all new potable finished water reservoirs serving small drinking water systems be covered to prevent contamination from various sources including: animals, microbes, algae, swimmers, and storm water run-off. The proposed rule also includes *Cryptosporidium* in the definition of GWUDI and in watershed protection regulatory requirements.

5.2 Health Benefits from Turbidity Provisions

Section 5.2 describes the risk assessment approach, the dose-response equation used for hazard identification, and the exposure assumptions used to estimate *Cryptosporidium* risk to populations served by regulated drinking water systems. This section also presents the health and economic benefits that accrue from the proposed LT1FBR turbidity provisions. Benefits are estimated on an annual basis because benefits and costs occur concurrently in the proposed rule (i.e., changing treatment and monitoring practices immediately reduces health risks) and remain relatively constant after the start up period. Thus, the annual approach generates a benefit/cost ratio that is comparable to using the net present value (NPV) approach. Furthermore, annual net benefits can be used to derive an estimate of NPV of net benefits over a complete policy horizon. Consequently, the use of annual benefits provides comparable results and streamlines the analysis.

5.2.1 Contaminants and Their Health Effects

Drinking water supplies can be contaminated by a number of pathogens that have been identified as the cause of waterborne disease outbreaks (Centers for Disease Control, 1996). In particular, drinking water supplies contaminated with the parasite *Cryptosporidium* pose a health risk to the public because the parasite is highly infectious, resistant to inactivation by chlorine, widespread among many animal species, and small in size and consequently difficult to filter (Guerrant, 1997). This benefits analysis of the proposed rule estimates the potential benefits of reducing human exposure to *Cryptosporidium* in drinking water supplies through improved operation and performance of the drinking water filtration process. In addition, nonquantified public health benefits from the proposed rule include reduced exposure to *Giardia lamblia* and other emerging pathogens in drinking water.

The presence of *Cryptosporidium* in surface water sources is relatively common. Exhibits 2–4 and 2–5 provide a summary of the current research and information available on the occurrence of *Cryptosporidium*. The ranges of concentrations cited in the 45 studies in these exhibits describe source and finished water. *Cryptosporidium* concentrations in rivers, creeks, and streams range between 0 and 417 oocysts per liter. Results from lake and reservoir studies show *Cryptosporidium* concentrations to range between 0 and 22 oocysts per liter. Researchers have identified *Cryptosporidium* concentrations in finished water of up to 0.57 oocyst per liter. Additional information on the level and occurrence of *Cryptosporidium* in surface and finished water can be found in Chapter 2 and the Occurrence Document (U.S. EPA, 1999a).

Because *Cryptosporidium* is exceptionally resistant to inactivation by chlorine, physical removal by clarification and filtration is extremely important to control this organism. Because of the turbidity provisions in the proposed rule, many water systems would be expected to place an increased emphasis on improving overall filtration performance. The result of improving overall and individual filter performance will be a reduction in the number of *Cryptosporidium* oocysts that make it through the treatment process to finished water supplies with the ability to infect humans and cause illness. In addition to improving overall filter performance, monitoring requirements for individual filters in the proposed rule will ensure that water treatment plant operators can identify problems with the filters and subsequently improve the performance of individual filters.

Ingesting *Cryptosporidium* oocysts can cause cryptosporidiosis, which is an acute, self-limiting illness lasting 7 to 14 days with symptoms that include diarrhea, abdominal cramping, nausea, vomiting, and fever (Juranek, 1995). There is no effective treatment for cryptosporidiosis (Guerrant, 1997).

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 (Rose, 1997). Subpopulations with compromised immune systems include 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 low grade 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).

Waterborne disease outbreak data from the Centers for Disease Control (CDC) for the period 1993–1994 estimates that *Cryptosporidium* was responsible for over 400,000 cases of gastrointestinal infection (Craun et al., 1998). The vast majority of these cases occurred in one outbreak in Milwaukee, Wisconsin, the largest recorded outbreak of waterborne disease in the United States. Using standard epidemiological methods for estimating cases of illness, CDC estimated that of the approximately 800,000 persons served by the water system, over 400,000 (50 percent) became ill (Exhibit 5–2). Of those, 4,000 required hospitalization (approximately 1 percent of those becoming ill), and there were at least 50 cryptosporidiosis-associated deaths among immunocompromised individuals (as reported on death certificates) (Mackenzie et al., 1994; Hoxie et al., 1997). Exhibit 5–2 contains detailed information on some of the symptoms of patients with cryptosporidiosis observed during the Milwaukee outbreak.

Exhibit 5–2. Symptoms of 205 Patients with Confirmed Cases of Cryptosporidiosis during the Milwaukee Outbreak

Symptom	Percent of Patients	Mean	Range
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

Although the Milwaukee outbreak represents the largest number of cases in a single cryptosporidiosis outbreak in the United States, most cryptosporidiosis outbreaks have occurred in small systems serving fewer than 10,000 persons (Exhibit 2–7). Between 1991 and 1996 there were 16 small water system outbreaks caused by either *Cryptosporidium* or *Giardia lamblia* resulting in 1,036 reported cases of cryptosporidiosis and 518 reported cases of giardiasis (U.S. EPA 1999a). Two of the 16 outbreaks were associated with *Cryptosporidium* in small surface-water systems, and four *Cryptosporidium* outbreaks occurred in ground water assumed to be under the direct influence of surface water (*see* Chapter 2) (U.S. EPA, 1999a). During small system outbreaks, the rate of morbidity (i.e., the percent of the exposed population becoming ill) varies from 8 to 80 percent of the exposed population.

Outbreak data represent only a portion of the incidence of cryptosporidiosis. 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).

5.2.2 Risk Assessment: Methods and Assumptions

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). The risk assessment developed by Rose was used to estimate potential benefits and follows a standard methodology employed by EPA and the Federal government (National Research Council, 1983). The standard methodology requires the use of scientific data or, 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 particular health risk assessment makes use of ranges and probability distributions to take into account scientific uncertainty.

Risk assessment generally involves three basic steps (National Research Council, 1983).

- **Hazard identification** identifies the potential health effects associated with exposure to the hazard and the exposure threshold (e.g., dose) above which the health effects may occur.

- **Exposure assessment** estimates the number of people exposed to the hazard and the level of exposure.

- **Risk characterization** combines the hazard identification and exposure assessment to characterize overall risk to the exposed population.

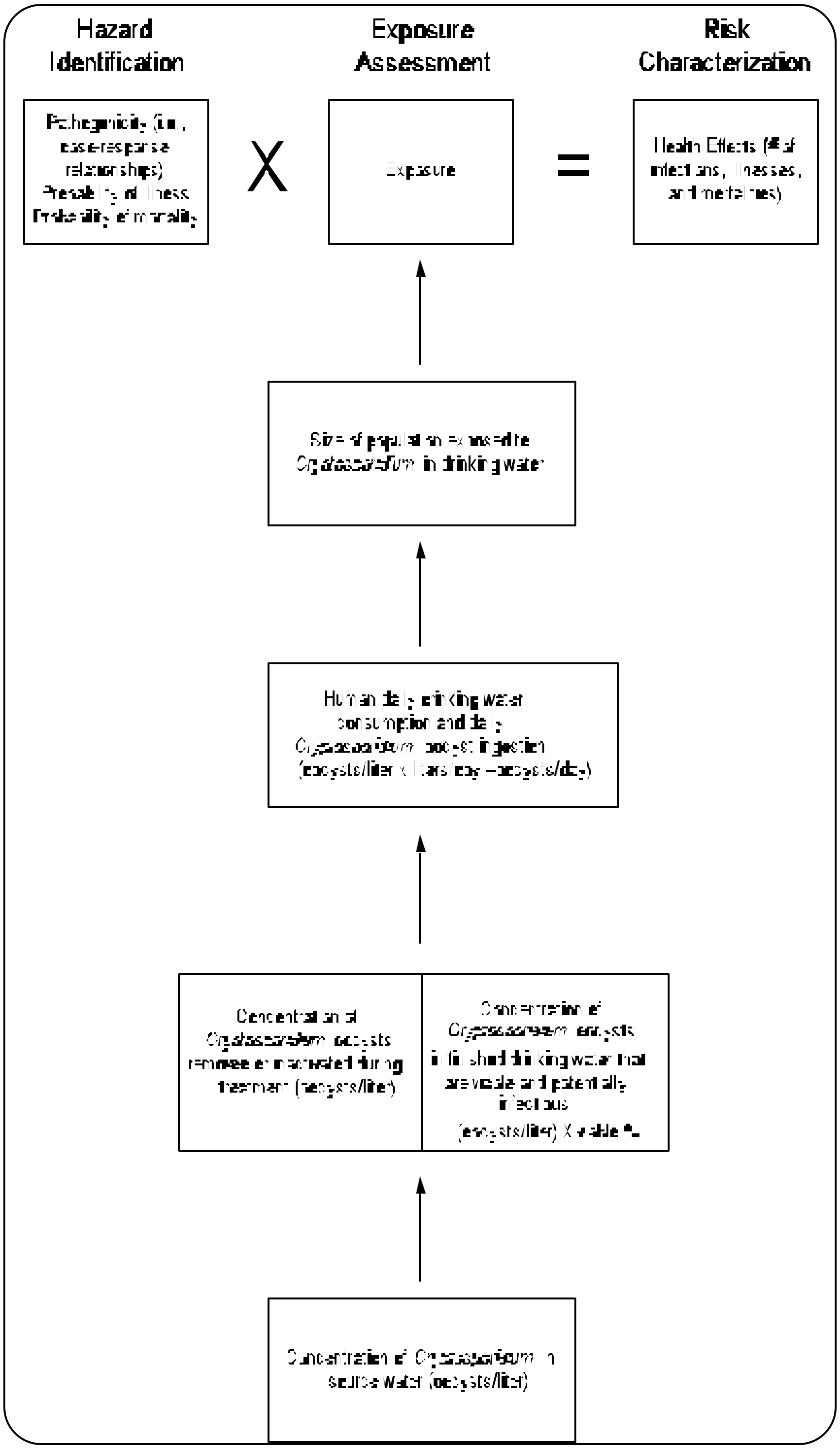
The three possible health endpoints to risk characterization are infection, illness (morbidity), and death (mortality). For the purpose of deriving benefits estimates, this analysis calculates the number of illnesses and the associated number of premature deaths attributable to infection from *Cryptosporidium*. Exhibit 5–3 displays the steps in the risk assessment process for characterizing the endemic risk of morbidity and mortality from *Cryptosporidium* in drinking water.

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

- Ingested dose (concentration of oocysts in the daily ingestion of finished water)
- Percent of ingested oocysts that are viable
- Dose-response function, which relates ingestion to infection
- Morbidity rate resulting from the infection
- Size of population exposed to *Cryptosporidium* in drinking water.

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

Exhibit 5–3. Steps in the Health Risk Assessment for *Cryptosporidium*



Source: Adapted from National Research Council, 1983

Hazard Identification

Hazard identification characterizes 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 in an individual given a single exposure to a dose of *Cryptosporidium* (Haas et al., 1996):

$$(= 1 \; ! \; \exp\,(\,!\,D / k\,).$$

Where: J = probability of infection

D = average dose

k = slope parameter (relation of ingestion to infection)

The benefit analysis evaluates the effect of daily exposures to drinking water because an individual could be repeatedly exposed to and infected by *Cryptosporidium* over the course of a year. Calculating the overall probability of being infected only once, or twice, or three times, or some other multiple over the course of a year is more difficult than calculating the probability of not being infected at all. The probability of not being infected in a single exposure, J_n is:

$$J_n = 1\text{-}\; J = 1 \; ! \; [1 \; ! \; \exp\,(\,!\,\mathrm{D} / \mathrm{k}\,)] = \exp\,(\,!\,\mathrm{D} / k).$$

The probability of not being infected at all during 365 exposures over the course of a year is:

$$(\,J_n\,)^{365} = [\exp\,(\,!\,\mathrm{D}/k)]^{365}.$$

Finally, the probability of being exposed at least once in a year is

$$1 \; ! \; (\,J_n\,)^{365} = 1 \; ! \; [\exp\,(\,!\,\mathrm{D}/k)]^{365}.$$

The probability of being exposed to *Cryptosporidium* at least once in a year depends upon the number of exposures (i.e., not all individuals will be exposed 365 times over the course of the year). EPA's model accounts for this by calculating exposure probabilities for three types of public drinking water systems: community water systems (CWSs); nontransient noncommunity water systems (NTNCs); and transient noncommunity water systems (TNCs). Exhibit 5–4 describes the three types of public drinking water systems and the annual number of exposures modeled for individuals served by these water systems.

Exhibit 5–4. *Cryptosporidium* Exposure Probabilities and Characteristics of Public Drinking Water Systems

Type of Water System	Annual Number of Exposures to *Crytosporidium*	Defining Characteristics
Community Water System	350	CWSs supply water to the same population year-round.
Nontransient Noncommunity Water System	250	NTNCs regularly supply water to at least 25 of the same people for at least six months per year, but not year-round.
Transient Noncommunity Water System	10	TNCs supply drinking water in places where people do not remain for long periods of time.

Using lognormally distributed data from human ingestion trials of *Cryptosporidium parvum* (*C. parvum*) Iowa strain, the estimated best fit value for *k* is 238.6, with a 90 percent confidence interval of 132.0 to 465.4 (Haas et al., 1996). Infection was defined as excretion of oocysts in the stool 36 hours or longer following the challenge dose. These trials were conducted with 29 healthy, medically screened individuals. Consequently, the slope parameter *k* may be different for sensitive subpopulations (i.e., it is possible that a lower dose may induce a response in sensitive individuals equivalent to what a higher dose induces in healthy individuals).

Infectivity varies among isolates of *C. parvum*, the *Cryptosporidium* species that is infectious to humans. In a comparison of the "Iowa" isolate of *C. parvum* used in the original human challenge studies by DuPont et al. (1995) with two other *C. parvum* isolates, Chappell et al. (1997) observed similar incubation periods and duration of illness among all isolates, but a 1 log lower ID_{50} (the average dose required to infect 50 percent of exposed persons) for the TAMU isolate of *C. parvum*. A third isolate tested, the UCP isolate, had a 1 log higher ID_{50} than the Iowa isolate (Chappell et al., 1997). Some researchers are also questioning the taxonomic designations of the various species of *Cryptosporidium,* and further research is needed to clearly identify the genetic similarities of isolates infective to humans (Tzipori and Griffiths, 1998). Until more complete experimental data are available, the dose-response relationship for the Iowa isolate of *C. parvum* (DuPont et al., 1995; Haas et al., 1996) will be used as a proxy for all species and strains of *Cryptosporidium*.

The analysis uses a log-normal 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 different strains and different population sensitivities.

Not all infections will result in illness and observable symptoms. The probability of becoming ill given infection is called the morbidity rate. A change in dose has not been found to affect the morbidity rate based on preliminary human ingestion trials. Therefore, the morbidity rate has been incorporated into the risk assessment independent of dose. Haas et al. (1996) provided information suggesting a morbidity rate value of 0.39, with 90 percent confidence bounds of 0.19 and 0.62. These data were used to develop a triangular distribution of the morbidity rate for use in the Monte Carlo simulation as described further below.

Combining the underlying risk of infection with the morbidity rate (M), the annual probability of at least one illness per year is:

$$M \times (1 - [\exp(-D/k)]^n).$$

Where n represents the average annual number of exposures to *Cryptosporidium*. The average annual number of exposures depends on the type of system providing water (Exhibit 5-4).

The preliminary human ingestion trials were conducted on healthy individuals with no evidence of previous *C. Parvum* infection (DuPont et al., 1995). Recently, however, it was found that after repeated exposure to *C. parvum* (Iowa strain) the morbidity rate was the same as for the initial exposure, but the symptoms were less severe and fewer oocysts were shed by re-infected subjects (Okhuysen et al., 1998). In addition, Chappell et al. (1997) observed that the diarrheal attack rate was significantly higher for the TAMU or UCP isolates of *C. parvum* in comparison with the attack rate for the Iowa isolate first studied by DuPont et al. (1995). Given these results and the variability of attack rates of *C. parvum* during reported outbreaks (Exhibit 2–7), it may be expected that the actual morbidity ratio may vary with the type of isolate to which a population is exposed as well as with the immune status of the exposed population. In the absence of scientific evidence on the direction and magnitude of such differences, the analysis will assume that a triangular morbidity rate distribution with a mode of 0.39 and endpoints of 0.62 and 0.19 characterizes the range of uncertainty.

Exhibit 5–5 summarizes the parameters used to characterize the infection and illness hazards associated with ingesting *Cryptosporidium* oocysts.

Exhibit 5–5. Summary of Hazard Identification Assumptions

Annual dose/response relationship reflecting the probability of being exposed at lease once in a year:
$1 - (J_n)^n = 1 - [\exp(-D/k)]^n$

k value:	mean = 238.6, 5^{th} percentile = 132.0, 95^{th} percentile = 465.4 (data fit to log normal distribution)
Morbidity:	mode = 0.39, minimum = 0.19, maximum = 0.62 (assumed triangular distribution)
n:	number of days per year of exposure to drinking water: CWSs = 350; NTNCs; 250; TNCs = 10.

Source: Haas et al., 1996.

Exposure Assessment

In general, the exposure assessment focuses on characterizing an individual's daily dosage, which is denoted D in the equations previously discussed. Estimating the daily exposure to *Cryptosporidium* requires five basic pieces of information:

- 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
- The percent viability of *Cryptosporidium* oocysts in finished water supplies (i.e., the number that are potentially infectious) the amount of drinking water consumed on a daily basis.

The benefit analysis estimates exposure under two sets of conditions to evaluate the potential human health impacts of the proposed rule:

- Baseline conditions, which characterize how many infectious *Cryptosporidium* oocysts an individual may ingest under current conditions
- Rule conditions, which characterize how many infectious *Cryptosporidium* oocysts an individual may ingest under improved removal conditions proposed by the rule.

The baseline and rule conditions use the same assumptions about source water quality, *Cryptosporidium* oocyst viability, and daily drinking water intake. The two differ with respect to assumptions about the concentrations of *Cryptosporidium* oocysts removed during filtration and the concentrations in finished water. The following describes each set of assumptions.

Source Water Quality

The source water quality distribution (i.e., the distribution of *Cryptosporidium* in source water) is based on a survey of *Cryptosporidium* oocyst occurrence in source water (LeChevallier and Norton, 1995) that was analyzed by EPA in 1996. These data were also the basis for the source water quality distribution used to estimate benefits for IESWTR and are shown in Exhibit 5–6.

Exhibit 5–6. Baseline Expected National Source Water *Cryptosporidium* Distributions (oocysts/100L)

Percentile	Source Water Concentration
25	103
50	231
75	516
90	1,064
95	1,641
Mean	**470**
Standard Deviation	**841**

The mean concentrations at the 69 sites from the eastern and central United States appears to be represented by a lognormal distribution. Although limited by the small number of samples per site (i.e., 1 to 16 samples with most sites sampled 5 times), variation within each site appears to be described by the lognormal distribution. The distribution of *Cryptosporidium* oocysts used in this analysis is lognormal with a mean concentration of 470 and a standard deviation of 841 oocysts per 100 liters. Exhibit 5–6 reports concentrations for selected points in the cumulative density function of the lognormal distribution. EPA continues to evaluate the potential biases caused by limited geographical data and analytical methods for *Cryptosporidium* recovery. EPA assumed that geographic and analytic uncertainties introduced off-setting biases in the IESWTR benefit analysis, and this approach is carried through in this analysis.

Cryptosporidium Oocyst Viability

The concentration of *Cryptosporidium* 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 et al., 1991a) found that one tenth to one third of oocysts in untreated water are viable and potentially infectious. Oocyst viability is defined by the presence of one or more internal morphological structures (nuclei, axonemes, or median bodies). Empty oocysts are assumed to be non-viable (LeChevallier et al., 1997a).

This analysis uses the same viability assumptions employed for the IESWTR benefit analysis. In that analysis, EPA chose to use a viability range about 50 percent lower than the range suggested by LeChevallier et al. (1991a). The lower range was chosen to account for uncertainty regarding the lack of specificity for species detection (many of which may not be infectious) and inability of research methods to distinguish between a live and dead oocyst. The percentage of potentially viable and infectious oocysts in finished water was assumed to be a uniform distribution ranging from 5 percent to 15 percent with a mean value of 10 percent

Daily Drinking Water Consumption

In the Interim Enhanced Surface Water Treatment Rule, EPA assumed the daily water ingestion of healthy adults to be lognormally distributed with a mean of 1.948 liters per person. This value was used in developing the benefits of the IESWTR. EPA's Office of Water has subsequently evaluated drinking water consumption data from USDA's 1994-1996 Continuing Survey of Food Intakes by Individuals (CSFII) study. EPA's analysis of the CSFII study resulted in a daily water ingestion lognormally distributed with a mean of 1.2 liters per person. The risk and benefit analysis contained within the LT1FBR RIA reflect this distribution.

EPA has conducted additional risk and benefit analyses using water consumption distributions with means of 0.9 liters and 1.9 liters per day for comparative purposes. These analyses are found in the Appendices to the RIA. The 0.9 liters per day distribution is another CSFII-based distribution that reflects an alternative approach to characterizing water consumption from public water supplies.

Removal and Finished Water Concentrations: Baseline Conditions

Recognizing the uncertainty in knowing the current removal rates of *Cryptosporidium* being achieved by water supplies subject to the proposed LT1FBR, EPA has adopted two alternative assumptions in this analysis for characterizing the baseline:

- Median 2.0 log removal
- Median 2.5 log removal

These removal assumptions are similar, but not identical, to the assumptions used in the IESWTR RIA (2.5 and 3.0 logs). EPA based the removal assumptions for IESWTR on historical studies of *Cryptosporidium* and *Giardia lamblia* removal efficiencies by rapid granular filtration as discussed in the IESWTR Notice of Data Availability (62 FR 59485, November 3, 1997), which noted an observed range across different source water concentrations and treatment plant efficiencies of 2 to 6 log removal of *Cryptosporidium* oocysts.

In the IESWTR RIA, EPA stated that the SWTR and the Partnership for Safe Water have influenced the removal range of typical plant performance upward from 2.0 or 2.5 log removal to 2.5 or 3.0 log removal. The Partnership for Safe Water is a voluntary program that works closely with systems to help optimize their performance; however, few systems serving under 10,000 individuals participate in the Partnership for Safe Water. In addition, EPA's turbidity performance data shows higher finished water NTU levels for plants serving fewer than 10,000 customers than for systems serving more than 10,000 customers. Thus, EPA assumes that systems serving under 10,000 are likely to achieve slightly lower removal on average than systems serving 10,000 or more. To further characterize the variability in *Cryptosporidium* removal currently being achieved by water systems subject to the proposed LT1FBR, EPA incorporated the assumed alternative log removal rates of 2.0 and 2.5 as distributions in the Monte Carlo analysis. Specifically, EPA has characterized the variability in the current log removal being achieved nationally as normal distributions with a mean of 2.0 or 2.5 log, and a standard deviation of 0.63 log for both distributions.

Exhibit 5–7 presents expected baseline national finished water *Cryptosporidium* distributions derived from the source water occurrence distributions and the baseline log removed distributions.

Exhibit 5–7. Baseline Expected National Finished Water *Cryptosporidium* Distributions, Based on Current Treatment (oocysts/100L)

Percentile	2.0 log	2.5 log
25	1.16	0.20
50	3.45	0.73
75	10.21	2.59
90	27.14	8.10
95	48.71	16.04
Mean	**12.60**	**4.26**
Standard Deviation	**44.30**	**24.53**

Removal and Finished Water Concentrations: Rule Conditions

EPA assumes that the turbidity provisions in the proposed rule will result in lower exposure to *Cryptosporidium*, reflecting improvements in overall and individual filter performance.

Exhibit 5–8 gives the total number of small surface water systems currently using filtration, 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 is described in Chapter 4. The remainder of this section discusses the treatment and removal assumptions used in the exposure assessment.

Exhibit 5–8. Summary of Systems and Population Potentially Modifying Treatment under the LT1FBR Turbidity Provisions

System Size (population served)	Total Small Surface Water Systems		Systems Potentially Modifying Treatment	
	Number of Systems	Total Population Served	Number of Systems[a]	Total Population Served[b]
25–100	836	41,463	341	16,912
101–500	1,117	305,346	456	124,653
501–1,000	810	609,188	331	248,940
1,001–3,300	1,655	3,259,323	675	1,329,331
3,301–9,999	1,478	8,792,326	603	3,587,126
Total	**5,896**	**13,007,647**	**2,406**	**5,306,963**

a. Estimates of the share of systems potentially affected by size category are based on the share of systems using filtration in Community Water System Survey, Volume II (62 FR 59485).

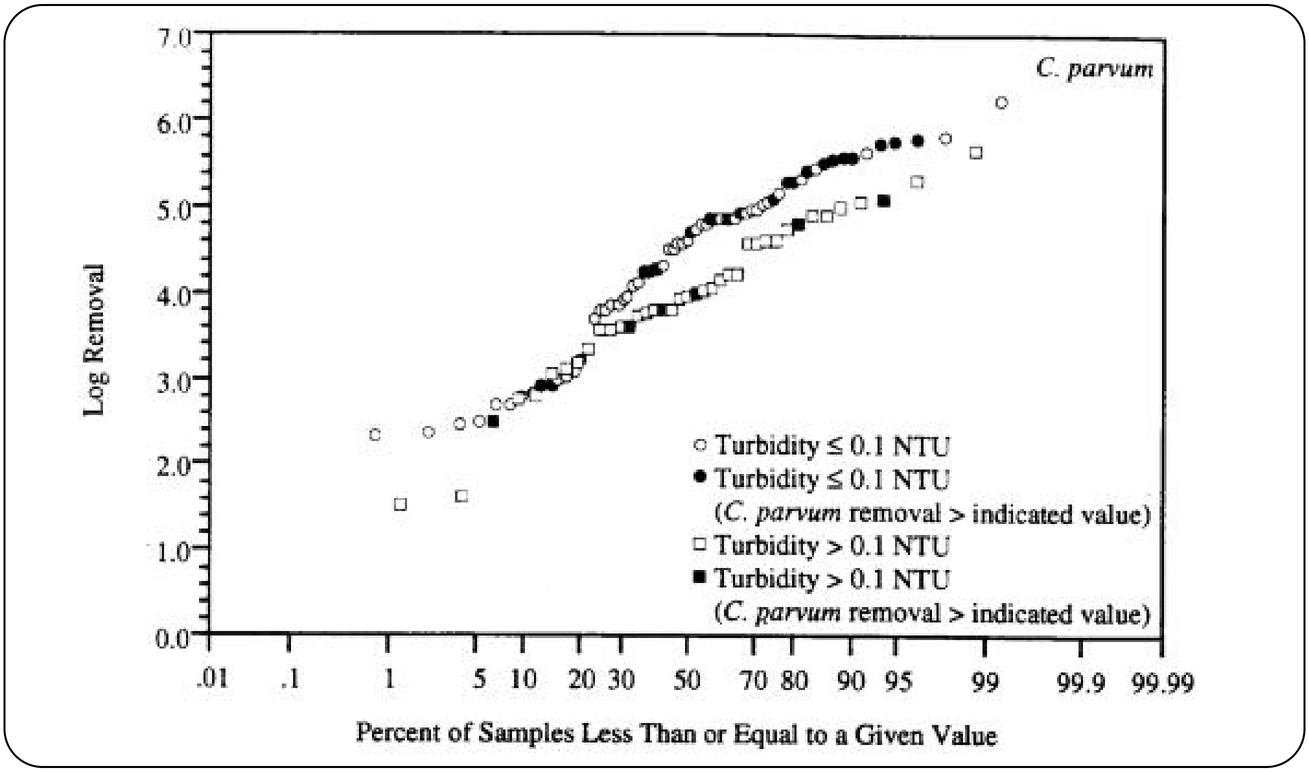
b. Population estimates by system size category are based on Water Industry Baseline Handbook. U.S. EPA, 1999c.

The assumed finished water *Cryptosporidium* distributions that would result from additional log removal under the proposed rule were based on the removal distributions in the IESWTR analysis. Those distributions were derived assuming that additional log removal was dependent on current removal, i.e., that plants 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 assumed dependence between the distribution of *Cryptosporidium* and turbidity level.

It should be noted that the ICR will provide 18 months of *Cryptosporidium* monitoring data for the development of a national source water *Cryptosporidium* occurrence distribution. Although the data collection efforts have been completed (January 2000), the last 6 months of data are still undergoing quality assurance review. EPA's supplementary survey is also providing *Cryptosporidium* and other microbial source water occurrence data; the full set of supplementary survey data will not be available for analysis until July 2000. The Technical Working Group supporting the Federal Advisory Committee involved with LT2ESWTR negotiation has been deliberating over the appropriate data analysis methods to create the national source water distribution for *Cryptosporidium* occurrence. This issue will continue to be discussed during the remainder of the LT2ESWTR Regulatory Negotiation process, scheduled to end in July 2000. It is likely that the data will undergo peer review only after the closure of the Regulatory Negotiation process. Due to the ICR data evaluation and peer review time frame, EPA does not envision being able to utilize these data in the LT1FBR regulatory impact analyses and instead intends to incorporate the data into the impact analysis for the LT2ESWTR.

Exhibit 5–9, based on a study by Patania et al. (1995), shows the relationship between *C. parvum* and removal efficiencies by rapid granular filtration as discussed in the IESWTR Notice of Data Availability (62 FR 59485, November 3, 1997). This study showed that a filter effluent turbidity of 0.1 NTU or less resulted in the most effective oocyst removal. The improved removal shown under the high removal assumptions for IESWTR are based on this observed level of oocyst removal. An incremental decrease in filter effluent turbidity from 0.3 to 0.1 NTU increased oocyst removal by up to one log. This oocyst removal range is the basis for the mid- and low- removal assumptions. Exhibit 5–10 contains the assumptions used in IESWTR to generate the new treatment distribution for a low-, mid-, and high-log removal assumptions.

Exhibit 5–9. Cumulative Probability Distribution of Aggregate Pilot Plant Data for *C. parvum* Removal



Patania et al. 1995.

Exhibit 5–10. Improved *Cryptosporidium* Removal Assumptions (Additional *Cryptosporidium* Log Removal with the Proposed Rule)

	Log Removal Assumption Scenarios		
	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	0.50	0.6
Plants now failing to meet 0.4 NTU Standard	0.50	0.75	0.9

The effect on finished water quality using these removal assumptions, based on current log removal of 2.0 and 2.5, is displayed in Exhibit 5–11.

Exhibit 5–11. Expected National Source Water and Finished Water *Cryptosporidium* Distributions with Improved Removal

Assuming Current Log Removal of 2.0					
		Finished Water Concentration (oocysts/100L)			
	Source Water Concentrations		Improved Removal		
Percentile	(oocysts/100L)	Current Treatment	Low	Mid	High
25	103	1.16	1.14	0.97	0.85
50	231	3.45	1.77	1.40	1.24
75	516	10.21	3.94	2.51	1.90
90	1064	27.14	8.585	4.83	3.42
95	1641	48.71	15.40	8.66	6.13
	Mean	**12.60**	**4.52**	**2.80**	**2.13**
	Standard Deviation	**44.30**	**14.96**	**8.37**	**5.90**
Assuming Current Log Removal of 2.5					
25	103	0.20	0.21	0.18	0.16
50	231	0.73	0.37	0.29	0.25
75	516	2.59	1.01	0.64	0.49
90	1064	8.10	2.56	1.44	1.02
95	1641	16.04	5.07	2.85	2.02
	Mean	**4.26**	**1.45**	**0.87**	**0.65**
	Standard Deviation	**24.53**	**6.53**	**3.66**	**2.59**

Using the assumption of a 2.0 current log removal and mid-case improvement in removal, the turbidity provisions are estimated to reduce the mean concentration of oocysts from 12.60 oocysts per 100 liters to 2.80 oocysts per 100 liters, a reduction of 78 percent (from Exhibit 5–11). Using the assumption of a 2.5 current log removal and mid-case improvement in removal, the turbidity provisions are estimated to reduce the mean concentration of oocysts from 4.26 oocysts per 100 liters to 0.87 oocysts per 100 liters, a reduction of 80 percent.

The final element required for the exposure assessment is an estimate of the number of people potentially exposed to *Cryptosporidium* by consuming drinking water from small systems. As presented earlier in Exhibit 5–8, EPA estimated the population is served by small surface water systems and ground water systems under the influence of surface water. Exhibit 5–8 also provides estimates of the number of systems and associated population that are expected to be affected by the proposed rule.

Exhibit 5–12 summarizes the assumptions used to characterize an individual's exposure to viable *Cryptosporidium* oocysts.

Exhibit 5–12. Summary of Exposure Assessment Assumptions

Source Water Quality
The source water concentration of *Cryptosporidium* oocysts is lognormally distributed (U.S. EPA 1998a):

- mean value of 470 oocysts/100L with a standard deviation of 841 oocysts/100L.

***Cryptosporidium* oocyst viability**
The viability or infectivity of oocysts in finished water is uniformly distributed (LeChevallier and Norton, 1992):

- low = 5%
- average = 10%
- high = 15%

Daily Water Intake
The drinking water consumption distribution used in this version of the benefits analysis (averaging approximately 1.2 liters per day) reflects Department of Agriculture CSFII data. This distribution is currently being considered as being reflective of water consumption among the population that consumes drinking water from either community or noncommunity water supplies.

Removal and Finished Water Concentrations:
Baseline Conditions
The median national *Cryptosporidium* removal efficiency for current conditions is estimated to be 2.0 log or 2.5 log, reflecting uncertainty in that value. Variability in these alternative removal rates is characterized using normal distributions with:

- Mean 2.0; standard deviation 0.63
- Mean 2.5; standard deviation 0.63

The two resulting baseline distributions of finished water *Cryptosporidium* concentrations (oocysts/100L) are right skewed distributions with the characteristics of:

- Mean 12.60, standard deviation 44.30; median 3.45 (for 2.0 log removal)
- Mean 4.26, standard deviation 25.43; median 0.73 (for 2.5 log removal)

Removal and Finished Water Concentrations:
Rule Conditions
Lognormal finished water *Cryptosporidium* oocyst concentrations (oocysts/100L) for:
2.0 log baseline

- low improved removal: mean 5.59 with standard deviation of 13.24
- mid improved removal: mean 4.07 with standard deviation of 9.88
- high improved removal: mean 3.45 with standard deviation of 6.38

2.5 log baseline

- low improved removal: mean 1.94 with standard deviation of 6.99
- mid improved removal: mean 1.33 with standard deviation of 4.01
- high improved removal: mean 1.12 with standard deviation of 3.09

Risk Characterization

The above assumptions are inputs to a model that estimates the annual number of *Cryptosporidium* infections and illnesses. The model uses the exposure assessment information provided above to calculate the ingested dose parameter (*D*) in the dose-response equation. Ingested dose is the number of potentially infectious oocysts an individual ingests daily, defined as:

$$D = C_F \times V \times Q$$

where C_F is the concentration of oocysts in finished water (oocysts/liter)
V is the percent of oocysts that are viable and potentially infectious
Q is the quantity of water ingested daily (liters/day).

The ingested dose parameter (*D*) combined with the slope parameter (*k*) forms the hazard quotient (*D/k*) portion of the dose-response relationship. The dose-response relationship describes an individuals daily *Cryptosporidium* infection risk, or an annual risk if taken to the nth exponent, where n is one of the annual exposures in Exhibit 5–4. The probability that an individual will experience at least one *Cryptosporidium* illness per year is predicted by multiplying annual risk of infection by the morbidity rate. Population risk is individual risk multiplied by the total exposed population.

$$I = P \times M \times (1 - [\exp(-D/k)]^n)$$

Where:

I = total number of illnesses
P = population exposed
M = morbidity rate
D = ingested dose (concentration of oocysts in finished water × daily ingestion of water)
k = slope parameter (relation of ingestion to infection)
n = number of days of exposure

5.2.3 Baseline and Reduced Health Risk of the Turbidity Provisions

Based on the assumptions and methodology described previously, risk assessment allows the estimation of existing risk under the current conditions (called baseline risk) and reduced risk when the turbidity provisions of the LT1FBR have been implemented. The endemic risk (isolated cryptosporidiosis cases that are not reported) is estimated by this risk assessment and is expected to be reduced due to improved overall filter performance resulting in the greater removal of oocysts on a regular basis (Exhibit 5–11). Outbreak-related risk is also expected to be reduced as the enhanced monitoring and tighter control over individual filter operations allow operators to detect and prevent breaches in treatment. Outbreak-related risk is more difficult to quantify using a standard risk assessment and is not included in the baseline or rule condition risk estimated in the following section.

Risk of Infection and Illness

EPA has developed the following types of risk characterizations for the LT1FBR impact assessment:

- Individual risk experienced by an average exposed person, and individual risk experienced by a highly exposed person
- General population risk
- Sensitive subpopulation risk.

The results of the risk characterization analyses performed are described in the following sections.

Individual Risk

The annual risk of infection and illness has been estimated for both an average individual having central tendency or typical exposed conditions, and for an individual who is highly exposed due to the combination of both high raw water *Cryptosporidium* levels and a high daily drinking water consumption rate.

Two LT1FBR treatment scenarios are modeled, the first in which systems achieve a median baseline oocyst removal efficiency of 2.0 logs, and the second in which systems achieve a median baseline removal efficiency of 2.5.

The average exposed individual is assumed to be served by a system with an average finished water oocyst concentration, equivalent to the mean of the finished water concentrations of 12.6 oocysts per 100 liters and 4.26 oocysts per 100 liters calculated for the 2.0 and 2.5 log treatment scenarios, respectively, as shown in Exhibit 5–7. It is also assumed that the average exposed individual has a daily drinking water consumption of 1.24 liters per day.

It is assumed that a highly exposed individual would be served by a system with a high finished water oocyst concentration, equivalent to the 90th percentile of the finished water distributions shown in Exhibit 5–7 for the 2.0 and 2.5 log treatment scenarios (27.14 oocysts per 100 liters and 8.10 oocysts per 100 liters, respectively). The highly exposed individual is also assumed to have a daily drinking water consumption of 2.35 liters per day, the 90th percentile of the custom consumption distribution described previously.

Point estimates for other parameters used in the model include: viability of treated oocysts = 0.1; for the dose-response equation, a *k*-value = 238.6, the mean of the distribution, where k is the average number of oocysts required to initiate an infection; and a morbidity rate of 0.39, the mean of the morbidity distribution (Haas et al.,1996).

Based on these assumptions, the following individual risk estimates were obtained:

<u>Average exposed individual</u> (assuming 2.0 log removal)

Annual risk of infection: 2.27×10^{-2}
Annual risk of illness: 8.84×10^{-3}

<u>Average exposed individual</u> (assuming 2.5 log removal)

Annual risk of infection: 7.72×10^{-3}
Annual risk of illness: 3.01×10^{-3}

<u>Highly exposed individual</u> (assuming 2.0 log removal)

Annual risk of infection: 8.91×10^{-2}
Annual risk of illness: 3.48×10^{-2}

<u>Highly exposed individual</u> (assuming 2.5 log removal)

Annual risk of infection: 2.75×10^{-2}
Annual risk of illness: 1.07×10^{-2}

Note that the individual annual risks shown above are for persons served by CWSs (approximately 95 percent of the affected population). The individual annual risks for consumers using NTNCs (approximately 2 percent of the affected population) are very similar to those for the CWSs. The individual annual risks for consumers using TNCs (approximately 3 percent of the affected population) are substantially lower (approximately 2 orders of magnitude) than the estimated individual risks for consumers using CWSs. For the most part, this lower risk value reflects the assumption that consumers using TNCs have fewer days of exposure, as compared with users of CWSs (10 days per individual versus 350 days at community supplies).

General Population Risk

EPA used a Monte Carlo simulation to develop estimates of the range of risks of infection and illness experienced in the general population, and of the number of annual infections and illnesses resulting from those risks. The algorithms used for calculating individual risk and the resulting number of infections and illnesses in the overall population at risk, as well as the details on the forms of the distributions used in the Monte Carlo simulation employing those algorithms, have been described previously in this chapter

Using the Monte Carlo simulation analysis, estimates of the distributions of annual risk of illness for the baseline and three improved removal assumptions were obtained. These are summarized in Exhibit 5–13. Note that these population estimates include exposures from CWSs, NTNCs, and

TNCs (summing to approximately 13 million). Exhibit 5–14 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.

Based on this risk assessment at an ingestion rate of 1.2 liters per day, LT1FBR is estimated to result in 77,500 fewer illnesses at the 2.0 log removal baseline and the mid-removal assumption and 27,900 fewer illnesses at the 2.5 log removal baseline.

Exhibit 5–13 Distribution of Annual Individual Risks of Illness Due to *Cryptosporidium* for the Baseline and Improved Removal Scenarios

Annual Risk of Illness range	2.0 Log Removal Baseline	Low Improved Removal	Mid Improved Removal	High Improved Removal
> 10^{-2}	2,173,000	762,000	390,000	240,000
10^{-3} to 10^{-2}	5,556,000	5,602,000	4,909,000	4,349,000
10^{-4} to 10^{-3}	4,102,000	5,453,000	6,410,000	7,022,000
10^{-5} to 10^{-4}	1,014,000	968,000	1,068,000	1,161,000
10^{-6} to 10^{-5}	146,000	88,000	97,000	100,000
< 10^{-6}	17,000	134,000	134,000	135,000
Annual Risk of Illness range	**2.5 Log Removal Baseline**	**Low Improved Removal**	**Mid Improved Removal**	**High Improved Removal**
> 10^{-2}	713,000	197,00	96,000	58,000
10^{-3} to 10^{-2}	3,323,000	1,968,000	1,297,000	950,000
10^{-4} to 10^{-3}	5,296,000	6,474,000	6,639,000	6,564,000
10^{-5} to 10^{-4}	2,885,000	3,539,000	4,107,000	4,538,000
10^{-6} to 10^{-5}	600,000	636,000	670,000	695,000
< 10^{-6}	191,000	194,000	198,000	202,000

Exhibit 5–14. Number of Illnesses and Illnesses Avoided

Improved Log-Removal Assumption	Daily Drinking Water Ingestion and Baseline *Cryptosporidium* Log-Removal Assumptions Mean = 1.2 Liters per person 2.0 log	 2.5 log
Current Treatment/Baseline		
Annual Illnesses—Mean	103,400	36,000
Annual Illnesses—10th Percentile	1,700	280
Annual Illnesses—90th Percentile	231,000	66,000
Low Improved *Cryptosporidium* Removal		
Annual Illnesses—Mean	40,600	13,200
Annual Illnesses—10th Percentile	1,500	250
Annual Illnesses—90th Percentile	81,900	22,600
Illnesses Avoided with Low Improved *Cryptosporidium* Removal Assumption		
Annual Illnesses—Mean	62,800	22,800
Annual Illnesses—10th Percentile	0	0
Annual Illnesses—90th Percentile	152,000	43,900
Mid Improved *Cryptosporidium* Removal		
Annual Illnesses—Mean	25,900	8,100
Annual Illnesses—10th Percentile	1,400	230
Annual Illnesses—90th Percentile	51,100	13,700
Illnesses Avoided with Mid Improved *Cryptosporidium* Removal Assumption		
Annual Illnesses—Mean	77,500	27,900
Annual Illnesses—10th Percentile	0	0
Annual Illnesses—90th Percentile	184,000	52,900
High Improved *Cryptosporidium* Removal		
Annual Illnesses—Mean	19,900	6,000
Annual Illnesses—10th Percentile	1,300	220
Annual Illnesses—90th Percentile	39,100	10,300
Illnesses Avoided with High Improved *Cryptosporidium* Removal Assumption		
Annual Illnesses—Mean	83,600	30,000
Annual Illnesses—10th Percentile	0	0
Annual Illnesses—90th Percentile	196,000	56,500

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

Sensitive Subpopulation Risk

In addition to estimating the risks of illness for the general population, EPA has developed separate estimates of the risk of illness for specific sensitive subpopulation groups. The sensitive subgroups considered include both age-based and health-based characteristics.

Data from Gerba et al. (1996) *Sensitive Populations: Who Is at the Greatest Risk?* and Bureau of the Census data are used to estimate the fraction of the exposed population whose sensitivity to *Cryptosporidium* is based on health status.

It is assumed that all infants, toddlers, children up to 5 years old, and elderly persons are more sensitive to *Cryptosporidium* infection than the general population. The toddler/young child subgroup is called out separately to allow flexibility for possible future calculations of person-to-person secondary spread common among children in this age group.

The seriously ill subgroups addressed in these calculations include:

- Non-hospitalized cancer patients
- Organ transplant patients
- AIDS patients
- Nursing home and related care facility residents.

The first three of the seriously ill subgroups comprise approximately 1 percent of the general population, calculated from population numbers presented by Gerba et al. (1996), and it is assumed that these persons are divided equally among all age groups. For the fourth category, the nursing home or related care facility residents, it is assumed that these persons are all older than 65 years; they constitute another 0.6 percent of the general population (calculated from population numbers presented by Gerba et al., 1996). The age-adjusted factor for nursing home patients is: (0.006 ÷ 0.126) = 4.8 percent of the population over 65 years old.

Assumptions regarding the number of pregnant women in the population are based on data cited in Gerba et al. (1996). There were 5,657,900 reported pregnancies in 1989 (Gerba et al., 1996). The 1990 Census (www.census.gov/statab/freq/98s0014.txt) reports that the total US population was 248,765,000 persons in that time frame. Assuming that each pregnant woman is pregnant only once per year, it can be estimated that pregnant women represent about 2.27 percent (5,657,900 ÷ 248,765,000) of the general population.

This factor is age-adjusted to the age group of most childbearing women, ages >16 to 50 years old. In 1990, there were 63,316,800 women ages >16 to 50 years. This age group makes up about 51.3 percent of the general population. The age adjusted factor for pregnant women is: (0.023 ÷ 0.513) = 4.5 percent of the general population from >16 to 50 years old. This factor is equivalent to about 8.9 percent of women ages >16 to 50 years old.

In all, approximately 23 percent of the population is assumed to be in the increased-sensitivity subpopulation. This breaks down as:

Infants:	2.8%
Toddlers:	4.4%
Elderly:	12.6%
Seriously ill:	1.0%
Pregnant women:	2.3%

Although it is reasonable to expect that the subpopulations identified here are likely to be at an increased risk of both infection and illness from exposure to *Cryptosporidium* relative the general population, there is no specific data available addressing those increased risks quantitatively. To develop estimates of the number of infections and illnesses in these subgroups, the following assumptions were made.

Infectivity: A higher rate of infectivity is assumed, and is modeled by setting *k* in the dose-response function to 132, the lower bound of the 95 percent confidence limits on this factor (Haas et al., 1996).

Morbidity: A higher rate of illness given an infection is assumed by setting the morbidity rate to 0.62, a point estimate equal to the upper bound of the triangular distribution of morbidity rate for the general population (Haas et al., 1996).

All other assumptions used in calculating the incidence of cryptosporidiosis infections and illnesses in sensitive subgroups are the same as for the general population under average exposure conditions.

The estimated annual baseline illnesses for the sensitive subpopulations in the aggregate are approximately 60,000 assuming systems are currently achieving 2.0 log removal, and 21,100 assuming systems are currently achieving 2.5 log removal.

The reader is cautioned that these numbers cannot be directly added to the general population estimates of annual illness presented earlier. Doing so would result in some double counting since these sensitive subgroups were included in the general population estimates without accounting directly for their increased risks there. An estimate of the number of annual illnesses resulting if these higher risk factors were included for these subpopulations can be made by subtracting out approximately 23 percent of the illnesses estimated in the baseline (currently attributable to these groups) and adding back the specific estimates noted above. Doing so would result in an increase in the baseline number of annual illnesses of approximately 35– 40 percent. However, the reader is reminded that the key quantitative assumptions used in performing this analysis on sensitive populations (specifically, increasing the infectivity and morbidity rates) are based on best professional judgement in view of the limited relevant data available to describe the actual risks to these groups.

Risk of Mortality

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 mortality rate can be estimated at approximately 0.0125 percent (0.0125 percent of all illnesses would result in a mortality—50 mortalities/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 mortality 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 mortality rate if more significant symptomatic response were associated with infection influenced by higher ingested dosages. No data are yet available, however, to support this hypothesis; data are available to indicate only a higher probability of infection resulting from higher ingested dose levels. There is some evidence that the mortality rate among susceptible subpopulations may not be linked to community-wide exposure levels (Rose, 1997). The majority of mortalities identified from the Milwaukee outbreak (46 of 50) were among individuals with AIDS (Hoxie et al., 1997). 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).

The Milwaukee mortality rate might also not be representative of the national mortality rate if there are larger or smaller sensitive subpopulations in Milwaukee than nationally. According to Hoxie et al. (1996), "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 mortality rate to the general population.

Exhibit 5–15 provides a distribution of the estimated individual annual risks of mortality derived from the Monte Carlo simulation. Assuming the Milwaukee mortality rate of 0.0125 percent, Exhibit 5–16 displays the estimated range of mortalities and mortalities prevented as modeled in the Monte Carlo simulation.

Exhibit 5–15. Distribution of Annual Individual Risks of Mortality Due to *Cryptosporidium* for the Baseline and Improved Removal Scenarios

Annual Risk of Mortality Range	2.0 Log Removal Baseline	Low Improved Removal	Mid Improved Removal	High Improved Removal
> 10^{-2}	0	0	0	0
10^{-3} to 10^{-2}	0	0	0	0
10^{-4} to 10^{-3}	0	0	0	0
10^{-5} to 10^{-4}	206,000	35,000	11,00	7,000
10^{-6} to 10^{-5}	2,427,000	964,000	505,000	333,000
< 10^{-6}	10,375,000	12,009,000	12,491,000	12,668,000
Annual Risk of Mortality Range	**2.5 Log Removal Baseline**	**Low Improved Removal**	**Mid Improved Removal**	**High Improved Removal**
> 10^{-2}	0	0	0	0
10^{-3} to 10^{-2}	0	0	0	0
10^{-4} to 10^{-3}	0	0	0	0
10^{-5} to 10^{-4}	52,000	10,000	5,000	3,000
10^{-6} to 10^{-5}	825,000	249,000	125,00	79,000
< 10^{-6}	12,131,000	12,748,000	12,877,000	12,925,000

Exhibit 5–16. Number of Mortalities and Mortalities Avoided among Exposed Population

Improved Log-Removal Assumption	Daily Drinking Water Ingestion and Baseline *Cryptosporidium* Log-Removal Assumptions — Mean = 1.2 Liters per person: 2.0 log	2.5 log
Current Treatment/Baseline		
Annual Mortalities—Mean	13	5
Annual Mortalities—10th Percentile	0	0
Annual Mortalities—90th Percentile	29	8
Low Improved *Cryptosporidium* Removal		
Annual Mortalities—Mean	5	2
Annual Mortalities—10th Percentile	0	0
Annual Mortalities—90th Percentile	10	3
Mortalities Avoided with Low Improved *Cryptosporidium* Removal Assumption		
Annual Mortalities—Mean	9	3
Annual Mortalities—10th Percentile	0	0
Annual Mortalities—90th Percentile	19	5
Mid Improved *Cryptosporidium* Removal		
Annual Mortalities—Mean	3	1
Annual Mortalities—10th Percentile	0	0
Annual Mortalities—90th Percentile	6	2
Mortalities Avoided with Mid Improved *Cryptosporidium* Removal Assumption		
Annual Mortalities—Mean	10	3
Annual Mortalities—10th Percentile	0	0
Annual Mortalities—90th Percentile	23	7
High Improved *Cryptosporidium* Removal		
Annual Mortalities—Mean	2	1
Annual Mortalities—10th Percentile	0	0
Annual Mortalities—90th Percentile	5	1
Mortalities Avoided with High Improved *Cryptosporidium* Removal Assumption		
Annual Mortalities—Mean	10	4
Annual Mortalities—10th Percentile	0	0
Annual Mortalities—90th Percentile	25	7

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

5.2.4 Monetization of Reduced Risks

The health benefits of the LT1FBR can be evaluated in terms of two valuation measures; 1) COI avoided and 2) 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 goods have 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 is a comprehensive measure of the welfare effect of a change in risk and is generally expected to exceed the out-of-pocket financial effect of the change (Chestnut and Alberini, 1997). WTP includes the intuitive notion that illness is 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 WTP for reduced health risk is likely to exceed the expected value of avoided COI is the general acceptance of additional costs to avoid risk. WTP values for avoidance of premature death include the value of reductions in the risk of out-of-pocket costs (i.e., COI) plus the value of reduced risk of the lost enjoyment of life (Chestnut and Alberini, 1997). The use of expected COI, instead of WTP, tends to understate the economic value of risk reduction because COI does not incorporate nonpecuniary benefits such as avoided pain and suffering.

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, reduced 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 5.3.

Monetization of Illness

Information is not available on direct measurements of either COI or WTP to reduce risk specifically for *Cryptosporidium*. For the purposes of this analysis, an adjusted giardiasis COI is used as a proxy for the COI 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). However, this COI study did not include averting expenditures or value the "pain, suffering, stress, and anxiety, or any other psychological or resulting physiological consequences of the outbreak." (Harrington et al., 1985).

Exhibit 5–17 contains a summary of the average losses for confirmed cases of giardiasis in 1984 dollars and updated using the Consumer Price Index to a January 1999 price level.

Exhibit 5–17. Losses per Case of Giardiasis by Category

Loss Category	Average Losses (1984 $) (Harrington et al., 1985)	CPI Update Factor	Average Losses (1999 $)
Direct Medical Costs:			
Doctor visits	$ 36	2.31[a]	$ 83
Hospital visits	100	2.31	231
Emergency room visits	27	2.31	62
Laboratory tests	63	2.31	146
Medication	28	2.31	65
Subtotal	*$ 254*		*$ 587*
Indirect Medical Costs:			
Time costs for medical care	$ 18	1.58[b]	$ 28
Value of work loss days	359[c]	1.58	567
Loss of work productivity	371[c]	1.58	586
Loss of leisure time	876[c]	1.58	1,384
Subtotal	*$1,624*		*$2,565*
Mean total expected losses per case -- giardiases	$1,878		$3,152
Mean total expected losses per case – cryptosporidiosis			$2,403

a. Consumer Price Index, Medical Care: 246.6 (January 1999)/106.9 (1984 average)

b. Consumer Price Index, All Items: 164.3 (January 1999)/103.9 (1984 average)

c. 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.

The average losses per case of giardiasis reported in the survey are approximately $3,150 at the current price level (1999 $). The average losses per case of cryptosporidiosis could be less than those of giardiasis 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 distribution derived for cryptosporidiosis has a mean of approximately $2,400 and a median of approximately $1,400. This mean value is the value presented in Exhibit 5–17.

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 $2,400 COI avoided per case mean estimate. Exhibit 5–18 contains the values of annual illnesses avoided by the LT1FBR turbidity provisions, using the distribution of adjusted COI estimates.

To compare these results against previous studies, Mauskopf and French (1991) estimated WTP to avoid food borne 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 (1999 $) for illnesses similar to cryptosporidiosis range from $166 to $7,424 for mild to moderate cases of botulism (5 to 21 days of weakness, vomiting, and nausea) and $284 to $1,139 for salmonellosis (3 to 7 days of similar symptoms). Using these estimates, the value for cryptosporidiosis (7 to 14 day duration) could range from $233 ($33.25/day for 7 days) to $4,942 ($353/day for 14 days). The cost of illness estimates (with a mean of $2,403) 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, and pain and suffering) have not been monetized.

Exhibit 5–18 that follows displays the potential benefits from preventing illnesses using the COI estimates as described above.

Exhibit 5–18. Number and Cost of Illnesses Avoided Annually from Turbidity Provisions* ($Millions)

Improved Log-Removal Assumption	Daily Drinking Water Ingestion and Baseline *Cryptosporidium* Log-Removal Assumptions Mean = 1.2 Liters per person 2.0 log	2.5 log
Illnesses Avoided with Low Improved *Cryptosporidium* Removal Assumption		
Mean	62,800	22,800
10th Percentile	0	0
90th Percentile	152,000	43,900
COI Avoided with Low Improved *Cryptosporidium* Removal Assumption		
Mean	$150.3	$53.9
10th Percentile	$0.0	$0.0
90th Percentile	$288.2	$81.4
Illnesses Avoided with Mid Improved *Cryptosporidium* Removal Assumption		
Mean	77,500	27,900
10th Percentile	0	0
90th Percentile	184,000	52,900
COI Avoided with Mid Improved *Cryptosporidium* Removal Assumption		
Mean	$185.3	$66.2
10th Percentile	$0.0	$0.0
90th Percentile	$350.9	$98.8
Illnesses Avoided with High Improved *Cryptosporidium* Removal Assumption		
Mean	83,600	30,000
10th Percentile	0	0
90th Percentile	196,000	56,500
COI Avoided with High Improved *Cryptosporidium* Removal Assumption		
Mean	$199.5	$71.1
10th Percentile	$0.0	$0.0
90th Percentile	$376.7	$105.8

* All values presented are in January 1999 dollars.

Monetization of Mortality

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, capped at $13.5 million (in 1990 price level), based on 26 individual study estimates (62 FR 59485, November 3, 1997). Updating the VSL for current price levels results in a distribution with a mean of $5.7 million and a standard deviation of $3.16 million, truncated at $16.87 million.

Because cryptosporidiosis mortalities 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).

For the purposes of this RIA, Exhibit 5–19 displays the potential benefits from preventing mortalities using the updated VSL distribution, recognizing the uncertainties inherent in this or any available valuation methodology.

Exhibit 5–19. Number and Cost of Mortalities Avoided Annually from Turbidity Provisions* ($Millions)

Improved Log-Removal Assumption	Daily Drinking Water Ingestion and Baseline *Cryptosporidium* Log-Removal Assumptions	
	Mean = 1.2 Liters per person	
	2.0 log	2.5 log
Mortalities Avoided with Low Improved *Cryptosporidium* Removal Assumption		
Mean	9	3
10th Percentile	0	0
90th Percentile	19	5
Cost of Mortalities Avoided with Low Improved *Cryptosporidium* Removal Assumption		
Mean	$45.0	$16.2
10th Percentile	$0.0	$0.0
90th Percentile	$101.7	$28.8
Mortalities Avoided with Mid Improved *Cryptosporidium* Removal Assumption		
Mean	10	3
10th Percentile	0	0
90th Percentile	23	7
Cost of Mortalities Avoided with Mid Improved *Cryptosporidium* Removal Assumption		
Mean	$55.5	$19.9
10th Percentile	$0.0	$0.0
90th Percentile	$123.3	$34.8
Mortalities Avoided with High Improved *Cryptosporidium* Removal Assumption		
Mean	10	4
10th Percentile	0	0
90th Percentile	25	7
Cost of Mortalities Avoided with High Improved *Cryptosporidium* Removal Assumption		
Mean	$59.8	$21.3
10th Percentile	$0.0	$0.0
90th Percentile	$132.0	$37.3

* All values presented are in January 1999 dollars.

5.2.5 Health Effects to Sensitive Subpopulations

The health effects of *Cryptosporidium* on sensitive subpopulations is much more severe and debilitating than the health effects on the general public. The estimated COI avoided calculated earlier likely does not capture the full value of costs to sensitive subpopulations, health trials were only 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. COI from cryptosporidiosis is expected to be much larger than $2,400 per case for sensitive subpopulations. 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 was 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. Sensitive subpopulations are more susceptible to *Cryptosporidium* infections, thus these individuals may purchase bottled water, boil water, or take other health precautions on a daily basis.

5.3 Other Benefits of Turbidity Provisions

Section 5.3 describes qualitative benefits of the turbidity provisions from the reduction in outbreak risk, enhanced aesthetic water quality, and avoided costs of averting behavior.

5.3.1 Reduction in Outbreak Risk

Besides reducing the endemic risk of cryptosporidiosis, the LT1FBR will 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 $2,400 per cryptosporidiosis infection estimate is applied to the estimated 2,000 cryptosporidiosis cases attributed to a sewage contaminated well in Braun Station, Texas (Craun et al., 1998), health damages could reach $4.8 million. Other types of costs associated with outbreaks include spending by local, State, and national public health agencies; emergency corrective actions by utilities; and possible legal costs if liability is a factor. Affected water systems and local governments may incur costs through provision of alternative water supplies and issuing customer water use warnings and health alerts. Commercial establishments (e.g., restaurants) and their customers may incur costs due to interrupted and lost service (e.g., lost producer and consumer surplus). Local businesses, institutions, and households may incur costs associated with undertaking averting and defensive actions. To the extent that LT1FBR reduces the likelihood of waterborne disease outbreaks, avoided response costs are potentially numerous and significant.

5.3.2 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. Aesthetic improvements from the proposed rule may not be noticeable to the general public and, therefore, these benefits are not quantified for this analysis.

5.3.3 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 figures are applied to a small drinking water system serving 10,000 customers, total expenditures on averting behavior during a *Cryptosporidium* outbreak could range between $17,400 and $55,300 per day. 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 are expected to be substantial.

Five additional studies were identified that used the averting cost approach to estimate household and other costs attributable to short-term contamination of drinking water supplies (Abdalla, 1990; Abdalla et al., 1992; Harrington et al., 1985; Sun et al., 1992; Van Houtven, et al., 1997). The most relevant of these for the LT1FBR analysis is a study by Harrington et al., (1985), that analyzes the costs associated with drinking water contamination by *Giardia* in Luzerne County, Pennsylvania. The December 1983 outbreak resulted in 366 confirmed giardiasis cases resulting from sewage leaking into the unfiltered source water. The total affected population was 75,000 individuals across Pittston Burough and 17 other municipalities. The Harrington study also developed a theoretical and empirical example of how outbreak costs are incurred, based on the Luzerne County example.

The four stages associated with a waterborne outbreak that may impose costs on society are discovery, survey and testing, reaction and aftermath. (Harrington et al., 1985). These are described below.

- **Discovery.** Health care providers or State, local, or hospital laboratory technicians send reports to State authorities notifying them of the need for further investigation when the rate of new cases suddenly increases above the normal rate.

- **Survey and testing.** A host of epidemiological surveys may be conducted, along with tests of the water supply, once a few cases are confirmed.

- **Reaction.** Local authorities and the water system may issue boil-water advisories, or other warnings to reduce exposure once a link is made between the drinking water supply and the disease outbreak. Businesses as well as households may be affected by such action, requiring government agencies to begin surveillance and enforcement activities and in some cases, provide alternative water sources.

- **Aftermath.** This final stage involves discussions of any long-term solutions to the problem, and how the costs of the outbreak and prevention of future ones may be shared. These discussions can only take place once the outbreak is contained by actions taken during the previous phase.

The Luzerne County outbreak resulted in losses, due to actions taken by individuals to avoid the contaminated water, estimated to be between $20.8 million and $61.8 million. The predominant cost was time lost to boiling water. Losses due to averting actions for restaurants, bars, schools and other businesses during the outbreak averaged $1.0 million. The burden for government agencies was $230,000 and the outbreak cost the water supply utility $1.8 million. These costs do not include legal fees, outbreak effects on businesses that were not investigated, leisure activities, or net losses due to substituting more expensive beverages for tap water.

5.4 Benefits from Other Rule Provisions

Section 5.4 describes qualitative benefits associated with the proposed rule including benefits from the recycle provisions, disinfection benchmarking, covered finished water reservoirs, including *Cryptosporidium* in the GWUDI definition, and provisions modifying watershed regulatory requirements for unfiltered systems.

5.4.1 Benefits of Recycle Provision

EPA has identified four primary public health concerns arising from the recycle of spent filter backwash and other recycle streams within the treatment process of public water systems.

1. Data establishes recycle flows can contain *Cryptosporidium* oocysts, often at higher concentrations than plant source waters, and recycling these flows may increase the number of oocysts entering the plant, reaching the filters, and entering the finished water. Since *Cryptosporidium* is not inactivated by standard disinfection practice, it is critical that all available physical removal processes (coagulation, flocculation, clarification, filtration) be protected from the hydraulic and chemical treatment disruptions recycle events may cause. Note that recycle returns oocysts to the plant at precisely the time treatment efficiency may be challenged by hydraulic and chemical disruption induced by recycle events. This may cause more oocysts to enter the finished water.

2. Returning spent filter backwash, thickener supernatant, and liquids from dewatering into, or downstream of, the point of primary coagulant addition may disrupt treatment chemistry by introducing residual coagulant or other treatment chemicals to the process stream. Recycle flow returned to the sedimentation basin may not reside in the basin long enough for recycled oocysts to settle, or it may create hydraulic currents within the basin that lower the unit's overall oocyst removal efficiency. Additionally, recycle can cause large variations in influent flow, which may result in harming of treatment efficiency by chemical under or over dosing (Patania et al., 1995; Edzwald and Kelley, 1998; Bellamy et al., 1993; Conley, 1965; Dugan et al., 1999; Robeck et al., 1964).

3. The direct recycle of spent filter backwash without first providing treatment, equalization, or some form of hydraulic detention for the flow, may cause plants to exceed State-approved operating capacity during recycle events. Exceeding operating capacity can cause

sedimentation/clarification and filter loading rates to be exceeded, which may lower overall oocyst removal provided by the plant and increase finished water oocyst concentrations.

4. Direct filtration plants do not employ a sedimentation basin in their primary treatment process to remove solids and oocysts; all oocyst removal is achieved by the filters. If treatment for the recycle flow is not provided prior to its return to the plant, all of the oocysts captured by a filter during a filter run will be returned to the plant and again loaded to the filters. This may lead to ever increasing levels of oocysts being applied to the filters and could increase the concentration of oocysts in finished water.

The LT1FBR recycle provisions are based on the assumption that improving the aforementioned recycle practices will prevent the accumulation of *Cryptosporidium* within the treatment plant and minimize the risk of oocysts entering into the finished water. EPA expects these provisions to reduce the incidence of cryptosporidiosis in two ways. First, endemic risk is likely to be reduced because improved recycle processes will consistently reduce *Cryptosporidium* occurrence in finished water relative to the recycle baseline. Second, endemic and outbreak risk is likely to be reduced by returning certain recycle flows (spent filter backwash, thickener supernatant, and liquids from dewatering) to the plant prior to the point of primary coagulant addition because all available physical removal processes will be employed to remove oocysts before they reach the filters. Returning these recycle flows prior to the point of primary coagulant addition will also protect the integrity of chemical dosing, which determines the treatment efficacy of sedimentation/clarification and filtration, by minimizing the potential for large fluctuations in plant influent flow volume and chemistry that can render chemical doses less than optimal.

EPA has not developed a national benefit estimate because the overall impact on finished water quality of different treatment changes brought about by the provisions depends on a wide variety of system operational parameters that cannot be easily modeled. In order to model the affect of recycle practice, data regarding the ability of a wide range of unit processes (sedimentation, DAF, contact clarification, filtration) to remove oocysts from a wide variety of source water types, under a range of treatment conditions, is needed to calibrate the model. This data is currently not extensive enough to model the impact of recycle on a wide variety of treatment configurations. Due to limited calibration data, EPA did not quantify benefits for these provisions. However, data show that oocysts occur in recycle streams and in the finished water of normally operated plants (unchallenged, well performing plants). Recycle adds additional oocysts to the plant and risks lowering plant treatment efficiency during recycle events by means of hydraulic and chemical disruption. The following discussion provides a qualitative description of how the filter backwash provisions are expected to reduce health risks.

Returning spent filter backwash, thickener supernatant, and liquids from dewatering prior to the point of primary coagulant addition, will pass recycled oocysts through available physical removal processes and protect the integrity of treatment chemistry, thereby improving log removal of *Cryptosporidium* oocysts during recycle. Returning these flows prior to the point of primary chemical addition, which is included in each of the recycling alternatives of the proposed rule, generates positive health benefits by controlling pathogens and improving treatment chemistry during recycle events. For example, eliminating return of recycle flow to the flocculation or clarification basin mitigates the possibility the recycle flow will generate disruptive currents that can harm the oocyst removal efficiency of these processes. Furthermore, returning these flow prior to the point of primary coagulant addition, rather than at this location or downstream of it, improves the accuracy of chemical treatment and protects the integrity of the process, as the dose can be targeted for the mixture of recycle and source water rather than just source water.

Plants that recycle directly (i.e., return recycle to treatment process without providing equalization, treatment, or some other form of hydraulic detention) may exceed State approved operating capacity during recycle events. Even if a system reduces or eliminates its raw water influent flow for the duration of the recycle event, the filter loading rate of some plants may still exceed State-approved operating capacity during recycling. Also, overly abrupt changes in filtration rate may occur - such changes have been shown to cause particles lodged in filter media to pass into the filter effluent (Cleasby et al., 1963; Glasgow and Wheatley, 1998; McTigue et al., 1998). The potential benefits of the proposed rule would differ among the proposed alternatives to the extent that modification to recycle practice differ across the alternatives. No benefits are realized under alternative R1 for hydraulic surge reduction, because the option does not contain a provision to address hydraulic surge. Under R2, the States determine whether systems are required to modify recycle practice to address public health risk; therefore, the number of affected systems is uncertain. The option allows States to determine whether recycle practice needs to be modified to allow the consideration of site-specific factors. Under alternatives R3 and R4 all systems either install a flow equalization basin or a sedimentation basin, respectively. Installing equalization basins will hold the recycle in tanks and gradually release it back into the treatment stream, thereby reducing the risk of hydraulic disruption and the associated health risk. Installing sedimentation basins will cause a majority of oocysts in recycle flows to settle before being returned to the primary treatment process, thereby eliminating the possibility they will pass through the filter and risk public health. EPA believes the greatest benefit will be realized by systems with the fewest number of filters because they are the most vulnerable to hydraulic and treatment chemistry upset induced by recycle events. Since the volume of recycle flow is a larger percent of plant influent at plants with fewer filters, they are more vulnerable to disruptions, in terms of both hydraulics and water quality.

Similarly, changes in recycle practices among direct filtration systems will differ across the proposed alternatives, and the resulting health benefits will differ. Under R1, direct filtration plants are required to return spent filter backwash prior to the point of primary coagulant addition. However, there are no expected benefits under R1 because the analysis assumes direct filtration plants return recycle to the required location. Under R2 and R3, States will determine whether modifications to recycle practice is required to reduce health risks, but R4 requires that all direct filtration plants install a sedimentation basin if they do not already provide recycle flow treatment equivalent to or superior to sedimentation for recycle flow. The reductions in health risks will depend on the number of systems that ultimately modify recycle practice and the extent to which the modification increases oocyst removal from the recycle flow.

Under any of the proposed alternatives, facilities may choose to alter their recycle practices by directly discharging recycle flows to surface waters or publicly owned treatment works (POTW). In terms of finished water quality, direct discharge generates the largest possible health benefits because recycle flows containing oocysts are completely removed from the treatment plant, thereby eliminating the risk of introducing oocysts from recycle flows into finished water.

Finally, in addition to the benefits from reduced occurrence of *Cryptosporidium* in the finished water, the proposed recycle provisions are likely to reduce the occurrence of other contaminants in the finished water. *Giardia lamblia* will likely be more effectively removed by the primary treatment process under the proposed recycle provision. Furthermore, the changes in recycle practices that result from LT1FBR may reduce the risk from other emerging disinfection resistant pathogens that may exist in source water such as *Toxoplasma*, *microsporidia*, and *Cyclospora*.

Sensitivity Analysis for the Recycle Provisions

Available research literature demonstrates that increased hydraulic loading or disruptive hydraulic currents, such as may be experienced when plants exceed State-approved operating capacity or when recycle is returned directly into the sedimentation basin, can disrupt filter performance (Cleasby, 1963; Glasgow and Wheatley, 1998; and McTigue et al., 1998) and sedimentation performance (Fulton, 1987; Logsdon, 1987; and Cleasby, 1990). However, the literature does not quantify the extent to which performance can be lowered and, more specifically, does not quantify the log reduction in *Cryptosporidium* removal that may be experienced during direct recycle events.

In the absence of quantified log reduction data, EPA performed a sensitivity analysis at the system-level for small and large systems to estimate a range of potential benefits for the recycle provisions. For the analysis, EPA assumed both system sizes would meet the proposed 2.0 log removal for *Cryptosporidium* provision except for problems caused by recycle practices that disrupt filter or sedimentation performance. The analysis incorporates the effect of these recycle practices by reducing the average baseline log removal[7] by a range of values (0.05 logs to 0.50 logs) to account for the reduction in removal performance plants may experience if they exceed State-approved operating capacity or return recycle to the sedimentation basin. EPA assumed that installing equalization to eliminate exceedences of State-approved operating capacity or moving the recycle return location from the sedimentation basin to prior to the point of primary coagulant addition will result in health benefit by returning the system to a 2.0 log removal of *Cryptosporidium* and thereby improving finished water quality. The benefit estimate is conservative, because it does not account for the fact that recycle also returns additional oocysts to the plant.

The difference between the number of illnesses that result from the 2.0 log removal assumption and the reduced performance assumptions (i.e., 1.95 or 1.50 log removal) is used to calculate the annual benefit using the $2,400 COI value. EPA compared the benefit to cost estimates for returning recycle prior to the point of primary coagulant additional and installing equalization for two service populations:

[7]The reduction in baseline log removal is an average over periods when recycle is and is not occurring. The actual reduction will be greater during recycle periods than other production periods. For this sensitivity analysis, EPA assumed that the potential health impacts of recycle practices could be captured by an average overall reduction in log removal.

a service population of 1,900 persons, which represents a plant serving fewer than 10,000 people, and a service population of 25,108, which represents a plant serving greater than 10,000 people. Annual benefits and annualized costs are summarized in Exhibits 5–20 and 5–21.

Exhibit 5–20. Potential Benefit for a System Serving 1,900 People

Log Removal Reduction	Benefit for Population of 1,900	Cost of Moving Recycle Return[1]	Cost of Installing Equalization[1]
0.05	$1,400	$5,200	$25,200
0.50	$30,700	$5,200	$25,200

[1]Costs are annualized assuming a 7 percent discount rate over 20 years.

Exhibit 5–21. Potential Benefit Range for System Serving 25,108 People

Log Removal Reduction	Benefit for Population of 25,108	Cost of Moving Recycle Return[1]	Cost of Installing Equalization[1]
0.05	$18,700	$18,700	$57,200
0.50	$405,800	$18,700	$57,200

[1]Costs are annualized assuming a 7 percent discount rate over 20 years.

Although research literature does not quantify the log reduction caused by specific recycle practices, the results of the sensitivity analysis show that the benefit a plant serving 25,108 people would realize by improving its baseline performance to 2.0 logs would range from $18,700 to $405,800. Benefits would range from $1,400 to $30,700 for a plant serving 1,900. This benefit range supports EPA's determination that unquantified benefits will justify costs.

5.4.2 Benefits of Disinfection Benchmark Provision

Disinfection benchmarking helps ensure that existing microbial protection is not significantly reduced or undercut as a result of steps taken to comply with maximum contaminant levels (MCLs) for total trihalomethanes (TTHMs) and 5 haloacetic acids (HAA5) set forth in Stage 1 DBP. The disinfection benchmark provision will prevent future incremental illnesses associated with pathogens that are controlled by current disinfection practices. However, it is not possible to quantify the health benefits from disinfection benchmarking on a national basis. The level of benefits will depend on how individual systems alter their disinfection practices and how those alterations might have increased pathogen risks without the disinfection benchmark provision in the proposed LT1FBR.

5.4.3 Benefits of Covered Finished Water Reservoirs

The quality of water in finished water reservoirs is subject to similar environmental influences as surface water, including deposition of airborne chemicals, surface water runoff, animal carcasses, animal or bird droppings, and growth of algae and other aquatic organisms. In one study, sea gulls contaminated a 10 million gallon reservoir and increased bacteriological growth, and in another study waterfowl were found to elevate coliform levels in small recreational lakes by 20 times their normal levels (Morra, 1979). Algal growth increases the biomass in the reservoir, which reduces dissolved oxygen and thereby increases the release of iron, manganese, and nutrients from the sediments. This, in turn, supports more algal growth (Cooke and Carlson, 1989). Algae can cause drinking water taste and odor problems. Further, uncovered finished water reservoirs may be subject to contamination by illegal swimming and dumping. Documented water quality problems in open finished water reservoirs include increased algal cells; heterotrophic plate count (HPC) bacteria; turbidity; color; particle counts; biomass; and decreased chlorine residuals (Pluntze, 1974; AWWA, 1983; Silverman et al., 1983; LeChevallier et al., 1997b).

Finished water may not be treated again prior to consumption, so any contamination in the uncovered reservoir may be passed directly to the customer. Therefore, requirements to cover new finished water reservoirs will result reduce the risk of contamination and result in positive health benefits. Data are not available, however, to quantify the benefits associated with covering all new finished water reservoirs.

5.4.4 Benefits from Including *Cryptosporidium* in the GWUDI Definition

Including *Cryptosporidium* in the definition of GWUDI will change drinking water treatment requirements for a nonquantified number of small drinking water systems. Although EPA does not currently have data on the number of systems that will be required to change treatment practices, the Agency anticipates that the health benefits from increased oocyst log removal will be positive when these small systems are reclassified as GWUDI.

5.4.5 Benefits from Including *Cryptosporidium* in Watershed Requirements for Unfiltered Systems

The proposed rule requires small unfiltered surface water and GWUDI systems to control *Cryptosporidium* contamination within the watershed. EPA expects that control of *Cryptosporidium* will reduce the incidence of cryptosporidiosis in populations served by these small drinking water systems. EPA does not currently have data on the number of unfiltered or GWUDI systems that will be required to control for *Cryptosporidium*; however, EPA anticipates that the health benefits will be positive as these systems take proactive steps to minimize the potential for oocyst contamination within watersheds.

5.4.6 Risk Reduction from Emerging Pathogens

While the benefits analysis for the LT1FBR only includes reductions in illness and mortality attributable to *Cryptosporidium,* the LT1FBR is expected to increase the level of protection from exposure to other pathogens (i.e. *Giardia* or other waterborne bacterial or viral pathogens such as *Cyclospora* and *Microsporidium*). Strengthened filtration requirements will translate to increased removal of additional pathogens and a resulting reduction in risk. This may prove essential, as the susceptibility of emerging pathogens to inactivation by chlorination is not well established. Unfortunately, EPA is unable to quantify the resultant benefit associated with a reduction in risk from emerging pathogens due to current data limitations.

5.5 Summary

EPA estimated the potential health benefits of the proposed rule using a health risk assessment approach to characterize baseline infections, illnesses, and mortalities caused by exposure to *Cryptosporidium* oocysts in treated drinking water from small surface water systems and small GWUDI systems for the turbidity provisions. Baseline estimates were compared with risk assessment results incorporating the improved *Cryptosporidium* removal rates that are assumed to occur because of the requirements in the proposed rule that will alter treatment practices.

5.5.1 Summary of Quantified and Monetized Benefits

Exhibit 5–22 presents the mean value of avoided illnesses from the LT1FBR turbidity provisions under the 1.2 liter per day daily water consumption assumption (*see* Exhibit 5–12). The mean value of avoided illnesses with this consumption rate under a 2.5 log baseline removal ranges from $53.9 million under the low removal assumption to $92.4 million under the high removal assumption. For the 2.0 log removal baseline, mean benefits range from $150.3 million under low removal to $199.5 million under the high removal assumption. Mortality results suggest that the mean value of avoided deaths under the 2.0 log removal baseline ranges from $45.0 million under low removal to $59.8 million under the high removal assumption. The value of avoided mortalities under the 2.5 log removal baseline ranges from $16.2 million to $21.3 million across the low and high removal assumptions.

EPA's Office of Water is continuing to evaluate drinking water consumption data from USDA's 1994-1996 CSFII study. The drinking water consumption distribution used in this version of the benefits analysis (averaging approximately 1.2 liters per day) reflects CSFII data. This distribution is currently being considered as being reflective of water consumption among the population that consumes drinking water from either community or noncommunity water supplies.

Exhibit 5–22. Summary of Annual Benefits Associated with Avoided Illnesses and Mortalities for the Turbidity Provisions* ($Millions)

Log Removal Assumption	Daily Drinking Water Ingestion and Baseline *Cryptosporidium* Log Removal Assumptions	
	Mean = 1.2 Liters per person	
	2.0 log	**2.5 log**
Low Removal		
Avoided Illnesses	$150.3	$53.9
Mortalities	$45.0	$16.2
Total	$195.3	$70.1
Mid Removal		
Avoided Illnesses	$185.3	$66.2
Mortalities	$55.5	$19.9
Total	$240.8	$86.1
High Removal		
Avoided Illnesses	$199.5	$71.1
Mortalities	$59.8	$21.3
Total	$259.4	$92.4

* All values are in January, 1999 dollars. Totals may not equal detail due to rounding.

5.5.2 Summary of Non-Quantified Benefits

As noted in Sections 5.3 and 5.4, several types of potential benefits were not included in the quantitative analysis. Exhibit 5–23 shows how the rule provisions that have not been quantified would be expected to affect the overall benefits derived from LT1FBR.

Exhibit 5–23. Summary of Non-Quantified Benefits

Item	Potential Effect on Benefits	Comments
Reducing mortality and morbidity rates by changes to recycle practices in small and large surface water and GWUDI treatment facilities.	+	Changing recycle practices is expected to generate positive benefits by lowering the risk of contracting cryptosporidiosis from drinking water. See Section 5.4.1.
Reducing risks to sensitive subpopulations	+	The study probably does not capture the full value of benefits to sensitive subpopulations because of a lack of scientific data. See Section 5.2.5.
Reducing outbreak risks and response costs	+	Determining the precise reduction in outbreak risk and resulting benefits is not possible given current information; however, the positive benefits associated with a reduction in outbreak risk are expected to be significant. See Sections 5.3.1, and 5.3.3.
Improving aesthetic water quality	+/no change	It is not clear that this rule will improve aesthetic water quality and generate any associated positive benefits; however, the rule is not expected to reduce aesthetic water quality and generate negative benefits. See Section 5.3.2.
Reducing averting behavior (e.g., boiling tap water or purchasing bottled water).	+	Averting behavior is associated with both out-of-pocket costs (e.g., purchase of bottled water) and opportunity costs (e.g., time required to boil water) to the consumer. Reductions in averting behavior are expected to have a positive impact on benefits from the proposed rule. See Section 5.3.3.
Covering new finished water reservoirs	+	Although insufficient data were available to qualify benefits, the reduction of contaminants introduced to finished water reservoirs would produce positive public health benefits. See Section 5.4.3
Including *Cryptosporidium* in the definition of GWUDI	+	The change in GWUDI definition will change the treatment practices at an undetermined number of system. Although data to quantify the number of systems are not available, EPA anticipates increased health benefits. See Section 5.4.4
Including *Cryptosporidium* in watershed requirements for unfiltered systems	+	Similar to the inclusion of *Cryptosporidium* in GWUDI, EPA anticipates that the proposed rule increases health benefits. See Section 5.4.5
Reducing exposure to other pathogenic protozoa, waterborne bacteria, or viral pathogens	+	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. See Section 5.4.6

+ = resolving the omission, bias, or uncertainty will tend to increase benefits.

! = resolving the omission, bias, or uncertainty will tend to reduce benefits.

+/! = the effect of the omission, bias, or uncertainty on benefits is undetermined.

5.5.3 Summary of Uncertainties

The benefits analysis has several biases and uncertainties. There is one source of identifiable bias in the analysis. The values for avoided illnesses were COI-based and not WTP-based; using WTP values might increase benefits. WTP values tend to be greater than COI values because they include nonpecuniary benefits of avoiding illness (i.e., benefits aside from avoiding out-of-pocket costs).

Exhibit 5–24 describes how uncertainties may affect the benefit analysis. Although several of the sources of uncertainty were incorporated in the Monte Carlo analysis, other sources could not be incorporated in a quantitative manner. These are described in the table.

Exhibit 5–24. Damages/Benefits Summary of Bias and Uncertainty

Item	Potential Effect on Benefits	Comments
Biases		
COI values were used to monetize morbidity risk reductions	+	WTP values are generally higher than the expected value of COI. No WTP values were identified in the literature that were usable for this analysis.
Uncertainties		
The slope parameter *k* may be different for sensitive subpopulations.	+/!	If lower doses of *Cryptosporidium* to members of sensitive subpopulations produce equivalent responses as higher doses in healthy individuals, a reduction in finished water oocyst concentrations may only have positive benefits to healthy populations and no change to sensitive subpopulations.
Different strains of *Cryptosporidium* may produce different dose-response relationships.	+/!	The dose-response relationship for *C. Parvum* is used as a proxy for all *Cryptosporidium* species until more complete experimental data becomes available. Some strains are more infectious, but less common while others are equivalent to *C. Parvum*.
Source water quality for the proposed rule is assumed to be identical to source water quality used to estimate IESWTR benefits.	+/!	Data are not available to show that source water quality for small systems is different than, or the same as, source water quality for large systems. (Note: ICR data that could clarify this issue are not yet available - see P. 5-15 for a discussion of ICR data availability)

Exhibit 5–24. Damages/Benefits Summary of Bias and Uncertainty

Item	Potential Effect on Benefits	Comments
IESWTR source water measurements were from the eastern and central United States and may not be representative of the United States as a whole.	!	LeChevallier and Norton may have sampled poorer quality source water (than the United States as a whole) resulting in a higher measured distribution and overstatement of benefits by the model used in this RIA. The outbreak information in Exhibit 2–7, however, shows several outbreaks in the western and southern United States. Other appropriate datasets were not identified for the current RIA model.
The existing analytic method provides poor *Cryptosporidium* recovery.	+	Poor recovery acts to produce a lower than expected source water distribution and possible understatement of benefits.
Removal efficiencies for small systems may or may not be comparable to large systems.	!	EPA is currently evaluating whether small system removal efficiencies are comparable to large system removal efficiencies. Small systems may have comparable removal efficiencies, which could lead to overstatement of benefits by the current model.
The mortality rate of 0.0125 percent used in the model is based on data from the Milwaukee outbreak.	+/!	The mortality rate from Milwaukee may reflect overall mortality rates from low level exposure by immunocompromised individuals. The population of immunocompromised individuals in other towns and cities may be different than Milwaukee and, thus, result in different mortality rates.
The VSL was not adjusted to reflect mortalities in sensitive subpopulations.	+/!	The valuation literature is unclear as to whether risk to sensitive subpopulations is associated with a higher or lower WTP. Review of existing literature does not provide a strong basis for adjusting the VSL up or down.
Transient Systems may not be accurately characterized.	+/!	There is uncertainty as to the precise number of transient systems. Also, it is assumed that transient systems use approximately the same technologies as community water systems. This may overestimate the number of systems affected by the rule. Also, the number of people served by these systems might be over or underestimated, to a lesser degree.

+ = resolving the omission, bias, or uncertainty will tend to increase benefits.

! = resolving the omission, bias, or uncertainty will tend to reduce benefits.

+/! = the effect of the omission, bias, or uncertainty on benefits is undetermined.

6. Cost Analysis

6.1 Introduction

This chapter reports national cost estimates for the proposed Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Rule (LT1FBR) and discusses the methods EPA used to estimate implementation costs incurred by drinking water systems and States.[1] EPA anticipates that water system compliance with the proposed LT1FBR provisions will increase monitoring and reporting burdens and entail adjustments to existing treatment processes and plant operations. EPA also expects the proposed rule to increase the labor requirements for additional compliance tracking activities among States. Consequently, the cost analysis includes labor costs associated with additional monitoring, reporting, and compliance requirements, as well as capital and operating and maintenance (O&M) expenditures associated with changes in water treatment processes.[2]

Sections 6.2 through 6.5 provide detailed cost information for each component included in the quantitative analysis. Each section includes the cost assumptions and data elements used in the analysis, describes how the costs were estimated, and reports the results. Additional documentation for the cost estimates in this chapter can be found in Appendices C through H. Total national costs are summarized in Section 6.6, which also includes a discussion of the impact of potential biases, omissions, and uncertainties on the national cost estimate. Section 6.7 discusses how system-level costs were translated into annual cost increases per household. Section 6.8 summarizes a cost effectiveness analysis that estimates costs per illness avoided.

6.1.1 Cost Assumptions

EPA estimated costs at the water system and State level, then multiplied these costs by the number of affected entities to obtain total costs. EPA used existing data sources and stakeholder inputs to determine system and State responses to the proposed LT1FBR. This included identifying treatment process improvements that systems may implement and estimating labor burdens for monitoring and reporting activities. EPA estimated costs for these various responses using industry cost models, equipment prices, and wage rates from standard engineering sources, stakeholder inputs, as well as assumptions in the IESWTR RIA. System costs were estimated for several

[1] Throughout the cost analysis, the term State refers to the 56 States, Commonwealths, Territories, and the District of Columbia that are eligible for primary enforcement authority or primacy. This definition is consistent with the assumption used for the cost analysis in the final IESWTR RIA. Currently, however, Wyoming and the District of Columbia do not have primacy; EPA regional offices administer their drinking water programs. Indian Tribes are also eligible for primacy, although none have yet obtained it and EPA regional offices also administer drinking water programs for Tribal lands.

[2] This analysis of social costs is limited to compliance cost estimates. Consequently, costs may be overstated because consumer and producer responses that minimize cost impacts are not incorporated. The analysis assumes that drinking water systems pass incremental costs on to consumers in the form of higher water prices and there are no impacts such as system closure.

different service population size categories because systems that serve larger populations will often incur higher costs.
To be consistent with the annual basis used in the benefit analysis, EPA also estimated costs on an annual basis. All one-time costs such as investments in capital equipment or training were annualized before they were added to annual O&M expenditures or recurring annual labor costs. Capital costs for most process improvements[3] were annualized over a 20-year period to reflect a typical capital investment lifetime. Two results are reported because EPA used two different discount rates that have been recommended for policy analysis: a 7 percent rate, which is recommended by OMB guidance (OMB, 1993 and 1996), and a 3 percent rate, which is recommended in *Guidelines for Preparing Economic Analyses* (U.S. EPA, 1999c). Start-up labor costs were also annualized over 20 years to obtain equivalent annual values.

The process improvements that EPA used to estimate costs for the turbidity provisions were revised from a set of technology enhancements used in the IESWTR RIA cost analysis to reflect conditions at smaller facilities. For the recycled provisions, the set of feasible process improvements was limited. EPA relied on information provided in stakeholder and SBREFA meetings, best professional judgment, the schematic of ICR systems, and the AWWA survey (1998) of recycling practices, which indicated the current range of recycling techniques to develop a list of potential treatment changes.

System-level cost estimates for all turbidity or recycle modifications are described in detail in *The Cost and Technology Document for the Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Rule* (U.S. EPA, 1999b). Most capital and O&M costs are functions of system flow rates, which were obtained from the Community Water System Survey database. Consequently, these costs are more representative of costs for community water systems, but EPA used the same costs for noncommunity systems as well because of a lack of data concerning the flow capacities and technologies employed by these systems. Thus, the cost analysis may over estimate costs for noncommunity systems.

Overall costs for the provisions affecting only small systems will also be overestimated because EPA included "purchased water" systems in the baseline. These systems purchase water from other systems and, therefore, are not likely to incur treatment or monitoring costs. EPA included these systems in the baseline to obtain a better estimate of benefits. The SDWIS database associates the population served with these systems and not the wholesale systems that treat and supply the water. Consequently, if EPA included only the wholesale systems in the RIA, the affected population would be under estimated; including the purchased systems adds the missing population, but also adds systems to the cost analysis.

EPA's labor cost estimates incorporate assumptions about incremental system and State labor hours and hourly labor rates for managerial and technical labor categories. For systems, EPA used labor rates based on a range of rates recommended by the Technology Design Panel (TDP). To verify that these labor rates were consistent with the January 1999 basis for benefits and costs,

[3] The exception is individual filter turbidimeter installation, which was annualized over a 7-year period to reflect a shorter equipment lifetime.

EPA compared the rates to the rates for water and wastewater treatment system operators in the *1998–1999 Occupational Outlook Handbook* (BLS, 1999b). The TDP-recommended ranges, particularly the low to medium rates, were consistent with the reported labor rates in BLS (1999b), after escalating the latter to December 1998 dollars using the Employment Cost Index (BLS, 1999a).[4]

The loaded technical labor rate for systems with design flows under 1.0 million gallons per day (i.e., systems serving 3,300 or fewer) is $28 per hour, and the rate for systems with design flows above 1.0 mgd (i.e., systems serving 3,301 or more) is $40 per hour. EPA assumed that systems serving 1,000 or more also have a management labor category, which has a loaded labor rate of $56 per hour. All of the labor rates in the cost analysis incorporate a 1.4 load factor on top of a base hourly rate to account for fringe benefits and other nonwage costs.[5] Thus, the base labor rates are $20 per hour for technical labor at systems serving 3,300 or fewer; approximately $28.60 for technical labor for larger systems, and $40 per hour for managerial labor.

State labor rate assumptions are the same as those used in the IESWTR RIA, escalated from June to December 1998 dollars using the Employment Cost Index for State and local employees (BLS, 1999a). The unloaded hourly rate for technical staff is $15.21 and the unloaded rate for managerial staff is $22.31. Loaded rates, assuming the same 1.4 load factor used in the system estimates above, are $21.29 and $31.23, respectively.

To reduce the potential burden on small systems, EPA developed and evaluated the cost implications of several regulatory alternatives for the following provisions: individual filter turbidity monitoring, disinfection benchmark applicability monitoring, disinfection benchmark profiling, and recycle provisions. Chapter 3 describes the alternatives in detail, they are briefly summarized below in the cost analysis sections for these provisions.

6.2 Turbidity Provisions Cost Analysis

The national annual cost estimate includes costs for two provisions that address finished water turbidity levels. The combined filter effluent (CFE) provision has requirements that differ across filtration methods. Systems using conventional or direct filtration must meet a 95th percentile turbidity value of 0.3 nephelometric treatment units (NTUs) and a maximum turbidity value of 1 NTU. Systems using membrane filtration will be required to meet these standards or standards determined by the State not to exceed 1 NTU in 95 percent of monthly measurements and a maximum of 5 NTU. Systems using alternative filtration methods will need to meet turbidity standards determined by the State, not to exceed 1 NTU in 95 percent of monthly measurements

[4] The quarterly index does not allow an exact match with January 1999 units for all other cost items. The December 1998 index value is a closer approximation than the March 1999 value; the growth rate between these two index values was 0.6 percent and any partial adjustment is not expected to affect reported costs, which are generally reported in tenths of millions of dollars.

[5] The load factor for fringe benefits and supplemental pay for professional and technical occupations is approximately 1.3 (BLS, 1999a), and the IESWTR cost analysis used a slightly higher load factor of 1.4 to include other costs. The same rate is used to develop labor costs for the proposed LT1FBR.

and a maximum of 5 NTU. The second provision requires all systems that use conventional or direct filtration to monitor individual filter turbidity levels and submit exceptions reports when turbidity levels exceed reporting thresholds.

To comply with the CFE provision, some conventional and direct filtration systems will need to implement process improvements. The applicable annual cost estimate for those systems include the annualized capital cost of the new equipment and the annual cost of incremental labor and supplies (e.g., electrical power and polymer stock) needed to operate and maintain the equipment. Systems that use other filtration methods will need to demonstrate that their systems meet the microbial removal or inactivation goals noted in the proposed rule, which will form the basis for State determinations regarding their turbidity standards. Annual costs will comprise annualized demonstration and determination costs.

Exhibit 6–1 summarizes EPA's estimate of the number of systems potentially affected by each element of the turbidity provisions. The costs associated with each system and the methods for estimating the numbers of affected systems are described in more detail in Sections 6.2.1 through 6.2.3.

Exhibit 6–1. Summary of the Estimated Number of Small Systems Affected by Turbidity Provision

Provision	System Size Category					Total
	#100	**101–500**	**501–1,000**	**1,001–3,300**	**3,301–9,999**	
Combined Filter Effluent Provision						
Turbidity Treatment Modifications (Section 6.2.1)	341	456	331	675	603	2,406
Individual Filter Monitoring Provision						
Monitoring (Section 6.2.2)	836	1,117	810	1,655	1,478	5,896
Exceptions Reporting (Section 6.2.3)	150–167	201–223	146–162	298–331	266–296	1,061–1,179
Individual Filter Assessment (Section 6.2.3)	33	45	32	66	59	236
Comprehensive Performance Evaluation (Section 6.2.3)	17	22	16	33	30	118

Detail may not add to total due to rounding.

6.2.1 Combined Filter Effluent Provision: Turbidity Treatment Costs

Unit Costs

EPA identified 24 treatment process improvements that small conventional and direct filtration systems might implement to improve finished water quality to meet the proposed CFE turbidity standards. The unit costs developed for these process improvements are based on cost models,[6] best engineering judgment, and existing cost and technology documents. In most cases, EPA derived costs from estimates of system design and average flow rates. *The Cost and Technology Document for the Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Rule* (U.S. EPA, 1999b) describes the methods and assumptions used to develop unit costs. Exhibit 6–2a reports capital costs per system for each treatment process improvement by system size category. These are actual costs; they do not reflect annualized values. Exhibit 6–2b reports the annual O&M costs.

Compliance Forecast

EPA based the compliance forecast on its understanding of current levels of finished water turbidity and the requirements in the proposed rule. Systems generally measure turbidity in two ways: as the output from an individual filter and as a combined stream of all individual filter outputs (i.e., combined filter effluent). During the development of the rule, EPA analyzed CFE maximum and 95th percentile turbidity results from finished water turbidity data provided by States to determine how many systems currently fail to meet the proposed turbidity standards. Predicted compliance was measured as meeting a limit such as 0.3 NTU at least 95 percent of the time and not exceeding a CFE maximum such as 1 NTU. In general, plants that expect to meet a 0.3 NTU limit 95 percent of the time will target operations to achieve 0.2 NTU to ensure that they would consistently meet the 0.3 NTU level. EPA took this into consideration when it developed estimates of the numbers of systems expected to modify treatment.

Using the baseline information on filtration practices and finished water turbidity results, which was discussed in Chapter 4, EPA developed a compliance forecast for the proposed 95th percentile turbidity standard of 0.3 NTU. EPA also developed forecasts for two other standards, 0.2 NTU and 0.1 NTU, to evaluate the effect of more stringent standards on marginal treatment costs (see Appendix tables C–1 through C–3 for detailed compliance forecasts). A compliance forecast first estimates the number of systems expected to modify their treatment practices to meet the turbidity requirements, and then it identifies the process modifications they would likely select. The number of systems requiring each process modification were multiplied by the unit costs in Section 6.2.1 to obtain total costs per treatment alternative. Costs were then summed across the treatment alternatives to obtain total costs and then annualized using the 3 percent and 7 percent discount rates.

The compliance forecast estimates in Appendix tables C–1 through C–3 vary across the five system size categories because compliance needs will vary by system size. Furthermore, the treatment modifications are generally not mutually exclusive (i.e., some systems are expected to

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[6] EPA used three cost models: the Very Small System (VSS) Model, which is a spreadsheet model based on cost equations in *Very Small Systems. Best Available Technology Document* (U.S. EPA, 1993); the WATER Model, which is a spreadsheet model based on cost equation in *Estimation of Small System Water Treatment Costs* (U.S. EPA, 1984); and the W/W COSTS Model, which contains cost estimating routines based on cost equations in *Estimating Water Treatment Costs. Volume 2. Cost Curves Applicable to 1 to 200 mgd Treatment Plants* (U.S. EPA, 1979).

Exhibit 6–2a. Treatment Process Improvement Capital Costs per System (January 1999 dollars)

System Population Size Categories	#100	101–500	501–1,000	1,001–3,300	3,301–9,999
Chemical Addition					
Install coagulant aid polymer feed capability	$9,016	$9,016	$9,016	$9,016	$9,016
Install backwash water polymer feed capability	$9,016	$9,016	$9,016	$9,016	$9,016
Install pH adjustment for enhancing alkalinity purposes	$8,137	$8,137	$8,137	$8,137	$8,137
Coagulant Improvements					
Primary coagulant feed points, control, measurement	$9,016	$9,016	$9,016	$9,016	$9,016
Rapid Mixing					
Rapid mix improvements—mechanical	$2,444	$2,444	$3,157	$3,768	$6,212
Rapid mix improvements—structural	$2,852	$2,852	$3,768	$4,583	$9,064
Flocculant Improvements					
Flocculation improvements—mechanical	$8,351	$9,064	$12,730	$16,397	$32,081
Flocculation improvements—structural	$15,888	$22,406	$39,210	$52,755	$100,418
Settling Improvements					
Equipment modification—weirs, inf/effl, etc.	$519	$1,348	$3,157	$6,824	$14,665
Add tube settlers	$2,953	$10,694	$28,882	$70,476	$207,150
Filtration Improvements					
Filter media additions	$415	$933	$1,660	$3,259	$12,221
Filter media overhaul	$7,333	$28,516	$76,281	$186,170	$423,466
Backwashing—increase flow/velocity	$9,879	$15,277	$22,609	$65,282	$144,516
Backwashing—install surface wash	$10,388	$17,212	$30,451	$117,324	$162,339
Post backwash filter-to-waste	$3,055	$5,194	$10,490	$46,543	$55,505
Filter control systems	$2,139	$4,176	$7,027	$29,229	$36,358
Individual filter turbidimeter installation [1]	$3,941	$3,941	$3,941	$7,862	$10,816
Membrane (microfiltration)	$56,523	$162,441	$341,482	$741,014	$1,635,914
Administrative Culture Improvements					
Plant staffing—increase (1 or 2 persons) [2]	$0	$0	$0	$0	$0
Staff qualifications [2]	$0	$0	$0	$0	$0
Laboratory Modifications					
Bench top turbidimeter purchase—replace obsolete units	$1,293	$1,293	$1,293	$1,293	$1,293
Jar test apparatus purchase	$2,342	$2,342	$2,342	$2,342	$2,342
Alternative process control testing equipment	$8,534	$8,534	$8,534	$8,534	$8,534
Process Control Testing Modifications					
Staff training (advanced)	$4,888	$4,888	$4,888	$4,888	$4,888

[1] Turbidimeter installation was included with other capital costs for modeling purposes although this treatment change will be undertaken because of the individual turbidity monitoring provision instead of the CFE provision.
[2] There are no capital costs for this treatment process improvement.

Exhibit 6–2b. Treatment Process Improvement Operation & Maintenance Costs per System (January 1999 dollars)

System Population Size Categories	#100	101–500	501–1,000	1,001–3,300	3,301–9,999
Chemical Addition					
Install coagulant aid polymer feed capability	$2,908	$2,908	$2,908	$2,908	$4,081
Install backwash water polymer feed capability	$2,908	$2,908	$2,908	$2,908	$4,074
Install pH adjustment for enhancing alkalinity purposes	$5,581	$5,707	$5,991	$6,814	$12,246
Coagulant Improvements					
Primary coagulant feed points, control, measurement	$2,908	$2,908	$2,908	$2,908	$4,081
Rapid Mixing					
Rapid mix improvements—mechanical	$2,803	$2,803	$2,953	$3,157	$5,296
Rapid mix improvements—structural	$2,803	$2,803	$2,953	$3,157	$5,296
Flocculant Improvements					
Flocculation improvements—mechanical	$2,750	$2,852	$2,852	$2,953	$4,787
Flocculation improvements—structural	$2,852	$2,852	$2,852	$2,953	$4,787
Settling Improvements					
Equipment modification—weirs, inf/effl, etc.	$741	$741	$2,224	$2,224	$6,355
Add tube settlers	$741	$741	$2,224	$2,224	$6,355
Filtration Improvements					
Filter media additions[2]	$0	$0	$0	$0	$0
Filter media overhaul[2]	$0	$0	$0	$0	$0
Backwashing—increase flow/velocity (10–20% increase)	$3,870	$4,277	$4,583	$6,212	$17,619
Backwashing—install surface wash	$1,731	$2,037	$2,241	$4,583	$5,805
Post backwash filter-to-waste	$3,768	$4,074	$4,379	$5,907	$8,555
Filter control systems	$2,750	$3,157	$3,972	$8,555	$18,332
Individual filter turbidimeter installation[1]	$825	$825	$825	$825	$825
Membrane (microfiltration)	$13,647	$23,730	$46,543	$90,132	$251,146
Administrative Culture Improvements					
Plant staffing—increase (1 or 2 persons)	$14,828	$14,828	$29,657	$29,657	$42,367
Staff qualifications	$672	$672	$672	$713	$1,080
Laboratory Modifications					
Bench top turbidimeter purchase—replace obsolete units	$76	$76	$76	$76	$76
Jar test apparatus purchase[2]	$0	$0	$0	$0	$0
Alternative process control testing equipment	$1,483	$1,483	$1,483	$1,483	$2,118
Process Control Testing Modifications					
Staff training (advanced)[2]	$0	$0	$0	$0	$0

[1]Turbidimeter installation was included with other O&M costs for modeling purposes although this treatment change will be undertaken because of the individual turbidity monitoring provision instead of the CFE provision.
[2]There are no O&M costs for this treatment process improvement.

adopt more than one of the treatment process improvements). Consequently, the sum of percentages across the treatment process improvements exceeds 100 for each system size category.

The percentages provided in the compliance forecast tables in Appendix C generally indicate the percent of the systems expected to modify treatment that will adopt each treatment process change. For individual filter turbidimeter installation, however, the percentage applies to all systems affected by the proposed individual filter turbidity monitoring provision, not just to those systems that are expected to modify their treatment to meet the turbidity levels in the rule. All systems that practice conventional or direct filtration will be required to install individual filter turbidimeters under the rule, regardless of current performance. For the IESWTR RIA, EPA assumed that approximately 20 percent of systems already have turbidimeters in place and 80 percent will need to install a turbidimeter for each filter. EPA has no data to suggest that small systems are any more or less likely to have turbidimeters installed. Thus, EPA will use the same assumption until better data for small systems is available.

EPA estimated that 2,406 or 41 percent of the 5,896 conventional and direct filtration systems incur treatment modification costs to meet a revised turbidity standard of 0.3 NTU.[7] Exhibit 6–3 summarizes the number of systems needing to modify treatment by size category. Treatment modifications for the proposed 0.3 NTU standard and 0.2 NTU sensitivity analysis included a wide variety of technologies. For the 0.1 NTU sensitivity analysis, however, EPA assumed that increased protection would be achieved primarily through adoption of membrane technology rather than altering other treatment practices to reduce turbidity.

System Costs

Exhibit 6–4 summarizes annual cost estimates including annualized capital costs and annual O&M expenditures by system size and turbidity level. Total annualized costs for the proposed 0.3 NTU standard are $47.4 million to $52.2 million, depending on the discount rate assumption. The sensitivity analysis shows that costs increase rapidly for more stringent turbidity standards. Total costs for the 0.2 NTU case are approximately 157 percent higher than costs for the 0.3 NTU standard (at the 7 percent discount rate), and costs for the 0.1 NTU case are approximately 675 percent higher than the 0.3 NTU costs. As noted, the cost estimates for the 0.2 NTU and 0.1 NTU cases are likely to be under estimated because the number of systems modifying treatment was assumed to be the same; if more systems would need to modify treatment to meet the stronger standards, costs would be higher than those reported in Exhibit 6–4. EPA identified several cost drivers for the 0.3 NTU and 7 percent discount rate assumptions. O&M expenditures account for 59 percent of annual costs; the remaining 41 percent is annualized

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[7] EPA assumed that the number of systems expected to modify treatment remains the same for the 0.2 NTU and 0.1 NTU sensitivity analyses, but altered the mix of treatment changes. This potentially under estimates the marginal costs for the 0.2 NTU and 0.1 NTU standards because it excludes costs that might accrue to systems that currently meet the 0.3 NTU standard (i.e., that currently achieve 0.2 NTU turbidity levels at least 95 percent of the time), but do not meet a 0.2 NTU or a 0.1 NTU standard.

Exhibit 6–3. Number of Systems Modifying Treatment Practices to Meet New Turbidity Standards

System Size	Number of Conventional and Direct Systems	Number of Systems Expected to Modify Treatment
# 100	836	341
101–500	1,117	456
501–1,000	810	331
1,001–3,300	1,655	675
3,301–9,999	1,478	603
Total	**5,896**	**2,406**

Exhibit 6–4. Annual Cost Estimates for Turbidity Treatment Requirements (January 1999 dollars, millions)

System Size	0.3 NTU		0.2 NTU		0.1 NTU	
	3%	7%	3%	7%	3%	7%
# 100	$4.3	$4.5	$5.4	$5.7	$8.0	$8.6
101–500	$5.6	$6.0	$8.7	$9.4	$17.8	$19.8
501–1,000	$5.5	$5.9	$10.1	$11.1	$24.8	$27.9
1,001–3,300	$14.4	$16.0	$33.7	$38.0	$96.7	$109.9
3,301–9,999	$17.5	$19.9	$62.2	$69.9	$212.6	$238.5
Total	**$47.4**	**$52.2**	**$120.0**	**$134.1**	**$360.0**	**$404.6**

Results for the 3 percent discount rate are in Appendix D and results for the 7 percent discount rate are in Appendix E.
Detail may not add to total due to rounding.

capital costs. Approximately 36 percent of total O&M expenditures are for plant staffing increases. Plant staffing is one of four process improvements that together account for almost 50 percent of total turbidity treatment costs:

- Filter control systems (8 percent of total costs)
- Filter media overhaul (8 percent of total costs)
- Backwashing-install surface wash (10 percent of total costs)
- Plant staffing increase (21 percent of total costs).

6.2.2 Individual Filter Monitoring Provision: Monitoring Costs

The proposed rule requires that all small surface water or GWUDI systems using conventional or direct filtration continuously monitor turbidity for each filter in their system. This section discusses EPA's estimate of monitoring costs for systems and States. Turbidity monitoring costs include both start-up and annual costs for systems and States. In each case, the underlying estimation approach is the same. Costs for monitoring activities reported below, however, do not include the capital and O&M costs of the turbidimeters, which were included in the previous discussion on turbidity treatment. EPA estimated that total annualized costs for turbidimeters will be approximately $9.0 million assuming a 3 percent discount rate or $9.8 million assuming a 7 percent discount rate. Annual O&M expenses for calibration materials are $3.9 million and annualized capital expenses account for the remainder.

The following analysis includes cost estimates for three alternatives, which are described below. These alternatives will affect both the frequency and duration of system monitoring activities as well as the number of exceptions reported, which is discussed in Section 6.2.3.

- Alternative T1: Individual filter monitoring and exceptions reporting requirements are identical to the final IESWTR. They include a requirement to submit an exceptions report for any individual filter that exceeds 1 NTU in two consecutive measurements taken 15 minutes apart at any time or for any individual filter that exceeds 0.5 NTU in two consecutive measurements taken 15 minutes apart at the end of 4 hours of filter operation, which necessitates daily analysis and review of turbidity data gathered by the turbidimeters. Finally, a filter profile is required when any of the above exceedances cannot be explained.

- Alternative T2: Individual filter monitoring and exceptions reporting requirements are slightly revised from the final IESWTR provisions of T1 to exclude the exceptions report for an individual filter that exceeds 0.5 NTU in two consecutive measurements taken 15 minutes apart at the end of 4 hours of filter operation, which allows systems to shift from daily to weekly analysis and review of the monitoring data if they so chose. For the cost analysis, EPA assumed that all systems review data weekly. Finally, the filter profile requirement does not apply.

- Alternative T3: Individual filter monitoring and exceptions reporting requirements are revised to a distributional standard. Only systems that exceed 0.5 NTU in more than 5 percent of monthly measurements or exceed 2 NTU in two consecutive measurements are required to submit an exceptions report. Thus, monthly analysis review of data should be sufficient to detect instances that require an exceptions report. The filter profile requirement does not apply.

System Costs

System start-up activities were based on the list of activities included in the IESWTR cost analysis, which were discussed with small entity representatives and stakeholders during the SBREFA and stakeholder meetings. System start-up activities include reading and understanding the rule, mobilization and planning, and employee training. The cost analysis assumes durations for each activity that adequately reflect staffing and expertise typically found in small systems. First, it assumes that system managers (or system operators for systems serving 1,000 or fewer, which are assumed to have no managerial staff) would spend 6 hours reviewing the rule to understand the monitoring provision and how it affects their operations. Second, it assumes that 30 hours are required for mobilization and planning activities, (e.g., assessing current plant operations and employee schedules to develop a strategy for monitoring the turbidity data.) Finally, it assumes 16 hours for additional staff training among systems serving 1,001 to 3,300, and 40 hours for training among systems serving 3,301 to 9,999. There are no training costs for the three smallest system size categories because the first two activities are assumed to be sufficient given their small staff size.

Annual system monitoring activities at the plant level include data analysis, data review, and recordkeeping. Exhibit 6–5 summarizes the activities for each of the three monitoring alternatives EPA developed, and shows that labor hour assumptions differ by system size. The larger size categories will require more time for data analysis and review because they have more filters and, therefore, more turbidimeter readings to review.

Exhibit 6–5. Summary of Labor Requirements for Turbidity Monitoring Alternatives

Compliance Activity	System Size	Alternative T1 (minutes/day)	Alternative T2 (preferred option) (minutes/week)	Alternative T3
Data Analysis	# 1,000	15	10	All systems will require at most 2 hours/month for data analysis, review, and recordkeeping.
	1,001–9,999	30	15	
Data Review	# 1,000	15	10	
	1,001–9,999	30	15	
Recordkeeping	all systems	2 hours/month	2 hours/month	

The burden estimate per system for Alternative T1 is about five times larger than the estimate for Alternative T2 because it requires more data analysis. The burden estimate for Alternative T3 is the smallest because the streamlined exceptions reporting requirement substantially reduces the amount of time operators need to review data. EPA assumed that operators can complete the required Alternative T3 analysis in approximately 24 hours per year compared to slightly higher burdens for Alternative T2 (i.e., 41 to 50 hours across size categories), and substantially higher burdens for Alternative T1 (i.e., 207 to 389 hours).

Estimated annual costs to systems for turbidity monitoring range from $5.6 million for Alternative T3 to $63.3 million for Alternative T1 (Exhibit 6–6). The labor burden for annual monitoring and reporting requirements ranges from 140,000 (T3) to 1.8 million (T1) hours per year. The annualized national system start-up and implementation costs are $1.2 million assuming a 7 percent discount rate. The total labor burden associated with system start-up activities is almost 300,000 hours.

Exhibit 6–6. Annual System Turbidity Start-Up and Monitoring Cost by Alternative (January 1999 dollars)

Compliance Activities	Annual Cost by Alternative ($ millions)		
	Alternative T1	Alternative T2 (preferred)	Alternative T3
Annualized Monitoring Start-Up Cost (7%)[1]	$1.2	$1.2	$1.2
Annual Monitoring Cost	$62.1	$8.8	$4.4
Total Annual Cost[2]	**$63.3**	**$10.1**	**$5.6**

Detail may not add to total due to independent rounding. See Appendices G–1a through G–1f for detail.
[1]Total start-up cost of $13.0 million is annualized over 20 years assuming a 7 percent discount rate. Using the 3 percent discount rate, annualized start-up cost is $0.9 million.
[2]Total annual cost assuming a 3 percent discount rate is $63.0 million (T1), $9.7 million (T2), and $5.3 million (T3).

State Costs

One-time State start-up activities include 12 hours to review the final rule, 120 hours for mobilization and planning activities, and 120 hours for State staff training. The cost analysis assumes that managerial staff account for about 80 percent of these hours and technical staff account for the remaining 20 percent of hours. These assumptions are similar to the cost analysis in the final IESWTR RIA and may overstate costs if similar activities undertaken to implement the IESWTR reduce the subsequent start-up burden for the proposed LT1FBR.

The State's annual responsibility under the rule includes ensuring that all systems are in compliance by reviewing monthly reports from each system. These reports indicate whether individual filter monitoring occurred. State activities also include reviewing exceptions reports, record keeping, and determining compliance. State activities for the proposed rule are based on assumptions made for the cost analysis in the final IESWTR RIA, which were based on interviews with State officials, a review of similar regulatory requirements, and confirmation by the M-DBP Committee. The burdens have been adjusted from the IESWTR RIA assumptions to reflect effort levels more appropriate for tracking compliance for small systems.

Exhibit 6–7 summarizes the estimated State cost of implementing the individual filter turbidity monitoring provision. The rule would collectively cost States an estimated $413,000 in start-up costs. Amortizing this cost at 7 percent results in an annual cost of almost $40,000. The national labor burden for the State program start-up is estimated to exceed 14,000 hours. Annual monitoring costs are $838 per system and the total cost for 5,896 systems is approximately $4.9 million. The annual labor burden is approximately 212,000 hours. These costs are more applicable for alternatives T1 and T2; costs for T3 might be higher because States may need to establish two tracking systems—one for small systems and one for large systems—because the exceptions reporting requirements for small systems differ from the requirements in IESWTR. Maintaining two reporting systems might impose annual costs on States that offset the potential cost-savings of T3. Consequently, EPA believes that T2 may actually be more cost effective in the long run even though the estimated costs of T3 are lower.

Exhibit 6–7. State Turbidity Start-Up and Monitoring Annual Cost (January 1999 dollars)

Compliance Activities	Respondents Affected	Unit Cost ($)	Annual Cost ($ millions)
Annualized Monitoring Start-Up Cost (7%)[1]	56 Entities	$7,373	$0.04
Annual Monitoring Cost	5,896 Systems	$838	$4.94
Total Annual Cost[2]			**$4.98**

See Appendices G–1a, G–1b, and G–1g for detail.
[1]Total start-up cost of $0.4 million is annualized assuming a 20-year time period and a 7 percent discount rate. Assuming a 3 percent discount rate, annualized start-up cost is $0.03 million.
[2]Total annual cost assuming a 3 percent discount rate is $4.97 million.

6.2.3 Individual Filter Monitoring Provision: Exceptions Reporting Costs

If monitoring activities indicate that individual filter turbidity levels exceed certain thresholds, the proposed rule requires that systems submit an exceptions report to the State. If exceedances are persistent, systems may be required to conduct an Individual Filter Assessment (IFA). States will need to review the exceptions reports, and may need to complete Comprehensive Performance Evaluations (CPE).

The regulatory alternatives differ primarily with respect to what turbidity levels trigger an exceptions report. These differences generated a wide range of burden estimates for data collection and analysis activities, which was discussed in the previous section. EPA expects, however, that the overall effect on the number of exceptions reported will be minimal, reflecting comparable levels of filter problem detection and health protection across the alternatives. Exhibit 6–8 summarizes the exceptions reporting requirements for the alternatives. It also describes the conditions under which an IFA and CPE are required.

Exhibit 6–8. Exceptions Reporting, Individual Filter Assessment, and Comprehensive Performance Evaluation Requirements for the Individual Filter Turbidity Monitoring Alternatives

Activity	Alternative T1[1]	Alternative T2[1] (preferred)	Alternative T3[1]
Exceptions Reporting	> 1 NTU > 0.5 NTU[2]	> 1 NTU	> 0.5 NTU ($5%)[3] > 2 NTU
Individual Filter Assessment	> 1 NTU for 3 consecutive months	> 1 NTU for 3 consecutive months	If an exceptions report is required for 3 consecutive months
Comprehensive Performance Evaluation	> 2 NTU for 2 consecutive months	> 2 NTU for 2 consecutive months	> 2 NTU for 2 consecutive months

[1]All standards are based on any two consecutive measurements taken 15 minutes apart, except those noted below.
[2]Based on two consecutive measurements taken 15 minutes apart at the end of the first 4 hours of filter operation.
[3]Based on turbidity levels exceeding 0.5 NTU in at least 5 percent of measurements taken in a month.

Individual filter turbidity measurements are assumed to trigger the equivalent of one monthly exceptions report to the State at 20 percent of all systems each year for Alternatives T1 and T3, generating about 1,179 exceptions reports per year.[8] Based on existing turbidity data, EPA estimated that systems will exceed 0.5 NTU in 5 percent of their measurements each month with the same frequency that they exceed 1 NTU in two consecutive measurements. For Alternative T2, EPA assumed that the equivalent of 18 percent of systems will generate one monthly exceptions report (i.e., 1,061 reports per year); omitting the 0.5 NTU exceptions report trigger (see Exhibit 6–8) leads to this slight reduction. Preparation, submission, and review time is estimated to take 1 hour per exceptions report for all system size categories and all regulatory alternatives. Under T1, EPA assumes that all systems will also require an additional 30 minutes to develop a filter profile. This over estimates costs because some systems will not need to develop a profile. EPA does not have the necessary data, however, to estimate the fraction of systems that will not require a filter profile.

For all alternatives, EPA assumed that 4 percent of all systems each year will conduct an IFA. Consequently, the levels of health protection provided by the monitoring alternatives are expected to be comparable among one another. At this percentage, approximately 236 IFAs will be conducted each year. The cost per IFA assumes that it takes 10 hours to complete at a labor rate of $28/hour for systems with 1,000 or fewer served (costing $280 per IFA). IFAs for systems in the two larger size categories (1,001–3,300 and 3,301–9,999) will cost more ($336 and $432, respectively) because of the more costly mix of technical and managerial labor.

For all alternatives, EPA assumes that each year 2 percent of all systems will require a CPE. Approximately 118 CPEs are assumed conducted each year. The cost estimate assumes that it will require States 60 hours to complete a CPE at systems serving 1,000 or fewer and 120 hours to complete a CPE at larger systems. The assumed labor rate of $100/hour is the same rate used in the IESWTR RIA to approximate a third-party cost including travel expenses.

Exhibit 6–9 summarizes estimated annual costs for water systems and States. System costs for the preferred alternative, which include filing exceptions reports and conducting IFAs, total approximately $0.12 million. States are expected to incur annual costs of $0.09 million to review the exceptions reports and $1.08 million to perform CPEs. Cumulative annual costs for exceptions reports, IFAs, and CPEs total $1.29 million under alternative T2.

Costs for monitoring alternatives T1 and T3 are approximately the same; the difference is that T3 does not include the filter profile requirement for systems. Costs for alternative T2 are lower because of the reduced number of exceptions reports and because it does not include the filter profile requirement for water systems.

[8] This does not mean that 1,179 individual systems will submit a report because systems requiring an IFA or CPE will submit multiple reports.

Exhibit 6–9. System and State Costs for Exceptions Reports, Individual Filter Assessments, and Comprehensive Performance Evaluations (January 1999 dollars)

		Annual Cost ($ millions)		
Compliance Activities	**Annual Occurrence**	**Alternative T1**	**Alternative T2 (preferred)**	**Alternative T3**
System Costs				
Annual Exceptions Reports	1,061–1,179 Reports	$0.07	$0.05	$0.05
Annual IFAs	236 IFAs	$0.08	$0.08	$0.08
Total System Cost		**$0.15**	**$0.12**	**$0.13**
State Costs				
Annual Exceptions Reports	1,061–1,179 Reports	$0.10	$0.09	$0.10
Annual CPEs	118 CPEs	$1.08	$1.08	$1.08
Total State Cost		**$1.18**	**$1.17**	**$1.18**
Total Annual Cost		**$1.33**	**$1.29**	**$1.31**

Detail may not add to total due to independent rounding. See Appendices G–2a and G–2b as well as G–1c through G–1g for detail.

6.3 Disinfection Benchmarking Provision Cost Analysis

To comply with the Stage 1 Disinfectants and Disinfection Byproducts Rule (Stage 1 DBPR) (63 *FR* 69389, December 16, 1998), some small systems that use disinfection may need to alter practices to reduce the presence of disinfection byproducts in finished water. Systems disinfect to reduce the risk of microbial contamination in drinking water. Chemical reactions between the disinfection products and organic material in source water, however, produce disinfection byproducts. Chronic exposure to these byproducts over a long period of time has been associated with health risks such as cancer. Consequently, this provision does not apply to drinking water systems that are classified as transient noncommunity water systems, because the population using these systems changes over time. The benchmarking provision of the proposed LT1FBR will provide information on the current level of *Giardia* inactivation to ensure that altered disinfection practices do not increase risks of microbial infection. It is assumed that the 9,450 small surface water and GWUDI systems that are classified as community or nontransient noncommunity systems are subject to the disinfection benchmarking provision of the proposed rule.

Section 6.3.1 describes the activities systems will undertake to implement this provision and estimates the associated costs. Section 6.3.2 provides the cost analysis for State activities.

6.3.1 System Costs

Systems will incur startup costs and they will implement this provision in two distinct phases: an applicability monitoring phase, which determines whether a system needs to develop a benchmark, and a profile and benchmark development phase. To minimize the potential burden of this provision on systems, EPA developed a set of alternative regulatory requirements for each phase.

Startup Costs

Initial start-up activities—reading and understanding the rule, and mobilizing and planning—and record keeping are assumed to require 20 hours of managerial or technical labor time per affected system. Costs will range from $560 to $864 across the system size categories because wage rates and hour allocations differ. Exhibit 6–10 summarizes total start-up costs.

Exhibit 6–10. Disinfection Benchmark Development Start-up Costs by System Size (January 1999 dollars)

System Size Category (# systems)	Unit Cost ($)	Total Cost ($ millions)
# 500 (3,737)	$560	$2.1
501–1,000 (1,301)	$560	$0.7
1,001–3,300 (2,553)	$672	$1.7
3,301–9,999 (1,859)	$864	$1.6
Total		**$6.1**
Annualized Cost (3%) **Annualized Cost (7%)**		**$0.4** **$0.6**

Detail may not add due to independent rounding. See Appendices G–3a through G–3f for detail.

Applicability Monitoring

Each small system may also be required to obtain water samples to test for total trihalomethanes (TTHM) and five haloacetic acids (HAA5) concentrations, which will determine whether it must develop a disinfection profile and benchmark. EPA evaluated four monitoring alternatives that differ with respect to data collection and analysis burdens on systems.

- Alternative A1: The TTHM and HAA5 monitoring requirements for small systems are the same as the final IESWTR provisions for large systems, which required all systems to obtain four samples in each of 4 quarters. A system may request that the State waive its applicability monitoring requirement.

- Alternative A2: Small systems serving more than 500 are required to obtain one sample in each of 4 quarters. Small systems serving 500 and fewer are required to obtain one sample during the critical period, which is determined by the State, and systems may choose to obtain an optional second sample. A system may request that the State waive its applicability monitoring requirement.

- Alternative A3: All small systems must sample once during a critical period, which is determined by the State. A system may request that the State waive its applicability monitoring requirement.

- Alternative A4: Applicability monitoring is optional and systems do not need to request a State waiver. All systems are required to develop a disinfection profile beginning January 1, 2003, based on weekly calculation of log inactivation of *Giardia* *lamblia*, unless a system opts to perform the applicability monitoring during the month of warmest water temperature in 2002 (i.e., collect one sample), and demonstrates that TTHM and HAA5 levels are less than 80 percent of their respective MCLs. This alternative can only be paired with the second profile development alternative, which is described in the next section. Systems that choose to forego applicability monitoring under the LT1FBR may still need to gather TTHM and HAA5 samples after January 1, 2003, under the Stage 1 DBPR.

Exhibit 6–11 summarizes the disinfection byproduct sampling requirements across the alternatives. EPA assumed that each sample can be used for both a TTHM analysis and an HAA5 analysis. The exhibit summarizes the total number of chemical analyses for each individual alternative (e.g., the total number of analyses for Alternative A1 is 32: 4 sample locations × 2 analyses × 4 quarters). EPA assumes that each sample requires 2 hours of operator time to collect and process, and that total lab fee will be $360 (assuming that it costs $180 to analyze each individual contaminant). Consequently, the labor burden and laboratory fees both decline as the number of required samples declines.

Exhibit 6–11. Summary of Proposed Applicability Monitoring Sampling Alternatives[1]

System Size Category	Alternative A1	Alternative A2	Alternative A3	Alternative A4 (preferred)
# 500	Sample 4 times per quarter for 4 quarters (32 analyses)	Sample once during critical monitoring period[2,3] (2 analyses)	Sample once during critical monitoring period[2] (2 analyses)	Optional sample during warmest water temperature month (2 analyses)
501–9,999	Sample 4 times per quarter for 4 quarters (32 analyses)	Sample once per quarter for 4 quarters (8 analyses)	Sample once during critical monitoring period[2] (2 analyses)	Optional sample during warmest water temperature month (2 analyses)

[1]Each sample will be used for a TTHM analysis and an HAA5 analysis.
[2]The State will determine the critical monitoring period, usually the month of warmest water temperature.
[3]Systems may obtain an additional sample.

Exhibit 6–12 shows total costs by system size category and monitoring alternative. System-level costs for the two smallest size categories are identical, so the exhibit combines those categories. These costs differ across the categories because the labor rate assumptions differ, as noted in Section 6.2. Total annualized cost for the preferred alternative, A4, is either $0.03 million or $0.04 million depending on the discount rate assumption. By comparison, annualized cost for A1 is $4.3 million or $6.0 million.

Exhibit 6–12. Disinfection Benchmark Applicability Monitoring Costs by Alternative and System Size (January 1999 dollars)

System Size Category (# systems)[1]	Alternative A1		Alternative A2		Alternative A3		Alternative A4 (preferred)	
	Unit Cost ($)	Total Cost ($ million)	Unit Cost ($)	Total Cost[2] ($ million)	Unit Cost ($)	Total Cost ($ million)	Unit Cost ($)	Total Cost ($ millions)
# 500 (3,737 / 463)	$6,684	$25.0	$444	$1.9	$444	$1.7	$444	$0.21
501–1,000 (1,301 / 128)	$6,684	$8.7	$1,692	$2.2	$444	$0.6	$444	$0.06
1,001–3,300 (2,553 / 253)	$6,712	$17.1	$1,720	$4.4	$472	$1.2	$472	$0.12
3,301–9,999 (1,859 / 116)	$7,096	$13.2	$1,816	$3.4	$496	$0.9	$496	$0.06
Total		**$64.0**		**$11.9**		**$4.4**		**$0.44**
Annualized Cost (3%)		**$4.3**		**$0.8**		**$0.3**		**$0.03**
Annualized Cost (7%)		**$6.0**		**$1.1**		**$0.4**		**$0.04**

Detail may not add due to independent rounding. See Appendices G–3a through G–3f for detail.
[1]The first number of systems are those assumed to conduct applicability monitoring under A1, A2, and A3; the second number is those assumed to conduct applicability monitoring under A4.
[2]The total cost for Alternative A2 assumes that 15 percent of systems in the #500 size category will collect an optional second quarter sample to get an average DBP level. This assumption is based on the estimate that 29 percent of all systems will need to develop a profile and benchmark and half this amount will collect an optional second sample. Consequently, total cost is slightly higher than the total cost for A3 although unit costs are the same.

The preferred alternative, A4, allows systems to forego applicability monitoring and begin disinfection profile development in 2003. The cost estimates for alternative A4 reported in Exhibit 6–12 assume that almost all systems choose to forego applicability monitoring. This flexibility combined with the lower cost per system reduces applicability monitoring costs by about 99 percent compared to the Alternative A1, which is the most similar to the IESWTR provision for large systems. EPA assumed that the only systems that would choose conduct applicability monitoring would be the 960 systems in States where total organic carbon levels tend to be 2 ppm or lower (Washington, Oregon, Nevada, Idaho, Alaska, Wisconsin, and West Virginia). EPA assumed that these systems could reasonably expect to have TTHM and HAA5 levels below the profiling thresholds and, thereby, would only incur applicability monitoring costs. EPA assumed that all other systems would choose to forego applicability monitoring rather than potentially incur both applicability monitoring and profile development costs. Thus, systems implement either applicability monitoring or profiling; no system performs both. This alternative is more cost effective than A3, which requires the same number of samples per system, but makes monitoring mandatory.

Profile and Benchmark Development Activities

Systems must develop a disinfection profile and may need to develop a benchmark if they choose to forego monitoring under alternative A4 or if applicability monitoring data under any applicability monitoring alternative show that either TTHM or HAA5 are equal to or exceed 80 percent of their respective maximum contaminant levels (MCLs):

- TTHM levels are at least 80 percent of the MCL (i.e., 0.064 mg/L)
- HAA5 levels are at least 80 percent of the MCL (i.e., 0.048 mg/L).

EPA based its assumption regarding the number of small systems on its earlier assumptions for the IESWTR and the Stage 1 DBPR RIAs. The final IESWTR RIA determined that 29 percent of all large systems would need to develop disinfection benchmarks based on data in the 1996 Water Industry Database (WIDB). This percentage reflects the number of systems with levels that are equal to or greater than either 0.064 mg/L for TTHM or 0.048 mg/L for HAA5.[9] The final Stage 1 DBPR RIA reported that approximately 24 percent of large systems would exceed at least one of the thresholds, based on another analysis of 1996 WIDB data. Furthermore, the Stage 1 DBPR RIA compliance forecast assumed that the rate would be applicable to small systems. This analysis makes a similar assumption, but applies the higher rate, 29 percent, to small systems. Preliminary data reviewed by EPA suggest this assumption is within an acceptable range of uncertainty for small systems. Additional data, however, are still under review.

A disinfection benchmark is based on a disinfection profile, which is a compilation of *Giardia lamblia* log inactivation levels (as well as viral inactivation levels for systems using either chloramines or ozone for primary disinfection). System operators will compute log inactivation levels based on measurements of operational data (i.e., disinfectant residual concentration at the first customer and just prior to each additional point of disinfectant addition, contact time during peak flow conditions, temperature, and pH). The disinfection benchmark is lowest level of inactivation in the disinfection profile. It will be used by the system in consultation with the State to evaluate potential changes to disinfection practices that systems may make to comply with the Stage 1 DBPR.

[9] The 1996 Water Industry Data Base (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 0.064 mg/L and/or HAA levels greater than 0.048 mg/L.

EPA considered three alternative data collection regimes for profile development, which are summarized in Exhibit 6–13.[10] The alternatives differ with respect to the total number of profile observations, which depend on the frequency of data collection and the length of the collection period:

- Alternative B1: Daily data collection for 1 year

- Alternative B2: Weekly data collection for 1 year

- Alternative B3: Daily data collection for 1 month.

Exhibit 6–13. Summary of Alternative System-Level Data Collection Requirements for the Disinfection Profile

Collection Requirement	Alternative B1	Alternative B2 (preferred with A4)	Alternative B3
Frequency	Daily	Weekly	Daily
Duration	1 year	1 year	1 month
Total profile observations	365	52	30
Profile burden (hours)	91	13	8
Benchmark burden (hours)	48	48	48

The burden estimate assumed that system operators will use a spreadsheet to calculate inactivation levels and that they will require 15 minutes per observation to collect, enter, and review data. If a benchmark is required because a system plans to alter its disinfection practices, then additional effort is required to develop the benchmark and prepare a report for the State (40 hours) that describes the profile and benchmark calculations and how the proposed change may affect inactivation levels in comparison with the benchmark. Furthermore, the system will require a total of 8 hours on average to meet with the State. Exhibit 6–13 reports the total burden per system for each alternative in hours. Regardless of the differences in system burden, all three alternatives are expected to achieve comparable levels of health protection.

EPA assumes that only 29 percent of affected systems calculate benchmarks, regardless of how many gather profile data because benchmarks need only be calculated when disinfection practices must change. Thus, Exhibit 6–14 reports profile and benchmark costs separately. Exhibit 6-14 also reports supplementary costs for developing viral inactivation profiles and benchmarks, which will be required of a subset of systems changing disinfection practices because they use chloromines or ozone. According to CWSS data, between 0.3 and 2.9 percent of small systems utilize chloromines or ozone and would require the additional profile and benchmark effort.

[10] The Preamble contains an additional “no action” option that is not included in the cost analysis because feedback from small system operators indicated that it is beneficial for them to know their system’s level of microbial inactivation. Furthermore, the public health protection principles developed during the regulation negotiation and Federal Advisory Committee should be applied to small system as well as large systems.

Total costs range from $5.4 million (B3) to $13.6 million (B1). These cost estimates are conservative because they do not include any of potential cost savings from waivers. Systems serving 500 or fewer people can apply for waivers to allow them to submit observed data to the State rather than calculate inactivation levels for the profile. Shifting part of the system's labor burden to the State would decrease the cost estimates because the hourly labor rate assumptions used for State staff are somewhat lower than the system rates.

Overall, B2 costs about 60 percent more than B3 (the lowest cost alternative) because EPA assumed that substantially more systems would forego monitoring and develop profiles. Yet, EPA selected B2 as the preferred alternative because it provides a profile over an entire year rather than one month for a small incremental increase in system-level cost.

Exhibit 6–14. Summary of System Disinfection Profile and Benchmarking Costs by Alternative and System Size (January 1999 dollars)

System Size Category (# systems)	Alternative B1		Alternative B2 (preferred with A4)		Alternative B3	
	Unit Cost ($)	Total Cost ($ million)	Unit Cost ($)	Total Cost ($ million)	Unit Cost ($)	Total Cost ($ million)
Profile Development						
# 500 (1,084/3,274)[1]	$2,583	$2.8	$392	$1.3	$238	$0.3
501–1,000 (377/1,173)[1]	$2,583	$1.0	$392	$0.5	$238	$0.1
1,001–3,300 (740/2,300)[1]	$3,463	$2.6	$541	$1.2	$336	$0.2
3,301–9,999 (539/1,743)[1]	$4,193	$2.3	$645	$1.1	$396	$0.2
Subtotal		**$8.6**		**$4.1**		**$0.8**
Benchmark Development						
# 500 (1,084)	$1,344	$1.5	$1,344	$1.5	$1,344	$1.5
501–1,000 (377)	$1,344	$0.5	$1,344	$0.5	$1,344	$0.5
1,001–3,300 (740)	$1,680	$1.2	$1,680	$1.2	$1,680	$1.2
3,301–9,999 (539)	$2,112	$1.1	$2,112	$1.1	$2,112	$1.1
Subtotal		**$4.3**		**$4.3**		**$4.3**
Supplemental Viral Profile/Benchmark						
# 500 (11)	$3,675	$0.04	$1,484	$0.01	$1,330	$0.01
501–1,000 (4)	$3,675	$0.01	$1,484	$0.01	$1,330	$0.01
1,001–3,300 (74)	$4,751	$0.35	$1,829	$0.14	$1,624	$0.12
3,301–9,999 (39)	$5,865	$0.23	$2,317	$0.09	$2,068	$0.08
Subtotal		**$0.6**		**$0.2**		**$0.2**
Total		**$13.6**		**$8.7**		**$5.4**
Annualized Cost (3%) **Annualized Cost (7%)**		**$0.9** **$1.3**		**$0.6** **$0.8**		**$0.4** **$0.5**

Detail may not add to total due to independent rounding. See Appendices G–3a through G–3f for detail.
[1]In the profile development section, the first number is the number of systems affected by B1 and B3; the second is the number of systems affected by B2, assuming it is paired with A4.

6.3.2 State Costs

Similar to IESWTR, each State will review disinfection benchmarks and meet with systems to approve any significant changes 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). Supporting materials for these consultations must include a description of the proposed change, the disinfection benchmark, and an analysis of how the proposed change will alter 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 systems and consultants. The cost analysis assumes these start-up activities require about 144 hours and cost $3,472 per State. For each of the 9,450 systems affected by the rule, the State must track compliance (e.g., track whether an applicability monitoring or profiling notification was submitted) and keep records. EPA assumes an average burden of 8 hours or $190 per system for all such activities. The burden associated with *Giardia lamblia* benchmark activities such as reviewing data, approving significant changes in disinfection practices, and meeting with systems are assumed to require 32 hours per system and cost $761 per system. Supplementary viral benchmark data review and determination activities will require 16 additional hours and cost $380 per system. The supplementary viral benchmark time estimate is lower because the meeting cost can address both benchmarks. Although meetings require 4 hours for systems, EPA assumed a higher burden for States to account for travel time, which is assumed to average 4 hours per meeting.

Exhibit 6–15 summarizes State costs for reviewing system disinfection benchmarks including start-up and benchmark review costs per State, and total costs for all States**.** As noted above, the State burden would increase if systems serving fewer than 500 people apply for a waiver that would shift part of the system's profiling and benchmark burden to the State.

Exhibit 6–15. State Disinfection Benchmarking Costs (January 1999 dollars)

Compliance Activities	Respondents Affected	Unit Cost ($)	Total Cost ($ millions)
Start-up Cost[1]	56 Entities	$3,472	$0.19
Compliance Tracking/Record Keeping Cost	9,450 Systems	$190	$1.80
Giardia Profile and Benchmark Cost	2,741 Systems	$761	$2.09
Supplemental Viral Benchmark Cost	128 Systems	$380	$0.05
Total Cost			**$4.13**
Annualized Cost (3%) **Annualized Cost (7%)**			**$0.28** **$0.39**

Detail may not add to total due to independent rounding. See Appendices G–3a, G–3b, and G–3g for detail.

[1]The $3,472 unit cost is applicable for B1 and B2. The unit cost for B3 of $3,662 is higher because States need to determine the critical monitoring period. The total startup cost is $0.19 million.

6.4 Covered Finished Water Reservoir Provision Cost Analysis

The proposed LT1FBR requires that small public water systems using surface water or GWUDI 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, disposal of garbage into the reservoir, microbial organisms, 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.

6.4.1 Unit Cost

The calculations for this rule element use a model finished water reservoir, assuming a 10-foot depth for systems serving 3,300 or fewer people, and a 20-foot depth for systems serving 3,301 to 9,999 people. It assumes a reservoir storage volume equal to 1 day of average water flow capacity for each system size category. Cover costs are approximately $2.00 per square foot for a floating cover. O&M costs include visual inspections, cleaning, and repair expenses. Exhibit 6–16 summarizes the capital and O&M costs by system size.

Exhibit 6–16. Unit Cost Assumptions to Cover New Finished Water Reservoirs

System Size	Reservoir Volume (ft^3)	Cover Area (ft^2)	Capital Cost ($)	O&M Cost ($)
#100	936	94	$188	$3,370
101–500	3,743	375	$750	$2,860
501–1,000	10,027	1,003	$2,006	$4,423
1,001–3,300	28,476	1,424	$2,848	$4,067
3,301–9,999	100,000	5,000	$10,000	$7,501

6.4.2 Compliance Forecast

The analysis of costs for covering new finished water reservoirs is complicated by the lack of data regarding the construction of reservoirs over the next 20 years. The precise number of systems constructing finished water reservoirs is unknown. Because the proposed rule requires all systems constructing finished water reservoirs to cover them, its cost impact is only on those that were not originally planning to construct covers. EPA assumes that future construction rates can be approximated by historical rates and assumes that no small systems would include storage covers without the proposed rule. Historical construction rates suggest that new reservoirs over the next 20 years will roughly equal 5 percent of the existing number of systems. Exhibit 6–17 summarizes the number of new storage reservoirs affected by the proposed rule.

6.4.3 System Costs

Exhibit 6–17 summarizes the total cost by system size. Total annual costs, including annualized capital costs and 1 year of O&M costs, are expected to be $2.55 million or $2.59 million depending on the discount rate. This estimate over states costs because it assumes that the new storage facilities are built in the first year rather than over a 20-year period.

Exhibit 6–17. Total Cost Estimates to Cover New Finished Water Reservoirs (January 1999 dollars)

System Size	Number of New Reservoirs	Total Annualized Cost (3%) ($ millions)	Total Annualized Cost (7%) ($ millions)
#100	140	$0.474	$0.475
101–500	143	$0.416	$0.419
501–1,000	70	$0.319	$0.323
1001–3,300	132	$0.560	$0.570
3,301–9,999	95	$0.776	$0.802
Total	**580**	**$2.545**	**$2.589**

Detail may not add to total due to independent rounding. See Appendix C–9 for detail.

6.5 Recycle Provisions Cost Analysis

Unlike the provisions discussed above, the proposed recycle provisions apply to both large and small surface water or GWUDI systems. The recycle provisions primarily affect three types of systems. Exhibit 6–18 summarizes the number of systems potentially affected by system type and size category.

- **Systems that do not return recycle prior to the point of primary coagulant addition**, defined as systems employing rapid granular filtration that currently return spent filter backwash, thickener supernatant, or liquids from dewatering processes concurrent with or downstream from the point of primary coagulant addition, will need to move the reintroduction point unless the State grants a waiver for an alternative location.

- **Direct recycle systems** that employ conventional rapid granular filtration treatment, use 20 or fewer filters to meet production requirements during the highest production month in the 12-month period prior to the proposed rule's compliance date, and recycle spent filter backwash or thickener supernatent to the primary treatment process will be required to conduct a recycle self assessment to determine whether it exceeds its State approved operating capacity during recycle events and consult with the State to determine whether changes to recycle practices are necessary. Alternatively, EPA also considered requirements that all direct recycle systems construct a flow equalization basin or a sedimentation basin.

- **Direct filtration systems** that recycle to the primary treatment process will be required to report their recycling practices to the State, which will decide if changes to recycle practices are necessary. EPA also evaluated an alternative requirement that these systems install a sedimentation basin.

Exhibit 6–18. Systems Potentially Affected by the Proposed Recycling Provisions

Type of System Affected by a Provision[1]	System Size		
	Small Systems <10,000	Large Systems $10,000	Total
Total rapid granular filtration systems that recycle	3,538	1,098	4,636
Systems moving recycle return to point prior to primary coagulant addition	569	221	791
Direct recycle systems	757	342	1,099
Direct filtration systems	248	77	325

Detail may not add to total due to independent rounding.
Note: To be consistent with the baseline numbers in Chapter 4, these system estimates exclude seven individual plants that belong to systems serving more than one million people, which have been included in the cost analysis as indicated in Appendices C–13, D–11, E–11, and G–4 through G–6. See footnote 11 for discussion.
[1] EPA is considering an alternative under which conventional filtration systems that currently have flow equalization basins would be required to provide sedimentation or more advanced treatment. This alternative would affect an additional 296 small conventional systems and an additional 141 large conventional systems for a total of 437 conventional systems.

EPA considered four regulatory alternatives for the recycle provisions. The alternatives are discussed in detail in Chapter 3 (see Exhibit 3–4 for a summary). The alternatives differ with respect to their affect on the three types of systems described above.

- Alternative R1 requires all systems to return spent filter backwash, thickener supernatant, and liquids from dewatering to a point prior to primary coagulant addition, unless the State grants a waiver. Systems that must change their recycle practices are required to submit a plant schematic, which shows the current return location(s) and the proposed new return location, to the State. This provision is the same for all of the alternatives.

- Alternative R2 requires direct recycle systems to conduct a self assessment and report the results to the State, and it requires direct filtration systems to report their recycle practices to the State. In both instances, the State will make determinations regarding changes in recycle practices. The requirement for the return flow location is the same as R1.

- Alternative R3 has the same requirements as R2 for direct filtration systems and the recycle return location. It differs from R2 in that all direct recycle systems are required to install a flow equalization basin; no self assessment is required, although States must still review basin installation plans.

- Alternative R4 requires that all systems provide treatment for recycle flows that is equivalent to or more advanced than sedimentation. This affects all systems that practice direct recycle, direct filtration systems that do not have recycle treatment, and conventional filtration systems that only provide flow equalization for recycle streams. The requirement for recycling prior to the point of primary coagulant addition is the same as R1.

Sections 6.5.1 through 6.5.3 describe the system expenditures to modify practices and labor burdens for systems and States across the various alternatives for the new return location, direct recycle, and direct filtration provisions, respectively. Section 6.5.4 summarizes costs for the four regulatory alternatives.

Cost estimates for all three provisions include capital and O&M costs. As described in *The Cost and Technology Document for the Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Rule* (U.S. EPA, 1999b), unit capital and O&M costs were estimated using engineering models and system-level flow rates. Using these unit costs to develop cost estimates for large systems introduced some uncertainty because total system flows at large systems—especially systems serving more than 100,000—may be treated by two or more plants, some of which may not recycle flow to the treatment process. Consequently, EPA potentially overestimated compliance costs for large systems that do not need to change recycle practices at all of their plants. Conversely, EPA may have underestimated compliance costs for large systems that need to change recycle practices for all of their plants because installing new equipment at two or more plants with smaller flow rates may cost more than estimated unit cost of installing equipment at a single large plant that handles the same flow rate. Although these biases will tend to offset one another, EPA cannot determine whether total costs are more likely to be over or under estimated because it does not have details about the plant configurations of all large plants that recycle.[11]

6.5.1 Recycle to New Return Location

Under Alternative R1, systems that do not return select recycle flows prior to the point of primary coagulant addition will be required to move the return point to this location. As noted in Exhibit 6–18, an estimated 791 systems will need to move their recycling return point. EPA based this estimate on information provided by a sample of large and small systems that responded to a 1998 AWWA survey on recycle practices (AWWA, 1998) and plant schematics gathered under the Information Collection Rule (61 *FR* 24354, May 14, 1996). The data were not sufficient to allow EPA to distinguish practices for system size categories and system types. EPA was able to obtain, however, a single percentage (25 percent) for all direct recycle system size categories, and two percentage estimates for the systems with recycle treatment (15 percent for small systems and 20

[11] The exception to this approach is EPA's analysis of systems serving more than 1 million. EPA used the schematic of ICR systems and SDWIS to determine whether these systems would be affected by the recycle provisions. First, EPA identified 17 systems in SDWIS that serve populations greater than 1 million. Then EPA identified schematics of the individual plants within these systems. Of the 24 plants identified, only seven would be affected by the rule. Two plants (both serving 10,000 to 50,000) would have to move their recycle return location, one plant (serving 10,000 to 50,000) would be required to perform a self assessment, and four direct filtration plants (two serving 50,000 to 100,000 and two serving more than 100,000) would be required to submit data on their recycle practice to the State. EPA included these individual plants in the cost analysis, with the exception of one direct filtration plant that alone served more than 1 million.

percent for large systems). Further analysis of the data for direct recycle systems showed that large and small systems recycle prior to the point of primary coagulant addition at roughly the same frequency.

EPA excluded direct filtration plants from this cost analysis because available data on the return location of these plants suggest that almost all of them already return recycle prior to the point of primary coagulant addition. Only one plant out of 37 direct filtration plants in EPA's database returned recycle after primary coagulant addition. Many direct filtration plants may be configured in a manner that makes returning recycle prior to primary coagulant addition the logical location.

The proposed rule requires each of these systems to prepare documentation that describes its plans to move recycle return to a new location. This documentation will be submitted to the State for review. EPA estimated system and State burdens for these activities. Subsequent to State approval of plans, systems will need to install additional pipe and may need to install additional pump capacity to recycle to the new location. Additional energy will be required to pump water the extra distance, which raises annual operating costs. Thus, EPA also estimated capital and O&M expenditures associated with these changes in recycling practices. The aggregate burden, capital, and O&M costs, all of which are described below, do not differ across the alternatives because this provision remains the same.

Some systems may require a recycle return location other than the one specified in the proposed rule to maintain optimal performance. The proposed rule allows these plants to apply for a waiver to recycle to an alternative location. States will review the waivers and decide whether to approve them. EPA did not have information sufficient to estimate how many of the approximately 791 systems that return recycle concurrent with or below the point of primary coagulant addition will apply for and qualify for a waiver. Consequently, EPA's cost analysis assumed that all of these systems will develop and implement plans to move their point of recycle return. This assumption overstates costs for these systems because the cost of applying for a waiver will be less than the combined cost of planning and moving the recycle influent.

System Start-up and Reporting Costs

EPA assumed that systems will incur start-up and reporting costs for the following activities: read and understand the rule, mobilize and plan, prepare and submit plan to State, meet with State, and maintain records. The system-level burden across these activities is 50 hours. Exhibit 6–19 summarizes total costs by system size category. Total cost is $1.5 million, and annualized cost is approximately $0.10 million to $0.14 million depending on the discount rate assumption.

Exhibit 6–19. Total Annualized System Costs for Reporting Proposed New Return Location by System Size (January 1999 dollars)

System Size (# systems)	Alternatives R1, R2, R3, and R4	
	Unit Cost ($)	**Total Cost ($ millions)**
# 1,000 (267)	$1,400	$0.4
1,001–3,300 (160)	$1,764	$0.3
3,301–9,999 (143)	$2,208	$0.3
$ 10,000 (221)[1]	$2,224	$0.5
Total		**$1.5**
Annualized Cost (3%) **Annualized Cost (7%)**		**$0.10** **$0.14**

Detail may not add to total due to independent rounding. See Appendices G–4a through G–4c for detail.
[1]Total cost includes two plants for systems serving more than 1 million in addition to the 221 systems serving 10,000 to 1 million.

State Start-up and Review Costs

State start-up activities include reading and understanding the rule, mobilizing and planning, and training State staff. EPA estimated that these activities will require an average of 51 hours per State. States will also need to review the plans submitted by systems, and meet with systems to discuss proposed recycling changes. These activities will require about 12 hours per system. Total costs for all State activities, which are summarized in Exhibit 6–20, are $0.29 million; annualized costs are $0.02 million to $0.03 million depending on the discount rate assumption.

Exhibit 6–20. State Cost Estimate to Review and Approve Plans to Move Recycle Return Location (January 1999 dollars)

Compliance Activities	Respondents Affected	Unit Cost ($)	Total Cost ($ millions)
State Start-up Cost	56 Entities	$1,187	$0.07
State Plan Review Cost[1]	791 Systems	$278	$0.22
Total Cost			**$0.29**
Annualized Cost (3%) **Annualized Cost (7%)**			**$0.02** **$0.03**

Detail may differ from total due to independent rounding. See Appendices G–4a, G–4b, and G–4d for detail.
[1]Total cost includes 791 systems serving 10,000 to 1 million and two plants that belong to systems serving more than 1 million.

Recycle to New Return Location Capital Costs

Appendices C–11 and C–12 summarize the capital and O&M costs per system for conventional filtration systems that need to redirect their recycle flows prior to the point of primary coagulant addition. EPA (1999b) discusses how these costs were derived.
To obtain total annualized costs for this provision, unit costs were first multiplied by the 791 systems EPA assumed would move their recycle return location. Capital costs were annualized

over a 20-year period assuming either a 3 percent or a 7 percent discount rate. EPA added 1 year of O&M expenditures to annualized capital costs to obtain total annualized costs. Appendices D and E provide detail cost estimates by system size category and Exhibit 6–21 summarizes costs. The total cost of this provision is $13.8 million or $16.7 million, depending on the discount rate assumption. The cost to move recycle prior to primary coagulant addition is the same for all four alternatives.

Exhibit 6–21. Total Annualized Costs for Recycling to Return Location by System Size (January 1999 dollars)

System Size (# systems)	3% Discount Rate ($ millions)	7% Discount Rate ($ millions)
# 1,000 (267)	$0.9	$1.0
1,001–3,300 (160)	$0.7	$0.8
3,301–9,999 (143)	$1.0	$1.1
$ 10,000 (221)[1]	$11.2	$13.8
Total	**$13.8**	**$16.7**

Detail may differ from total due to independent rounding. See Appendices D–12 and E–12 for detail.
[1]Total cost includes expected modification costs (i.e., probability of modification multiplied by unit cost) for the two plants that belong to systems serving 1 million or more.

6.5.2 Direct Recycle Provision Costs

EPA considered three alternative approaches to address the risks posed by direct recycle practices, and costs for each provision include a burden component as well as capital and O&M expenditures. Alternative R2 requires systems to conduct a single one-month hydraulic self assessment and report the findings to the State. Subsequent requirements to modify recycle practices are at the discretion of the State. EPA estimate a cost range for this alternative to incorporate uncertainty regarding the indirect costs of State determinations.

Alternative R3 does not require a self assessment, although system and State start-up costs are still applicable because it requires that all direct recycle systems provide flow equalization for their recycle flows. Consequently, the cost analysis for that alternative includes capital costs and O&M costs associated with this change in recycle practice. Alternative R4 also has capital and O&M cost components for sedimentation basins as well as system and State start-up costs, although no self assessment is required. This section describes the start-up costs, self assessment costs, and treatment costs for all three alternatives.

System Start-up Costs

Under all three alternatives, systems will incur start-up costs. System start-up costs include reading and understanding the rule, mobilization and planning, and record keeping. EPA estimated these activities will require approximately 44 hours for systems serving 1,000 and fewer and 46 hours for larger systems. The cost per system ranges from approximately $1,200 to $2,000 depending on system size.

System Reporting and Consultation Costs

Under R2, a system will also need to perform a recycle self assessment for Alternative R2 if it satisfies ***all*** of the four following criteria.

- The system uses surface water or GWUDI as a source and employ conventional rapid granular filtration treatment
- The system employs 20 or fewer filters to meet production requirements during the highest production month in the 12-month period prior to LT1FBR's compliance date
- The system recycles spent filter backwash or thickener supernatant directly to the treatment process (i.e., recycle flow is returned within the treatment process of a PWS without first passing the recycle flow through a treatment process designed to remove solids, a raw water storage reservoir, or some other structure with a volume equal to or greater than the volume of spent filter backwash water produced by one filter backwash event).

The proposed rule requires that each affected system identify the month with the highest water production in the calendar year preceding the proposed rule's effective date. During the 12-month period after the effective date, a system must monitor one recycle event per day for that month and estimate the combined raw water influent and recycle flow rate. It must prepare and submit a self assessment report to the State that provides all of the flow rate monitoring data along with other descriptions of filter operation and recycling practices. Prior to conducting the self assessment, each system must submit a monitoring plan to the State that describes how it will conduct the self assessment.

EPA estimated that the monitoring plan and self assessment activities will require 46 to 54 hours, which includes 45 minutes per day for monitoring and flow rate calculation and 16 hours to prepare the self assessment report for the State. Any systems needing to modify recycle practices will also need to consult with the State to review the modifications. EPA assumed this will require a total of 8 hours. Costs per system range from $1,500 to $2,800 and vary with system size because the labor rate assumptions and labor mix between operator and manager as well as the burden assumptions differ by size.

Exhibit 6–22 summarizes total direct recycle provision cost estimates by system size category, combining the three smallest categories in one entry and all of the large systems in another. For Alternatives R3 and R4, EPA assumed that all direct recycle systems incur consultation costs in addition to start-up costs because these alternatives require significant changes in recycle practices. Consultation costs are for meetings with the State to review plans to install either a flow equalization basin or a sedimentation basin.

Exhibit 6–22 also reports total cost by system size category. Total cost ranges from $2.2 million (R3) to $3.9 million (R2). Annualized cost for the preferred alternative is $0.26 to $0.36 million depending on the discount rate assumption.

Exhibit 6–22. Total System Start-up and Self Assessment Costs by System Size for the Direct Recycle Provision (January 1999 dollars)

System Size (# systems) [1]	Alternative R2 (preferred) ($ millions)	Alternative R3 ($ millions)	Alternative R4 ($ millions)
# 1,000 (355/494)	$0.9	$0.5	$0.7
1,001–3,300 (212/296)	$0.7	$0.4	$0.6
3,301–9,999 (190/264)	$0.8	$0.5	$0.6
$ 10,000 (342/483)[2]	$1.5	$0.8	$1.2
Total Cost	**$3.9**	**$2.2**	**$3.1**
Annualized Cost (3%) **Annualized Cost (7%)**	**$0.26** **$0.36**	**$0.15** **$0.21**	**$0.21** **$0.30**

Detail may differ from total due to independent rounding. See Appendices G–5a through G–5c for detail.
[1] Total cost for R2 and R3 is based on the first system estimate, which is the number of direct recycle systems. Total cost for R4 is based on the second system estimate, which includes all direct recycle systems and all other conventional filtration systems that do not already have a sedimentation basin for their recycle stream.
[2] The cost estimates include one plant belonging to a system that serves more than 1 million in addition to the 342 or 483 systems serving 10,000 to 1 million.

State Start-up and Review Costs

State activities under this provision include start-up activities such as reading and understanding the rule, mobilizing and planning and staff training, and activities that depend on the number of systems such as reviewing the monitoring plans and self assessments, determining which systems need to change their recycling practices, reviewing changes to recycle practices, and record keeping. EPA assumed that start-up activities will require 106 hours per State and that reviewing the monitoring plans and self assessments and making determinations under R2 will require 31 hours per system on average. Additional activities such as meeting with systems to discuss changes to recycle practices and keeping records will require 12 hours per system, and follow-up inspections will require 8 hours per system. Under alternatives R3 and R4, all these burdens will accrue to States except the 31 hours to review the monitoring plan and the self assessment and make determinations.

Exhibit 6–23 summarizes State costs across the alternatives. Total cost ranges from $0.50 million to $0.77 million. The annualized value for the preferred alternative is $0.05 million or $0.07 million depending on the discount rate assumption.

Exhibit 6–23. Total State Start-up and Review Costs for the Direct Recycle Provision (January 1999 dollars)

Compliance Activities	Alternative R2 (preferred) ($ millions)	Alternative R3 ($ millions)	Alternative R4 ($ millions)
Start-up Costs	$0.14	$0.14	$0.14
Review and Follow-up Costs	$0.63	$0.36	$0.50
Total Cost	**$0.77**	**$0.50**	**$0.64**
Annualized Cost (3%) **Annualized Cost (7%)**	**$0.05** **$0.07**	**$0.03** **$0.05**	**$0.04** **$0.06**

Detail may differ from total due to independent rounding. See Appendices G–5a, G–5b, and G–5d for detail.

Direct Recycle Capital and O&M Costs

Under Alterative R2, States will determine which systems need to change recycle practices under this provision. For this alternative, EPA estimated the potential indirect costs of the proposed rule with respect to these follow-on investments. To develop a compliance forecast, EPA first estimated how many systems are likely to exceed capacity during recycle events based on the results of the AWWA Survey (AWWA, 1998). Then, EPA determined the types of process changes systems might implement to ensure they remain below State approved operating capacity during recycle events, and estimated how many of the systems exceeding capacity would implement each one. These compliance forecast results were multiplied by annualized per system capital costs and O&M costs to obtain total annual costs.

This method may over estimate costs for R2 because State determinations may lead to fewer changes in recycle practices than EPA estimated. Consequently, EPA developed a cost range to account for uncertainty regarding State determinations. The high cost for the range is based on the method described above. EPA has no additional information, however, to develop a plausible estimate for minimum indirect costs. Consequently, the lower cost estimate is a bounding estimate based the assumption that State determinations do not require any systems to alter their recycle practices.

For Alternative R2, EPA identified eight modifications that systems could implement. Appendix C lists these modifications and shows the unit capital and O&M costs by system size. *The Cost and Technology Document for the Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Rule* (U.S. EPA, 1999b) describes how EPA derived the unit costs using engineering models, existing cost and technology documents, and best engineering judgment.

Appendix C also reports the number of systems that EPA assumes will implement each modification under this regulatory alternative. Using responses to the AWWA (1998) survey of recycling practices, EPA determined that 359 systems potentially exceed their design capacity during recycle events. To make this determination, EPA calculated the sum of an instantaneous backwash flow rate and an instantaneous peak system flow rate and compared this sum to the design flow rates reported in the AWWA survey.

Under Alternative R3, all direct recycle systems would be required to provide flow equalization treatment for recycle flows. This alternative has higher costs than R2 because it requires all of the 1,099 direct recycle systems to make modifications. EPA assumed that all systems would install a flow equalization basin, which may over estimate costs because some systems may choose a lower cost option such as discharging recycle flows.

Alternative R4 requires that all systems that recycle provide treatment for their recycle stream equivalent to or more advanced than sedimentation. EPA assumed that all of the 1,099 direct recycle systems would install sedimentation basins under this alternative. Furthermore, the provision would affect approximately 437 conventional filtration plants that currently have flow equalization basins. The analysis assumes that these conventional systems would also install sedimentation basins.

Exhibit 6–24 summarizes total annualized costs by system size for each alternative. Annualized costs include annualized capital costs (assuming a 20-year period and either a 3 or 7 percent discount rate) and one year of O&M expenditures. The treatment costs for Alternative R4 are substantially higher than costs for R2 or R3.

Exhibit 6–24. Total Annualized Costs to Modify Recycling Practices for the Direct Recycle Provision by System Size and Regulatory Alternative (January 1999 dollars)

System Size (#systems)[1]	Alternative R2 (preferred) ($ millions)[2]		Alternative R3 ($ millions)		Alternative R4 ($ millions)	
	3%	7%	3%	7%	3%	7%
# 1,000 (142/355/494)	$0–$0.6	$0–$0.6	$3.0	$3.3	$10.4	$13.6
1,001–3,300 (85/212/296)	$0–$0.9	$0–$1.0	$4.2	$5.3	$7.3	$9.5
3,301–9,999 (76/190/264)	$0–$1.4	$0–$1.5	$4.6	$5.9	$9.1	$11.7
$ 10,000[3] (57/342/483)	$0–$1.7	$0–$2.3	$17.5	$23.3	$75.6	$98.2
Total	**$0–$4.6**	**$0–$5.4**	**$29.3**	**$37.8**	**$102.4**	**$132.9**

Detail may differ from totals due to independent rounding. See Appendices D–12 and E–12 for detail.
[1]Costs for Alternative R2 are based on the first system number, which is direct recycle systems currently exceeding capacity; costs for R3 are based on the second system number, which is all direct recycle systems; and costs for R4 are based on the third system number, which is all direct recycle systems plus other conventional filtration systems without sedimentation treatment for recycle streams.
[2]The cost range for R2 assumes a lower bound of no costs for recycle practice modifications and an upper bound based on the modification costs of EPA's assessment of the number of systems that exceed State approved capacity.
[3]The costs include expected costs for one plant that belongs to a system serving more than 1 million in addition to the estimates of affected systems serving 10,000 to 1 million.

6.5.3 Direct Filtration Provision Costs

EPA estimated that direct filtration plants account for approximately 7 percent of all plants that use conventional or direct filtration. Because these plants do not have sedimentation basins in their main treatment train, recycling can lead to higher concentrations of *Cryptosporidium* oocysts in the system compared to conventional filtration systems, unless recycle streams are treated to remove oocysts. Based on the AWWA Survey (1998) and the schematics from ICR systems, EPA estimated that 7 percent of all direct filtration systems do not currently provide treatment for their recycle streams. This equals approximately 23 systems across all size categories.

Alternatives R2 and R3 require that all direct filtration systems report their recycling practices to the State, which will determine whether changes in those practices are necessary. EPA also evaluated a provision, Alternative R4, that requires these systems to install sedimentation basins or more advanced treatment if they do not already provide treatment for recycle streams.

The cost analysis includes system and State reporting costs and capital and O&M costs to modify recycle practices. System modification costs for R2 and R3 will ultimately depend on the States' determinations, but EPA developed a cost range using a method similar to the one described above for the direct recycle provision.

System Start-up and Reporting Costs

EPA estimates that it will require about 23 hours per system to complete start-up activities such as reading and understanding the rule, and mobilization and planning. Small and large systems will require another 6 or 12 hours, respectively, to compile the information for the report, which includes:

- Whether recycle flow treatment or equalization is in place
- The type of treatment provided for the recycle flow
- If equalization, sedimentation, or some type of clarification process is used, the physical dimensions of the unit (i.e., sufficient for calculating its volume) and the type, typical dose, and frequency at which treatment chemicals are used.
- The minimum and maximum hydraulic loading the unit experiences
- The maximum backwash rate, duration, typical filter run length, and the number of filters at the plant.

Record keeping will require an additional 4 hours per system. Finally, systems that are required to modify recycling practices will spend approximately 8 hours meeting with the State to discuss the modifications.

For R4, EPA assumes that all direct filtration systems will spend 8 hours reading and understanding the rule. Only those systems that do not currently provide treatment for recycle streams will also incur costs for mobilizing and planning (15 hours), meeting with the State (8 hours) to review plans to install sedimentation basins or provide more advanced treatment, and record keeping (4 hours).

Exhibit 6–25 reports total costs and annualized costs for system start-up and reporting activities by system size category. Total costs range from $0.12 million to $0.42 million across the alternatives; costs for Alternatives R2 and R3 are identical because the reporting requirements are the same. Annualized costs for the preferred alternative are $0.03 million to $0.04 million depending on the discount rate assumption.

Exhibit 6–25. Total System Start-up and Reporting Costs for the Direct Filtration Provision by System Size (January 1999 dollars)

System Size (# systems)[1]	Alternative R2 (preferred) ($ millions)	Alternative R3 ($ millions)	Alternative R4 ($ millions)
# 1,000 (116/8)	$0.11	$0.11	$0.03
1,001–3,300 (70/5)	$0.08	$0.08	$0.02
3,301–9,999 (62/4)	$0.09	$0.09	$0.03
$ 10,000[2] (77/5)	$0.14	$0.14	$0.03
Total Cost	**$0.42**	**$0.42**	**$0.12**
Annualized Cost (3%) **Annualized Cost (7%)**	**$0.03** **$0.04**	**$0.03** **$0.04**	**$0.01** **$0.01**

Detail may differ from totals due to independent rounding. See Appendices G–6a through G–6c for detail.
[1]The first system numbers indicate systems that incur all start-up and reporting costs under R2 and R3, and start-up costs under R4. The second number indicates systems that incur State consultation costs to discuss changes to recycling practices under all three alternatives.
[2]Costs include three plants that belong to systems serving more than 1 million in addition to the estimated number of systems serving 10,000 to 1 million.

State Start-up and Review Cost

Under Alternatives R2 and R3, States should use the reports to determine which plants need to change their recycle practice to provide additional public health protection. State start-up activities include 51 hours for reading and understanding the rule, mobilization and planning, and training. For these two alternatives, EPA assumed that States will spend 6 hours reviewing a system's report, 20 hours making a determination for each system, and 4 hours for record keeping. The State may waive the reporting requirement at the plant operator's request if the State already has sufficient data to determine whether a plant has recycle treatment in place, and has information to make an assessment of treatment provided. EPA did not estimate how many systems this waiver provision might affect so the cost estimate may overstate costs. EPA's analysis assumes that State follow-up activities such as consultations and inspections will require 16 hours for each system making modifications to its recycle practices. Total costs for all States range from $0.10 million to $0.16 million (Exhibit 6–26) and the annualized costs for the preferred alternative are $0.011 million or $0.015 million depending on the discount rate assumption.

Exhibit 6–26. Total State Start-up and Review Costs for the Direct Filtration Provision (January 1999 dollars)

Compliance Activities	Alternative R2 (preferred) ($ millions)	Alternative R3 ($ millions)	Alternative R4 ($ millions)
State Start-up Costs	$0.07	$0.07	$0.07
State Review and Follow-up Costs	$0.09	$0.09	$0.04
Total Cost	**$0.16**	**$0.16**	**$0.10**
Annualized Cost (3%) **Annualized Cost (7%)**	**$0.011** **$0.015**	**$0.011** **$0.015**	**$0.007** **$0.010**

Detail may differ from totals due to independent rounding. See Appendices G–6a through G–6c for detail.

Direct Filtration Capital and O&M Costs

For Alternatives R2 and R3, States will determine whether modifications to recycle practices are necessary. Consequently, the potential capital and O&M costs for these alternatives are uncertain. EPA estimated a cost range to reflect the degree of uncertainty. For the high cost, EPA assumed that States would require modifications for the 23 direct filtration systems that EPA estimated do not provide recycle treatment. EPA identified four modifications that direct filtration systems might use to treat or discharge recycle flows. Appendix C summarizes the unit costs for each option by system size category. The low cost assumes no modifications are required by States. For Alternative R4, EPA assumed that 23 systems would install a sedimentation basin.

For each system size category, unit costs were multiplied by the number of affected systems to obtain total costs for that category. Amortized capital costs (assuming a 20-year period and either 3 percent or 7 percent discount rate) and annual O&M costs were summed across the system size categories to obtain total annual costs. Exhibit 6–27 summarizes costs by system size and discount rate and includes low and high cost ranges for Alternatives R2 and R3. Annualized high costs range from $1.56 million to $1.65 million across the alternatives, assuming a 7 percent discount rate.

Exhibit 6–27. Annualized Costs for Altering Recycle Practices for the Direct Filtration Provision by System Size (January 1999 dollars)

System Size (# systems)	Alternative R2 (preferred) ($ millions)		Alterative R3 ($ millions)		Alternative R4 ($ millions)	
	3%	7%	3%	7%	3%	7%
# 1,000 (8)	$0–$0.04	$0–$0.05	$0–$0.04	$0–$0.05	$0.17	$0.22
1,001–3,300 (5)	$0–$0.05	$0–$0.06	$0–$0.05	$0–$0.06	$0.12	$0.16
3,301–9,999 (4)	$0–$0.10	$0–$0.11	$0–$0.10	$0–$0.11	$0.15	$0.19
$ 10,000 (5)[1]	$0–$1.32	$0–$1.44	$0–$1.32	$0–$1.44	$0.76	$0.99
Total	**$0–$1.51**	**$0–$1.65**	**$0–$1.51**	**$0–$1.65**	**$1.20**	**$1.56**

Detail may not add to total due to independent rounding.
[1]Costs include expected costs (i.e., unit costs multiplied by the probability of each system incurring costs) for three plants that belong to systems serving more than 1 million in addition to the estimated number of systems serving 10,000 to 1 million.

6.5.4 Summary of Costs by Regulatory Alternative

Exhibit 6–28 summarizes the results of the cost analyses described in the previous sections by provision and regulatory alternative. Annualized costs for the preferred alternative, R2, are $14.3 million or $24.5 million depending on the discount rate assumption. The alternative with the lowest cost is R1, which does not address direct recycle or direct filtrationsystems. Costs for Alternative R2 are the lowest of the three alternatives that address direct recycle and direct filtration systems because it gives systems the greatest flexibility regarding recycle practice changes.

Exhibit 6–28. Total Annual System and State Costs by Recycling Provision and Regulatory Alternative (January 1999 dollars)

Provision	Alternative R1 ($ millions)	Alternative R2 (preferred) ($ millions)	Alternative R3 ($ millions)	Alternative R4 ($ millions)
3% Discount Rate				
Recycle Location	$13.9	$13.9	$13.9	$13.9
Direct Recycle	—	$0.3–$4.9	$29.5	$102.6
Direct Filtration	—	$0.04–$1.5	$0.04–$1.5	$1.2
Total	**$13.9**	**$14.3–$20.4**	**$43.5–$45.0**	**$117.8**
7% Discount Rate				
Recycle Location	$16.9	$16.9	$16.9	$16.9
Direct Recycle	—	$0.4–$5.9	$38.1	$133.3
Direct Filtration	—	$0.1–$1.7	$0.1–$1.7	$1.6
Total	**$16.9**	**$17.4–$24.5**	**$55.0–$56.7**	**$151.8**

Detail may not add to total due to independent rounding.

6.6 Summary of Costs

National costs for the proposed LT1FBR are the sum of costs across the compliance forecasts. The turbidity treatment and recycle modifications selected for the forecasts omit potential double-counting of costs across the provisions. Exhibit 6–29 summarizes the estimate of total annual national costs for the preferred LT1FBR alternatives:

- Turbidity Monitoring: Alternative T2
- Disinfection Benchmarking Applicability Monitoring: Alternative A4
- Disinfection Profiling and Benchmarking: Alternative B2
- Recycle: Alternative R2.

Exhibit 6–29. Total Annual Costs for Two Combinations of Alternatives (January 1999 dollars)

Compliance Activity	Preferred Alternatives ($ millions)		IESWTR Alternatives ($ millions)	
	3%	**7%**	**3%**	**7%**
System Costs				
Turbidity Treatment	$47.42	$52.23	$47.42	$52.23
Turbidity Monitoring	$9.71	$10.06	$62.98	$63.34
Turbidity Exceptions	$0.12	$0.12	$0.15	$0.15
Disinfection Benchmarking	$1.03	$1.44	$5.63	$7.90
Covered Finished Storage	$2.55	$2.59	$2.55	$2.59
Recycle Return Location	$13.91	$16.88	$13.91	$16.88
Direct Recycle[1]	$4.86	$5.80	$4.86	$5.80
Direct Filtration[1]	$1.54	$1.69	$1.54	$1.69
Total System Costs	$81.14	$90.82	$139.04	$150.59
State Costs				
Turbidity Monitoring	$4.97	$4.98	$4.97	$4.98
Turbidity Exceptions	$1.17	$1.17	$1.18	$1.18
Disinfection Benchmarking	$0.28	$0.39	$0.28	$0.39
Recycle Return Location	$0.02	$0.03	$0.02	$0.03
Direct Recycle	$0.05	$0.07	$0.05	$0.07
Direct Filtration	$0.01	$0.01	$0.01	$0.01
Total State Costs	$6.50	$6.65	$6.51	$6.66
Total Costs	**$87.64**	**$97.48**	**$145.55**	**$157.25**

Detail may not add to total due to rounding.
[1]Only the high cost estimate from Alternative R2 is reported.

The exhibit compares these costs with the costs that EPA estimates small systems would have incurred if the turbidity, disinfection benchmarking, and covered finished water provisions were to reflect the provisions promulgated for the IESWTR:

- Turbidity Monitoring: Alternative T1
- Disinfection Benchmarking Applicability Monitoring: Alternative A1
- Disinfection Profiling and Benchmarking: Alternative B1
- Recycle (not a component of IESWTR): Alternative R2.

For both the preferred alternatives and the IESWTR alternatives, annual costs include annualized capital and start-up costs as well as annual O&M and labor costs.

On an annual basis, the cost of the preferred alternatives is $87.64 million to $97.48 million, depending on the discount rate assumption. This combination of alternatives, designed to minimize the impact of the proposed rule on small systems, represents a cost savings of about 38 to 40 percent, depending on the discount rate, compared to the estimated cost for alternatives that are similar to the IESWTR provisions. Excluding the recycle costs, the cost savings for the provisions included in both rules is approximately 45 percent.

The turbidity treatment costs account for approximately 54 percent of total costs under the preferred alternatives, and aggregate system and State turbidity monitoring costs of $16.0 million to $16.3 million represent approximately 17 to 18 percent of total costs. In contrast, under the alternatives that closely match the IESWTR provisions, aggregate turbidity monitoring costs are $69.3 million to $69.6 million, which represents approximately 44 to 48 percent of total costs. This comparison illustrates the relative importance of the turbidity monitoring cost savings under the preferred alternative in terms of the reducing the overall cost of the proposed rule.

Community water systems account for approximately 88 percent of total system costs. Transient noncommunity systems, which represent approximately 17 percent of affected systems, incur only 8 percent of costs, largely because they are not affected by the disinfection benchmark provision. Nontransient, noncommunity systems account for 4 percent of system costs.

Exhibit 6–30 shows costs for the preferred combination of alternatives broken down by system size. The five small system size categories are shown separately; large systems are aggregated into a single column. The three smallest size categories incur approximately 27 percent of the total costs of the proposed rule even though they account for more than 60 percent of the affected systems. In comparison, large systems, which are only affected by the recycling provisions and account for only 5 percent of total affected systems, incur approximately 18 percent of total costs.

Exhibit 6–30. Summary of Total Annual Costs for the Preferred Alternatives by System Size (January 1999 dollars)

Compliance Activity	Total Annual Costs by System Size Category ($ millions)					
	#100	101–500	501–1,000	1,001–3,300	3,301–9,999	$10,000
System Costs						
Turbidity Treatment	$4.50	$5.97	$5.90	$15.98	$19.89	—
Turbidity Monitoring	$1.05	$1.40	$1.01	$2.96	$3.64	—
Turbidity Exceptions	$0.01	$0.02	$0.01	$0.04	$0.04	—
Disinfection Benchmarking	$0.24	$0.24	$0.17	$0.42	$0.38	—
Covered Finished Storage	$0.47	$0.42	$0.32	$0.57	$0.80	—
Recycle Return Location	$0.29	$0.45	$0.34	$0.83	$1.11	$13.87
Direct Recycle	$0.17	$0.27	$0.28	$1.11	$1.55	$2.43
Direct Filtration	$0.02	$0.02	$0.02	$0.06	$0.12	$1.45
Total System Costs	$6.74	$8.80	$8.05	$21.97	$27.52	$17.76
State Costs						
Turbidity Monitoring	$0.71	$0.94	$0.68	$1.40	$1.25	—
Turbidity Exceptions	$0.17	$0.22	$0.16	$0.33	$0.29	—
Disinfection Benchmarking	$0.06	$0.10	$0.05	$0.11	$0.08	—
Recycle Return Location	$0.003	$0.004	$0.003	$0.01	$0.01	$0.01
Direct Recycle	$0.01	$0.01	$0.01	$0.02	$0.01	$0.02
Direct Filtration	$0.002	$0.002	$0.002	$0.003	$0.003	$0.004
Total State Costs	$0.94	$1.28	$0.91	$1.86	$1.64	$0.03
Total Costs	**$7.68**	**$10.08**	**$8.96**	**$23.83**	**$29.16**	**$17.79**
Share of Total Costs	**7.9%**	**10.3%**	**9.2%**	**24.4%**	**29.9%**	**18.2%**

Detail may not add to total due to rounding.

6.6.1 Omissions, Biases, and Uncertainty

There are several omissions, biases, and uncertainties that affect EPA's estimate of total costs, which are summarized in Exhibit 6–31. The cost analysis does not include the costs of two provisions: including *Cryptosporidium* in the definition of GWUDI systems and including *Cryptosporidium* in watershed requirements for unfiltered systems. EPA does not have data sufficient to estimate either the number of systems that will be affected by including *Cryptosporidium* in the definition of GWUDI systems or the potential effects on these systems of including them under rules that apply to GWUDI systems.

Exhibit 6–31. Summary of Cost Analysis Uncertainty

Item	Potential Effect on Costs	Comments
Omissions		
Excluded analysis of provision that includes *Cryptosporidium* in the definition of GWUDI	+	Any affected systems will incur incremental costs of changes in compliance requirements.
Excluded analysis of provision that includes *Cryptosporidium* in the watershed requirements for unfiltered systems	+	Any affected systems will incur incremental costs of changes in compliance requirements.
Excluded analysis of demonstrations	+	Systems and States will incur costs associated with preparing and reviewing demonstrations. EPA is gathering data to develop cost estimates.
Biases		
Assumed no market responses to system cost increases	–	Demand responses to price changes may mitigate total costs.
Assumed system-level costs for community systems were applicable to noncommunity systems	–	Noncommunity systems may have lower flow rates than community systems, which would generate lower system-level costs using the engineering cost models.
Included purchased water systems	–	Excluding these systems from the baseline and compliance forecast would reduce costs.
Assumed all affected systems would move their recycle location	–	Some of these systems may only incur the cost of preparing a waiver to allow another return location.
Uncertainties		
Cost estimates based on model drinking water systems and aggregate costs based on compliance forecasts constructed from SDWIS, AWWA, and ICR data	+/!	The engineering models and burden analyses are based on model systems or expected burdens. Actual costs and burdens will differ across systems. The compliance forecasts are based on sample data; the actual number of systems implementing treatment changes will most likely differ from EPA's projections.

\+ = resolving the omission, bias, or uncertainty will tend to increase costs.
! = resolving the omission, bias, or uncertainty will tend to reduce costs.
+/! = the effect of the omission, bias, or uncertainty on costs is undetermined.

Under the SWTR, unfiltered systems are required to meet watershed control requirements that include developing a watershed control program to minimize the potential for source water contamination by *Giardia lamblia* and viruses. Because the sources of contamination for both *Giardia lamblia* and *Cryptosporidium* are the same (e.g., wild animal populations, wastewater treatment plants, grazing animals, feedlots, and recreational activities), EPA believes existing watershed programs will not require significant modification to comply with the LT1FBR. Therefore, the Agency has not developed costs for this component of the rule. In addition, EPA does not have sufficient data to estimate costs associated with the preparation and review of demonstrations.

Some of EPA's assumptions introduced bias into cost estimates. As noted in Section 6.1, the cost analysis estimates only implementation costs, which potentially overstate social costs because it excludes market responses to changes in drinking water production costs. Demand-side responses to price increases may reduce social costs in the long run by reducing demand for water or by shifting demand from systems that may incur large cost increases to systems that operate at a lower cost.

The system estimates in the compliance forecasts include purchased water systems. The majority of these systems will not actually incur the costs discussed in this chapter because they purchase treated water from a wholesale system. This approach will over state costs for the provisions that only affect small systems because EPA is including costs for small wholesale systems and for the small systems that purchase treated water from them, although only the wholesale systems treat water. There are some wholesale systems, however, that report a small number of retail customers in SDWIS. These systems are included among the smallest system size categories in the baseline, thereby inflating these numbers while decreasing the larger system estimates. Although these systems are classified as serving fewer customers than their production rates suggest, costs for these systems will not be underestimated because EPA has included costs for the wholesale system and the systems that purchase the treated water, so all of the production is captured in the cost analysis. Finally, EPA may be including costs and benefits for small systems that purchase water from large systems, both of which properly accrue to the IESWTR, but these will offset one another in the net benefit analysis. EPA cannot determine the extent of this effect on the cost analysis and chose to retain all small systems to develop consistent cost and benefit analyses.

Finally, the methods used to estimate costs introduced uncertainty into the analysis because actual system and State-level costs will vary from the modeled treatment costs or estimated burden costs. Furthermore, the compliance forecasts are EPA's estimates of the numbers of systems potentially affected by various provisions. These forecasts are based on a variety of sources including sample data from the AWWA recycle survey and information gathered under the ICR. They may over or under estimate the actual number of systems affected by various proposed provisions (e.g., the number of direct recycle systems) and/or the number of systems altering treatment practices. EPA cannot determine whether the methods and data tend to over or under estimate total costs.

6.7 Household Costs

Water system cost increases are often passed on to customers, including households, in the form of higher monthly water bills. This section approximates potential household impacts of the proposed LT1FBR by estimating two distributions of household costs based on the system costs discussed above:

- Costs for the turbidity, disinfection benchmarking, and covered finished water reservoir provisions

- Costs for the recycle provisions.

EPA estimated two distributions because it cannot determine how many small systems incurring turbidity treatment costs will also incur recycle treatment costs. Of the 5,896 small conventional and direct filtration systems, EPA expects approximately 2,406 systems to alter turbidity treatment practices and 889 to alter recycling practices; the extent to which these two subsets overlap is uncertain.

6.7.1 Household Cost Estimation Method

Most annual system costs were the same for all systems and these costs could be readily converted to household costs by dividing per-system costs by the average number of households reported in SDWIS. Turbidity treatment costs, however, needed to be allocated across systems because only a subset of systems incur these costs. To obtain estimates of maximum potential household impacts, EPA developed an allocation method that distributed costs across systems in a way that maximizes costs for a subset of systems. First, EPA identified a subset of process improvements that are mutually exclusive (i.e., systems would not implement them together), then distributed the costs for these improvements across the systems expected to modify treatment. For example, systems may implement any or all three of the chemical addition activities, so the analysis assumes that some systems (i.e., based on the minimum compliance estimate across the activities) undertake all three. These changes, however, are substitutes for adding or overhauling filter media, which are applied, therefore, to a different subset of systems. Appendix H illustrates these distributions. Then the remaining process improvement costs, which any system might incur, were allocated across the systems from highest to lowest cost. Thus, some systems incur the highest cost combination from the first set as well as costs for all of the other improvements, totaling as many as 12 treatment changes. Because the compliance forecast differs across the five small system size categories, Appendix H shows distributions by size category.

EPA added expected costs for the turbidity monitoring, benchmark, and covered finished water provisions to the treatment cost distributions to calculate the aggregate cost per system. The percentiles from the allocation process determine how many systems incur aggregate costs for each part of the distribution. This distribution was then converted to a household basis. System costs were converted to household costs by dividing total annual costs by the mean number of households per community water system, and numbers of community water systems were multiplied by mean households per system. EPA limited the analysis to community water systems because only those systems serve residential customers. Aggregating these results across system size categories EPA obtained a cumulative distribution of cost per household for the turbidity, benchmarking, and covered finished water provisions. Household cost estimate details are shown in Appendix H.

This method tends to overestimate the highest costs. To be on the upper bound of the curve, a system would have to implement a large number of the treatment process improvements. Such system-level costs are unlikely to occur because there are less costly alternatives such as purchasing a package plant or connecting to a larger regional water system. The degree of overestimation, however, is less severe than the method used for the household cost analysis of the IESWTR. That analysis identified only four mutually exclusive treatment activities, so some systems incurred costs for as many as 28 treatment changes. As a sensitivity analysis, EPA replicated this approach for the proposed LT1FBR and reports the results below.

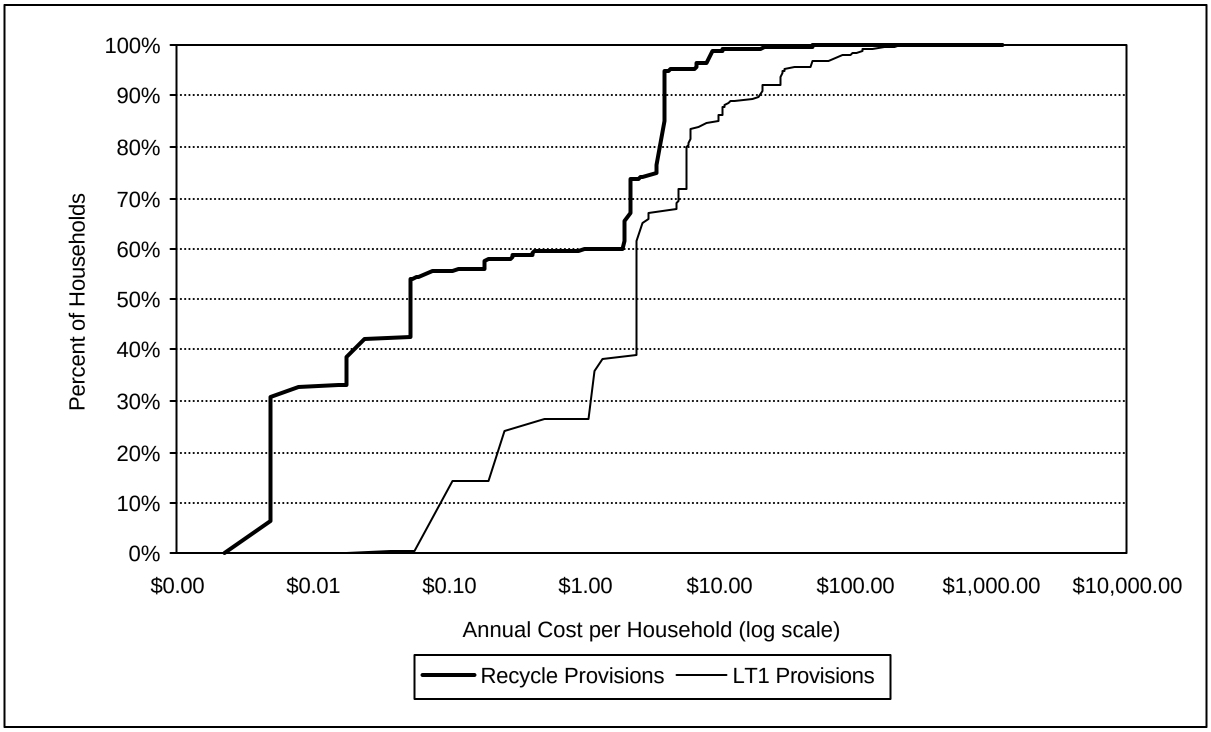
The distribution of costs for the recycle provisions is less complex because the only overlap in recycle process changes is among direct recycle systems, some of which may need to move recycle to the point prior to primary coagulant addition as well as install a flow equalization basin. EPA estimated this overlap by size category based on data in the AWWA Survey (1998). EPA calculated a system cost distribution across all of the recycle provisions and converted it to a household cost distribution using the approach described above (see Appendix H for details).

6.7.2 Results of Household Cost Analysis

Exhibit 6–32 illustrates the cumulative distribution of household costs for all small systems for the LT1 provisions (e.g., turbidity, benchmarking, and covered finished water). The mean cost per household is $8.66. The chart shows per-household costs of $10 per year or less for 86 percent of the 6.6 million households affected by those provisions, and costs of $120 per year (i.e., $10 per month) or less for approximately 99 percent of households. Per-household cost exceeds $240 per year (i.e., $20 month) for approximately 12,000 households. It exceeds $500 per year for fewer than 600 households. Costs exceeding $500 per household occur only for the smallest size category, and the number of affected households represent about 34 of the smallest systems. The highest per-household cost estimate is $2,177. This extreme estimate, however, is an artifact of the way the system cost distribution was generated. As noted above, it is unlikely that any small system will incur annual costs of this magnitude because less costly options are available. In comparison, the maximum cost per household would be $3,147 using the cost allocation method developed for the IESWTR RIA because that approach would tend to shift treatment costs toward a smaller set of systems. Consequently, 90 percent of households would have costs below $10 per year.

Exhibit 6–32 also illustrates the distribution of household costs for the recycle provisions. The mean cost per household is $1.79 and the cost per household is less than $10 for 99 percent of 12.9 million households potentially affected by the proposed rule. The cost per household exceeds $120 for approximately 1,800 households and it exceeds $500 for approximately 100 households. The maximum cost of $1,238 would only be incurred if a direct filtration system in the smallest size category installed a sedimentation basin.

Exhibit 6–32. Distributions of Annual Household Costs for the Turbidity,



Benchmarking, and Covered Finished Water Provisions and Recycle Provisions

There are approximately 1.5 million households served by small drinking water systems that may be affected by the recycling provisions in addition to the turbidity, benchmarking, and covered finished water provisions. The expected aggregate annual cost to these households can be approximated by the sum of the expected cost for each distribution, which is $10.45.

6.8 Cost Effectiveness

The cost effectiveness of the proposed rule can be measured as the cost per case of avoided illness. The quantified benefit of mean avoided cases of illness per year ranges from 22,800 to 83,600 avoided cases for the turbidity provisions alone. Dividing the associated costs of $68.6 million (assuming a 7 percent discount rate) by this range, the resulting cost per case of avoided illness ranges from $800 to $3,000.

The overall cost of the preferred combination of regulatory alternatives for LT1FBR is $97.5 million (assuming a 7 percent discount rate); this includes the $68.6 million in costs attributed to the turbidity provisions. Dividing this preferred combination total by the quantified benefit of total avoided cases (i.e., 22,800 to 83,600) would overstate the cost per case estimate. If the other provisions are equally effective in reducing illness, the per case cost of avoided illness would be the same (i.e., $800 to $3,000 per case). If the other provisions are less effective than the turbidity provisions, then the costs would be higher, not to exceed $4,300 as a highest estimate (i.e., the

$97.5 million divided by 22,800 cases—all presumably attributable, in this worst case estimate, to the turbidity provisions). If, however, the other provisions are more effective than the turbidity provisions in avoiding illness, then the cost per case would be lower than the $800 to $3,000 per case estimate range.

7. Economic Impact Analysis

The rule promulgation process requires EPA to perform a series of distributional analyses that address the potential regulatory burden placed on entities directly or indirectly affected by the rule. This chapter contains all or part of EPA's analyses and statements with regard to six Federal mandates:

(1) The Unfunded Mandates Reform Act (UMRA) of 1995;
(2) Executive Order 12886 (Regulatory Planning and Review);
(3) the Regulatory Flexibility Act (RFA) of 1980, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996;
(4) Technical, Financial, and Managerial Capacity Assessment required by Section 1420(d)(3) of the 1996 amendments to the Safe Drinking Water Act (SDWA);
(5) Executive Order 13045 (Protection of Children From Environmental Health Risks and Safety Risks); and
(6) Executive Order 12989 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations).

The preparation of this regulatory impact analysis for the LT1FBR is a response to the requirements of Executive Order 12886. This chapter is a response to the remaining five mandates. In addition, this chapter contains a summary of the analysis conducted to fulfill requirements set forth by the Paper Work Reduction Act. A separate Information Collection Request (ICR) document, entitled the *LT1FBR Information Collection Request*, contains the complete analysis.

This chapter is organized into three sections. The first section addresses how the proposed rule pertains to those mandates concerning potential impacts to government and business entities. The next section considers the impact of the proposed rule on possible sensitive subpopulations, such as children. The final section addresses the potential impact to minority and low-income populations.

7.1 Impacts on Governments and Business Units

The following sections contain the analyses necessary to fulfill Executive Orders pertaining to governments and businesses. Section 7.1.1 provides the UMRA analysis. Section 7.1.2 discusses possible impacts to Indian Tribal Governments. Section 7.1.3 is the required RFA and SBREFA analysis. Section 7.1.4 is the Capacity analysis, and Section 7.1.5 gives a summary of the ICR.

7.1.1 Unfunded Mandates Reform Act

Title II of the UMRA, 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 generally must prepare a written statement, including a cost-benefit 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 1 year. EPA estimated annual aggregate State, local, and Tribal government expenditures for the 7 percent discount rate assumption scenario by adding State program costs of $6.7 million to the share of system costs potentially incurred by publicly owned systems. These systems account for approximately 73.9 percent of the $90.8 million in total annual system costs, which is $67.1 million per year. Thus, State program costs and publicly owned system costs total $73.8 million per year.

Although this falls below $100 million, the cost figure is close enough to the threshold that the Agency expects it to surpass the threshold within the 20-year analysis period due to inflation at some point in the future. Therefore, EPA has determined that this rule contains a Federal mandate that may eventually result in expenditures of $100 million or more for State, local, and Tribal governments, in the aggregate and the private sector in any 1 year. Accordingly, under Section 202 of the UMRA, EPA is obligated to prepare a written statement addressing:

- The authorizing legislation
- Cost-benefit analysis including an analysis of the extent to which the Federal government will pay for the costs of State, local and Tribal governments
- Estimates of future compliance costs and disproportionate budgetary effects
- Macroeconomic effects
- A summary of EPA's consultation with State, local, and Tribal governments and their concerns, including a summary of the Agency's evaluation of those comments and concerns
- Identification and consideration of regulatory alternatives and the selection of the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule.

Chapter 2 details the authorizing legislation. Cost-benefit analyses, disproportional budgetary effects, macroeconomic effects, and consultations are addressed in the rest of this chapter. Future compliance costs are discussed in Chapter 6. And both Chapters 3 and 6 address the potential regulatory alternatives, with Chapter 6 showing that the preferred alternatives are the most cost effective ones that achieve the public health objectives.

Before promulgating a rule that requires a written statement, Section 205 of the UMRA generally requires EPA to identify and consider a reasonable number of regulatory alternatives and then adopt the least costly, most cost effective or least burdensome alternative that achieves the objectives of the rule. However, the provisions of Section 205 do not apply when they are inconsistent with applicable law.

Under Section 1412(b), the SDWA requires that MCLs be set as close to MCLGs "as is feasible," except when EPA determines that the cost of a standard at that level are not justified by the benefits, or when certain "risk-risk" considerations apply. Whereas, MCLGs are nonenforceable health goals based only on health effects and exposure information, MCLs are enforceable standards that

SDWA directs EPA to set with the use of the best technology, treatment techniques, and other means that the Administrator finds available. Also, SDWA requires the Agency to identify the best available technology (BAT) that is feasible for meeting the MCL for each contaminant. Under Section 1412 (b)(7)(A), if it is not economically or technically feasible to ascertain the level of a contaminant in drinking water, EPA may require the use of a prescribed treatment technique instead of an MCL.

As a result of this mandate set forth by the SDWA, EPA can choose an alternative that is not the most cost effective if it determines that this is necessary to attain health goals as close to MCLGs as feasible. Moreover, Section 205 allows EPA to adopt an alternative other than the least costly, most cost effective, or least burdensome alternative if the Administrator publishes an explanation why that alternative was not adopted within the final rule.

Before EPA establishes any regulatory requirements that may significantly or uniquely affect small governments, including Tribal governments, it must have developed under Section 203 of the UMRA a small government agency plan. The plan must provide for notifying potentially affected small governments, enabling officials of affected small governments to have meaningful and timely input in the development of EPA regulatory proposals with significant Federal intergovernmental mandates, and informing, educating and advising small governments on compliance with the regulatory requirements.

Social Costs and Benefits

The social benefits are those that accrue to the public through an increased level of protection from exposure to *Cryptosporidium* and other pathogens in drinking water. Chapter 5 presents the benefit analysis, which includes both qualitative and monetized benefits of improvements to health and safety. Because of scientific uncertainty regarding the exposure assessment and the risk assessment for LT1FBR, the Agency has used statistical methods to assess the benefits of LT1FBR. The methods quantified and valued the cryptosporidiosis illnesses and mortalities avoided due to the revised combined filter effluent standards. This rule, however, may also decrease illness from *Giardia* and other emerging disinfection resistant pathogens further increasing the benefits of the rule. Additional benefits of the rule include reduced risks of outbreaks and enhanced aesthetic water quality.

Measuring the social costs of the rule requires identifying affected entities by ownership (public or private), considering regulatory alternatives, calculating regulatory compliance costs, and estimating any disproportionate impacts. Chapter 6 of this document details the cost analysis performed for the LT1FBR. EPA expects the proposed rule to have a total annualized cost of approximately $87.6 or $97.5 million depending on the discount rate.

The Federal government may defray a portion of the cost of the rule by providing financial assistance to State, local, and Tribal governments in complying with this rule. The Federal government provides funding to States that have primary enforcement responsibility for their drinking water programs through the Public Water Systems Supervision Grants program.[12] Additional funding is available from other programs administered either by EPA or other Federal agencies. These include the Drinking Water State Revolving Fund (DWSRF) and Housing and Urban Development's Community Development Block Grant Program. For example, SDWA authorizes the Administrator of the EPA to award capitalization grants to States, which in turn can provide low-cost loans and other types of assistance to water systems for eligible projects. The DWSRF assists public water systems with financing the costs of the infrastructure needed to achieve or maintain compliance with SDWA requirements. Each State has considerable flexibility to determine the design of its program and to direct funding toward its most pressing compliance and public health protection needs. The *Drinking Water State Revolving Fund Program Guidelines* detail a variety of ways that States can use funds to assist small systems (U.S. EPA, 1997b). The State must use a minimum of 15 percent of the DWSRF grant to provide infrastructure loans to small systems. Furthermore, the State may use 2 percent of the grant to provide technical assistance to small systems. For disadvantaged small systems, the State can use up to 30 percent of its DWSRF money to increase loan subsidies. States may also, on a matching basis, use up to 10 percent of their DWSRF allotments for each fiscal year to assist in running the State drinking water program.

Disproportionate Impacts

This section examines disproportionate impacts on geographic or social segments of the nation. In general, the costs that a PWS, whether publicly or privately owned, would incur to comply with this rule would depend on many factors that are independent of location. However, the data needed to confirm this assessment and to analyze other impacts of this problem is not available; therefore, EPA looked at four other factors:

- The impacts of small versus large systems and the impacts within the five small system size categories

- The costs to public versus private water systems

- The costs to households (See Chapter 6)

- The distribution of costs across States.

First, small systems will experience a greater impact than large systems under LT1FBR because large systems are subject only to the recycle provisions; the Interim Enhanced Surface Water Treatment Rule (IESWTR) promulgated turbidity, benchmarking, and covered finished storage provisions for large systems in December, 1998. However, small systems have realized cost savings over time due to their exclusion from the IESWTR.

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[12]The Federal government also defrays State costs by providing for the administrative cost and burden for States and Territories that do not have primacy. In addition, the Federal government administers many of the treatment plants in national forests and military installations.

The second measure of impact is the relative total cost to privately owned water systems compared to that incurred by publicly owned water systems. A majority of the systems are publicly owned (60 percent of the total). As a result, publicly owned systems will incur a larger share of the total costs of the rule. However, EPA has no basis for expecting the cost per system to differ systematically with ownership.

The third measure of impact is at the household level. Chapter 6 includes this analysis, as part of the overall cost analysis.

The fourth measure of budgetary impacts is geographically across States. There is nothing to suggest that costs to individual systems would vary significantly from State to State. Yet this does not preclude a specific State or region from being significantly impacted more by the rule. Therefore, EPA conducted an analysis of the potential geographic impact of LT1FBR on the various States.[13] For State budgetary impacts, the costs for starting and annually administering the LT1FBR rule are combined with information on the distribution of PWSs across States.

Exhibit 7–1 shows the distribution of annual costs to States for the proposed rule. From the map it is apparent that Texas, New York, California, Oklahoma, and Illinois are the States with the highest annual costs. As mentioned in Chapter 6, the turbidity monitoring provision of the LT1FBR would be the source of the greatest financial burden to States. Since the turbidity provision only applies to small surface and GWUDI systems, those States with the greatest number of small systems would incur the highest costs. Exhibit 7–2 shows the distribution of surface and GWUDI systems serving fewer than 10,000 over the 50 States. A comparison of the two maps suggests that the geographic distribution of costs is closely correlated with the distribution of small systems.

Estimates of the cost increase are only one measure of potential budgetary impacts, and other comparisons can provide additional perspective. For instance, the five States with the highest potential costs also had the highest number of small systems. Of these five States, four have very large populations.[14] States with larger populations may already have larger budgets for program expenditures, and the proportional cost increase due to LT1FBR may be smaller than or comparable to other States. Therefore, EPA compared the estimated percentage increase to overall State drinking water program costs that would result from the rule.

[13]The information on systems per State was derived from the Water Industry Baseline Handbook (U.S. EPA,1999c). This information is from 1997 and previous years, whereas the cost analysis in Chapter 6 is based upon the most recent information contained in the SDWIS, therefore there are some discrepancies in the total number and distribution of systems between the two analyses.

[14]California, Texas, New York, and Illinois will be the first, second, third, and sixth most populated States, respectively, in 2000 according to population projections of the United States Census Bureau. www.census.gov/population/projections/state/stpjpop.txt

Exhibit 7–1. Geographic Distribution of Annual LT1FBR Costs to States

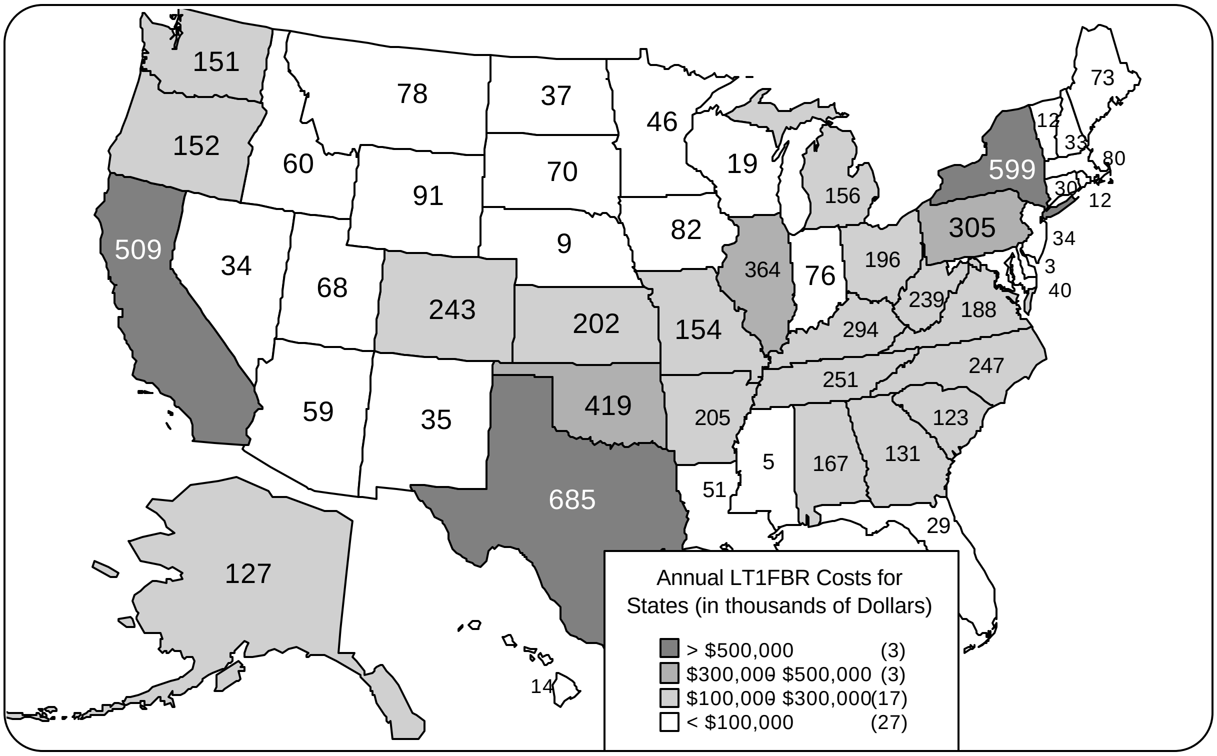

Exhibit 7–2. Small Surface and GWUDI System Distribution

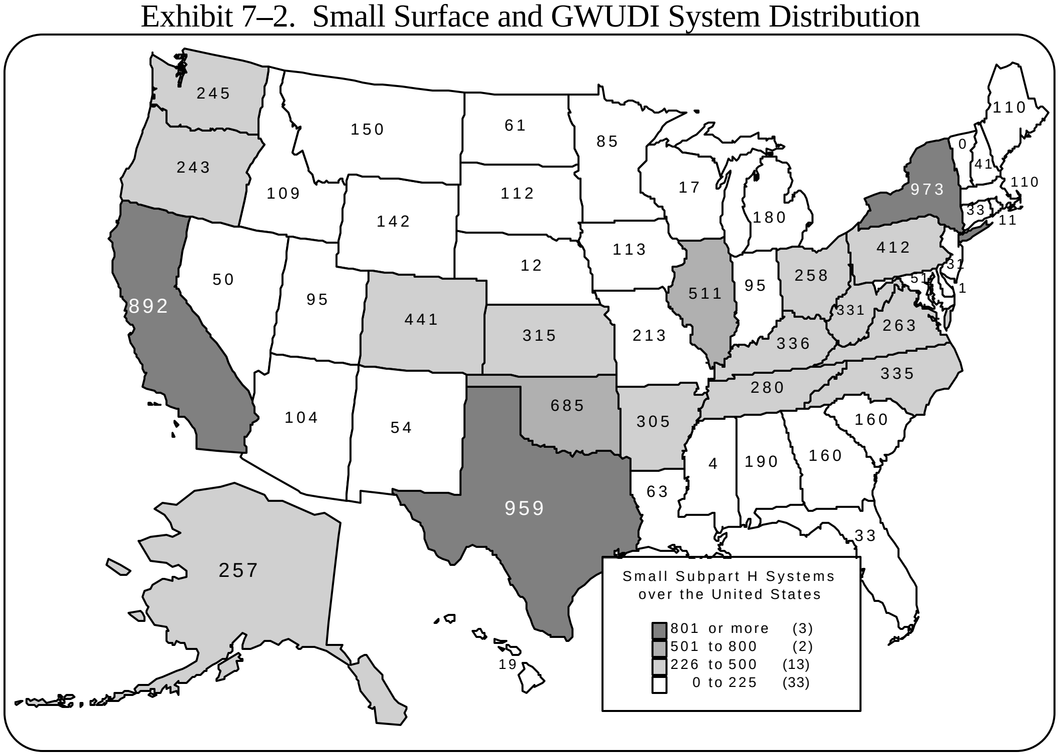

Exhibit 7–3 shows the cost increase to the States as a percentage of overall State drinking water expenditures that would result from implementation the LT1FBR.[15] Over the entire country, the average increase in program expenditures would be 4.1 percent. The States of Colorado, Alabama, Oklahoma, Texas, West Virginia, Kansas, and Kentucky would have the greatest increase in expenditures as a result of the rule. However, if the State's per capita drinking water expenditures are relatively low, in relation to other States then a large percentage increase still may not result in a significant burden to the State.[16] Conversely, if the State already has higher than average expenditures per person, then the percentage increase may underestimate the actual burden of the rule.

Exhibit 7-3: LT1FBR Costs as a Percentage of State Drinking Water Expenditures

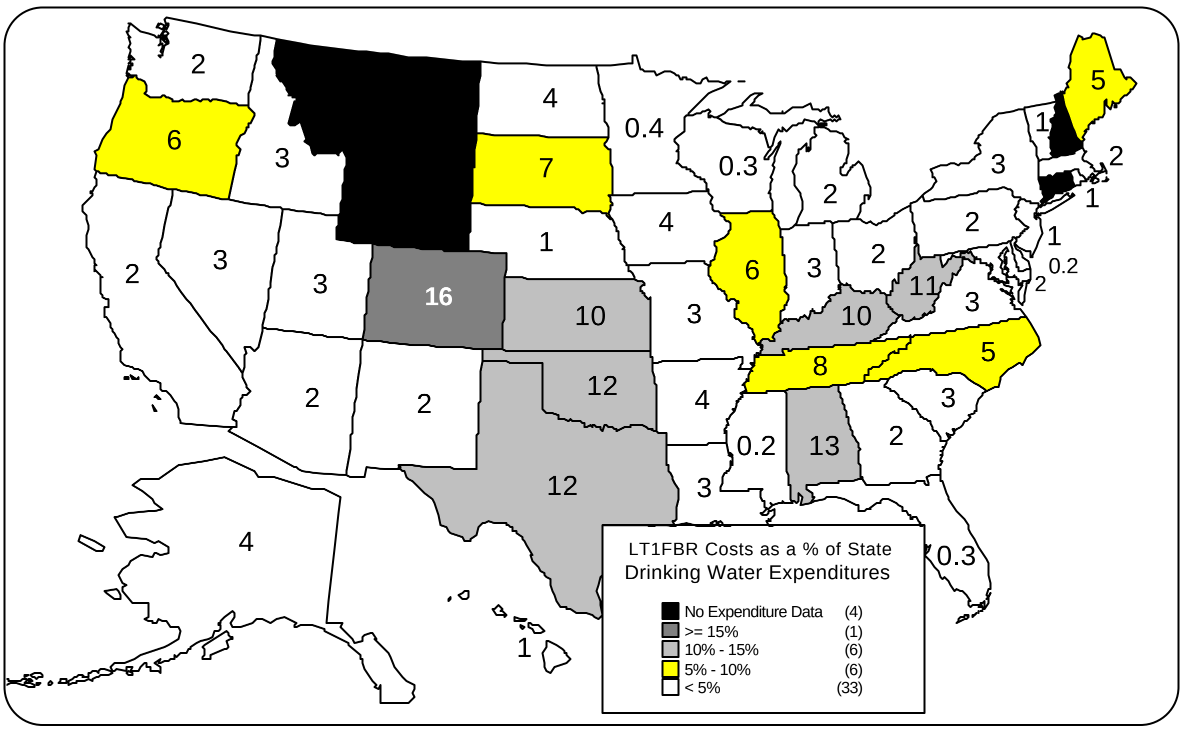

Exhibit 7–4 shows the geographic distribution of per capita drinking water expenditures. From this exhibit it is apparent that, if the rule were implemented, none of the seven States mentioned in the previous paragraph would likely be required to spend more than $1.50 per person annually. The

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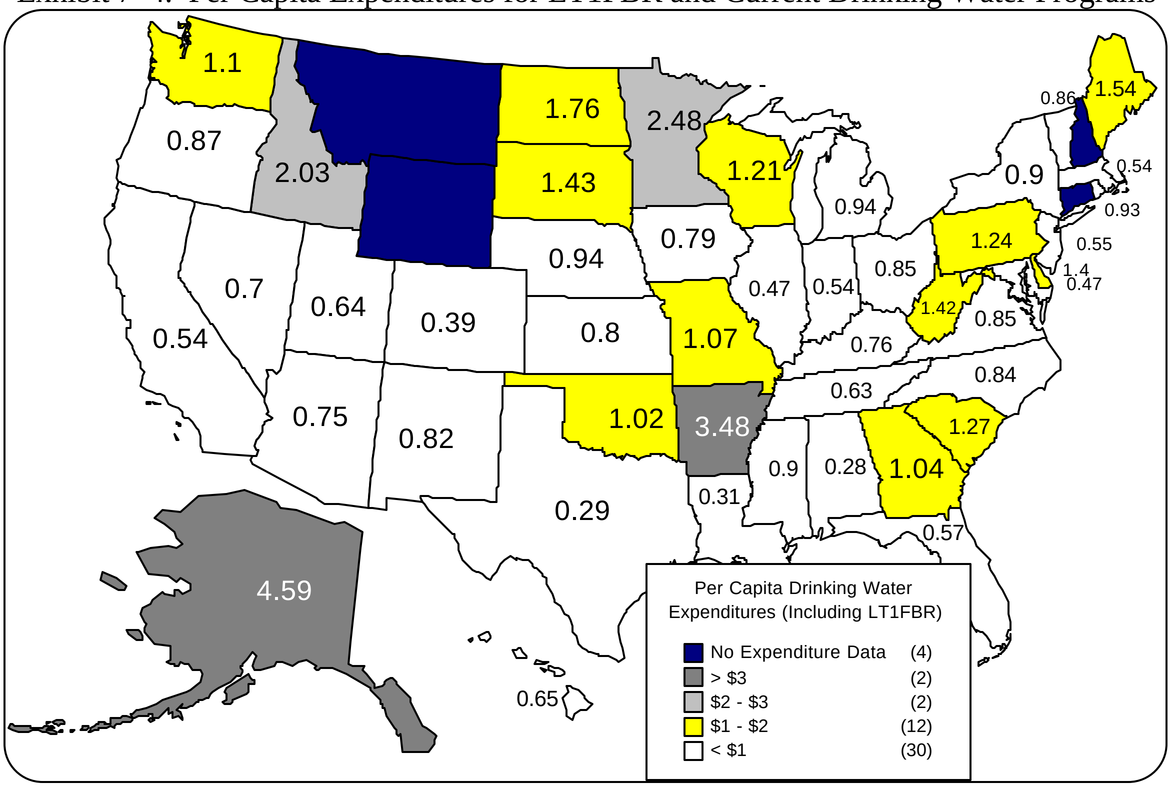
[15]State expenditure data was not available for the States of Alaska, Connecticut, Louisiana, Montana, Nevada, New Hampshire, New Mexico, North Dakota, and Wyoming. Annual revenue data was available for Alaska, Louisiana, Nevada, New Mexico, and North Dakota (U.S. EPA, 1999d). This data was used as an approximate measure of likely expenditures for the respective States. These expenditures and revenues do not incorporate the compliance costs for the IESWTR and the Stage 1 DBPR, so the percentage increases are overstated and the overall costs are underestimated.

[16]Per capita expenditure is based upon total State Drinking water expenditures for the 1997 divided by the number of people served by Public Drinking Water Systems in 1997 (U.S. EPA, 1999d).

average annual State cost per person for just LT1FBR and then for current drinking water expenditures plus LT1FBR costs would be $0.04 and $1.05, respectively. Exhibit 7–4 does show that combined drinking water costs would require Alaska and Arkansas to spend more than $3 per person.

Exhibit 7–4. Per Capita Expenditures for LT1FBR and Current Drinking Water Programs



Yet examining potential budgetary impacts alone, provides an incomplete description of the likely financial burden to the States. For Alaska the cost of LT1FBR would be $0.18 per person, bringing its drinking water expenditures to $4.56 per person. However, in 1997 Alaska acquired three-fourths of its drinking water budget in the form of Federal PWSS grant money.[17] By contrast, Arkansas expenditures would be $3.47 after promulgation of LT1FBR, but it received only 17 percent of its 1997 drinking water budget from Federal funds. From this perspective Arkansas would bear the greater financial burden.

In conclusion, the evidence exhibited on the four maps (Exhibits 7–1 to 7–4) does not suggest that there would be a disproportionate budgetary effect resulting from the rule. Exhibits 7–1, 7–3 and 7–4 do not show evidence of a geographic concentration of higher impact attributed to the rule. Nor does any one State consistently fall into the top two categories of impact in all four exhibits. Furthermore, it is possible that the financial impact of the rule to States could be offset partially by additional PWSS grant money from the Federal Government.

[17]In 1997, 75 percent of Alaska's Drinking water program budget came from Federal PWSS grant money, 22 percent from State General Funds, and 3 percent from other revenue sources (U.S. EPA, 1999d).

Macroeconomic Effects

EPA is required, under UMRA Section 202, to estimate the potential macroeconomic effects of the regulation. Macroeconomic effects tend to be measurable in nationwide econometric models only if the economic impact of the regulation reaches 0.25 to 0.5 percent of Gross Domestic Product (GDP). In 1998, the GDP was $8,511 billion so a rule would have to cost at least $21 billion annually to have a measurable effect. A regulation with a smaller aggregate effect is unlikely to have any measurable impact unless it is highly focused on a particular geographic region or economic sector. The macroeconomic effects on the national economy from the preferred alternatives of FBR would be negligible based on the estimated total annual cost range of $87.6 to $97.5 million. In addition, from the analysis in the previous section EPA does not expect that costs would be highly concentrated on any particular geographic region.

Summary of Consultation Efforts with State, Tribal, and Local Governments

Under UMRA Section 202, EPA is to provide a summary of its consultation with elected representatives (or their designated authorized employees) of affected State, local and Tribal governments in this rulemaking. EPA initiated consultations with governmental entities and the private sector affected by this rule through various means. This included participation on a Regulatory Negotiation Committee, chartered under the Federal Advisory Committee Act (FACA), in 1992–93 that included stakeholders representing State and local governments, public health organizations, public water systems, elected officials, consumer groups, and environmental groups.

In accordance with the Regulatory Flexibility Act (RFA), as amended by the SBREFA, EPA convened a Small Business Advocacy Review Panel. The Review Panel allows small regulated entities to provide advice and perspective to EPA early in the regulatory development process. EPA also provided an informal draft of the preamble to SBREFA representatives and individuals who attended either of the two stakeholder meetings. Because this was an informal review process, EPA did not prepare formal responses to the comments, however, the Agency reviewed the comments carefully and considered their merit when developing the regulatory provisions in the proposed rule.

To inform and involve Tribal governments in the rulemaking process, EPA presented the LT1FBR at the 16th Annual Consumer Conference of the National Indian Health Board, the Annual Conference of the National Tribal Environmental Council, and the OGWDW/Inter Tribal Council of Arizona, Inc. Tribal consultation meeting. More than 900 attendees representing Tribes from across the country attended the National Indian Health Board's Consumer Conference and over 100 Tribes were represented at the annual conference of the National Tribal Environmental Council. At both conferences, an OGWDW representative conducted two workshops on EPA's drinking water program and upcoming regulations, including the LT1FBR. At the OGWDW/Inter Tribal Council of Arizona meeting, representatives from 15 Tribes participated. In addition, EPA sent the presentation materials and meeting summary to more than 500 Tribes and Tribal organizations.

The primary concern expressed by the governments was the ability of the smallest systems to staff drinking water treatment facilities adequately to perform the monitoring and reporting associated with the new requirements. The proposed rule attempts to minimize the monitoring and reporting burden to the greatest extent feasible and still accomplish its objective of protecting public health. The Agency believes the monitoring and reporting requirements are necessary to ensure consumers served by small systems receive a comparable level of public health protection as consumers served by large systems.

7.1.2 Indian Tribal Governments

Under Executive Order 13084, EPA may not issue a regulation, which is not required by statute, that significantly or uniquely affects the communities of Indian Tribal governments, and that imposes substantial direct compliance costs on those communities, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by the Tribal governments or EPA consults with those governments. If EPA complies by consulting, Executive Order 13084 requires EPA to provide to the Office of Management and Budget, in a separately identified section of the preamble to the rule, a description of the extent of EPA's prior consultation with representatives of affected Tribal governments, a summary of the nature of their concerns, and a statement supporting the need to issue the regulation. In addition, Executive Order 13084 requires EPA to develop an effective process permitting elected officials and other representatives of Indian Tribal governments "to provide meaningful and timely input in the development of regulatory policies on matters that significantly or uniquely affect their communities."

EPA has concluded that this rule will significantly affect communities of Indian Tribal governments.[18] It will also impose substantial direct compliance costs on such communities, and the Federal government will not provide the funds necessary to pay the direct costs incurred by the Tribal governments in complying with the rule. In developing this rule, EPA consulted with representatives of Tribal governments pursuant to UMRA and both Executive Order 12875 and Executive Order 13084. As described in the UMRA discussion in the previous section, EPA held extensive meetings that provided the opportunity for meaningful and timely input in the development of the proposed rule. The public docket for this rulemaking includes summaries of the meetings.

7.1.3 Regulatory Flexibility Act and Small Business Regulatory Enforcement Fairness Act

The provisions of the Regulatory Flexibility Act, 5 U.S.C. 601 et seq., as amended by the Small Business Regulatory Enforcement Fairness Act of 1996, require EPA to prepare a regulatory flexibility analysis unless the Agency certifies that the rule will not have "a significant economic impact on a substantial number of small entities." A regulatory flexibility analysis describes the impact of the regulatory action on small entities as part of the rule promulgation process. The 1996 amendments to the SDWA define a small public water system as a system serving fewer than 10,000 persons. This

[18] There are approximately 60 small PWSs that use surface water or GWUDI classified as Tribal systems in the SDWIS.

definition reflects the fact that the original 1979 standard for total trihalomethanes applied only to systems serving at least 10,000 people. The definition thus recognizes that baseline conditions from which systems serving fewer than 10,000 people will approach disinfection byproduct control and simultaneous control of microbial pathogens is different from that for systems serving 10,000 or more persons.

Background and Quantitative Analysis

When a proposed or final rule may potentially have an adverse effect on one or more small entities, the RFA and SBREFA require EPA to determine the extent of the impact and the number of small entities affected. If it is determined that the rule would not have a "significant impact on a substantial number of small entities," then the Agency can certify the rule. If the Agency determines that the rule would have an impact then the RFA/SBREFA requires that EPA prepare an Initial Regulatory Flexibility Analysis (IRFA) for a proposed rule, or Final Regulatory Flexibility Analysis for a final rule. Chapter 4 of this document provides data on the small entities potentially affected by LT1FBR, and Chapter 6 discusses the changes systems would have to make and the likely costs. Using information found in these two chapters, along with additional information from SDWIS and CWSS, EPA conducted a quantitative analysis to assist in determining whether to certify the rule or prepare an IRFA.

The Agency recognizes that economic characteristics will vary among entities affected by a given rule. Therefore, EPA evaluated the potential economic impact by comparing compliance costs as a percentage of sales, revenues, and operating expenses for small businesses, governments, and non profit organizations respectively. Data on water systems changes frequently, which makes it difficult to describe the universe of surface water systems with specificity. Similarly, ownership data is difficult to ascertain as most data sets, such as SDWIS (Safe Drinking Water Information System), do not maintain such information. For this analysis, the number of publicly and privately owned water systems was derived using the ratio of public to private water systems as reported in the 1995 Community Water System Survey (CWSS). Using SDWIS and CWSS, EPA estimates that the changes to the Surface Water Treatment Rule will potentially affect 11,593 surface water systems and GWUDI systems. Of these systems, EPA estimates that small businesses own 37.2 percent, 56.7 percent are small governments, and 6.1 percent are nonprofit organizations.[19] While it was not possible to use existing data to establish the exact profile of water system ownership, EPA used information in the Water Industry Baseline Handbook (U.S. EPA, 1999c) to approximate an ownership profile. As shown in Exhibit 7–5, the data suggest that a majority of small systems are publicly owned.[20]

[19]The Water Industry Baseline Handbook separates system ownership data into public, private or other (U.S. EPA, 1999c). For this analysis, EPA assumed for the small systems that public represents small government, private represents small business, and other represented small non-profit.

[20]A public water system provides piped water for human consumption. The term "public water system" applies not only to water utilities, but also to wide range of privately or publicly owned businesses and entities that provide drinking water (e.g., campgrounds, factories, restaurants, and schools). Public water systems are classified as community, nontransient noncommunity, or transient noncommunity systems.

Exhibit 7–5. Number and Percent of Public and Private System, by Size of System

System Type	System Size					Total
	<100	101–500	501–1,000	1,001–3,300	3,301–9,999	
Public	691 (24.6%)	1,308 (45.7%)	913 (65.3%)	2,020 (76.8%)	1,638 (86.3%)	6,570 (56.7%)
Private	1,755 (62.6%)	1,350 (47.2%)	418 (29.8%)	555 (21.1%)	236 (12.4%)	4,314 (37.2%)
Other	358 (12.8%)	202 (7.1%)	68 (4.9%)	56 (2.1%)	25 (1.3%)	709 (6.1%)
Total	**2,804 (24%)**	**2,860 (25%)**	**1,399 (12%)**	**2,631 (23%)**	**1,899 (16%)**	**11,593 (100%)**

Note: Number (percent) within system size category.

The LT1FBR proposed rule contains provisions for turbidity monitoring and treatment, disinfection benchmarking, and filter backwash recycling. Chapter 6 discusses these provisions and Exhibits 7–6 through 7–8 summarize EPA's estimate of the number of small entities that LT1FBR provisions will affect.[21]

Exhibit 7–6. Small Entities Affected by the Turbidity Monitoring and Turbidity Treatment Provisions of LT1FBR

System Size (population served)	Total Number of Systems	Systems to Modify Treatment and Monitor	Systems to Monitor Only
< 100	836	341	495
101–500	1,117	456	661
501–1,000	810	331	479
1,001–3,300	1,655	675	980
3,301–9,999	1,478	603	875
Totals	**5,896**	**2,406**	**3,490**

Exhibit 7–7. Small Entities Affected by the Benchmarking Provisions of LT1FBR

System Size (population served)	Total Number of Systems	Systems to Do Applicability Monitoring	Systems Disinfection Profiling	Systems to Develop Benchmarks
< 100	1,404	162	1,242	407
101–500	2,333	301	2,032	677
501–1,000	1,301	128	1,173	377
1,001–3,300	2,553	253	2,300	740
3,301–9,999	1,859	116	1,743	539
Totals	**9,450**	**960**	**8,490**	**2,741**

[21]The numbers of systems potentially affected by each provision is based upon the preferred alternative set.

Exhibit 7–8. Small Entities Affected by the Filter Backwash Recycle Provisions of LT1FBR

System Size (population served)	Systems Moving Recycle Return Location	Systems Performing Self Assessments	Systems with Direct Filtration
< 100	81	107	35
101–500	108	143	47
501–1,000	78	104	34
1,001–3,300	160	212	70
3,301–9,999	143	190	62
Totals	**569**	**757**	**248**

The major impact of the rule is the requirement to install and operate water filtration equipment to meet turbidity standards of quality in delivered water. These requirements pertain to systems that use either conventional or direct filtration to treat their water. Systems that purchase treated water from another source may see an increase in their wholesale costs, but a database sufficient to track all the wholesale treated water transactions in the country does not exist. Impacts are therefore evaluated as though all small systems treat water. The data with which to characterize the capacities and flows of these facilities that treat water does exist and provides an adequate basis for assessing total capital and operating costs. In Chapter 6 of this document, as part of a household cost analysis, EPA developed assumptions regarding the steps that systems of various sizes will need to take to comply with the LT1FBR rule. EPA was then able to generate a hypothetical distribution of per-system costs.

For the quantitative analysis, EPA used data from the CWSS to estimate mean sales, revenues, and expenditures for each system size and ownership category.[22] EPA then used the cost distributions for the turbidity, benchmark, and covered finish storage provisions to estimate cost-to-revenue ratios with each system size and ownership category to determine the potential extent of the financial impact on small entities. Some of these systems may also incur costs under the recycle provisions, but EPA cannot determine the number of systems for which this cost overlap would occur, and the majority of any system's recycle costs would be for changes in recycle practices, which will be determined by the State. However, not including the potential costs of the recycle provisions as part of the analysis does not change EPA's conclusion regarding the potential impact of the proposed rule on small entities.

Exhibit 7–9 presents the results from the analysis of the potential financial burden on PWSs from the proposed rule. The exhibit shows a comparison between the distribution of system costs developed in Chapter 6 and the financial data from CWSS. The complete distribution of costs for each system size category is located in Appendix H. Exhibit 7–9 summarizes the financial data and the number of

[22]Due to insufficient data, EPA could not determine the sales, revenues, or expenditures distributions by system within each size category. Instead, EPA estimated the *mean* sales, revenues, or expenditures for a system within each size category. This mean was then used to develop the cost-to-revenue ratios. Ideally, costs would be compared to financial data for every entity, or a distribution of that data.

systems incurring costs in excess of 1 percent and 3 percent of sales, revenues, or expenditures. As shown in the exhibit, EPA estimates that the cost of the LT1FBR rule may exceed 3 percent for 2,575 small systems. As a result of this analysis, EPA determined that there would be a significant impact on a substantial number of small systems and thus prepared an IRFA for this rule.

Exhibit 7–9. Results of Comparison of Mean Sales, Revenues, and Operating Expenditures to Costs

Population Category	100 and below	101-500	501-1,000	1,001-3,300	3,301-10,000	Total # of Systems	Total % of Systems
Annualized Cost Distribution Summary[1]							
High Range of Compliance Cost	$47,009	$51,784	$74,204	$122,905	$186,510		
Low Range of Compliance Cost	$24	$21	$16	$29	$40		
Small Business: Includes Private and Ancillary Systems as recorded in CWSS							
Mean Total Sales	$11,481	$49,682	$83,937	$343,153	$776,189		
Number of Systems >1%	523	527	241	279	52	1,624	37.6%
Number of Systems >3%	523	422	193	57	22	1,218	28.2%
Small Governments: Includes Public Systems as recorded in CWSS							
Mean Total Revenues	$13,220	$86,459	$127,171	$317,751	$806,802		
Number of Systems >1%	206	510	529	1,017	364	2,626	40.0%
Number of Systems >3%	206	408	151	207	156	1,129	17.2%
Small Nonprofit Organizations: Includes Homeowners' Associations as recorded in CWSS							
Mean Operating Expenditures	$5,815	$43,348	$121,538	$79,949	$528,204		
Number of Systems >1%	107	79	40	35	15	276	38.9%
Number of Systems >3%	107	79	11	28	3	228	32.1%
Total:							
Number of Systems >1%	**836**	**1,117**	**810**	**1,331**	**432**	**4,526**	**39.0%**
Number of Systems >3%	**836**	**909**	**356**	**292**	**181**	**2,575**	**22.2%**

[1]Compliance costs are based on the preferred alternative set. See Chapter 6 for a discussion of the regulatory alternatives.

Requirements for the Initial Regulatory Flexibility Analysis

Because EPA is not certifying the proposed rule under SBREFA, the Regulatory Flexibility Act requires EPA to complete an IRFA addressing the following:

- The need for the rule
- The objectives of and legal basis for the proposed rule
- A description of, and where feasible, an estimate of the number of small entities to which the rule will apply

- A description of the proposed reporting, record keeping, and other compliance requirements of the rule, including an estimate of the types of small entities, which will be subject to the requirements and the type of professional skills necessary for preparation of reports or records

- An identification, to the extent practicable, of all relevant Federal rules that may duplicate, overlap, or conflict with the proposed rule

- A description of "any significant regulatory alternatives" to the proposed rule that accomplish the stated objectives of the applicable statutes, and that minimize any significant economic impact of the proposed rule on small entities; the analysis is to discuss significant regulatory alternatives such as:

  - Establishing different compliance or reporting requirements or timetables that take into account the resources of small entities

  - Clarifying, consolidating, or simplifying compliance and reporting requirements under the rule for small entities

  - Using performance rather than design standards

  - Exempting small entities from coverage of the rule or any part of the rule.

EPA has considered and addressed the above requirements as part of this RIA for the proposed LT1FBR rule. The following is a summary of how this and the preceding chapters met the various requirements. Chapter 2 explains the need, objectives of, and legal basis for the rule. The previous Section 7.1.3 and Chapter 6 provide a description and estimate of the small entities affected. Section 7.1.3 also discusses the coordination with other Federal rules. Chapter 3, Chapter 6, and the current chapter provide a discussion of regulatory alternatives. The compliance requirements are discussed in Chapter 6 as well as section 7.1.5 of this chapter concerning the Paperwork Reduction Act and in the Information Collection Request prepared for the LT1FBR.

Coordination With Other Federal Rules

The proposed rule does not directly overlap with any other existing or proposed rules, yet the development of LT1FBR has occurred in coordination with several other rules, all of which are a direct result from amendments to the SWDA. To better understand how the proposed rule relates to other proposed and existing rules, it is necessary to briefly summarize several earlier Drinking water regulations. For a more comprehensive history of these regulations refer to Section 2.3 of Chapter 2.

Three initial rules that addressed both the control of specific pathogens and disinfection byproducts preceded the amendments to the SWDA in 1996. These were the Total Trihalomethane Rule,

passed in November 1979 (44 FR 68624); the Total Coliform Rule (TCR) (54 FR 27544, June 29, 1989); and the SWTR (54 FR 27486), passed on June 29, 1989.
Under the Total Trihalomethane Rule, EPA set an interim MCL for total trihalomethanes (TTHM—the sum of chloroform, bromoform, bromodichloromethane, chlorodibromomethane) of 0.10 mg/l as an annual average. The interim TTHM standard applied to community water systems using surface water and/or ground water serving at least 10,000 people that add a disinfectant to the drinking water during any part of the treatment process. At their discretion, States could extend coverage to smaller PWSs; however, to date few States have chosen to exercise this option.

The TCR, which applies to all public water systems, sets compliance with the MCL for total coliforms (TC). All systems must have a written plan identifying where samples are to be collected. If a system has a TC-positive sample, it must test that sample for the presence of fecal coliforms or *E. coli*. The system must also collect a set of repeat samples, and analyze for TC (and fecal coliform or *E. coli* within 24 hours of the first TC-positive sample). The TCR also requires an on-site inspection (referred to as a sanitary survey) every 5 years for each system that collects fewer than five samples per month.

Under the SWTR, EPA set maximum contaminant level goals of zero for *Giardia lamblia*, viruses, and *Legionella*; and promulgated regulatory requirements for all PWSs using surface water sources or groundwater sources under the direct influence of surface water. The SWTR includes treatment technique requirements for filtered and unfiltered systems intended to protect against the adverse health effects of exposure to *Giardia lamblia*, viruses, and *Legionella*, as well as many other pathogenic organisms.

In 1992 EPA instituted a formal regulatory negotiation (RegNeg) process with potentially affected parties (57 FR 53866; November 13, 1992), to consider potential amendments to the SDWA. Through an extensive consensus-building effort, the RegNeg Committee agreed that EPA should propose: an Information Collection Rule (ICR) (final in 1996); a staged Enhanced Surface Water Treatment Rule, and a staged Disinfectants/Disinfection Byproducts Rule. These rules formed the basis for the provisions of the 1996 amendments. Those amendments established a number of regulatory deadlines, including schedules for a Stage 1 and a Stage 2 Disinfection Byproduct Rule (DBPR), and for two stages of the Enhanced Surface Water Treatment Rule 1412(b)(2)(C). The SDWA as amended also requires EPA to promulgate regulations to "govern" filter backwash recycling within the treatment process of public systems (Section 1412(b)(14)) and to promulgate regulations specifying criteria for requiring disinfection "as necessary" for ground water systems. The LT1FBR if approved will be part of the first stage of the Enhanced Surface Water Treatment Rule, and will address recycling requirements.

The Stage 1 DBPR (63 FR 69389, December 16, 1998) applies to all PWSs that are CWSs and NTNCWs that treat their water with a chemical disinfectant for either primary or residual treatment. In addition, certain requirements for chlorine dioxide apply to TNCWSs. The Stage 1 DBPR finalizes maximum residual disinfectant level goals (MRDLGs) for chlorine, chloramines, and chlorine dioxide; MCLGs for four trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane, and bromoform), two haloacetic acids (dichloroacetic acid and trichloroacetic acid), bromate, and chlorite;

and NPDWRs for three disinfectants (chlorine, chloramines, and chlorine dioxide), two groups of organic disinfection byproducts TTHMs and HAA5 and two inorganic disinfection byproducts, chlorite and bromate.

As part of the first stage of the Enhanced Surface Water Treatment Rule, the Agency promulgated the Interim Enhanced Surface Water Treatment Rule (IESWTR) in December 1998, in conjunction with the Stage 1 DBPR**.** The purposes of the IESWTR are to improve control of microbial pathogens, specifically the protozoan *Cryptosporidium*, and address risk takeoffs between pathogens and disinfection byproducts. The provisions of IESWTR only pertain to public water systems serving 10,000 or more people that use surface water or GWUDI. Key provisions of the rule include: a Maximum Contaminant Level Goal (MCLG) of zero for *Cryptosporidium*; 2 log *Cryptosporidium* removal requirements for systems that filter; strengthened combined filter effluent turbidity performance standards of 1.0 NTU as a maximum and 0.3 NTU at the 95th percentile monthly, based on 4-hour monitoring for treatment plants using conventional treatment or direct filtration; requirements for individual filter turbidity monitoring; disinfection benchmark provisions to assess the level of microbial protection provided as facilities take the necessary steps to comply with new disinfection byproduct standards; inclusion of *Cryptosporidium* in the definition of ground water under the direct influence of surface water and in the watershed control requirements for unfiltered public water systems; requirements for covers on new finished water reservoirs; and sanitary surveys for all surface water systems regardless of size.

The proposed turbidity monitoring, disinfection benchmarking, and covered finished reservoir provisions of the LT1FBR, parallel several IESWTR provisions, extending them to surface and GWUDI systems serving fewer than 10,000 people. In addition, the LT1FBR recycling provisions, which apply to all surface and GWUDI systems that recycle, are meant to control pathogens in filter backwash that may increase as a result of changes in disinfection practices.

Minimization of Economic Burden

On an annual basis, the cost of the preferred alternatives is $87.6 to $97.5 million, depending on the discount rate assumption. This combination of alternatives, designed to minimize the impact of the proposed rule on small systems, represents a cost savings of about 38 to 40 percent over the estimated cost for alternatives that are similar to the IESWTR provisions. For the preferred alternative, EPA streamlined monitoring requirements, which reduced annual monitoring costs. The turbidity monitoring costs are 17 to 19 percent of total costs under the preferred alternatives in contrast to 45 to 48 percent under the alternatives that closely match the IESWTR provisions. Also by staggering the implementation of the changes to the SWTR, smaller systems will gain from the experience of larger systems on how to most cost effectively comply with the LT1FBR. Larger systems will generate a significant amount of treatment and cost data from the IESWTR ICR and in their efforts to achieve compliance with the IESWTR requirements. EPA intends to summarize this information and make it available through guidance manuals. EPA believes this information will assist smaller systems in achieving compliance with the LT1FBR.

7.1.4 Effect of Compliance With the LT1FBR on the Technical, Financial, and Managerial Capacity of Public Water Systems

Section 1420(d)(3) of the SDWA as amended requires that, in promulgating an NPDWR, the Administrator shall include an analysis of the likely effect of compliance with the regulation on the technical, financial, and managerial capacity of public water systems. The following analysis fulfills this statutory obligation. In EPA guidance (EPA 816-R-98-006) (U.S. EPA, 1998) the Agency defines water system capacity as the ability to plan for, achieve, and maintain compliance with applicable drinking water standards. Capacity has three components: technical, managerial, and financial.

Technical capacity is the physical and operational ability of a water system to meet SDWA requirements. Technical capacity refers to the physical infrastructure of the water system, including the adequacy of source water and the adequacy of treatment, storage, and distribution infrastructure. It also refers to the ability of system personnel to adequately operate and maintain the system and to otherwise implement requisite technical knowledge. Examining key issues and questions can determine a water system's technical capacity, including:

- Source water adequacy. Does the system have a reliable source of drinking water? Is the source of generally good quality and adequately protected?

- Infrastructure adequacy. Can the system provide water that meets SDWA standards? What is the condition of its infrastructure, including well(s) or source water intakes, treatment, storage, and distribution? What is the infrastructure's life expectancy? Does the system have a capital improvement plan?

- Technical knowledge and implementation. Is the system's operator certified? Does the operator have sufficient technical knowledge of applicable standards? Can the operator effectively implement this technical knowledge? Does the operator understand the system's technical and operational characteristics? Does the system have an effective operation and maintenance program?

Managerial capacity is the ability of a water system to conduct its affairs in a manner enabling the system to achieve and maintain compliance with SDWA requirements. Managerial capacity can be assessed through key issues and questions, including:

- Ownership accountability. Are the system owner(s) clearly identified? Can they be held accountable for the system?

- Staffing and organization. Are the system operator(s) and manager(s) clearly identified? Is the system properly organized and staffed? Do personnel understand the management aspects of regulatory requirements and system operations? Do they have adequate expertise to manage water system operations? Do personnel have the necessary licenses and certifications?

- Effective external linkages. Does the system interact well with customers, regulators, and other entities? Is the system aware of available external resources, such as technical and financial assistance?

Financial capacity is a water system's ability to acquire and manage sufficient financial resources to allow the system to achieve and maintain compliance with SDWA requirements. Financial capacity can be assessed through key issues and questions, including:

- Revenue sufficiency. Do revenues cover costs? Are water rates and charges adequate to cover the cost of water?

- Credit worthiness. Is the system financially healthy? Does it have access to capital through public or private sources?

- Fiscal management and controls. Are adequate books and records maintained? Are appropriate budgeting, accounting, and financial planning methods used? Does the system manage its revenues effectively?

A total of 13,689 large and small systems are potentially subject to the proposed LT1FBR. Of these, EPA estimates that 10,850 systems would need to take some action to come into compliance with the rule. Much of the activities undertaken by these systems would be one time start-up activities associated with reporting requirements. For example, there are 9,450 small systems that will need to comply with the disinfection benchmark provision. Approximately 5,136 of these systems are among the 5,896 small systems that would undertake turbidity monitoring are the only systems that would incur annual monitoring costs, and of these 2,406 of them may need to modify their turbidity treatment process. EPA estimates that the maximum number of systems that would be required to change their recycling treatment practices is 1,172. The expected number of small systems needing to comply with the covered finished water provision is 580. Some large or small systems may require significantly increased technical, financial, or managerial capacity to comply with these new requirements.

Systems needing to modify treatment will do so to meet turbidity or recycling provisions. EPA identified numerous process improvements that small systems might implement to improve finished water quality to meet the proposed turbidity standards. The unit costs developed for these process improvements are based on cost models, best engineering judgement, and existing cost and technology documents. In most cases, cost estimates were derived by system size based on estimates of system design and average flow rates. Exhibits 6–2a and 6–2b detail the capital costs and O&M costs for the turbidity provisions. The Agency estimates turbidity capital and O&M costs for small systems to be $62.4 million using a 7 percent discount rate. *The Cost and Technology Document for the Long Term 1 Enhanced Surface Water Treatment Filter Backwash Rule* (U.S. EPA, 1999b) describes in detail the methods and assumptions used to develop unit costs.

Systems modifying treatment to meet recycling provisions may need to move recycle return to the plant headworks or alter treatment processes. As noted in Exhibit 6–18, the compliance forecast estimated that 791 plants would need to move their recycling return flow to the head of the plant. Exhibits in

Appendix C detail the unit capital and O&M costs for direct and conventional filtration plants that need to redirect theirs recycle flows. Direct recycle plants would need to conduct self assessments and report the findings to the State; subsequent requirements to alter treatment practices are at the discretion of the State. Appendix C reports the number of systems that would need to implement treatment changes and the unit capital costs. EPA estimates that approximately 359 direct recycle systems potentially exceed their design capacity during recycling events and would need to alter treatment. Direct filtration plants will report their recycling practices to the State which would determine if treatment changes are necessary. EPA assumes that 23 direct filtration systems that recycle would be required to install treatment. Appendix A summarizes the treatment process options, the forecast of how many systems would need to alter treatment, and the unit cost for each option. Annualized capital costs associated with the recycling provisions are approximately $13.6 million (assuming a 7 percent discount rate) and the O&M costs are approximately $10.2 million.

7.1.5 Paperwork Reduction Act

The information collected as a result of this rule will allow the States and EPA to evaluate PWS compliance with the rule. For the first 3 years after promulgation of this rule, the major information requirements pertain to monitoring, and compliance reporting. Responses to the request for information are mandatory (Part 141). The information collected is not confidential.

The Paper Work Reduction Act requires EPA to estimate the burden on PWS, States, and territories for complying with the final rule. Burden refers to the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency. This includes the time needed to review instructions; develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information; adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of information; and transmit or otherwise disclose the information.

Information collection activities of PWSs required under this rule during the first 3 years following promulgation will result in an average annual burden of 248,978 person-hours collectively for the PWSs. For States and territories, the analysis suggests the annual average burden to be 62,508 hours. The national, average annual labor cost of PWSs associated with information collection activities averages $9.3 million annually. The average annual costs incurred by PWSs for turbidimeter installation would be $2.7 million in capital costs and $1.8 million in average O&M costs. The annual cost for laboratory analyses would be $115,000. Nationally, States and territories will incur annual average costs of $1.5 million. Exhibit 7–10 presents a summary of the burden hours and costs associated with the LT1FBR rule for the 3 years covered by the ICR.

The costs and burdens during ICR approval period do not reflect all the costs and burdens that would result from the rule, as several provisions are not scheduled for implementation until after the first 3 years. The recycling provisions would be implemented in the fourth and fifth years following promulgation. The total burden and costs to systems for the recycle provisions would be 157,768 hours and $5.7 million, respectively. For States the recycling provisions would result in a 52,411 hour burden and a $1.2 million cost.

Exhibit 7–10. Summary of Respondents, Responses, Burden, and Costs for PWSs and States for the ICR Approval Period

	Number Respondents Average	Number Responses Average	Average Annual Burden	Average Annual Labor Cost	Average Annual Laboratory Costs	Average Annual Turbidimeter Costs	
						Capital	O&M
PWSs	5,980	9,222	248,978	$9,313,919	$115,200	$2,713,815	$1,783,395
States	39	7,275	62,508	$1,513,000	$0	$0	$0
Total	**6,019**	**16,497**	**311,486**	**$10,826,919**	**$115,200**	**$2,713,815**	**$1,783,395**

Turbidity monitoring, the only annual activity that the proposed rule requires, would not begin until the fourth year after promulgation. By the sixth year after promulgation all start-up activities would be completed and the remaining compliance activity associated with the rule would be annual turbidity monitoring. In year 6 the annual burden and cost for all PWSs would be 274,274 hours and $9.0 million, respectively. Similarly, for States in the sixth year the burden and cost would be 219,286 hours and $6.1 million. The derivation of all LT1FBR burdens and costs for start-up and annual information collection activities can be found in *LT1FBR Information Collection Request*.

7.2 Impacts on Subpopulations

A primary purpose of the proposed LT1FBR is to improve control of microbial pathogens, specifically the protozoan *Cryptosporidium*. The health effect of cryptosporidiosis on sensitive subpopulations is much more severe and debilitating than on the general population. 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).

Mortality as a result of cryptosporidiosis infection is a much greater risk for sensitive subpopulations than it is for the general population, particularly for the immunocompromised.

> The duration and severity of the disease are significant: whereas the disease may hospitalize 1 percent of the immunocompetent population 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).

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 cost of illness (COI) from cryptosporidiosis would be much greater than for the general populace. During a 1993 outbreak in Milwaukee, 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).

Because of the severity of illness and high costs for treatment experienced by sensitive subpopulations, as a result of *Cryptosporidium* infection, the Agency expects LT1FBR to have a disproportionately positive impact on the subpopulations mentioned earlier.

Protecting Children From Environmental Health Risks and Safety Risks

Executive Order 13045 (62 *FR* 19885, April 23, 1997) applies to any rule initiated after April 21, 1997, or proposed after April 21, 1998, that 1) is determined to be "economically significant" as defined under Executive Order 12866 and 2) concerns an environmental health or safety risk that EPA has reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, EPA must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by EPA.

In promulgating the LT1FBR EPA recognizes that the health risks associated with exposure to the protozoan *Cryptosporidium* are of particular concern for certain sensitive subpopulations, including children and immunocompromised individuals. Cryptosporidiosis acquired by the drinking water exposure pathway can spread quickly among children in group settings, especially diapered children in day care centers (Juranek, 1998). This type of transmission is called secondary transmission, and can result in spread of the disease to both children and adults. Evidence of such secondary transmission of cryptosporidiosis from children to household and other close contacts has been found in many outbreak investigations (Casemore, 1990; Cordell, et al., 1997; Frost, et al., 1997). During the 1993 Milwaukee outbreak, 74 percent of day care centers interviewed reported cryptosporidiosis among children or staff members, although only 3.4 percent of facilities closed because of the epidemic (Cordell, et al., 1997). Having a child under 5 years of age in a household was a risk factor (i.e., with a matched odds ratio of 17) among laboratory-confirmed cryptosporidiosis cases during the post-outbreak period in Milwaukee (Osewe, et al., 1996).

Malnourished and immunocompromised children are at greater risk of developing chronic diarrhea when infected with *Cryptosporidium* due to impaired immune response (Griffiths, 1998, Casemore, 1990). The progression from acute cryptosporidiosis to chronic diarrhea and death among malnourished children is not well understood (Griffiths, 1998). However, information on mortality from diarrhea shows the greatest risk of mortality occurring among the very young and elderly (Gerba, et al., 1996). Specifically, young children are a vulnerable population subject to infectious diarrhea caused by *Cryptosporidium* (CDC, 1994). Cryptosporidiosis is prevalent worldwide, and its occurrence is higher in children than in adults (Fayer and Ungar, 1986). Moreover, Cryptosporidiosis appears to be more prevalent in populations that may not have established immunity against the disease and may be in greater contact with environmentally contaminated surfaces, such as infants (DuPont, et al., 1995). Once a child is infected, it may spread the disease to other children or family members.

These concerns were considered as part of the regulatory development process, particularly in the establishment of the MCLG at zero for *Cryptosporidium* in drinking water established under IESWTR. The proposed LT1FBR continues to take into account the need to protect sensitive populations (e.g., children) and provide for an adequate margin of safety. For public water systems that use surface water, filter, and serve less than 10,000 people, EPA is establishing physical removal treatment requirements to control for *Cryptosporidium*. For systems that use conventional, direct, or membrane filtration, EPA is strengthening the existing turbidity standards for finished water and is also requiring individual filter monitoring for conventional and direct filtration systems to assist in controlling pathogen breakthrough during the treatment process.

7.3 Environmental Justice

Executive Order 12898 (59 FR 7629) establishes a Federal policy for incorporating environmental justice into Federal agency missions by directing agencies to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations. For example, to assist in identifying the need for ensuring protection of populations who principally rely on fish or wildlife for subsistence, the Executive Order directs agencies, whenever practicable and appropriate, to collect, maintain, and analyze information on the consumption patterns of those populations, and to communicate to the public the risks of those consumption patterns.

The Agency has considered environmental justice related issues concerning the potential impacts of this proposed action and has consulted with minority and low-income stakeholders. Three aspects of the rule comply with the Environmental Justice Executive Order and they can be classified as follows: 1) The overall nature of the rule; 2) the inclusion of sensitive subpopulations in the regulatory development process; and 3) the convening of a stakeholder meeting specifically to address environmental justice issues. The overall nature of the LT1FBR rule mimics the 1998 IESWTR by regulating small public water systems to improve control of microbial pathogens. Therefore, the minority and impoverished populations served by small systems will realize the health protection benefits currently provided to populations served by larger systems. The Water Industry Baseline Handbook provides limited information concerning the distribution of impoverished households served by small systems.

In addition, the proposed rule includes concerns of the sensitive sub-populations through the Reg. Neg. and M-DBP Advisory Committee process undertaken to craft the regulation. Both Committees were chartered under the FACA authorization, and included a broad cross-section of regulators, regulated communities, industry, public interest groups, and State and local public health officials. Representatives of sensitive subpopulations, in particular people with AIDS, participated in the regulatory development process. Extensive discussion on setting treatment requirements that provide the maximum feasible protection took place, and the final consensus that resulted in the rule considered issues of affordability, equity, and safety.

Finally, as part of EPA's responsibilities to comply with Executive Order 12898, the Agency held a stakeholders' meeting to address various components of pending drinking water regulations; and how they may impact sensitive subpopulations, minority populations, and low-income populations. Topics discussed included treatment techniques, costs and benefits, data quality, health effects, and the regulatory process. Participants included national, State, Tribal, municipal, and individual stakeholders. The major objectives for the meeting were:

- Solicit ideas from environmental justice stakeholders on known issues concerning current drinking water regulatory efforts

  •Identify key issues of concern to stakeholders

  •Receive suggestions from stakeholders concerning ways to increase representation of communities in OGWDW regulatory efforts.

Furthermore, EPA developed a plain-English guide specifically for this meeting to assist stakeholders in understanding the multiple and sometimes complex issues surrounding drinking water regulation.

8. Weighing the Benefits and the Costs

This chapter compares the benefit estimates discussed in Chapter 5 with the cost estimates discussed in Chapter 6. The comparison method used is an estimate of net benefits, which is the difference between benefits and costs. Most of the potential range of quantifiable benefits, which exclude many types of benefits discussed in Chapter 5, exceeds the cost estimates associated with the preferred alternatives. Consequently, even though there are costs associated with the proposed rule, EPA expects the benefits to exceed costs such that the net benefits will be positive.

8.1 Incremental and Marginal Analysis

EPA estimated the incremental benefits and costs of the proposed rule, which are the benefits and costs expected to accrue compared to a baseline in which the provisions of the rule are not implemented. Both benefits and costs are expressed as annual values. Annual benefits are monetized estimates of avoided morbidity or mortality cases. Annual costs include annualized capital investments to alter treatment processes and annual O&M expenditures. They also include annualized start-up cost estimates for all of the provisions of the proposed rule.

EPA compared the costs of the proposed CFE requirement (i.e., 0.3 NTU 95th percentile) with the costs that would be associated with more stringent requirements of 0.2 NTU and 0.1 NTU. For these two sensitivity tests, EPA developed assumptions about which process changes systems might implement to meet the requirement and how many systems would adopt each change. The decision trees in Appendix C summarize these assumptions, which were inputs to the cost model that calculated total annual costs. The comparison of total compliance cost estimates in Chapter 6 showed that marginal costs of more stringent requirements rise rapidly. Compared to the proposed 0.3 NTU requirement, the turbidity treatment costs of the 0.2 NTU sensitivity test were 157 percent higher and the costs of the 0.1 NTU case were 675 percent higher.

8.2 Benefit-Cost Comparisons

EPA compared annual benefits and costs by calculating net benefits, which is the difference between the two. The assessment of benefits was based on a health risk assessment that characterized the scientific uncertainty regarding the exposure assessment and health hazards associated with exposure to *Cryptosporidium* through drinking water. The benefits analysis used Monte Carlo simulations to derive a distribution of estimates, rather than a single point estimate.

Exhibit 8–1 summarizes the mean expected value of potential annual benefits for the turbidity provisions under both baselines, the three improved removal assumptions, and two daily consumption distributions. Assuming a 2.0 log removal baseline for small systems, benefits range from $195.3 million to $259.4 million. Alternatively, if a 2.5 log removal baseline is more representative of current small system performance, the benefits are less, ranging from $70.1 million to $92.4 million. The range across these assumptions, is therefore, $70.1 million to $259.4 million. The corresponding mean estimates of avoided illnesses, which account for almost 80 percent of benefits, range from approximately 22,800 cases to 83,600 cases per year.

Exhibit 8–1. Summary of Annual Mean Benefits Associated with Avoided Illnesses and Mortalities for the Turbidity Provisions of the Proposed Rule (January 1999 dollars)

Improved Log Removal Assumption	Baseline *Cryptosporidium* Log-Removal Assumptions ($ millions) Mean = 1.2 Liters per person 2.0 log Baseline	2.5 log Baseline
Low Removal	$195.3	$70.1
Mid Removal	$240.8	$86.1
High Removal	$259.4	$92.4

Exhibit 8–2 summarizes the annual cost of the rule at the 3 percent and 7 percent discount rates for two combinations of alternatives. Annual costs for the combination of preferred options are $87.6 or $97.5 million depending on the discount rate, and they are $145.5 or $157.3 million for the combination of alternatives that closely resembles provisions in the IESWTR. This comparison shows that the proposed rule reduces total cost by 38 to 40 percent compared to what costs would be without tailoring the turbidity and disinfection benchmark provisions to meet the needs and circumstances of small systems while fulfilling public health protection goals that are comparable to the IESWTR.

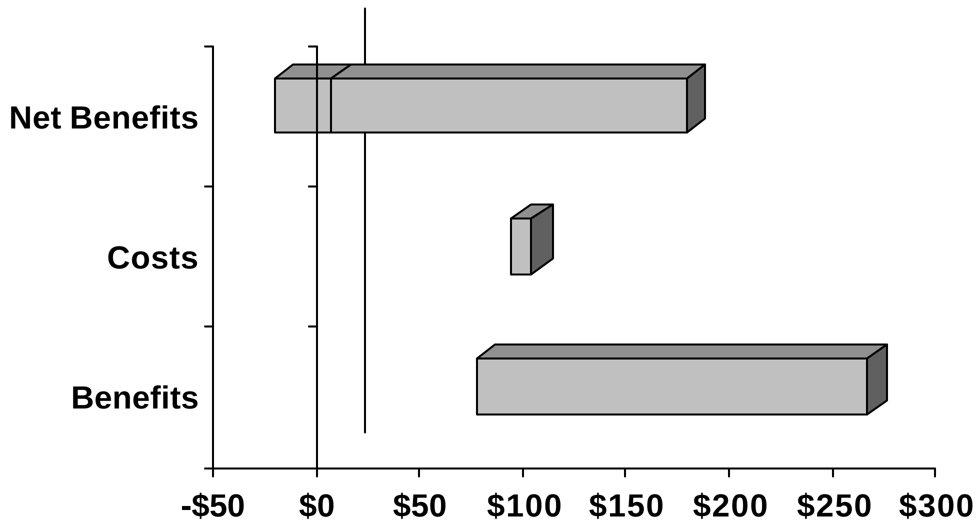
Exhibit 8–2. Total Annual Costs for Two Combinations of Alternatives (January 1999)

Compliance Activity	Preferred Alternatives (T2, A4, B2 with R2) ($ millions)		IESWTR Alternatives (T1, A1, B1 with R2) ($ millions)	
	3%	7%	3%	7%
Turbidity Provisions	$63.4	$68.6	$116.7	$121.9
Disinfection Benchmarking	$1.3	$1.8	$5.9	$8.3
Covered Finished Storage	$2.5	$2.6	$2.5	$2.6
Recycle Provisions	$20.4	$24.5	$20.4	$24.5
Total Costs	**$87.6**	**$97.5**	**$145.5**	**$157.3**

Detail may not add to total due to independent rounding.

The bottom bar in Exhibit 8–3 shows the range of expected benefits from $70.1 million to $259.4 million. The middle bar shows the range between the two total cost estimates for the preferred alternatives, $87.6 million and $97.5 million. Finally, it plots a range of potential net benefits, which compares the quantified benefits for the turbidity provisions with the total costs for all provisions. The lowest potential net benefit is the difference between the lowest benefit estimate and the highest cost estimate (i.e., $70.1 million – $97.5 million = –$27.4 million). The highest potential net benefit is the difference between the highest benefit estimate and the lowest cost estimate (i.e., $259.4 million – $87.6 million = $171.8 million). As the chart shows, the range of potential net benefits from negative $27.4 million to $171.8 million lies primarily to the right of zero, showing that benefits are likely to exceed costs.

Exhibit 8–3. Comparison of Annual Benefit, Cost, and Net Benefit Ranges (January 1999 dollars, millions)



Although monetized net benefits may be as low as negative $27.4 million, total social benefits are likely to be positive if the qualitative benefits are taken into consideration. Exhibit 8–4 shows that although costs have been estimated for most of the provisions, benefits have not. Benefits were only estimated for the turbidity provisions. Furthermore, the benefits that were quantified for the turbidity provisions exclude some benefits of those provisions such as reducing exposure to other pathogens (e.g., *Giardia lamblia*) and avoiding the cost of averting behavior. The nonquantified benefits could represent substantial additional economic value. Overall, EPA expects the proposed rule to improve health protection for more than 18 million households, which are the households served by systems EPA estimates will alter treatment or practices under the rule. If the aggregate benefit per household for these nonquantified benefits is at least $1.52 per year, then even the low range of net benefits will be positive.

Exhibit 8–4. Summary of Benefit and Cost Analysis Completeness (January 1999, millions)

Compliance Activity	Range of Costs for Preferred Alternatives (T3, A4, B2, R2)	Range of Benefits
Small System Provisions Comparable to IESWTR:		
• Turbidity Provisions	$63.4 – $68.6	> $70.1 – $259.4
• Disinfection Benchmarking	$1.3 – $1.8	not estimated
• Covered Finished Storage	$2.5 – $2.6	not estimated
• *Cryptosporidium* in GWUDI Definition	not estimated	not estimated
• *Cryptosporidium* in Watershed Requirements	not estimated	not estimated
Subtotal for LT1 Provisions	$67.2 – $73.0	> $70.1 – $259.4
Recycle Provisions	$20.4 – $24.5	not estimated
Total Costs	**$87.6 – $97.5**	**> $70.1 – $259.4**

Under the 1996 Amendments to the Safe Drinking Water Act, EPA is required to make a determination of whether benefits justify costs for the rulemaking. EPA has determined that the benefits of the LT1FBR justify the costs. EPA made this determination for both the LT1 (i.e., the five provisions in the first row of Exhibit 8–4) and the FBR (i.e., the recycle provisions) portions of the rule separately as described below.

EPA has determined that the benefits of the LT1 provisions justify their costs on a quantitative basis. The LT1 provisions include enhanced filtration, disinfection benchmarking, and other nonrecycle-related provisions. The quantified benefits of $70.1 million to $259.4 million annually exceed the annual cost range of $67.2 million to $73.0 million over a substantial portion of the range of benefits. In addition, the nonquantified benefits include avoided outbreak response costs, avoided costs of averting behavior, and reduced uncertainty about drinking water quality.

For the recycle provisions, the Agency has determined that the benefits of the provisions justify their cost on a qualitative basis although the analysis in the following section provides a quantitative perspective on the health benefits needed to break even given EPA's cost estimates. The recycle provisions will reduce the potential for certain recycle practices to lower or upset treatment plant performance during recycle events. Therefore, the provisions will help prevent *Cryptosporidium* oocysts from entering finished drinking water supplies and will increase the level of public health protection.

Returning *Cryptosporidium* to the treatment process in recycle flows, if performed in a manner that is inconsistent with fundamental engineering and water treatment principles, can increase public health risks. EPA believes that there are three instances, in particular, that increase health risks. First, returning recycle flow directly to the plant—without equalization or treatment—can cause large variations in the influent flow magnitude and the influent water quality. If chemical dosing is not adjusted to reflect these variations, then less than optimal chemical dosing can occur, which may lower sedimentation and filtration performance. Returning recycle flows prior to the point of primary coagulant addition will help diminish the likelihood of this occurring. Second, exceeding State-approved operating capacity, which is more likely to occur if recycle equalization or treatment is not in place, can hydraulically overload plants and diminish the ability of individual unit processes to remove *Cryptosporidium*. Exceeding approved operating capacity violates fundamental engineering principles and water treatment objectives. States set limits on plant operating capacity and loading rates for individual unit processes to ensure that treatment plants and individual treatment processes operate within their capabilities and, thereby, provide the necessary levels of public health protection. Third, returning recycle flows directly into flocculation or sedimentation basins can generate disruptive hydraulic currents, which lower the performance of these units and increase the risk *Cryptosporidium* will be present in finished water supplies.

The objective of the recycle provisions is to eliminate practices that are counter to common sense, sound engineering judgement, and that create additional and preventable risk to public health. EPA's proposed rule addresses these practices while providing States and affected systems with the flexibility necessary to implement the most cost-effective solutions. Consequently, EPA believes the public health protection benefit provided by the recycle provisions justifies their cost.

8.3 Breakeven Analysis for the Recycle Provisions

The LT1FBR recycle provisions are expected to improve recycle practices, thereby preventing the accumulation of *Cryptosporidium* within the treatment plant and minimizing the risk of oocysts entering into the finished water. Estimating the magnitude of the risk posed by existing recycle practices and the risk reduction resulting from the recycle provisions, however, is complicated by the lack of scientific data to support assumptions and analyses. Given the large population served by systems that are potentially subject to the proposed rule (66.8 million—the total population served by all rapid granular filtration systems that practice recycle), even a small risk reduction could have a substantial impact. To assess the costs of the recycle provisions against the possible range of risks, EPA used a breakeven analysis to explore net benefits of the alternatives. Breakeven analysis represents an approach to assessing the benefits of the recycle provisions given the scientific uncertainties surrounding the risk posed by recycling practices.

Breakeven is a standard benchmark of cost effectiveness and economic efficiency and is essentially the point where the benefits of the recycle provisions would be equal to the costs. Normally, the benefits and costs of an option are calculated separately and then compared to assess whether and by what amount benefits exceed costs. In the case of the recycle provisions, independently estimating benefits is difficult, if not impossible, because of the uncertainty surrounding the risk and resulting risk reduction. Instead, the breakeven analysis works backwards from those variables that are less uncertain. In this case, implementation costs for the rule and the monetary value associated with the health endpoints are used to calculate what risk reduction estimates are needed for the rule to just pay for itself in avoided health damages associated with cryptosporidiosis.

The first step in the breakeven analysis is to calculate the number of cryptosporidiosis cases that would need to be avoided for the benefits of avoiding those cases to be equal to the cost of the rule. The simple calculation is to divide the annual costs of the rule by the value per cryptosporidiosis case to derive the number of cryptosporidiosis cases needed to cover the costs of the rule. The value of a cryptosporidiosis case differs based on whether the case results in illness or fatality. Fatal cases are valued at the VSL with a mean of $5.7 million as mentioned earlier. It is assumed that .0125 percent of all cryptosporidiosis cases are fatal and are, therefore, assigned the VSL.

For the cryptosporidiosis illnesses (nonfatal), comprising 99.9875 percent of the total, the cost of illness estimate of $2,400 was used as a valuation. It is important to note that this value reflects 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 $2,400 COI avoided per case mean estimate.

The average cost per cryptosporidiosis case avoided is approximately $3,100 [($5.7 million × 0.000125) + ($2,400 × 0.999875). This value is divided into the implementation costs for the various rule alternatives to estimate the number of cryptosporidiosis cases reduced needed to break even (Exhibit 8–5). For the preferred alternative at a 7 percent rate, the recycle provisions would have to prevent 5,600 to 7,900 illnesses annually to break even.

Exhibit 8–5. Breakeven Analysis Summary

	3% Cost of Capital		7% Cost of Capital					
	Alternative R2		Alternative	Alterative R2		Alterative R3		Alternative
	Low	High	R1	Low	High	Low	High	R4
Implementation cost ($ millions)	$14.3	$20.4	$16.9	$17.4	$24.5	$55.0	$56.7	$151.8
Total number of cases prevented to break even	4,600	6,600	5,500	5,600	7,900	17,700	18,300	49,000
Fatal cases	1	1	1	1	1	3	3	7
Nonfatal cases	4,599	6,599	5,499	5,599	7,899	17,697	18,297	48,993

The breakeven number of cases provides only part of the information needed to assess under what conditions the recycle provisions will break even. Two other factors, the baseline number of cryptosporidiosis illnesses and the percent reduction in risk due to the provisions, combine to give the number of illnesses avoided by the rule. In general, these two factors have an inverse relationship with respect to the breakeven point: the higher the baseline number of illnesses, the lower the reduction needs to be to break even. Conversely, the lower the baseline number of cases, the higher the reduction in risk needs to be.

The baseline number of illnesses can be estimated using the risk characterizations performed for the IESWTR (for systems serving 10,000 and over) and the turbidity provisions of the proposed LT1FBR (for systems serving less than 10,000). The baseline number of illnesses remaining after the implementation of the LT1FBR and IESWTR range from a low estimate of 62,000 to a high estimate 344,600 (Exhibit 8–6).

Exhibit 8–6. Combined Annual Number of Illnesses Remaining After LT1FBR and IESWTR

Improved Log Removal Assumption	Baseline Assumption (LT1FBR/IESWTR)			
	2.0/2.5	**2.0/3.0**	**2.5/2.5**	**2.5/3.0**
Low Improved Removal	344,600	139,600	317,200	112,200
Mid Improved Removal	235,900	92,900	218,100	75,100
High Improved Removal	199,900	75,900	186,000	62,000

Exhibit 8–7 contains a graph that addresses the question: "Given the range of baseline risk, what risk reduction due to the recycle provisions would you need to reach the breakeven illnesses in Exhibit 8–5?"

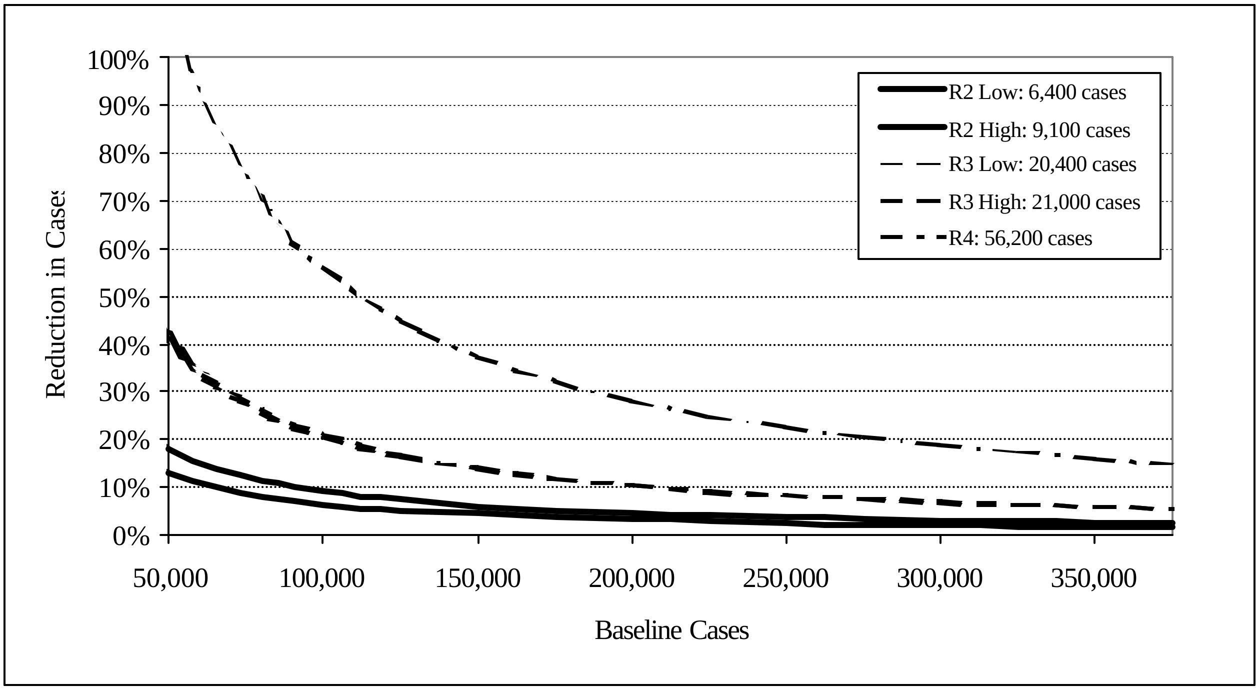
Exhibit 8–7 displays three sets of breakeven lines assuming a 7 percent discount rate, one for Alternative R4, and two lines each for Alternatives R2 and R3; the line for Alternative R1 lies on top of the low line for Alternative R2 and is therefore not shown in the graph. Each point on the line represents the combination of baseline illnesses and percent reduction needed to produce the breakeven cases. For Alternative 4, the combination of baseline number of illnesses and percent reduction at each point on the line produces 56,200 cases avoided. Graphically, at any combination of baseline risk and percent reduction in the area to the right of the lines, the recycle provisions would exceed a breakeven point (i.e., benefits would exceed costs) and at any combination in the area to the left of the lines, the costs of compliance would exceed the benefits.

Alternative R4 is expected to result in the greatest reduction in risk. If the estimated baseline risk is low (below about 115,000 cases), Alternative R4 would need to reduce baseline cases by more than 50 percent to break even. At the highest baseline risk, Alternative R4 would need to result in about a 15 percent reduction in risk to break even.

For Alternative R3, if the baseline risk is low (115,000 cases), the rule would need to reduce 20 percent of cases to breakeven. At the highest baseline risk, Alternative R3 would need to result in about a 5 percent reduction in risk to break even.

For Alternative R2, the preferred alternative, if the baseline risk is low (115,000 cases) the rule would need to reduce only about 6 percent to 9 percent of the risk to break even. At the high end of baseline risk, the rule would break even at a minimal reduction in risk (about 2 percent). At the mid range of baseline risk, the required reduction is under 5 percent. EPA selected Alternative R2 because it was felt to have a greater likelihood to be able to achieve reductions in risk due to *Cryptosporidium* that would break even and justify the costs.

Exhibit 8–7. Percent Reduction in Illnesses Needed to Break Even by Alternative



8.4 Summary of Uncertainty/Sensitivity Analysis

The results of the benefit and costs analyses were based on several assumptions that introduce uncertainties. Areas where important sources of uncertainty enter the benefits assessment include the following:

- Occurrence of *Cryptosporidium* oocysts in source waters
- Baseline occurrence of *Cryptosporidium* oocysts in finished waters
- Reduction of *Cryptosporidium* oocysts due to improved 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 health risk
- Willingness-to-pay to reduce risk and avoid costs.

The benefit analysis incorporates all of these uncertainties in either the Monte Carlo simulations or the assumption of two baselines—2.0 log removal and 2.5 log removal—as discussed in Chapter 5. The results in Exhibit 8–1 show that benefits are more sensitive to the baseline log removal and the daily water consumption assumptions than the range of low to high improved removal assumptions. Other unquantified benefits stemming from illnesses avoided from other rule provisions were also discussed in Chapter 5.

Cost analysis uncertainties are primarily caused by baseline assumptions made about how many systems will be affected by various provisions and how they will likely respond. Capital and O&M expenditures account for a majority of total costs. EPA derived these costs for a “model” system in each size category using engineering models, best professional judgement, and existing cost and technology documents. Costs for systems affected by the proposed rule could be higher or lower, which would affect total costs.

8.5 Combined Regulatory Effects with Other Rules

The proposed LT1FBR is one of several rules that potentially affect surface water and GWUDI drinking water systems. Exhibit 8–8 summarizes recent and forthcoming rules. Thus far, EPA’s cost estimates suggest that costs associated with small systems will total $59 million under the existing IESWTR and Stage 1 DBPR, and could increase by another $73 million under the proposed rule assuming a 7 percent discount rate. Costs associated with larger systems are substantially larger, totaling $569 for the existing rules, and may reach $587 million including costs for the proposed LT1FBR. Adding costs across rules may over state the social costs of regulatory activities because actions to satisfy one rule may reduce the costs of subsequent rules that have related public health goals.

Exhibit 8–8. Annualized Costs for Recent and Forthcoming Rules that Affect Surface Water and GWUDI Drinking Water Systems

Rule	Small Systems (serving < 10,000 customers)	Large Systems (serving $ 10,000 customers)
IESWTR (12/98)	$2 million	$291 million
Stage 1 DBPR (12/98)	$57 million	$278 million
LT1FBR (11/00)	$73 million	$18 million
Stage 2 DBPR (11/ 02)	yet to be determined	yet to be determined
Stage 2 LTESWTR (05/02)	yet to be determined	yet to be determined
Total Costs	**$132 million**	**$587 million**

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