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Safe Drinking Water Act: Costs of Compliance

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I. Introduction

This working paper examines the national costs associated with federal drinking water regulations promulgated by the U.S. Environmental Protection Agency (EPA) under the statutory mandate of the Safe Drinking Water Act Amendments of 1996 (SDWAA). Building on EPA's estimates and other available research, it presents cost estimates for each major national rule finalized under the SDWAA since the Amendments were signed into law. [1]

We show compliance cost estimates in terms of capital investment requirements, and also in terms of total annualized costs (these include the annualized costs of the capital requirements, plus the estimated annual expense of operation and management, O&M). In addition, we disaggregate and report costs by Community Water System (CWS) size categories where data permit.

We then combine our cost estimates for these recent regulations issued under the SDWAA with previously generated cost estimates for regulations issued between 1986 and 1996. Our analysis suggests that regulations issued under the 1996 SDWAA cost communities $1.8 billion per year. The annualized cost of drinking water regulations issued since 1986 are $4.8 billion per year.

The report is organized as follows. Section II provides background on the SDWAA and the associated federal regulatory program for drinking water. Section III describes the methodological approach and data used in this analysis. Section IV provides a summary of our findings, and Section V discusses our analysis on a rulemaking-specific basis. Conclusions are provided in Section VI.

II. The Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) was enacted in 1974. Initially, EPA focused on converting 15 long-standing drinking water guidelines, previously issued by the Public Health Service, into enforceable Maximum Contaminant Levels (MCLs), as required under the statute. In other words, EPA converted public health guidelines that predated the SDWA into enforceable federal standards.

Under the SDWA, MCLs are concentration-based limits typically expressed in terms of micrograms of contaminant per liter of water. The MCL establishes the highest concentration of the contaminant allowed under the law. Under the statute, MCLs are

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established as follows. First, EPA must define a "no risk" drinking water concentration that can serve as a public health goal. This zero risk level is defined as the Maximum Contaminant Level Goal (MCLG), and is intended to be precautionary in the sense of erring on the side of safety in terms of establishing a zero risk level concentration for even the most highly exposed and most sensitive subpopulations. As a matter of EPA policy, MCLGs are set at zero for all carcinogens (based on the presumption that some nonzero risk may exist for any positive exposure level, under the linear no-threshold dose-response model typically applied to carcinogens). The statute then requires that EPA set the enforceable MCL "as close as feasible" to the MCLG, where feasibility has been interpreted in terms of technological limits of contaminant removal (i.e., treatment) and analytical methods (i.e., sampling and measurement).

In 1979, the Agency added its first "new" standard by setting an MCL for total trihalomethanes (TTHMs), the sum of four trihalomethanes. TTHMs are a set of disinfection byproducts (DBPs), created by the interaction of disinfection chemicals (e.g., chlorine) with natural organic materials found in most waters, especially those drawn from surface sources. No other rules were issued under the Act until after 1986.

The SDWA was first amended and reauthorized in 1986, after several Congressional leaders had become frustrated by the lack of EPA progress in developing regulations for additional contaminants. This frustration was heightened in part by the perceived need to have more MCLs in place to help guide Superfund site cleanups. Another driving force for amending the Act was that monitoring efforts began to reveal the presence of numerous unregulated contaminants (e.g., volatile and synthetic chemicals) at low levels in many of the nation's waters. This raised concern that the limited set of then current federal standards might not be protecting public health from the numerous unregulated compounds (National Research Council, 1997). The 1986 version of the Act set an aggressive schedule under which EPA was instructed to issue MCLs for over 80 statute-specified contaminants, before 1989.

In response to the 1986 Amendments, EPA aggressively pushed forward many new MCLs, but the Agency could not keep up with the mandated schedule. More importantly, given the number of compounds and the aggressive schedule, EPA typically lacked the data to understand the occurrence, costs, or health risk reductions associated with its required regulatory actions. Several of the emerging MCLs and associated monitoring requirements were seen by many as ill-conceived or unnecessary, and questions began to emerge about how much the slew of new MCLs would cost and whether they would generate the types and levels of public health benefits that would justify the expense (see, for example, Raucher et al., 1994; Raucher, 1996). In response to the problems created by the 1986 version of the statute, the Act was amended again in 1996. The 1996 SDWAA brought a more reasoned approach to the regulatory process by removing the statutory listing of specific contaminants to be regulated (although some specific contaminants from the 1986 version were still mandated for regulation, including arsenic, radon, and Disinfection Byproducts). This removal of Congressionally-specified lists of which contaminants to regulate was broadly seen as an improvement because it provided more discretionary authority on which contaminants to regulate. It also placed the responsibility of periodic development and updating of Candidate Contaminant Lists

(CCLs) on EPA, subject to public review and comment. Overall, this was seen as a way to allow science and other risk management considerations to influence regulatory needs and priorities, rather than an arbitrary listing of contaminants by a legislative body. The 1996 SDWAA also added an explicit provision requiring EPA to estimate the benefits and costs of each proposed and final rule, and requiring the Administrator to issue a signed determination that the benefits "justify" the costs.

III. Approach

A. Rulemakings Covered by this Cost Analysis

In the nearly 8 years since the 1996 SDWAA, several major rulemakings have been promulgated:

- Information Collection Rule (ICR), issued in 1996, establishing monitoring and reporting requirements for a large-scale, in-depth, nationwide effort to obtain information on *Cryptosporidium* oocyst levels in utility source waters and on DBPs in finished waters.
- Stage 1 Disinfection Byproducts (DBP) Rule, finalized in 1998, establishing new MCLs for total trihalomethanes (TTHMs), the sum of five haloacetic acids (HAA5), and bromate.
- Interim Enhanced Surface Water Treatment Rule (IESWTR), promulgated in 1998 (in concert with Stage 1 DBP rule), mandating certain treatment practices intended to avoid potential microbial disease outbreaks (e.g., as posed by drinking water pathogens such as *Giardia* and *Cryptosporidium*).
- Long-Term 1 Enhanced Surface Water Treatment Rule (LT1), promulgated in 2002, extending coverage of the IESWTR to systems serving fewer than 10,000 persons that relied on surface waters or groundwaters deemed to be under the influence of surface waters.
- Filter Backwash Recycling rule (FBR), promulgated in 2001, eliminating the recycling of waters used to backwash (i.e., clean) filter media back to the plant intake, to eliminate some microbials from being reintroduced into waters about to be filtered and, thereby, potentially reduce the probability that microbial agents might pass through filters to finished (post-treatment) water.
- Arsenic rule, promulgated in 2001, setting an MCL of 10 micrograms per liter (µg/L, which is roughly equivalent to parts per billion).
- Radionuclides rule, finalized in 2000, setting MCLs for uranium, radium, and other radioactive compounds (radon is not included in this rulemaking)

In the sections below, we evaluate each of these major rulemakings, review the available data on the costs of implementing them, and present cost estimates. Other regulations also developed by EPA since 1996, but not included here because of their relative insignificance, include the Unregulated Contaminants Monitoring Rule (UCMR), the

Consumer Confidence Report (CCR) rule, minor revisions to the Lead and Copper Rule (LCR), regulations on operator certification, and the Public Notification Rule (PNR). These rulemakings (and minor revisions to existing standards) have had very little cost impact (Steve Via, AWWA Regulatory Affairs Office, personal communication, March 2003).

B. Methods

As part of its rulemaking responsibilities under the SDWAA and a series of Executive Orders (E.O.s, including E.O. 12291 and E.O. 12866), EPA develops estimates of the cost of compliance with each drinking water regulation it proposes and promulgates. The EPA cost estimates serve as the starting point for the assessment developed in this report.

Many water professionals, government officials, independent expert reviewers, and stakeholders have expressed concerns about the completeness and accuracy of EPA's cost estimates for various SDWAA-related regulations. Well-reasoned and empirically justified evidence often has been brought to light to suggest that EPA's cost estimates may be lower than what is likely to be realized in real world settings, and sometimes the underestimation appears to be significant [e.g., Frey et al. (2000), Harrington et al. (2000), Gurian et al. (2001), and Hahn and Burnett (2001)].

The estimates presented in this report use EPA's cost estimates as a baseline. We then conduct sensitivity analysis on some key assumptions that are most open to question, and make transparent adjustments when appropriate. The types and sizes of these cost adjustments vary across rulemakings, depending on the specific issues identified in each EPA cost estimate. We believe the resulting estimates, while still conservative, reflect a more realistic perspective on what compliance costs might be. The types of adjustments and their sizes are kept fairly modest here, so that the revised estimates generally do not diverge too extensively from the EPA versions (even though for some rulemakings, it may turn out that EPA's cost estimates are considerably off target).

Where available, we also report alternative cost estimates derived by other parties. We identify the major factors that drive the cost differences, but do not develop in detail highly technical discussions about divergent engineering details. Instead, we refer readers interested in more detail to the original research.

All cost estimates reported here have been updated to first quarter 2004 U.S. dollars, using the Consumer Price Index (US Department of Labor, Bureau of Labor Statistics, accessed via http://www.bls.gov/cpi/, April 2004). Annualized capital outlays are based on a 7 percent real rate of interest (opportunity cost of capital), unless stated otherwise, consistent with long-standing directives from the U.S. Office of Management and Budget.

C. Issues Leading to Divergent Cost Estimates

For many major EPA rulemakings under the SDWA and SDWAA, independent researchers and other knowledgeable parties have developed alternative cost estimates to those presented by EPA. These often indicate that regulatory compliance costs for drinking water standards may be considerably higher than those estimated by EPA (such studies have at times indicated compliance cost projections as much as twice as great or more than EPA's estimates) (e.g., Chwirka et al., 2000 and Frey et al., 2000).

Numerous reasons may underlie the discrepancies between the cost estimates. Often the criticisms of EPA's cost estimates appear to be legitimate, and in other cases EPA has provided reasonable rebuttals. Typically, differences in cost of compliance estimates can be traced to alternative assumptions about technically complex issues such as engineering design parameters and technology performance. In other instances, cost differences can be traced to more transparent matters such as potentially omitted cost elements (e.g., sometimes EPA cost estimates did not include costs for items as may be applicable, such as waste disposal costs for treatment plant residuals or the need to retrofit existing treatment facilities to accommodate an additional contaminant removal process).

In addition, differences in national cost of compliance estimates often are the cumulative product of multiple factors that get compounded in the analysis (Raucher et al., 1995). For example, a study may (1) estimate that more systems will be affected by the rule than projected by EPA; (2) assign higher unit costs to the treatment technologies, and (3) add residuals management costs that EPA does not apply. Such a series of alternative assumptions, component estimates, and parameter values often collectively have a large impact on total costs, even if each of the individual differences is relatively modest (e.g., three cost-influencing factors that are each only 25% higher than the EPA-applied values will lead to a cumulative impact wherein total costs are double the EPA estimate).

IV. Summary of Results

The sections that follow develope and discuss cost estimates for each of the applicable rulemakingsin. This section compiles a summary of these findings and compares them to EPA's estimated costs for each rule.

Table 1, below, lists the major rules issued between 1996 and 2003 and between 1986 and 1996, along with our best estimates of each rule's cost. We report both total annualized cost estimates and estimates of initial capital outlays. Table 2 provides a side-by-side comparison of the cost estimates developed by EPA to the estimates we develop here, for the rules promulgated since 1996. This reveals that our estimates are 16% higher than EPA's in aggregate, with the key differences stemming from the arsenic and radionuclides rules (for which our estimates are nearly 80% higher). For three of these rules, we have adopted EPA's cost estimates without change (as discussed in the next section).

As shown in Table 1, in the bottom half of the table, our estimate of the costs of the seven significant rules issued by EPA since 1996 (shown in first quarter 2004 U.S. dollars) amounts to a total of $7.7 billion in initial capital outlays (and similar one-time expenses), and $1.8 billion per year in total annualized compliance costs. The cost estimates for pre-1996 rules, in the top half of the table, are based on a methodology similar to that used in this paper.[2] Initial capital outlays for the seven major rules included here are $11.7 billion, and annualized costs are $3.0 billion per year. Summing the costs for rules issued between 1986 and 1996 and since 1996 suggests that American consumers spend $4.8 billion per year to comply with safe drinking water requirements.

A comparison of the costs of the pre-1996 rules to the costs imposed by regulations issued since 1996 reveal that the majority of rule-imposed compliance expense is due to the rules issued before the SDWAA of 1996. However, some important caveats need to be considered in such an interpretation. First, the costs for the 1986-era rules are dominated by two significant rulemakings—the lead and copper rule and the surface water treatment rule. Second, there is still considerable debate and uncertainty over the true costs of the post-1996 rules, especially the 2001 arsenic rule (which might be considerably higher than the level stated here—see discussion below). Third, there are several rules en route to promulgation that will impose appreciable additional costs in the near future (including the LT2 and Stage 2 rules, the groundwater rule, and the radon rule).[3]

[2] These estimates are from an earlier study conducted by one of the authors. Raucher et al., 1993 and 1994, as compiled by the American Water Works Association (AWWA).

[3] EPA cost analyses of these proposed rules suggest they would add between $500 million and $1 billion to the annualized costs of the post-1996 rules, and several informed stakeholders believe the actual costs could be much higher. Additional future cost pressures water utilities are likely to face include infrastructure renewal; security; likely regulations for MTBE, perchlorate, and chromium 6; and more stringent versions of the lead and copper and arsenic rules.

Table 1. National cost of compliance estimates for drinking water regulations (all costs in millions of 2004 Q1 US dollars)

Rulemaking (date)	**Annualized costs**	**Capital outlay**
Rules promulgated from 1986 to 1996		
Fluoride	$12	$49
Phase I: Volatile Organic Chemicals	$131	$246
Phase II: Synthetic and Inorganic Chemicals	$340	$853
Phase V: Synthetic and Inorganic Chemicals	$92	$339
Total Coliform Rule	$189	$-
Lead and Copper Rule	$1,035	$5,778
Surface Water Treatment Rule	$1,218	$4,390
Subtotal (1986 to 1996)	***$3,018***	***$11,655***
Rules promulgated since 1996		
Information Collection Rule (1996)	$-	$155
Stage 1 Disinfection Byproducts Rule (1998)	$796	$2,662
Interim Enhanced Surface Water Treat. Rule (1998)	$351	$868
Long-Term 1 Enhanced SWTR	$48	$184
Filter Backwash Rule	$10	$53
Radionuclides Rule (2000)	$157	$719
Arsenic Rule (2001)	$400	$3,080
Subtotal (1996 to present)	***$1,762***	***$7,721***
Total (1986 to present)	**$4,780**	**$19,370**
(percent of total since 1996)	36.9%	39.8%

Table 2. Comparing EPA annualized cost estimates to our national cost of compliance estimates for drinking water regulations issued since 1996 SDWAA (all costs in millions of 2004 Q1 US dollars)

Rulemaking (date)	**Our estimate**	**EPA estimate**
Information Collection Rule (1996)	$-	$-
Stage 1 Disinfection Byproducts Rule (1998)	$796	$796
Interim Enhanced Surface Water Treat. Rule (1998)	$351	$351
Long-Term 1 Enhanced SWTR	$48	$48
Filter Backwash Rule	$10	$8
Radionuclides Rule (2000)	$157	$95
Arsenic Rule (2001)	$400	$217
Total (1986 to present)	**$1,762**	**$1,515**

It also is informative to examine how the costs are distributed across system size categories. Approximately one-third of the estimated compliance costs in Table 2 are borne by customers of the smaller systems. This is significant because costs per household are typically much greater in small systems than in larger ones, due to the appreciable economies of scale found in virtually all applicable drinking water treatment methods. For example, a rule that might cost $10 or $20 per household per year for typical residential customers in large systems (e.g., serving over 100,000 persons) may cost households served by smaller systems (e.g., serving under 100 persons) $500 per year. This raises the question of whether the health benefits received by households served by small systems outweigh the costs they bear, given that rulemaking benefit-cost analyses tend to focus on national averages dominated by the lower per-household costs found in large systems.

A good presentation of the disparity between large and small system impacts was included in the Federal Register notice supporting the Stage 1 Disinfectants and Disinfection Byproducts Rule.[4] The cost-per-household estimates were presented in the form of a cumulative frequency distribution for different types and sizes of systems. The results are summarized in Table 3.

[4] USEPA 1998c.

Table 3. Cost-per-household impact comparisons between system sizes for the Stage 1 D/DBP Rule based on cumulative frequency distributions within each grouping.[5]		
System Type & Size	**Percentile where $/hh/month = $1**	**Percentile where $/hh/month = $10**
Large Surface Water Systems (>10,000 pop)	98th	100th
Small Surface Water Systems (<10,000 pop)	72nd	98th
Large Ground Water Systems (>10,000 pop)	95th	100th
Small Ground Water Systems (<10,000 pop)	91st	97th

As illustrated in Table 3, economies of scale can reduce the per household cost of a drinking water regulation in large systems; most households served by large systems (95 to 98 percent in this example) will therefore see only marginal increases in costs. Of the total number of households served by small systems, a larger fraction will experience larger cost increases.

V. Analysis of Individual Regulations

This section examines EPA's cost estimates for post-1996 SDWAA regulations and makes adjustments when appropriate to derive our best estimate, upper, and lower bound of costs. Subsection A, below, covers the first four rules on our list; they were developed together as part of a negotiated rulemaking process. Subsections B and C examine the radionuclides and arsenic rules.

A. The Microbial/DBP Rule Cluster and Implications for the Cost Estimates

The Microbial and Disinfectants/Disinfection Byproducts (M/DBP) rulemakings were developed as part of a stakeholder consensus process that was formally convened as a negotiated rulemaking process (Reg Neg) under the Federal Advisory Committee Act. This M/DBP process resulted in a large family of rules, including:

[5] USEPA 1998c.

- the ICR (May 14, 1996)
- the Stage 1 DBP (December 16, 1998)
- the IESWTR (December 16, 1998)
- the FBR (June 8, 2001)
- the LT1ESWTR (January 14, 2002)
- the LT2ESWTR (proposed August 11, 2003)
- the Stage 2 DBP (proposed August 18, 2003).

The last two rules, pending final promulgation in 2005 are not covered in the discussion that follows. The others are discussed in chronological sequence.

Because these rules were developed as part of a stakeholder-inclusive process, there is far less difference in the cost estimates of drinking water regulations that emerged, compared to other rules. In the consensus process, EPA formed a Technical Work Group (TWG), consisting of technical representatives of all the stakeholders that were parties to the negotiations. This group was subdivided into numerous subgroups studying various issues of cost and benefit estimation. The subgroups worked in parallel to the negotiations for nearly 10 years. In this unprecedented process, the technical analysts confronted the challenge of developing national cost and benefit assessment methods as consensus analyses for consideration by the negotiators. This allowed negotiations to proceed with the confidence that the analyses being presented were fully vetted and reviewed by all parties. In addition to drawing upon the considerable technical expertise of water treatment engineers and equipment and chemical suppliers from the industry, the Reg Neg stakeholder group also included consumer advocates, low-income advocates, and representatives of immune-compromised populations.

This "Reg Neg" process had several effects on national cost estimation and the running debates over actual versus estimated impacts. First, it exposed all the stakeholder groups to the inherent difficulties of estimating national costs, especially when the water quality characteristics that cause treatment to be required are highly site-specific and dynamically interrelated. The presence of microbial contaminants in finished water, for example, may be inversely correlated to the presence of disinfectants and their by-products. It is not too surprising, therefore, that the TWG helped the negotiators agree on a phased approach to M/DBP regulation with an extensive effort to gather more data (the ICR) placed in between Phase 1 (IESWTR and Stage 1 DBP) and Phase 2 (LTESWTR 1&2, Stage 2 DBP, and FBR). But even with the benefit of such additional data, the process of developing national estimates was still routinely regarded by the TWG as inherently difficult and, as a rule of thumb, a $\pm$ 30% assessment of the uncertainty was often cited as a minimum scale for a confidence interval around the results (USEPA, 1998c, p.69437).

A large part of the TWG analyses focused on assessing whether a given regulatory alternative could be met through lower cost approaches to optimizing existing treatment processes or much more expensive shifts to totally different treatment technologies. The potential for error in this "decision tree" part of the analysis was widely acknowledged. It became the subject of intensive Monte Carlo simulations to test the robustness of treatment choices given uncertainties in underlying influences. At one point, the TWG also launched a "reality check" survey under the auspices of AWWA simply to ask the major utilities that had responded to the ICR data collection what they would choose to do under various scenarios. In the end, TWG analysts concluded there was still considerable uncertainty in their forecasts of compliance choices. The water industry comments provided to EPA on the proposed IESWTR and Stage 1 DBP Rule within the M/DBP cluster do not raise significant issues with the cost estimates because the issues had been worked over thoroughly in the Reg Neg process. The AWWA concluded that the decision tree estimates were reasonable considering the data available. One of the greatest unknowns concerning the decision tree estimates relates to the interplay between Phase 1 treatment choices for Stage 1 and the IESWTR, and the ultimate decisions that utilities will make to meet the Phase 2 requirement of the LT2ESWTR and Stage 2 DBP, which will require more significant shifts to alternative treatments. The phased rulemaking process has complicated the Regulatory Impact Analysis (RIA) because some utilities will undoubtedly look to combine major treatment shifts with other major projects such as infrastructure rehabilitation and replacement investments. It would not make sense to invest in a new replacement facility designed to meet Phase 1 compliance requirements if there is some perspective on what the Phase 2 requirements might look like. As the time interval between Phase 1 and Phase 2 has stretched out, more plants have had to face reinvestment decisions before the final rules are promulgated.[6]

Specific issues in the national cost analyses are noted in the following rule-by-rule summaries.

1. Cost Estimates for the Information Collection Rule

As discussed above, the EPA and the stakeholder groups participating in the M/DBP Reg Neg process jointly developed the cost estimates for the ICR data collection effort. Thus, no prominent challenges to these estimates were raised during the rule promulgation process. Anecdotally, many utility representatives believe that implementation costs may have been double the amounts estimated by the simple desk-top arithmetic that the TWG employed. Additional costs are likely to have resulted from the novelty and complexity of the monitoring requirements as well as from the extra care utilities took in developing and implementing their monitoring and reporting programs. This extra attention was a result of the unique character of the ICR data collection; since the data was to be used as a basis for regulatory development, utilities typically felt it extremely important to avoid contributing data that could in any way provide an erroneous characterization of their circumstances.

[6] A closing element of the first phase of negotiations was the development of a consensus position on possible Stage 2 regulatory targets for DBPs with associated national cost estimates supported by an assessment of the effect on treatment choices as reflected in a projected Stage 2 decision tree. Although identified as extremely tentative, it was acknowledged as a benefit to utilities facing long-term planning decisions to provide a preview of future requirements.

Table 4 provides estimated costs for the ICR, based on the EPA rulemaking (U.S. EPA, 1996). EPA's "best estimate" is $155 million in 2004 dollars. These are characterized as capital costs here because they were one-time expenditures, typically split over a 2-year period. We made no adjustments to the EPA-furnished estimates (other than to update them to 2004 price levels), because of the consensus process involved in developing the estimates. However, we have used the TWG's rule of thumb to develop an upper and lower bound.

Table 4. Updated aggregate cost estimate for ICR (millions of 2004 Q1 US dollars)

Estimate	Annual cost	Capital outlay	Comments
Best estimate	$0	$155	From EPA FR (U.S. EPA, 1996)
Lower bound	$0	$141	EPA less 30%
Upper bound	$0	$178	EPA plus 30%

2. Cost Estimates for the Paired Stage 1 DBP Rule and IESWTR

EPA issued its disinfection byproducts (DBP) and (IESWTR) rules together on the same day. Although the cost analyses presented for these rules did not generate objections when they were proposed—due to their origins in a consensus rulemaking process—the cost estimates were significantly changed in the promulgation of the final rule. The changes resulted from a change in the IESWTR structure and from new occurrence and treatment information.

The original IESWTR was based on a strategy of increasing disinfection sufficient to provide additional reductions in waterborne disease risks. This required the addition of expensive contact basins as part of the IESWTR and expensive advanced technologies for DBP removal as part of the Stage 1 DBP Rule. In the period following the proposal, EPA acknowledged that microbial monitoring methods were inadequate to support a regulatory approach based on increased disinfection in the manner previously conceived. An approach based on enhanced removal of turbidity was substituted at much lower cost. Because of the reduction in disinfection, the costs of DBP removal were reduced also.

The proposed IESWTR was projected to have an equivalent 2004 capital cost of $5 billion. EPA's regulatory analysis for the final rule estimated capital costs of only $0.87 billion (U.S. EPA, 1998a, 1998d). Even with increased annual costs for enhanced turbidity removal estimated to require an additional $110 million per year ($2004), EPA estimated the total annual cost of the final rule at about $100 million less than the proposal. We use EPA's estimate as our best estimate, as shown in Table 5. The costs are borne by systems serving over 10,000 persons since the rule applied only to these larger systems.

Table 5. Aggregate cost estimate for IESWTR (millions of 2004 Q1 US dollars)

Estimate	Annual cost	Capital outlay	Comments
Best estimate	$351	$868	From EPA FR (U.S. EPA, 1998d)
Lower bound	$235	$581	EPA less 30%
Upper bound	$456	$1,128	EPA plus 30%

The Stage 1 DBP Rule costs were reduced in part because of the reduced disinfection required in the IESWTR and in part based on new data available from the 1996 results of the AWWA WATERSTATS database, which provided better documentation of existing levels of total organic carbon (TOC), byproducts, and existing pre-disinfection practices. The revised treatment choice decision tree analysis showed a reduction in the number of water systems affected by the Stage 1 DBP Rule (from 39% to 28%) and a reduction in the number of systems projected to have to resort to expensive advanced technologies (from 17% to 6.5%). EPA estimated the capital cost of the proposed Stage 1 DBP Rule at $5.7 billion in equivalent 2004 dollars; but reduced its estimate of the capital cost of the final rule to $2.6 billion (Table 6). It estimated total annualized cost at $796 million, with about 40 percent borne by systems serving 10,000 or fewer individuals (Table 7) (U.S. EPA, 1998b, 1998c). We rely on EPA estimates for our best estimate, and apply the TWG's 30 percent rule of thumb to calculate lower and upper bound estimates.

Table 6. Aggregate cost estimate for Stage 1 DBP rule (millions of 2004 Q1 US dollars)

Estimate	Annual cost	Capital outlay	Comments
Best estimate	$796	$2,662	From EPA FR (U.S. EPA, 1998c)
Lower bound	$533	$1,784	EPA less 30%
Upper bound	$1,034	$3,461	EPA plus 30%

The stakeholders developed these changes in cost estimates and agreed that they were the best estimates of national costs for the final rules. The process is illustrative of the results' sensitivity to small changes in the projected treatment choices when the decision space is adjacent to sharp breaks in the cost functions. The TWG found that small differences in understanding existing treatment and levels of key parameters, as well as inherent measurement challenges, were significant drivers in the cost estimation process. In this case, changes in the scientific understanding supporting the need for disinfection and in the empirical understanding of the existing status of disinfection caused significant changes in the estimated impacts of the rule.

Table 7. Compliance costs for Stage 1 DBP rule by system size (annual cost in 2004 Q1 dollars)

System size (population served)	Annual cost	Share of cost
25-100		
101-500		
501-1000	$313	40.1%
1,001-3,300		
3,301-10,000		
10,001-50,000		
50,001-100,000	$468	59.9%
More than 100,000		
Total[a]	**$781**	**100.0%**

a. Does not include state implementation costs, hence total is less than complete cost of rule.

3. Cost Estimates for the LT1 Rule

The LT1ESWTR national cost estimates were actually developed initially as a part of the M/DBP Reg Neg process since the decision to phase in the implementation of this requirement for small systems did not arise until midway through the consensus process. As a result, there were few issues raised with the cost estimates during the promulgation process. The rule's impact—extending the new surface water treatment requirements to small systems—was buffered somewhat by the fact that the vast majority of small water systems use groundwater instead of surface water. The EPA estimated the total annual cost of the rule to be $41 million in equivalent 2004 dollars (Table 8) (U.S. EPA, 2002). All these costs are borne by systems serving 10,000 or fewer individuals. As with the other rules issued under the Reg Neg, we rely on EPA's figures here.

Table 8. Aggregate cost estimate for LT1ESWTR (millions of 2004 Q1 US dollars)

Estimate	Annual cost	Capital outlay	Comments
Best estimate	$48	$184	From EPA FR (U.S. EPA, 2002)
Lower bound	$37	$142	EPA less 30%
Upper bound	$62	$239	EPA plus 30%

4. Cost Estimates for the Filter Backwash Rule

During the M/DBP deliberations, it became apparent that the routine practices employed in cleaning filter beds via backwashing held significance for both microbial treatment and disinfection byproduct control due to the recycling of the wash water back into the head of the treatment plant. This was significant in the sense that it created a possibility that microbial agents trapped in the filters initially would be reintroduced into the treatment plant (and in concentrated numbers) when filters were backwashed, thereby increasing the chance that infectious agents might pass through into finished water delivered to the tap. This issue of controlling filter backwash was not originally anticipated and not initially envisioned as part of the M/DBP rule, and therefore was developed as its own separate rulemaking.

EPA estimated the cost of the FBR to be $8 million per year (updated here to 2004 dollars) (U.S. EPA, 2001b, 2001c). To our knowledge, no other, independent cost estimates of the rule were derived, although AWWA submitted comments on the proposed rule that indicate there were several technical reasons why the EPA estimate was likely to be understated, and perhaps to a significant degree. For example, AWWA notes that the capital cost estimates are based on systems using equalization, but that the cost of equalization was not included in the estimates, and that EPA's own reported data reveal that only 10 percent of plants use equalization. EPA also assigns a cost of $4,000 to $10,000 for pilot studies at each water plant, but AWWA notes that actual experience suggests costs of $100,000 to $200,000 per plant. These and other technical points that EPA estimated costs are "substantially lower than what would be incurred under actual conditions" (AWWA, 2000).

Table 9 shows our estimated cost for the rule, using EPA's estimate as a lower bound estimate (in view of AWWA comments) and EPA plus 20% as a "best guess" estimate. The 20% adjustment to the EPA cost estimate is simply a guess on our part, but given a lack of any specific data or analyses of the likely impact of the AWWA concerns on the total regulatory compliance costs, we have adopted 20% as a somewhat arbitrary but transparent and probably conservative correction factor. Table 10 shows how costs are borne by systems of different size categories.

Table 9. Aggregate cost estimate for FBR (millions of 2004 Q1 US dollars)

Estimate	Annual cost	Capital outlay	Comments
Best estimate	$10	$64	EPA estimate plus 20%
Lower bound	$8	$53	EPA estimate (2001a) for both annual and capital costs
Upper bound	$17	$106	Double EPA estimate

Table 10. FBR compliance costs by system size (annual cost in millions of 2004 Q1 US dollars)

System size (population served)	Annual cost	Share of cost
25-100	$0.2	1.6%
101-500	$0.3	2.7%
501-1,000	$0.2	2.1%
1,001-3,300	$0.5	5.2%
3,301-10,000	$0.7	7.4%
10,001-50,000	$1.2	11.7%
50,001-100,000	$0.8	7.4%
More than 100,000	$6.3	61.8%
Total[a]	**$10.2**	**100.0%**

a. Total may not add due to rounding. Annual costs for large systems (10,001 +) dissaggregated based on relative capital outlays per EA Ex C-1 (U.S. EPA, 2001c).

B. Cost Estimates for the Arsenic Rule

Considerable debate and disagreement has surrounded the cost of the final arsenic rule of 2001, which updates the original, 1942-era public health standard by lowering the MCL of 50 µg/L down to 10 µg/L. EPA initially proposed an MCL of 5 µg/L, but it opted for the slightly less stringent alternative of 10 µg/L at promulgation, in part because of concerns over cost.

The arsenic rule was finalized in January 2001 (U.S. EPA, 2001a), one of the last actions taken by EPA under the Clinton administration. However, the rule was very controversial because of the anticipated high cost and other issues related to implementation, the number of water systems affected, and concerns that the health risk reductions associated with the new standard were being overstated [see, for example, Hahn and Burnett (2001), Mercatus Center (2001), and Frost et al. (2002)].

The Bush administration placed the new rule on hold so that several expert panels could be convened and examine the myriad issues and controversies associated with the MCL. After receiving reports on costs, benefits, and health risks—from the National Drinking Water Advisory Council (NDWAC), the Science Advisory Board (SAB), and the National Research Council (NRC), respectively—the Administration ultimately decided by late 2001 to let the January 2001 rule move forward as originally promulgated. Several EPA staff and key stakeholders have suggested that the arsenic standard is likely to be revisited again when eligible for a 6-year review under the SDWAA, with an apparent intent to make the rule more stringent based on the NRC findings on health risks (e.g., Erik Olsen, NRDC, personal communication, December 2002).

On the cost side of the regulatory debate, the issues involved are complex and multifaceted. The expert panel established under NDWAC examined the cost issues and offered some recommendations for the EPA Administrator. The NDWAC process did not derive any "alternative" cost estimate, but the work group's activities did provide a mechanism to consider where and why cost estimates developed for the rule by EPA (U.S. EPA, 2000b, 2000e) varied so much from those developed by a research team (Frey et al., 2000) funded by the AWWA Research Foundation (AwwaRF) but jointly reviewed and managed by EPA.

EPA's cost estimates also seemed quite low compared to estimates that individual utilities had developed for their own facilities. For example, the City of Albuquerque found that although its unit treatment costs for the applicable treatment processes were "similar" to those applied by EPA, other aspects of EPA's analysis seemed to be off the mark (City of Albuquerque, 2000):

> *The EPA has not made correct assumptions related to the treatment technologies and their application which has resulted in the estimated national costs being grossly underestimated. The EPA has assumed that a large fraction of water utilities will select ion exchange and that the waste brine will simply be dumped into the sanitary sewer. We conclude that assumption is very much in error and most impacted water utilities will not select the ion exchange technology because it may generate a hazardous waste stream and also because of the need to use and dispose of large quantities of salt. When the cost of residuals handling is added to the basic process of ion exchange, the cost will increase by at least 150%. The EPA has erroneously assumed that ion exchange will be used without the use of residuals handling and disposal facilities.*

EPA's cost estimate for the 10 μg/L MCL was $217 million (2004 US dollars) in total annualized costs (U.S. EPA 2001a). EPA did not provide an explicit estimate of capital outlays for the final rule, but based on EPA's total annualized costs and assuming the same proportional relationship between annual and capital costs as derived by Frey et al. (2000) for an estimate most comparable to EPA's approach, an EPA-level estimate of the initial capital outlay requirement is $1.7 billion (217 times 7.7, where 7.7 is the ratio observed from the Frey et al. results of estimated capital outlays relative to total annualized costs). In contrast, Frey et al. (2000) developed a total annualized cost estimate of $471 to $794 million per year (updated to 7% interest rate in lieu of 4% applied by the original authors, and updated to 2004 Q1 dollars), resulting in a lower end annual cost more than 2 times greater than EPA's estimate (471/217 = 2.17) and an upper end estimate more than 3.6 times greater than EPA (794/217 = 3.66). The large difference in cost estimates clearly indicates that there are several areas of disagreement in the underlying cost components, models, input data, and approaches.

The range noted above for the Frey et al. estimates reflects how many treatment plants are needed per water utility. The low end estimate is based on using system level total flows (similar to EPA) to base treatment size scaling and costs (i.e., assuming that one centrally located treatment plant per system can handle all of a utility's needs). In contrast, the higher cost estimates by Frey et al. reflect the more realistic context in which a total system's flow is divided across multiple treatment plants (because well fields and surface sources typically are spatially dispersed and must be addressed individually, resulting in more than one treatment facility per utility in many cases). This latter "entry point to the distribution system" (EPDS)-based estimate reflects the fact that the cost of multiple treatment sites per utility will be higher than the cost of a single central facility. Frey et al. (2000) developed an initial capital outlay requirement of over $5 billion in the context of its multiple, dispersed site (EPDS) estimate.

The NDWAC panel (NDWAC, 2001) attempted to disentangle the differences underlying the Frey et al. and EPA estimates, and made several observations. Ignoring the EPDS approach in lieu of the single facility estimate because the latter most closely matched EPA's approach, the panel found that the largest drivers of cost differences were (1) the decision tree probabilities assigned to the various compliance choices available to water utilities (i.e., the probability-based forecast of what technologies will get selected by what percentage of systems with waters above the MCL), and (2) the unit cost estimates associated with some key technologies. One of the drivers of the cost differential was an embedded EPA assumption that a large number of systems could use *disposable* activated alumina (AA) treatment, whereas Frey et al. had projected that a *regenerated* AA approach would be more prevalent than the disposable version. EPA also used a newer design approach for AA that eliminated one of the four media vessels per AA treatment system that had been included in the prior EPA engineering footprint, and it had been the prior footprint version that had been adopted by Frey et al. Together, these differences were found to account for about 33 percent of the Frey et al. cost estimate under the single treatment site approach (NDWAC, 2001), dropping the corresponding Frey et al. estimate to $316 million per year (i.e., 67% of $471 = $316). Assuming the same relationship of cost impact also applies to the multiple site, EPDS approach that is more applicable to real world settings, a 33% reduction in the upper end Frey et al. estimate yields a national cost projection of $532 million (67% of $794 = $532).

Other differences exist between the EPA data and methods relative to the Frey et al. estimates, including the generation and handling of arsenic-laden residuals generated by water treatment processes. Both EPA and Frey et al. assumed no water treatment wastes would need to be handled and disposed of as hazardous waste, although some research analyses presented to the NDWAC panel did indicate that in California, the waste streams probably would require management as hazardous waste under that states' regulatory program and associated testing procedures for determining what wastes were considered hazardous. EPA assumed that all liquid waste streams could be discharged into public sewer systems and handled without added costs by wastewater treatment plants, whereas Frey et al. believed that was not a viable option and added costs for alternative waste management techniques.

In the end, the NDWAC panel offered several recommendations that, in large measure, would increase EPA-based cost estimates. These include recommendations to account for (1) the cost of land that may need to be purchased to accommodate new treatment facilities (especially in groundwater-based systems with wellfields dispersed throughout the community), (2) pilot testing costs that add to capital requirement estimates, (3) labor expenses for monitoring and analytic requirements, (4) the cost of increased operator training and certification often needed with a transition to new, more complex treatment facilities, (5) the possibility (at least through sensitivity analysis) that waste disposal costs could be appreciably higher than projected if treatment residuals could not be as readily handled as EPA assumed, and (6) multiple treatment sites per utilities, where applicable (NDWAC, 2001).

The NDWAC panel report concluded that EPA (NDWAC, 2001, p.2):

> *…produced a credible estimate of the cost of arsenic compliance given the constraints of the present rulemaking, data gathering and cost models. Although there are considerable uncertainties in the development of national cost estimates, the working group agreed that if the recommendations in this report are implemented, the estimate will be improved for the purposes of rule making.*

Many readers have focused on the first phrase to infer that EPA's estimate was deemed "accurate," whereas the panel's intent was more narrowly meant to acknowledge that EPA had followed a generally credible approach and developed an estimate within a broad range of possibly credible findings. More importantly, the panel notes the uncertainties inherent in the process, and states that the resulting cost estimates could be and needed to be improved to properly inform regulatory decision-making. Thus, the original EPA cost estimates need to be considered in light of the panel's recommendations for modification.

In summary, the EPA estimate of annualized costs is $217 million, whereas the NDWAC-based downward adjustment to Frey et al. yields a range of $316 to $532 million. To help interpret this still broad range, consider the following:

- Splitting the difference between the EPA estimate and the comparable single site Frey et al. value, one obtains a midpoint estimate of $267 million (i.e., $267 is the average of $217 and $316). Given the considerable remaining uncertainty about the "true" costs, using the midpoint provides a transparent way to reflect the low end of the range.

- If one accounts for the applicability of the EPDS approach of multiple treatment sites, then the relationship between the two Frey et al. estimates indicates that the EPDS value is 168% of the single site estimate (532/316 = 1.684). Applied to the midpoint of the single site estimates, one obtains an value of $450 million (1.68 x $267).

Accordingly, for the purposes of this report, our opinion is that perhaps the most reasonable, yet conservative (potentially low) annual cost estimate is in the range between $267 and $532 million. This is still higher than the base EPA estimate at the low end, but capped at the more realistic distributed treatment scenario underpinning the higher Frey et al. estimate ($532 million). From this range, the mid-point of $400 million is adopted here as a "best guess" central estimate.

The national aggregate results are shown in Table 11, including both total annualized costs and initial capital investment costs. The capital costs for the "best guess" estimates are scaled proportionally between the bounds provided by the original estimates by Frey et al.

Table 12 presents the annualized costs distributed across system size categories, estimated as proportional to the EPA-based estimates by size.[7] The cost breakout by system size is important because economies of scale imply that per household costs will be much higher in small systems than in larger ones. As shown in the rightmost column of Table 12 (which is based on adjusting EPA's (2000e) estimated per system compliance costs by size category to reflect our best guess national aggregate cost estimate), average households in the smallest system size category will pay at least 14 times as much (on average) as households served by utilities in the largest size categories. These households will receive the same benefits as those served by larger systems, but pay significantly more to realize those health risk reductions.

[7] This adjustment accounts for both differences between EPA's published estimates and the "best estimate" developed here, as well as for the change in price levels between 1999 and 2004.

Table 11. Aggregate cost estimate for arsenic rule (millions of 2004 Q1 US dollars)

Estimate	Annual cost	Capital outlay	Comments
Best estimate	$400	$3,080	As discussed in main text
Lower bound	$267	$2,056	Mid-point of EPA estimate (2001a) for annual (capital estimated proportionally from Frey et al.) and NDWAC-adjusted low end Frey et al. estimate
Upper bound	$532	$4,097	Frey et al. EPDS estimate, adjusted per NDWAC review comments

Table 12. Arsenic compliance costs by system size (2004 Q1 dollars)

System size (population served)	Annual national costs[a]	Share of cost	Annual cost per household
25-100	$12.2	3.1%	$707
101-500	$25.9	6.5%	$269
501-1,000	$15.7	3.9%	$163
1,001-3,300	$53.0	13.3%	$119
3,301-10,000	$57.8	14.4%	$83
10,001-50,000	$111.6	27.9%	$71
50,001-100,000	$39.3	9.8%	$66
More than 100,000	$84.5	21.1%	$50
Total	**$400.0**	**100.0%**	-

a. Millions of dollars per year, nationwide.

C. Cost Estimates for the Radionuclides Rule

The radionuclides rule, finalized December 7, 2000 (Federal Register, Vol. 65, No 236, p. 76708), updates the rule initially established in 1976. The final rule establishes MCLs for:

- two radium isotopes (the MCL is set at 5 picocuries per liter—pCi/L—for the combined levels of Ra 226 and Ra 228)
- uranium (MCL of 30 pCi/L)

- gross alpha (including Ra 224, at 15 pCi/L)
- beta/photon radioactivity (no greater than 4 mrem per year).

The rule has a long and complex history. It was proposed in 1991, and then no action was taken until a Notice of Data Availability (NODA) was issued by EPA on April 21, 2000 (U.S. EPA, 2000a).[8]

In the Federal Register notice for the final rule, EPA estimated that the annualized cost of the rule would be $95 million (2004 dollars) (U.S. EPA, 2000d). Nearly two-thirds (63%) of this total annualized cost was attributed to the uranium MCL. Another 31% was attributed to the combined radium MCL, and the small remaining balance accounted for EPA's estimated costs for updated monitoring requirements for radium (there also was a small, $60,000 per year, cost associated with state administration of the rule). The costs for the radium MCL stem from anticipated noncompliance that would be detected by the revised monitoring scheme (the MCL of combined Ra 226 and Ra 228 remains unchanged from its original 1976 level).[9]

It is extremely difficult to verify or interpret the accuracy of the EPA cost estimate noted above. There are discrepancies between the EPA costs stated in the Federal Register and those shown in the Agency's Economic Analysis (EA) document (U.S. EPA, 2000c). Further, the cost estimates developed and presented throughout the EA are internally inconsistent across chapters. The numeric results are typically well within 10 percent of each other, so the impact is not large. However, it is difficult to ascertain which numbers may be the final estimates or the ones that the Agency believes to be most accurate, or which results serve as critical underpinnings for subsequent steps in the cost analysis.

In addition, efforts to replicate any of EPA results, using EPA's own data, methods and assumptions, proved to be impossible. Dr. Joe Drago made several efforts, on behalf of AWWA, to replicate the EPA cost estimates using the methods and information provided by the Agency in its docket. Dr. Drago also revealed the extent to which the EPA estimates might increase significantly with each of several possible alternatives (see, for example, Raucher and Drago, 2001, and AWWA, 2000).

[8] Radon is not regulated under the post-1991 versions of this rulemaking, but instead is being developed under separate rulemaking. An MCL for radon was proposed in 1991 and reproposed in 1999; a final MCL for radon currently is anticipated in late 2004 or (more likely) 2005.

[9] The radium compliance picture is complicated by the fact that the 1991 proposal indicated separate MCLs of 20 pCi/L would be established for Ra 226 and Ra 228. Therefore, many systems that were out of compliance with the original combined MCL from 1976 expected that they would easily be within full compliance with the rules once updated after 1991. Accordingly, there are numerous CWSs (especially throughout the midwestern states, including Illinois and Wisconsin) that are now incurring compliance expenditures due to the final rule from 2000, but technically these compliance costs are associated with the MCL as originally established in 1976.

To further complicate the situation, the final uranium MCL of 30 pCi/L was not one of the options proposed in the NODA, and therefore was not subject to economic assessment by the Agency. Instead, EPA had suggested MCL options of 80, 40, and 20 pCi/L at the NODA stage, and the cost analyses were developed for those options only. Ultimately, when 30 pCi/L was selected as the MCL, EPA developed a last-minute cost estimate by interpolating between the cost estimates for 20 and 40 pCi/L. This interpolation was loosely based on the Agency's occurrence analyses that were themselves a bit suspect, with the resulting cost estimate for the MCL of 30 pCi/L being about 29% of the difference between costs for 40 pCi/L and 20 pCi/L (U.S. EPA, 2000c).

The EPA cost estimation is further obfuscated by the Agency's use of two different occurrence profiles to develop estimates of how many community water systems (CWSs) would be out of compliance and of the distribution of these systems across size categories. EPA's estimates of costs based on the "log normal" interpretation of limited occurrence data were considerably greater than the cost estimates developed by EPA when it applied a "directly proportional" occurrence profile.[10] EPA opted to develop a "best estimate" by arbitrarily splitting the difference.

An additional complication is that EPA's cost estimates dropped considerably between the NODA and the final rule. For example, at NODA, EPA's EA estimated that the cost of the 40 pCi/L MCL option would be $5.0 to $5.5 million for systems in the 25 to 500 persons served category. In contrast, for the final rule, the EA cost estimates ranged from $2.5 to $3.5 million (all reported here in 2004 dollars). Further investigation reveals that EPA removed monitoring costs from the estimates developed for the final rule, which consisted of between 40% and 60% of total annualized costs for the small groundwater-based systems (the size and type most affected by the MCL) for the 20 pCi/L and 40 pCi/L options at NODA. Since monitoring was required under the rule, the costs of monitoring should have remained as part of the cost of compliance estimate. EPA also developed adjustments to raise capital and O&M costs for the final rule (in most instances, the changes are more than 50%, and in some cases nearly double the NODA estimates). Similar results are seen for surface water systems (see Raucher and Drago, 2001, for more detail). To add yet another layer of complexity, EPA developed two compliance forecasts to the costing analysis. One set of EPA's costs is based on a forecast in which a relatively large proportion (66%) of CWSs above the MCL would, according to EPA, achieve compliance by finding a new, low cost source water supply (e.g., drilling a new well, getting water from a neighboring system, or blending source waters) in lieu of adding treatment processes to their existing sources (U.S. EPA, 2000c). The availability of such options for CWSs is likely to fairly limited, more expensive than projected, or both. EPA also developed a

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[10] For example, for the final rule, the annualized compliance costs for a uranium MCL option of 40 µg/L was $2.2 million using the direct proportional approach, and $64.3 million for the log normal approach—a difference factor of over 29 times (64.3/2.2 = 29.23). These costs are in 1999 dollars, from EPA's EA (U.S. EPA, 2000c), Exhibit 6-7.

more conventional compliance forecast of 10% of CWSs using alternative water sources as a cost-effective compliance option. The national costs under the latter scenario are more than double the costs under the alternative source-dominated compliance forecast. EPA then blends the resulting set of cost estimates (apparently using the midpoints), but this still implies that roughly one-third of CWSs would pursue a relatively low cost, alternative source compliance strategy.[11] The 10% scenario seems more plausible (and perhaps still a bit optimistic in terms of the lower cost alternatives), because not many systems have viable opportunities to develop new sources (or to find new sources that do not pose water quality or other cost-associated challenges of their own). Given all of the above complications and observations, it is difficult to place much confidence in the accuracy of the EPA cost estimates as derived from the final rule's Federal Register notice. These may be reasonable as lower bound estimates, but the inconsistencies and assumptions used by EPA, and the removal of monitoring costs, suggest that a more realistic cost estimate might be considerably higher than that forecast by EPA. Alternative estimates are thus developed here as follows:

- For a best estimate, we add monitoring costs back into the EPA estimate, and use a compliance forecast in which the alternative sources strategy applies to 10% of CWSs. This results in a cost estimate of $157 million in total annualized costs.[12] The approximate capital investment is $719 million.[13]

- Our upper bound estimate relies on the log normal occurrence profile as the basis for costing the rule (rather than a mix of occurrence profiles), including monitoring expenses and the reduced use of alternative sources as an available compliance option (the latter two adjustments are per the best estimate above). This results in an annualized total cost estimate of $286 million, and a proportionally estimated capital outlay of $1.3 billion.[14]

- EPA's estimates of $95 million per year for total annualized costs (from U.S. EPA, 2000c), and $436 million in capital outlays (derived from Appendix G of the EA, U.S. EPA, 2000c) serve as lower bounds.

[11] For the radium MCL costs, EPA appears to rely on the high alternative source forecast alone rather than the 50-50 blend it appears to apply for uranium.

[12] Monitoring costs for uranium add over $2.7 million in annualized costs. Adjusting the uranium results for alternative treatment increases costs by factor of 1.38 (the difference between the Agency's costs using the midpoint of the compliance scenarios versus the treatment-dominated version). Adjusting radium MCL costs for a smaller percentage of systems using alternatives supplies in lieu of treatment results in an adjustment factor of 2.21. The above are derived from midpoints of ranges provided by EPA in the EA (U.S. EPA, 2000c; Exhibit 4-12, p. 4-27).

[13] Proportional to annualized costs, with proportional basis derived from comparing EPA capital cost forecast from EA (U.S. EPA, 2000c) to EPA annualized cost estimates.

[14] Based on adjustment factor of 1.87 for log normal versus a blended occurrence profile, based on Raucher and Drago (2001), Table 2.1, for uranium MCL of 30 pCi/L.

Table 13 provides a summary of the total national costs, in terms of total annualized costs and capital outlays. Table 14 indicates the distribution of total annualized costs across system size categories.

Table 13. Aggregate cost estimate for radionuclides rule (millions of 2004 Q1 US dollars)

Estimate	Annual cost	Capital outlay	Comments
Best estimate	$157	$719	Adds monitoring costs for uranium, reduces alternative source as compliance choice for CWS.
Lower bound	$95	$436	EPA estimate (2000c) for annual and capital costs.
Upper bound	$286	$1,311	Best estimate, but relies on log normal occurrence profile only.

Table 14. Radionuclides compliance costs by system size (annual cost in millions of 2004 Q1 dollars)

System size (population served)	Annual cost	Share of cost
25-100	2.1	1.3%
101-500	5.7	3.6%
501-1,000	2.3	1.5%
1,001-3,300	7.9	5.0%
3,301-10,000	13.7	8.7%
10,001-50,000	44.4	28.3%
50,001-100,000	28.7	18.3%
More than 100,000	52.3	33.3%
Total[a]	**156.9**	**100.1%**

a. May not add due to rounding.

VI. Conclusions

EPA's regulatory program for drinking water has issued seven cost-significant rules since 1996, the year that the SDWA was last amended. This working paper examines the costs of these, relying on estimates presented by EPA in its regulatory analyses supporting the rule, as well as other research. We estimate that the combined cost of these seven major rules promulgated through early 2004 amounts to approximately $7.7 billion in capital outlays and $1.8 billion in annual costs.

These estimates are based on EPA's published estimates. In the case of the suite of rules issued as part of the M/DBP cluster, the EPA estimates reflect the efforts of stakeholder-involved technical work groups working in an open, consensus-oriented framework. Therefore, there is limited debate over the accuracy or completeness of these estimates. For other rulemakings, however, there has been considerable debate and disagreement over the costs (especially for contentious rulemakings such as the arsenic rule). For these latter rules, we have discussed necessary modifications and made what we believe to be reasonable (and perhaps conservative) adjustments to EPA costs, as discussed in relatively great detail above.

The most appreciable changes made to the EPA estimates reflect:

- Relying on NDWAC-based adjustments to the Frey et al. estimates of arsenic compliance costs, to embody differences from the EPA estimates in terms of (1) assigning different probabilities to predict some of the compliance technology choices by utilities, (2) accounting for the possibility of multiple treatment sites per utility, and (3) recognizing that treatment residuals (waste) disposal will not always be feasible through inexpensive dumping to sanitary sewers (and that more costly residuals management approaches may often be necessary, even if the wastes are not considered hazardous).

- Updating the EPA estimates for radionuclide rule compliance, by (1) adding regulatory monitoring costs back into the compliance cost estimate, and (2) applying a more conventional, lower-end probability to estimate how many systems could comply at relatively low cost by tapping a new, high quality water source.

In addition, the post 1996 compliance costs do not include several relatively expensive rule-makings that currently are in progress. The final Stage 2 DBP rule and the Long Term 2 Enhanced Surface Water Treatment Rule are expected to be promulgated in the summer of 2005, and the groundwater rule is expected to be finalized by late 2004 or early 2005. The proposed MCL for radon also should be finalized in the coming years.

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