# Online Appendix to Richard Belzer, Achieving Economically Feasible Drinking Water Regulation[[1]](#footnote-1)

This Appendix provides reviews of the economic feasibility of individual post-SDWA 1996 National Primary Drinking Water Regulations (NPDWRs), summarized in Section 5. Subsection (a) covers the cluster of regulations dealing with microbial risks, disinfection, disinfection byproducts, and disinfection-resistant pathogens. Subsection (b) summarizes NPDWRs for radionuclides, arsenic, and lead and copper. Subsection (c) summarizes miscellaneous drinking water regulations related to routine bacterial pathogens. Only those regulations in which USEPA asserted that benefits justified costs and conducted an economic analysis are included.

This review generally takes as given USEPA’s benefit and cost estimates unless alternative estimates were readily available at the time, even when there are good reasons to doubt their accuracy (e.g., due to structural bias) or reliability (e.g., due to excess precision). Certain methodological errors were endemic, such as estimating expenditures instead of opportunity costs and calculating net benefits as the difference between opportunity-cost based benefits and expenditures. These errors are noted but generally ignored here because the objective is to ascertain whether prior adoption of the economic feasibility principle would have resulted in a different decision when all other factors are held constant. Thus, it is assumed that if the Agency had adopted and followed the economic feasibility principle it would not have used different data or analytic methods to estimate benefits and costs. It is further assumed that the relevant economic analyses were not reverse-engineered to “serve primarily as a mechanism for promoting agency decisions rather than scrutinizing them” (Wagner 2009, p. 56).

There is no practical way to review the Agency’s work and draw inferences concerning what decisions it might have made under the economic feasibility principle where these assumptions do not hold or if superior analytic methods had been used. Nonetheless, it is clear that if USEPA had adopted and applied the economic feasibility principle, Maximum Contaminant Levels (MCLs) would have been less stringent, the minimum system size subject to regulation would have been larger, or some combination thereof. These effects would have been more pronounced if the Agency had estimated opportunity costs instead of expenditures, and objectively estimated risks and benefits as required by SDWA 1996 § 1412(b)(3)(A).

## Microbial/Disinfection Byproducts Rule Cluster

USEPA formed the Microbial-Disinfection/Disinfection Byproducts Advisory Committee (M-DBP) in February 1997 as a follow-on regulatory negotiation (colloquially referred to as a “Reg Neg”) to a similar proceeding conducted in 1992-93. The domain of the more recent Reg Neg included certain proposed rules specifically referenced in SDWA 1996 § 1412(b)(2)(C).

The suite of rules in this cluster seeks to address microbial risks through disinfection, countervailing risks posed by disinfection byproducts (DPBs) after disinfection, and microbial contaminants that are resistant to control by disinfection (principally *Cryptosporidium* and *Giardia*). Risks were estimated and characterized in accordance with standard Agency methods designed to ensure that they were not “*unrealistically* conservative” (Browner 1995, p. 3, emphasis added). This is an ambiguous but clearly different approach than required by SDWA 1996 § 1412(b)(3)(A)(i), which states that risk assessments must be objective. For example, in the Stage 1 Disinfection Byproduct Rule (Stage 1 DBPR), USEPA described the scientific evidence that DBPs cause bladder cancer and reproductive and developmental effects as “inconclusive” (USEPA 1998f, p. 5-15). Nevertheless, the Agency assumed that there was an 80% probability that the weak associations with bladder cancer observed in some epidemiological studies were causal (USEPA 1998f, pp. 4-12 and 6-20, Exhibit 4.5).

In addition to the M-DBP, three Small Business Advocacy Review Panels (SBARs) were created pursuant to § 244 of the Small Business Regulatory Enforcement and Flexibility Act of 1974 (SBREFA 1996). Each panel included multiple stakeholders and nongovernmental experts (USEPA 2018c, 2018d, 2019). According to Raucher and Cromwell (2004), USEPA’s *ex ante* compliance cost estimates were not controversial largely because of stakeholder participation. However, because USEPA predetermined that the MCLs for total trihalomethanes, haloacetic acids, and bromate that were proposed prior to SDWA 1996 would not be changed (USEPA 2009c, Sec. 2.1), the M-DBP and SBARs did not examine the rules’ economic feasibility.

The two DBP rules were intended to reduce (primarily) bladder cancer risks assumed to result from exposure to disinfectants used to reduce certain pathogens. In 1996, bladder cancer incidence was 36.7 per 100,000 for men and 20.8 per 100,000 for women. NCI’s SEER 9 data indicate that rates rose a statistically significant 0.2% from 1986-2007 and declined a statistically significant 1.1% from 2007-2015 (National Cancer Institute 2018a). Relative to the approximately 80,000 new bladder cancer cases per year reported (National Cancer Institute 2018b), the number of bladder cancer cases attributed by USEPA to drinking water disinfectants has been uncertain (USEPA 1998c, p. 69434) or small (USEPA 1998f, p. 4-21 [0–9,300]; 2005b, Exhibit 6.20 [275–874]). USEPA acknowledged that no causal relationship had been established (USEPA 2005b, p. 6-65).

The three surface water treatment rules and the ground water rule were intended to control cryptosporidiosis and giardiasis from parasites that are resistant to inactivation by disinfection. Cryptosporidiosis and giardiasis result from the ingestion of sufficient *Cryptosporidium* oocysts or *Giardia* trophozoites through the consumption of fecally contaminated food or water, or person-to-person or animal-to-person transmission (Fayer et al. 2000). Most cases go undiagnosed, few who are infected seek medical attention, hospitalization is rare. Mortality from cryptosporidiosis is rarer still and highly concentrated among immunocompromised subpopulations; mortality from giardiasis is virtually nonexistent (Painter et al. 2015a; Painter et al. 2015b; Centers for Disease Control and Prevention 2017c). Both parasites are endemic, but infections are associated with warm weather use of recreational water, which has been estimated to be responsible for 37% of all cases of cryptosporidiosis (Centers for Disease Control and Prevention 2017a, p. 14).

In 1999, incidence of cryptosporidiosis across the continental U.S. ranged from 0.1 to 7.2 cases per 100,000, with a mean of 1.0 case per 100,000 (Hlavsa et al. 2005). By 2011, the mean and range had grown to 3.0 and 17.7 per 100,000, respectively (Painter et al. 2015b). FDA’s FoodNet (a nonrepresentative sample of 10 States comprising about 15% of the U.S. population) reported no statistically significant change in foodborne cryptosporidiosis incidence from 2006-13 (Gilliss et al. 2013; Crim et al. 2014). Underreporting is believed to be widespread because cryptosporidiosis and giardiasis are typically mild gastrointestinal infections, etiologic confirmation requires laboratory analysis, and confirmation of the underlying pathogen has no value added for guiding treatment decisions. Hospitalization is infrequent and mortality is rare, especially since the development of retroviral drugs to treat AIDS. From 2000-17, the average annual numbers of nationwide cryptosporidiosis and giardiasis cases were 7,274 and 16,747, respectively (Centers for Disease Control and Prevention 2018a). The average annual numbers of nationwide mortalities were 1.74 and 0.42, respectively (Centers for Disease Control and Prevention 2018b).

Finally, two rules in this suite were intended to control potential viral and bacterial infections attributed to ground water used as drinking water. Like the other regulations, the causal nexus between drinking water and illness is unclear and estimated benefits are small.

USEPA risk assessment practices would have materially adverse effects on economic feasibility determinations in the same way they affect determinations that benefits justify costs. This is further discussed in .

### Stage 1 Disinfectants and Disinfection Byproducts Rule (Stage 1 DBPR)

In this rulemaking, USEPA revised NPDWRs for disinfectants and DBPs, which included maximum residual disinfectant levels (MRDLs), maximum contaminant levels (MCLs), and treatment techniques. Community Water Systems (CWSs) and Non-Transient Non-Community Water Systems (NTNCWSs) were generally covered, and some provisions also applied to Transient Non-Community Water Systems (TNCWSs). MRDLs and MCLs were based on technological feasibility (USEPA 1998c); cost played no role. Nonetheless, the Agency asserted that the benefits of the rule justified the costs, thus making this rule potentially susceptible to economic feasibility analysis.

USEPA estimated aggregate expenditures for treatment and monitoring at $701 million ($1998, annualized at 7%) including capital, operations and maintenance, and monitoring (USEPA 1998c, Table IV-6). Expenditures for DBP control depended on technology and system size. The range across technologies for surface water systems was as great as 162x, and the range across system sizes was as great as 608x. Similar variability was reported for ground water systems (USEPA 1998c, Tables IV-4 and IV-5). Raucher and Cromwell (2004) estimated that 40% of expenditures would be borne by systems serving fewer than 10,000 persons.

Nearly 12,000 such systems were expected to be required to modify their treatment trains and 62,000 small systems were expected to expend significant new resources to collect over 1 million new monitoring samples (USEPA 1998f, Exhibits 5.8 and 5.9). An estimated 96% of CWSs and NTNCWSs serve fewer than 10,000 persons, and 22% of them were estimated to bear additional costs. About 8,200 small groundwater systems and 3,600 surface water systems were estimated to expend about $1 billion and $240 million in capital improvements, respectively, for modified treatment.

USEPA analyzed small-system cash flow and viability to gain insight on the risk of financial failure, a proxy for system affordability. USEPA acknowledges that small systems would have preferred that the Agency promulgate different standards for large and small systems to avoid small-system nonviability and forced consolidation, but the Agency did not analyze these options and there is no evidence that it gave them serious consideration (USEPA 1998f, pp. 5-23 to 5-25). The Agency’s economic analysis does not consider forced consolidation with larger systems to be a social cost because consolidation is a longstanding Agency goal (USEPA 1998f, pp. 5-19 to 5-23).

The Agency acknowledged that benefits were “difficult to quantify because of the uncertainty associated with risks from exposure to DBPs (and the resultant reductions in risk due to the decreased exposure from DBPs)” (USEPA 1998c, p. 69434). These uncertainties include a nine-fold range in the Agency’s estimated number of bladder cancer cases caused by DBPs, plus an acknowledgement that the true number of cases could be zero (USEPA 1998c, Table IV-8; 1998f, Exhibit 6.3c). Estimated aggregate annual benefits ranged from $0 to $4 billion, with the upper-bound implying a 24% reduction in new bladder cancer cases resulting from a 24% reduction in exposure (USEPA 1998f, p. 6-1). No cessation lag appears to have been applied.

USEPA’s net benefit estimates were derived by subtracting a range of expenditures ($500–$900 million) from the $0–4 billion range of opportunity cost-basedhealth benefits. The Agency described these ranges as “overlapping,” thus providing a “substantial basis” for the rule (USEPA 1998f, p. 6-2). Net benefits depended on the number of annual bladder cancer cases prevented, and USEPA acknowledged that taking no action is a superior choice if the number of cases prevented is less than a figure somewhere between 1,000 and 2,500 per year (USEPA 1998f, Exhibit 6.2).

In the end, USEPA concluded that “there is a reasonable likelihood that the benefits will exceed the costs” (USEPA 1998c, p. 69434), and that the rule was “needed for protection of public health from exposure to DBPs” due to the extent of potential exposure, evidence of DBP carcinogenicity and reproductive or developmental harm in laboratory animals at high doses, and weak associations in some epidemiological studies (USEPA 1998f, p. 5-15). Thus, the new standards were grounded in precaution with respect to *potential* health risks without regard for *actual* opportunity costs.

The extent to which prior adoption of the economic feasibility principle would have enhanced efficiency or reduced inequity cannot be determined based on the information disclosed, however. The selected alternative was the only one examined in the economic analysis (USEPA 1998f, p. 6-3) and only nationwide estimates of benefits and costs were reported, without disaggregation by system size, region, or other key factors. However, if USEPA had adopted the economic feasibility principle *and* followed the risk- and economic analysis requirements in SDWA 1996, the Agency would have either adopted less stringent standards or declined to modify existing standards.

### Interim Enhanced Surface Water Treatment Rule (IESWTR)

The IESWTR (USEPA 1998d) was a response to the 1993 cryptosporidiosis outbreak in Milwaukee, which was attributed to a sudden increase in *Cryptosporidium* in source water at the intake for the treatment plant on the city’s south side combined with treatment failure (Fox and Lytle 1996). Turbidity (a measure of suspended particulates, and thus a proxy for *Cryptosporidium*) in finished water increased from about 0.4 nephelometric turbidity unit (NTU) to a peak of 2.7 NTUs at the height of the crisis (Fox and Lytle 1996, p. 92 and Figure 2). Turbidity is an imperfect indicator of *Cryptosporidium*; other water systems utilizing Lake Michigan also experienced increases in turbidity but did not have a cryptosporidiosis outbreak (Fox and Lytle 1996, p. 94 and Table 1).

Using a RDD telephone survey, Mac Kenzie et al. (1994) estimated more than 400,000 persons were “affected” by the outbreak; cryptosporidiosis was clinically confirmed in more than 600 people. Cryptosporidiosis can be “unrelenting and fatal” in those who are immunocompromised (p. 161). Hoxie et al. (1997) report that AIDS was the underlying cause of death recorded in 46 (85%) of the 54 cryptosporidiosis-associated fatalities. AIDS mortality declined for about 18 months thereafter, then resumed its previous upward trend. Hlavsa et al. (2005) reported that cryptosporidiosis-associated fatalities among HIV-infected subpopulations decreased substantially after the Milwaukee outbreak due to the contemporaneous introduction of effective antiretroviral therapy.

IESWTR required water systems serving at least 10,000 persons that relied on surface water sources to use a treatment technique in lieu of achieving an MCL, and meet other regulatory controls (USEPA 1998d). Increasing the stringency of turbidity control was assumed to reduce *Cryptosporidium* and *Giardia* in finished water. The Agency asserted that the regulation’s benefits justified the costs (USEPA 1998d, pp. 69499, 69509), so the rule is potentially susceptible to economic feasibility analysis.

For benefit estimation, USEPA relied on health risk-precautionary risk assessment methods and data from the Milwaukee outbreak (USEPA 1998e, § 4.2); cost of illness (COI) valuations derived from previous survey research on giardiasis (Harrington et al. 1985); and assumptions about the effectiveness of turbidity reduction in removing *Cryptosporidium* oocysts (USEPA 1998e, § 4.2.4).

The Agency’s mid-level estimates of regulatory effectiveness were annual reductions of 432,000 illnesses and 60 deaths (USEPA 1998e, Exhibits 4.12 and 4.16). However, the number of illnesses and deaths reported from all pathways in 1998 was 3,111 and zero, respectively (Centers for Disease Control and Prevention 2018a). Fewer than two deaths per year were reported for 1999-2017 (Centers for Disease Control and Prevention 2018b). USEPA’s risk model did not account for reductions in mortality among immunocompromised individuals resulting from the inexpensive implementation of certain best practices (e.g., bottled water) or antiretroviral therapy for AIDS. Even before the ISESTWR was promulgated, it was suspected that the underlying cause of the Milwaukee outbreak was a failure in sewage treatment upstream of the drinking water intake (Peng et al. 1997).

USEPA reported estimated aggregate annualized expenditures of $596 million for disinfection and $189 million for turbidity reduction (both $1998, 7%), the latter expenditure substantially varying by system size (USEPA 1998e, Tables V.1 and V.2). USEPA’s affordability doctrine figured implicitly in the Agency’s household-level expenditures, which were $12 or less per year for 92% of households; $12–60 per year for 7% of households; and “approximately $100 per year” for the remaining 1% of households (USEPA 1998e, Figure V.1; 1998e, p. 5-25). No further breakdown by system size was provided. The economic analysis included a brief, qualitative opportunity-cost justification of the lower-end of these estimated household-level expenditures (USEPA 1998e, ES-6). Aggregate expenditure estimates were reported to span ± 30% (USEPA 1998d, p. 69437).

The Agency reported opportunity-cost based benefit estimates that varied depending on the assumed number of illnesses and mortalities avoided, and the level of *Cryptosporidium* removal (USEPA 1998e, Table V.4). Regulatory effectiveness was acknowledged to be highly uncertain. The number of illnesses estimated by USEPA to be prevented ranged from zero to 1.029 million, and the estimated number of fatalities prevented ranged from zero to 129. Illnesses were valued at $2,000/each using COI methods. Premature mortalities, concentrated among immunocompromised persons, were valued using the then-applicable VSL (USEPA 1998e, ES-4).

Several potential unquantified benefits also were mentioned (USEPA 1998d, p. 69501). Unquantified costs were not discussed and opportunity costs were not estimated, however. Thus, to conclude that benefits justified costs, USEPA relied on a range of *opportunity-cost derived* benefit estimates ($0–$2.7 billion) encompassing a point estimate of annualized *compliance* expenditures ($633 million) (USEPA 1998d, p. 64509; 1998e, pp. ES-7). The relative probabilities of these estimates were not taken into account.

Like in the case of the Stage 1 DBPR, savings from prior adoption of the economic feasibility principle cannot be determined based on the information disclosed. Moreover, USEPA’s decision appears to have been driven by its internal policy preferences for precaution with respect to uncertain risks (but not certain costs) and quantity-based equity. Finally, as discussed in , USEPA’s estimated numbers of illnesses and deaths from cryptosporidiosis prevented significantly exceed estimates of baseline illnesses and deaths reported by CDC.

### Filter Backwash Recycling Rule (FBRR)

During the consideration of SDWA, Congress became aware of concerns that the routine recycling of filter backwash water could inadvertently result in recontamination of finished water. SDWA 1996 § 1412(b)(14) directed USEPA to manage this risk, which it did via the FBRR (USEPA 2001b). Annualized costs were estimated at about $7 million ($2000, 7%) (Exhibit 6-5). Raucher and Cromwell (2004) note that post-promulgation cost estimates were considerably higher. Potential benefits were described qualitatively, so the Agency’s determination that benefits justified costs was qualitative as well (USEPA 2001d, p. 31096; 2000b, p. 8-2). The potential effects of having relied on the economic feasibility principle cannot be estimated without quantitative benefit estimates.

### Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR)

This regulation extended the IESWTR to systems serving fewer than 10,000 persons (USEPA 2002b). The Agency determined that the benefits of the regulation justified the costs (USEPA 2002b, p. 1827), making this rule potentially susceptible to economic feasibility analysis.

USEPA estimated combined annualized system and State compliance expenditures at $44.8 million ($1999, 7%) (USEPA 2002b. p. 1822). Key expenditures (e.g., for land acquisition) and opportunity costs generally (e.g., the value of owned land newly committed to treatment) were not estimated. System-level expenditures were assumed to be passed through to households. Annual expenditures per household were estimated at $6.24 (mean), $15.00 (90th percentile), $15–$120 (91st to 98th percentile), and over $120 for the 99th percentile. Expenditures were estimated to exceed $240 per year for 5,600 households. USEPA reported having estimated benefits for three assumed risk levels and two baseline assumption for pre-regulation cryptosporidium removal. Illness cases were valued at $796–$1,411 per case based on the cost of treating giardiasis (an illness of longer duration), and mortalities were valued at the then-applicable VSL.

USEPA’s reported net benefit calculations subtract a point estimate for annualized expenditures ($44.8 million) from a range of opportunity-cost based benefits ($18.9–$90.9 million) (both $1999). The extent to which adoption of the economic feasibility principle would have reduced costs or increased net benefits cannot be determined from the information made public because key analytic documents (USEPA 2000g, 2001a) referenced in the preamble to the final rule were not included in the docket and are not electronically available to the public despite an aggressive Google search. Finally, as noted in Section , USEPA’s estimated numbers of illnesses and deaths from cryptosporidiosis prevented significantly exceed the numbers of illnesses and deaths from all pathways reported by CDC.

### Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2 DBPR)

This regulation expanded upon the Stage 1 DBPR, targeting systems in compliance but with peak concentrations greater than Stage 1 MCLs (USEPA 2006a). Aggregate annualized system expenditures were estimated at $76.8 million ($2003, 7%) for nine system-size categories (USEPA 2006a, p. 445). Unquantified costs were not identified (USEPA 2005b, p. 7-47). Increases in mean household-level expenditures were estimated at $4.58 or less, depending on system size (USEPA 2006a, Table VI.E-1), and appear to be consistent with the affordability doctrine. Opportunity costs to systems or their customers were not estimated.

Annualized benefit estimates consist of the value of “reasonable estimate[s] of the range of potential [bladder cancer] risks” from peak DBP exposure, acknowledging that “the existing epidemiological evidence has not conclusively established causality between DBP exposure and any health risk endpoints.” USEPA acknowledged that “potential risks may be as low as zero” but nevertheless assumed causality. The Agency attributed 2–17% of baseline bladder cancer cases to DBPs (USEPA 2006a, p. 444). Depending on the risk model used (all of which excluded zero risk), the estimated number of cancers prevented ranged from 61 to 610 (USEPA 2006b, Table VI.C-1).

Unquantified benefits are discussed, notably reproductive and developmental risks derived from “possible associations” reported in certain epidemiological studies described as having “mixed” results (USEPA 2006a, p. 391). USEPA further asserted that the rule might provide these additional benefits because “a weight of evidence evaluation of the health effects data suggests a potential association” (USEPA 2005b, p. ES-11). USEPA’s net benefit calculation was positive (Table VI.F-1), but as before was obtained by subtracting *virtually certain expenditures* from the value of *potential benefits*. The number of cancers that must be prevented to cover annualized opportunity costs cannot be calculated because opportunity costs were not estimated.

Adoption of the economic feasibility principle may have yielded a substantially different decision because risk and benefit per person are assumed to be linear while expenditures per person vary greatly by broad system size category, as shown in

Table 7‑1 below.[[2]](#footnote-2) Mean annualized expenditures per household range from $2.83 to $49.69 per year, a span of more than 17x, depending on system size. At the 90th percentile, estimated household expenditures range from $6.98 to $173.53, a factor of 25x. Detailed results by system size are reported in an appendix to USEPA (2005b) that is not publicly available, however.

USEPA acknowledged that the scope of potential exposure (> 260 million persons) “played a significant role” in its decision to promulgate the Stage 2 DBPR, not the strength of evidence for risk. USEPA also described the rule as necessary to ensure “more consistent, equitable protection from DBPs” (USEPA 2006a, p. 391), thus indicating that achieving quantity-based equity was a significant consideration.

Table ‑: Stage 2 DBPR: Annualized Expenditure Increases per Household, Breakeven Annualized Cancer Cases per household, and Breakeven Minimum Households per Cancer Case Avoided

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Annualized Expenditure/  Household | System Category | Breakeven Minimum Annualized Cancer Cases per Household | Breakeven Minimum Households per Cancer Case Avoided | |
| AVERAGE | | | |
| $ 2.83 | SW > 10k | 2.53 × 10-6 | 395,505 | |
| $ 49.69 | GW < 10k | 4.44 × 10-5 | 22,525 | |
| 90th PERCENTILE | | | |
| $ 6.98 | SW > 10k | 6.24 × 10-6 | 160,355 | |
| $ 173.53 | SW < 10k | 1.55 × 10-4 | 6,450 | |
| Derived from USEPA (2005a). Value of prevented fatal and nonfatal bladder cancer = $2.028 million and $0.8 million, respectively. Proportion of bladder cancers assumed fatal = 26%. | | | | |

### Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)

This regulation expanded regulatory requirements for the treatment of surface waters used for drinking water for the control of *Cryptosporidium* and other microbial pathogens resistant to disinfection (USEPA 2006b). The rule targeted systems that rely on surface waters with unusually high *Cryptosporidium* occurrence (not concentration) rates; subjected to treatment requirements systems that previously were not required to filter; and required existing finished water storage reservoirs to be covered. USEPA determined that benefits justified the costs (USEPA 2006b, p. 748), thus making the rule potentially susceptible to economic feasibility analysis.

USEPA examined three alternatives besides the Agency’s preferred alternative (A3) (USEPA 2005a, Chapter 3), which the Agency described as “the most cost-effective and [] deliver[ing] the best value” (USEPA 2005a, p. 3-3). These alternatives vary principally by monitoring frequency, with resulting treatment expenditures determined by monitoring results. No formal alternatives were examined with respect to provisions that were agreed upon through the Stage 2 M-DBP Reg Neg. Compliance with the LT1ESWTR was assumed in the analytic baseline.

Selected point estimates for aggregate compliance expenditures (not opportunity cost) are provided in . Estimates of annualized household-level expenditures generally were not clearly inconsistent with the affordability doctrine, though expenditures for households at the upper end might not have been affordable (USEPA 2005a, Exhibit ES.8-3). Unquantified costs were briefly discussed but not otherwise accounted for (USEPA 2005a, pp. 6-33 to 6-34).

Quantified benefits consist of estimated averted illnesses and deaths, which were valued at $844 and $7.4 million per case ($2003), respectively, for three different data sets that the Agency said were “equally likely to represent the true distribution of *Cryptosporidium* in source waters for all systems” (USEPA 2005a, ES-8). Depending on the data set, estimated annual cases (deaths) averted ranged from 146k to 500k (38 to 130), a range of 3.4x. (USEPA 2005a, Exhibits 5.16 and 5.17). Risk was estimated using a simulation model (USEPA 2005a, § 5.2). Certain forms of variability and uncertainty (e.g., exposure via drinking water) were captured by stochastic distributions. Uncertainty about morbidity subsequent to exposure and mortality subsequent to infection are modeled as assumptions. Thus, estimated benefits critically depend on the accuracy of these embedded assumptions. As noted in Section , all model outputs of illnesses and deaths prevented significantly exceed the numbers of cases and deaths from all pathways reported by CDC.

Morbidity and mortality were valued using cost of illness (COI) methods and WTP, respectively, under multiple scenarios reflecting substantial uncertainty about hazard, dose-response, exposure, risk model structure, and limited data (USEPA 2005a, Chapter 5). The estimated numbers of illnesses averted were reported with up to seven significant figures, ranging from 363,328 to 1,501,445, depending on risk model and regulatory alternative/data set combination (USEPA 2005a, Exhibit 5.5). The Agency modeled illness risk from *Cryptosporidiosis* exposure as a triangular distribution (30%, 50%, 70%), and further assumed that the probability of mortality given illness was 24.07 per 100,000 illnesses among AIDS patients served by unfiltered systems, 14.56 per 100,000 illnesses for AIDS patients served by filtered systems, and 1.98 deaths per 100,000 for all others, with no uncertainty (USEPA 2005a, p. 5-22).

Risk and benefit estimates were disaggregated to reflect variability by system type and size, baseline filtration, and *Cryptosporidium* occurrence. The Agency also provided an extensive discussion of potential unquantified benefits. Mean net benefits were calculated by subtracting expenditures from opportunity-based benefit estimates, and were positive for most scenarios using both conventional and “enhanced” COI methods (USEPA 2005a, Exhibit 8.12a, b). The reported dominant uniform regulatory alternative depends on the choice of data set and discount rate (3% and 7% were examined), but uncertainty in the illness risk component of the model clearly dominates both data set choice and discount rate. Small changes in the parameters of the triangular distribution would swamp estimated reductions. Moreover, any validity that might have attached to USEPA’s results was vitiated by the assumption that qualitative benefits were five times as great as quantified benefits (USEPA 2006b, Table VI.C-1; 2005a, p. 8-21).

The likely effect of the economic feasibility principle is difficult to ascertain because the Agency’s analysis was structured in ways that made estimated net benefits more likely. In addition, detailed estimates are needed by system size to determine where to draw the line between covered and exempt systems. USEPA analyzed benefits and costs by system-size categories but only reported aggregate estimates in the main analysis. Twenty-one appendices to the economic analysis contained, among other things, the Agency’s analysis of small-system impacts. They are not publicly available.

Table ‑: USEPA-estimated Aggregate Annualized Expenditures for LT2ESWTR

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data Set a | Total Annualized Costs $M (3%) | | | Total Annualized Costs $M (7%) | | |
|  | 90% Confidence Bound b | |  | 90% Confidence Bound b | |
| Mean | Lower (5th %ile)b | Upper (95th %ile)b | Mean | Lower (5th %ile)b | Upper (95th %ile)b |
| ICR | $133 | $111 | $160 | $150 | $125 | $181 |
| ICRSSL | 93 | 72 | 112 | 107 | 83 | 129 |
| ICRSSM | 106 | 86 | 126 | 121 | 99 | 144 |
| Source: (USEPA 2005a, Exhibit 8.5]).  a ICR = 1996 Information Collection Rule; ICRSSL = ICR Supplemental Surveys (Large Systems); ICRSSM = ICR Supplemental Surveys (Medium-Size Systems).  b Meaning of 5th and 95th percentiles with 90% confidence bounds is not explained. | | | | | | |

Table ‑: LT2ESWTR: USEPA-estimated Annual Illnesses and Deaths Avoided

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data Set a | Annual Illnesses Avoided | | | Annual Deaths Avoided | | |
|  | 90% Confidence Bound b | |  | 90% Confidence Bound b | |
| Mean | Lower (5th %ile)b | Upper (95th ile)b | Mean | Lower (5th %ile)b | Upper (95th ile)b |
| Annual Total after Full implementation | | | | | | |
| ICR | 964,360 | 149,241 | 2,277,367 | 207 | 34 | 468 |
| ICRSSL | 230,730 | 38,281 | 521,925 | 52 | 9 | 113 |
| ICRSSM | 455,170 | 72,128 | 1,112,374 | 100 | 17 | 230 |
| Annual Average over 25 Years | | | | | | |
| ICR | 712,732 | 109,486 | 1,685,176 | 154 | 25 | 348 |
| ICRSSL | 170,977 | 28,314 | 392,979 | 39 | 7 | 85 |
| ICRSSM | 336,652 | 52,763 | 826,004 | 74 | 12 | 172 |
| Source: (USEPA 2005a, Exhibit 8.3]).  a ICR = 1996 Information Collection Rule; ICRSSL = ICR Supplemental Surveys (Large Systems); ICRSSM = ICR Supplemental Surveys (Medium-Size Systems).  b Meaning of 5th and 95th percentiles with 90% confidence bounds is not explained. | | | | | | |

### Ground Water Rule (GWR)

This regulation added an additional layer of treatment requirements for ground water systems believed by USEPA to be susceptible to fecal contamination “because such contamination is the likely source of viral and bacterial pathogens in drinking water supplies” (USEPA 2006f, p. 65576). USEPA determined that the risk-targeting strategy was cost-effective (USEPA 2006d, Chapter 8) and that the benefits justified the costs (USEPA 2006f, p. 65637). Thus, this rule is potentially susceptible to economic feasibility analysis.

The regulation’s “risk-targeting strategy” included triennial or quintennial sanitary surveys with survey-triggered monitoring requirements, mandatory corrective action by treatment, and compliance monitoring. Costs were estimated conventionally based on paperwork, recordkeeping, and engineering expenditures, not opportunity costs. Benefits were based on potentialrisks and estimated using both “traditional” and “enhanced” COI methods. “Enhanced” methods included the value of lost nonmarket work time based on opportunity costs, the value of lost leisure time, and the value of lost productivity (USEPA 2006d).

shows USEPA estimates of benefits and costs of the selected regulatory alternative for two benefit estimation methods (“enhanced” and “traditional” COI) and two discount rates (3% and 7%) (USEPA 2006f, Table VII-1). Aggregate net benefits at the mean, 5th percentile, and 95th percentile were negative regardless of dataset, discount rate, and COI methodology.

The determination that benefits justified costs depended on substantial unquantified co-benefits and the virtual absence of unquantified costs. Unquantified co-benefits were assumed to be at least four times greater than quantified benefits (USEPA 2006d, § 5.4.3.2). Unquantified costs were assumed to be minor (USEPA 2006d, § 6.6). Three alternatives were analyzed, and aggregate net benefits also were negative for each. Alternative 1 had the smallest negative net benefits (–$11.7 million $2003 at 3%; –$12.4 million $2003 at 7%) (USEPA 2006d, Exhibit 8.10a).

Net benefits objectively estimated would have been more severely negative. As noted in Section , USEPA’s estimates of illnesses and deaths prevented were significantly greater than the baseline numbers of cases and deaths from all pathways reported by CDC. USEPA’s institutional reliance on risk assessment methods that yield upwardly biased estimates of risk (U.S. EPA Office of the Science Advisor 2004) result in upwardly biased estimates of benefits.

Figure ‑: Ground Water Rule: USEPA-Estimated Benefits and Costs at 3% and 7% using “Enhanced” and “Traditional” Cost of Illness (COI) Benefit Estimation Methods

### Analytical deficiencies adversely affect determinations of economic feasibility

Several of these rules sought to reduce illnesses and fatalities potentially attributable to pathogens not amenable to risk-reduction through disinfection, such as *Cryptosporidium* and *Giardia*. Drinking water may be a key vector in the transmission of these pathogens, but not in the United States. Worldwide incidence of cryptosporidiosis has been estimated at 69.7 cases per 1,000 children aged < 5 worldwide, resulting in 4.2 million acute disability-adjusted life-years (DALYs) and 48,300 fatalities. U.S. incidence, however, is estimated at 0.2 cases per 1,000 children (99.7% lower), 31 DALYs (99.999% lower), and zero deaths (Khalil et al. 2018). shows that the number of reported U.S. cases rose from about 2,000 in 1997 to about 12,000 in 2017, but the number of deaths remained rare and exhibited no upward trend. shows a rising incidence rate of cryptosporidiosis but no change in the fraction of illnesses leading to death. shows a declining incidence rate for giardiasis, from about 20,000 cases per year in 2010 to about 16,000 cases per year in 2016. Reported deaths from giardiasis have never exceeded a single case per year.

The numbers of illnesses and deaths claimed to be prevented by the suite of surface water treatment rules greatly exceeds the total number of illnesses and deaths reported. In its analysis of the 2006 LT2ESWTR, USEPA estimated 154k to 2.3 million annual cases of cryptosporidiosis would be *prevented*, over and above the numbers of cases prevented by the 1998 IESTWR, 2001 FBRR, and 2002 LT1ESWTR. But the annual average number of cases *reported* since 1997 is 6,590. This is 10% of the lower-bound estimate and 0.5% of the upper-bound estimate of the number of cases prevented by LT2ESWTR alone. The Agency estimated 7 to 468 deaths would be prevented annually, but the average annual number of deaths reported from all pathways since 1999 is 1.74.

USEPA’s estimates of benefits from avoided giardiasis are similarly inconsistent with empirical data. The Agency describes giardiasis reduction as a qualitative benefit in the IESTWR (USEPA 1998c, the FBRR (USEPA 2000b), LT1ESWTR (USEPA 2002b), and LT2ESWTR (USEPA 2005a). But shows a negligible number of deaths and a declining number of illnesses from giardiasis from all pathways since 2002, and shows no change in the already low fraction of giardiasis cases resulting in death.

A plausible case might be made that the vast majority of cryptosporidiosis and giardiasis cases are too minor to seek medical attention, and thus are significantly underreported (Hlavsa et al. 2005). But if this is true, the Agency’s unit valuation of the benefit of preventing a case of illness seems overstated. Meanwhile, deaths from cryptosporidiosis and giardiasis are much less likely to be underreported, and the gap between reported and model-predicted deaths is more troubling. The upper-bound estimate of the number of cryptosporidiosis deaths prevented by just one of the surface water treatment rules is 270 times the average annual number of baseline deaths reported from all pathways. Even small downward adjustments in the model would result in benefits that are considerably below expenditures, and well below opportunity costs.

Figure ‑: U.S. Cryptosporidiosis Incidence, 1997-2016

Sources: Centers for Disease Control and Prevention (2018a [cases]; 2017b [fatalities]).

Figure ‑: U.S. Cryptosporidiosis Case Rate/100k Population & Death Rate/Case, 2000-2017

Sources: Centers for Disease Control and Prevention (2018a [cases]; 2017b [fatalities]).

Figure ‑: U.S. Giardiasis Incidence, 1999-2016

Sources: Centers for Disease Control and Prevention (2018a [cases]; 2017b [fatalities]).

Figure Ad: U.S. Giardiasis Rates, 2002-2017

Sources: Centers for Disease Control and Prevention (2018a [cases]; 2017b [fatalities]).

## NPDWRs for Other Contaminants

USEPA promulgated revised NPDWRs for three other contaminants since 1996. In each case, the adoption of the economic feasibility principle would have effectively eliminated inefficiency and substantially reduced inequity. Uniform MCLs would have been less stringent, the minimum system size subject to regulation would have been larger, or both. These effects would have been stronger if the Agency had estimated opportunity costs instead of expenditures, and objectively estimated risks and benefits as required by SDWA 1996 § 1412(b)(3)(A).

### Radionuclides/Uranium NPDWRs

In 2000, USEPA revised the NPDWR for radionuclides by retaining the existing MCLs for combined Ra226 and Ra228 (though with intensified monitoring requirements), beta particle and photon emitters, and gross alpha activity; and promulgated a new 30 μg/L MCL for uranium. More stringent MCLs for radionuclides that the Agency had proposed were not promulgated because more recent research indicated that risk was lower than previously estimated (USEPA 2000d). At the same time, the Agency did not raise these MCLs on the ground that, in its view, SDWA 1996 § 1412(b)(9) forbids it from relaxing MCLs even if new science shows that the existing MCL was no longer scientifically supported. Economically feasible alternatives are likely to have been precluded by this policy decision.

The Agency stated that the uranium MCL represented the first time it was exercising the statutory authority delegated in SDWA 1996 § 1412(b)(6) to set a standard less stringent than the level it had determined was technologically feasible. USEPA asserted that benefits of the uranium MCL would not justify costs if it was set at 20 μg/L because of “relatively modest” risk reductions and “high annual compliance costs.” However, the Agency also asserted that a 30 μg/L MCL “maximize[d] the health risk reduction benefits at a cost justified by the benefits” (USEPA 2000d, p. 76715). Thus, one would expect a 30 μg/L MCL to be economically feasible.

An objective reading of the rule, economic analysis, and Health Risk and Cost Analysis leads to a contrary conclusion, however. As shown in , estimated net benefits were negative for every alternative the Agency examined. Depending on the risk model, average cost per cancer case prevented ranged from $81 million to $182 million for the regulatory alternative USEPA rejected, and $60 million to $105 million for the regulatory option that “maximize[d] the health risk reduction benefits at a cost justified by the benefits.” As shown in , costs were deemed to justify benefits at $68 million per cancer case avoided. The preamble to the final rules suggests that USEPA was primarily concerned about ensuring quantity-based equity, which it defined as achievement of *ex* post risk within its preferred (but non-statutory) 10-4 to 10-6 risk range (USEPA 2000d, pp. 76710-76716).

If USEPA had used the economic feasibility principle to set the uranium MCL, the Agency would have set it higher than 80 μg/L, which the Agency estimated would cost on average about $11 million per cancer case avoided (USEPA 2000c, p. 6-5).[[3]](#footnote-3) Setting the MCL at 80 μg/L would have reduced USEPA’s “best estimates” of compliance cost by $36.4 million and reduced the number of cancer cases prevented by 0.35 case (USEPA 2000c, Exhibit 7-7).

Table ‑: Radionuclides NDWPR: Comparison of Quantified Annual Costs and Benefits

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Regulatory Option | Directly Proportional Hazard Model | | Lognormal Distribution Hazard Model | | “Best Estimate” | |
| Cost/Cancer Case Avoided | Net  Benefits | Cost/Cancer Case Avoided | Net  Benefits | Cost/Cancer Case Avoided | Net  Benefits |
| ***Compliance with existing MCLs after closing monitoring loopholes (combined radium = 5 pCi/L, gross alpha = 15 pCi/L)*** | | | | | | |
| Eliminate gross alpha monitoring loophole only | $35.0 million | ($1.2 million) | $79.1 million | ($26.4 million) | $73.0 million | ($13.8 million) |
| Eliminate combined radium monitoring loophole only | $51.6 million | ($14.8 million) | $64.6 million | ($32.7 million) | $59.3 million | ($23.8 million) |
| Eliminate both loopholes | $50.9 million | ($15.0 million) | $71.3 million | ($57.9 million) | $65.8 million | ($36.4 million) |
| ***Compliance with new uranium MCL options*** | | | | | | |
| 20 μg/L | $182.1 million | ($25.0 million) | $81.4 million | ($148.0 million) | $87.8 million | ($86.4 million) |
| 30 μg/L | $105.0 million | ($6.1 million) | $58.9 million | ($87.0 million) | $60.6 million | ($46.6 million) |
| 40 μg/L | $73.3 million | ($2.1 million) | $46.3 million | ($58.9 million) | $46.9 million | ($30.5 million) |
| 80 μg/L | $20.0 million | ($0.1 million) | $27.7 million | ($21.9 million) | $27.4 million | ($11.1 million) |
| Source: USEPA (2000h, Exhibit 7-6). | | | | | | |

Table ‑: Uranium NPDWR: Incremental Costs and Benefits for Alternative MCLs

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Uranium MCL (μg/L)\*\_ | Exposure Change (μg/L)\* | Incremental Annual Cancer Cases Avoided\* | Incremental Annual Compliance Costs ($M)\* | Incremental Annual Monetized Cancer Benefits ($M)\* | Incremental Number of Community Water Systems Affected\* | Average Cancer Cases per Community Water System | Average Cost/CWS† | Average Incremental Costs/Cancer Case ($M) † |
| 80 | ∞ to 80 | 0.5 | $ 16 | $ 2 | 100 | 0.0050 | $ 160,000 | $ 32 |
| 30 | 80 to 30 | 0.4 | $ 38 | $ 1 | 400 | 0.0010 | $ 95,000 | $ 95 |
| 20 | 30 to 20 | 0.2 | $ 39 | $ 1 | 290 | 0.0007 | $ 134,483 | $ 195 |
| Incremental Costs and Benefits for Uranium MCLs of 30 μg/L and 20 μg/L only | | | | | | | | |
| 30 | ∞ to 30 | 0.8 | $ 54 | $ 3 | 500 | 0.0016 | $ 108,000 | $ 68 |
| 20 | 30 to 20 | 0.2 | $ 39 | $ 1 | 290 | 0.0007 | $ 134,483 | $ 195 |
| \* USEPA (2000c, Table 1-1).  † Derived from USEPA (2000c). | | | | | | | | |

### Arsenic NPDWR

In the preamble to the arsenic NPDWR (USEPA 2001b), USEPA reported having exercised the discretion in SDWA 1996 § 1412(b)(6) to set a standard less stringent than what it had determined was technologically feasible for large systems. The Agency further asserted that 10 μg/L “maximizes health risk reduction benefits at a cost that is justified by the benefits” (p. 7023) and that $492–559 per household per year was affordable, depending on system size (Table I.G-3).

Interpreting the statutory language consistent with the economic feasibility principle, benefits must exceed costs for the smallest water system subject to Federal regulation. Table 7‑6 summarizes for four alternative MCLs USEPA’s risk estimates under two alternative exposure scenarios; provides present value estimates of cancer risk reductions at the then applicable VSL ($6.1 million); and reports annualized risk-reduction benefits discounted over 35 years at 3% and 7%. Table 7‑7 summarizes USEPA estimates of average treatment cost per household by system size. Cost and benefit estimates reported in USEPA (2000e) are not in comparable units, as benefits must be adjusted for household size. This is done in (for the “lower bound” exposure scenario) and (for the “upper bound” exposure scenario) for household sizes of 3 and 5.[[4]](#footnote-4)

shows the smallest-size community water system for which USEPA’s 10 μg/L MCL is economically feasible and (in parentheses) annualized net benefits per household. In addition to household size, whether benefits exceed costs depends on the discount rate and exposure scenario. The sensitivity of net benefits to these factors indicates that considerably more effort should be devoted to developing objective risk estimates rather than relying on historical default assumptions and policy-driven risk models, and conducting comprehensive uncertainty analysis (Office of Management and Budget 2003). Complicating matters further, Hilkert Colby et al. (2010) present substantial empirical evidence that 10 μg/L also is not *technologically* feasible for small systems; 145 (mostly small) systems in California were out of compliance in January 2009, three years after the effective date.

Where USEPA’s estimated net benefits are positive at 10 μg/L, they also are small. Annualized net benefits per household range from $0.52 to $6.05 per household in the “lower bound” exposure scenario and $18.81 to $31.92 in the “upper bound” exposure scenario. These estimates do not account for uncertainty in the hazard assessment, which if taken into account would render all net benefit calculations negative (Burnett and Hahn 2001b, a). Other analysts have reported much larger compliance cost estimates (Frey et al. 1998; Frey et al. 2000; Frost et al. 2002; Raucher and Cromwell 2004; Hilkert Colby et al. 2010; Gingerich et al. 2017), which further suggests that net benefits may be less than estimated by USEPA.

The arsenic rulemaking established 10 μg/L as the MCL for all systems, but for all systems serving fewer than 1 million persons it was not economically feasible. Thus, if USEPA had set the MCL at 10 μg/L based on the economic feasibility principle, all systems serving fewer than 1 million persons would have been exempt. The households they serve would have not realized the risk-reduction benefits in but avoided the costs shown in , and thus been better off by the amounts shown in : $19.14 to $325.44 per household per year (depending on system size) and $126 million per year in the aggregate. These savings would have been partially offset by risk-reduction benefits if economically feasible technology existed to enable systems serving fewer than 1 million persons to achieve standards less stringent than 10 μg/L and these technologies were voluntarily adopted by system managers. Setting the arsenic MCL at 20 μg/L instead of 10 μg/L would have reduced welfare losses by $7.3–$55 million.

Unlike post-1996 SDWA regulations generally, there is a substantial nongovernmental literature on the costs of arsenic treatment. Almost all of these studies indicate higher central tendency cost estimates and much greater variability. For example, in a study of California systems, Hilkert Colby et al. (2010) found capital costs ranging from $2–115,033 per design gpm; O&M costs ranging from $0.16–89.00 per 1,000 gallons; 22% of systems with costs exceeding the USEPA affordability threshold for a new regulation; and 15% of systems with costs exceeding the USEPA affordability threshold for drinking water. To the extent that nongovernmental studies are more accurate predictors of actual cost than USEPA’s economic analyses, the economic feasibility of the arsenic MCL is less likely.

Table 7‑6: Arsenic NPDWR: USEPA-estimated Annual Costs and Monetized Annual Cancer-prevention Benefits

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Level (μg/L) | Annualized Cost ($M) ($1999, 7%) | Annual Bladder Cancer Benefits | Annual Lung Cancer Benefits | Total Annual Benefits ($M) | Net Annual Benefits ($M) |
| 3 | $792.1 | $58.2–$156.4 | $155.6–$334.5 | $213.8–$490.0 | ($578.3)–($302.1) |
| 5 | 471.7 | $52.0–$113.3 | $139.1–$242.3 | $191.1–$355.6 | ($280.6)–($116.1) |
| 10 | 205.6 | $38.0–$ 63.0 | $101.5–$134.7 | $139.6–$197.1 | ($ 66.0)–($ 8.5) |
| 20 | 76.5 | $20.1–$ 21.5 | $46.1–$ 53.8 | $ 66.2–$ 75.3 | ($ 10.3)–($ 1.2) |
| Source: USEPA (2000e). | | | | | |

Table ‑: Arsenic NPDWR: USEPA-estimated Value of per Capita Cancer Risk Reduction by System Size and MCL

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| MCL  (μg/L) | Risk for Mean Exposed Population Risk | PV Per Capita Risk Reduction | Annualized Value of Per Capita Risk Reduction, 35 years | |
| *r* = 3% | *r* = 7% |
| “Lower Bound” Exposure Scenario | | | | |
| 3 | 1.10E-4 | $67 | $3.12 | $0.24 |
| 5 | 2.70E-4 | $165 | $7.67 | $0.59 |
| 10 | 6.30E-4 | $384 | $17.89 | $1.38 |
| 20 | 1.10E-4 | $671 | $31.23 | $2.41 |
| “Upper Bound” Exposure Scenario | | | | |
| 3 | 1.25E-4 | $763 | $35.49 | $2.74 |
| 5 | 2.02E-4 | $1,232 | $57.35 | $4.43 |
| 10 | 2.99E-4 | $1,824 | $84.88 | $6.56 |
| 20 | 3.85E-4 | $2,349 | $109.30 | $8.44 |
| Source: USEPA (2000e). VSL = $6.1 million. “Lower Bound” and “Upper Bound” exposure scenarios as described on p. 5-13. | | | | |

Table ‑: Arsenic NPDWR: USEPA-estimated Average Annual Household Cost by System Size and MCL

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **System Size** | **MCL (μg/L)** | | | |
| **3** | **5** | **10** | **20** |
| < 100 | $317.00 | $318.26 | $326.82 | $351.15 |
| 101-500 | 166.91 | 164.02 | 162.50 | 166.72 |
| 501-1,000 | 74.81 | 73.11 | 70.72 | 68.24 |
| 1,001-3,300 | 63.76 | 61.94 | 58.24 | 54.36 |
| 3,301-10,000 | 42.84 | 40.18 | 37.71 | 34.63 |
| 10,001-50,000 | 38.40 | 36.07 | 32.37 | 29.05 |
| 50,001-100,000 | 31.63 | 29.45 | 24.81 | 22.63 |
| 100,001-1,000,000 | 24.29 | 23.34 | 20.52 | 19.26 |
| > 1,000,000 | 7.41 | 2.79 | 0.86 | 0.15 |
| Source: USEPA (2000e). | | | | |

Table ‑: Arsenic NPDWR: USEPA-estimated Annualized Net Benefit per Household of “Lower Bound” Cancer Risk Reduction by System Size for Four Alternative Arsenic MCLs and Two Household Sizes, 7% Discount Rate

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **System Size** | **MCL (μg/L)** | | | |
| **3** | **5** | **10** | **20** |
| *Household Size = 3* | | | | |
| <100 | ($316.28) | ($316.48) | ($322.68) | ($343.91) |
| 101-500 | ($166.19) | ($162.24) | ($158.36) | ($159.48) |
| 501-1,000 | ($74.09) | ($71.33) | ($66.58) | ($61.00) |
| 1,001-3,300 | ($63.04) | ($60.16) | ($54.10) | ($47.12) |
| 3,301-10,000 | ($42.12) | ($38.40) | ($33.57) | ($27.39) |
| 10,001-50,000 | ($37.68) | ($34.29) | ($28.23) | ($21.81) |
| 50,001-100,000 | ($30.91) | ($27.67) | ($20.67) | ($15.39) |
| 100,001-1,000,000 | ($23.57) | ($21.56) | ($16.38) | ($12.02) |
| > 1,000,000 | ($6.69) | ($1.01) | $3.28 | $7.09 |
| *Household Size = 5* | | | | |
| <100 | ($315.79) | ($315.30) | ($319.91) | ($339.09) |
| 101-500 | ($165.70) | ($161.06) | ($155.59) | ($154.66) |
| 501-1,000 | ($73.60) | ($70.15) | ($63.81) | ($56.18) |
| 1,001-3,300 | ($62.55) | ($58.98) | ($51.33) | ($42.30) |
| 3,301-10,000 | ($41.63) | ($37.22) | ($30.80) | ($22.57) |
| 10,001-50,000 | ($37.19) | ($33.11) | ($25.46) | ($16.99) |
| 50,001-100,000 | ($30.42) | ($26.49) | ($17.90) | ($10.57) |
| 100,001-1,000,000 | ($23.08) | ($20.38) | ($13.61) | ($7.20) |
| > 1,000,000 | ($6.20) | $0.17 | $6.05 | $11.91 |
| Source: Derived from and . and . | | | | |

Table ‑: Arsenic NPDWR: USEPA-estimated Annualized Net Benefit per Household of “Upper Bound” Cancer Risk Reduction by System Size for Four Alternative Arsenic MCLs and Two Household Sizes, 7% Discount Rate

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **System Size** | **MCL (μg/L)** | | | |
| **3** | **5** | **10** | **20** |
| *Household Size = 3* | | | | |
| <100 | ($307.63) | ($295.26) | ($273.16) | ($311.12) |
| 101-500 | ($157.54) | ($141.02) | ($108.84) | ($126.69) |
| 501-1,000 | ($65.44) | ($50.11) | ($17.06) | ($28.21) |
| 1,001-3,300 | ($54.39) | ($38.94) | ($4.58) | ($14.33) |
| 3,301-10,000 | ($33.47) | ($17.18) | $15.95 | $5.40 |
| 10,001-50,000 | ($29.03) | ($13.07) | $21.29 | $10.98 |
| 50,001-100,000 | ($22.26) | ($6.45) | $28.85 | $17.40 |
| 100,001-1,000,000 | ($14.92) | ($0.34) | $33.14 | $20.77 |
| > 1,000,000 | $1.96 | $20.21 | $52.80 | $39.88 |
| *Household Size = 5* | | | | |
| <100 | ($301.39) | ($279.93) | ($237.39) | ($195.01) |
| 101-500 | ($151.30) | ($125.69) | ($73.07) | ($10.58) |
| 501-1,000 | ($59.20) | ($34.78) | $18.71 | $87.90 |
| 1,001-3,300 | ($48.15) | ($23.61) | $31.19 | $101.78 |
| 3,301-10,000 | ($27.23) | ($1.85) | $51.72 | $121.51 |
| 10,001-50,000 | ($22.79) | $2.26 | $57.06 | $127.09 |
| 50,001-100,000 | ($16.02) | $8.88 | $64.62 | $133.51 |
| 100,001-1,000,000 | ($8.68) | $14.99 | $68.91 | $136.88 |
| > 1,000,000 | $8.20 | $35.54 | $88.57 | $155.99 |
| Source: Derived from and . and . | | | | |

Table ‑: Arsenic NDPWR: Smallest Community Water System and USEPA-estimated Annualized Household Net Benefit by Household Size for which 10 μg/L is Economically Feasible

|  |  |  |
| --- | --- | --- |
| **Discount Rate** | **Risk Estimate** | |
| **“Lower Bound”** | **“Upper Bound”** |
| *3%* | | |
| **Household Size = 3** | 3,301–10,000 $15.95 | 101–500 $92.15 |
| **Household Size = 5** | 501–1,000 $18.71 | < 100  $97.60 |
| *7%* | | |
| **Household Size = 3** | >1 million $3.28 | >1 million $18.81 |
| **Household Size = 5** | >1 million $6.05 | 10,001–50,000 $0.41 |
| Source: Derived from USEPA (2000e). | | |

Table ‑: Arsenic NPDWR: Savings per Household and Aggregate Savings from an Economic Feasibility Rule Based on USEPA-estimated Benefits and Costs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **System Size** | **MCL (μg/L)** | | | |
| **3** | **5** | **10** | **20** |
| **Savings/Household Served by Systems Expected to Treat ($/Yr)** | | | | |
| <100 | $316.76 | $317.67 | $325.44 | $348.74 |
| 101-500 | $166.67 | $163.43 | $161.12 | $164.31 |
| 501-1,000 | $74.57 | $72.52 | $69.34 | $65.83 |
| 1,001-3,300 | $63.52 | $61.35 | $56.86 | $51.95 |
| 3,301-10,000 | $42.60 | $39.59 | $36.33 | $32.22 |
| 10,001-50,000 | $38.16 | $35.48 | $30.99 | $26.64 |
| 50,001-100,000 | $31.39 | $28.86 | $23.43 | $20.22 |
| 100,001-1,000,000 | $24.05 | $22.75 | $19.14 | $16.85 |
| > 1,000,000 | $7.17 | $2.20 | $0.00 | $0.00 |
| **Savings/All Households Served by Systems Expected to Treat ($M/Yr)** | | | | |
| <100 | $31.5 | $18.7 | $8.6 | $3.6 |
| 101-500 | $61.3 | $37.3 | $16.8 | $6.6 |
| 501-1,000 | $26.9 | $15.9 | $7.1 | $2.7 |
| 1,001-3,300 | $63.7 | $38.2 | $16.4 | $6.1 |
| 3,301-10,000 | $69.0 | $40.4 | $17.3 | $6.2 |
| 10,001-50,000 | $123.2 | $73.7 | $30.9 | $10.8 |
| 50,001-100,000 | $45.6 | $26.1 | $11.0 | $3.8 |
| 100,001-1,000,000 | $72.5 | $44.1 | $17.9 | $6.1 |
| > 1,000,000 | $0.0 | $0.0 | $0.0 | $0.0 |
| **Total Savings** | **$493.8** | **$294.4** | **$126.0** | **$46.0** |
| Source: Derived from  Table 7‑8 and Table 7‑9. | | | | |

### Lead and Copper: Short-Term Regulatory Revisions and Clarifications

In 2007, USEPA made seven changes in its existing NPWDR for lead and copper (USEPA 2007b). The Agency described the rule’s purpose as “to protect populations from exposure to lead in drinking water to reduce potential health risks associated with lead” (USEPA 2007a). No benefits are quantified, however, so the economic feasibility of none of the seven provisions can be evaluated.

## Miscellaneous Standards

### Drinking Water Regulations for Aircraft Public Water Systems

In 2009, USEPA promulgated a final rule setting standards for drinking water in scheduled and charter passenger aircraft that serve on average at least 25 persons daily at least 60 days per year (USEPA 2009a).[[5]](#footnote-5) USEPA obtained data indicating that about 4% of aircraft lavatory water samples tested positive for coliform (Table III-2). The Agency considered four options in its RIA but did not examine the no-action alternative (USEPA 2009b). No benefits were estimated, so the effects of having applied the economic feasibility principle cannot be characterized.

### Revisions to the Total Coliform Rule

In 2013, USEPA promulgated a Revised Total Coliform Rule (RTCR) asserting that it provided “a meaningful opportunity for greater public health protection beyond the 1989 TCR” (USEPA 2013, p. 10270 [citing SDWA 1996 § (b)(1)(A)(iii)]). The rule required all CWSs and NCWSs “vulnerable to microbial contamination to identify and fix problems, [and] establish[ed] criteria for systems to qualify for and stay on reduced monitoring, thereby providing incentives for improved water system operation” (p. 10270). USEPA estimated 155,000 public water systems serving 310 million individuals were covered (p. 10271). The Agency determined that the benefits of the rule justified the costs (p. 10335), so this rule is potentially susceptible to economic feasibility analysis.

The reported number and rate of positive total coliform and *E. coli* tests was described as “an indicator of baseline water,” and ranged from a low of 0.00% (8 system type/size combinations) to a high of 0.46% (TNCWSs serving 101-500 persons) (USEPA 2013, p. 10308). These data were used to populate a model calculating MCL violations and triggers for regulatory requirements. A causal nexus between differences in violation frequency within these ranges and human health risk was asserted but not substantiated.

Three regulatory options were examined: the no-action alternative, the final rule as promulgated, and a more stringent “Alternative” option that would have required more frequent sampling. Though USEPA stated that the rule was cost-effective, it did not quantify social benefits (pp. 10308, 10319-10320). The Agency estimated expenditures for compliance (not opportunity costs) by system type and size. Estimated annualized compliance expenditures for the rule (and the more stringent Alternative) were $200 million ($216 million) at 3%, and $193 million ($210 million) at 7% (p. 10321 [Exhibit VI-15]).

Outcomes (e.g., health risk reduction) were assumed based on changes in inputs (e.g., monitoring frequency and corrective actions triggered by positive test results).[[6]](#footnote-6) It is therefore unclear how the Agency determined that benefits justified costs. Finally, because USEPA did not include a less stringent alternative other than no-action, improvements in net social benefits from the adoption of the economic feasibility principle cannot be estimated.

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1. The proposed online appendix is included here for readability. [↑](#footnote-ref-1)
2. [↑](#footnote-ref-2)
3. USEPA (2000a) and (USEPA 2000h) have somewhat different estimates of the average cost per cancer case avoided. These differences are too small to affect the inferences drawn here, however. Estimates by system-size were not reported, but it is reasonable to infer that 30 μg/L would have been economically feasible for very large water systems. [↑](#footnote-ref-3)
4. For household sizes smaller than 3, net benefits per household are negative for all system sizes and all four MCLs the Agency considered. [↑](#footnote-ref-4)
5. “[I]f an aircraft has a sink in the lavatory, then the water provided to that sink must be suitable for human

   consumption” (p. 53591) [↑](#footnote-ref-5)
6. USEPA (2013, p. 10309): “More frequent monitoring has the potential to decrease the risk of contamination in PWSs based on an enhanced ability to diagnose and mitigate system issues in a more timely fashion." Conversely, less frequent monitoring has the potential to increase risk. Real-time continuous sampling would mitigate the most risk possible based on sampling schedule; however, it would cost prohibitively more than the periodic sampling practiced under the 1989 TCR and included in the RTCR and the Alternative option.” [↑](#footnote-ref-6)