

The cost of compliance with a new drinking water standard for arsenic in New Mexico

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Introduction

Over 90% of drinking water consumed in New Mexico is obtained from ground-water supplies (Water Quality Control Commission, 2000). Although this resource has historically provided a reliable supply of safe, high-quality water, the presence of high natural arsenic levels in many geologic formations results in corresponding elevated concentrations of arsenic in many public water supplies. The current drinking water standard of 50 $\mu\text{g}/\text{L}$ was first established by the United States Public Health Service in 1942 and was continued as an interim standard under the Safe Drinking Water Act (SDWA) of 1975. In the 1996 amendments to the SDWA, Congress directed the United States Environmental Protection Agency (US EPA) to propose a final arsenic maximum contaminant level (MCL) by January 2000 and to promulgate the final standard by January 2001. Accordingly, on June 22, 2000, the US EPA proposed an enforceable standard for arsenic of 5 $\mu\text{g}/\text{L}$ and requested comments on MCLs of 3, 10, and 20 $\mu\text{g}/\text{L}$. Whereas nearly all public water systems in New Mexico meet the 50 $\mu\text{g}/\text{L}$ MCL, approximately 60% of them will not meet a standard of 5 $\mu\text{g}/\text{L}$, and 20% will not meet a standard of 10 $\mu\text{g}/\text{L}$.

The US EPA conducted a cost-benefit analysis as part of the process of proposing the new arsenic drinking-water standard that estimated the annualized cost for public water supplies to install and maintain arsenic-treatment systems to be \$442 million per year for a standard of 5 $\mu\text{g}/\text{L}$ and \$195 million per year for a standard of 10 $\mu\text{g}/\text{L}$ (Abt Associates, 2000). Another cost analysis was conducted by the American Water Works Association Research Foundation (AWWARF), which reported an annualized cost estimate of \$1.46 billion per year and \$495 million per year for 5 $\mu\text{g}/\text{L}$ and 10 $\mu\text{g}/\text{L}$ standards respectively (Frey et al., 2000). The large discrepancy between these national cost estimates prompted this study to determine the cost of compliance with the lower arsenic standard in New Mexico. We developed an estimate of the compliance cost in New Mexico that is based on individual cost estimates for each community water system that would be affected by the proposed standard.

Methodology

Data on community water systems were

provided by the New Mexico Environment Department (NMED) Drinking Water Bureau. These data show that 346 and 114 community water systems contain arsenic at or above the proposed MCLs of 5 and 10 $\mu\text{g}/\text{L}$ respectively. Of those systems serving communities with a population of 1,000 or more, 79 have arsenic concentrations greater than 5 $\mu\text{g}/\text{L}$ and 34 have arsenic concentrations greater than 10 $\mu\text{g}/\text{L}$. Community water systems are defined in the SDWA as those systems with at least 15 hookups or serving at least 25 people on a year-round basis. Nontransient, noncommunity water systems were not included in this cost estimate as they were not required to comply with the new standard as it was first proposed. Those systems include jails, hospitals, schools, military bases, and seasonal camps. Also, none of the Native American tribes or pueblos were included in this analysis because their water systems are not regulated by the NMED.

For each community water system analyzed, an estimate was prepared of the costs to construct, operate, and maintain three different treatment technologies that have been considered for arsenic removal from ground water. Community water systems that extract ground water through wells generally distribute the water from the well directly to the customer; therefore, arsenic removal treatment for these systems must be done at the well head. The cost estimates for each community water system are based on the sum of the construction and maintenance costs for treatment at each well that produces water with

arsenic concentrations of 5 or 10 $\mu\text{g}/\text{L}$.

The costs were estimated using cost curves developed for AWWARF (Frey et al., 2000) and were based on the volume of water to be treated at each well. In New Mexico, most of the water systems that would be affected by the proposed arsenic MCL produce between 0.1 and 1 million gallons per day (mgd; Fig. 1). The costs are considered "budget level estimates," as defined by the American Association of Cost Engineers, and normally are expected to be accurate within +30% or -15%. The construction-cost curves for the three treatment technologies considered in this study are shown in Figures 2 through 4. The costs per unit flow were developed by preparing flow sheets, layouts, and equipment details for each of the three processes considered. For example, the capital-cost curve includes the unit cost of contractor labor burden, equipment, and material costs. Mark-ups include contractor's overhead and profit, mobilization, bonds, insurance, and a 20% contingency. The total capital costs do not include engineering and service during construction. All costs are presented in January 1999 dollars.

Three treatment technologies were considered: activated-alumina adsorption, ion exchange, and ferric hydroxide coagulation and microfiltration. Ion exchange and activated alumina were designated as "best available technology" by US EPA (2000a). Coagulation/microfiltration has been successfully pilot tested on two wells in Albuquerque but was not included by the EPA as "best available technology" because it has not been tested on a larger

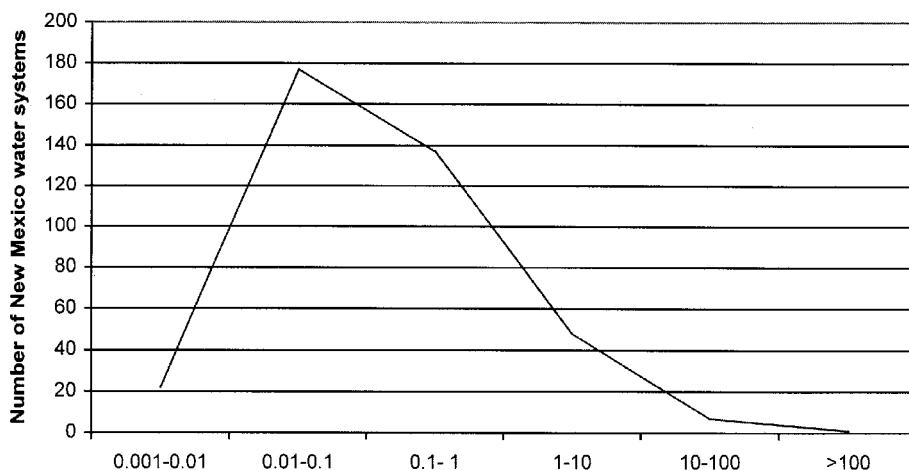


FIGURE 1—Size distribution of New Mexico community water systems affected by an arsenic MCL of 5 $\mu\text{g}/\text{L}$.

scale. All three of the treatment technologies depend on adsorption of arsenic by different media. Discussions of these three technologies for arsenic removal from ground water and descriptions of the costs associated with each technology have been provided by Frey et al. (2000) and Chwirka et al. (2000).

The ion-exchange process involves exchange of an arsenate ion ($H_2AsO_4^-$) in solution with a chloride ion (Cl^-) on a polystyrene resin matrix. This exchange continues until the resin is exhausted, and the resin is then regenerated by washing with brine to reverse the reaction. The activated-alumina treatment process is similar to ion exchange, but the arsenic is removed by exchange with a hydroxide ion (OH^-) on the activated-alumina media. Regeneration is accomplished by washing with caustic soda ($NaOH$). The regeneration step in these two treatment technologies creates a waste product, either salt brine or caustic soda, which may contain enough arsenic to be considered a hazardous waste and therefore regulated under the Resource Conservation and Recovery Act (RCRA). If the regenerants are hazardous waste, special equipment and procedures would be needed for the residuals, and they would require disposal in a permitted hazardous-waste disposal facility. The cost of managing these residuals as hazardous wastes was not included in the cost estimates for these treatment technologies.

For smaller treatment systems (less than 0.2 mgd), the EPA has suggested a throw-away activated-alumina treatment system as a cost-effective alternative that disposes of the spent media instead of regenerating it. For this cost analysis, it was assumed that all community water systems with less than 1,000 people would use the throw-away activated-alumina treatment technology.

The coagulation/microfiltration treatment technology involves the addition of ferric chloride to the feedwater, which in turn forms a ferric hydroxide precipitate ($Fe(OH)_3$) that is removed from the water by microfiltration. Arsenic is removed from solution by adsorption and co-precipitation onto the ferric hydroxide floc.

Results

The results of our cost estimates are summarized in Table 1. The capital costs for compliance with an MCL of 5 $\mu\text{g/L}$ range from \$1.0 to \$1.2 billion, and from \$374 to \$436 million for an MCL of 10 $\mu\text{g/L}$, depending on the treatment technology

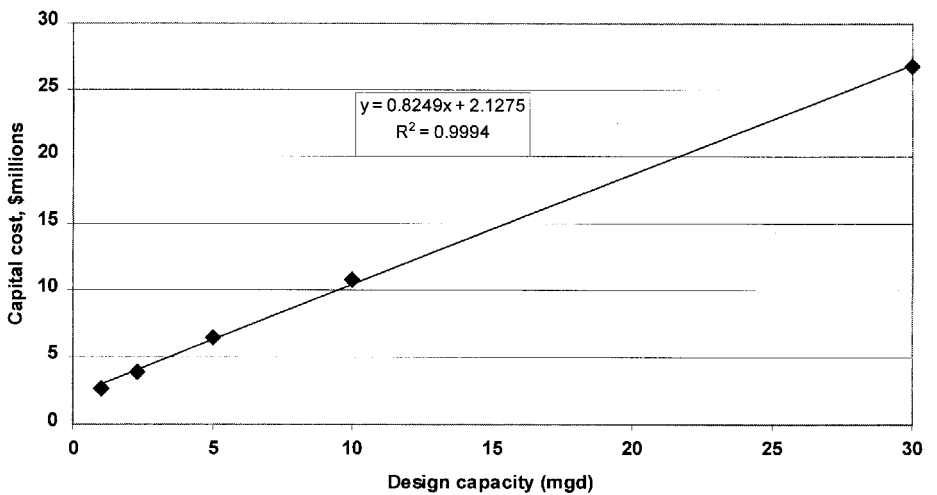


FIGURE 2—Capital costs for arsenic removal by ion exchange as a function of design flow rate (Frey et al., 2000).

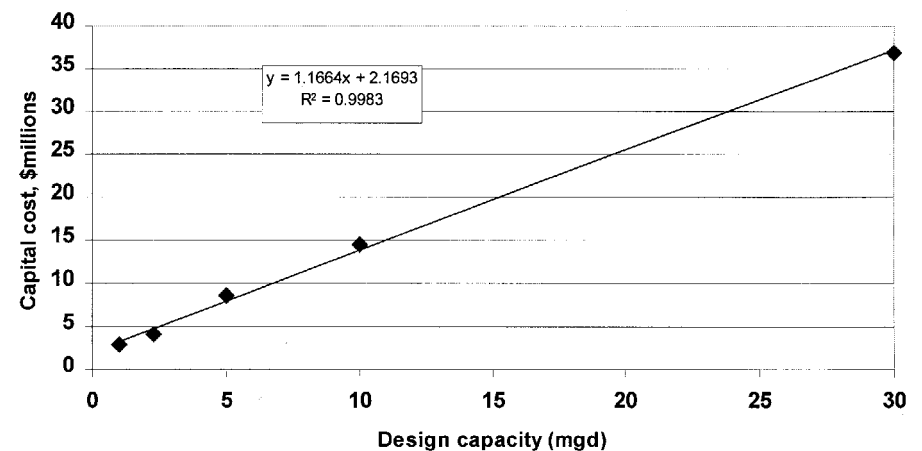


FIGURE 3—Capital costs for arsenic removal by activated-alumina adsorption as a function of design flow rate (Frey et al., 2000).

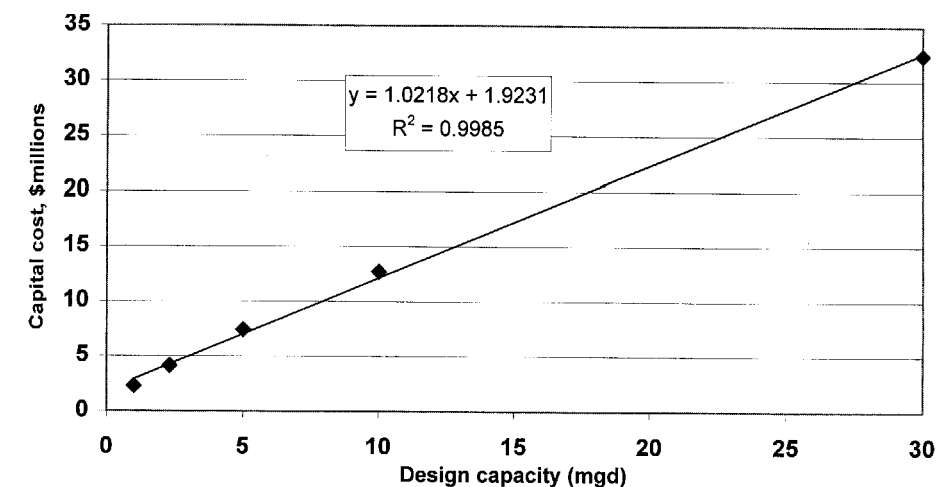


FIGURE 4—Capital costs for arsenic removal by iron coagulation/microfiltration as a function of design flow rate (Frey et al., 2000).

TABLE 1—Summary of estimates of the cost of compliance for arsenic drinking-water standards of 5 $\mu\text{g/L}$ and 10 $\mu\text{g/L}$.

| Study | No. of systems affected | | Capital costs | | Annual operation and maintenance costs | | Annualized costs | |
|-------------------|-------------------------|--------------------|-------------------|--------------------|--|--------------------|-------------------|--------------------|
| | 5 $\mu\text{g/L}$ | 10 $\mu\text{g/L}$ | 5 $\mu\text{g/L}$ | 10 $\mu\text{g/L}$ | 5 $\mu\text{g/L}$ | 10 $\mu\text{g/L}$ | 5 $\mu\text{g/L}$ | 10 $\mu\text{g/L}$ |
| New Mexico | 346 | 114 | \$1.0–1.2 billion | \$374–436 million | \$48–67 million | \$16–21 million | \$139–172 million | \$49–60 million |
| National (EPA) | 6,956 | 3,034 | not provided | | not provided | | \$442 million | \$195 million |
| National (AWWARF) | 4,004 | 1,697 | \$14.1 billion | | not provided | | \$1.46 billion | \$495 million |

used. Large systems (greater than 0.2 mgd) in 79 communities account for about 80% of the estimated capital costs, and small treatment systems (less than 0.2 mgd) in 267 communities account for about 20% of the estimated capital costs for an MCL of 5 µg/L. To put these numbers in perspective, the estimated capital costs for a 5 µg/L standard would constitute 3% of 1999 New Mexico State gross product and 50% of the 1999 New Mexico State gross product in construction.

The annual operation and maintenance (O&M) costs include power, chemicals, residuals disposal, labor, and equipment maintenance. For New Mexico, the annual O & M costs for compliance with an MCL of 5 µg/L range from \$48 to \$67 million, and from \$16 to \$21 million for a 10 µg/L MCL, depending on the treatment technology. Large systems (greater than 0.2 mgd) account for about 95% of the estimated annual O & M costs, and small systems (less than 0.2 mgd) account for about 5% of the estimated annual O & M costs.

Annualized costs are calculated by combining annual O & M costs with the capital costs amortized over a specified time frame and applying an appropriate interest rate. In this study, the annualized costs were calculated over a 20-yr period and assumed a 6% interest rate. The estimated annualized costs in New Mexico for compliance with an MCL of 5 µg/L range from \$139 to \$172 million, and from \$49 to \$60 million for a 10 µg/L MCL, depending on the treatment technology. Large systems (greater than 0.2 mgd) account for about 90% of the estimated annualized costs, and small systems (less than 0.2 mgd) account for about 10% of the estimated annualized costs. The estimated annualized costs are the cost measure that is comparable to the annualized costs developed by EPA (\$442 and \$195 million for 5 µg/L and 10 µg/L respectively) and AWWARF (\$1.46 billion and \$495 million for 5 µg/L and 10 µg/L respectively). EPA used an interest rate of 7% and did not disclose the period of amortization, whereas the AWWARF estimate assumed a 6% interest rate and a 20-yr amortization period.

The estimated monthly increase in the cost of water for households can be calcu-

lated by dividing the annualized cost for each water system by the number of customers connected to the system and then dividing by 12 months in a year. In large systems, average monthly cost increases range from about \$50 to \$65 per customer, depending on the treatment technology. This represents an annual cost increase of \$600 to \$780. For small systems, the average monthly increase in the cost of water is estimated to be approximately \$90 per customer, equivalent to a yearly increase of about \$1,100. The EPA cost analysis considered the issue of affordability. EPA considered that the median household expends about 0.7% of its income on water and other public services (Abt Associates, 2000). The annual increases in the cost of water with the proposed arsenic standards would mean the median New Mexico household would expend 2% of the annual income (\$31,500 in 1998) on water alone.

Conclusions

This study found that the annualized costs to meet a new drinking water standard for arsenic in public water supplies in New Mexico represent about 30% of the national costs estimated by EPA and about 10% of the costs estimated by the AWWARF (Table 1). This suggests that the AWWARF cost estimate is more realistic. However, the discrepancy between the estimate for New Mexico and the national estimates is likely the result of the approach used for estimating arsenic occurrence. Arsenic-occurrence estimates were the basis for the number of water systems that will be impacted by the revised arsenic MCL. Three separate estimates of arsenic occurrence were completed. The first was sponsored by the Water Industry Technical Action Fund and was conducted by Frey and Edwards (1997). The second estimate was done by the US Geological Survey in 1999 (Focazio et al., 1999), and the third was completed by the EPA in 2000 (US EPA, 2000b). Each of these estimates used water-quality data from a subset of states to develop the regional distribution of mean arsenic concentration. The regional distributions were combined to determine a national estimate of percent of systems

expected to exceed different arsenic levels.

The national estimate of percent of systems exceeding a new arsenic standard was 15% for 5 µg/L and 5–8% for 10 µg/L. In New Mexico, about 60% of the community water systems exceed 5 µg/L, and 20% of the systems exceed 10 µg/L. Furthermore, the number of affected communities in New Mexico is about 5% of the EPA national estimate of number of systems affected and about 8% of the AWWARF national estimate (Table 1). The higher percentage of affected systems in New Mexico than predicted in the three national arsenic-occurrence studies is probably the source of the discrepancy in compliance cost estimates.

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