Report of the Arsenic Cost Working Group to the National Drinking Water Advisory Council

FINAL

August 14, 2001

Table of Contents

Appendices

Tables

Figures

Abbreviations used in this report

μg – Microgram, one-millionth of a gram (3.5 x 10^{-8} of an ounce)
μg/L – micrograms per liter (equal to parts per billion (ppb))
AA – Activated alumina
ANSI – American National Standards Institute
As (III) – Trivalent arsenic. Common inorganic form in water is arsenite
As (V) – Pentavalent arsenic. Common inorganic form in water is arsenate
ASE – AwwaRF study estimate, the cost estimates presented in the AwwaRF report *Cost Implications of a Lower Arsenic MCL* (revised October 2001)
AWWA – American Water Works Association
AwwaRF – American Water Works Association Research Foundation
BAT – Best available technology
CMF – Coagulation assisted microfiltration
CCR – Consumer confidence report
CWSS – Community Water System Survey
EBCT – Empty bed contact time
ECF – Enhanced coagulation filtration
e.g. – *exempli gratia*, Latin for “for example”
EPA – U.S. Environmental Protection Agency
EPDS – Entry points to the distribution system
et al. – *et alia*, Latin for “and others”
GFH – Granular ferric hydroxide
i.e. – *id est*, Latin for “that is”
L – Liter
M$ – Million dollars
MCL – Maximum contaminant level
MCLG – Maximum contaminant level goal
mg – Milligrams, one-thousandth of a gram, 1 milligram = 1,000 micrograms
mg/L – Milligrams per liter
NAOS – National Arsenic Occurrence Survey
NAS – National Academy of Sciences
NCE – The EPA national cost estimate prepared for the arsenic rule promulgated January 2001
NDWAC – National Drinking Water Advisory Council for EPA
NSF – National Sanitation Foundation
O&M – Operation and maintenance
OGWDW – Office of Ground Water and Drinking Water in EPA
pH – Negative log of hydrogen ion molar concentration
POE – Point-of-entry treatment devices
POTWs – Publicly owned treatment works, treat wastewater
POU – Point-of-use treatment devices
ppb – Parts per billion (equal to micrograms per liter (µg/L))
ppm – Parts per million
RO – Reverse osmosis
SAB – Science Advisory Board
SDWA – Safe Drinking Water Act

SDWIS – Safe Drinking Water Information System
TCLP – Toxicity Characteristic Leaching Procedure, tests for toxicity of potential hazardous waste
TDP – Technology Design Panel
TDS – Total dissolved solids
T&C – *Technologies and Costs for Removal of Arsenic from Drinking Water*, EPA document published December 2000 (draft issued November 1999)
WET – California Waste Extraction Test, tests for toxicity of potential hazardous waste

1 Executive Summary

The Arsenic Cost Working Group of the National Drinking Water Advisory Council has completed its analysis for the cost of implementation of the arsenic rule. This report includes the group's findings and recommendations. This chapter provides a brief summary of the report. Details of the findings and recommendations from this group can be found in chapters 3, 4, 5, and 6. A list of the members of the working group and a description of the deliberation process are included in chapter 2.

1.1 Working group's charge and deliberation process

The charge of the National Drinking Water Advisory Council (NDWAC) Arsenic Cost Working Group was to review the costing methodologies, assumptions, and information underlying the system-size cost estimates as well as the aggregated national estimate of system costs of the Arsenic in Drinking Water Rule. As part of this review, the working group was to evaluate alternative costing approaches or critiques that may have a significant impact on the estimated system costs. In making this evaluation, the working group was charged to determine whether there is adequate supporting information upon which to evaluate the basis for the alternate approaches or critiques and note where there is not adequate supporting information. The final element of the working group's charge was to develop, based on its review and analysis, a written recommendation to the NDWAC. Such recommendations are to be provided with the understanding that EPA will decide whether and how any revision of the arsenic rule's cost analysis will occur. The working group recognizes that the recommendations will be subject to review, and possible change, by the NDWAC, who will transmit the final recommendations to EPA for consideration should EPA decide to revise the arsenic national cost estimate or when it pursues other cost estimates. This group's charge did not include the consideration of benefits, which is being addressed by the EPA Science Advisory Board Panel on Arsenic Benefits.

The working group conducted five 2-day meetings around the country between May 29th and August 3rd, 2001. In addition, there have been numerous conference calls, e-mails, and subgroup meetings to review, edit, and amend many details on a multitude of issues affecting the impact of a national cost analysis.

1.2 Overview of costing approaches

The national cost estimates are projected through computer modeling and construction of cost curves. These models are based upon available data and certain baseline assumptions. These baseline assumptions involve a number of factors that may have a significant affect on the final cost if they are changed. These key factors include:

- Number of systems and the total volume of water per system requiring arsenic treatment,
- Number of entry points into the distribution system,
- Type of technology selected,
- Method of disposal for residuals,
- Water quality characteristics of the source waters being treated, and
- Items and dollar amounts assumed under the unit costs of technologies.

1.3 Conclusions and recommendations

The working group believes that the U.S. Environmental Protection Agency (EPA) produced a credible estimate of the cost of arsenic compliance given the constraints of 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. The working group made a number of specific recommendations to improve the national cost estimate, which are described in this section. The working group acknowledges the usefulness of the AwwaRF study to evaluate the national cost estimate and recommends that any use of the AwwaRF estimation for system-level or national cost should also reflect the modified assumptions and recommendations stated in this report. Major conclusions and recommendations are organized below in the order of the topics covered in the main body of the report.

1.3.1 Use, value, and limits of the national cost estimates (Chapter 3)

The value of existing national cost estimates is now limited by the large uncertainty associated with the estimated outcomes. Reducing this uncertainty where possible will provide a higher value and confidence in the forecasting process.

Recognizing the uncertainties

- It is generally acknowledged that the current baseline data sets and input parameters have individual inherent uncertainties that will create a wide band of uncertainty for any forecast of national cost. To help clarify the issue, EPA should clearly explain the limitations of each estimate and quantify the uncertainty associated with the arsenic rule estimates and all such national cost estimates.

Cost estimates conducted for future rules

- An approach based on aggregated county, regional, or state costs, coupled with extensive individual case analysis would yield significantly better results than current procedures. However, the working group recognizes the practical limitations and the need for authority, resources, and cooperation from other entities in implementing this approach. Water systems are complicated: significant non-treatment options are available in many cases and standard definitions of best available technology (BAT) will not apply in all cases. No cost estimating system can be precise, as discussed above, but the group believes that new effort should be made to establish a better system and that the extra cost of administering such a system will pay dividends and should be considered for inclusion in appropriate budgets.
- To achieve this in the future EPA should evaluate the feasibility of developing a more representative methodology to assess compliance cost. This evaluation should consider the most recent Community Water System Survey information, describe specific data acquisition needs, provide a set of common criteria to be used in data gathering, and a schedule for obtaining data. The resources expended in implementing this new approach to a national cost estimate should be commensurate with the relative economic impact anticipated from a proposed drinking water rule.

1.3.2 Development of national costing approaches (Chapter 4)

Conclusions

- The difference in the EPA national cost estimate and the AwwaRF study estimates was explained predominantly by differences in the input assumptions regarding the selection of arsenic control technologies (i.e., compliance forecasts) and unit cost models developed for selected technologies. While differences were found in the estimates of the numbers of affected systems and the flow conditions assigned to systems of various sizes, the differences in these two factors offset each other so that their net effect explained little of the difference between the cost estimates. All of these factors explained differences in the cost estimates as summarized in table 4.4
- The unexplained differences (table 4.4) are attributable to the noted differences in residual handling and disposal assumptions, non-quantitative effects from the compliance forecast assumptions, and the approaches used for national cost methodology.
- The working group's review focused on a methodology that could be applied to any of the MCLs being considered for arsenic.

1.3.3 Recommendations for the arsenic national cost estimate (Chapter 5)

Taking into account the discussion above, the working group makes the following recommendations for the arsenic national cost estimate:

Arsenic occurrence estimation

- Continue to use the most representative data bases available for community and non-community water systems when determining national arsenic occurrence.

Determination of number of affected systems, flow, and entry points to the distribution system

- For each population size category, a distribution of flows should continue to be applied rather than a unique flow (e.g., the mean or median flow) to represent the category.
- Due to significant uncertainty associated with EPDS determination, EPA should reexamine the sources of information used to determine the number of EPDS per system size category and use up-to-date and representative information (e.g., Community Water System Survey, AWWA Large Groundwater-using Utilities Survey (Stratus Consulting, January 2000), Water Industry Data Base (WIDB), WATER:/STATS, and Intra-Site Six State database) in its calculation.
- Mixed systems (i.e., those treating both surface water and ground water) should continue to be classified as groundwater systems if more than 50 percent of the water they distribute is ground water.
- For entry points with arsenic concentrations above the current regulatory level of 50 μg/L, only the incremental costs of treating from 50 μg/L to the level of the new standard should continue to be considered in the cost.
- The approach and results used to estimate what percent of a water system's EPDS will exceed a given MCL should be carefully explained.

Unit technology and cost

The working group believes that the technologies utilized by EPA are, in general, the appropriate technologies for arsenic removal; however, the working group recommends some important changes in the costing approach used by EPA for these technologies.

- The technologies available now are changing rapidly, and EPA should include new technologies in the revised national cost estimate if they are feasible as defined in the SDWA – 1412(b)(4)(D) and 1412(b)(4)(E).
- The working group also recommends that land costs be included for all technologies even though land may not be a major cost driver and poses certain difficulties of estimation. This may be done as a percentage figure of 2 to 5% of total unit capital cost.
- The working group reviewed the cost of the key components for several technologies (e.g. AA). Based on its review, the working group recommends that EPA reevaluate, update, and validate the design and cost of the components in order to develop the cost curve for different technologies. In addition, the working group recommends that example line item tables (example formats shown in tables 5.1 and 5.2) for representative flow categories be included for each technology in the revised *Technologies and Costs* document (preferably for two community sizes).
- The group also discussed the capital cost multipliers that were used in the previous national costing approach to convert the process costs to capital costs. The working group recommends a multiplier of 2.5 for systems serving populations of 10,000 or smaller and 1.8 for systems serving populations larger than 10,000. In the future, EPA should carefully reevaluate the assumptions involved in developing capital cost multipliers.
- The working group recommends that EPA should reexamine the labor cost estimates to include process monitoring and routine maintenance of the treatment system. These costs should include administration, analytical, sampling and sample delivery costs associated with this monitoring.
- The group recommends that pumping be adequate to overcome the head loss through the adsorbent media and be a single stage pump when the treatment system is extracting groundwater.
- EPA should revise the capital costs to include on-site pilot testing of all technologies.
- Small systems that will be affected by the arsenic rule will now be required to operate sophisticated treatment technologies. These systems may require a higher level of trained and certified operator. To accomplish this, states may be required to expand training and certification requirements to meet these needs. The working group recommends that EPA reevaluate what costs related to operator training and certification were included in the national cost estimate and make adjustments if necessary.

Activated Alumina (AA)

- Based upon the information presented, for purposes of developing the national cost estimate, the working group agrees with the assumption of using disposable activated alumina rather than the regenerable activated alumina.
- Based upon the information presented, for the purposes of developing the national cost estimate, the working group agrees with the assumption of using two columns in series (i.e., roughing and polishing columns with a third standby column). The working group also recommends the media costs for the stand-by column be included in the capital costs for AA technology or any other similar treatment technology using a standby column.
- The contactor and media cost analysis should be updated with the most recent additional information to reflect realistic contactor and media costs (to be determined by averaging costs obtained from at least four independent suppliers).
- The empty bed contact time (EBCT) for the AA design should be such that the media life is at least three months for the lowest bed volume assumptions.
- The capital and O&M cost associated with adequate pumping capacity, which is needed to overcome the head loss through the adsorbent media, should be included.
- EPA should reexamine its unit cost development and curve-fitting technique to ensure that the unit cost equations represent appropriate economies of scale.
- The working group recommends EPA reevaluate spent media disposal cost estimates, including appropriate capital and/or O&M costs (labor, transportation, landfill fees, on-site storage facilities, etc.).

Enhanced Coagulation and Filtration

- No changes are recommended for the process design of the enhanced coagulation and filtration process assuming ECF is to be used only in systems that currently have sedimentation basins. However, if ECF is to be used in ground water systems that treat for iron and/or manganese reduction, it may be necessary to add sedimentation basins and cost them accordingly.

Coagulation Assisted Microfiltration

- Due to lack of time, the working group was not able to perform an exhaustive evaluation of the unit cost curve development for the coagulation-assisted microfiltration process. The group, therefore, recommends that EPA reevaluate and revise the unit cost curves as necessary.

Point-of-Use Technologies

- EPA should revise the unit costs using the latest figures of capital and operation and maintenance costs.

Determination of decision tree and compliance forecast

- After updated unit costs are developed, EPA should continue to use the existing thirteen listed technologies and others as appropriate in its decision tree analysis. In its compliance forecast EPA should continue to use the same approach with the modified assumptions recommended herein regarding the selection of technologies based on system size, type of water supply, arsenic levels, source water quality, existing treatment scheme, and lower cost of the technology.
- Simple treatment technologies (e.g., disposable media adsorption processes without pH adjustment) should be used for systems serving a population of 3,300 or fewer persons where possible.
- Consider expanding the use of POU option to larger size categories if the new cost evaluations show a significant advantage and if the access question and other issues identified in section 5.9 and appendix C are resolved. If issues associated with implementation are not resolved, the working group understands its application will be limited.

Technologies not included in the current national cost estimate

- Based on the presentations made, the working group recommends that EPA determine whether the granular ferric hydroxide (GFH) process meets the requirement for "feasible technology" as defined in the SDWA – 1412(b)(4)(D) and 1412(b)(4)(E). If the GFH process meets these criteria, the group recommends that EPA include it in the compliance forecast.
- EPA should evaluate the use of direct filtration technology particularly for systems with high iron content.

Recommendations for residual handling and disposal

- The working group recognizes that the disposal of residual solids generated by arsenic treatment facilities will impact the cost to comply with the arsenic MCL. Based on existing federal requirements EPA has determined that these arsenic contaminated residuals will not be classified as hazardous wastes. This assumption conforms to federal guidelines for developing national estimates. Therefore, the working group agrees that the national cost estimate for residuals disposal under the arsenic rule needs to be based on this assumption. However, the working group also acknowledges that under more stringent state hazardous waste requirements, such as those already existing in California, these residuals may be designated as hazardous wastes, which could lead to higher disposal costs. Such disposal costs are, however, a result of state-by-state decisions, rather than a direct requirement of this federal rulemaking.
- The working group was presented with information about the technique to determine whether a waste is hazardous (this is called the toxicity characteristics leaching procedure (TCLP) test). Based on the information presented, this test may underestimate the toxic characteristics of these residuals. Therefore, the working group recommends that the EPA reevaluate the effectiveness of TCLP test for hazardous characteristics determination.

Administrative Costs

- The working group recommends that EPA reevaluate the additional administrative costs to states that will be required to implement a stricter arsenic standard.

Summary Tables

- The working group recommends that the final report of the revised national cost estimate include tables (as shown in appendix B of this report) that indicate the total capital and annual operation and maintenance costs, as well as the number of systems affected for each of the eight system size categories. A separate table shall be used for each arsenic MCL being considered (e.g., 3, 5, 10, and 20 μg/L).

Point-of-use technologies

- The working group recommends that the economic analysis be reevaluated with the latest figures of capital and operating costs to clearly mark the line in terms of the size of community where cost alone would indicate the desirability of using the POU option for arsenic reduction. Consider expanding the use of POU option to larger size categories if the new cost evaluations show a significant advantage and if the access question and other issues identified in section 5.9 and appendix C are resolved.
- Because the working group is concerned about the ability of all communities to achieve 100 percent access, the group recommends that EPA specify steps to be taken by communities to achieve compliance. For example:
    1. Provide details of ordinances that state, regional, and local governmental bodies may wish to pass for use by the communities.
    2. Provide a description of recommended customer outreach programs and education efforts to reach maximum participation by the residents. These may include initial town hall meeting to define the program along with the costs of alternate approaches and frequency of entry into each household for monitoring and maintenance.
    3. Include in the rule a general statement allowing the use of this option by the community when all the required efforts have been taken but some residents still do not allow access to their homes.
- EPA's national cost estimate has estimated that 4 to 7 percent of communities requiring treatment to comply with the standard (10 μg/L) with a population of less than 500 people will use the POU option. If the new cost evaluations show a significant advantage to all small systems, the working group recommends that higher percentages (as shown below) be considered, if it can be shown that it is appropriate and practical.

25 to 100	5-20 percent
101 to 500	5-15 percent
501 to 3300	5-10 percent
3301 to 10000	0-5 percent

- The cost associated with pilot testing must be taken into account in estimating the overall cost of using the POU option in each community.
- Because of the certification by third parties and the conservative field evaluations, it is recommended that sampling and monitoring of the individual units be done by testing a certain percentage of units each year and visiting all households at least once a year. The working group agrees with EPA's approach of sampling 25% the households each year. It may, however, be necessary to visit all households once a year to examine the units, especially the working of the warning feature of the devices. Any cost associated with such visits should be included in the cost evaluations.

1.3.4 Recommendations for affordability considerations (Chapter 6)

The working group discussed affordability issues surrounding the EPA and AwwaRF cost estimates, based on current cost data, and recognizes the inseparable link between cost and affordability. Affordability considerations are an integral part of the EPA's national cost methodology in that how affordability is measured and the affordability threshold selected may directly impact the treatment technologies and treatment trains that could be included in EPA's national cost estimate. In addition, the arsenic rule illustrates that national compliance cost estimates cannot be used to assess local challenges that may be faced by small water systems and their customers. There may be small water systems and populations that will be unable to afford compliance with the arsenic rule and with future rules under the SDWA. Although the working group did not develop a solution, the group did discuss various tools and approaches that could be considered as potential solutions, both partial and permanent, for system affordability and rate payer affordability as listed in appendix A.

- The working group recommends that a sustainability fund that would be designed to assist small systems that have demonstrated no feasible alternatives to keep water users' fees within the limits of affordability be created.
- The working group recommends that the NDWAC convene a working group to review EPA's methodology and assumptions for determining national affordability for regulations.

2 Introduction

2.1 NDWAC Arsenic Cost Working Group charge

The charge of the National Drinking Water Advisory Council (NDWAC) Arsenic Cost Working Group was to review the costing methodologies, assumptions, and information underlying the system-size cost estimates as well as the aggregated national estimate of system costs of the Arsenic in Drinking Water Rule. As part of this review, the working group was to evaluate alternative costing approaches or critiques that may have a significant impact on the estimated system costs. In making this evaluation, the working group was charged to determine whether there is adequate supporting information upon which to evaluate the basis for the alternate approaches or critiques and note where there is not adequate supporting information. The final element of the working group's charge was to develop, based on its review and analysis, a written recommendation to the NDWAC.

While the Arsenic Cost Working Group has been tasked to review the underlying cost issues of the rule, other panels are addressing other elements of the arsenic rulemaking process. The National Academy of Sciences is tasked with reviewing the health-effects science of the rule, and a panel of EPA's Science Advisory Board is reviewing the benefits of the rule. All reviews are to be complete by September 2001.

2.2 Overview of the arsenic in drinking water rulemaking process

The Safe Drinking Water Act requires EPA to revise the existing fifty micrograms per liter (μg/L) standard for arsenic in drinking water. In June 2000 the Federal Register published EPA's proposed arsenic regulation for community water systems and non-transient, non-community water systems. EPA proposed a health-based, non-enforceable goal, or maximum contaminant level goal, of zero μg/L and a maximum contaminant level (MCL) of five μg/L. EPA also requested comments on alternate MCLs of three, ten and twenty μg/L. In January 2001 the Federal Register published EPA's final arsenic regulation setting the MCL at ten μg/L with an effective date of March 23, 2001 and a compliance date in 2006. In March 2001 EPA extended the effective date of the rule to allow for further review.

2.3 NDWAC Arsenic Cost Working Group membership

On May 4, 2001 the Federal Register published a notice announcing the formation of the NDWAC Arsenic Cost Working Group and soliciting nominations to the group. Criteria listed in the notice included that working group members are recognized experts in their fields; that working group members are as impartial and objective as possible; that working group members represent an array of backgrounds and perspectives (within their disciplines); and that the working group members are available to participate fully in the review. More than sixty candidates were nominated. EPA and the chair of the National Drinking Water Advisory Council selected the following individuals to serve as members of the NDWAC Arsenic Cost Working Group:

Frank Ardite, Engelhard Corporation
Steve Bigley, Coachella Valley Water District

Dennis Clifford, University of Houston
Jerry Gilbert, J. Gilbert, Inc.
Carol Kozloff, Pennsylvania Public Utility Commission, representing the National Association of Regulatory Utility Commissioners Committee on Water
Jim Leckie, Stanford University
Pankaj Parekh, Los Angeles Department of Water and Power
Robert Raucher, Stratus Consulting
"Regu" P. Regunathan, ReguNathan & Associates, Inc.
Cynthia Roper, Clean Water Action
Dennis Schwartz, Rural Water District #8
John Scheltens, City of Hot Springs, SD
Matt Simmons, Arsenic Solutions Inc.
Dave Spath, California Department of Health Services
Jeff Stuck, Arizona Department of Environmental Quality
William Suchodolski, American Water Services, Inc.
Amy Zander, Clarkson University

2.4 NDWAC Arsenic Cost Working Group deliberation process

The working group met in plenary five times in 2001: May 29-30, June 28-29, July 9-10, July 19-20, and August 2-3. The working group was supported by a team of technical consultants and EPA staff. The technical consultants included Zaid Chowdhury, Malcolm Pirnie, Inc.; Michelle Frey, McGuire Environmental Consulting; Michael MacPhee, Environmental Engineering & Technology, Inc.; and Scott Summers, University of Colorado. At the first meeting the group heard overviews of the EPA rulemaking process and the process followed by EPA to develop the national cost estimates for the Arsenic in Drinking Water Rule. The group also heard overviews of the purpose and components of the EPA national cost estimates for arsenic and the estimates developed by the AwwaRF research team in the study *Cost Implications of a Lower Arsenic MCL*.

Based on the overviews the working group identified issues for more detailed review, requested further analysis from the consultant team, and formed several subgroups on specific issues. At the remaining meetings, by conference call, and in subgroups the working group reviewed the components of the national cost estimates in detail and examined related issues.

Based on analysis of the information presented, the group discussed and reached consensus on the summary of observations and recommendations provided in this report. The purpose of these recommendations is to make improvements in the development of future national cost estimates, specifically for the arsenic rule and generally for other rules that are considered by EPA.

3 Use, value, and limits of national cost estimates

3.1 Inherent limitations and value of the product

3.1.1 Limitations

The development of a methodology to estimate the national cost of any new or revised water quality standard is circumscribed by limitations inherent in the nature of the undertaking. First, and foremost, the task is an attempt to forecast the future response of thousands of different and independent local/regional water suppliers, all with uniquely different circumstances. Therefore, it is important to recognize at the outset that a national cost estimate provides a national-level picture; it cannot and will not capture the actual decisions that will be made by utilities at the individual level once the rule is promulgated. History shows that unforeseen and unanticipated challenges and opportunities arise which lead to unexpected increases and/or decreases in cost.

3.1.2 Value

Although necessary to meet statutory requests, the major value of estimating national costs for the arsenic rule is the estimation process itself. The process of developing the cost methodology and the analysis of the resultant product yields insights and understanding of potential impacts and issues of implementation that would otherwise go unexplored.

Because the inherent uncertainty in the final national cost estimate leads to a wide range of projected outcomes, no single numerical value can be informative. It is truly, at best, an order-of-magnitude calibration exercise. However, when multiple MCLs are being evaluated, the estimated relative marginal costs between different MCLs provide a useful calibration on the impacts of increasingly lower MCLs. These marginal cost differences must be tempered, however, with the knowledge that uncertainty likely increases non-linearly as MCLs decrease.

3.2 Effect of uncertainty on cost estimations

3.2.1 Uncertainty and reliability

A summary of the working group's mission includes: a review of the costing processes for the implementation of the arsenic rule, alternative costing approaches that could have a significant impact on costs and the adequacy and limitations of supporting information. To complete this task the group divided its work into three areas of study. The first was a review of relative confidence and reliability of the cost projections as they relate to decision-making. The two cost estimates reviewed are based on a series of assumptions regarding such criteria as: a predicted number of entry point sources of contaminated water, treatment process assumptions for each source, plant configurations, and implementation methodology. The notice requirements for arsenic with respect to the consumer confidence report (CCR) create additional uncertainties. When the calculations are serial, with each assumption depending upon the previous calculations, the confidence in the final product depends upon the degree of certainty of each of the components in the series. The uncertainties associated with the final product are greater than the uncertainties of each individual assumption. Ideally, this review should contribute to increasing the reliability or confidence that can be placed on the cost estimates when they are used for subsequent calculations that compare benefits and costs or are used in connection with the establishment of public policy including MCLs and future financial assistance that might be approved by Congress.

The group then reviewed the AwwaRF and EPA estimates considering uncertainties, and non-quantifiable factors that could increase or decrease cost. As required by law and regulation, the national aggregated cost estimates prepared by EPA are based on the cost of treating water produced from individual sources, primarily wells. The cost estimates are fundamentally theoretical models based on a series of independent assumptions with some supporting verification studies. They are not an aggregation of state, regional or local estimates based on actual field conditions. The models produce costs based on several individual criteria that can vary as much as ±50 percent. The resulting national cost is at a lower confidence level than a traditional professional engineer's reconnaissance level estimate.

The process of quantifying the cost of any element in the overall national cost methodologies necessarily propagates the inherent uncertainties in the data and parameters used in the estimation process. When the parameters are independent and uncorrelated, as is the case at hand, then the uncertainty of the outcome of the estimation methodology will always be larger than the largest single uncertainty in the input data set. Table 3.1 summarizes examples of the estimated uncertainties in several data sets and input parameters used in the cost estimating methodologies. At best the national cost estimate is an order of magnitude estimate (–30 to +50 percent) as defined by the American Association of Cost Engineers.[1]

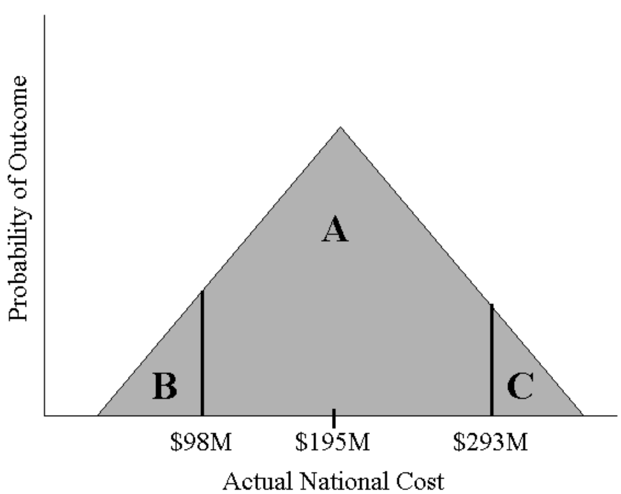
Although the range of potential outcomes (actual national costs) can be quite wide, each potential outcome does not have the same probability of occurring. The working group would expect that outcomes closer to the "best estimate" would have the highest probability of occurring. For example, as illustrated in figure 3.1, the probability of the actual national cost being within the range of $98 million (best estimate minus 50%) to $293 million (best estimate plus 50%) is defined as area A (in figure 3.1). Although it is possible that the actual national cost is greater than $293 million, the probability of this occurring is much smaller (area C in the figure below). Likewise, although it is possible that the actual national cost is less than $98 million, the probability of this occurring is also smaller (area B in figure 3.1).

[1] Barrie, D. S. and B. C. Paulson, Jr. *Professional Construction Management, 2nd Ed*. McGraw Hill. 1984.

Table 3.1 – Examples of approximate uncertainties in input data and parameters identified in the current review

Source of Uncertainty	Range of Uncertainty (±%)
Baseline Data	
❑ Number of systems per population category	5-10
❑ Average number of EPDS per utility	10 – 50
❑ Volume of water treated	10 - 20
Process Parameter Assumptions	
❑ Energy Unit Cost	5 - 25
❑ Labor Unit Cost	10 - 25
❑ Bed Volumes	20 - 50
Equipment Unit Costs	
❑ Piping	5-10
❑ Vessel Costs	20 – 50
❑ Media Costs	20 - 30
Capital Cost Multiplier	
❑ Small systems	10 - 25
❑ Large systems	25 - 50
The ranges of uncertainties represent those values indicative of various sources of information provided to the working group for its review. To illustrate the derivation of these estimates: ***Baseline Data:*** The number of EPDSs varied among system size categories of 10% – 50% depending on the originating source of information on EPDSs in drinking water systems. ***Process Parameter Assumptions:*** Bed volumes assigned to any given treatment configuration must represent the central tendency for systems that might install that technology. This means then that a range of variability in actual bed volume productivity of up to a factor of 2 may reasonably be expected given the variation in natural water matrices. ***Equipment Unit Costs:*** Variability in vendor quotes for treatment vessels was found to exhibit a 20% to 50% variation. ***Capital Cost Multiplier:*** For large systems, multiple estimates of construction cost multipliers were identified, exhibiting a range of values that varied between 25% and 50%.	

Figure 3.1 - Illustration of possible actual national costs



Note: This diagram is for illustrative purposes only. The actual shape of the distribution of potential actual national costs is not known.

The working group's third area of study involved the cost implications of the actions that are likely to be taken by a water system to meet an MCL for arsenic that are not considered by these models. When a utility is faced with compliance within a five-year period, it usually will seek the least costly solution. The solution options may involve treatment variants including new technologies, system reoperation, or a variety of other solutions including development of unregulated private wells. It is not possible to prepare a national cost estimate that considers all these alternatives or utility attitudes regarding implementation feasibility – such as aversion to the use of treatment chemicals or production of large volumes of liquid waste streams.

It is worth noting that the difference between the EPA national cost estimate and the AwwaRF study is not statistically significant; both estimates fall within the range of uncertainty (table 3.2). This table also shows the magnitude of the unexplained differences developed in chapter 4.

The co-occurrence of other constituents in source waters creates two types of problems that may have cost impacts. The first is the impact of other elements such as iron and its removal (present or potential) on the process for removing arsenic. This can be addressed in planning for control of each individual system and has been predicted in national cost estimating models. The other and more difficult problem to assess is the present or potential water quality factors that will affect future system performance during the period that the arsenic rule is being implemented. EPA is now considering a groundwater treatment rule, modifications to the surface water treatment rule, and control of radon. If compliance with these and other potential regulatory requirements is considered, future cost reductions could result depending upon local conditions.

Table 3.2 – Comparison of estimated annual national cost values related to the January 2001 rule to illustrate uncertainty in the estimates

Estimate	Estimated Value ($M/year)	Envelope of Estimates ($M/year)	
		-50%	+50 %
EPA National Cost Estimate (195 $M/Year published in January 2001)	195	98	293
AwwaRF Study Estimate (400 $M/year published in October 2000, adjusted to 7%)	400	200	600
Group est. of initial differences*	205		
Group est. of unexplained differences*	35		

* Differences were estimated during the group's analysis based on the published numbers. See chapter 4 for a discussion of the estimated differences.

3.2.2 Future and unquantifiable factors

The national cost estimate (EPA) and the AwwaRF-sponsored estimate do not include consideration of factors that will have a major affect on actual compliance costs. The most significant of these is that utilities, large and small will resort to the most economical and practical compliance strategy, which in many instances will not involve individual wellhead treatment limited to removal of arsenic. For those systems that do treat at individual or manifolded wells, a new lower cost and more practical technology may be available within the compliance schedule. These and other factors and their relative significance are shown in tables 3.3 and 3.4. Their collective impact would result in an actual cost of compliance that could be lower than any estimate based on a theoretical number of wellhead units using current BAT treatment as the only compliance method.

In contrast, past experience in the implementation of treatment for small and medium sized systems has shown that the knowledge-base of local engineers and utility staff strongly affects the decisions about technology selection. Typically, these decisions are based on either (1) limited information regarding treatment technologies and the "comfort-zone" of local engineers and operators in terms of technology familiarity and design capabilities, or, more often, (2) the recommendations from local equipment representatives regarding available technologies and package systems. The reality is that the latter can be a more significant driver for technology selection within a given geographic region than minimization of technology cost.

Table 3.3 - Factors that could increase the actual cost of arsenic rule implementation

Factor	Comments
Energy costs	Energy costs could rise at a significant rate.
Hazardous waste disposal	Residuals from some arsenic removal processes could generate additional costs.
Land	Water systems may need to purchase additional land and/or relocate wells and add distribution facilities to install arsenic removal facilities at sites with insufficient land.
Administrative	Training, public communications activities, legal and regulatory response costs
Technical	Potential requirement in special circumstances for site and treatability studies
Monitoring	Required for routine support of treatment operations and/or distribution systems
CCR notice effect for treatment or local implementation	Public reaction to CCR notification triggered by arsenic occurrence above 50% of the MCL may cause a percentage of water systems, particularly medium to large systems, to implement treatment when arsenic is detected at levels above this trigger level.
CCR notice effect for further treatment and removal	Public reaction to CCR notification triggered by arsenic occurrence above 50% of the MCL may cause a percentage of water systems, particularly medium to large systems, to design treatment facilities to achieve arsenic removal to levels below this trigger level to avoid public notification.

Table 3.4 - Factors that could decrease the actual cost of arsenic rule implementation

Factor	Comments
Alternative technologies	GFH or other currently marketed adsorbents could reduce the volumes of chemicals and residual solids that are handled, and have lower operating costs.
Automated operations	Computer control systems are currently available to improve reliability and reduce labor costs. They also create an opportunity for centralized oversight and resulting economies of scale.
Competition/market development	Treatment units required for the arsenic MCL of 10 µg/L could create a competitive market among service providers and materials suppliers that will reduce implementation costs, such as the experience with GAC use in the remediation technologies.
Design flow	Peaking factors used in models exceed national standards by a factor of 2, split stream treatment could reduce treated flow, and no credit has been given for the national trend (particularly in the Southwest) for per capita use reduction as a result of conservation and recycling.
Design economies	Unit processes used in cost estimates have not been optimized (for instance, a probably unnecessary raw water booster has been added to wellhead treatment), and detailed design, particularly with competitive proposals will result in more efficient layouts often for sites requiring more than one standard module.
Alternate sources	New wells, interconnections, and well abandonment will be compliance strategies in a significant number of cases
Reoperation	Reallocation of the existing storage capacity, construction of new storage, control of system peaking, seasonal operation of some wells, and use of high concentration wells for emergencies only may provide reduction in arsenic concentrations
Regionalization	Interconnections may be available to many small systems, noting, however, that political or physical constraints may exist in some cases. Other forms of regionalization such as public or private cooperative management approaches may have benefits. This possibility could reduce costs and potentially address other quality concerns.
SRF and other financial assistance	Expansion and implementation of existing federal programs could allow states to provide enough assistance to small high unit cost systems, that when combined with local repayment capacity would make rule implementation affordable. (See separate discussion of affordability.)

3.3 Recommendations

The value of existing national cost estimates is now limited by the large uncertainty associated with the estimated outcomes. Reducing this uncertainty where possible will provide a higher value and confidence in the forecasting process.

3.3.1 Recognizing the uncertainties

It is generally acknowledged that the current baseline data sets and input parameters have individual inherent uncertainties that will create a wide band of uncertainty for any forecast of national cost. To help clarify the issue, EPA should clearly explain the limitations of each estimate and quantify the uncertainty associated with the Arsenic Rule estimates and all such national cost estimates.

3.3.2 Cost estimates conducted for future rules

An approach based on aggregated county, regional, or state costs, coupled with extensive individual case analysis would yield significantly better results than current procedures. However, the working group recognizes the practical limitations and the need for authority, resources, and cooperation from other entities in implementing this approach. Water systems are complicated: significant non-treatment options are available in many cases and standard definitions of best available technology (BAT) will not apply in all cases. No cost estimating system can be precise, as discussed above, but the group believes that new effort should be made to establish a better system and that the extra cost of administering such a system will pay dividends and should be considered for inclusion in appropriate budgets.

To achieve this in the future EPA should evaluate the feasibility of developing a more representative methodology to assess compliance cost. This evaluation should consider the most recent Community Water System Survey information, describe specific data acquisition needs, provide a set of common criteria to be used in data gathering, and a schedule for obtaining data. The resources expended in implementing this new approach to a national cost estimate should be commensurate with the relative economic impact anticipated from a proposed drinking water rule.

4 Development of national costing approaches

4.1 Background of costing approaches reviewed

Aware of the limitations and confidence in cost estimating described above, the working group reviewed two estimates of national-level compliance costs, neither of which included non-treatment compliance options.

The EPA national cost estimate (NCE) was developed in support of the arsenic regulation as it was promulgated in January 2001. The EPA document *Technologies and Costs for Removal of Arsenic from Drinking Water* (2000) summarizes the available technologies and the anticipated unit costs for the technologies. The EPA document *Arsenic in Drinking Water Rule Economic Analysis* (2000) summarizes the approach used to determine the national costs.

In August 1999, the American Water Works Association Research Foundation (AwwaRF) sponsored a study to investigate the cost implications of controlling arsenic in drinking water. The study addresses two important factors that could affect utility costs for arsenic control: (1) the installation of treatment facilities at multiple locations for groundwater systems that operated highly distributed systems (i.e., potable water enters the distribution system at a number of locations from various well supplies), and (2) the design of groundwater treatment facilities with appropriate handling and disposal of wastes.

4.2 Summary of EPA and AwwARF estimates

The working group examined the differences in cost estimates at the various options of MCLs but reviewed the differences at an MCL of 10 micrograms per liter (µg/L) with more scrutiny. The working group focused on 10 µg/L because that was the MCL of the rule promulgated in January 2001. The group's focus on an MCL of 10 µg/L in its review does not imply that the group recommends an MCL of 10 µg/L. The working group's recommendations on cost-estimating methodology apply to any MCL.

The EPA national cost estimate of 195 $M/year was the agency's best estimate for compliance with a 10 µg/L MCL. EPA also examined the sensitivity of the national cost estimate to changes in factors involving professional judgment and factors with uncertainty with respect to the status quo of the water supply industry. The factors considered in the sensitivity analysis relate only to unit technology costs and the compliance forecast. The factors considered in the analysis raised the cost estimate to 210 $M/year.

All of the estimates presented in the AwwaRF study were adjusted to a 7% discount rate in this report in order to be consistent with the EPA estimate, and therefore are higher than those published in the report *Cost Implications of a Lower Arsenic MCL* (Frey et al., October 2000). The national cost estimated in the AwwaRF study for an MCL of 10 µg/L was 400 M$/year (345 M$/year in the published report). However, use of an entry-point-level analysis and revised unit cost data based on case studies of six large systems resulted in a new estimate of 675$M/year (585 M$/year in the published report). After examining the two AwwaRF study estimates, the working group chose to focus on the estimate of 400 $M/year in its review. The predominant differences between the two AwwaRF estimates resulted from the use of revised unit cost estimates for the selected technologies. The 400 M$/year estimate was used to further understand differences between the EPA national cost estimate and the AwwaRF study estimates.

The differences between the national cost estimate (NCE) and the AwwaRF study estimate (ASE) were explored by the working group to identify the important “drivers” or factors that explain the differences in the two estimates. The review focused on the costing approaches used in both estimates.

4.3 Major drivers in estimates of national cost

The working group explored various factors that could affect an estimate of national cost considering the assumptions and information available supporting the two analyses. The factors included arsenic occurrence estimates, number of affected systems, flow conditions, decision trees and compliance forecast, unit technology costs, residual handling and disposal assumptions, and cost estimation methodologies. The sections below summarize the conclusions reached by the working group regarding the importance of each factor.

4.3.1 Arsenic occurrence estimates

Arsenic occurrence is the amount of arsenic in drinking water supplies. While different methods were used to estimate occurrence, reasonable agreement was found between the EPA and AwwaRF assumptions.

4.3.2 Number of affected systems and the flow conditions assumed for treatment facilities

The number of systems affected by an arsenic MCL is estimated based on occurrence estimates and a national inventory of systems. The EPA inventory data included community water systems, both purchased water systems (7,296 systems) and producing water systems (47,295 systems), as well as non-transient non-community water systems. The AwwaRF study inventory data included only producing water systems (51,127 systems). As a result of this difference, EPA’s analysis estimated a higher number of affected systems than the AwwaRF study.

The EPA estimate of flow conditions (i.e., the amount of water distributed by a system) was related to the population served by a system. The AwwaRF study used the mid-point population of 12 different system-size categories to calculate the flow conditions for all affected systems within a given size category.

The working group found that using the mid-point population of 12 different system sizes led to an over-estimate of the mean flow condition within each system size category in the AwwaRF study. However, because number of affected systems and flow conditions are inter-related, the over-estimate of mean flow was offset by the lower estimate of number of affected systems in the AwwaRF study. Thus, the working group finds that although affected systems and flow conditions are critical to any national cost estimate methodology, they do not explain much of the difference in the two cost estimates.

Entry Points to the Distribution System

Another difference in the estimates was the use of entry points to the distribution system. The AwwaRF study estimate of 400 $M/year is based on system-level treatment of flows. EPA's national cost estimates are based upon treatment at the entry-point level rather than the system level.

EPA used data from the Community Water System Survey (USEPA,1997) to estimate the number of entry points per system. Responses to two questions were summed to approximate the number of entry points for each system that responded to the survey: question 18, which asks for the number of treatment facilities in the system, and question 20, which asks for the number of untreated wells or surface water intakes in the system.

To the extent the CWSS data are reliable and representative for this variable, this method tends to over-estimate the number of entry points per system, especially in ground water systems, because it presumes that each untreated well is an unique entry point to the distribution system. In other words, it assumes that no untreated wells are manifolded.

According to the CWSS 1996 responses, the maximum number of entry points in any system size category was 37. Therefore, for each system size category, EPA calculated the probability that a system would have 1, 2, 3, 4,...., or 37 entry points. These probability distributions were then entered into the SafeWaterXL simulation model. As the simulation ran, each system was assigned a number of entry points based on these probability distributions.

To determine whether an entry point required treatment in the national cost model, a system was assigned a mean arsenic concentration based on occurrence. Arsenic concentrations for each entry point were estimated using the distribution of entry points for the size category and the system mean concentration. The weighted average of all entry points equaled the system mean arsenic concentration. Costs were estimated for those entry points that exceeded the MCL.

Mixed Systems

Classification of mixed systems (i.e., those systems that distribute water from both ground-water and surface-water sources) also differed between the NCE and ASE. In the AwwaRF study all mixed systems are classified as surface-water systems, the default classification for mixed systems in SDWIS. EPA evaluated the fraction of supply provided by ground water for the mixed systems surveyed in the Community Water System Survey (CWSS). EPA then extrapolated the CWSS data to estimate the number of mixed systems in the national cost estimate receiving more than fifty percent of their water from ground-water sources. These systems were reclassified as ground-water systems, while the remaining mixed systems were left as surface-water systems. The difference in mixed-system classification, however, does not explain the differences between the NCE and the ASE. If the EPA classification method had been used for the AwwaRF estimates, the AwwaRF estimates would have been higher, thus increasing rather than decreasing the difference between the estimates.

4.3.3 Decision tree and compliance forecasts

A compliance forecast (derived from a decision tree) is a prediction of the treatment options that will be used by affected water utilities. It is hard to predict these control technologies, but utilities should favor optimal technologies if they are feasible given their source water quality and existing treatment facilities. The rationale applied by EPA and the AwwaRF study researchers was similar.

The array of possible technologies included in the two forecasts differed somewhat. EPA included more technologies than the AwwaRF researchers (table 4.1). The selection of available technologies was dependent on best available technologies (BAT), source water type, and system size conditions given expected differences in water quality, existing treatment practices, and cost of the various technologies.

Differences in technology selection and related unit costs contributed significantly to the differences between the NCE and the ASE. The major difference was in the application of regenerated activated alumina (regenerated AA) for medium and larger systems in the AwwaRF study versus the application of disposable activated alumina (disposable AA) for these same systems in the EPA estimate. The unit cost of regenerated AA is significantly higher than disposable AA due to additional associated costs such as the treatment needed to regenerate the AA media and the handling of the resultant liquid waste stream. (The effect of this difference on the estimates of national costs is summarized in section 4.3.4.)

The working group recognizes that EPA, in consideration of the limitations that systems will face in using publicly owned treatment works (POTWs) for disposal of residuals, significantly reduced (from the proposal to the January rule) the estimate of the number of systems that would select anion exchange.

Table 4.1 – Summary of technologies included in the EPA and AwwaRF study compliance forecasts for the arsenic MCL option of 10 μg/L.

Technology Name	Description of the Technology	Groundwater Systems		Surface Water Systems	
		EPA	AwwaRF	EPA	AwwaRF
Modify Lime Softening	Improve existing lime softening facilities to enhance arsenic removal.	YES	YES	YES	YES
Modify Coagulation/ Filtration	Improve existing coagulation and filtration facilities to enhance arsenic removal.	YES	YES	YES	YES
Anion Exchange	Resin-based technology that replaces arsenic with chloride in the treated water.	YES	NO	NO	YES
Greensand Filtration	For systems with iron or manganese in their source water, sorption of arsenic onto the greensand filter media can occur.	YES	NO	NO	NO
Coagulation Assisted Microfiltration	Low pressure membrane filtration is used to remove arsenic solids formed with coagulants.	YES	YES	YES	YES
Disposable Activated Alumina	Granular media that sorbs arsenic to its surface and is disposed (thrown away) when exhausted.	YES	YES	YES	NO
Regenerated Activated Alumina	Granular media that sorbs arsenic to its surface and is regenerated when exhausted.	NO	YES	NO	YES
Point of Use Devices (activated alumina or reverse osmosis)	Under-the-sink type treatment units that would remove arsenic from the drinking water used in consumers' kitchens.	YES	NO	NO	NO
Nanofiltration	Medium pressure membrane filtration that removes arsenic through molecular sieving.	NO	NO	NO	YES

4.3.4 Unit technology cost

To estimate the cost of technologies, models are developed based on the conceptual design and flow schematic of each treatment process. These unit cost estimates and models serve as the basis for estimating national costs. They do not reflect what an individual system may experience. The numbers of systems affected, the flow rate that would have to be treated, and the technology selection (compliance forecast) are combined with the unit cost models for relevant technologies to estimate the national cost of treatment for arsenic control.

Differences in the unit cost models used in the NCE and the ASE were evaluated to determine their significance in explaining the differences in total cost. As noted above, the greatest differences were found in disposable AA. The AwwaRF study used only the unit cost model for disposable AA provided in a draft version of the *Technologies and Costs* document (USEPA, April 1999) rather than the final EPA unit cost models for this technology (USEPA, December 2000). Table 4.2 summarizes the differences in national cost at an MCL of 10 μg/L due to differences in unit cost models and use of disposable

AA. The numbers presented show the effect of adjusting the AwwaRF estimate by using EPA inputs because the AwwaRF model was easier to modify than the EPA model. If time had permitted and the EPA model had been adjusted by using AwwaRF study inputs, the same cost drivers would have been identified.

Unit cost models – and the extent of use of each technology – are key factors in generating reasonable estimates of national costs.

Table 4.2 – Summary of the difference in cost* at an MCL of 10 μg/L based on changes to AwwaRF study assumptions

- Adjusting the AwwaRF study estimate (ASE) to include flow conditions similar to those used by EPA and EPA's number of affected systems lowers the estimate from 400 $M/year to 390 $M/year.
- Further adjusting the ASE by using the EPA final unit cost model for disposable AA lowers the estimate to 315 $M/year, a decrease of about 21% from the original 400 $M/year.
- Further adjusting the ASE by replacing regenerated AA with disposable AA in the compliance forecast lowers the estimate to 270 $M/year, a decrease of about 33% from the original 400 $M/year.
- Further adjusting the ASE by using the EPA unit cost models for all technologies lowers the estimate to 230 $M/year, a decrease of about 43% from the original 400 $M/year.

* All cost estimates include amortized capital cost at a 7% discount rate for a 20-year life cycle in addition to the annual operation and maintenance costs.

Capital Cost Multipliers

Indirect capital cost factors, or capital cost multipliers, are used to estimate the total capital costs associated with treatment implementation. The capital cost multiplier is applied to the process capital costs to estimate the total capital cost. The approach used by EPA for the arsenic rule was based on recommendations from the EPA Technology Design Workshop (TDP) held in November 1997.

To determine the multipliers, capital costs were sorted into three categories: process, construction, and engineering. The cost models were used to estimate process costs; then, construction and engineering costs were estimated by using the multipliers. For the small systems, it was assumed that process, construction and engineering costs were 40%, 40% and 20% of total costs, respectively. Thus, once the process cost is derived from the cost models, the total capital cost can be estimated by multiplying by 2.5. For large systems, it was assumed that process, construction and engineering were 30%, 40% and 30% of total costs, respectively. Thus, for large systems a multiplier of 3.33 was applied to process costs to estimate total capital costs.

The multipliers of 2.5 for small systems and 3.33 for large systems were used in both the EPA national cost estimate and the AwwaRF study baseline estimates.

4.3.5 Residual handling and disposal assumptions

Each of the treatment technologies identified for arsenic control produce a waste stream that must be handled and ultimately disposed. The waste stream can include both solid and liquid wastes that have separate handling and disposal requirements. The residual handling and disposal features assumed in the NCE and the ASE are summarized in table 4.3. Several key assumptions are similar in both estimates:

- All waste streams are considered non-hazardous for disposal purposes due to Federal regulations.
- Dewatering of coagulant solids formed by coagulation assisted microfiltration (CMF) is necessary.
- Existing systems that are modified to control arsenic will experience an increase in waste stream production, but will use their existing facilities to handle and dispose of the wastes.

EPA's analysis assumed that discharge of anion-exchange liquid-waste streams to sanitary sewers was feasible, while the AwwaRF study assumed that treatment of such streams and alternative disposal techniques (such as evaporation ponds) would be required. This difference, however, affected only a few systems in both estimates.

4.3.6 Cost estimation methodologies

Two approaches to the calculation of national compliance costs were used:

- EPA national costs were estimated using a simulation-based model called SafeWaterXL. The model included all community water systems individually within the modeling framework and used randomized inputs from defined distributions to determine whether systems were affected, the flow conditions of affected systems, and the technology selected by the systems. For each affected system, the model determined the number of entry points requiring treatment by first distributing the system's average arsenic concentration among the entry points based on the intra-system standard deviation and then comparing each entry point's concentration to the MCL. After all inputs were assigned, the national costs were estimated by aggregating the total system costs for all systems included in the model.
- AwwaRF study estimates were determined using an independent calculation for each class of systems: 12 size categories for groundwater and surface water systems with 4 initial arsenic concentration ranges, yielding a total of 96 classes of systems. Estimates of the number of systems affected, flow conditions per affected system, and proportion of affected systems selecting each given technology were used to generate a cost per system class. The national cost was then calculated as the aggregate of costs across all system classes.

Based on several comparative analyses, the working group determined that the differences resulting from using these approaches were quite small. While methodologies are important, they do not create the difference in the final results.

Table 4.3 - Comparison of residual handling and disposal assumptions for the EPA and AwwaRF study estimates of national costs

Technology Name	EPA Residual Handling & Disposal Assumptions	AwwaRF Study Residual Handling and Disposal Assumptions
Modify Lime Softening	Practices of existing system is continued with only increase in solids production	Practices of existing system is continued with only increase in solids production
Modify Coagulation/Filtration	Practices of existing system is continued with only increase in solids production	Practices of existing system is continued with only increase in solids production
Anion Exchange	Discharge of regenerant brine to sanitary sewer	Chemical precipitation of arsenic-containing solids, solids dewatering and non-hazardous landfill disposal with evaporation ponds for liquid brine waste stream.
Greensand Filtration	Discharge of backwash water to sanitary sewer	Not Included
Coagulation Assisted Microfiltration	Mechanical and non-mechanical dewatering of coagulant solids with non-hazardous landfilling of solids	Mechanical dewatering of coagulant solids with non-hazardous waste landfilling of solids. Liquid decant recycled to the head of the plant.
Disposable Activated Alumina	Non-hazardous waste landfill of spent media	Non-hazardous waste landfill of spent media
Regenerated Activated Alumina	Not Included	Acid addition for precipitation of aluminum-arsenic solids, dewatered and disposed by non-hazardous waste landfill. Treated brine handled by evaporation ponds.
Point-of-Use Devices (activated alumina or reverse osmosis)	Spent cartridge cost assumed within replacement cartridge cost. Reject water from RO sent to sanitary sewer.	Not Included
Nanofiltration	Not Included.	Reject water sent to sanitary sewer.

4.4 Conclusions

The difference in the EPA national cost estimate and the AwwaRF study estimates was explained predominantly by differences in the input assumptions regarding the selection of arsenic control technologies (i.e., compliance forecasts) and unit cost models developed for selected technologies. While differences were found in the estimates of the numbers of affected systems and the flow conditions assigned to systems of various sizes, the differences in these two factors offset each other so that their net effect explained little of the difference between the cost estimates. All of these factors explained differences in the cost estimates as summarized in table 4.4.

The unexplained differences (table 4.4) are attributable to the noted differences in residual handling and disposal assumptions, non-quantitated effects from the compliance forecast assumptions, and the approaches used for national cost methodology.

The working group's review focused on a methodology that could be applied to any of the MCLs being considered for arsenic.

Table 4.4 – Amount of differences in EPA and AwwaRF study cost estimates explained by major factors examined by the working group[1]

Arsenic MCL µg/L	Initial Difference Found [2] M$/year	Amount of Difference Explained [3] M$/year (%)	Amount of Difference Unexplained [3] M$/year (%)
3	815	545 (67%)	270 (33%)
5	375	300 (80%)	75 (20%)
10	205	170 (83%)	35 (17%)
20	45	50 (111%)	-5 (0%)

1. All annualized costs presented were determined using a 7% discount rate for a 20-year lifecycle cost.
2. Initial difference represents the difference in the AwwaRF study baseline national cost estimate and the EPA national cost estimate for the final arsenic regulation.
3. The amount of difference explained refers to the change in the AwwaRF cost estimate if EPA inputs were used for the numbers of systems affected, system flow conditions, compliance forecast predictions, and unit technology costs. The amount of difference unexplained is the remaining difference. The percentages shown are the percentage of the cost difference either explained or remaining unexplained by the analyses performed.

5 Recommendations for the arsenic national cost estimate

The working group believes that EPA produced a credible estimate of the cost of arsenic compliance given the constraints of 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. The working group made a number of specific recommendations to improve the national cost estimate, which are described in this chapter. The working group acknowledges the usefulness of the AwwaRF study to evaluate the national cost estimate and recommends that any use of the AwwaRF estimation for system-level or national cost should also reflect the modified assumptions and recommendations stated in this report.

5.1 Arsenic occurrence estimation

A. The Arsenic Cost Working Group recommends EPA continue to use the most representative databases available for community and non-community water systems when determining national arsenic occurrence.

5.2 Determination of number of affected systems, flow, and entry points to the distribution system

In forecasting the size and number of systems that will have to implement arsenic treatment and the number of entry points to the distribution system (EPDS) at which treatment will be required, the working group recommends the general approach described below.

A. For each population size category, a distribution of flows should continue to be applied rather than a unique flow (e.g., the mean or median flow) to represent the category.

B. Due to significant uncertainty associated with EPDS determination, EPA should reexamine the sources of information used to determine the number of EPDS per system size category and use up-to-date and representative information (e.g., Community Water System Survey, AWWA Large Groundwater-using Utilities Survey (Stratus Consulting, January 2000), Water Industry Data Base (WIDB), WATER:/STATS, and Intra-Site Six State database) in its calculation.

C. Mixed systems (i.e., those treating both surface water and ground water) should continue to be classified as groundwater systems if more than 50 percent of the water they distribute is ground water.

D. For entry points with arsenic concentrations above the current regulatory level of 50 µg/L, only the incremental costs of treating from 50 µg/L to the level of the new standard should continue to be considered in the cost.

E. The approach and results used to estimate what percent of a water system's EPDS will exceed a given MCL should be carefully explained. Specific attention should be focussed on the following questions: (1) should the estimated intrasystem variability in arsenic concentrations be constant or variable across the alternative MCL options under consideration? (2) how should the results be applied to systems with system-wide mean arsenic concentrations above a given MCL option versus systems with mean concentrations below a given MCL option? and (3) are the EPDS occurrence results applied consistently in the cost analysis and other components of the economic analysis?

5.3 Recommendations for unit technology and costs

This subsection contains the recommendations of the working group with respect to the unit costs of technologies. Recommendations that apply to a specific technology are listed under that technology, beginning with activated alumina (AA) at recommendation H. Only the technologies for which the working group felt changes should be made are included. Recommendations for considering additional technologies are included in section 5.6. The working group believes that the technologies utilized by EPA are, in general, the appropriate technologies for arsenic removal; however, the working group recommends some important changes in the costing approach used by EPA for these technologies.

A. The technologies available now are changing rapidly, and EPA should include new technologies in the revised national cost estimate if they are feasible as defined in the SDWA – 1412(b)(4)(D) and 1412(b)(4)(E).

B. The working group also recommends that land costs be included for all technologies even though land may not be a major cost driver and poses certain difficulties of estimation. This may be done as a percentage figure of 2 to 5% of total unit capital cost.

C. The working group reviewed the cost of the key components for several technologies (e.g., AA). Based on its review, the working group recommends that EPA reevaluate, update, and validate the design and cost of the components in order to develop the cost curve for different technologies. In addition, the working group recommends that example line item tables (example formats shown in tables 5.1 and 5.2) for representative flow categories be included for each technology in the revised *Technologies and Costs* document (preferably for two community sizes).

D. The group also discussed the capital cost multipliers that were used in the previous national costing approach to convert the process costs to capital costs. The working group recommends a multiplier of 2.5 for systems serving populations of 10,000 or smaller and 1.8 for systems serving populations larger than 10,000. In the future, EPA should carefully reevaluate the assumptions involved in developing capital cost multipliers.

E. The working group recommends that EPA reexamine the labor cost estimates to include process monitoring and routine maintenance of the treatment system. These costs should include administration, analytical, sampling and sample delivery costs associated with this monitoring.

Table 5.1 – Capital Cost Breakdown for AA System
(Design Flow = 0.27 mgd, Average flow = 0.08 mgd)

Item	Quantity	Unit Cost	Item Cost ($)
Pressure vessel: 7 ft diameter, 6 ft tall Carbon Steel (100 – 150 psi).			
Media			
Housing (including HVAC)			
Pipes and Valves			
Instrumentation and Control			
Pre-oxidation			
Land			
Sub Total Process Cost			
Capital Cost Multiplier			
Total Capital Cost			

Note: This chart will be filled in by EPA as a part of the revision of the T&C document. The recommended methodology will be used to fill in these cells and the methodology used for filling each cell will be explained.

Table 5.2 – O & M Cost Breakdown for AA System
(Design Flow = 0.27 mgd, Average flow = 0.08 mgd)

Item	Quantity	Unit Cost	Item Cost ($/Yr)
Media Replacements			
Labor Cost			
Media Disposal Cost			
Electricity			
Process Performance samples			
Preoxidation Chemical			
Total O&M Cost			

Note: This chart will be filled in by EPA as a part of the revision of the T&C document. The recommended methodology will be used to fill in these cells and the methodology used for filling each cell will be explained.

F. The group recommends that pumping be adequate to overcome the head loss through the adsorbent media and be a single stage pump when the treatment system is extracting groundwater.

G. EPA should revise the capital costs to include pilot testing of all technologies.

H. Small systems that will be affected by the arsenic rule will now be required to operate sophisticated treatment technologies. These systems may require a higher level of trained and certified operator. To accomplish this, states may be required to expand training and certification requirements to meet these needs. The working group recommends that EPA reevaluate what costs related to operator training and certification were included in the national cost estimate and make adjustments if necessary.

Activated Alumina (AA)

I. Based upon the information presented, for purposes of developing the national cost estimate the working group agrees with the assumption of using disposable activated alumina rather than the regenerable activated alumina.

J. Based upon the information presented, for the purposes of developing the national cost estimate, the working group agrees with the assumption of using two columns in series (i.e., roughing and polishing columns with a third standby column). The working group also recommends the media costs for the stand-by column be included in the capital costs for AA technology or any other similar treatment technology using a standby column.

K. The contactor and media cost analysis should be updated with the most recent additional information to reflect realistic contactor and media costs (to be determined by averaging costs obtained from at least four independent suppliers).

L. The empty bed contact time (EBCT) for the AA design should be such that the media life is at least three months for the lowest bed volume assumptions.

M. The capital and O&M cost associated with adequate pumping capacity , which is needed to overcome the head loss through the adsorbent media, should be included.

N. EPA should reexamine its unit cost development and curve-fitting technique to ensure that the unit cost equations represent appropriate economies of scale.

O. The working group recommends EPA reevaluate spent media disposal cost estimates, including appropriate capital and/or O&M costs (labor, transportation, landfill fees, on-site storage facilities, etc.).

Enhanced Coagulation and Filtration

P. No changes are recommended for the process design of the enhanced coagulation and filtration process assuming ECF is to be used only in systems that currently have sedimentation basins. However, if ECF is to be used in ground water systems that treat for iron and/or manganese reduction, it may be necessary to add sedimentation basins and cost them accordingly.

Coagulation Assisted Microfiltration

Q. Due to lack of time, the working group was not able to perform an exhaustive evaluation of the unit cost curve development for the coagulation-assisted microfiltration process. The group, therefore, recommends that EPA reevaluate and revise the unit cost curves as necessary.

Point-of-Use Technologies

R. EPA should revise the unit costs using the latest figures of capital and operation and maintenance costs.

5.4 Determination of decision tree and compliance forecast

A. After updated unit costs are developed, EPA should continue to use the existing thirteen listed technologies and others as appropriate in its decision tree analysis. In its compliance forecast EPA should continue to use the same approach with the modified assumptions recommended herein regarding the selection of technologies based on system size, type of water supply, arsenic levels, source water quality, existing treatment scheme, and lower cost of the technology.

B. Simple treatment technologies (e.g., disposable media adsorption processes without pH adjustment) should be used for systems serving a population of 3,300 or fewer persons where possible.

C. Consider expanding the use of POU option to larger size categories if the new cost evaluations show a significant advantage and if the access question and other issues identified in section 5.9 and appendix C are resolved. If issues associated with implementation are not resolved, the working group understands its application will be limited.

5.5 Recommendations for technologies not included in the current national cost estimate

A. Based on the presentations made, the working group recommends that EPA determine whether the granular ferric hydroxide (GFH) process meets the requirement for “feasible technology” as defined in the SDWA – 1412(b)(4)(D) and 1412(b)(4)(E). If the GFH process meets these criteria, the group recommends that EPA include it in the compliance forecast.

B. EPA should evaluate the use of direct filtration technology particularly for systems with high iron content.

5.6 Recommendations for residual handling and disposal

A. The working group recognizes that the disposal of residual solids generated by arsenic treatment facilities will impact the cost to comply with the arsenic MCL. Based on existing federal requirements EPA has determined that these arsenic contaminated residuals will not be classified as hazardous wastes. This assumption conforms to federal guidelines for developing national estimates. Therefore, the working group agrees that the national cost estimate for residuals disposal under the arsenic rule needs to be based on this assumption. However, the working group also acknowledges that under more stringent state hazardous waste requirements, such as those already existing in California, these residuals may be designated as hazardous wastes, which could lead to higher disposal costs. Such disposal costs are, however, a result of state-by-state decisions, rather than a direct requirement of this federal rulemaking.

B. The working group was presented with information about the technique to determine whether a waste is hazardous (this is called the toxicity characteristics leaching procedure (TCLP) test). Based on the information presented, this test may underestimate the toxic characteristics of these residuals. Therefore, the working group recommends that the EPA reevaluate the effectiveness of TCLP test for hazardous characteristics determination.

5.7 Recommendations for administrative costs

A. The working group recommends that EPA reevaluate the additional administrative costs to states that will be required to implement a stricter arsenic standard.

5.8 Recommendations for summary tables

A. The working group recommends that the final report of the revised national cost estimate include tables (as shown in appendix B of this report) that indicate the total capital and annual operation and maintenance costs, as well as the number of systems affected for each of the eight system size categories. A separate table shall be used for each arsenic MCL being considered (e.g., 3, 5, 10, and 20 μg/L).

5.9 Recommendations for point-of-use technologies

The working group's recommendations regarding point-of-use (POU) technologies are stated below. Appendix C provides the group's comments on POU legal requirements and implementation and management issues.

A. The working group recommends that the economic analysis be reevaluated with the latest figures of capital and operating costs to clearly mark the line in terms of the size of community where cost alone would indicate the desirability of using the POU option for arsenic reduction. Consider expanding the use of POU option to larger size categories if the new cost evaluations show a significant advantage and if the access question and other issues identified in this section are resolved.

B. Because the working group is concerned about the ability of all communities to achieve 100 percent access, the group recommends that EPA specify steps to be taken by communities to achieve compliance. For example:

   1. Provide details of ordinances that state, regional, and local governmental bodies may wish to pass for use by the communities.
   2. Provide a description of recommended customer outreach programs and education efforts to reach maximum participation by the residents. These may include initial town hall meeting to define the program along with the costs of alternate approaches and frequency of entry into each household for monitoring and maintenance.
   3. Include in the rule a general statement allowing the use of this option by the community when all the required efforts have been taken but some residents still do not allow access to their homes.

C. EPA's national cost estimate has estimated that 4 to 7 percent of communities requiring treatment to comply with the standard (10 μg/L) with a population of less than 500 people will be using the POU option. If the new cost evaluations show a significant advantage to all small systems, the working group recommend that higher percentages (as shown below) be considered, if it can be shown that it is appropriate and practical.

25 to 100	5-20 percent
101 to 500	5-15 percent
501 to 3300	5-10 percent
3301 to 10000	0-5 percent

D. The cost associated with pilot testing must be taken into account in estimating the overall cost of using the POU option in each community.

E. Because of the certification by third parties and the conservative field evaluations it is recommended that sampling and monitoring of the individual units can be done by testing a certain percentage of units each year and visiting all households at least once a year. The working group agrees with EPA's approach of sampling 25% of the households each year. It may however be necessary to visit all households once a year to examine the units, especially the working of the warning feature of the devices. Any cost associated with such visits should be included in the cost evaluations.

6 Affordability considerations

The working group discussed affordability issues surrounding the EPA and AwwaRF cost estimates, based on current cost data, and recognizes the inseparable link between cost and affordability. Affordability considerations are an integral part of the EPA's national cost methodology in that how affordability is measured and the affordability threshold selected may directly impact the treatment technologies and treatment trains that could be included in EPA's national cost estimate. In addition, the arsenic rule illustrates that national compliance cost estimates cannot be used to assess local challenges that may be faced by small water systems and their customers. There may be small water systems and populations that will be unable to afford compliance with the arsenic rule and with future rules under the SDWA. Although the working group did not develop a solution, the group did discuss various tools and approaches that could be considered as potential solutions, both partial and permanent, for system affordability and rate payer affordability as listed in appendix A.

Recommendations

A. The working group recommends that a sustainability fund that would be designed to assist small systems that have demonstrated no feasible alternatives to keep water users' fees within the limits of affordability be created.

B. The working group recommends that the NDWAC convene a working group to review EPA's methodology and assumptions for determining national affordability for regulations.

Appendix A

Potential Affordability Tools Discussed by the Working Group

The working group suggests the following:

1. The establishment of a financial assistance program that is targeted to small systems of all ownership types with demonstrated affordability problems and which are committed to meeting capacity development criteria.

2. The provision of direct assistance to low-income households to help them pay their water bills, which could include any or a combination of the following:
   - New federal assistance programs similar to:
     - The Low Income Home Energy Assistance Program and/or
     - The provision of food stamps or coupons for water service.
   - Utility initiatives, such as establishing customer assistance programs and designing special rates, including:
     - Funds contributed by shareholders are matched by ratepayer contributions (such as a dollar check-off on the water bill);
     - Coordination with local community-based organizations to offset arrearages, coupled with conservation education, installation of low usage plumbing fixture devices and repair of plumbing leaks;
     - Providing special discounts on water bills;
     - Phasing-in rate increases in stages;
     - Implementation of "single tariff pricing" for water systems having multiple divisions throughout a state.
       - Consolidation of rates serves to levelize higher rates of stand-alone systems among the larger customer base of the entire system.
       - Significant rate spikes can be avoided when major capital improvements are needed.
       - Administrative cost savings also are achieved, along with reducing rate case filing expenses.
       - The EPA recognized that single tariff pricing can be an important tool in capacity development efforts.
     - Implementation of monthly versus quarterly billing to keep bills smaller so payments may be more attainable; and/or
     - Implementation of lifeline rates coupled with conservation education, including the installation of low usage plumbing fixture devices and repair of leaking plumbing fixtures.

3. The utilization of alternate treatment technologies and management approaches to reduce costs yet achieve rule compliance.
   - POU/POE technology should be considered where feasible.
   - Encourage economies of scale through regionalization**.** Voluntary collective utility efforts on a regionalized basis hold much potential to improve economies of

scale. Significant costs can be reduced while technical, managerial and financial enhancements can be achieved.
    - Regionalization includes direct interconnection of one or more water systems but it is not limited to this approach.
    - Other forms of regionalization include retention of local ownership and control (if desired) with a coordination of contractual management services for two or more systems. Two common practices are:
        - Flexible satellite management – one entity performs all services such as water treatment, meter reading, billing and collections, and
        - The use of circuit riders – one or more certified plant operator/s and/or maintenance personnel travel throughout the collective service territory to perform treatment and repair duties for all systems on an ongoing basis.
- Encourage innovative public-private partnerships and best management practices in order to achieve improved regulatory compliance and higher levels of customer service by improving operating efficiencies and overall enhancement of technical and managerial expertise.
    - New sources of private investment capital are made available to public sector utilities to enable significant infrastructure and operational improvements.
    - Arrangements can be tailored broadly, ranging from outsourcing an array of services, to lease arrangements or asset sales.
        - Cooperative county, area wide or regional service providing centers can be established that can bundle support activities, or
        - The management capability can be created to undertake design-build-operate contracting for a number of small systems.

4. Encourage realistic pricing structures and conservation programs that provide for the needs of low-income households; methods include:
    - Utilizing all water utility revenue collected from ratepayers towards water utility functions;
    - Charging rates that reflect the actual cost of service, including depreciation expenses which should be earmarked for investments in ongoing plant improvements; and
    - Utilities should implement special rate considerations targeted to low-income customers (as listed above in number 2).

Appendix B

Summary Tables

Tables such as these will be filled in by EPA as explained in section 5.8 of this report.

(Individual entries are estimates of national forecast for compliance by category. It should be noted that this is a national aggregate projection. Actual unit costs for individual systems may vary widely from the average due to specific local conditions.)

Estimated National Cost – Arsenic Standard at 20 μg/L

System Size (Population)	Number of Systems Affected	Total Capital Cost	National Annual O & M Cost
0 – 500		$	$
101- 500		$	$
504 – 3,300		$	$
3,301 – 10,000		$	$
10,000 – 50,000		$	$
50,000 –100,000		$	$
100,000 – 1,000,000		$	$
>1,000,000		$	$
Total		$	$

Estimated National Cost – Arsenic Standard at 10 μg/L

System Size (Population)	Number of Systems Affected	Total Capital Cost	National Annual O & M Cost
0 – 500		$	$
101 – 500		$	$
504 – 3,300		$	$
3,301 – 10,000		$	$
10,000 – 50, 000		$	$
50,000 – 100,000		$	$
100,000 – 1,000,000		$	$
1,000,000		$	$
Total		$	$

Estimated National Cost – Arsenic Standard at 5 μg/L

System Size (Population)	Number of Systems Affected	Total Capital Cost	National Annual O & M Cost
0 – 500		$	$
101 – 500		$	$
504- 3,300		$	$
3,301 – 10,000		$	$
10,000 – 50,000		$	$
50,000 – 100,000		$	$
100,000 – 1,000,000		$	$
>1,000,000		$	$
Total		$	$

Estimated National Cost – Arsenic Standard at 3 μg/L

System Size (Population)	**Number of Systems Affected**	**Total Capital Cost**	**National Annual O & M Cost**
0-500		$	$
101-500		$	$
504 – 3,300		$	$
3,301 – 10,000		$	$
10,000 – 50,000		$	$
50,000 – 100,000		$	$
100,000 – 1,000,000		$	$
>1,000,000		$	$
Total		$	$

Appendix C

Point of Use Technology: Legal Requirements and Implementation and Management Issues

As per the present rule, any community or non-transient non-community water system can consider the use of POU/ POE technology option for compliance with arsenic regulations. However, there are several issues that need to be evaluated by the utility prior to such a possible decision. These include legal requirements, implementation factors, and the overall costs uniquely associated with this choice.

Legal Requirements (per SDWA Amendments 1996)

A. Prohibition of POU devices for microbial contaminants does not apply here.

B. POU/POE units shall be owned, controlled and maintained by the public water system or by a person under contract with the public water system to ensure proper operation and maintenance and compliance with the maximum contaminant level.

C. Devices have to be equipped with mechanical warnings to automatically notify customers of operational problems.

Illustrations to accomplish mechanical warnings are shown below:

1. POU RO devices should be required to be outfitted with TDS monitoring of the influent and effluent water streams and provide a visual warning to the user when a predetermined percentage is exceeded.
2. POU AA (or similar media) devices should be equipped with a volume monitoring means that would provide a visual or audio warning to the user OR shut the water flow when a predetermined volume is reached.

D. SDWA requires that if ANSI standards have been developed, they must be followed. For arsenic, ANSI standards have been developed; therefore these devices must be certified pursuant to the following standards:

1. *ANSI/NSF Standard 58: Reverse Osmosis Water Treatment Systems.* Performance tests are done under this standard with 50 µg/L arsenic V fortified water along with background chemicals that may interfere with its performance. (This is not a life test because of its long life and the impossibility of conducting a lifelong test for such a product.)
2. *ANSI/NSF Standard 53: Drinking Water Treatment Units-Health Effects*. Performance tests are to be done under this standard at two different pH levels, 6.5 & 8.5 with 50 µg/L arsenic V fortified water along with silicate, fluoride, sulfate, phosphate and other ions that would interfere with its capability. (As per the standard these life tests are required to be done for 120 percent of claimed life, with a 20% safety factor for devices with

performance indication means such as shutoff devices or visual warnings at end of life. All effluent samples shall be below the MCL for arsenic.)

Implementation Issues

There are many implementation issues with their own complexities and related cost factors. It is important to recognize each of these, make a choice, and cost out the specific issue if such a step is appropriate. Following sections describe some of the basic issues grouped together as community size, source water, and management issues. Some of these are interconnected issues that may have to be sometimes decided together.

Community Size

A. There are no legal limitations on what size communities can use POU option. However, practical limitations of management issues would dictate system size limitations even when economic factors may indicate otherwise.

B. The economic analysis needs to be refined with the latest figures of capital and operating costs to clearly mark the line where cost alone would indicate the use of POU for arsenic reduction.

C. EPA has used a community size of 500 people as the cutoff point. This may be have been appropriate on the basis of information available in 1997. New products and higher activity in this area are yielding fairly significant changes in these cost figures. The cutoff point may have moved up to a larger community level of approximately 1000 or 1500 people. Careful evaluation of this new information is necessary.

Source Water

D. Quality of the source water is a very important consideration for POU option. For example, if the source water is high in hardness levels (over 140 ppm as calcium carbonate) it may be better not to use POU RO because of its scaling effect on membrane life. Similarly if the pH is high, over 9.0 then the life of POU AA units may be significantly affected.

E. If the community water system adds fluoride to the water at the central plant, it should consider the fact that POU RO and POU AA devices would remove the fluoride from the water they treat. Users should be notified of this fact.

F. Source water must be free chlorinated or otherwise oxidized at the wellhead or central plant converting the arsenic, if present partially or wholly in trivalent form to the pentavalent form for effective reduction of the Arsenic by either of the two POU options.

G. In spite of the fairly conservative conditions of testing per the ANSI/NSF protocols it is essential an accelerated test be conducted using the source water of the community to confirm the units' capability as well as obtain a realistic and conservative value of actual life in that community. This can be done following the same protocol approach as evolved in the ANSI/NSF standards. These protocols use an ON/OFF cycle that is by nature accelerated, but provide reasonable OFF times to get life in volumes (gallons) under realistic conditions. Such a field test can be conducted using one or two weeks of actual condition in the community. This cost needs to be taken into account in estimating the overall cost of using the POU option.

H. The life value achieved in such testing can be further reduced to provide for relative variation in water quality conditions including background chemical characteristics and the arsenic levels in the water. An appropriate figure for use in such adjustment may be to reduce the life value by 50 percent. When this value is decided then it can be used for deciding media replacement frequency and the setting of the warning features of the devices.

Management Issues

This is probably the most important issue in this consideration. Several specific issues need to be evaluated and decided prior to final decision on the feasibility of this option.

I. The first issue is how to gain access to all the homes and other sites. State, regional, or local governmental organizations will need federal guidance to provide a mechanism for the communities to pass appropriate ordinances to achieve such a result. If this approach is not available to the community for any reason this POU option may not be implementable. (The example in San Yesidro, NM example should be examined for applicability in all states.)

J. If access cannot be obtained to 100 percent of the households due to one or two recalcitrant individuals, are there other recourses from a regulatory point of view? Is there a minimum percentage that can be established as acceptable? Would there be an exemption available to those communities? These may need to be examined by EPA as well as states for clarification.

K. Another issue to be evaluated by EPA is the use of outside parties under contract to own and/or maintain the units for the utility. There are potentially three different possibilities: Utility to own and maintain the units; utility to own, but have them maintained by one of the outside parties that are in this business; and utility to contract out the ownership and maintenance to the dealer of the manufacturer on a rental or lease basis. Each has its own advantages and disadvantages for a specific community. Proper choice depends on the community's economic and manpower limitations.

L. It is important to make sure that the selected POU device has a visual warning is actually visible to the user as this water is used on a regular basis. This mechanism would ensure that the customer is automatically notified of operational problems as required by the SDWA.

M. Frequency of monitoring the performance of all the units has to be chosen based on factors such as cost, assurance of performance and monitoring cost versus replacement of media on a conservative schedule. Each state may develop its own approach. Because of the certification by third parties and conservative field evaluations sampling, the monitoring of the individual units can be based on a certain percentage of units per month visiting all households at least once a year. Some percentage of households may also be sampled during that yearly visit, while other units may be simply examined for the working of the monitoring means.

N. Regardless of the chosen approach of ownership, administrative duties of the utility will be higher than that of central treatment. This expense needs to be added to the basic cost of this option.

<u>Cost Evaluations and Comparisons</u>

Below are two updated "mock" cost quotations provided by a POU manufacturer and a POU water treatment dealer in June 2001. This information is provided as an example to support the recommendations given in section 5.9.

A. Manufacturer's quote is based on the suitability of the source water to the selected POU product and an assumed community size of 100 households. It covers both a POU RO and POU adsorbent media (AA).

Adsorbant Filter with separate faucet and shutoff mechanism (for a 500 gallon life)	$ 200 (includes installation)
Replacement Cartridge	$ 35

If this is contracted out, the manufacturer has estimated that the monthly rate per household for this type of product will be 10 to 15 dollars per month, which includes installation, general service, and replacement cartridges.

POU RO System with separate faucet and a TDS monitor	$ 450 (includes installation)
Replacement Cartridges	$ 50

B. POU dealer has provided a cost quotation based solely on renting out POU RO units on a minimum 3-year contract with the public water system of 350 people. His estimate for such a service is $18.50 per month per household. This cost includes the product, installation, annual service, replacement of all cartridges, and annual disinfection and cleaning of the all the systems.

References

American Water Works Research Foundation. *Cost Implications of a Lower Arsenic MCL*. Prepared by Frey, M.M., et al. Revised October 2000.

Barrie, D. S. and B. C. Paulson, Jr. *Professional Construction Management, 2nd Ed*. McGraw Hill. 1984.

Frey, M.M., et al. National Compliance Assessment and Cost for the Regulation of Arsenic in Drinking Water. Prepared for the Water Industry Technical Action Fund. January 1997.

US EPA. *Arsenic in Drinking Water Rule Economic Analysis.* Prepared by Abt Associates, Inc. December 2000. EPA 815-R-00-026.

US EPA. *Community Water System Survey, Volume II: Detailed Survey Result Tables and Methodology Report*. January 1997. EPA 815-R-97-0016.

US EPA. *Technologies and Costs for Removal of Arsenic from Drinking Water*. Prepared by International Consultants, Inc. and Malcolm Pirnie, Inc. December 2000. EPA 815-R-00-028.

US EPA. *Technologies and Costs for Removal of Arsenic from Drinking Water*. Prepared by International Consultants, Inc. and Malcolm Pirnie, Inc. April 1999. EPA 815-P-01-001. DRAFT.