Groundwater

Disinfection Regulations Benefits Conference

SPONSORED BY

National Water Research Institute

March 17, 1997

Arnold and Mabel Beckman Center
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FOREWORD

Water is recognized as *the* vital substance in sustaining life. However, not everyone recognizes that water is equally vital in every facet of this nation's economic development as well as its sustainability, e.g., food production and processing, and manufacturing of micro-processor and associated electronics, metals, automobiles, fabrics, papers and plastics.

Our nation's gross domestic product and the value of water is a paradox. Why is water one of the most undervalued substances in the nation, if not the world? Is the value of water based on perception or fact? One compelling reason might be that the general population really does not understand what water is or how it affects their daily lives. To many citizens, water lacks value.

The reason that water is perceived to lack value is its ready availability and its low price. Water utility managers are so remarkably efficient and successful in delivering a high-quality product to over 150 million consumers on a daily basis that people now expect water will arrive whenever a tap or wheel is turned. This is not to imply that water utility managers are responsible for what can be termed an attitude, but they have become so good at delivering a high-quality and dependable product that the general public has become insensitive to the value of water.

In 1994, the recognition of this perspective or attitude prompted the National Water Research Institute (NWRI) to embark on a program to encourage the inclusion of benefit valuing within the context of future groundwater supplies. Joining with the U.S. Environmental Protection Agency (USEPA), U.S. Department of Energy, and the U.S. Department of Defense, NWRI sponsored a study, conducted by the National Research Council (NRC) through its Water Science and Technology Board, to examine approaches to assessing the future economic value of groundwater. This study will be available from the NRC in April 1997.

Then in 1996, NWRI developed a project to examine the application of benefit values to the rule-making process. Specifically, the Groundwater Disinfection Rule (GWDR) was targeted for consideration because it was anticipated to be the first of several such rules to be promulgated by the EPA during the latter half of the decade.

The first step was to convene a group of nationally-recognized individuals with expertise in water utility management, federal and state regulations, public health, economics, microbiology, and engineering to a Nominal Group Technique (NGT) Workshop held on January 6-8, 1997. The purpose of the NGT was to identify and prioritize the most significant benefits that should be considered in the development of a GWDR. These benefits were documented in the workshop proceedings[1].

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1. Groundwater Disinfection Regulation Workshop, National Water Research Institute, Fountain Valley, CA, Occasional Paper NWRI-97-1. January 1997.

Arising from the NGT was an action plan describing the process of organizing Task Groups to further develop the ten highest priority benefits into reports that would detail:

- Why the benefit is important to groundwater disinfection regulations.
- How to measure the effects of the benefit.
- How to value (monetize) the benefit.
- Recommendations for the next step to be undertaken to link the benefit to the rule-making process.

The Task Group reports were presented at a GWDR Benefits Conference held on March 17, 1997, at the Arnold and Mabel Beckman Center of the National Academies of Sciences and Engineering located in Irvine, California.

Prior to the conference, each Task Group received guidelines for preparation of their reports (see Appendix C.) A part of the content was the preparation of one or more examples of *how to measure the effect(s) of the identified benefit*. This proved to be the most difficult task as each Task Group cited difficulty in preparing examples comfortable to all members from the perspective of their individual areas of expertise. Nevertheless, this report reflects the very best thinking of the conference participants.

This document contains eight Task Group reports. Two of the ten highest priority benefits reports were consolidated into other reports at the conference, thus the eight reports.

A presentation by Bruce Macler entitled *Current Thoughts on the Groundwater Disinfection Rule* (see Appendix E) provided the participants with the very latest thoughts by the rule manager on the direction of the rule-making process.

NWRI is very pleased that the conference participants were successful in reaching the goal of creating a high-quality product that can now be delivered to all interested parties throughout the nation.

Ronald B. Linsky
Executive Director
National Water Research Institute

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TASK GROUP 1

Reduced Risk of Waterborne Illness

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TASK GROUP MEMBERS:
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*presenter

Executive summary:

The major benefit of an effective Groundwater Disinfection Rule (GWDR) is risk reduction of waterborne illnesses through the control of exposure and re-exposure to pathogenic microorganisms in groundwater. Reductions in acute and chronic morbidity, disability (e.g., liver disease, reactive arthritis), and mortality would accrue to both the general population and to sensitive subpopulations (e.g., infants, elderly, diabetics, and immuno-compromised). This Task Group strongly recommends that ranges of plausible risk estimates be developed because this is a key step in valuing this benefit. Quantifying the pre-regulatory (i.e., baseline) and post-regulatory microbial risks from drinking groundwater is not an exact science. Resulting benefits would include lower health costs, increased lifespan, increased worker productivity and leisure time, and reduced reliance on bottled and boiled water specifically for health reasons. Willingness to pay (WTP) is the appropriate method to value the benefit. The Task Group recommends that additional research be performed to better define the uncertainty and to demonstrate the concepts necessary to estimate the baseline risks and risk reduction benefits associated with various disease agents.

Why benefit is important to groundwater disinfection regulations:

The primary public health goal of the rule is to prevent waterborne infectious disease (WBID) while the regulatory goal would be to actively prevent microbial contamination from reaching the consumers of groundwater from public water supplies. Reduction in the risk of waterborne illness is the primary goal of a GWDR, and reductions in this risk by an effective GWDR would be expected to occur over the long term, and would include protection for as yet identified (emerging) microorganisms. The United States Environmental Protection Agency's (USEPA) assessment indicates that the majority of these illnesses are attributable to community systems rather than noncommunity systems.

A key to valuing these benefits will be to develop a well-defined baseline of microbial risk that currently exists for drinking water consumers served by public water systems (PWSs) using groundwater. This Task Group observes that the USEPA's preliminary risk assessment (which is not yet available for external review) of an estimated 4-5 million illnesses per year that could be attributed to consumption of groundwater from public water supplies (Macler and Pontius, 1997) is much higher, by an order of magnitude, than other reported occurrences of overall WBID (e.g., Bennett et al., 1987; Morris and Levin, 1995). Thus, development of the baseline risks must be carefully documented. In addition to projected illnesses, ratios of disabilities to illnesses and deaths to illnesses, based on data from appropriate viruses (the target of the GWDR), need to be derived from case studies.

How to measure the effect(s) of the benefit:

The major measurement challenge is to develop a realistic baseline correlation between microbial contamination of groundwater and waterborne health effects using the endpoints of morbidity, disability, and mortality for both the general population and sensitive subpopulations. In addition, the impact on transient populations served by noncommunity supplies also must be addressed. Baseline risk assessment and epidemiological studies (with retrospective follow-up studies after rule implementation) and probabilistic models are suggested as methods to develop these estimates. The estimates need to indicate the distribution of health impacts according to the duration and severity of illness and age of the affected.

The Task Group believes that it is premature to provide a quantitative estimate of this benefit, as more work needs to be performed to define the plausible range of risk reduction (see "Recommendations"). The steps needed to quantify the benefit, in terms of illnesses avoided, would include determining, for both the general population and sensitive subpopulations served by public groundwater supplies:

- Number of waterborne illnesses prevented (range and most likely value).
- Percent of illnesses resulting in disability.
- Percent of illnesses resulting in death (range and most likely value).

These results would be used to define the occurrence profiles of waterborne disease for the pre-regulatory and post-regulatory scenarios.

How to value (monetize) the benefit:

Willingness to pay (WTP), or accept compensation, is the appropriate valuation concept (Just, 1982; Sassone and Schaffer, 1978; U.S. Water Resources Council, 1983). Contingent valuation (e.g., surveys to identify values people place on incremental changes in drinking water quality) and hedonic (e.g., wage-based) studies could be used to estimate the WTP for actions that reduce the risk of waterborne illness.

Specific values for benefits will vary depending on the type of risk reduction and the affected population. Morbidity and disability can be addressed by these methods to estimate the WTP to avoid various symptomatic effects. Cost-based measures, such as lost wages/productivity and medical treatment expenses, can be used as proxy benefits for the general public (to the extent that reliable WTP estimates are not available), while lost wages/productivity may not be appropriate for sensitive subpopulations. Mortality would be addressed by existing or newly derived value(s) of a statistical life saved based on WTP concepts and using calibrated quality adjustment life years. Multiple valuation approaches should be employed to provide a weight of evidence for values and to enable comparisons across values derived by the different methods.

Once the occurrence estimates are made, measurements of the expected reductions in societal costs (lost time and wages/productivity), medical treatment expenses, and loss of life would be developed. The steps needed to value the benefit would include determining the following for both the general population and sensitive subpopulations served by public groundwater supplies:

- Morbidity (Cost per illness)

    -number of lost days per illness
    -value of medical costs
    -value of loss wages/productivity

- Disability (over the regulatory time period; e.g., 20-year period)

    -ratio of disabilities per illnesses
    -number of lost days per disability
    -value of medical costs
    -value of loss wages/productivity

- Mortality

    -ratio of deaths to illnesses
    -value of a statistical death

After the above factors are developed, the value of the benefits would be aggregated over the entire population that receives its drinking water from public groundwater supplies. The sum of the value of reduced morbidity, disability, and mortality would represent the value of the total benefit for reducing waterborne risks.

Recommendations:

As a next step, additional research is required to assemble and analyze the degree of uncertainty inherent in the interpretation of available data on baseline disease incidence, the share attributable to drinking water exposures, the degree to which the GWDR might reduce the number of drinking water-related cases, and the economic value to assign to the various adverse health outcomes. As a preliminary research effort that can be accomplished within a modest timeframe and using available data, the Task Group recommends a first phase agenda to either:

- Select a single microbial agent and lay out, in a decision tree or flow diagram type logic format that helps to illustrate the logical sequence of the analysis and the uncertainty it contains, the process for assembling and interpreting the available data on baseline cases of infection from all sources, the share attributable to drinking water and prevented from the GWDR, the types and numbers (or percentages) of adverse heath outcomes manifested from exposure/infection, and the implications and economic values associated with these outcomes (e.g., % cases resulting in mortality, hospitalization, lost work or restricted activity days, etc.).

  and/or

- Develop an initial lower bound estimate of the benefits by using available data (e.g., on reported cases), but realizing that these data are likely to understate true levels and values.

These first phase research efforts could serve as "strawman" analyses that can be reviewed, critiqued, and revised. They would serve to illustrate the concepts and issues and, hopefully, provide "blueprints" for larger-scale studies to reflect a broader range of disease agents and adverse health outcomes. The analyses also can be used to illustrate the overall level of uncertainty, identify which uncertainties are most important in terms of the quantified results, and to help define a research agenda well-targeted on addressing those uncertainty issues where new information would be of greatest value.

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TASK GROUP 2

Increased Reliability and Availability of Groundwater Systems

TASK GROUP CO-CHAIRS:
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Executive summary:

Congress intended the GWDR to be proactive (by preventing fecal contamination in groundwater systems) rather than reactive (to contamination episodes). Potential regulatory approaches to fulfill this intention stress best management practices (BMPs) focusing on maintaining a distribution system residual and requiring adequate maintenance and operating procedures or some combination of both. If the rule is to successfully utilize BMPs for system and distribution protection, means to assess the effectiveness of these practices must either be utilized (if available) or developed.

Quantitative correlations between system failures and consequences (e.g., coliform violations) which could be affected by various BMPs are not currently known. An effort to understand and analyze the individual elements in groundwater systems, in terms of both failure rates and risk reduction due to implementation of BMPs, should be undertaken. Unless new data and analyses are obtained, the weakness in understanding cause/effect links means that uncertainty consideration will be critical in any attempts to estimate benefits in this area. It might be possible to use as indicators measures of:

- Coliform violations in systems with and without disinfection or other BMPs.

- Housing density in areas with and without disinfection.

- Results from contingent valuation method (CVM) studies to obtain WTP estimates before or after outbreaks, emergencies attributable to known or possible system failures, or public notices in response to coliform violations.

- Increases or decreases in capital and maintenance costs associated with preventing or mitigating specific system failures or failure modes (such as line breaks or pressure loss).

Why benefit is important to groundwater disinfection regulations:

Congress intended the GWDR to be proactive (by preventing fecal contamination in groundwater systems) rather than reactive (to contamination episodes). To meet this intention, the formal GWDR regulatory work group has chosen the philosophical approach of focusing the regulation on BMPs and multiple barriers, rather than on treatment barriers alone. Under consideration as part of the implementation of this philosophical approach in the regulation, two candidate elements for the GWDR focus on physical system integrity and protection from failure. Potential regulatory approaches for these elements stress some combination of:

- Best management practices.

    - maintaining a distribution system residual
    - sanitary surveys
    - well sitting and construction standards
    - operator training

- Requiring the development and performance of adequate maintenance and operating procedures, including:

    - cross-connection control
    - backflow prevention
    - flushing and valve exercise programs
    - pressure testing and maintenance

These approaches are familiar and have substantial acceptance among the states and utilities.

If the rule is to successfully utilize BMPs for system and distribution protection, means to assess the effectiveness of these practices must either be utilized (if available) or developed. It is not clear what the overall best indicators of system failures are, though coliform violations are acknowledged as the best current indicator. Correlations between coliform violations and system failures which could be affected by various BMPs is not currently known. An effort to understand and analyze the individual elements in groundwater systems in terms of both failure rates and risk reduction due to implementation of BMPs should be undertaken. Such an effort would yield data which would help evaluate the effectiveness of current distribution system protective practices in preventing failures resulting in recontamination of drinking water and yielding quantification of regulatory approaches being considered.

How to measure the effect(s) of the benefit:

It is clear that increased reliability and availability (reduced failures and optimized system functioning) of physical systems will result in:

- Reduction of disease outbreaks, endemic illness, and their costs.

- Increases in consumer confidence and reduction in averting expenditures.

- Reduced losses from failures and whole system breakdowns.

- Shifts in capital and maintenance costs.

However, only a limited understanding of all of these individual benefits and liabilities and their quantification exists. As mentioned above, data on physical systems is either unavailable or poorly correlated with current management practices. Unless new data and analyses are obtained, this weakness in understanding cause/effect links means that uncertainty considerations will be critical in any attempts to estimate benefits in this area. Additionally, the liabilities associated with the impact of this rule must be weighed against its benefits (i.e., how does this rule adversely impact other regulatory requirements).

As far as system failures are concerned, one way to measure the potential effect of the regulation is to compare failure rates (as indicated by coliform violations) for systems in the same geographic/geologic area operating with and without disinfection, or with and without any other specified BMP to which adherence can be measured. In particular, with additional information on the contamination rates of the source groundwater itself (and in many cases there will be none) BMPs which have a clear effect on coliform violations can be said to effect system reliability in a quantifiable manner.

Ideally, estimations of the differences that various regulatory components may have on failure modes, failure rates, and the consequences or effects of failures could be obtained. It might also be possible to use as indicators measures of:

- Housing density in areas with and without disinfection.

- WTP evaluations after outbreaks, emergencies attributable to failures of a specific system, or public notices in response to coliform violations.

- Increases or decreases in capital & maintenance costs associated with preventing or mitigating specific system failures or failure modes (such as line breaks or pressure loss).

Specific system failures may be indicated by the following:

- Coliform MCL violations (acute and non-acute).
- Waterborne disease outbreaks.
- Boil water notices.
- Presence of viral indicators in the source water (AWWARF study[1]).

How to value (monetize) the benefit:

The economic evaluation of this benefit is not an easy step. Not only are there the difficulties in cause/effect data mentioned above, but there are weaknesses in economic methods which will add to the uncertainties of any result. Once there are better data available in terms of causes and effects, it will be an easier task to assign dollar values. However, some means to monetize this benefit might be to:

- Evaluate changes in total coliform violations, estimate downtimes and the avoided costs of using alternatives available in those times.
- Estimate increases in maintenance or capital costs as a result of failures and their prevention.
- Estimate the transactional costs associated with failure events.
- Estimate the health costs of exposures associated with specific failure modes.
- Estimate costs of lost economic activity and lost revenue from system downtimes due to failures.
- Estimate costs associated with disaster-related activities that may result from specific types of failures (i.e., boil water notices, emergency activities, and transactional costs).
- Avert expenditures resulting from consumer's and businesses' concerns about the reliability of the water supply.
- Estimate contingent valuation of individuals' perception of and WTP for preventing, avoiding, or reducing water system failures.

A CVM can be used to measure WTP for increased "availability and reliability". It is important to recognize that such availability/reliability is an ultimate outcome or "endpoint" for the water supply system. Water consumers will value this increased availability/reliability as a potential benefit of the GWDR. A challenge that must be addressed if the CVM approach is to be used is for

availability/reliability to be specified in a way that consumers can understand and value. Therefore, work will be needed by technical experts to construct scenarios that will yield a reliable system with a certain level of reliability (e.g., no coliforms in the water 99.5 percent of the time). Then the consumer can respond to the scenarios and express a WTP to obtain the desired amount of availability or reliability.

The measurement approaches listed above respond to the benefit question from either the cost/supply or a demand orientation. Care must be taken in using results from these methods together. One reason is that different disciplines make different assumptions about the conceptual basis for valuation. An approach developed by an interdisciplinary group is contained in a recent National Research Council report[7] on groundwater valuation. These different assumptions need to be considered in interpreting the results. Second, using benefits from different approaches may lead to a double-counting of some benefit areas and may lead to overestimating the value of the GWDR.

As a final note, there are several programs or funding efforts just in the development stages that examine available data regarding issues such as how to measure the effectiveness of operations and maintenance (O&M) practices and the relationship between pathogen intrusions and different types of system failures (AWWA Research Foundation, ASDWA, USEPA). The GWDR O&M work group also has a contractor analyzing data from a recent survey to determine the relationship between water system Total Coliform Regulation (TCR) compliance status and the use of BMPs. Therefore, so it is possible that within the next year or two we will begin to see data analyses that can better support measurement and monetization of this benefit.

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TASK GROUP 3

Preventing Microbial Contamination of Source Water

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Executive summary:

Source Water Protection (SWP) is a community-based pollution prevention approach designed to protect ground and surface waters used for drinking water from contamination. To illustrate the value of a SWP program, Task Group 3 examined the benefits of SWP with respect to preventing microbial contamination of groundwater within the context of a federal GWDR. While the benefits of a SWP program will vary based on local conditions, water supply systems and the communities they serve are expected to benefit from a SWP program. This is particularly true if the water system is able to reduce the need to disinfect their drinking water over time. While the discussion here is limited to microbial contamination of groundwater, the benefits of a SWP program are applicable to surface waters and chemical contamination as well.

What is source water protection?:

Source water protection is a pollution prevention approach for both ground and surface water sources of drinking water. While applicable to both chemical and microbial contamination, the focus of this effort is on preventing microbial contamination of groundwater. States will develop their SWP programs based on guidance from the USEPA as specified in the Safe Drinking Water Act of 1996. Development and implementation of local programs is a community-based effort that may involve federal, state, regional and interjurisdictional partnerships. For microbial contamination, the delineated protection area will have to be large enough to allow for microbial die-off prior to water reaching the well. The size of this area is likely to be smaller than the area typically defined for chemical contamination, e.g., five to ten years.

Description of the benefit:

The following benefits may result from the inclusion of source water protection as one of the barriers to microbial contamination allowed under a groundwater disinfection rule.

1. *Reduction in human health risks from exposure to microbial contaminants.* Effective prevention of source water contamination will reduce the exposure of human beings to pathogens, and therefore, their risk of contracting waterborne diseases.

2. *Reduction in human health risks from exposure to disinfection by-products.* As source water quality is protected from microbial contamination, water supplied from those sources may require less disinfection. With less disinfection, the exposure of human beings to disinfection by-products should decline, and so should their risk of developing diseases from these exposures.

3. *Avoid treatment costs either by reducing or eliminating treatment in systems that would otherwise be required to disinfect.* As source water quality is protected from microbial contamination, water supplied from those sources may require less disinfection. The avoided cost of this disinfection is a benefit of source water protection.

4. *More secure drinking water sources will result in fewer resources being spent to respond to illness outbreaks.* Effective source water protection increases the dependability of the drinking water supply, and therefore reduces the risk of illness outbreaks. Therefore, the avoided cost of responding to such outbreaks, such as substitute water supplies, is a benefit of source water protection.

5. *Information related spillover benefits of source water protection.* An effective source water protection program requires drinking water purveyors to invest resources to better understand the environment in which their wells are located. This information may result in reduced risk to human health, and other benefits, beyond those benefits provided by source water protection directly. SWP programs that include public education and involvement in local program development and implementation will enhance the spillover benefits.

6. *Improved drinking water taste.* As source water quality is protected from microbial contamination, water supplied from those sources may require less disinfection. Consumers may find that this water tastes better than water which requires more disinfecting.

7. *Existence, or nonuse, value to individuals of knowing that the groundwater is being protected.* Individuals, who may or may not be served by groundwater, may gain in knowing that the groundwater is being protected, as they feel that groundwater is an important resource.

How to measure the effect(s) of the benefit:

The benefits of source water protection must be measured against a baseline. The baseline should be the best assessment of what the world would look like without source water protection. The following table helps to understand the two states of the world between which benefits will be measured. We are attempting to identify the margin of benefits that are attributable to source protection in the table, but the categories of benefits listed above are generic and apply to many of the task group topics in this report. Within the table, we are trying to account for different benefit categories that relate to source protection, but do not address the different groups in society for whom the benefits and costs will accrue.

Future Situation Under Groundwater Disinfection Program without Source Protection Component	Future Situation Under Groundwater Disinfection Program with Source Protection Component	Possible Benefits
Disinfecting	A. Disinfect the same	1, 4, 5, 7
	B. Disinfect less	1, 2, 3, 4, 5, 6, 7
Not Disinfecting	C. Not disinfecting	1, 4, 5, 7

For each scenario, the possible benefits which might accrue to each system are shown in the table. Many factors will affect the presence, and level, of each benefit category for a particular system. For example, a system which practices groundwater recharge using treated wastewater may not be able to reduce the level of disinfection, even though they institute source water protection. In this case, the system will not accrue benefits associated with benefit categories 2, 3, and 6. Therefore, it will be necessary to determine which benefit categories will accrue to each system, and then to measure the level of benefits. The manner in which each benefit category should be measured is discussed below.

1. *Reduction in human health risks from exposure to microbial contaminants.* This benefit should be measured as the WTP for a reduction in the risks to human health from exposure to microbial contamination. WTP will capture both the expected direct costs of becoming ill (such as medical expenses and lost wages) as well as the risk premium consumers are willing to pay for a margin of safety.

2. *Reduction in human health risks from exposure to disinfection by-products.* This benefit should be measured as the WTP for a reduction in the risks to human health from exposure to disinfection by-products. WTP will capture both the expected direct costs of becoming ill (such as medical expenses and lost wages) as well as the risk premium consumers are willing to pay for a margin of safety.

3. *Avoid treatment costs either by reducing or eliminating treatment in systems that would otherwise be required to disinfect.* This benefit should be measured as the opportunity costs of the resources which will not have to be used to disinfect drinking water.

4. *More secure drinking water sources will result in fewer resources being spent to respond to illness outbreaks.* This benefit should be measured as the expected opportunity cost of the resources which will not have to be used to respond to illness outbreaks.

5. *Information related spillover benefits of source water protection.* This benefit should be measured as the WTP for any future reduction in risk of illness, as well as avoided costs, which might result from the existence of information gathered as a result of source water protection implementation.

6. *Improved drinking water taste.* This benefit should be measured as the consumer's WTP for improved drinking water taste.

7. *Existence, or nonuse, value to individuals of knowing that the groundwater is being protected.* This benefit should be measured as the WTP to insure that the groundwater is protected, over and above the WTP for the other benefits listed above.

How to value (monetize) the benefit:

Here we suggest alternative measurement approaches that are intended to approximate the conceptual values identified in the previous section. It should be stressed from the outset that the validity and reliability of some of the suggested approaches are being debated by economists and policy makers. We suggest using multiple valuation techniques to establish the convergent validity of estimates derived from measurement approaches that have differing strengths and weaknesses, and to provide a plausible range of value estimates. While implementation of source protection will occur at the local level, we are not advocating the conduct of original benefit analysis for each site. Rather, we argue that benefit analyses should be conducted for a variety of case studies that will allow transfers of benefit estimates to unstudied sites.

1. *Reduction in human health risks from exposure to microbial contaminants.* The ideal means to determine the WTP for a reduction in risk is to look at peoples' revealed preference, or market choices, regarding risky activities which are involuntary. An example of this might be the purchase of disability or health insurance. However, it may be difficult to distill from these market choices an acceptable surrogate for the WTP to reduce the risk to human health from exposure to microbial contaminants, as people have different risk attitudes toward different harmful effects. Therefore, it may be necessary to do one of several things:

First, a survey-based study, using the CVM, may be used to illicit peoples' ex ante WTP for risk reduction directly. This method has been employed in numerous studies in the valuation of statistical life literature (see Viscusi[4] and Tolley et al.[5]) and has also been specifically applied to value consumer WTP to reduce groundwater health risks (see Boyle et al.[2]).

Second, it may be adequate to use as a surrogate for WTP the expected value of costs of illness. In this case, one assumes that consumers are indifferent between taking a chance of becoming ill and incurring the cost of becoming ill (lost wages and medical expenses), and being risk-free and giving up income equal to the cost of becoming ill multiplied by the probability of becoming ill. This surrogate for WTP, although often used (e.g., Harrington et al.[3]; Abdalla et al.[1]), will most likely underestimate the true WTP for risk reduction.

Revealed public preferences for water quality protection obtained through an evaluation of past referenda in specific localities might also provide an indication of community and household WTP.

Finally, a benefits transfer approach drawing estimated values from the statistical "life or limb" literature could be multiplied by changes in the probability of occurrence to approximate values.

2. *Reduction in human health risks from exposure to disinfection by-products.* The ideal means to determine the WTP for a reduction in risk is to look at peoples' revealed preferences, or market choices, regarding risky activities which are involuntary. An example of these market choices might be the purchase of disability or health insurance. However, it may be difficult to distill from these market choices an acceptable surrogate for the WTP to reduce the risk to human health from exposure to disinfection by-products, as people have different risk attitudes towards different harmful effects. Therefore, it may be necessary to do one of several things:

First, a survey-based study, using the CVM, may be used to illicit peoples' WTP for risk reduction directly. This method has been employed in numerous studies in the valuation of statistical life literature (see Viscusi[5] and Tolley et al.[4]), and has also been specifically applied to value consumer WTP to reduce groundwater health risks (see Boyle et al.[2]).

Second, it may be adequate to use as a surrogate for WTP the expected value of avoided costs of illness. In this case, one assumes that consumers are indifferent between taking a chance becoming ill and incurring the cost of illness (lost wages and medical expenses), and being risk-free and giving up income equal to the cost of illness multiplied by the probability of becoming ill. This surrogate for WTP, although often used (e.g., Harrington et al.[3]; Abdalla et al.[1]), will most likely underestimate the true WTP for risk reduction.

Revealed public preferences for water quality protection obtained through an evaluation of past referenda in specific localities might also provide an indication of community and household WTP.

Finally, a benefits transfer approach drawing estimated values from the statistical "life or limb" literature could be multiplied by changes in the probability of occurrence to approximate values.

3. *Avoided costs of treatment either by reducing or eliminating treatment in systems that would otherwise be required to disinfect.* The opportunity cost can be measured directly as the price of labor and materials which are no longer used to disinfect the water supply.

4. *More secure drinking water sources will result in fewer resources being spent to respond to illness outbreaks.* The opportunity cost can be measured directly as the price of labor and materials which are no longer used to respond to illness outbreaks. The avoided cost can be calculated as the cost of responding to an outbreak multiplied by the probability of an outbreak.

5. *Information related spillover benefits of source water protection.* Since it is not known what use spillover information will serve in the future, it is not possible to determine the value of the spillover information.

6. *Improved drinking water taste.* The ideal means to determine the WTP for a reduction in risk is to look at peoples' revealed preferences, or market choices, regarding drinking water selection. An example of these market choices might be the purchase of bottled water or water filters. However, it may be difficult to distill from these market choices an acceptable surrogate for the WTP for improved drinking water taste, as many factors, including risk reduction, may be behind these market choices. Therefore, a survey-based study, using the CVM, may be used to elicit peoples' WTP for improved drinking water taste.

7. *Existence, or nonuse, value to individuals of knowing that the groundwater is being protected.* Since non-use values, by definition, are not revealed in markets, the only means to determine the value people place on knowing that groundwater is protected is to elicit their WTP directly through the use of a survey-based approach such as the CVM.

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TASK GROUP 4

(At the GWDR Benefits Conference, Benefit 4 subsumed Benefit 6 and is presented herein; Benefit 7 subsumed Benefit 10 and is presented in the report by Task Group 6.)

A Quality Assurance Program for Maintaining the Quality of Drinking Water and Integrating Public Health Surveillance Efforts

TASK GROUP 4 CO-CHAIRS:
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Executive summary:

Good management practices for maintaining the quality and safety of drinking water obtained from groundwater will be an integral point of the GWDR. Although disinfection and/or treatment may be specified in the rule, a comprehensive quality assurance (QA) plan will be the driving force for maintaining the safety of the product in the long term. The benefit of a water quality assurance plan for all groundwater systems will be manifested in the form of fewer disease outbreaks, prevention of false alarms that result in boil water orders and greater public confidence in the quality and safety of the drinking water. In addition to a QA plan, efforts should be made to incorporate disease surveillance information into the water quality management process. The use of complementary water quality, public health data will allow a holistic approach to be taken with respect to delivering safe water.

A majority of reported waterborne disease outbreaks are associated with groundwater systems. If water utilities adopt and use a good QA plan as a result of the GWDR, there should be a lowering of the frequency of disease outbreaks. Long-term maintenance of high quality water also will enhance public confidence in water supplied by public utilities.

The economic benefits of avoidance of illness associated with drinking water are difficult to determine because good data are not available. There is, however, one study which indicates that a case of **giardiasis** in an outbreak situation costs about $3,000. This estimate implies that monetary benefits of avoidance of disease outbreaks through the use of good quality assurance practices are potentially very great.

Why benefit is important to groundwater disinfection rule:

The key to providing high quality drinking water is to establish a QA management plan based on sound scientific principles. Although the structure of the GWDR has not been decided at this point, two options have been presented as good possibilities[1]. One option would require disinfection with a provision for "avoidance criteria" which, if met, would preclude a system from disinfecting. A second option would be based on the multiple barrier concept which includes source water protection, maintaining system integrity and monitoring. In this same report the second option, the multiple barrier approach, was pointed out as being the most desirable of the two. Regardless of the approach taken in the GWDR, good management practices will have to be put into place to ensure the quality of the drinking water.

Quality control measures can be put in place at the well head, after treatment, or in the distribution system. These locations in the system lend themselves to the use of quality control chart techniques[2] and to the Hazard Analysis Critical Control Point (HACCP) strategy[3]. Control chart techniques are easily understood and simple to use. A substance in the water, such as particles, is measured over a period of time while the system is operating in control. The variability of the substance is determined. The 95 percent confidence intervals and the mean are drawn on a linear chart which is used to record each result from the assayed samples taken on a routine basis. Untoward events, such as contamination of the well from the surface or intrusion of sewage through a cross-connection, will be recorded as points which fall outside of the confidence interval, indicating the need for immediate action. The control chart procedure is also useful because trends may be observed where measures of the substance used to control the system move slowly to the confidence interval which may indicate a slow degradation of water quality. Thus, in some instances the use of control charts may have predictive capabilities.

The HACCP approach is a management strategy for operations control, as well as monitoring. Critical control points in the production process are identified. These critical points are intensely monitored for hazards or surrogates for hazards. Both of these approaches can be used to minimize the risk of delivering contaminated water to consumers. Monitoring and surveillance measures can be put in place at the wellhead, to ensure the quality of the source water, post-treatment to ensure the treatment process is working properly or in the distribution system to protect against cross-

connection events or other intrusions from the surface. In addition to monitoring procedures described above, other measures can be taken to routinely check the operation and maintenance of the treatment process. Standard operation procedures which include check-off lists would provide an additional means of assuring the quality of the water.

The standard quality control measures listed above should be supplemented with surveillance information on the incidence of water-related illness in the communities served by water utilities. Current practice has been to ignore health surveillance, and this has resulted in a situation where waterborne disease receives public health attention and resources only when disease outbreaks of sufficient magnitude create public alarm. Surveillance of endemic illness, as well as outbreaks of disease, would provide valuable feedback to alert water utilities of possible malfunctions in the water delivery system. This holistic approach, integrating public health disease surveillance efforts with water quality monitoring, should reduce to some degree the uncertainty associated with the relationship between water quality measurements and disease.

Monitoring, however, will be the most important element of the DWDR[4]. This aspect of the rule will be difficult to implement because the currently used microbial indicator, coliforms, is not adequate to meet the requirements of good QA procedures. Studies have shown that they do not predict waterborne assays[5] and that endemic gastrointestinal disease associated with drinking water occurs in the absence of coliforms[6]. Therefore, research will be needed to develop more effective means of measuring water quality.

Ideally, a monitoring system that is highly specific, i.e., identifies only fecal contamination in a reasonable volume of sample, and can be used on a continuous basis, would be highly desirable. Unfortunately, such a system is not available at this time. This problem, however, has recently been considered by a group composed of academics, state government personnel, federal government representatives and individuals from water utilities[1]. They deliberated on a number of measures of water quality including, **E. Coli**, enterococci, **Clostridium perfringens**, coliphage, PCR for pathogenic viruses, microscopic particulate analysis, pathogenic protozoa, chemical substances, total coliform, and enteric viruses. This group agreed that no indicator of fecal contamination was perfect but that some indicators might be adequate. The group decided that **E. Coli**, enterococci, **Clostridium perfringens**, somatic and male-specific coliphage should be considered and that some critical research was needed for some of these potential indicators. Their conclusions indicate that the search for an ideal indicator should continue.

An example of the benefit associated with disease surveillance efforts was reported from the state of Florida.[7] It involved a small town waterborne outbreak of dysentery. Local treatment plant personnel were informed of the situation by public health authorities and subsequently found that the disinfection process at the plant had malfunctioned. Steps were taken to correct the system. These joint actions taken by public health and water utility personnel probably prevented further cases of dysentery in the community.

The benefits of an effective quality assurance plan are four-fold.

1. A water system which is managed appropriately through the use of a good QA plan and a disease surveillance effort should be less subject to outbreaks of waterborne illness or endemic disease compared to systems that do not operate with a good QA plan.

2. Systems that are monitored and maintained with highly specific monitoring tools are less likely to be burdened by false alarms, i.e., the monitoring tool indicates the system is not in compliance when in fact it is. The December 1993 boil water order in Washington, D.C., which was initiated because of high turbidity in the system is a good example of a false alarm that was very costly and caused much anxiety in the consuming population. Fewer false alarm also means that the costs of unnecessary treatment could be avoided.

3. A comprehensive QA plan which was integrated with public health considerations would be applicable to all types of systems and broadly address risk associated with all microbial hazards.

4. A QA plan that minimizes risk of infectious disease, maintains water quality, and protects public health (coupled with public outreach programs) will increase public confidence in the quality of drinking water.

How to measure the effect(s) of the benefits:

Measuring the benefits of developing and using QA plans for drinking water obtained from groundwater is difficult because of the paucity of data relating good management to significant results with regard to health, economics, or public awareness. One reason that good data are lacking is that there is no linkage between regulatory monitoring and public health efforts. It is safe to assume that good water quality management practices and improved data management will have an effect in those areas. Most of the disease outbreaks associated with groundwaters are either related to drinking water that is untreated or to systems that have inadequate or interrupted disinfection. Between 1946 and 1980, approximately 43 percent of the waterborne outbreaks of disease were associated with groundwater (229 outbreaks)[8]. In another review that covered the period 1971 to 1977, 60 outbreaks were reported which included 5,574 cases[9]. These groundwater-related outbreaks contributed to about 49 percent of the total number of outbreaks that occurred during that time period. In another report of waterborne disease outbreaks covering the period 1991 and 1992, 26 were associated with groundwater[10]. These latter outbreaks made up 71 percent of the total number of outbreaks reported during this period. There were 4,061 cases associated with the outbreaks. The 1993-94 report of waterborne disease outbreaks indicated that 16 of 23 (70 percent) community and non-community systems using groundwater were associated with outbreaks[11]. The approximate

number of outbreaks per year estimated from the above reports is about eight. This number should be sufficient to determine whether or not good water quality management practices will make a difference with respect to fewer waterborne disease outbreaks occurring in systems using ground waters. Thus, avoidance of waterborne disease outbreaks through the use of a water quality assurance plan should be a good measure of this benefit.

Another way to measure the effects of this benefit is to record the frequency of non-compliance in each system. USEPA enforcement data in the Federal Reporting Data Systems shows that about 19 percent of groundwater systems have not been in compliance with the Total Coliform Rule[1]. Current record keeping probably does not include instances wherein non-compliance was indicated in cases where a hazard did not actually exist, but records could be kept.

Documentation of the frequency of false alarms, i.e., boil water orders, that occur in groundwater systems might indicate the effectiveness of the QA plan. It can be assumed that better water quality management will result in a decrease in the frequency of false alarms.

The most difficult measure of this benefit is the one dealing with public confidence in the quality of their drinking water. It is recognized that a QA program by itself may not increase consumer confidence; however, coupled with public outreach programs, consumer confidence can be improved. A lack of confidence may be reflected in the level of sales of bottled water but this measure has not been reported. Surveys of water consumers may be one means of obtaining bottled water use information or information on public confidence in the quality of their tap water. This approach should be taken with some caution because the use of bottled water may be associated with factors other than avoidance of illness.

How to value (monetize) the benefit:

The monetary value of this benefit can be measured in terms of avoidance of outbreaks of waterborne disease. An example is given in a study of the cost of an outbreak of **giardiasis** which occurred in Luzerne county, Pennsylvania, in 1983[12]. Three hundred and seventy cases of **giardiasis** were confirmed by the Pennsylvania Department of Health. Individual costs were calculated by looking at losses due to illness, which includes medical costs, loss of work, and loss of productivity and leisure time. Losses due to averting behavior, such as using bottled water, were also considered. The total loss for each individual affected was about $2,300. Other losses were incurred by bars and restaurants as well as other businesses such as hospitals, dentists, nursing homes and day-care centers. Losses were also incurred by schools. The total per case cost in 1991 dollars was probably about $3,000. Therefore, the monetary value of avoiding an outbreak through the use of quality assurance procedures could be calculated by multiplying the exposed population by the attack rate times $3,000. For, example, if the exposed population was 5,000 individuals and the attack rate was 50 percent, the monetary value of avoidance would be over $7.5 million.

It should be kept in mind that these costs are related to cases of **giardiasis** and may not be translatable to other diseases. **Giardiasis** is an intestinal disease with symptoms that include diarrhea, nausea, vomiting and stomach cramps. The illness may last up to 10 days. **Cryptosporidiosis** produces similar symptoms, but it has a tendency to last longer. Therefore, **Cryptosporidiosis** costs may be similar to those observed for **giardiasis**. Gastrointestinal illness caused by enteric viruses, on the other hand, usually last only two to three days. The symptoms, however, are similar and include vomiting, diarrhea, nausea and stomach ache. Intestinal infections caused by bacteria again have similar symptoms to **giardiasis** but the duration of illness usually falls between that seen for viruses and pathogenic protozoa.

The economic study of the Luzerne county outbreak does not take into account fatalities that might be associated with a waterborne disease. In addition, the economic analysis did not consider the benefits of avoiding the economical and psychological costs to the affected community, nor did it consider the benefits of additional public confidence. Similarly, the WTP for the reduction in the risk of incurring damages was not considered. It did consider cost that might be associated with non-working hours. This approach was taken because it is much easier to quantify wages and medical expenses. In all likelihood, the $3,000 value placed on a case of **giardiasis** may be an underestimate even when translated to 1997 dollars. It is, however, the only available data that will help us to monetize this value.

Other measurements of the benefit probably can be monetized but data is not readily available. False alarms that result from ineffective monitoring tools might be monetized if data could be collected. "Boil Water" orders incur costs because of emergency treatment, i.e., high concentration chlorination, consumers buying bottled water, increased frequency of scalding accidents and the need to inform the public through the electronic media. All of these factors are measurable from a monetary point of view but the lack of baseline data would probably preclude their use.

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TASK GROUP 5

Close the Information Gap on the Microbial Quality of Drinking Water to Enhance State, Local and Utility Surveillance and Regulatory Programs and to Identify the Impact and Extent of Contamination

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Executive summary:

Most surfacewater supplies in the United States serve large populations and already have pretty good water quality monitoring programs. Also, large groundwater-supplied public systems usually have good quality control programs. A much larger problem is the small public water supplies served by wells, or usually one well. These might serve a small-town trailer court, school, or other institution or isolated business establishment.

It is important to better protect these small systems from microbial contamination. And, determining the extent of contamination is the first logical step. Historically, disease prevention has been a basic function of state government, often through the political subdivisions of county and local health departments. A major thrust of the GWDR then is to assure that all states, and their political subdivisions, perform the necessary minimal surveillance and follow-up regulatory programs.

Why benefit is important to groundwater disinfection regulations:

Three steps are critical in identifying the entire national problem and not relying on case-by-case examples when a waterborne disease outbreak has already occurred:

1. A complete inventory by state and county of all public water supplies served by groundwater is a necessity. The "forest" of those systems must be identified.

2. A planned water quality monitoring program at the local and county level is necessary to determine the extent of pathogenic microbial contamination as well as indicator organism contamination.

3. A sanitary survey of each system showing pathogenic microbes or indicator organism contamination must be conducted with priority given to the former.

We are past the time of counting our public health prevention mistakes after the fact. Prevention by recognizing active or latent opportunity for contamination through adequate monitoring and surveillance is a logical thrust of the GWDR. USEPA would then have the benefits of:

- Evaluating the extent to which each state has instituted and implemented a groundwater-served public water supply protection program, be it a state health or environmental agency.

- Making recommendations to each state regarding the adequacy of their program (the rule should include elements of a minimally-approvable program) or, in the alternative, assuming federal primacy.

- Advising Congress on alternative means to attain a minimally-acceptable program within each state.

How to measure the effect(s) of the benefit:

Assuming that we do not have a complete and accurate assessment of all small public water supplies served by groundwater, an obvious measurement would be determining the total number of "trees" out in that national "forest" of groundwater-supplied public systems. A good measurement then would be the annual reporting of such inventory.

A second measurement would be an annual evaluation by the USEPA as to the number of states with "adequate" programs, based upon the USEPA's national standard for same.

Third, based on annual state reporting, the number of public groundwater supplies where pathogenic contamination has been found, and eliminated, is a good measuring device. A corollary to this is the reporting of those systems which had indicator organism contamination which was subsequently eliminated.

A fourth means of evaluating the benefit of strengthened state, local, and water-supply-owner surveillance and regulatory programs is to measure the annual reduction of waterborne disease outbreaks.

How to value (monetize) the benefit:

This is more difficult; however, there are several approaches:

Method 1

A dollar figure could be amassed for the cost of estimated future outbreaks based upon data compiled over the past several years including:

- Laboratory costs of fecal specimens.
- Doctor, hospital and other direct medical costs including antibiotics, etc.
- Lost work time (income).
- Lost school time.
- Lost leisure time.
- Legal costs and damages awarded (this is very subjective).

Based upon annual reporting of the reduction of disease outbreaks, a cost avoidance figure could be determined. Or, it could be assumed that systems corrected did prevent outbreaks, and avoided costs were estimated based upon the total number of people at risk.

The Centers for Disease Control (CDC) reported that for the year 1991-92 there were 34 reported incidents of waterborne disease outbreaks related to drinking water.[1] Twenty-six of the reported cases were from well supplies and stemmed from microbial contamination. The number of people infected was 4,042. These cases were reported from a total of 17 states and territories. What about the other 30+ states and territories?

The USEPA (Bruce Macler) has stated, "Using risk assessment approaches similar to those used for the ESWTR, an estimated 4 to 5 million illnesses per year could be attributed to consumption of groundwater from public supplies[2]." For the years 1991-92, this means that the "tip of the Iceberg" was 1/1,000 of the total berg.

For example, assume that only 4,000 of the four to five million people would seek medical attention when becoming ill from drinking "bad" water. This is quite conservative. Associated costs might include:

Laboratory ($65/stool specimen, 10% tested)	$26,000
Doctor, hospital and medicine ($200/person)	$800,000
Lost time (work, school or leisure) 5 days @ $80/day	$1,600,000
Legal costs (assume 10% of 4,000 would sue @ $100,000/person, exclusive of damages above)	$40,000,000
The costs for 4,000 people equal	$42,426,000

But, what about the costs for the other four to five million probable waterborne illnesses not reported? (Let's assume there would be a total of 4,004,000 cases.)

Assuming <u>only</u> a lost time cost of $400 per case (person), that would amount to another $1,600,000,000

The total cost then would amount to $1,642,426,000

<u>Method 2</u>

There is an avoided cost to the federal government by the strengthening of state, local and utility surveillance programs in lieu of requiring the assumption of primacy by the Feds. This brings up an interesting economic facet. How much are states, locals, and groundwater-served public water system owners now spending on surveillance? If they were not expending such state, local, and utility dollars, could the USEPA really assume primacy? Will those proposing the GWDR recognize this phenomenon? State and local drinking water protection programs are now spending unknown amounts on surveillance. How much more is needed to ensure adequate programs? Could the owners of the drinking water systems be required to pay for the necessary monitoring and reporting costs -- similar to municipal and industrial waste dischargers?

<u>Method 3</u>

Another way to approach the economics of a strengthened program would be to total how much is being spent now on monitoring/surveillance/regulation programs and how much more would need to be expended to avoid a major part of that $1.6 billion economic loss to persons becoming ill from drinking contaminated groundwater from public supplies.

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TASK GROUP 6

(At the GWDR Benefits Conference, Benefit 4 subsumed Benefit 6 and is presented in the report by Task Group 4; Benefit 7 subsumed Benefit 10 and is presented herein.)

Reduced Waterborne Disease Due to Identification of and Response to Wells that Pose the Maximum Threat to Public Health

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Executive summary:

Wells vary in potential for microbial contamination and subsequent risk of waterborne disease. Evidence suggests that 43-56 percent of all reported disease outbreaks were caused by contaminated groundwater.[1] Of the outbreaks occurring in small and non-community water systems supplied by groundwater, 77 percent were attributed to source water contamination.[2] Given that most of the 120,000 non-community water systems in the United States rely on groundwater, immediate benefits can be attained by focusing finite resources on those systems that pose the greatest public health risk from waterborne pathogens. Categorization of wells into three groups by risk of microbial contamination is based on geological setting, well construction, and proximity to sanitary hazards. The identification of "at-risk" wells or aquifers will allow remedial actions to be implemented to eliminate or reduce pathogenic exposure.

An additional benefit of this process will be the identification of low-risk wells where natural or man-made barriers to fecal contamination may negate the need for disinfection. Disinfection of only those wells identified as vulnerable to microbial contamination will reduce incidence of waterborne disease at minimal cost, reduce public exposure to carcinogenic disinfection by-products, and reduce the safety risk from transport and storage of hazardous chemicals used for disinfection, such as gaseous chlorine.

Why benefit is important to groundwater disinfection regulations:

The prevention of waterborne disease through disinfection of public water systems is the primary goal of the GWDR. Identification of wells that should be equipped with disinfection systems will help reach this goal. At the January 6-8, 1997, GWDR Workshop a two-category ranking process for "at-risk" wells was proposed. A third category of wells is proposed herein where little or no risk exists, and thus no disinfection is required. Category 1 wells are those which test positive for microbial pathogens and are not under the influence of surfacewater. Microbiological experts would be consulted regarding appropriate indicators for the presence of microbial pathogens and remedial actions. As described in the Task Group 5 report, one of the first requirements of the GWDR could be a national microbial pathogen survey of existing wells to identify Category 1 wells. Once identified, these wells would either be taken out of service or equipped with disinfection systems. The result would be an immediate reduction in public exposure to pathogens.

Category 2 wells are those considered to have a high probability of microbial contamination from any combination of a well's: (a) poor construction or maintenance, (b) close proximity to contaminant sources, and (c) location in a sensitive hydrogeologic environment. The ranking of a well in this category would depend on the number of "high-risk" criteria applying to this well. The following courses of remedial action could be taken for wells in this category: (a) abandon, relocate or improve the well, (b) disinfect groundwater prior to distribution or (c) manage or relocate contaminant sources affecting a well.

Wells that are least vulnerable to contamination because of proper well design, construction, and operation and lack of aquifer sensitivity can be classified as Category 3 wells.

Assignment of a well to a specific category will be subject to reclassification as groundwater quality conditions changes. Effective microbial source identification and remediation, for example, can cause a Category 1 well to be reassigned as a Category 2 well.

Because of the vast number of non-community wells in the country, it may be practical to perform groundwater sensitivity/vulnerability assessments (SVAs) on a regional or sub-regional basis, rather than on a well-specific basis. For less extensive areas, however, robust methods of identifying and ranking "at-risk" aquifers have been developed by the USEPA[3,4] and the American Society of Testing Materials (ASTM).[5] The following definitions have been developed by the USEPA's GWDR Hydrogeologic Discussion Group for clarification of key concepts for conducting SVAs:

Groundwater sensitivity - *The relative ease with which a microbial pathogen applied on or near a land surface can migrate to the aquifer of interest. Aquifer sensitivity is a function of the intrinsic characteristics of the geologic materials in question, any overlying saturated materials, groundwater, and the overlying unsaturated zones. Groundwater sensitivity may increase when one or more of the following conditions exist:*

- *Shallow or outcropping mature karst.*
- *Shallow or outcropping fractured bedrock.*
- *Shallow or outcropping coarse-grained deposits.*
- *Soils with extensive macroporosity.*
- *Clay soils with a high shrinking and swelling potential.*
- *Shallow groundwater table.*

Sensitivity is not dependent on land-use practices or microbial pathogen characteristics.[3] By relating population and hydrogeologic data, the number of people adversely affected by waterborne disease can be estimated.

Groundwater vulnerability - *The relative ease with which a microbial pathogen can move to groundwater or an aquifer of interest under a given set of land-use practices, contaminant characteristics and sensitivity conditions.* Other factors which affect groundwater vulnerability include well design and construction, location, inappropriate operation, condition, and improper abandonment.

How to measure the effect(s) of the benefit:

The proposed benefit received for identifying and responding to high-risk wells and aquifers is a reduction in waterborne illness. For Category 1 wells, this benefit would be measured by (1) quantifying the number of wells initially found to contain microbial pathogens or indicators of microbial contamination, (2) determining the exposed population supplied by these wells, and (3) estimating the number of preventable illnesses based on reduced pathogenic exposure. Surveys based on prior outbreaks in individual water service areas would be expected to yield the most reliable exposure vs. illness prevention data. General statistical approaches using regional public health data could also be implemented, but only as a rough approximation that may not be representative of a given area.

The quantification of preventable waterborne illnesses is more uncertain for Category 2 wells, where pathogenic microbes have not been identified but have a high probability of occurrence. This is due to the difficulty in estimating the probability that a given well or aquifer would eventually become

contaminated, thereby exposing its potable water users. The factors that affect this probability are numerous and include hydrogeologic conditions, well design and construction practices, well operation and maintenance, and proximity to contaminant sources.

Application of this benefit creates an overarching protection that affects all users of Categories 1 and 2 wells. All of these wells and the people that are served are one measure of the benefit of protection from microbial contamination. Dynamic changes in land use and sanitary hazards suggest that all Category 2 wells have a probability of contamination.

A primary benefit received by identifying Category 3 wells with adequate man-made (or aquifers with natural pathogenic) barriers would be the avoided costs for unnecessary disinfection, particularly for small and non-community water systems having limited financial resources. In addition, reduced public exposure to hazardous disinfection chemicals, such as gaseous chlorine, and to disinfection by-products will lessen potential chemical spill safety hazards and cancer cases.

How to value (monetize) the benefit:

Valuation of the benefit for identifying and responding to contaminated or "at-risk" wells or aquifers may be estimated based on avoided costs for prevented illnesses and lost work days. These monetized benefits apply to both Category 1 and 2 wells, but the uncertainty of avoided costs is greater for Category 2 wells for the reasons discussed in the previous section.

For Category 3 wells, the monetary benefits from preventing unnecessary disinfection may be based on avoiding costs for the following:

- Construction, operation, and maintenance of disinfection systems.
- Morbidity and mortality from exposure to hazardous disinfection chemicals and carcinogenic by-products.
- Consumer use of bottled water or point-of-use treatment devices due to taste and odor of disinfectants.

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TASK GROUP 7

Measuring Benefits To Future Generations

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Executive summary:

Groundwater benefits extend over time encompassing all of the benefits identified for the current generation. Intergenerational benefit estimation is inherently complicated as future choices are not represented in current decisions, and it is unknown what future preferences will be. Key tasks for this group are to: (1) make recommendations regarding the proper conduct of benefit cost analysis (BCA) over generational time scales and (2) discuss criteria for addressing intergenerational fairness through sustainability constraints. The discussion separates these issues into two areas: efficiency and equity. Responses to these issues are that:

- Economic efficiency ultimately implies the choice of the correct discount rate. The majority of the economics literature points to a social rate of time preference between zero and four percent per annum, significantly lower than that mandated by the OMB. The correct functional form for discounting may also be questioned in light of evidence that individuals do not behave consistent with "exponential" discounting.

- Equity issues question the premise of discounting and suggest alternative decision rules to BCA. Intergenerational equity implies that a minimum level of natural resource quality is bequeathed to future generations. Concern for equity can also mean a preference for time streams of costs and benefits that are more balanced even though they have less net present value. Valuation functions are needed that can include issues of discounting and equity.

Why benefit is important to groundwater disinfection regulations:

Groundwater benefits extend over time encompassing all of the benefits identified for the current generation. For instance, current improvements to drinking water systems provide an infrastructure that will generate services to future generations. Groundwater benefits may also include benefits and costs which are borne by future generations. If the GWDR entails source water protection, then

benefits to future generations may accrue in terms of risk reduction and savings to future generations from not having to clean up contaminated groundwater. Alternatively, intergenerational equity demands that we preserve for future generations equal opportunities for safe drinking water, including preserving uncontaminated aquifers and maintaining resources for water withdrawals at sustainable levels. In deciding what protective actions to take, regulatory agencies take into account benefits to both present and future generations. In taking future and present benefits into account, there are two fundamental questions: (1) What is an efficient distribution of benefit (and cost and risk)? (2) What is a fair distribution of benefit (and cost and risk)?

- Issues of Efficiency

Describing and valuing costs and benefits for future generations is difficult for a variety of reasons. For instance, it is difficult to include future choices in the description of options that are available for current decisions, and it is uncertain what the preferences and the quality of life of future generations will be. For the latter, one approach is to assume that future preferences and future quality of life will be roughly the same as current preferences and current quality of life.

We anticipate that sustainability of preferred water reservoirs will continue to be a priority given that pure freshwater resources are limited; population and industrial growth are likely to continue at a moderate pace; and, once contaminated, groundwater resources in particular are unlikely to be available (i.e., untreated) to the next generation at a reasonable cost. It may be argued that future generations may achieve levels of advanced efficiency in water use/reuse and resource identification and protection that we have yet to approach. If this is true, choices of water use preferences will still reflect the cost, availability, and quality issues which most concern users today. Inherent assumptions in this argument are:

- No "new" sources of freshwater near current/future population centers will be discovered which would be cheaper to produce and of comparable quality despite inevitable technological advances in reservoir evaluation or treatment.

- There is no substitute for pure freshwater which is essential to human and environmental health.

<u>Benefit Cost Analysis</u>

The standard decision criterion in BCA is to accept that rule for which

$$PV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t}$$

is maximized over alternative possible rules, where PV is the present value, $B_t - C_t$ (benefits minus costs in year t) is the net benefit in year t and r is the discount rate. The usual justification for this criterion is that following it leads to intergenerational efficiency. The present value criterion is a generalization of the standard BCA criteria intratemporally, when n = 1. In this case the best rule is the one that maximizes $B_t - C_t$

A net benefit of zero can be achieved by having no rule (the net benefits are measured by valuations of departures from the zero starting point). This criterion implies that for a rule to be chosen under the BCA criterion,we must have $B_t > C_t$ (otherwise no rule would be better).

In traditional BCA, distributional issues are set aside. A dollar's worth of benefits count the same no matter to whom it accrues. The same idea applies intergenerationally, once the benefits are discounted into present value terms -- one dollar's worth of benefits this year counts the same as $1/(1+r) accruing to someone else next year.

Because of this neglect of distributional fairness, BCA is generally viewed as inadequate as a complete criteria for evaluating decisions. Thus, most people agree that criteria for selecting decisions with fair distributions are essential, when there is evidence that the distributions might be unequal or unfair.

Current Values for Future Benefits: Altruistic Values, Bequest Value, Existence Values

Concerns for future generations may be expressed by the current generation in the values they reveal or state for groundwater protection. Concerns such as altruistic values and bequest values will not be captured in market behavior. The possibility of double counting non-paternalistic altruism in benefit cost analysis needs to be addressed (Lazo, McClelland et al. 1997[8]) (as does the inappropriate exclusion of paternalistic altruism). The possibility of pure existence values for groundwater protection also require special consideration and is primarily an empirical question (Fisher and Raucher 1984[3]), (McClelland, Schulze et al. 1992[10]). These values are held by the current generation for future generations and thus do not technically fit under the category of "benefits to future generations." They must be appropriately recognized and measured though as they may represent a significant portion of the values individuals have for groundwater protection (Lazo, Schulze et al. 1992[9]).

- Issues of Equity

Economists, philosophers, and political scientists find it difficult to reach a consensus on how best to specify criteria defining fair intergenerational distributions of benefits. A central idea in the literature on intergenerational equity may be summarized as follows: Present decision-makers hold a duty to ensure that the well-being, or life opportunities of future generations, are undiminished relative to the present. In a context of strong uncertainty where irreversibilities and potentially catastrophic losses could result from environmental degradation, the only way that they can make good on this duty is to maintain the integrity of natural systems. Decision-makers might, in the

interests of efficiency, substitute new technologies or produce capital for natural resources (i.e., solar collectors for lumps of coal) in cases where it was clearly in the interests of both present and future generations. But the burden of proof would fall on those advocating resource exploitation and development, and adequate compensation would need to be paid. (Page 1977[12], Bromley 1989[1])

It is generally accepted that groundwater contamination is a particular risk to the life and well-being of young children. Under this view, one might argue that society holds a duty to ensure that each child has access to clean, safe water -- i.e., that water quality constitutes a basic entitlement or "property right" that should be enforced by political and legal institutions.

In addition to the deontological approaches described above, decision-makers might employ consequentualist models for the evaluation of the options for a groundwater policy that can include an aversion toward intergenerational inequity. Such models of social preferences would allow a policy-maker to gain insight into trade-offs between equity and the other features of a policy option. A wide range of consequentualist and deontological approaches for social decisions with effects that extend into the distant future are discussed and compared in Broome and Ulph (1992[2]). There are several alternatives:

- Specify target levels of groundwater protection to be maintained over generational time. If the present generation can pass on groundwater resources essentially the same as those inherited, there will be a " world of equals" with respect to the groundwater resource base, and by being equally distributed over time the groundwater will be fairly distributed.

- Where intergenerational distributional issues are important (because the distributions may be highly unequal), it is sometimes recommended that the present value criterion be used but within especially low r (two or three percent rather than the seven percent mandated by the OMB). An objection to this approach is that it may sacrifice intergenerational efficiency without gaining much intergenerational equity (i.e., fairness) by trying to use one criterion for two purposes.

- Where intergenerational distribution of benefits and costs from groundwater contamination (and rules to protect it) may be highly unequal, it is fairly often recommended that some other compensation be paid to future generations so on balance its welfare will not be diminished by groundwater contamination. A problem with this approach is that many people believe that fairness requires preserving the future rights to specific resources, like groundwater quality.

It appears that the USEPA and other government agencies have attempted to make intergenerational fairness part of their criteria for decision-making for special assets. For example, the preservation of Yellowstone Park is not done on the basis of maximizing a present value, but monitoring this special asset is done on the basis of preserving it equally and fairly over generational time because it "belongs in common ownership" to all generations.

It appears that the USEPA has also treated groundwater resources as special assets to be kept intact over generational time, as a manner of fairness. This view is another rationale for the fairness approach, keeping special assets intact to "preserve special assets intact" to preserve a world of equals over generational time with respect to the asset's use.

If a government agency accepts criteria to ensure a fair distribution of benefits across generational time, the remaining question is how to do this while preserving as much efficiency as possible. A fairly standard answer to this last question is to choose a least cost rule which also satisfies the fairness criteria.

How to measure the effect(s) of the benefit:

- Benefit Cost Approach

The future is inherently unknown. To estimate benefits to future generations using traditional approaches of BCA, we would need to:

  - Make assumptions about future generations preferences for safe drinking water. A default approach would be to assume that future preferences (and thus values) for safe drinking water are similar to the current generation's preferences.

  - Make forecasts with respect to likely changes in benefits and costs over time. This would include forecasts of changes in population and water demand, projections of methods for treating the impacts of contaminated groundwater, and making assumptions with respect to the rate of technological innovation in groundwater protection and treatment technology.

  - Identify areas of unknown or uncertain impacts and the associated benefits and costs. Many of these are dependent on the successful implementation of groundwater disinfection regulations.

- Methods of Discounting

The value of a benefit or cost can depend on the time at which it occurs. BCA addresses this issue by assigning so-called discount weights to the outcomes at different times. Usually the discount weights are decreasing with time, but equal discount weights can be used to represent the assignment of equal value to future outcomes. For discussion, suppose that $t = 0, 1$, etc. denote years from the current time, and $d(t)$ denote the discount weights for the t.

The ratio between the discount weights for two adjacent times can be interpreted in terms of a "discount rate" for the period between the times. For instance, the ratio $d(0) / d(1)$ can be written as $1 + r$ where r is the discount rate for the first year. The present value of a one-time benefit received a year from now is the estimated net benefit in that year divided by $1 + r$. The higher the discount rate, the less value is assigned to a benefit in one year compared to a current benefit.

Two primary issues in discounting are the choice of the functional form for the discounting function and the choice of the discount rate.

Parametric Forms for the Discounting Weights

To be tractable for public policy analysis, the discount weights should belong to a parametric family of functions. Then, relatively simple assessments of social values can be used to assign the discount weights. Two alternative forms of discounting weights are constant discounting and proportional discounting.

- Discount rates that are constant from year to year are called constant discounting. For example, if benefits now are 10% more valuable than benefits after one year, then benefits after 500 years are 10% more valuable than benefits after 501 years. Constant discounting implies that the discount weights belong to the one-parameter family of negative exponential functions. Constant discounting is regarded as having the virtue of conforming to certain normative principles of economic efficiency and temporal consistency. It has the limitation that for a discount rate that seems appropriate for outcomes in the near term, very little importance is assigned to outcomes in the distant future. For instance, with a 7% real discount rate, an outcome that occurs after 200 years is 750,000 times less important than an outcome that occurs now.

- Using proportional discounting, discount weights will decrease more slowly than exponentially provided so that discount rates decrease with time. Such "slow-discounting" can be represented by parametric families of discount weights, usually called hyperbolic discounting. Conditions on timing preferences have been defined (in Harvey 1995[6]) that imply the one-parameter family of linear fractional discount weights, $d(t) = 1 / (1 + rt)$. Such so-called proportional discounting can assign appreciable importance to outcomes in the distant future. For instance, with an initial discount rate of $r = 0.07$, an outcome that occurs after 200 years is 141 times less important than an outcome that occurs now. Harvey (1994[5]) discusses economic efficiency and temporal consistency as reasons for the use of constant discounting and argues that these reasons do not apply for long-range public policy choices.

Choice of Discount Rate

- OMB Requirement of the Discount Rate: The OMB requires the use of a 7 percent real discount rate in the analysis of most federal programs. This reflects the pre-tax return on private capital. The theoretical literature, however, is clear that it is the after-tax return on assets in the appropriate risk class that is conceptually relevant. For low-risk assets (Treasury bills), the real, after-tax rate of return is on the order of one percent. The increased returns on private capital include risk premia that are, in an important sense, inappropriate to groundwater regulation. Note, for example, that the purpose of groundwater regulations is to reduce the presumed risks of an environmental harm. Since efficient regulations would reduce this risk, they might be economically attractive even if they paid comparatively low returns.

- Social Rate of Time Preference: The recent literature on discounting has emphasized that interest (and hence discount) rates are generally variable over time. In particular, there is some consensus that interest rates will fall in the future as the capital stock grows, and hence the marginal product of capital will decline. (Freeman III 1993[4]) reviews some of the literature on the social rate of time preference concluding, "I would feel comfortable using a rate of two to three percent at least where the streams of benefits and costs accrue to people in the same generation" (p. 216).

How to value (monetize) the benefit:

Traditional methods to value future services are currently being questioned. It may not be just a question of "choosing" the right discount rate. There are new approaches being considered to attain intergenerational equity in access to non-renewable and renewable resources. Two approaches have been suggested:

- Implement traditional BCA using very low discount rates to avoid disregarding benefits and costs to future generations.

- Set a constraint of sustainable safe drinking water considering projections of future generation's needs and provide flexibility for uncertainty with respect to future conditions (e.g., impacts of climate change which may have significant impacts on water resource distribution).

Regardless of the choice of interest rate, functional form for discounting, or constraints on intergenerational choice, it must be recognized that a diverse set of assumptions regarding the preferences of future generations and the endowment we leave to future generations must be made before monetizing the benefits to future generations.

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TASK GROUP 8

Improved Approaches to Developing Drinking Water Regulations

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Executive summary:

The open, participatory approach being used to discuss and develop a National Primary Drinking Water Regulation for disinfection of groundwater systems (Groundwater Disinfection Rule, GWDR) could be used to yield substantial improvements to all subsequent drinking water regulations. The ultimate benefits include enhanced public health protection, more efficient use of resources for regulatory implementation, and increased consumer confidence.

The degree to which these benefits can be measured and monetized is unclear. The measurement process most likely to provide some estimate of the value of this benefit involves an ex poste assessment based on interviews with stakeholders to learn of their experiences under the participatory approach and how this experience might have differed under the traditional closed approach. Differential costs for the approaches and contingent valuation techniques could be used to monetize the benefits.

Why benefit is important to groundwater disinfection regulations:

The GWDR is currently in development. The approach being taken for this is to emphasize egalitarian participation by all interested parties; to maintain open and complete communication; to focus on achieving public health goals; to understand the circumstances of the affected populations, utilities and states; to base the rule on best available science and technology; to consider the issues for implementation and enforcement as elements of feasibility; and, to evaluate and weigh costs and benefits. While none of these features is unique to the development of drinking water regulations, the inclusion of all of these features (and the high degree of attention to each) is unique.

A participatory approach that involves the principal stakeholders early and fully in the development of drinking water regulations offers some promise of providing both health and financial benefits relative to the more-traditional top-down approach for establishing federal regulations. Implementation of the final rules depends on the cooperation and understanding of state and local community officials and utility managers. Involving these groups in the development of the rules increases the likelihood that they will then have the will, and the means, to implement them. Moreover, broad participation in the development of the rules increase the prospect that the rules will be responsive to the varying needs and problems of different communities. The problems and preferable solutions vary widely depending on factors such as location, access to alternative sources of water, financial capacity, and the populations at risk. The participatory approach can help identify and tailor responses to meet the needs of different communities and, thereby, help reduce implementation costs and focus resources on those areas where they would be most effective in achieving the public health goals. Broad stakeholder participation is also critical to defuse public antipathy toward federal regulations and to help educate the public as to the health benefits of providing safe drinking water.

Background:

The USEPA has traditionally developed drinking water regulations using a small, intra-agency, work group approach. The majority of input into rule conception and development has resided with the Regulation Manager and those within the Office of Groundwater and Drinking Water. Typically, only limited discussion with stakeholders has occurred prior to regulatory proposal. A difficulty with this approach arises from the legal restrictions limiting the nature of responses possible to the proposal. Essentially, stakeholders are presented with a complete rule with very few options to consider. A review of drinking water regulations shows that the USEPA typically promulgates a rule with very few changes from that which was proposed. The overall effect is that stakeholders have not been able to contribute much to the development of these rules.

Another difficulty is that the issues for implementation and enforcement of the rule by States under their primacy are generally not adequately discussed nor are solutions developed by the USEPA prior to promulgation. States and utilities are put into the position of reacting to rule requirements that may not be understandable or feasible under their circumstances. As a result, the intended public health benefits may be substantially less than what is possible to achieve by a regulation, and/or may be difficult and costly to implement. For example, with the USEPA's Lead and Copper Rule, the requirements and guidance were such that many states were incapable of developing and implementing a program adequate (to the USEPA) to allow the states primacy for this rule. In several cases, the USEPA regional offices had to initiate implementation and enforcement of this rule for the state. Not only did this prove problematical for all concerned, the public health benefits achieved by this rule remain unclear.

In recent years, the "regulatory negotiation" approach has been used to help develop the Disinfectants and Disinfection Byproducts Rule. This has allowed increased stakeholder participation in the development of this rule prior to proposal, by formally identifying specific stakeholders and tasking them with their input and review. It has resulted in increased attention to many issues and details often ignored in the traditional process. It has proved somewhat limited, however, in that only those chosen (about 20 individuals representing their constituencies) may contribute at the negotiating table. Additionally, the formal structure of meetings and deliverables has limited discussion. As a result, some issues, such as implementation and enforcement feasibility, continue to be poorly considered prior to proposal.

Finally, problems have emerged as a result of the general lack of communication by the USEPA on the status, direction and content of drinking water regulations during development. States and utilities have not been able to plan ahead for anticipated requirements in these regulations. Because many drinking water regulations involve relatively large infrastructures and operational changes, forward planning of several years may be necessary to ensure funding and construction will be complete to achieve compliance by mandated dates.

How to measure the effect(s) of the benefit:

The potential benefits that might be achieved through a participatory, as opposed to a top-down, approach to developing drinking water regulations are of three types:

1. Improved public health: Better public health might result if the rules are designed to meet local problems, consistent with their capabilities to implement them, and widely supported by stakeholders.

2. Lower costs: Broader involvement in, and acceptance of, the regulatory process could help lower implementation costs by reducing transaction costs and the legal and administrative expenses that result when stakeholders are inclined to fight rather than support government regulations. This could result in higher levels of regulatory compliance. The participatory approach might also result in a more cost-effective allocation of scarce public funds, thereby increasing the public health benefits per dollar.

   More-feasible regulations will allow dollars spent on implementation and compliance to be more efficient in producing public health improvements.

3. Increased public welfare and consumer confidence: Increased communication and attention to consumer stakeholder interests may increase the public welfare, attributable to a perception that drinking water is safe and public funds are not being misused. This category includes welfare implications not already captured in the public health and cost categories.

Measuring the net benefits of the participatory approach involves comparing the public health, cost, and other public welfare implications of that approach with those of the traditional top-down approach. An ex ante evaluation of the net benefits would necessarily be extremely speculative. The absence of any actual experience with employing either approach to the development of groundwater regulation would make measures of differences in public health, costs, and public perceptions under the alternative approaches arbitrary and of questionable use.

An ex poste assessment might start from surveys of federal regulators, states, local communities, and utilities to learn of their experiences under the participatory approach and how this experience might have differed under a top-down approach. Studies of past regulatory experience, such as with the Lead and Copper Rule, might help identify some of the problems and costs that might have emerged under the top-down approach but be avoided by the participatory approach.

How to value (monetize) the benefit:

The idea of actually quantifying and then monetizing the net benefits of the participatory approach is fanciful at best. However, if we assume, as economists are often prone to do, that we have reasonable measures of the benefits, they might be monetized as follows:

- Cost savings associated with achieving a given public health benefit can be measured simply as the difference between the cost of the two approaches.

- The net benefits of improvements in public health can be valued as the avoided costs of disease and illness that result from adopting the participatory, as opposed to the top-down, approach. These costs include the value of work and leisure time lost as a result of illness (which is the marginal value of labor multiplied by the time lost due to illness), the costs of medical care, and the costs of averting actions such as purchasing bottled water and boiling tap water to avoid contaminated drinking water. These costs might be estimated directly from past experiences of illness associated with exposure to contaminated drinking water or indirectly through surveys to identify the public's willingness to pay for good-quality, reliable drinking water.

- The net benefits from regulations that have more-feasible regulatory requirements and have been structured to improve implementation and enforcement can be valued as avoided costs as well. This may appear as cost savings or as increased compliance.

- Contingent valuation techniques might be used to estimate the public's willingness to pay for improvements in drinking water.

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APPENDICES

APPENDIX A

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GLOSSARY OF ACRONYMS

ASDWA	Association of State Drinking Water Administrators
ASTM	American Society of Testing Materials
AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation
BMP	Best Management Practice
CBA	Cost Benefit Analysis
CDC	Centers for Disease Control
CVM	Contingent Valuations Method
ESWTR	Enhanced Surfacewater Treatment Rule
GWDR	Groundwater Disinfection rule
HACCP	Hazard Analysis Critical Control Point
NRC	National Research Council
NWRI	National Water Research Institute
O & M	Operations and Maintenance
OMB	Office of Management & Budget
PV	Present Value
QA	Quality Assurance
SVM	Sensitivity/Vulnerability Assessment
SWP	Source Water Protection
TCR	Total Coliform Regulation or Rule
USEPA	United States Environmental Protection Agency
WBID	Waterborne Infectious Disease
WTP	Willingness to Pay

APPENDIX C

Task Group Guidelines

Preparations for Benefits Conference

Task Groups will meet as required to prepare working reports describing the Most Significant Benefits that Should be Considered in the Development of Groundwater Disinfection Regulations
17 March 1997
Arnold and Mabel Beckman Center of the National Academies of Science and Engineering
Irvine, California

Purpose of Guidelines

These guidelines are intended to encourage uniformity of analysis for the high priority benefit reports to be submitted no later than one week before the Benefits Conference. Each specified section should be addressed as directly and succinctly as the allowable space will permit.

Source Document

The primary source document for task group deliberations will be the National Water Research Institute report titled Groundwater Disinfection Regulations Workshop. This report was prepared on 6-7-8 January 1997 and defines the priority benefits that task groups are to expand and refine in preparation for the Benefits Conference to be held on 17 March 1997.

Typeface and Margins

A formatted disk is provided. Please submit draft report on this disk using 12 point Times typeface double-spaced. Page limits given below must include all figures, tables, and graphs as well as text. Appendices will be counted as additions to the page limits specified. All appendix materials must be submitted in reproducible form.

Benefits Write-Up

Each task group will prepare their benefits write-up by providing text for the following sections:

- Executive Summary (0.5 page max.)
- Why Benefit is Important to Groundwater Disinfection Regulations (Use data to support argument, cite references where appropriate) (2.0 page max.)
- Recommend How to Measure the Effect of the Benefit (2.0 pages max.)
- Recommend How to Value (Monetize) the Benefit (2.0 page max.)
- References (2.0 page max.)

Example of How to Measure the Effect of the Benefit

Show one or more numerical examples (real or hypothetical) of exactly how to apply the measurement

method you propose.

- Theory or principal of measurement method
- Quantities to be measured
- Instrumentation required
- Accuracy of measurements required
- Sensitivity to change of measurement program
- Recommend format for measurement data

Example of How to Monetize the Value of the Benefit

Show a sample calculation of how to apply the monetizing method that you propose. If practical, relate it to the measurement example used above.

Submission Deadline

Task Group write-up will be due in the National Water Research Institute office on or before Monday 3 March 1997 so that they can be reproduced and distributed to participants before the Conference.

Illustrations and Visual Materials

Illustrations used in the text of Task Group reports should be reproducible in black and white using xerographic processes. Visual materials used by Task Groups at the Benefits Conference should be placed on transparencies for use with an overhead projector. No more than 10 viewgraphs should be used during the 10-15 minute period allowed for presentation by each task group.

If you have questions, please contact Dr. William S. Gaither, Chair, Benefits Conference at (215) 386-6800 or Ron Linsky, Executive Director, NWRI at (714) 378-3278.

APPENDIX D

GROUNDWATER DISINFECTION REGULATIONS BENEFITS CONFERENCE

Arnold and Mabel Beckman Center, Lecture Room
100 Academy Drive, Irvine, California 92715

March 17, 1997

AGENDA

6:45 AM	Bus departs from Atrium Hotel	
7:00 AM	Breakfast/Registration	
8:00 AM	Welcome and Conference Purpose	
8:15 AM	Task Group #1 -	Presentation and Discussion
9:00 AM	Task Group #2 -	Presentation and Discussion
9:45 AM	Task Group #3 -	Presentation and Discussion
10:30 AM	Break	
10:45 AM	Task Group #4 -	Presentation and Discussion
11:30 AM	Task Group #5 -	Presentation and Discussion
12:15 PM	Lunch	
1:00 P.M.	Current thoughts on the GDR - Bruce Macler	
1:15 P.M.	Task Group #6 -	Presentation and Discussion
1:50 P.M.	Task Group #7 -	Presentation and Discussion
2:25 P.M.	Task Group #8 -	Presentation and Discussion
3:00 P.M.	Break	
3:15 P.M.	Task Group #9 -	Presentation and Discussion
3:50 P.M.	Task Group #10 -	Presentation and Discussion
4:25 P.M.	Re-visit Task Group #1	
5:45 P.M.	Adjourn	

APPENDIX E

BRUCE MACLER PRESENTATION VIEWGRAPHS

The following viewgraphs entitled *Current Thoughts on the Groundwater Disinfection Rule* were used by Bruce Macler, USEPA Regulation Manager, as the visuals employed in his 1:00 p.m. talk to conference attendees.

Current Thoughts on the Groundwater Disinfection Rule

Bruce Macler
EPA Regulation Manager
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The World of Public Groundwater Systems

- 70-110 million people drink groundwater daily from public supplies
  - 4500 community systems serve >3300 people
  - 44,000 community systems serve <3300 people
  - About 55% currently disinfect in some manner
- Everyone sometimes drinks water from one of the 120,000 non-community systems
  - 20,000 non-transient non-community systems
  - 100,000 transient systems
  - Only about 28% NTNC and 17% TNC disinfect

GWDR Public Health Concerns

- GW sources, systems implicated in half of all waterborne microbial disease outbreaks
- GW systems have >85% of all coliform MCL violations
- Occurrence studies indicate that half of public wells have fecal contamination
- Public health implications unclear
  - Inadequate epidemiological data
  - Risk assessments estimate 4-5+ million illnesses/ year from GW systems

Approach to Developing GWDR Regulatory Elements

- Consider the majority of states, systems do an adequate job most of the time
  - Toughen up the details
- Make others ~~to~~ come up to speed
- Go with what works
  - Existing state regulations and programs
  - Best management practices
- Give states flexibility as appropriate, but have enforceable national criteria
- Recognize limitations and feasibility of implementation and enforcement

GWDR Status and Schedule

- Discussion activities open to all
  - Includes states, utilities and other stakeholders
- Lots of work has been done
  - Many conference calls, workshops, talks
  - 1st-cut regulatory elements evolved
  - Most research initiated
- On schedule for proposal late 1998
  - May be slowed some by new RIA, SBREFA, Unfunded Mandates requirements
- Anticipate promulgation 2001
  - Could be linked with ESWTR, D/DBPR

Intergration of GWDR with Other DW Regulations

- ESWTR
  - Some elements in common, need to be uniform
  - Many mixed GW/SW systems exist
- D/DBPR
  - Some concerns for DBPs from GW treatment
  - ICR will provide some information for GWDR
- Arsenic, Radon
  - Similar small GW system world
  - Concern for compatability of BAT options
- Source Water Protection Program
  - SWP assessments could support implementation of GWDR assessments

GWDR Public Health Goals and Regulatory Approach

- Public health goals to be achieved by GWDR
  - Prevent waterborne microbial disease outbreaks
  - Reduce endemic illness levels
- Regulatory goal is to proactively prevent fecal contamination reaching the consumer
- Regulatory appproach uses multiple barriers
  - GW protection
  - System integrity
  - Distribution system protection
  - Disinfection treatment
  - Enhanced microbial monitoring

GW Protection Elements

- Provide barrier to infective fecal contamination reaching the well
- Approach to control sources or ensure adequate natural disinfection in the ground
- Two requirements for systems achieve this:
  - Sourcewater/Wellhead Protection Program delineates area, provides attention to sources
  - Vulnerability assessment for each well considers hydrogeological barriers, estimates adequate natural disinfection

GW Vulnerability Criteria

- More Vulnerable
  - Fecal sources in recharge, capture zones
  - Less than two-year time-of-travel source to well
  - Nitrate >?ppm
  - Above confining layer
  - In rock or volcanics
  - Limited unsaturated layer
  - Positive monitoring results
- Less Vulnerable
  - No fecal sources in recharge capture zones
  - More than two-year time-of-travel source to well
  - Nitrate <?ppm
  - Below confining layer
  - In unconsolidated soil
  - Deep unsaturated layer

System Integrity

- Provides barrier to contamination at wellhead and in distribution system by ensuring system integrity
- Approach requires periodic sanitary surveys and correction of significant defects
  - Responsibility of system to have this done
  - Defects corrected or system disinfects
- States currently required to have sanitary survey program for primacy
  - 90% of GW systems already covered

Distribution System Protection

- Provides barrier to recontamination in distribution system by protecting against failures and accidents
- Approach requires systems with vulnerable distribution to maintain a disinfectant residual
- Systems must also have functional, enforceable O&M programs in place
  - Flushing, valve exercise, etc
  - Cross-connection and backflow prevention
- Alternative is either, not both

Disinfection Requirements

- Disinfection can provide a barrier at any point in the system
- Could be a general requirement or to make up for lack of other barriers
- Degree of "disinfection" important issue
  - 99.99% virus inactivation/ removal at first customer, consistent with SWTR, more expensive
  - Detectable/ measurable (chlorine) residual in distribution yields less protection, cheaper

GWDR Microbial Monitoring

- Need microbial monitoring for GWDR
  - Determine if treatment is necessary
  - Ensure protective barriers are functional
- Need virus monitoring component
  - Occurrence studies show virus contamination about 10X that indicated by total coliform/ *E.coli* tests
- Could require enhanced monitoring for systems not disinfecting
  - More frequent (at least monthly)
  - Wellhead as well as distribution system
  - Virus indicators as well as bacteria