

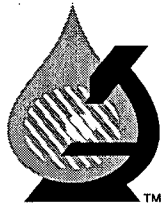
## **11. Awwa Research Foundation**

**Advancing the Science of Water**

### **Presenter**

**James F. Manwaring, Awwa Research Foundation**





## **Awwa Research Foundation**

*Advancing the Science of Water*

### **Awwa Research Foundation's Drinking Water Research Priorities**

*Prepared for  
Japan-US Conference on Water Supply and Water Resources Management  
Tokyo, Japan  
October 2002*

**James F. Manwaring  
Executive Director  
Awwa Research Foundation  
6666 West Quincy Avenue  
Denver, Colorado 80235  
USA  
<http://www.awwarf.com>**

The Awwa Research Foundation is a non-profit corporation dedicated to the implementation of a research effort to help drinking water utilities respond to regulatory requirements and traditional high-priority concerns of the industry. The Foundation serves as a planning and management function and awards research contracts to institutions such as water utilities, universities, and engineering firms. The funding for this research effort comes primarily from a subscription program. Through this program, approximately 950 water utilities voluntarily subscribe to the research program and make an annual payment proportionate to the volume of water the system delivers.

The mission of AwwaRF is to advance the science of water to improve the quality of life. The focus of AwwaRF's research is practical utility needs – technology to help water suppliers optimize operations and ensure customer satisfaction.

The Foundation's research agenda addresses a broad spectrum of water supply issues: resources, treatment and operations, distribution and storage, water quality and analysis, economics, and management. The ultimate purpose of the coordinated effort is to assist water suppliers in providing the highest possible quality of water, economically and reliably. True benefits result when utilities implement research findings. The general characteristics of the program are:

- Estimated 2002 AwwaRF research value: \$28 million
- Value of 2001 research agenda, including in-kind contributions; \$25 million
- Research funded through 2002 (with in-kind): \$258 million
- Number of research projects funded: 710
- Number of published reports: 425
- Number of ongoing projects: 285
- Number of research contractors: 250

Member utilities in the Foundation come from 48 of the United States, the District of Columbia, nine Canadian provinces, Australia, the Czech Republic, France, Great Britain, The Netherlands, and New Zealand. The population served by The Foundation's membership exceeds 175 million people.

## **Current Research Agenda**

The Foundation's planning process is designed to produce a balanced research agenda that is directed toward four goal areas:

- **High Quality Water.** Provide research to help water utilities, through effective treatment, distribution system management and monitoring, delivery high quality water that ensures public health and safety and exceeds expectations for aesthetics. The Foundation intends to invest 45 percent of its total effort in this research area.
- **Efficient and Customer Responsive Organization.** Develop and optimize organizational systems and processes that help water utilities be efficient, effective and customer responsive organizations. The planning guideline for this area is 15 percent of the total research effort.
- **Infrastructure Reliability.** Provide research to help water utilities achieve and optimize infrastructure reliability to ensure a continuous, safe and uninterrupted supply to customers. The research investment target for infrastructure is 25 percent.
- **Environmental Leadership.** Provide research to help water utilities demonstrate environmental leadership through protection and sustainable use of water resources, development of alternative water sources and proper management of residuals. The planning guideline for the Foundation's investment in this area is 15 percent.

The value of the Foundation's 2002 research agenda is expected to be approximately \$28 million, a slight increase over the 2001 level. The principal philosophy underpinning AwwaRF's research effort is that public health protection is a fundamental objective.

To accomplish these goals, AwwaRF employs a number of operational strategies including the development of national and international partnerships. These cooperative ventures serve to avoid duplicative research and stretch existing resources by coordinating activities. The type of global network also serves to identify emerging drinking water issues. The Foundation's involvement in security related research is a perfect example of the subscribers' involvement in the planning process. Based upon the membership's concern, the Foundation was involved in security research prior to the September 11, 2001 attacks. This planning allowed the Foundation

to be in a very anticipatory and responsive position. The following paragraphs qualitatively describe the basis of the research priorities.

### **Security Related Research**

Since September 11, the nation's drinking water utilities have been on a heightened state of alert to protect against the potential disruption of water service and biological and chemical contamination of drinking water supplies. Fortunately, before September 11, the water supply community was already at work to develop new methods and tools to protect water system facilities and consumers. This unique partnership was established in response to Presidential Decision Directive (PDD) 63 where EPA was identified as the lead federal agency for water supply and the Association of Metropolitan Water Agencies (AMWA) was appointed as the water sector's liaison.

Work has been progressing for a number of years, but more knowledge must be gained and disseminated on the characteristics of possible biological and chemical toxins, instantaneous and on-line probes to detect those contaminants, and remedial/preventive actions to neutralize those contaminants. Useful and practical techniques for evaluating and upgrading the security of water systems and new approaches for the design and operation of these systems, especially the drinking water distribution systems, are also critical needs. Understanding of the current threats and the development of tools and techniques to effectively evaluate the evolution of those threats must also be developed. Techniques for hardening water systems from cyber attack must be developed and installed. In short, practical research is absolutely essential to anticipate potential terrorist scenarios.

Over the last two years, AwwaRF, EPA and other water organizations have sponsored a number of research and development projects addressing water system security issues. These projects include tools for assessing vulnerabilities, preparations for response and recovery in the event of an attack, understanding the impact of potential biological and chemical agents, and training of water system personnel on security issues.

AwwaRF, in association with EPA, is funding a study to prepare a comprehensive list of security events and hoaxes at water utilities for the past ten years. These security events will also be analyzed relative to trends and common features, if any. Law enforcement or other agencies have not commonly tracked this information, and understanding of these events is critical information in properly understanding the design basis threat, related security upgrades, and possible prudent response and recovery operations for the utility.

EPA has started a project to develop a cyber vulnerability assessment component of the AwwaRF's vulnerability assessment tool. This module of the tool would allow water systems to conduct a risk-based self-assessment of cyber vulnerabilities at water facilities including process controls, SCADA, and vulnerabilities through Internet access.

EPA and the Center for Disease Control and Prevention (CDC) is developing a list of potential chemical and biological agents that could potentially be used to contaminate water systems. The report will address information on the nature of chemical and biological agents' impacts on water systems, and human health effects

Research on water infrastructure security is needed in a number of areas. . Details on both the short-term and long-term research needs are shown in Attachment #1. Water systems need to determine their potential vulnerabilities through assessment tools. The first generation of tools is emerging but advances in assessment methodologies are important. Water systems are also interested in new and innovative technologies and processes for protecting physical assets. Systems are concerned about preventing both contamination and disruption of water supplies.

As a result of advances in information technology and the necessity of improved efficiency, water systems have become increasingly automated. These advances have created vulnerabilities to cyber attacks.

Water systems are also looking at the needs for real-time monitoring and detection systems. Early detection systems may be essential in alerting water systems about potential biological, chemical and radiological contamination. Another area identified as critical to water systems'

preparation is the need for appropriate response and recovery plans. All large systems, and many smaller systems, have emergency response plans in place. However, these plans were developed to address mainly accidental spills and natural disasters such as floods, hurricanes, and earthquakes. Water systems need improved guidance and tools for updating these plans to address intentional acts including terrorist attacks.

### **High Quality Water**

Over the past ten years, microbials and disinfection by-products (M/DBP) have become the centerpiece of the regulatory development efforts of the federal government and thus, by extension, a priority of AwwaRF. Significant uncertainties remain in assessing the health risks not only of the combined use of chlorine, but also the use of alternative disinfectants such as ozone, chlorine dioxide, and chloramines.

The development of a framework for providing simultaneous protection against pathogens and DBPs gives rise to three questions:

- What are the health risks caused by exposure to microbial pathogens?
- What are the health risks caused by exposure to disinfection by-products from different treatment processes?
- How can these risks be simultaneously controlled?

The ranking of M/DBP as one of the highest research priorities is based on several factors. First, the *Cryptosporidium* outbreak in Milwaukee in 1993, in which more than a hundred people died and many thousands of people became ill, served to underscore the risks of infectivity from harmful pathogens and the vulnerability of certain subpopulations to protozoans such as *Cryptosporidium*. Second, officials have now recognized that DBPs also pose a health threat. Third, because of the high uncertainty, the widespread human exposure to drinking water, the severity of the known effects from certain microbes, and the potentially high costs of further regulation of drinking water, the combined issue of microbial risks and disinfection by-products was assigned a high priority.

Current and recent past research in the microbial area has focused largely on the protozoan pathogens *Cryptosporidium parvum* and *Giardia lamblia*. Primary areas of research include



treatment effectiveness (inactivation and physical removal methods) and analytical methods for quantifying these pathogens and determining viability and infectivity. Other microbial research has included occurrence and treatment studies for pathogenic bacteria, viruses and algae, and development of microbial risk assessment tools for water utilities.

Although it has now been more than 20 years since the discovery of chloroform and other trihalomethanes in drinking water, there is still substantial controversy and significant knowledge gaps regarding the adverse health effect of DBPs. Epidemiological studies conducted on populations exposed to chlorinated water have generally been inconclusive. Likewise, epidemiological studies of reproductive effects have been similarly inconclusive. Because of the uncertainty, knowledge gaps, and disagreements regarding the health effects of DBPs, more research is needed.

Arsenic is another chemical for which regulations are proceeding without a complete scientific understanding of the treatability of this contaminant. Work is continuing on cost effective and efficient treatment systems for small communities and for waste disposal techniques.

Pesticides are a general class of chemical compounds that are the topic of several research projects. The issues surrounding this class of compounds which can be addressed by research are:

- occurrence and levels of occurrence;
- sources of contamination;
- best means of control;
- detection methodology; and
- health risk of single compounds and/or mixtures of compounds.

In the United States, pesticides, herbicides, and fungicides are applied at a rate of more than 1.1 billion pounds per year. The obvious concern is the potential contamination of the surface water and groundwater from the pesticides and their degradation products. National occurrence studies conducted to date have detected pesticides in drinking water but the levels rarely (less than one percent of the samples) exceeded drinking water guidelines.

Volatile and semi-volatile organic contaminants, such as fuel-additives, solvents, degreasers, and plasticizers, are becoming more of a drinking water issue; and issue that must be addressed by research. A major research effort has begun on MTBE, the gasoline additive, because of its widespread detection in both surface water and ground water. Other sources of contamination of this class of compounds include leaking storage tanks, landfills, and industrial discharges. Little is currently known about the health risk of these compounds and their effective control or treatment.

AwwaRF has spent a great deal of time and effort researching the compounds in drinking water that produce objectionable taste and odors. While such compounds do not constitute a direct health risk, their presence contributes to customer dissatisfaction and may reduce the consumer's confidence in the water quality. These compounds are regulated under a set of secondary standards which relate to the esthetic quality of the water. The sources of the taste and odor compounds are varied and may include algae in the source water, leaching of material from, or biological activity in, the distribution system, the use of disinfectants, and leaching from household plumbing. The causative agent for taste and odor episodes are very difficult to identify and the events may be short-lived and localized.

### **Infrastructure Reliability**

It has been estimated that eighty-five percent of a water utility's assets are infrastructure – the treatment plants, storage tanks, and distribution system. A needs survey by AWWA has concluded that the near future rehabilitation and construction needs for the water industry are in the neighborhood of \$325 billion. It is also apparent that the water quality at the consumers' tap is strongly influenced by the utility's infrastructure. With so much at stake, it is no surprise that this area is one of the primary research topics for AwwaRF. AwwaRF has managed 107 applied infrastructure research projects valued at \$37 million since 1983. Half the research has been initiated in the past five years. The projects cover materials selection, emerging technologies, water quality management, structural integrity assessment, asset management, and operations and maintenance.

Improved management techniques have been promoted through Foundation-sponsored research on asset management. These include designing capital planning strategies, scheduling and prioritizing main replacement and repairs, and forecasting potential problems and their consequences. Cost savings and reduced inconvenience for customers are being realized through the development of new technologies for infrastructure repair and replacement. These include “no-dig” technologies, new relining methods, selecting suitable new pipe materials, and water main life extension.

Based upon several case studies, the average large utility has experienced benefits equal to \$1 million per year, from the application of the results of the infrastructure research. Research in technology and management reduces costs, increases productivity, protects public health, and enhances water quality. By ensuring a safe and reliable supply of water, infrastructure research is part of the foundation on which prosperity is built and sustained.

### **Efficient and Customer Responsive Organization**

The change in the management and organizational philosophy within utilities will be a major factor in shaping the future of the U.S. water community. Water utilities are beginning to adopt “best practice strategies” to make themselves more efficient. Planned maintenance, work force flexibility, employee empowerment, continuous improvement, and customer interaction are only a few of the organizational concepts being employed in order to increase productivity and improve customer confidence. AwwaRF has an active research agenda on several management aspects of drinking water.

Planned maintenance has been shown to save money, up to a point. The data available from water utilities in the U.S. indicates that optimum maintenance is 70 to 80 percent planned with the remainder being reactive. Utilities are decreasing operational costs by providing a base staff to do the planned maintenance and importing staff to do the reactive maintenance. Total productive maintenance means that the entire staff is working on planned maintenance work and that specialists are imported only when needed. Studies have shown that combining reactive and planned maintenance improved productivity over 50 percent.

Likewise, workforce flexibility reduces maintenance waiting time, saves money and enhances morale among the employees. Operational costs are reduced dramatically when employees are trained to be multifunctional. To accommodate this type of flexibility, it is essential that the utility utilize some type of skill-based compensation.

It is evident that hierarchical organizational structures are rigid and slow to change to meet new responsibilities. New organizational strategies that focus on empowered employees; a team approach to problems and opportunities, and a streamlined structure can increase the competitive stature of water utilities.

AwwaRF's management research includes a diverse range of topics that together help utilities improve efficiency, obtain optimum water quality and improve system reliability. A large amount of research is devoted to process development and management, including conventional process optimization, advanced process testing and development, and energy management. Another area of significant study is process automation and optimization through the use of control systems and on-line monitoring.

Since the ultimate judge of the success and applicability of AwwaRF's research effort is the consumer, a portion of the research agenda is devoted to helping utilities interact with their customers. Projects in this area are designed to provide the utility manager with tools necessary to identify customer needs, encourage their consumers' participation in the decision processes operating in the utility and communicating with the public about important issues.

Customer satisfaction is quickly becoming the key driving force behind the modernization of water services. Progressive water utilities have adopted proactive customer relations to identify exactly what consumers want. Planning, development and utility direction are designed around those customer needs. This focus will lead to increasing customer confidence.

The primary research topics under this goal area are: (1) customer perception, communication and education, and (2) aesthetics issues (taste, odor and color), including causes and control.

Work has also been completed on managing rate structures and on the cost/benefit of supplemental services and products offered by water utilities.

### **Environmental Leadership**

The water supply community is well aware of its position within the global environment. The future supply of dependable and safe drinking water is heavily dependent upon the quality of the watersheds and the operation of water utilities must have a minimal impact upon other uses of the environment. Research into watershed practices must proceed if optimal usage of this precious resource is going to be balanced among the numerous demands. Likewise, the by-products of water utility operations must be handled and disposed of in such a manner that will maintain, or even enhance, current environmental uses.

Recent work has focused on source water quality treatability impacts and associated cost to utilities. AwwaRF has sponsored an increasing amount of work in the past several years on wastewater reuse and reclamation. Recent studies have also been completed in the areas of residual management and minimization, water conservation, desalination, demand management, and control of invasive biota such as zebra mussels and non-native plant species.

### **2002 Research Direction**

This year AwwaRF will fund approximately 75 new studies. Many of the new projects will address issues of current important to water utilities, such as security, monitoring techniques, filtration optimization, ultraviolet disinfection, microbial quality, membrane technology, distribution system water quality and reliability, watershed protection, management issues, and customer relations. Area of potential future concern will also be examined with studies on early warning systems, the value of water, and water recycling.

Attachment #2 contains a description of the Foundation's general research priorities and a listing of the specific projects being sponsored in 2002. The agenda is separated into the Foundation's four planning areas and includes the planned priorities for 2003.

## **Research Expenditures**

In the United States, water utilities expend approximately 0.12 percent of their annual revenue on research. About one-half of that amount is for AwwaRF's centralized program and the remainder is for local issues and research concerns.

By contrast, the French water companies expend about 0.7 percent of their annual revenue on research, while the British companies have been estimated to use 0.5 percent. However, it should be noted that these are private water companies and some of this research investment is designed to produce products and processes that will provide a competitive advantage.

When compared to other industrial sectors, the water industry's expenditure on research is relatively small. The gas and electric utilities spend about one percent on research while the pharmaceutical industry expends almost nine percent.

Industry-sponsored research is absolutely essential to ensure a national balance between regulatory studies and operational research designed to address the practical issues of utility management. Governmental research has a strong emphasis on basic principals and regulatory concerns. Industry research is much more directed to process development and for providing operational tools and understanding.

## **Summary**

Future water utilities will be shaped by several, interdependent factors that will include, but certainly will not be limited to, technology, regulation, competition, consolidation, political pressures, and consumer satisfaction. An active research program is essential to help plot the most effective and efficient path through the myriad of alternatives and to help integrate the current systems with the future technologies.

The exact result of all of these interconnected forces cannot be accurately predicted, but what is apparent is that future changes will be global. The water community has become a global entity where changes on one continent are felt on all of the other continents. One of AwwaRF's primary goals is to participate in an international effort to globalize research strategies on a

number of common issues. Research agencies must aggressively seek opportunities for cooperation and leveraging of resources. Partnerships not only extend limited resources but also serve to cross-pollinate different research cultures, technologies and approaches.

**AwwaRF  
Research Priorities  
Security Related Issues for Water Supply Systems  
September 2002**

A substantial investment is needed for water infrastructure security research to address potential vulnerabilities at drinking water and wastewater systems. Research is needed to address three fundamental areas of vulnerabilities for water systems: physical vulnerabilities including disruption of flow and contamination by chemical, biological, or radiological agents; “cyber” vulnerabilities including process control equipment, Supervisory Control and Data Acquisitions (SCADA) systems, and other information systems; and vulnerabilities associated with interdependencies with other critical infrastructure sectors such as energy, telecommunications, transportation, and emergency services. Specific areas of research needed include: vulnerability assessment tools; technologies and processes for protecting physical assets, and information and process control systems; training, education, and awareness programs; information sharing tools; demonstration projects; real-time monitoring and detection systems; and response and recovery plans.

**Immediate Priorities**

The following projects were identified by an AwwaRF issue group in May 2002 as areas needing research attention over the next 2 to 3 years. Progress has already been made in responding to many of these priorities.

- **Utility-Relevant Information on Contaminants That Are Candidates for Purposeful Water Supply Contamination:** This is a phased project with the goal of ensuring that a central repository, accessible by drinking water utilities on a need-to-know basis, is created that provides accurate and actionable information on contaminants that could be used for purposeful contamination of drinking water.



- **Inventory and Assessment of Analytic Capabilities of Existing Monitoring Technologies for Use as Early Warning/Real-Time Systems Technologies:** This project would update and build on information from previous work on early/real-time warning system technologies. This project would include three primary steps: selection criteria for monitors, market assessment (what's out there and available), and assessment of the sample/capture/concentration/extraction methods of the various available technologies.
- **Extraction Methods for Early/Real-time Warning Systems for Biological Agents:** Screen 3 to 5 different water extraction methods for biological agent surrogates, and test the best method on actual bio-terrorism agents.
- **Standard Operating Procedures for Decontamination of Tainted Distribution Systems:** Provide utilities with practical, contaminant-specific best practices guidelines for how to decontaminate a distribution system and return it to safe use when contamination is known or suspected to exist in the distribution system.
- **Develop or Refine Models/Methods for Distribution System Monitoring to Detect Introduced Contaminants:** Develop (or upgrade/verify existing) models and methods for monitoring and projecting the fate and transport of potentially introduced contaminants in water distribution systems.
- **Lessons Learned from Initial Water Quality Vulnerability Assessments:** This project is designed to capture lessons learned and provide a forum for information exchange on vulnerability assessments conducted by the large drinking water utilities.
- **Vulnerability Assessment Template for Medium and Small Systems:** Develop an easy-to-use, intuitive, and scale-appropriate methodology for utility operators to characterize and assess the vulnerability of medium/small systems to a variety of terrorist (and other security-related) threats.
- **Primer on Security Best Management Practices:** This project will provide utility managers with a comprehensive, easy-to-use primer on “best practices” for security-related elements of utility operations.
- **Scenario Development and Training for Emergency Response Planning:** This project would build upon existing emergency response guidance and practices (AWWA Manual M19, USEPA *Emergency Response, Recovery & Remediation Actions to Man-Made and/or Technological Emergencies*, April 2002, etc.) to provide utilities with more security-oriented,

detailed, and specific materials with which to develop, test, and enhance their emergency response capabilities.

- **Security Implications of Innovative and “Unconventional” Water Provision Options:** To provide utilities with a security-oriented evaluation of alternative water supply provision options.
- **Guidance on Security-Related Utility Communication with the Public and Other Key Stakeholders:** This project would create a template or scripted set of pre-tested warnings and instructional messages to be communicated to the public; local, state, and federal emergency agencies; medical professionals; media; and other key stakeholders.
- **Assessment of Security Technologies:** This project would provide useful, needed information on commercially available security technologies and products so that utilities can make smart choices on what devices or systems to acquire/deploy to ensure the physical security of their facilities.

### **Long-Term Priorities**

The following are some examples of the longer-term, multiple-phase research objectives for the water supply industry.

- **Miniature Liquid Chem Lab.** A prototype portable analysis unit for the analysis of biotoxins likely to be used by terrorists that mimics the capability of a large laboratory instrument in a low-cost, hand-held package has been developed. By further reducing the size of the unit, it could be made applicable as part of an early-warning monitoring system in municipal water supply systems. Expansion of the analytical capabilities of the instrument beyond biotoxins to other toxins such as arsenic, heavy metals and pesticides could also be accomplished.
- **Gas Chromatograph on a Silicon Chip.** A prototype miniature gas chromatograph and detector on a silicon chip has been developed. The unit is presently configured for gaseous chemical agent detection. However, its capabilities can be expanded as an analytical instrument for other toxic compounds. By expanding the capabilities of this system, it could be used as a low-cost real-time detector for volatile organic compounds as a part of an early warning system in a municipal water distribution system.

- **Nanoelectrode Analysis System.** A chip-based micro-electrode system that can be used for the analysis of various inorganic toxic species in water such as cyanide, arsenic, lead, and chromium that might be encountered in a municipal water supply is being developed. Additional work would concentrate on the development of low-cost, low maintenance electrode analysis systems that could be easily deployed in a large network of interconnected sensors within a water distribution system.
- **Simple Solid State Sensors.** Low-cost sensors such as chemiresistor sensors and surface acoustic wave sensors based on microchip technologies that can effectively serve as hydrocarbon or other chemical spill detectors have been developed. Additional research would be used to optimize the performance of these sensors and package them in such a way that they could be included in an early warning system for a municipal water supply system.
- **DNA-Chips.** Considerable progress has been made in the development of DNA-chips, which have been used to detect specific microbiological pathogens in water using genetic information. Such a capability is desirable since biological agents in a water supply system would occur alongside other no-hazardous organisms. The ability to differentiate between organisms type in real-time would be desirable from an early warning standpoint.
- **Systems Integration.** Many different types of sensors have been developed that can detect a chemical or a class of chemicals, but they are not integrated into one, knowledge based system. A system integrator is needed to miniaturize and integrate multiple sensors into one system.

**AwwaRF's Research Priorities**

The following paragraphs describe the Research Foundation's priorities for the four planning areas of the strategic plan. The general programmatic priorities are followed by a listing of the actual projects funded in 2002 in that goal area and the planned topics for next year.

**High Quality Water**

**Mission:** Provide research to help water utilities, through effective treatment, distribution system management, and monitoring, deliver high quality water that ensures public health and safety and exceeds expectations for aesthetics.

**AREAS OF STRATEGIC EMPHASIS**

Emerging Contaminants: The research strategy for emerging contaminants includes occurrence surveys, fate/transport studies and refinement of analytical detection methods (particularly for microbials). Emerging contaminants of concern include pharmaceuticals/endocrine disruptors, pathogens, nitrosamines, and industrial contaminants such as perchlorate. The results of our research, along with those from ongoing health effects work being done by others, will be used to support pragmatic water quality regulations and assist utilities in complying with future regulations.

On-Line Monitoring: Upcoming research is focusing on two primary areas: Reliability and optimal usage of existing (established) instruments, and development of new capabilities for early warning and improved operations. An eventual objective of this research area is to support regulatory approval of on-line monitoring data in lieu of fixed laboratory results for compliance purposes.

Advanced Treatment Technologies: Our work on non-conventional treatment technologies includes multi-year research agendas for membrane treatment and UV disinfection. Research on these technologies is relatively mature, having advanced from proof-of-concept and optimization studies to current and planned work on scale-up and integration into existing treatment systems. Key objectives of our work in this area are to promote regulatory confidence in and acceptance of these technologies for drinking water applications, and to provide utilities with practical tools for evaluating and implementing them.

## 2002 PROJECTS

- A Rapid Ammonia-Oxidizing Bacteria Measurement Method As An Early-Warning Indicator Of Nitrification Episodes
- Application Of DNA Microarray Technology To Simultaneously Detect And Genotype Isolates Of Escherichia coli O157:H7 And Cryptosporidium parvum In Water
- Application Of Hazard Analysis And Critical Control Points For Distribution System Protection
- Assessment Of Seasonal Chlorination Practices And Impacts To Chloraminating Utilities
- Characterization Of Particles In Filter Effluents
- Chloroacetamide Herbicides And Their Transformation Products In Drinking Water
- Development Of Distribution System Optimization Plans
- Dissolved Organic Nitrogen (DON) In Drinking Water And Reclaimed Waste Water
- Early Detection Of Cyanobacterial Toxin Using Genetic Methods
- Evaluating Alternative Data Gathering Methods For The 1999 Disinfection By-Product Field Study
- Evaluation Of MIEX Process Impacts On Treated Water Quality For A Range Of Raw Water Supplies
- Evaluation Of Pathogen Transport In Karst Flow Zones Of The Biscayne Aquifer Near The Northwest Well Field, Miami-Dade County, Florida
- Evaluation Of Triclosan Reactivity In Chlorinated And Monochloraminated Waters
- Geochemical Controls On Chromium Occurrence, Speciation, And Treatability In Groundwater
- High-Silica Zeolites For The Removal Of Polar Organic Contaminants From Drinking Water - Development Of A "Green" Adsorption/Regeneration System
- Impact Of Chlorine Dioxide On Transmission, Treatment, And Distribution System Performance
- Impact of UV And UV Advanced Oxidation Processes On Toxicity Of Endocrine Disrupting Compounds In Water
- Integrating Membrane Treatment In Large Water Utilities; Investigating Treatment, Construction, And Cost
- Integrating UV Disinfection Into Existing Water Treatment Plants
- Linking Geographic Water Utility Data With Study Participant Residences Included From The National Birth Defects Prevention Study
- Methods For Real-Time Measurement Of THMs And HAAs In Distribution Systems

- Molecular Methods For Microsporidia Detection (MMMD)
- Occurrence Of Manganese In Drinking Water And Benefits Of Enhanced Manganese Control
- Optimization Of MF/UF Membrane Treatment For Direct And Clarified Water Filtration
- Optimizing Molecular Methods To Detect Human Caliciviruses In Environmental Samples
- Physical And Numerical Modeling Of Mixing In Water Storage Tanks
- Predictive Models For Water Quality In Distribution System
- Qualitative Procedures For Identifying Particulate Matter In Distribution Waters And At The Customer's Tap
- Removal Of Contrast Media
- Risk Based Prioritization Of Disinfection By-Products
- Standardization And Verification Of The MFI-UF To Measure Fouling Potential
- The Feasibility Of Allelochemicals As A Means To Control Toxic Cyanobacterial (Blue-Green Algae) Blooms In Water Bodies
- Treatability Of Algal Toxins Using Oxidation, Adsorption, And Membrane Technologies
- Treatment Of Elevated Organic Content Waters
- Use Of Membranes For Diffusion Of Ozone In Contactors
- Water Quality Implications Of Large-Scale Application Of Seawater Desalination
- Watershed Sources And Long-Term Variability Of Biodegradable Organic Matter And Natural Organic Matter As Precursors

### 2003 PRIORITIES

- DBPs (health effects, occurrence, monitoring, modeling and predicting formation, precursors)
- Organic nitrogen detection and control (Nitrosamines / NDMA)
- Distribution system water quality (biofilm control, pathogen intrusion, monitoring, operation/management)
- Organotin
- Manganese
- Pesticides
- Pharmaceuticals / Endocrine Disruptors / Personal Care Products
- Radionuclides
- VOCs
- Pathogens (viruses, bacteria, *Cryptosporidium*)
- On-line monitoring
- UV
- Membranes
- Taste and Odor

## **Efficient and Customer Responsive Organization**

**Mission:** Develop and optimize organizational systems and processes that help water utilities be efficient, effective and customer responsive organizations.

### **AREAS OF STRATEGIC EMPHASIS**

Strategic Management: Recent and upcoming management research focuses on developing new business strategies and applying modern business tools and techniques to the water utility business. This area of research will help utility managers develop business strategies that respond to the unique needs of their regional customer base. It will also help utilities assess the merits of modern private sector business practices for public and private utility business and tailor these for specific utility and customer needs.

Human Resources and Labor Management: With the recognition that we have an aging workforce and a changing utility business due to globalization, technological advancement, etc. the Foundation is funding a wide range of ongoing and upcoming projects on topics such as workforce planning, succession planning, labor relations, and business strategies that add value to human resource management. As the utility industry moves away from command and control management models, the Foundation is providing modern tools and strategies for planning and interacting with a modern and changing workforce.

Security and Crisis Management: The Foundation has been on the forefront of this recent and important trend in business and facility management. Beginning at the turn of this century, the Foundation was proactively responding with research to subscriber requests to ensure the protection of critical water utility infrastructure. This area of research also includes numerous ongoing and upcoming projects on disaster/emergency response, infrastructure design technology that optimizes security, infrastructure viability during natural and other disasters, security and disaster planning and response, and so forth.

Customer Perceptions and Communication. A considerable amount of ongoing research is focused on providing better understanding of customer perceptions and attitudes toward drinking water providers. A newer and related area of research is in the area of customer communication such as an improved understanding of how customers react to information and communicate with businesses. Customer communication research will help utilities develop methods and tools for reaching out to their customers and communicating on difficult topics such as water rates, drought related water restrictions, etc.

### **2002 PROJECTS**

- Asset Management Planning And Reporting Options For Water Utilities
- Customer Acceptance Of Infrastructure Reliability
- Enhancement Of Water Treatment Plant Infrastructure Assessment Manager
- Extraction Methods For Early/Real-Time Warning Systems For Biological Agents

- Identifying, Understanding, And Addressing The Technical And Societal Issues Associated With Implementing Chloramination
- Impact Of CCRs And Emerging Issues Communications On Customers
- Implementing An Artificial Intelligence System For Real-Time Automatic Control Of A Full-Scale DAF Water Treatment Plant
- Inventory And Assess The Analytical Capabilities Of Existing Monitoring Technologies For Use As Early/Real-Time Warning Systems, Phase I
- Lessons Learned From Initial Water Utility Vulnerability Assessments
- Pipeline Net Validation
- Stakeholder Perceptions Of Utility Role In Environmental Leadership
- Strategic Planning And Organizational Development For Water Utilities
- Succession Planning For A Vital Workforce In The Information Age
- Utility-Relevant Information On Contaminants That Are Candidates For Purposeful Water Supply Contamination
- Vulnerability Assessment Template For Medium And Small Systems
- Water Utility Collaboration With The Health Community To Enhance Communications On Drinking Water Issues

## 2003 PRIORITIES

- Customer Care
- Emergency Management
- Workplace Health and Safety
- Information Technology
- Risk Mitigation
- Communication and Public Affairs
- Regional Consolidation
- Strategic Planning
- Workforce Planning

### **Infrastructure Reliability**

**Mission:** Provide research to help water utilities achieve and optimize infrastructure reliability to ensure a continuous, safe and uninterrupted supply to customers.

## AREAS OF STRATEGIC EMPHASIS

Non Destructive Assessment and Rehabilitation: Considerable emphasis has been placed in the drinking water industry in recent years on non destructive techniques for pipe condition assessment, rehabilitation and maintenance. This topic would continue to be emphasized in



future years as the water utility industry grapples with ways to optimize programs and resources for renewing distribution system infrastructure.

Long-term Materials Testing: Beginning in 2001, the Foundation developed a multi year research plan to commence with materials research and testing to assess the long term viability of many of the common and new materials used in water treatment infrastructure. Substantial emphasis will be given to buried infrastructure such as pipes, gaskets, valves, and so forth.

Management of Distribution System Water Quality: This topic area has been emphasized throughout the Foundations history and will continue to be featured in much of the upcoming research. Work in this area has shifted considerably to the assessment of whether there is a potential for contaminant intrusion into drinking water distribution systems and how to manage such events. Other water quality research focuses on the manner in which potentially harmful chemicals may change or react with other chemicals within the distribution system.

## 2002 PROJECTS

- Criteria For Valve Location And System Reliability To Optimize Continuity Of Water Supply
- Long Term Performance Prediction For Polyvinyl Chloride Pipe
- Multi-Utility Buried Pipes And Appurtenances Location Workshop
- Non-Disruptive Tools For Remaking Connections After Pipe Rehabilitation
- Performance Of Water Supply Systems In The February 28, 2001 Nisqually Earthquake
- Risk Management Of Large Water Transmission Mains
- Workshop On Non-Interruptive Condition Assessment Inspection Devices For Water Transmission Mains

## 2003 PRIORITIES

- Water Loss
- Distribution System Security
- Service Pipe Issues
- Life Expectancy of Pipe Materials and Linings
- Rehabilitation Prioritizing and Techniques
- Water Treatment Plant Infrastructure
- New Construction

## **Environmental Leadership**

**Mission:** Provide research to help water utilities demonstrate environmental leadership through protection and sustainable use of water resources, development of alternative water sources and proper management of residuals.

### **AREAS OF STRATEGIC EMPHASIS**

Sustainable Water Supply: There are few remaining untapped sources of high quality water in the world, and watershed management technology has shifted over time to water supply sustainability and source protection. The Foundation is funding and will continue with projects that look at management of sustainable supplies by looking at regional watershed and utility management models, economic models for water supply, water wheeling, source protection, and related topics.

Water Utility Leadership in Management of Environmental Resources. In response to subscriber requests, the Foundation recently changed the water supply research goal to emphasize utilities as leaders in environmental management. New Research in this area focuses on stakeholder perceptions of a utility's role in environmental leadership, regional leadership in the protection of sensitive species and habitat, and decision support tools that will help water utilities build a prominent and influential role within their supply regions.

### **2002 PROJECTS**

- Advancement Of Early Warning System Technologies
- Decision Support System For Sustainable Water Supply Planning
- Development Of Effective Communication Tools Regarding Current Information On Reverse Osmosis/Nanofiltration(RO/NF) Concentrate Issues
- Innovative Treatment Alternatives To Minimize Residuals Containing Nitrate, Perchlorate, And Arsenic
- Monitoring Of BMPs To Determine Performance And Whole-Life Costs
- Producing New Potable Supplies from Seawater Desalination
- The Value Of Water In A Changing Economy
- Understanding Public Concerns And Developing Tools To Assist Local Officials In Planning Successful Potable Reuse Projects
- Use Of Water Treatment Residuals To Reduce Soil Phosphorus Loss And Protect Surface Water Quality: An Interregional Study

## 2003 PRIORITIES

- Global Climate Change
- Cooperative Water Quality Management with Agriculture Industry
- Alternative Water Sources/Regionalization
- Aquifer Storage and Recovery
- Early Warning Source Water Monitoring
- Environmental Management Systems
- Endangered Species Act Compliance
- Groundwater Vulnerability/Contamination
- Residuals/Waste Management
- TMDL
- Wet Weather Impacts
- Conservation

*Ela\Jim 2002\Japan Oct 2002*



## Awwa Research Foundation

*Advancing the Science of Water*

Future Research Priorities  
of the  
U.S. Water Supply Community

**James F. Manwaring**  
Executive Director

## About AwwaRF



**Mission:**  
*Advancing the science of water  
to improve the quality of life*

- Centralized research program
- 1,000 subscribers
- Focus on Water Utility Needs
- Research Contracted
- Diverse Agenda

## AwwaRF Security Research

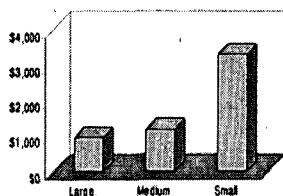
- Biological and Chemical Contaminants
- Real-time Monitors
- Cyber Vulnerability
- Management Strategies

### Seven Utility-Defining Macro-Trends

#### **1. Infrastructure management will become key**

- Quantify and articulate needs now
- Involve the community
- Explore private investment where needed
- Involve nontraditional stakeholders

## Average Household Cost for Infrastructure



*Small systems will be significantly impacted. Consumer rate shock is very likely in many communities. Rate resistance may foster political upheaval.*

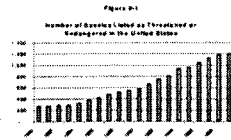
Figure 9.3: Average Cost Per Household to Meet Water System's 20-Year Infrastructure Need (Total Need in January '95 Dollars)  
(Source: USEPA, 1997)

### Seven Utility-Defining Macro-Trends

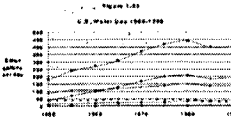
#### **2. Environmental regs will become more stringent**

- Explore new water delivery approach
- Develop partnerships with stakeholders
- Develop options to make Ag water available
- Convene stakeholders to address national environmental policy "disconnects"

## Water Diversion and the Environment



Source: Division of Endangered Species, U.S. Fish and Wildlife Service, May 2000.

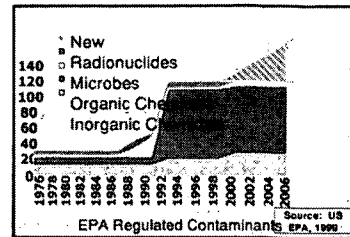


Source: USGS, Estimated Use of Water in the U.S. In 1990, Trends in Water Use

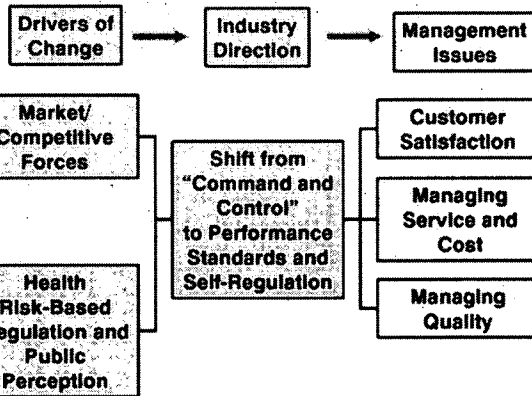
**Endangered species issues will become increasingly complex.**

**Population pressure (in the absence of conservation) will increase the need for additional water supplies.**

## Consumer Confidence



Regulations will continue to expand. Analytical methods have outstripped our ability to understand health risks. "Safe" water is a relative term. Bottled water & point of use device sales continue to rise. Regulators & utilities continue to debate the cost/benefit of drinking water regulations. Consumers are in the middle.



### Seven Utility-Defining Macro-Trends

#### 3. Water utilities will continue to restructure

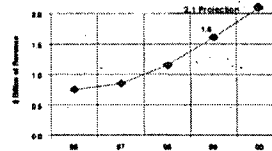
- Remove structural impediments to efficiency and satisfying customer demands
- Maintain oversight of water in public sector but accommodate private sector
- Increase regional water management
- Encourage water markets

### Seven Utility-Defining Macro-Trends

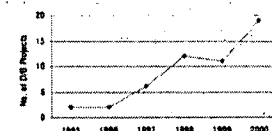
#### 3. Water utilities will continue to restructure (continued)

- Establish national water policy on Ag, demand management & pop/growth management
- Investigate consolidation into multiservice utilities
- Establish clear service delivery accountability in restructured utilities
- Consider changes in federal law and other policies to attract capital

## Service Alternatives



US Water/Wastewater Outsourcing Revenue (Contract Operations) (Source: PWFinancing, March 2000)



D/B Water and Wastewater Projects (includes studies or plans in process; Source: PWFinancing, February 2000)

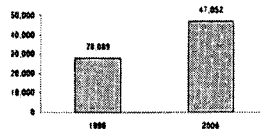
**Outsourcing & design/build contracts have grown and are expected to continue to. The rate of growth will likely be driven by local economic and political conditions.**

**Seven Utility-Defining Macro-Trends**

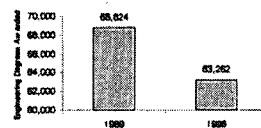
**5. The work environment will be transformed**

- Establish a workforce planning and development program
- Develop aggressive program to recruit/retain staff
- Offer competitive compensation packages and creative incentives to keep best and brightest
- Share info with employees
- Work for stable board/management relationships

**Human Resources**



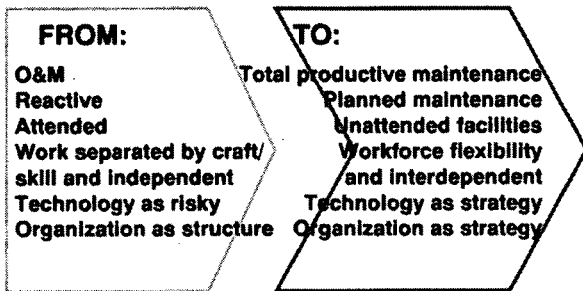
Growing Demand for Engineers (Source: Bureau of Labor Statistics, 1999-2008)



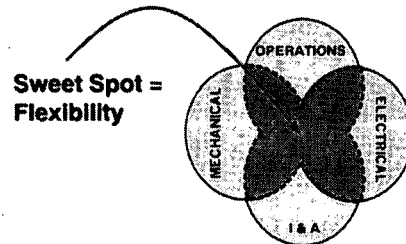
Decline of Engineering Degrees Awarded to Science and Engineering Graduates (Source: Benaimon, Helen Frank, January/February 2000)

*Finding technical staff will be increasingly difficult and utilities will increasingly compete for talent.*

**Adopting Best Practices Strategies Makes You Competitive**



**Cross-Training Increases Productivity by 20 Percent**

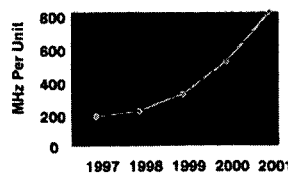


**Seven Utility-Defining Macro-Trends**

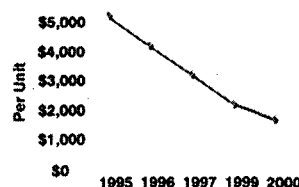
**6. Application of technology will grow**

- Install automation to reduce labor, save chemicals and energy
- Integrate information systems
- Use internet to improve purchasing, research, training, customer service. Operate like a business.
- Apply technology after optimizing and implementing best work practices
- Commit to R&D to foster innovation, new technologies and health risk understanding

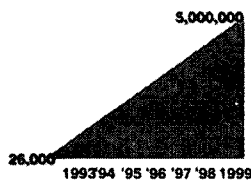
**Technology**



Computing power will continue to rise and the cost drop dramatically over time.

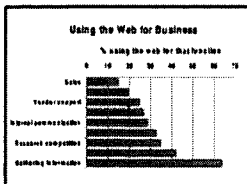


## Technology



Internet use will continue to exhibit exponential growth.

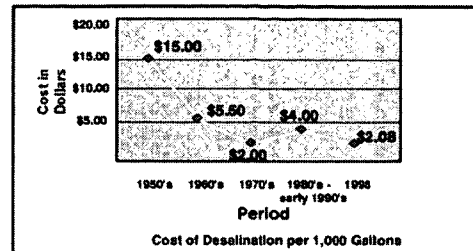
In 1993, there were 26,000 Web sites in use. In 1999, there were more than 5 million.



Leveraging the Web for conducting utility business and customer communication is in its infancy.

## Technology

The improving economics of desalting may help alleviate water shortages.

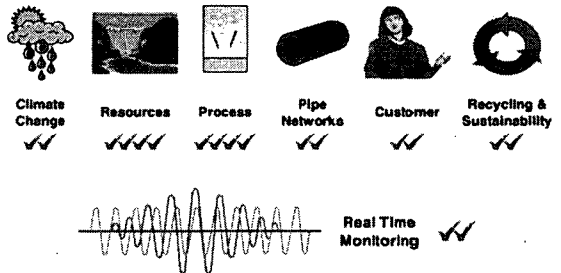


### Seven Utility-Defining Macro-Trends

#### 7. Total watershed management will be essential

- Develop watershed-based resource management approaches
- Create demand management/conservation/reuse programs using rate based incentives to manage water supply demands
- Evaluate multiquality tiered potable delivery and treatment systems

### Global Water Industry Technology Development Position



### Global Water Research Coalition

- International network of water research organizations
- Water supply, sanitation, wastewater treatment and water reuse

### The GWRC Founding Members

- Awwa RF
- CRC WQT
- Kiwa
- CIRSEE (Ondeo)
- STOWA
- TZW
- UK WIR
- Anjou Recherche (Vivendi Water)
- WERF
- WRC - SA
- WRF
- WSAA

Collectively these 12 research programs represent 500 M people and over \$100 M annual research budget.  
- Coordination of research programs at a (inter)national level  
- Managing the knowledge cycle

