YOUR DRINKING WATER:
A 21st Century Challenge and Solutions

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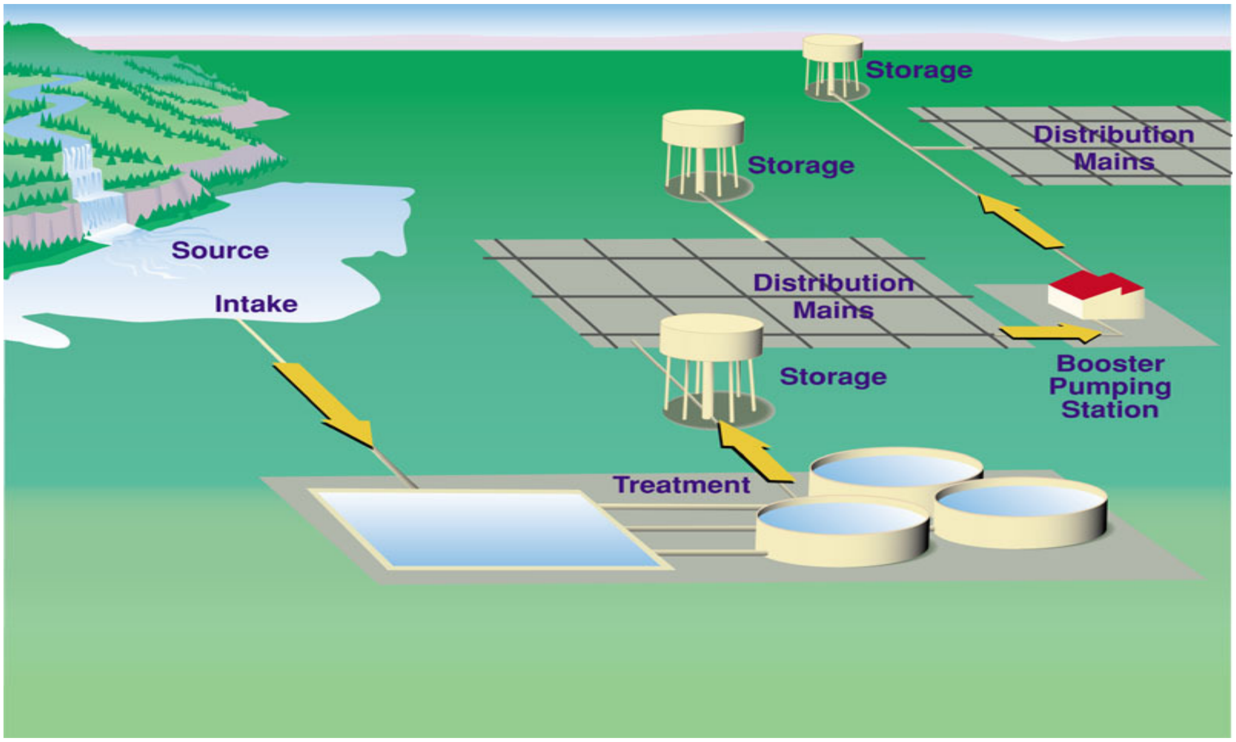
Drinking water utilities, their governing officials, and their customers will face many challenges in the 21st century as they to continue to provide safe and affordable drinking water. These challenges are significant; society's tendency to undervalue water; aging infrastructure; an aging workforce; climate change; and increased public concern over emerging contaminants. A variety of adaptive management approaches will be needed to overcome these challenges, and many of these future approaches will likely be less scientific and technical than past approaches. The will also be more holistic and social.

Drinking Water Basics

The provision of drinking water typically has three major components:

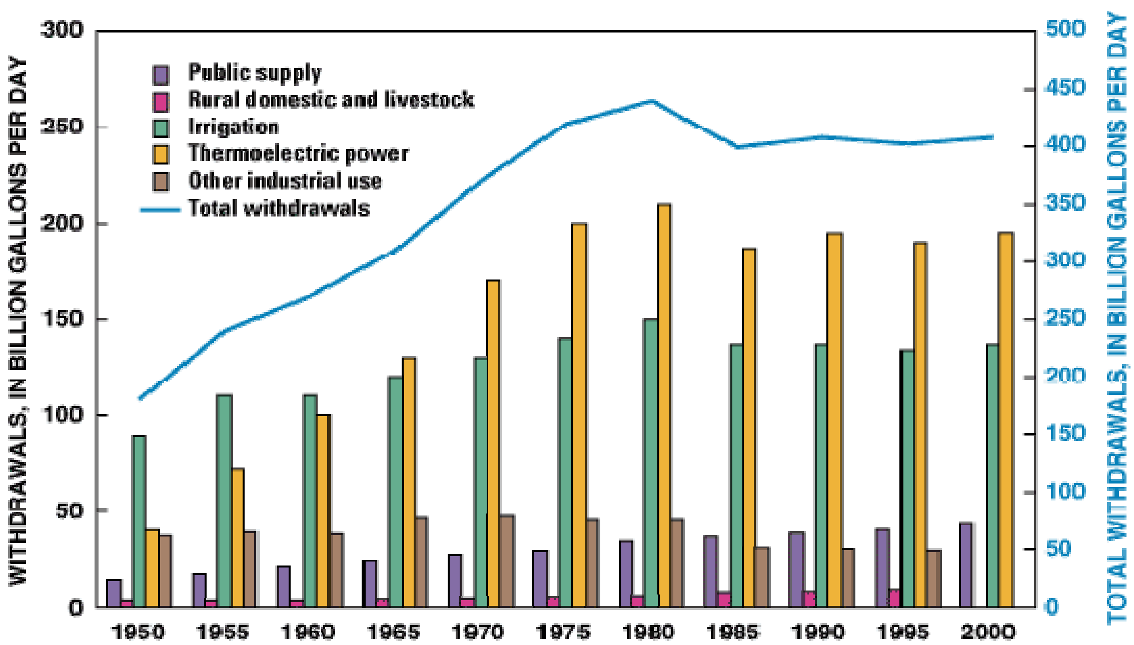
1. The source, which is either surface water or ground water or a combination of the two. Source water protection is important for all water systems;
2. Treatment can vary, depending on the source water quality and whether the source water is surface water or groundwater; and
3. Pumping and storage in the distribution system, which takes the water from the treatment plant to the tap. Maintaining water quality in the distribution system is important.



The above diagram from USEPA shows the relationship between source water, treatment, and pumping and storage in the distribution system.

Water utilities use the multiple barrier approach that generally follows the same three major components to provide safe drinking water. Source water protection helps in providing the best possible source. Sedimentation, filtration, and disinfection in conventional treatment cleanse the water and inactivate pathogens. Maintaining a residual disinfectant and maintaining the integrity of the distribution system provide the last two barriers before the consumer.

Approximately 350 billion gallons per day is used in the U.S. for all needs as shown on the graph on the next page (USGS, 2009). The vast majority (82%) is used for thermoelectric power production and irrigation, with approximately 11% being used for public water supply. About 42 billion gallons per day are used for public water supplies. Water systems are typically designed to provide 125 to 200 gallons per person per day, with the variation being due to the amount of outdoor lawn watering regionally. The average amount of water actually estimated to be used for drinking is only ½ gallon per person per day (USEPA, 2004). Most of the design capacity is for outdoor use, but indoor use (toilets, showers, dishwashers, clothes washers, etc.) can be significant. Fire protection is another key component in water system design, as pump stations must be designed to maintain a minimum pressure during a fire even during times of peak demand. Additionally, storage tanks must be designed with a specific storage volume for water for firefighting even during times of peak demand.



Drinking Water Regulatory Basics

The federal regulatory role in drinking water started with the "common cup" used on interstate railroads (Roberson, 2006). In the 1920s, the U.S. Public Health Service (USPHS) began developing drinking water quality guidelines that the states could (or could not) use as the basis for their own state-level enforceable standards. The USPHS continued to develop more guidelines for more chemicals and microbials until the 1960s, when the growing environmental movement pressed for improving air and water quality and increasing environmental protection. The publication of Rachel Carson's *Silent Spring* in 1962 generated a storm of controversy over the use of chemical pesticides, a controversy that helped establish the U.S. Environmental Protection Agency (USEPA) in 1970.

Congress passed the initial Safe Drinking Water Act (SDWA) in 1974, dramatically changing the way drinking water standards were developed and enforced in the U.S. The 1974 SDWA established the basic regulatory framework that is still used today. A Maximum Contaminant Level Goal (MCLG) is "…set at the level at which no known or anticipated adverse effects on the health of persons occur and which allows an adequate margin of safety." The enforceable standard, or Maximum Contaminant Level (MCL), is set "… as close to the MCLG as is feasible". Feasibility takes into consideration issues such as adequate analytical methods and treatment. Benefit-cost analysis (BCA) is an important component in establishing a specific MCL. The USEPA can establish a Treatment Technique (TT) for a specific contaminant, in cases where the contaminant cannot be measured adequately, or in cases where a surrogate is used for a specific contaminant.

The USEPA delegates regulatory and enforcement authority to the states that want such authority through its Public Water Supply Supervision (PWSS) Program. The states have to adopt their own standards that are at least as strict as the federal standard within a specific timeframe. The USEPA reviews each state's regulations, and if the regulations are approved, then the agency gives the state "primacy" for that regulation. All of the states have primacy except Wyoming. Therefore, USEPA directly implements the program in Wyoming, as well as in the District of Columbia, the Territories, and for the Indian Tribes. The USEPA gives states funding for their state-level regulatory and enforcement program thru the PWSS program, and this funding is the "hook" for the states and territories to adopt the EPA regulations. The fiscal year 2008 funding for the PWSS Program was $91.2 million for the states and territories (USEPA, 2009).

States typically have more discretion in enforcement than USEPA. Their informal actions, such as training and technical assistance, can achieve compliance with fewer resources than legal enforcement actions. However, the formality of state actions increases if the utility continues to have compliance problems.

Once the initial SDWA was passed in the 1974, the USEPA regulated 23 contaminants from 1974-1986. Many in Congress and many environmental advocates did not think that number was sufficient, so the SDWA was amended in 1986 with a much more prescriptive regulatory schedule. The USEPA was required to regulate a list of 83 contaminants in the first 3 years, and then 25 additional contaminants every 3 years thereafter. The USEPA increased the number of regulations after the 1986 SDWA Amendments, but could not meet this aggressive regulatory schedule and was sued several times for missing statutory mandates. Additionally, new regulations resulting from the 1986 SDWA Amendments increased the financial burden to states, and their limited resources, and increased the pressure to retain primacy

Both Congress and USEPA realized that the prescriptive regulatory schedule in the 1986 SDWA Amendments was not working, so Congress again amended the SDWA in 1996. The 1996 SDWA Amendments fundamentally revised the standard-setting process and made several other significant revisions. The 1996 SDWA Amendments split the standard-setting process into three major categories:

1. Priority regulations with specific deadlines in the 1996 SDWA Amendments;
2. The Contaminant Candidate List (CCL) and subsequent Regulatory Determinations (RD); and
3. The review of existing drinking water regulations every 6 years.

This paper will focus on the second regulatory development process. The identification of the appropriate contaminants is the starting point for the CCL and RD.

Identification of the appropriate contaminants and the decision to regulate (or not) are key for the CCL and RD processes. The 1996 SDWA Amendments listed three criteria for contaminant identification and potential regulation:

1. The contaminant may have an adverse health effect;
2. The contaminant is known or likely to occur with a frequency and at levels of public health concern; and
3. National regulation presents a meaningful opportunity for risk reduction.

The USEPA uses these three criteria as the foundation of its CCL and RD processes.

The 1996 SDWA Amendments required USEPA to publish the first CCL in 1998 and subsequent CCLs every five years. The 1996 SDWA Amendments also required USEPA to make the first regulatory determinations for at least five contaminants in 2003, and then every five years for at least five contaminants. In its RDs, USEPA can determine to regulate a specific contaminant, to not regulate, to issue a health advisory, or that more research is needed. If USEPA makes a determination to regulate a specific contaminant, then the 1996 SDWA Amendments require that the regulation be proposed 24 months after that determination and finalized 36 months after that determination.

The first CCL was published in 1998 and listed 50 chemicals and microbial contaminants (USEPA, 1998). The USEPA decided not to regulate nine contaminants in its first regulatory determinations in 2003 (USEPA, 2003). The nine contaminants were:

1. Aldrin;
2. Dieldrin;
3. Hexachlorobutadiene;
4. Manganese;
5. Metribuzin;
6. Napthalene;
7. Sodium;
8. Sulfate; and
9. *Acanthamoeba*

EPA determined that regulating any of these nine would not provide the meaningful opportunity for health risk reduction as mandated by the SDWA. For the first six listed above, the contaminant occurred infrequently and at levels lower than any public health concern.

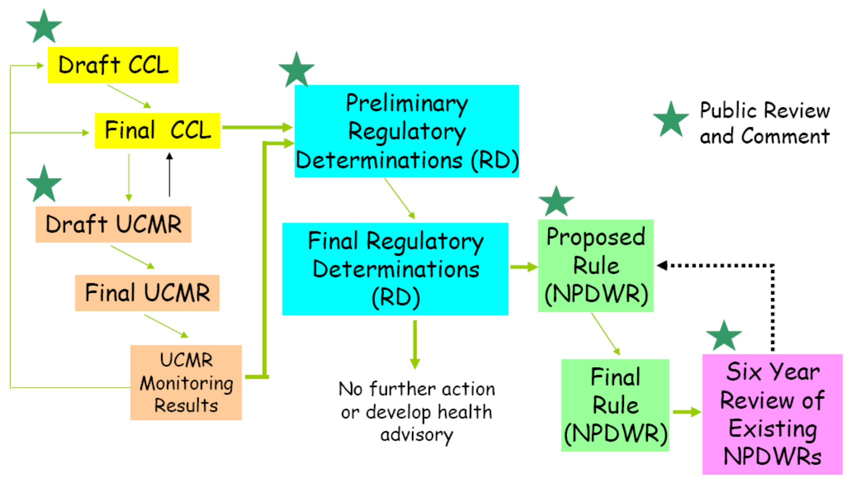
The reasons for not regulating sodium, sulfate, and *Acanthamoeba* were slightly different. USEPA decided not to regulate sodium, as drinking water accounts for a relatively small amount of total sodium intake. Food is a much greater source of sodium. USEPA decided not to regulate sulfate because the risk of adverse health effects is acute, the effects are felt for a limited time (a short duration of laxative-related response) and they occur at very high sulfate concentrations. USEPA decided to issue guidance for contact lens wearers to address any potential health risk from *Acanthamoeba*.

The second CCL was published in 2005 and listed the 51 remaining contaminants after the first regulatory determinations (USEPA, 2005). The USEPA made its second round of regulatory determinations in 2008 and decided not to regulate 11 contaminants (USEPA, 2008a). The 11 contaminants were:

1. Boron;
2. Di-dacthal acid degradate;
3. Mono-dacthal acid degradate;
4. DDE
5. 1,3-Dichloropropene (Telone);
6. 2,4- Dinitrotoluene;
7. 2, 6-Dinitrotoluene;
8. EPTC;
9. Fonofos;
10. Terbacil; and
11. 1,1,2,2-Tetrachloroethane.

Again, EPA determined that regulating any of these nine would not provide the meaningful opportunity for health risk reduction mandated by the SDWA. All 11 contaminants occurred infrequently and at levels lower than any public health concern.

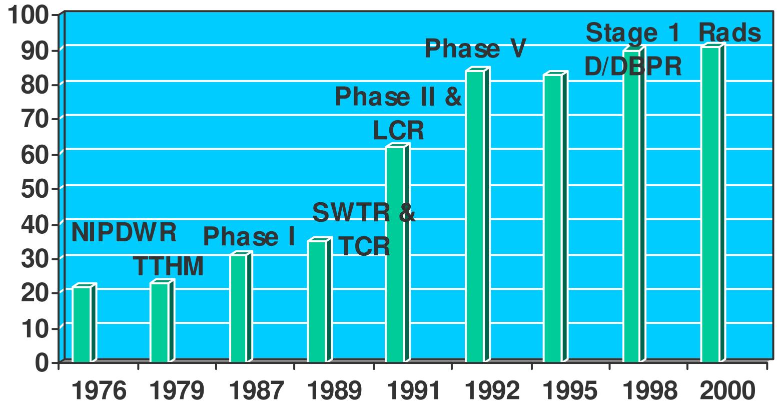
The illustration on the next page from USEPA shows the interrelationships between the CCL, RD, the proposed and final regulation, and the six-year review of regulations. The timeframe for a specific contaminant to be regulated between the Draft CCL and the final rule can span 8 to 10 years.



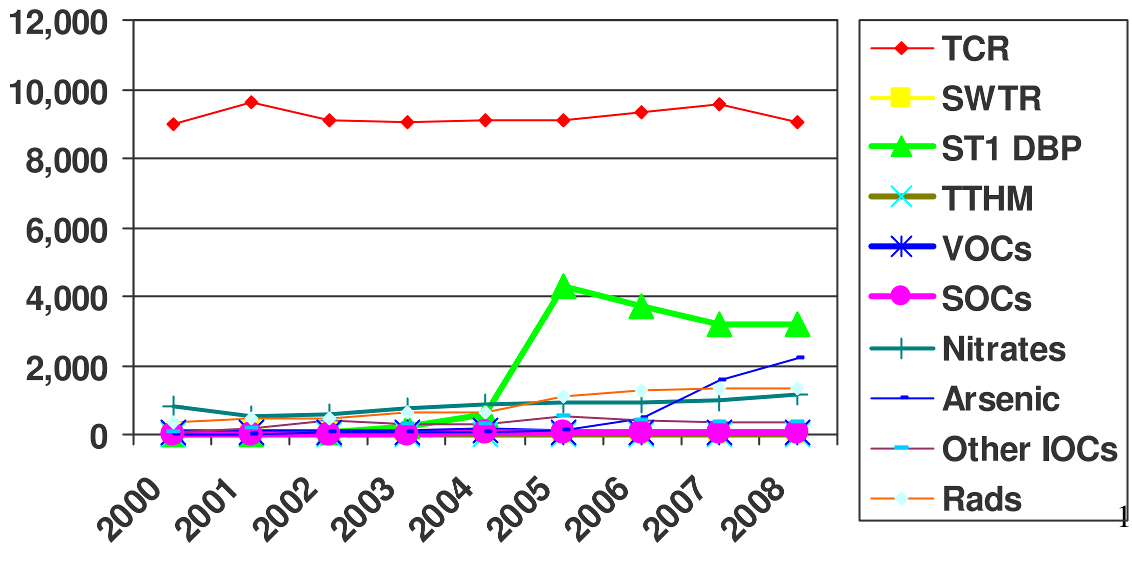
The SDWA defines a public water system (PWS) as serving >15 connections or serving > 25 people. Approximately 155,000 systems are regulated under this definition (USEPA, 2008b). Note that this definition does not provide federal regulations for very small systems (serving <25 people), or for private wells.

PWSs with permanent housing are further classified as community water systems (CWSs). There are approximately 52,000 CWSs regulated under the SDWA (USEPA, 2007). Very small CWSs serving <500 people number around 30,000, but approximately 400 systems serving >100,000 people serve 46% of the population served by CWSs. Most of the large systems use surface water and most of the small systems use groundwater as their source of water. Approximately 80% of the CWSs are municipal, with the balance being privately owned.

The SDWA regulatory program has grown substantially since the 1974 SDWA. Ninety-one contaminants are currently regulated by USEPA as shown in the illustration on the next page.



How can the effectiveness of the SDWA regulatory program be measured? USEPA uses compliance with regulations as the performance metric for its program, even though this metric has its limitations (Raucher, et al, 2007). The graph below shows MCL and Maximum Residual Disinfectant Level (MRDL) violations from 2000-2008. The number of violations resulting from different regulations remained relatively constant between 2000 and 2004. Total Coliform Rule (TCR) violations are on an order of magnitude greater than that for any other regulation during this timeframe. Nitrate had the second highest number of violations in this timeframe. In 2004, violations from the Stage 1 Disinfection By-Product (DBP) Rule increased substantially due to small systems being covered by DBP regulations for the first time. Arsenic violations started increasing in 2005 and 2006 due to compliance deadlines stemming from the 2001 revisions to the arsenic regulation.



The Challenges Ahead

This paper previously summarized the history of drinking water regulations in the U.S., and the current regulatory situation. As we look forward to rest of the 21st Century, many, many challenges appear for utilities as they work to provide safe and affordable drinking water.

Several groups have studied current and future trends potentially impacting water utilities:

1. The Water Research Foundation (formerly AwwaRF) conducted a study on trends impacting water utilities;
2. The National Environmental Services Center (NESC) conducted interviews with 13 people, each representing approximately 100 systems;
3. Steve Maxwell of TechKNOWLEDGEy Strategic Group conducts an annual report on the State of the Industry; and
4. The American Water Works Association (AWWA) conducts an annual survey for its State of the Industry (SOI) Report.

Each of these reports will be discussed briefly below.

The Water Research Foundation report identified the following 10 trends (Means, 2005):

1. Population and demographics;
2. Politics;
3. Regulations;
4. Workforce;

5. Technology;
6. Total water management;
7. Customer expectations;
8. Utility financial constraints;
9. Energy; and
10. Increased risk profile

The NESC survey had more of a security focus, and identified the following nine issues in decreasing order of priority, with the percentage of systems facing this risk in parentheses (McKenzie, 2008):

1. Aging infrastructure (80%);
2. Lack of planning (75%);
3. Retiring operator workfoce (61%);
4. Natural disaster (51%);
5. Local vandalism (41%);
6. Groundwater over pumping (19%);
7. Source water contamination (25%);
8. Climate change (23%); and
9. Terrorism (7%).

The 2008 State of the Industry Report by TechKNOWLEDGEy Strategic Group listed the following trends:

- Increasing regulation and government oversight;
- Dilapidated infrastructure;
- Conservation and efficiency;

- Focus on recycling and reuse;
- Better measurement and monitoring;
- Technological solutions;
- Residential water consumption;
- Surge of investment in water;
- Ownership changes and consolidation;
- Consolidation in the private sector; and
- Controversy over privatization and out-sourcing.

The last four bullets show some of the growing interest from the private sector and the investment banks in water—they just are not sure how to invest in water with approximately 80% of the water systems being municipal.

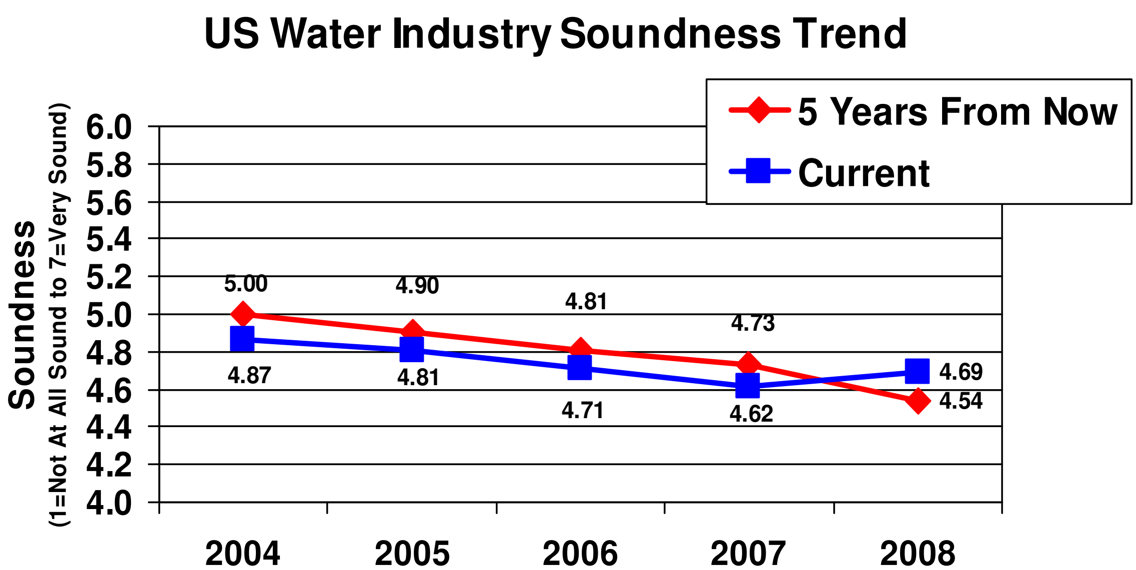
The AWWA State of the Industry (SOI) Report has been conducted annually since 2004 (Runge and Mann, 2008). The SOI Report is presented at the AWWA Annual Conference and Exhibition (ACE) and is published annually in the October issue of *JAWWA*. The objectives of the SOI are to identify the key issues and to prioritize them so that AWWA can incorporate the SOI data into its decision-making process for evaluating new products and services to offer to its members.

The 2008 SOI survey was mailed to 10,000 key AWWA members in March 2008 and more than 1,900 surveys were eventually returned. The respondent base was experienced and knowledgeable, with 53% having more than 20 years of experience in drinking water provision and 53% having a four-year college degree or higher, with 30% having a Masters or PhD. The survey respondents are asked to identify the critical issues:

- For the short term (1-2 years);

- For the long term (3-5 years); and
- That are inadequately addressed by the drinking water community.

Since 2004, the respondents have shown a slow but steady decline in the future soundness of drinking water. For the first time, future soundness rated lower than current soundness. Infrastructure decay combined with the difficulties in finding financing for infrastructure repair, increasing challenges with regulatory compliance and addressing an aging workforce continue to wear down on future optimism. Since these survey results were from March-April 2008, the ongoing economic downturn is not even reflected in the SOI.



The top five issues in the SOI for both short-term and long-term are:

- Source water;
- Business factors;
- Regulatory;

- Infrastructure; and
- Workforce.

A couple of trends are worth mentioning from the five SOI Reports form 2004-2008. Security has been declining in importance over this timeframe. This does not necessarily mean that water security is not still an important issue; moreover, it is a reflection of the growing timeframe since 9/11. Workforce has risen to the top five issues, as utilities are expecting 60% of their executives and managers to retire in the next five years.

Several issues were common between all four studies on current and future trends for water utilities:

- Infrastructure;
- Funding;
- Workforce
- Total water management; and
- Regulations.

Most of these issues are inter-related. Many systems have aging infrastructure, and increasing funding for rehabilitation/repair through higher water rates seems to be a simple solution. But local elected officials do not want to be held responsible for raising rates for fear losing the next election. Compliance with regulations in almost every case can be solved with additional treatment technologies. It just takes money to pay for the capital cost and the operations and maintenance costs for those additional treatment technologies.

Workforce and total water management are even more complex. Raising salaries for staff at utilities may help somewhat, but it will also take some educational and public affairs efforts to make careers in the water sector desirable. Total water management requires a shift in the mindset of utilities and consulting engineers to realize that creating additional water resources does not necessarily mean building more dams and reservoirs. It means building a diversified water portfolio that includes not only traditional surface water and ground water sources, but also water conservation and water reuse.

Solutions for the 21st Century

A variety of adaptive management approaches will be needed to address the issues listed above, and many of these future approaches will likely be less scientific and technical than past approaches. The will also likely be more holistic and social. A sustainable approach is needed to address these issues, and that means going beyond how sustainability is typically used in a water resources context. Sustainability generally means something along the lines of “the use of resources today so that there are not adverse impacts on the future uses of those resources”.

One could group the above issues into the following three main categories for future sustainability:

1. Total water management;
2. Funding; and
3. Workforce.

Sustainability for water utilities is typically focused on managing water resources and/or finding new sources of water. The concept of total water management (TWM) starts by looking at all potential sources of drinking water, going beyond the traditional surface water and groundwater to include brackish water and desalination, and water reuse and/or water recycling. A total water management (TWM) approach integrates management of the watershed, water supply sources, land-use practices, and related resources to provide sustainable supplies while considering equitable economic and social considerations and promoting a healthy ecosystem (Jeffcoat, 2009). A TWM approach provides flexible solutions for long-term water planning. "Adaptive management" is the new buzzword for utilities in preparing for climate change, although nobody really knows very specifically how climate change might potentially impact a specific water utility in an adverse manner.

The energy/water nexus has been getting increased attention over the past decade. As previously discussed, electric power generation is the largest consumer of water, and approximately 4% of energy use is for drinking water treatment and distribution and wastewater collection and treatment (Raucher, 2008). Energy and water efficiencies and water conservation are all starting to converge, but there are no simple solutions. For example, if a utility wanted to spend $500,000, how would it choose between buying more efficient pumps and motors, rehabilitating aging infrastructure to reduce the leakage rate or developing a rebate program for retrofits for low-flush toilets? In this hypothetical example, it might make sense for a utility to do undertake all three efforts, but how would relative priorities be set between the three efforts? Decision support tools are needed to help utilities make such prioritization decisions in this new age of "green" infrastructure.

Funding for water utilities needs to be sustainable. AWWA has an official policy that utilities should be self-sustaining through their own rates and revenues. This is easier said than done for a couple of reasons:

1. Water traditionally has been under-valued and under-priced. Water and wastewater rates in many areas are some cheap that there is no reason to conserve. Per capita water consumption in the U.S. is the highest in the world for comparable developed countries (The Conference Board of Canada, 2009). The percentage of household expenditures for water and wastewater services ranges from 0.6%-1.1% as opposed to 1.8%-3.9% for electricity and 1.7%-3.1% for telephone (Beecher, 2007). The general public thinks water should be free because it is a natural resource. Yes, water comes from nature, but the cost comes from collecting it, treating it, and delivering it to your house (and removing the waste matter).
2. Local elected officials do not want to make the difficult political decision of raising water rates. Elections are not won on water rates, but they can certainly be lost on water rates.

The increasing regulations fit under the sustainable funding umbrella, as additional treatment technologies can always be installed to remove a specific contaminant or to comply with a specific drinking water regulation. The rates will just have to be raised to generate the capital costs and the operation and maintenance (O & M) costs for the additional treatment technology.

As previously mentioned, more and more distribution system pipes will need rehabilitation and/or replacement in the future, and that will take additional funding that will need to be covered in a sustainable rate structure for a utility.

Finally, utilities need to be building a sustainable workforce, and this means going beyond the engineering and technical staff. The percentage of science and engineering degrees has remained basically constant over the past decade while attractive fields such as computer science have drawn graduates away from water and wastewater careers (NSF, 2006). Utilities need to offer interesting work assignments and competitive salaries to attract and retain technical staff. Utilities need to also develop knowledge management programs so that the knowledge that is in the brains of the older engineering and technical staff gets transferred to the new hires.

Going beyond the engineering and technical staff means managing the operator workforce. Treatment plant and distribution system operators are the backbone of a utility's operating staff—they are ones flipping the switches and managing the treatment plants and distribution systems. A different approach is needed to attract and retain operators. Water utilities need to become better known as a good place to work, with interesting work assignments, good pay, good benefits, and a chance to "do good". Education is needed about water and wastewater professions at high schools, community colleges, and vocational schools. Non-college-bound students that might have become an auto mechanic need to be educated about the water and wastewater profession. The American Water Works Association (AWWA) is starting a public affairs campaign ("Get Into Water") to highlight the water and wastewater profession.

Conclusions

The regulatory structure for drinking water quality has evolved significantly over time to the present regulatory framework under the SDWA. Drinking water utilities are faced with an array of issues that could potentially impact their future operations. Utilities need to build sustainable approaches for total water management, for their funding, and for their workforce.

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