Drinking Water

A Half Century of Progress

EPA Alumni Association

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Preface

Former managers and staff of the U.S. Environmental Protection Agency (EPA) have formed an EPA Alumni Association (EPA AA). The Association has developed this and six other web-based environmental reports in support of our *Half Century of Progress* project. An integrated summary based on all of these reports, *Protecting the Environment: A Half Century of Progress*, is available on the Association website. The Association has developed these materials to inform high school and college students and other members of the public about the major environmental problems and issues encountered in the United States in the 1960s and 70s and the actions taken and progress made in mitigating these problems over the last half-century. We also want to highlight continuing and emerging environmental challenges we face today. We hope that, besides summarizing the history of U.S. environmental programs, these reports might inspire some students and others to consider careers in the environmental field.

A number of retired EPA program managers and subject matter experts worked together to produce the first editions of these reports in 2016. Additional experts have updated these documents in 2020 in recognition of the 50th anniversary of Earth Day and the creation of the EPA. This updated report has been reviewed by relevant members the EPA AA Board of Directors and other alumni. We welcome comments on this document, which you may provide at this EPA Alumni Association link.

The Association has also produced a *Teacher's Guide* to facilitate the use of these materials by educators interested in including the *Half Century of Progress* in high school and college curricula. The *Guide* contains data interpretation and other questions related to the report topics, with answers. It also includes activities that challenge students to learn more about environmental issues in their communities, web-based resources for additional activities, and three lesson plans related to the HCP materials. These plans were designed and tested by three AP Environmental Science Teachers. Teachers may request a copy here.

Introduction

The federal *Safe Drinking Water Act*[1] (SDWA) was enacted by Congress in December 1974. It resulted in major changes in the way drinking water is managed and treated in the United States, and it achieved substantial, measurable benefits in risk reduction and public health protection. This overview describes the historical context in which the national drinking water program was launched and outlines the major elements of this historic legislation. It describes the scientific, technical, and political challenges that were addressed and how the U.S. Environmental Protection Agency (EPA) implemented the new program. It also identifies the factors that contributed to the successful implementation of the federal/state/water utility drinking water partnership. In addition, it identifies some of the major challenges to drinking water quality to be addressed in the future, recognizing that the health and well-being of the nation's citizens are significantly impacted by the safety and reliability of our drinking water.

Historical Context

The quality and taste of drinking water have been a concern throughout recorded history. The first established direct link between drinking water quality and diseases dates from the 1850s, when the physician John Snow observed a connection between the Broad Street shallow-well water pump and a deadly epidemic of cholera in London. Previously, it was generally believed that diseases were spread through breathing contaminated air or direct contact with infected individuals. While Dr. Snow's findings were controversial at the time, the authorities did reluctantly remove the handle from the Broad Street pump, and the epidemic eventually subsided.

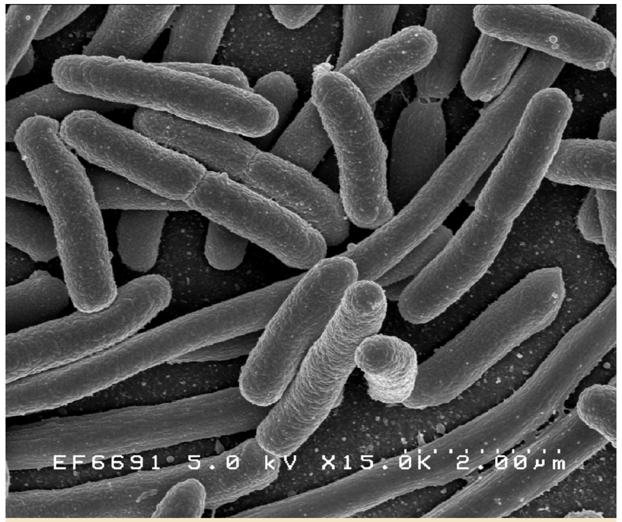
Within 30 years, Louis Pasteur and Robert Koch launched the science of microbiology, postulated the "germ theory of disease,"

[1] PL 93-523; SDWA, 1974

and identified the specific organisms that caused typhoid and cholera. By 1900, sand filtration was widely applied to produce clear water with greatly reduced microbial content. In 1908—and not without controversy—Jersey City, NJ became the first city in the U.S. to continuously apply chlorine to drinking water to kill germs.

The widespread application of chlorination and filtration led to dramatic reductions in waterborne diseases and child mortality rates in U.S. cities. At the turn of the 20th century, some 20% of children aged one to five years in some major river cities were dying (NCHS, 1981). It has been estimated that cleaning up water supplies accounted for reductions of about half of total deaths, three-fourths of infant deaths, and two-thirds of child deaths (Pontius 1993). Clean drinking water came about by the widespread application of improved community sanitation—primarily by ending the discharge of untreated sewage and other wastes to rivers and lakes used as sources of drinking water—and improved water treatment. Water treatment techniques, such as coagulation and filtration with subsequent disinfection, were employed by major cities. Such actions brought about one of the greatest public health breakthroughs of the 20th century. These practices were supported primarily by major water suppliers and interventions by state health departments.

The United States Public Health Service (USPHS) began issuing standards for drinking water quality in 1914. However, they were required at only about 700 watering points for interstate transportation carriers (Pontius, 1993). The standards were updated several times, up until 1962, but broad action to improve water quality was lacking. The deteriorating state of the nation's drinking water supplies was revealed in a 1969 Community Water Supply Survey by the USPHS (NEPIS, 2015). It illustrated major water quality and treatment problems, especially regarding microbial contamination and monitoring deficiencies. This survey covered 969 national water supplies, or about 5% of the estimated 19,236 national water supplies serving an estimated 12% of the population. Of the 969 systems, 238 exceeded recommended limits on contaminants, 159 exceeded mandatory limits for microbial contamination, and 547 had major deficiencies, such as inadequate disinfection, including 120 mostly small systems that exceeded the coliform bacteria limit. Coliform bacteria, and especially *E. coli*, populate human and animal digestive tracts. *E. coli* in water is a good indicator of probable sewage contamination; while lower levels of total coliforms are an indicator of general cleanliness.



Scanning electron micrograph of *Escherichia coli (E. coli)*. *Photo: National Institute of Allergy and Infectious Diseases*

The question of drinking water quality was also impacted by breakthroughs in analytical chemistry in the 1970s that enabled the detection and quantification of previously undetectable organic chemicals at concentrations in micrograms per liter, or parts per billion. In the early 1970s, EPA analytical studies in the Lower Mississippi River led to a report by the Environmental Defense Fund suggesting a potential link between drinking water and cancer mortality in Louisiana. This study received a great deal of media attention at that time (Harris and Brecher, 1974).

Employing enhanced analytical methods, studies detected trihalomethanes (THMs), chloroform, and three other related disinfection byproducts in all chlorinated public water systems. Thus the same chemicals that virtually eliminated waterborne diseases produced potentially harmful biproducts. Chloroform had produced cancer in laboratory animals fed high doses, in the initial studies using corn oil, but not when the studies were repeated with drinking water. The detection of a chemical that might be a cancer risk in drinking water was a major public health concern. The accumulated information, media attention, and pressure from environmental groups led the Congress to pass the *Safe Drinking Water Act* of 1974.

The Federal Role in Ensuring Drinking Water Quality

In the 1970s when the *Safe Drinking Water Act* was passed, the state of drinking water technology was not much different from what it was in the 1920s and 1930s. However, questions were being raised about the adequacy of water treatment to deal with new contaminants of concern, the uneven nature of the state supervision programs, and the lack of a focus for developing standards for the new contaminants of concern.

Prior to the enactment of the SDWA the federal role in drinking water quality was administered by the Public Health Service in collaboration with the state health departments. They used a small number of consensus standards for water quality that applied only at the watering points for interstate transportation carriers. The federal government did provide limited technical assistance and some research related to drinking water through its laboratories in Cincinnati, Ohio. The perception that the technological successes of the 20th century had virtually eliminated waterborne diseases led state health departments to shift priorities to other concerns, and they reduced their oversight of drinking water facilities. The state drinking water programs were highly variable, with limited oversight, monitoring, and compliance requirements. Some water works professionals were concerned about lax supervision of water utilities by the states and the microbial and chemical content of drinking water. The concerns applied especially to small systems, but these issues were not being addressed by all state programs. The coverage was variable, and often with limited oversight, monitoring, and compliance requirements.

Similarly, managers of water works generally believed that the major health issues of the past were largely resolved. They focused on expanding systems, providing reliable service in spite of aging infrastructure, safeguarding the microbial quality of the product, and minimizing costs to customers to avoid rate increases.

The Safe Drinking Water Act of 1974

The SDWA established a federal program to create scientifically based standards for drinking water quality that apply to all public systems. The law defined public systems as those that serve more than 25 customers or 15 service connections. The law envisioned that state regulators would become responsible for overseeing compliance with standards that were at least as stringent as the federal regulations. The SDWA established a three-step process for upgrading future standards. EPA was to:

1. Issue enforceable interim standards based on an update of the 1962 USPHS standards;
2. Contract with the National Research Council (NRC)/National Academy of Sciences (NAS) for a study of contaminants in drinking water that could impact public health; and
3. Issue more comprehensive revised standards based on the NRC/NAS study.

Water utilities would be responsible for monitoring the quality of the water they deliver and assuring that standards are met, with the states conducting the needed oversight function. Significant grants—$20 million initially—were provided to states to upgrade oversight programs. After a startup period, continued state eligibility for grants required them to take specific actions as part of their oversight implementation responsibilities. These included the adoption of standards at least as stringent as the federal requirement, determining that water utilities actually deliver water meeting the standards, record keeping, and other aspects. EPA would undertake direct supervision of drinking water suppliers only if a state were unwilling or unable to accept the responsibilities. Today, the federal grant support to state public water system programs has risen to $100 million annually.

Drinking water systems were traditionally financed by consumer rate payers. The 1996 amendments to the SDWA created a State Drinking Water Revolving Fund (SDWRF) to help water supply systems and the states achieve the health protection objectives of the SDWA. This program is administered as a shared responsibility between EPA and the states. EPA makes grants to states to capitalize a fund from which the states make below market-rate loans to water utilities. Repayments of loans and interest are added to that states' revolving fund to help finance future drinking water improvements. Building on a federal investment of over $20.0 billion, the state DWSRFs have provided more than $38.2 billion to water systems through 2018. This assistance was provided through over 14,577 assistance agreements for:

- Improving drinking water treatment
- Fixing leaky or old water distribution pipes
- Improving the quality of water supply sources

- Replacing or constructing finished water storage tanks
- Other water infrastructure projects needed to protect public health

In addition, Congress enacted the *Water Infrastructure Finance and Innovation Act* and more recently the *Water Infrastructure Improvement Act* to help finance some types of improvement for drinking water systems.

Another feature of the SDWA legislation is a requirement for public notification by the utilities to customers when standards are exceeded or when mandated monitoring does not take place. These requirements introduce an element of additional self-interest and self-enforcement by water utility managers. Although these public notification requirements initially worried utility managers because they were unaccustomed to such transparency, they have become a fully accepted feature of the drinking water program.

Initiation of the Drinking Water Program

Implementation of EPA's national program began with a focus on building and supporting state programs to oversee compliance with existing standards and developing new regulations for previously unregulated contaminants. Program implementation began with some troubling findings requiring immediate attention:

- The USPHS standards were limited, and were the product of expert panels that left minimal backup records or data. In addition, they failed to meet current legal requirements for due process and public comment in setting mandatory standards.
- Most states did not have comprehensive inventories of their existing public water supplies, their sources of water, or their treatment facilities. Thus, EPA began by providing technical assistance to initiate state inventories of water systems using newly available computer-based data processing systems. Ultimately, about 150,000 public water suppliers were identified, of which about 50,000 were community systems serving residential populations.
- The vast majority of citizens were served by one of several thousand large water systems, while the vast majority of

systems served small numbers of customers and lacked professional management. Small systems required new approaches to compliance, as some water treatment was not feasible due to both the lack of professional management and high costs stemming from the absence of economies of scale.

- Recently applied analytical techniques enabled the measurement of organic contaminants at previously undetectable levels, but the techniques were generally limited to research laboratories. Standard-setting activities had to begin with national monitoring surveys of contaminants occurring in public water systems using the new analytical techniques.

A strategy called "One Step at a Time" was developed as the new program began operations, to indicate that implementation would be incremental, with the highest priorities focused on addressing the greatest health risks. Transparent processes were used to ensure that all interested parties could have input to the implementation activities, and that costs and feasibility would be considered in all regulatory decisions as mandated in the legislation.

The SDWA anticipated that states would upgrade their drinking water oversight capabilities to meet federal requirements and then become designated for primary enforcement authority—that is, full authority to implement and enforce EPA-generated regulations.

Interior of a drinking water treatment plant. *Photo: EPA*

In 1974, very few states had the capability or legal framework to implement the new law. As a result of the high priority given to rebuilding state capabilities and with EPA's regional assistance, very high levels of state program acceptance were rapidly achieved. In the first few years, 52 of the 57 state and territorial programs received primary authority for their programs under the Act. In large part, the success of these efforts to promote state delegation for implementing the federal standards stemmed from the historic levels of cooperation between former USPHS officers in EPA's regional offices and state drinking water programs, together with the availability of federal grants. Over time, EPA's ten regions—working with states, territories, and tribes—forged one consistent national program. EPA's work was assisted by the National Drinking Water Advisory Council, which reviewed and advised on major actions.

The water works industry, represented by the American Water Works Association (AWWA) and the National Association of Water Companies (NAWC), was initially skeptical about the new regulatory program they faced. Historically, they had been subjected to limited state regulatory oversight. They eventually became more involved when they realized that they had to conform to the new mandatory federal regulations. This cooperation was driven by EPA's growing technical competency, willingness to provide technical assistance, and commitment to providing meaningful opportunities for all stakeholders to participate in program development activities. Environmental groups were impatient for quicker reforms and were not pleased with the time it took to produce new drinking water regulations. However, they realized that much of the requisite development work was underway.

Development of Drinking Water Standards

Interim standards for drinking water quality were issued as enforceable regulations on schedule in 1975 and became effective in 1977, as required by the SDWA. The standards were based on the last set of USPHS standards issued in 1962. They were generally accepted by the water industry, since they had been in use by many for years.

The National Research Council/National Academy of Sciences Study

The NRC report provided chemical-specific summary health information on some industrial chemicals and pesticides, using the available data. However, it was not sufficiently broad or detailed to allow direct use in setting the new regulations (NAS, 1977). The report did propose a science policy approach using mathematical models to estimate possible dose related risks posed by potentially non-threshold chemicals like genotoxic carcinogens (i.e., chemicals that interact with DNA) that was useful for later regulatory development.

Regulation Development

EPA's research and development laboratory conducted two national surveys of organic contaminants in drinking water using the new sensitive analytical methods. The surveys revealed that trihalomethanes (THMs), were present in all chlorinated waters, and that several other volatile organic chemicals were occasionally found, mostly in systems drawing on groundwater sources. The discovery of THMs was particularly troubling, because they were byproducts of disinfection—the same process widely associated with the virtual elimination of the microbes that caused major waterborne diseases of the past. The THM standard created by EPA was designed to serve as a measurable grouping of several chemicals. In that way, it was an indicator of other unmeasured disinfection byproducts that would also be managed as measures were taken to reduce THM levels. The regulatory method and supporting information on regulatory impact developed with the THM regulation became a model for subsequent regulations.

The THM rule was carefully crafted so as not to increase the risk of waterborne microbial diseases. It was initially applied only to large water suppliers that had the wherewithal to reduce THMs while maintaining disinfection efficacy. Although the water works industry expressed great concerns initially, it turned out that compliance was not as difficult as facility managers had originally thought. They could comply with the standard by more closely controlling water treatment and modifying where in the treatment process chlorine was introduced. In addition to covering the first new group of organic chemicals to be controlled, this regulation attracted international attention and was adopted by several countries. It has led to a great deal of research on all disinfectants and their byproducts, their toxicology, and treatment technologies, as well as studies of past disease cases attempting to relate these chemicals to cancer risks of disinfection byproducts. Results have been marginal and inconclusive.

When the THM regulation was proposed, EPA also proposed a regulation that would have required the application of granular activated carbon to replace sand filters in facilities whose source waters were determined to be subjected to significant industrial chemical contamination. After a contentious public comment period, that proposal was not promulgated, because of several technical and economic uncertainties related to a specific decision tool for reactivating granular activated carbon. In retrospect, it was the appropriate decision, and since then, contamination of source waters has been significantly reduced through requirements of the *Clean Water Act*. Improved treatment techniques are being required for industrial and commercial facilities and wastewater treatment plants that discharge pollutants. Essentially all wastewaters now receive significant treatment prior to their discharge to lakes, rivers, streams, or coastal waters. Some types of chemical discharges to sewage systems are treated prior to entering the wastewater collection system—to reduce their impact on treatment processes—through mandatory pretreatment programs and other requirements.

Comprehensive Drinking Water Regulations

Over the years, regulatory protection has been extended by group or individual maximum contaminant levels (MCLs) in drinking water, or by treatment requirements that include additional chemicals, radionuclides, and microbial contaminants. MCLs determine the maximum level of each covered substance deemed safe at the tap. They also include requirements for monitoring, remediation, and public notice when standards are exceeded. There are now MCLs for 89 individual organic and inorganic chemicals, including groups like THMs, haloacetic acids, and *E. coli* bacteria indicator microorganisms. In addition, treatment technology requirements that include specifications for surface water filtration and groundwater disinfection cover protozoa, viruses, and other bacteria. Radionuclides are regulated using two group-screening techniques. Corrosion control requirements consider the presence of lead and copper and the water's tendency to corrode plumbing to reduce amounts of lead and copper in drinking water (EPA, 1991).

Public concern about drinking water quality was accentuated by the large-scale outbreak of gastrointestinal illnesses that occurred in Milwaukee in 1993. The Centers for Disease Control (CDC) estimated that about 400,000 persons were affected, including over 50 deaths, primarily among people with compromised immune systems. (see Hoxie et. al.) The outbreak was traced to a specific microbiological protozoan called Cryptosporidium. As a result, EPA promulgated additional filtration regulations tightening requirements for water systems using surface water sources. Disinfection requirements were also strengthened later on for utilities using ground water sources. (see Regli et. al.) With these changes there has not been a similar outbreak, and except for legionellosis from aerosol inhalation of *Legionella* bacteria, all waterborne disease outbreaks continue to decline. (see Cotruvo 2019).

Another drinking water public health event occurred in Flint, Michigan in 2014. Elevated levels of lead were detected at the tap due to the increased corrosivity of the water after the water utility switched its source of water. This resulted in serious and long-lasting deterioration of the quality of the drinking water system, causing major anxiety and dislocations among customers and significant conflict within the community. The problems would not have happened if the water utility had complied fully with EPA's 1991 Lead and Copper rule (LCR) and standard industry practices associated with assessing impacts on corrosivity before proceeding with significant source water or treatment changes. State agencies with the legal responsibility for overseeing the program did not require prior assessment of consequences of the source water change, and did not immediately require compliance and reporting—nor did EPA aggressively intervene. A major adverse outcome was numerous cases of legionellosis from water aerosol inhalation and at least 12 deaths. Fortunately, average blood levels in Flint children were not as significantly elevated by this incident as originally thought (see Gomez et. al.) This was probably because the obvious deteriorated/discolored condition of water at the tap prompted many customers to seek out other sources for drinking water. Nationally, child blood lead levels are more than 95% below 1976–1980 levels as the result of eliminating leaded gasoline, banning and removing old lead paint, removal of leaded canned food solders, low lead brass plumbing, and the 1991 Lead and Copper Rule (Cotruvo, 2019).

National Guard delivering bottled water to Flint Michigan residents March 2016. *Photo: Army Master Sgt. Daniel Griego, Texas National Guard.* In 2014 a sudden increase of lead in drinking water in Flint, Michigan was caused by the water utility switching its water supply to a more corrosive source, without the addition of an appropriate corrosion inhibiter to the water. This serious and prolonged degradation in water quality as well as in the pipes that delivered the water to users led to major anxieties and significant conflicts in the community. The switch in water source violated EPA's 1991 regulations and standard industry practice, but authorities were slow to respond. Most residents switched to bottled water because of the unpleasant appearance and odor of their tap water, which helped limit increases in blood lead in children. The change was, however, believed to be linked to at least 12 deaths and more illness from Legionnaire's disease. Legionella bacteria levels were elevated in the water delivery system during this period. In December 2019, EPA proposed revisions to its drinking water rules to further reduce lead exposure.

Though much progress has been made, concerns regarding the public health effects associated with exposure to lead remains. In 2016, the AWWA published an estimate that the number of lead service lines in place in public water systems was about 6 million in 2014, down from about 10 million when the 1991 LCR was promulgated (Cornwell et.al.). About 6% of people served by community water systems were estimated to have full or partial lead service lines (Cornwell et.al.). In December of 2019, EPA proposed a revision to its 1991 LCR to reduce exposure to lead in drinking water by expanding monitoring, increasing the use of corrosion control technologies, accelerating the removal of endangering lead service lines and expanding public education about the risks posed by lead contamination.

Health Advisories

Promulgating regulations is a lengthy and tedious legal and technical process. More contaminants are being detected at low concentrations by new analytical methods, and states and communities need rapid guidance to make decisions for protecting public health. In 1981, EPA's Drinking Water Office created and began issuing Drinking Water Health Advisories to provide risk guidance for short/medium/long-term exposure situations, to assist in managing the detection of unregulated contaminants. This type of guidance proved so valuable that it was immediately used by other EPA programs. It has since been codified in the 1996 amendments to the SDWA. Health advisories for over 200 chemicals are now available on EPA's web site, including most recently for algal toxins that appear in the summer in some surface waters, and perfluorcompounds (e.g., PFOS, PFAS) that are legacy contaminants widely used in consumer products. In addition, EPA's Pesticide Program has published acute (short-term) and chronic (long-term) risk-based exposure guidance, called Human Health Benchmarks, for hundreds of pesticides that may be found in drinking water. These health advisories are invaluable for making rapid decisions in responding to spills and emergencies created by the detection of solvents, pesticides, and other chemical contaminants for which there are no standards.

Program Accomplishments

The SDWA program has brought about a progressive reduction in the number of waterborne disease outbreaks reported by the Centers for Disease Control and Prevention since 1980, when implementation became fully operational. This reduction has occurred during a period when surveillance and detection have improved significantly, and causes of disease outbreaks are more identifiable. Comprehensive science-based water quality standards are now applied in over 150,000 public water supplies. Regular monitoring of the quality of public water supplies is mandatory. Virtually all the states have improved their drinking water supervision programs, and regulations are being enforced. EPA currently reports that from 2013 through 2018 more than 90% of the population is served by public water systems that fully meet applicable drinking water standards, including monitoring requirements and MCLs. (page 685, President's 2020 budget submission).

Since 1996, federal funds—including EPA contributions to the state revolving funds—and other resources have been made available to help water suppliers improve their systems and the quality of drinking water that they provide. There has been great improvement in the professionalism of utility management, largely enhanced through the training and education programs of the professional organizations. For example, the larger utilities formed and funded the AWWA Research Foundation to give them an independent source of information on emerging drinking water science and technology issues. This organization, now called the Water Research Foundation, has grown into one of the largest research programs devoted to drinking water issues in the world. Improved public awareness about the condition of public water supplies and water quality is also occurring. The water utilities routinely provide consumers with information about water quality and known problems in their mandatory Consumer Confidence Reports.

THE Water Research FOUNDATION

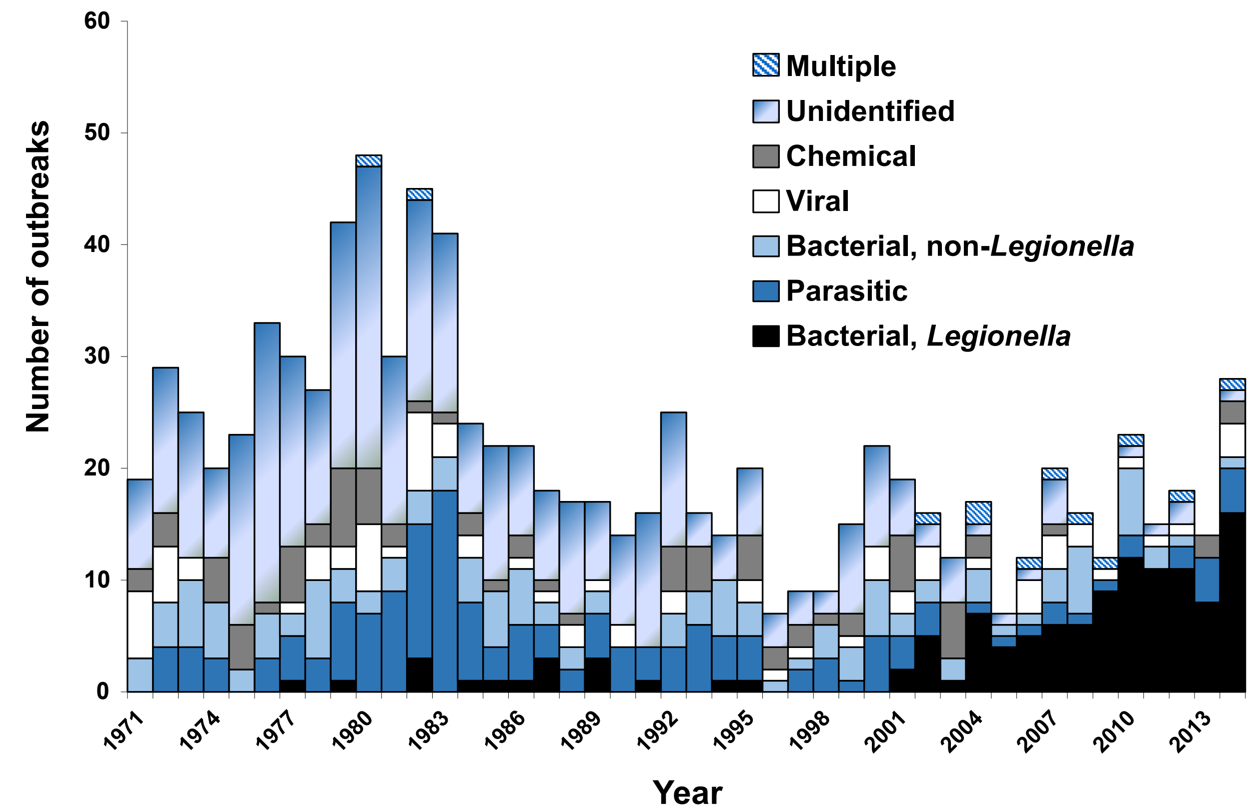
Scientific knowledge and research about drinking water have greatly expanded within the academic community. The sophistication of water management systems and treatment technologies, available through consulting engineers and system professionals, have been significantly enhanced. The need to upgrade water works has also attracted significant private sector stakeholders who see these facilities as potential markets for new technologies, applications of information technologies, and improved management systems. However, no regulatory program can change behavior in our society without adequate resources to oversee compliance and enforcement actions in cases of serious or persistent violations.

Future Challenges

Microbial disease risks will always be the most significant public health concerns, and prevention will always require diligent management at all levels, from regulators to water system operations. The most significant public health and institutional challenge facing U.S. water systems is the need to upgrade and replace aging infrastructure (Allen et.al. 2018). Many systems contain pipes that are over 100 years old and beyond their designed and useful lives. Myriad health and economic problems are affected by deteriorating infrastructure. Some of these include water recontamination by the infiltration of microbials, pipe leaks requiring emergency repairs, the need to detect and fix cross-contamination and back siphonage in plumbing systems, and water losses in the distribution system. Infrastructure upgrade cost estimates prepared by the American Society of Civil Engineers have ranged from $384 billion to $1 trillion dollars over the next 20 years. The respective future roles of the federal and state governments, local communities, and the state revolving loan funds need to be resolved. Paying for these critical improvements will be a major challenge to public finance in the years to come.

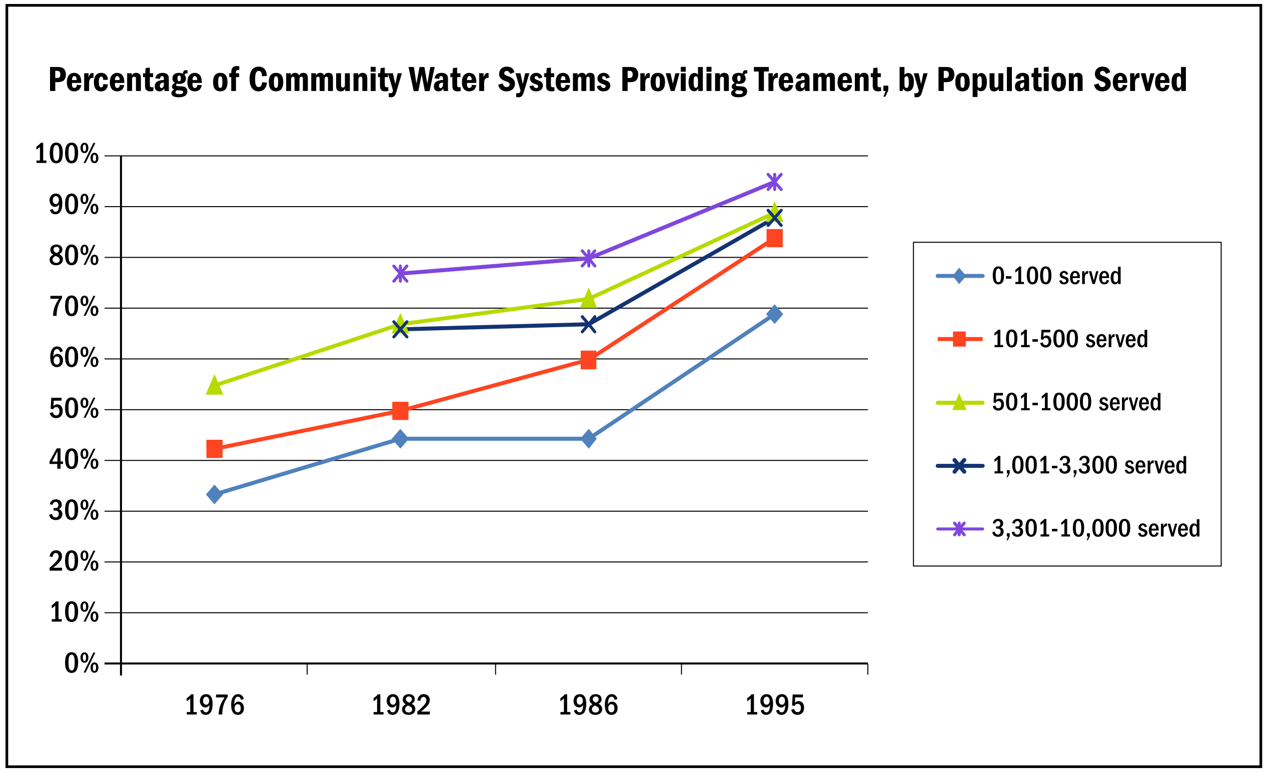
The most significant remaining health water quality concerns associated with distribution systems includes a need to control *Legionella* and other disease organisms that regrow in distribution and plumbing systems after the water has left the treatment plant. See the segmented bar graph of reported drinking water outbreaks through 2014 published by CDC. *Legionella* bacteria are pneumonia risks in municipal water systems spread by contaminated aerosols inhaled during showering and emitted from cooling towers and hot tubs. The bar graph below shows the decline of traditional source water contaminant risks and the shift toward detection of risks from post treatment distribution The latter have probably been historically present in all plumbing

Etiology of Drinking Water–Associated Outbreaks (N=928), by Year — United States, 1971–2014



systems, but are now recognized. Future efforts to prevent disease will require diligent management at all levels, from regulators to operators, in all parts of the drinking water treatment and distribution system.

Small drinking water systems have always been a vexing problem. Fortunately, most small systems draw on groundwater, which is generally protected, more stable, and of higher quality than most surface waters. Where feasible, opportunities to connect to or share management with nearby compliant systems are often the most practical way to meet regulatory requirements. However, when treatment upgrades are needed small systems face significant difficulties due to their greater financial and personnel limitations. Treatment technologies are becoming more complex, so even if a technology is installed the operation and maintenance issues can be substantial. Therefore, there is a need to develop more training and career opportunities for qualified operators.



Other challenges relate to making use of non-traditional sources of drinking water. In areas where population increases and droughts have created additional demands for drinking water, desalination of brackish source water and the use of treated sewage as a component of the public water supplies are becoming more prevalent. EPA and the states have roles to play in facilitating appropriate solutions and new technologies and promoting expanded conservation measures that reduce waste of treated water. Finally, although the nation's drinking water is safer than ever, there is need to maintain federal and state regulatory and oversight institutions to address new issues as they become identified, and avoid potential backsliding in monitoring and compliance. Continued efforts to prevent contamination of source waters are also necessary to reduce the treatment burdens on water suppliers.

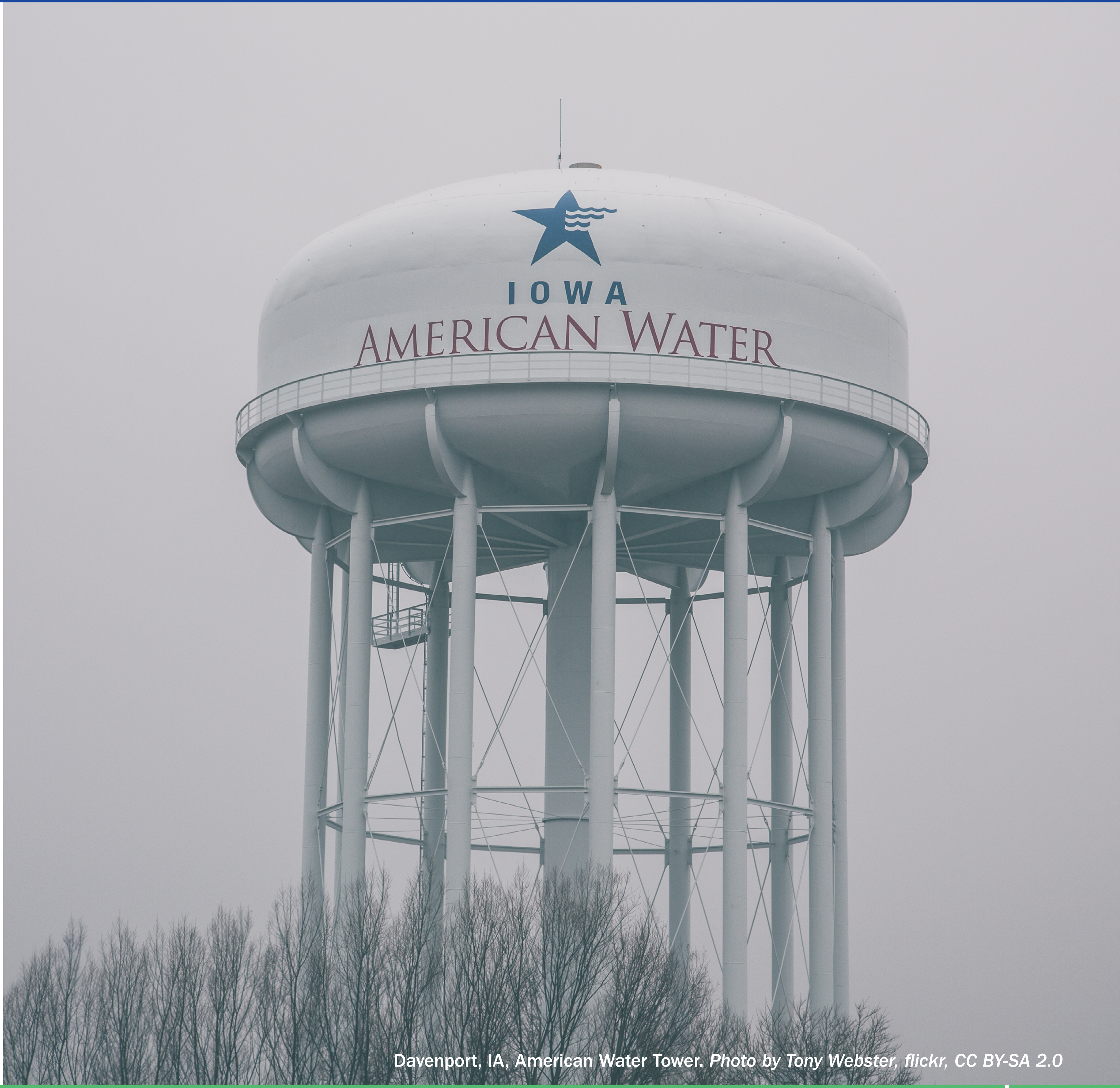
CONCLUSION

The implementation of the *Safe Drinking Water Act* has achieved better and more uniform levels of drinking water quality across the United States. Water-related gastrointestinal disease outbreaks have been reduced considerably since the SDWA's implementation, while surveillance and detection of such events have also improved. Most waterborne diseases are now associated with the distribution and plumbing system. Improvements in analytical chemistry have enabled the detection of trace levels of previously unknown contaminants. Continuing research has also led to introductions of improved treatment technologies and modernization of many water supplies. The SDWA has been successful in reducing risks and improving public health protection through the efforts of dedicated water professionals at the water utility, state, tribal, and federal levels. EPA can be proud of its essential role in the success of that joint enterprise.

There is always the need to look back and refine and update regulatory programs, reflecting the best available science and technology and expanding the number of needed standards and Drinking Water Health Advisories as well as eliminating those that are no longer relevant. A six-year review cycle is built into the SDWA and over time it should provide opportunities to remove unnecessary regulations and address new issues as they evolve. Although continuous reevaluations are always necessary, many of the most critical and fundamental regulatory decisions have been made and implemented. A broad consensus has been reached by professionals that the system is functioning as intended, and drinking water is measurably safer than prior to implementation of the SDWA.

In terms of future issues, it is notable that water for drinking and cooking represents only about one percent of the water provided by public suppliers. Many members of the public are exercising their options to consume more bottled water and use home treatment devices. A recent survey indicated that 56% of respondents were concerned or very concerned about their tap water, 77%

were regular users of bottled water, and 43% used some type of home treatment device (WQA, 2015). These findings are probably due to convenience and the greater availability of bottled water and home treatment devices, and more discretionary income among many consumers. However, this trend is also driven by consumers' dislike of the taste of some tap waters, as well as their reactions to media reports that stimulate concerns about risks that may be related to drinking water. Thus, the water industry and regulators will continue to face the challenges of how to promote the public's acceptance and confidence in their drinking water supplies and to maintain the public's support for needed improvements.



Davenport, IA, American Water Tower. *Photo by Tony Webster, flickr, CC BY-SA 2.0*

Authors

Victor Kimm, Director, Office of Drinking Water, 1975 to 1985. Victor J Kimm joined EPA at its inception, serving five years as the Deputy Director of the Office of Planning and Evaluation and a decade as the first Office Director for the drinking water program implementing the Safe Drinking Water Act of 1974. He then served ten years as Deputy Assistant Administrator for OPTS, the senior career official responsible for controlling industrial chemicals, promoting pollution prevention and licensing pesticides. He also provided expertise on environmental management problems in Central and Latin America, Asia and the Middle East. He subsequently taught public policy for five years at the University of Southern California's graduate school of Public Administration and 15 years community service as CEO of Share Inc. an all-volunteer non-profit organization serving the working poor in northern Virginia. Mr. Kimm holds a Bachelor's degree in Civil Engineering from Manhattan College, a Master's degree in Civil Engineering from New York University and a NIPA fellowship from the Woodrow Wilson School of Princeton University.

Joseph Cotruvo, Director of the Standards Division, Office of Drinking Water, 1977 to 1990. The Standards division developed comprehensive national drinking water regulations and risk assessments for microbial contaminants, organic and inorganic chemicals and radionuclides, THM disinfection by-products, surface water filtration, and lead and copper corrosion control. It also initiated EPA's Drinking Water Health Advisory Program for unregulated contaminants and emergencies. He was also Director of the Risk Assessment Division in OPPT. Joe is president of Joseph Cotruvo and Associates, LLC, Water, Environment and Public Health Consultants, and holds a doctorate in Physical Organic Chemistry from Ohio State University. He is Board Certified in Environmental Sciences and is a Research Professor in the Departments of Chemistry and of Environmental Sciences at the University of Toledo, and a member of the UT School of Green Chemistry and Engineering Science Advisory Board. For many years he has worked on the World Health Organization's Drinking Water Guidelines, and serves on numerous expert advisory panels on drinking water quality, desalination, and large scale wastewater and potable water reuse. He was chairman of the Water Quality Committee of the Board of Directors of the Washington DC Water and Sewer Authority. He is board certified in environmental science by the American Academy of Environmental Engineers and Scientists.

Arden Calvert, Office of Drinking Water, 1985 to 1995. He worked in several EPA programs including the Drinking Water Program's Office of Policy, Planning and Evaluation on budget, risk policy, regulations and water program evaluations. He has a bachelor's degree in government and a master's in political science. He moderated the EPA Alumni Association's oral history video of the SDWA's early implementation.

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