Drinking Water Research

Advancing the Science of Water®

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2010 Year in Review

WATER RESEARCH FOUNDATION®

Drinking Water Research

Advancing the Science of Water®

FEATURES

The Water Research Foundation is a member-supported, international, nonprofit organization that sponsors research to enable water utilities, public health agencies, and other professionals to provide safe and affordable drinking water to consumers.

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Program Changes Will Lead to Actionable, Timely Results

Two-thousand ten was a pivotal year for the Water Research Foundation. In addition to managing hundreds of ongoing projects and producing over 80 research reports and Webcasts, we took important steps in changing, and improving, the way we do business. These steps included restructuring the existing research program, adding a new Facilitated Research Services Program, and expanding and improving how we deliver research results to subscribers. These three separate actions center around one ultimate goal: providing indispensible value to our subscribers.

The restructuring of the research program, recommended by the Board of Trustees' Research Strategy Committee, was approved by the Board in January 2011. This restructuring is intended to streamline and focus the research planning process and to deliver research solutions to subscribers in a more timely manner. The number of discrete research programs was reduced from six to three: the Focus Area Program, the Emerging Opportunities Program, and the Tailored Collaboration Program. The Focus Area Program, comprising 60% of the annual research budget, will identify a limited number of broadly relevant subscriber issues and solve them with a targeted, multi-year research response. The Emerging Opportunities Program, comprising 20% of the research budget, will enable the Foundation to respond quickly to emerging subscriber challenges and research ideas identified throughout the year. The Tailored Collaboration Program, comprising the remaining 20% of the research budget and unchanged from previous years, enables the Foundation to partner with utility subscribers on research that may be more limited or regional in impact.

In 2010, we launched the Facilitated Research Services Program, designed to help subscribers more effectively manage and complete internal research. This program will let subscribers tap the Foundation's research management expertise, ensuring that projects are completed in a timely fashion with independent supervision and enhanced credibility. Participants benefit from the Foundation's independent management of research, the added credibility of the Foundation's established research management processes, and tailored communication of research results to other subscribers and the drinking water community.

Lastly, we began the transformation from an organization that funds research and produces reports, to an organization that produces actionable, timely information, whether in the form of email alerts about breaking news and regulations or synthesis documents summarizing what you need to know about important issues. We also undertook efforts to more effectively tailor our information to different subscriber audiences, recognizing that the needs of the utility CEO and water quality supervisor may be very different. In 2011, we plan to continue these efforts to target different audiences by incorporating other forms of communication, such as social media. We'll still produce research reports for those who need them, but we'll also produce summaries of those research results in ways that can be accessed immediately.

Moving forward, the Foundation will remain the leader in producing credible, groundbreaking research on drinking water. But through the research program restructuring, we'll provide more complete and timely solutions to subscriber problems. And we'll summarize results from our research, as well as information from other sources, and deliver it to you in the format that suits your needs.

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Introduction

Adam Lang, Water Research Foundation publishing manager

The 2010 "Year in Review" issue of *Drinking Water Research* provides readers with an overview on what the Foundation produced in 2010. The purpose of the Year in Review is to not to only describe what the Foundation produced, but more importantly, how Foundation subscribers can access and use this research. This issue touches upon the many different ways subscribers can retrieve research results for a specific project or topic, whether by viewing an archived Webcast or reading a printed research report. Besides focusing on Foundation information, this issue will also highlight some important topics in the water industry from the last year. The regulatory update and drinking water in the news articles provide readers with summaries of how government and the media are involved in, and influencing, decisions in the water industry.

The first section of the Year in Review contains information about the reports and other deliverables that the Foundation produced in 2010. A chart lists all the deliverables published with publication dates. Another chart lists the top five reports ordered by subscribers in 2010. On the following pages, 21 of the 64 project reports published by the Foundation in 2010 are highlighted. These reports were selected for a numbers of reasons, including popularity among subscribers based on orders, timeliness of the topic, or because they represent an important advancement of knowledge on a lesser-known but emerging topic.

"U.S. Drinking Water Regulations: A Look Back on 2010" reviews steps taken in 2010 by the USEPA and state agencies to study the risks related to a number of potential contaminants. The article also discusses Foundation research that will ensure utilities' needs and perspectives are considered in rulemaking and help subscribers comply with existing and future regulations.

"Drinking Water in the News 2010" provides an overview of the major drinking water issues discussed in the news in the last year, including such topics as the environmental impacts of hydraulic fracking, the growing scarcity of global water supplies, and possible threats to water quality from contaminants such as hexavalent chromium and lead. Overall, there was extensive media coverage of drinking water issues last year, underscoring key drinking water industry challenges and the need for swift, research-based solutions.

The following section focuses on Webcasts the Foundation conducted in 2010, both hosted here at the Foundation and conducted with partnering organizations. Lists are included of all the 2010 Webcasts as well as the Top 5 viewed Webcasts of 2010. All Foundation hosted Webcasts and/or the slides, audio, and Q&A are available to subscribers to view or download from the Foundation Website. As more subscribers are finding it necessary to limit conference attendance, Webcasts have become a great way for subscribers to learn from, and question directly, the researchers who conduct our projects.

Lastly, this issue wraps up with a list of projects that were funded by the Foundation in 2010. The list includes 47 projects under the various Foundation research programs. Over the next few months to years, these projects will produce workshops, research reports, partnership conferences, Web tools, and a number of other deliverables that describe the research and conclusions.

In 2010, as in every year, the Foundation produced a lot of important research. The Year in Review was developed to provide subscribers with an easy to access booklet summarizing this information and guide them on how to access and use it.

2010 PUBLISHED REPORTS

Top Five Reports of 2010

Publication Title	Order/ Project #	Publication Format	Publication Date	More on Page #
Water Sector Workforce Sustainability Initiative	4206	Print + PDF	1/25/2010	page 24
North American Residential Water Usage Trends since 1992	4031	Print + PDF	1/25/2010	page 19
Assessment of Inorganics Accumulation in Drinking Water System Sales and Sediments	3118	Print + PDF	3/1/2010	page 7
Effect of Nitrification on Corrosion in the Distribution System	4015	Print + PDF	2/8/2010	page 8
Innovative Applications of Treatment Processes for Spent Filter Backwash	3114	Print + PDF + Web Tool	3/1/2010	page 9

Other Reports Published in 2010

Publication Title	Order/ Project #	Publication Format	Publication Date	More on Page #
Arsenic Removal by Iron-Modified Activated Carbon	3158	PDF only	11/16/2010	N/A
Arsenic Removal with Iron-Tailored Activated Carbon Plus Zero-Valent Iron	4158	PDF only	12/21/2010	N/A
Bay Area Collaborative: Model for Regional Utility Cooperation	4157	Print + PDF	8/28/2010	N/A
Best Practices in Customer Payment Assistance Programs	4004	Print + PDF	2/2/2010	N/A
Biofouling of Spiral-Wound Membranes in Water Treatment	3040	Print + PDF	11/3/2010	N/A
Biological and Ion Exchange Nitrate Removal Evaluation	4131	Print + PDF	10/22/2010	N/A
Biological Destruction of Perchlorate and Nitrate in Ion Exchange Concentrate	3137	Print + PDF	7/22/2010	N/A
Biological Drinking Water Treatment Perceptions and Actual Experiences in North America	4129	PDF only	10/22/2010	N/A
Biological Nitrate Removal Pretreatment for a Drinking Water Application	4202	Print + PDF	10/12/2010	N/A
Challenge Organisms for Inactivation of Viruses by UV Treatment	3105	Print + PDF	6/24/2010	N/A
Chemical Permeation/Desorption in New and Chlorine-Aged Polyethylene Pipes	4138	Print + PDF	11/30/2010	N/A

Publication Title	Order/ Project #	Publication Format	Publication Date	More on Page #
Compendium of Best Practices in Water Infrastructure Asset Management	4111	PDF only	11/10/2010	N/A
Contaminant Candidate List Viruses: Evaluation of Disinfection Efficacy	3134	Print + PDF	8/23/2010	page 12
Contaminant Risk Management Strategy and Tools	4001	Print + PDF + CD Tool	10/8/2010	N/A
Contribution of Galvanic Corrosion to Lead in Water After Partial Lead Service Line Replacements	4088b	PDF only	11/19/2010	page 25
Cost-Effective Regulatory Compliance with GAC Biofilters	4155	Print + PDF	11/30/2010	page 13
Criteria for Optimized Distribution Systems	4109	Print + PDF + CD Tool	12/29/2010	page 14
Cryptosporidium Genotyping Method for Regulatory Microscope Slides	4099	DVD/PDF only	6/24/2010	N/A
Detection of Infectious *Cryptosporidium* in Conventionally Treated Drinking Water	3021	Print + PDF	11/9/2010	N/A
Determining Vulnerability and Occurrence of Residential Backflow	3022	Print + PDF	6/24/2010	page 15
Drinking Water Source Protection Through Effective Use of TMDL Processes	4007	Print + PDF	9/20/2010	page 11
Dynamic Influences on Deterioration Rates of Individual Water Mains (I-WARP)	3052	Print + PDF + CD Tool	8/5/2010	N/A
Effect of Changing Disinfectants on Distribution System Lead and Copper Release: Part 2—Research Results	3107	Print + PDF	3/25/2010	page 26
Effects of Climate Change on Water Utility Planning Criteria and Design Standards	4154	Print + PDF	10/8/2010	page 16
Evaluation of Gross Alpha and Uranium Measurements for MCL Compliance	3028	Print + PDF	4/27/2010	N/A
Evaluation of VSEP to Enhance Water Recovery During Treatment of Brackish Water and RO Concentrate	4148	PDF only	10/27/2010	N/A
Global Review of Spray-On Structural Lining Technologies	4095	Print + PDF	4/29/2010	N/A
Guidelines for Developing, Calibrating and Using Hydraulic Models	4018	Print + PDF	1/19/2010	N/A

Publication Title	Order/ Project #	Publication Format	Publication Date	More on Page #
Guidelines for Implementing Seawater and Brackish Water Desalination Facilities	4078	Print + PDF + CD Tool	12/29/2010	N/A
Impact of Chloride: Sulfate Mass Ratio (CSMR) Changes on Lead Leaching in Potable Water	4088	Print + PDF	6/1/2010	page 25
Impacts of Lining Materials on Water Quality	4036	Print + PDF	8/11/2010	N/A
Influence of Water Chemistry on the Dissolution and Transformation Rates of Lead Corrosion Products	4064	Print + PDF	7/16/2010	page 25
Innovative Arsenic Removal Onto Iron-Preloaded Activated Carbon That is Coupled with Zero Valent Iron Solubilization	3080	PDF only	3/31/2010	N/A
International Guidance Manual for the Management of Toxic Cyanobacteria (GWRC Report)	3148	PDF only	8/25/2010	N/A
An Investigation of the Mode of Action of Stannous Chloride as an Inhibitor of Lead Corrosion	3174	Print + PDF	7/12/2010	page 26
Membrane Fouling by Marine Algae in Seawater Desalination	4201	PDF only	11/16/2010	N/A
Method of Producing Commercially Viable Ceramic Bi-Polar Bi-Layer Nanofilter Membranes	4151	PDF only	11/16/2010	N/A
Methods for Measuring Toxins in Finished Water	4020	Print + PDF	10/8/2010	N/A
Microbiological Degradation of HAAs in Distribution Systems	3122	Print + PDF	7/16/2010	N/A
Minimizing Backwash Volume from Coagulation/ Filtration for Arsenic Removal	3164	Print + PDF	11/30/2010	page 18
Minimizing Water Treatment Residual Discharges to Surface Water	4086	Print + PDF	6/24/2010	N/A
Modeling of Variations in Watershed Pathogen Concentrations for Risk Management and Load Estimations	3124	PDF only	7/14/2010	N/A
Optimizing the Water Utility Customer Contact Center	4100	Print + PDF + CD Tool	5/26/2010	page 10
Organic Chloramine Formation and Influence on Disinfection Efficacy and Nitrification	4065	Print + PDF	10/12/2010	N/A
Oxidation of Pharmaceutically Active Compounds During Water Treatment	4066	Print + PDF	10/8/2010	N/A

2010 PUBLISHED REPORTS

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Publication Title	Order/ Project #	Publication Format	Publication Date	More on Page #
Removal and Fate of EDCs and Pharmaceuticals in Bank Filtration Systems	3136	Print + PDF	7/12/2010	N/A
Removal of MIB and Geosmin with High-Silica Zeolites and Zeolite-Enhanced Ozonation	3169	Print + PDF	7/12/2010	N/A
Sample Preparation Methods for Molecular Techniques for Drinking Water	3108	Print + PDF	9/20/2010	page 21
Seawater Desalination Implications for Drinking Water Quality	2841	Print + PDF	10/22/2010	N/A
Secondary Impacts of Corrosion Control on Distribution System and Treatment Plant Equipment	4029	Print + PDF	1/19/2010	N/A
Significance of Methods and Sample Volumes for *E. Coli* and Total Coliform Measurements	4024	Print + PDF	1/19/2010	N/A
Significance of Trihalomethanes in Preventing Distribution System Nitrifications in Chloraminated Waters	3173	Print + PDF	2/23/2010	N/A
Smart Sensors for Buried Utility Location and Performance Monitoring	3129	PDF only	8/12/2010	N/A
Source Water Protection Cost-Benefit Webtool	4143	web tool	6/29/2010	N/A
Surface Complexation and Dynamic Transport Modeling of Arsenic Removal on Adsorptive Media	3098	PDF only	1/25/2010	N/A
Treating Algal Toxins Using Oxidation, Adsorption, and Membrane Technologies	2839	Print + PDF	5/14/2010	page 22
Use of Membrane Contactors for the Diffusion of Ozone	2885	PDF only	3/31/2010	N/A
Water Conservation: Customer Behavior and Effective Communication	4012	Print + PDF	8/5/2010	page 23
Water Utility Safety and Health: Review of Best Practices	3104	Print + PDF	4/29/2010	N/A

Assessment of Inorganics Accumulation in Drinking Water System Scales and Sediments

Melinda Friedman, Confluence Engineering Group, LLC, principal investigator
Jian Zhang, Water Research Foundation research manager

The primary objective of this research effort was to investigate the accumulation of regulated inorganic contaminants and naturally occurring radionuclides in distribution system pipe scales and accumulated sediments. Research emphasis was on regulated metals, metalloids, and radionuclides, specifically antimony, arsenic, barium, cadmium, chromium, nickel, lead, radium, selenium, thallium, uranium, and vanadium.

Trace inorganic and radiological contaminants were found to occur in distribution system deposits at widely varying levels. Median occurrence levels for the various trace contaminants assessed spanned three orders-of-magnitude. Occurrence distributions of individual contaminants spanned, on average, four orders-of-magnitude. Trace contaminant occurrence trends were examined in the context of sample-specific finished water quality and deposit composition with regard to "major" matrix elements such as iron, manganese, calcium, and phosphorus.

Based on similarities in accumulation trends and contaminant behavior, the trace elements can be broadly divided into two groups—trace metal cations and anionic compounds. Trace metal cations include barium, lead, nickel, and radium isotopes. These elements have a strong affinity for hydrous manganese oxides (HMOs) and an apparent affinity for phosphate precipitates and/or phosphate surface groups. Their accumulation by adsorption/co-precipitation mechanisms is typically enhanced under conditions of elevated pH and when potentially competitive cations (e.g., Ca, Mg) are present at low levels. Trace anionic compounds include the oxoacids arsenate, chromate, and vanadate, as well as complexes of uranyl. These compounds have a strong affinity for HMOs and hydrous ferric oxides. Their accumulation by adsorption/co-precipitation mechanisms is typically enhanced under conditions of reduced pH and when potentially competitive anions (e.g., carbonate, phosphate, silicate) are present at low levels.

The findings from ***Assessment of Inorganics Accumulation in Drinking Water System Scales and Sediments*** (2010, order/project #3118) were framed in a manner to provide clear direction for future research as well as guidance for drinking water utilities. A 3-step management/mitigation program was developed to assist utilities assess and control the potential for accumulation and release in their systems: Step 1—Assess Existing Conditions and Vulnerability; Step 2—Address Existing Deposits; and Step 3—Reduce Contaminant and Solids Loading.

A Foundation Webcast was held on this project on May 25, 2010. Both the report and the Webcast can be accessed on the Foundation Website at www.WaterRF.org.

Effect of Nitrification on Corrosion in the Distribution System

Djanette Khiari, Water Research Foundation research manager

Although chloramination offers many benefits, one disadvantage is that it can trigger nitrification, which in turn can cause loss of disinfectant, increased levels of nitrite, higher heterotrophic bacteria counts, and increased problems with lead and copper leaching in premise plumbing. Water Research Foundation report, ***Effect of Nitrification on Corrosion in the Distribution System*** (order/project #4015) is the first comprehensive study of nitrification as it occurs in premise plumbing.

Two aspects of this issue were investigated: first, the impact of water quality and pipe corrosion on nitrification occurrence in drinking water systems and second, the impact of nitrification on water quality and pipe corrosion.

The research demonstrated that plumbing materials had profound impacts on the incidence of nitrification in homes. Effects were due to toxicity (i.e., release of cu^{2+}), recycling of nitrate back to ammonia substrate by reaction (zero valent iron, or zinc materials), or release of nutrients that are essential to nitrification by leaching from concrete or other materials.

Phosphate plays a key role in determining where, when, and if problems with nitrification will occur in a given distribution system. High levels of phosphate inhibitor can provide nutrients to nitrification, reduce the concentration of cu^{2+} ions, and make nitrification more likely, but phosphate can also sometimes lower corrosion rates and increase the stability of disinfectant and its efficacy on controlling nitrifiers.

Dependent on circumstances, nitrification had an increased, decreased, or no effect on aspects of material corrosion. For example, nitrification markedly increased lead contamination of low alkalinity potable water by reducing the pH, but dramatically decreased leaching of zinc to potable water from galvanized iron. Nitrification did not affect copper solubility in low alkalinity water but is expected to increase copper solubility in higher alkalinity waters.

Experiments also verified that nitrification could affect the relative efficacy of chlorine versus chloramines in controlling heterotrophic bacteria in premise plumbing.

A decision tree summarizing many of the key findings of the research was developed to help utilities understand the potential magnitude of nitrification impacts on lead and copper leaching in their system. If there is nitrification in the main water distribution system or the premise plumbing sampled for lead and copper under the USEPA Lead and Copper Rule (LCR), under certain circumstances significant effects on lead corrosion (i.e., low alkalinity water) and copper corrosion (i.e., high alkalinity) can be anticipated. Depending on the seriousness of the problems, corrosion or nitrification control could be implemented to try and improve water quality in these situations.

Innovative Applications of Treatment Processes for Spent Filter Backwash

Hsiao-wen Chen, Water Research Foundation research manager

Recycling spent filter backwash water (SFBW) can increase water recovery; however, untreated SFBW may negatively impact water treatment processes and/or water quality. SFBW can contain elevated levels of contaminants such as *Giardia*, *Cryptosporidium*, total organic carbon, disinfection by-product (DBP) precursors, DBPs, and manganese. Treatment of SFBW can eliminate carryover of these contaminants.

Innovative Applications of Treatment Processes for Spent Filter Backwash (2010, order/project #3114) evaluated SFBW treatment processes with a multipronged approach including: (1) summarizing previous pilot studies on standard- and high-rate processes, (2) conducting pilot- and full-scale studies on high-rate processes, and (3) assessing membrane treatment at bench scale. Processes evaluated included standard- and high-rate dissolved air flotation (DAF), sand-ballasted coagulation, high-rate solids contact clarification (SCC), and microfiltration/ultrafiltration membranes. Observations and recommendations from the evaluations are as follows:

- Equalization reduces the hydraulic impact of recycled water returning to the main process and also improves the performance of SFBW treatment systems. Furthermore, equalization minimizes the size of SFBW treatment needed and, hence, the cost. Sufficient mixing is required to prevent solids from settling in the equalization basin.
- Use of proper polymer at optimal dose and sufficient flocculation time are often necessary for achieving desired performance in high-rate SFBW treatment systems. In addition, they reduce the sensitivity of the treatment systems to the fluctuation in untreated SFBW quality.
- High-rate processes require a smaller footprint than lower-rate processes and, thus, are more suitable for sites with limited space.
- Standard- and high-rate DAF and SCC with solids recycle produce residuals with 3–5% solids. Other processes evaluated in the study produce residuals with <0.3% solids. The latter residuals probably need thickening prior to dewatering.
- It appears technically feasible to treat SFBW at high specific permeate flux rates of 10–200 gfd/psi using either hollow fiber or ceramic membranes. Pilot-scale testing is needed to confirm.
- Although SFBW contains high concentration of solids, it does not appear necessary to use large-bore (i.e., 1 cm) tubular membranes.
- Use of continuous cross-flow decreases the rate of flux decline compared to dead-end filtration. Yet it does not eliminate the need for periodic backflushing to maintain a desired permeate flux.
- Pilot testing of low- or high-rate SFBW treatment processes is strongly recommended to evaluate the effect of site-specific conditions on the performance.

The Web tool developed for this study allows users to evaluate cost and footprint implications of high-rate SFBW treatment options described in the project report. Users can review descriptions and schematics for the processes, including plan and profile drawings for sizes ranging from 150 to 5,000 gallons per minute. Users can also review the preliminary design reports for two case study sites.

Optimizing the Water Utility Customer Contact Center

Linda Reekie, Water Research Foundation research manager

The current business model for today's water utility customer call center is typically structured around a reactive, problem-solving mode; e.g., resolving billing and other complaints. With the enormous advances in customer contact center technologies and heightened awareness of the importance of customer service and satisfaction, water utilities can significantly expand and optimize the call center into a utility-wide resource to raise levels of service, promote customer satisfaction, and ultimately reduce costs to the utility. ***Optimizing the Water Utility Customer Contact Center*** (2010, order/project #4100) presents concepts and tools that help utilities optimize their customer contact center to meet future trends.

The report defines an optimized customer contact center as one that is efficient, effective, and produces outcomes that support the utility's strategic plan. The report also provides a toolkit on CD-ROM to help utilities transition to an optimized contact center. Components of the toolkit include:

- An outline of the current state of customer contact centers
- Trends in customer contact centers
- Characteristics of the water utility customer contact center of the future
- Self assessment tool that contains goals and strategies for managing and operating a customer contact center
- A benchmarking tool that contains benchmarks and benchmark definitions
- An improvement plan tool that will help utilities identify trends and develop an improvement plan for their contact center
- Resource guide that provides a discussion of a goal-strategy-tool planning approach
- Many useful case studies

The water utility customer contact center of the future will be shaped by trends that affect the water sector as whole, trends in customer contact centers of other service sectors, and new technologies. The report identifies a variety of future trends and the positive and negative impacts on customer contact centers.

Some important out-of-industry trends in customer contact centers that contrast with water industry practices include three areas of focus: automation, workforce, and benchmarking. Out-of-industry customer contact centers use automation to reduce call-time, provide self-service options, reduce agent workload, improve call center scheduling, and improve and expand service to customers. In addition, out-of-industry centers focus on using opportunities for home-shoring (working from home) and agent retention. Out-of-industry practices rely heavily on benchmarking and metrics to track and improve performance. An important out-of-industry metric is "first call resolution," not as widely used in the water industry.

Important technology trends to consider as utilities transition to optimized customer contact centers include:

- Self-service
- Social networking
- Cloud computing
- Electronic bill payment options
- Contracted centralized call centers

The final report and toolkit provide a helpful knowledge resource for water utilities looking to improve their customer contact center.

Drinking Water Source Protection Through Effective Use of TMDL Processes

Kenan Ozekin, Water Research Foundation senior research manager

The Clean Water Act (CWA) requires states to provide opportunities for stakeholder involvement in the preparation of the 303(d) list of impaired water bodies where standards are not being met, and the subsequent total maximum daily load (TMDL) development process. Greater involvement in the TMDL process can yield a number of benefits to drinking water utilities including improved source water quality, reduced treatment processes and costs, reduced disinfection by-products, increased reservoir volumes, and good public relations.

Recognizing these benefits, Water Research Foundation order/project #4007 was funded with the goal to provide water utilities with information and tools that help them better understand and use the TMDL process so they can protect and improve their source water quality. The project's goal was achieved by pursuing two objectives: (1) to identify successful strategies used by utilities to protect their source waters through the TMDL regulatory process, and (2) to identify specific measures that are being used to include drinking water objectives in TMDLs.

The project developed seven case studies for utilities that have been involved or are preparing to get involved with the development of TMDLs for their source waters. As part of those case studies, successful strategies used by the utilities were identified, as were missed opportunities. These helped the research team to develop user-friendly information and tools such as a step-by-step description of the TMDL process and how utilities can get involved, a flow chart to help utilities to get started with the TMDL process, a sample letter for utilities to use to request involvement in the TMDL process, and useful TMDL Websites.

Based on the project findings, the following recommendations were made to drinking water utilities:

- Understand that a TMDL may be under development for your source water based on impairment of a designated use other than it being a drinking water supply. Consider this an opportunity to get involved nonetheless.
- Check that your surface water source has been properly categorized by the state as a drinking water supply.
- Review the state ambient water quality standards (WQS) for drinking water supplies to see if your source water fails to meet any of those standards.
- Approach the TMDL development process with an understanding of state WQS and how they relate to drinking water standards.
- Participate in the TMDL development and review process.
- Be proactive. Early involvement in the TMDL process will increase opportunities for water utilities to effectively communicate with interested parties and will allow the utility to provide input on its water quality goals and needs.
- Share data and information with participating organizations.
- Maintain reasonable expectations.

Contaminant Candidate List Viruses: Evaluation of Disinfection Efficacy

Grace Jang, Water Research Foundation Research Manager

In 1996, the Safe Drinking Water Act (SDWA) amendments required the USEPA to establish a list of contaminants (called the contaminant candidate list [CCL]) that are known to or anticipated to occur in drinking water at levels that may pose a risk to public health. Since then, USEPA has updated the CCL periodically. The CCL3 was published in 2009 and includes 104 chemicals or chemical groups and 12 microbiological contaminants. Among the 12 microbiological contaminants, four virus types (Adenovirus, Calicivirus, Enterovirus, and Hepatitis A virus) are included on the CCL3.

Viruses are less efficiently removed by primary treatment of drinking water (e.g., coagulation and filtration) than the other pathogen types of concern (bacteria and protozoa). Therefore, the disinfection process is very important for removal of viruses from source water. Extensive research has been performed to investigate the effectiveness of conventional and alternative techniques for inactivating viruses during drinking water treatment. However, considerable research gaps still exist with respect to the disinfection of CCL viruses. ***Contaminant Candidate List Viruses: Evaluation of Disinfection Efficacy*** (2010, order/project #3134), co-funded by the Water Research Foundation and United Kingdom Drinking Water Inspectorate, evaluates the disinfection efficacy of free chlorine and monochloramine for the following CCL viruses: human adenovirus (HAdV), coxsackievirus, echovirus, and calicivirus. This project provides a comprehensive data set of Ct values addressing important disinfection factors, including pH, temperature, disinfectant concentration, and water quality.

One of the important findings of this project is Ct values for water treatment utilities to consider for reducing enteric viruses. According to the results, current recommendations are not effective for 4-$\log_{10}$ reduction of the studied virus when considering aggregation—the likely natural state of viruses in natural waters. For example, a Ct value of 10 may be needed to achieve a 4-$\log_{10}$ inactivation of coxsackievirus (CVB5) with free chlorine at 5° C (pH 8). This is above the Ct value of 8 as recommended in the USEPA's *Guidance Manual for Compliance with the Filtration and Disinfection Requirement for Public Water Systems Using Surface Water Sources,* which is meant to achieve a 4-$\log_{10}$ inactivation with chlorine at 5° C (pH 6–9).

As water utilities implement new disinfection strategies in order to comply with new regulations, a comprehensive knowledge of the disinfection efficacy of disinfectants in natural water is important. The results of this project can be used by water utilities to ensure that current and planned free chlorine and chloramination systems are designed and operated to meet specific disinfection goals.

Cost-Effective Regulatory Compliance With GAC Biofilters

Hsiao-wen Chen, Water Research Foundation research manager

Biofiltration is a treatment process that can remove turbidity, dissolved organic matter, taste-and-odor-causing compounds, iron, and manganese. In addition, it can improve the biological stability of finished water and minimize microbial regrowth in distribution systems. It was the process of choice for ***Cost-Effective Regulatory Compliance With GAC Biofilters*** (2010, order/project #4155) as the treatment alternative for compliance with the Stage 2 Disinfectants and Disinfection By-products (DBP) Rule.

In addition to pilot-scale biofilters, demonstration-scale biofilters were tested specifically for developing design criteria for a full-scale rehabilitation and retrofit of convention filters to granular activated carbon (GAC) biofilters without pre-ozone. Lessons learned from this project are as follows:

- Particle removal
  - All the biofilters tested maintained turbidity at <0.1 NTU for the majority of the study with levels consistently well below 0.3 NTU.
  - Chlorination of filter influent and backwash did not positively or negatively impact particle removal.
  - The anthracite and GAC biofilters achieved similar particle removal.
  - Media depth and empty bed contact time (EBCT) had little effect on particle removal.
- Natural organic matter (NOM) removal
  - Adsorption and biodegradation were the two mechanisms that removed NOM in the GAC biofilters.
  - During the adsorption phase, chlorination of the filter influent and backwash did not appear to affect NOM removal. During the steady-state biodegradation phase, the biofilters with unchlorinated influent and chlorinated backwash removed more NOM than those with chlorinated influent and chlorinated backwash. Nevertheless, biodegradation of NOM still occurred in the biofilters when the influent was chlorinated.
  - The GAC filters outperformed the anthracite filters during the adsorption phase but performed slightly better than the anthracite filters during the biodegradation phase.
- DBP formation potential
  - Formation potential of total trihalomethane (TTHM) and hacoacetic acids (HAA5) was not affected by chlorination of filter influent and backwash.
  - The GAC biofilters were significantly more effective for lowering TTHM formation potential than the anthracite biofilters.
- Microbial characterization
  - In all the filters, biomass developed in the first 150 days of operation and then stabilized.
  - The filters with chlorinated influent and chlorinated backwash contained less biomass on the top of the filter during the steady-state biodegradation phase than those with unchlorinated influent and chlorinated backwash.
  - There was approximately 13% greater biomass at the bottom of the GAC filters than at the bottom of the anthracite filters.
  - The bacterial communities in the biofilters were diverse. No known

human pathogens were detected in the communities.

– Chlorination of filter influent and backwash did not significantly impact the bacterial community structure in the biofilters. The communities in the GAC biofilters exhibited a higher degree of variability and a larger amount of change over time than those in the anthracite filters. Filter depth showed no significant effect on the community structure.

Criteria for Optimized Distribution Systems

Frank Blaha, Water Research Foundation senior research manager

The Water Research Foundation partnered with the Partnership for Safe Water (PSW) in funding the project, ***Criteria for Optimized Distribution Systems*** (2010, order/project #4109). The intent of this project was to define and develop a continuous improvement program based on optimization principles for water distribution system operation. In particular, a self-assessment approach was desired that defined critical components and objectives of optimized distribution system operations, and also defined parameters that could be used to measure the degree of optimization. Guidance was also to be prepared on how to better optimize distribution systems with minimal capital investment.

The project team concluded that three key metrics could be used to measure the degree of optimization of distribution systems. These metrics are measurement and management of chlorine residual, pressure, and main breaks and leaks in the distribution system. The justification for the choice of these three metrics and the related goals in an optimized distribution system are presented in the final report. While one metric would have been easier to measure, the project team felt that it was critical to have an optimization program that addressed all three of the National Academy of Sciences (NAS) distribution system integrity categories defined in 2006 report, *Drinking Water Distribution Systems: Assessing and Reducing Risks*. In this NAS study, three types of integrity were noted as being necessary to safely operate distribution systems: water quality integrity (which correlates to chlorine residual), hydraulic integrity (which correlates to pressure management), and physical integrity (which correlates to breaks and leaks).

Largely based on the results of this project, an expansion of PSW was launched in 2011. This type of voluntary excellence program is directly responsive to some of the concerns expressed in the recent literature where distribution systems are identified as a key source of risk for waterborne disease outbreaks.

This project identified and provided justification for key metrics to measure the degree of optimization of a distribution system, along with goals for those metrics that define an optimized distribution system. This had not previously been done, and based on these results, a new and important expansion of PSW is being launched that will encourage improved management of distribution systems for the foreseeable future.

A Webcast covering the results of this project was held in January 2010, and is archived on the WaterRF Website. It provides additional guidance and detail on the work conducted and the results of this project.

Determining Vulnerability and Occurrence of Residential Backflow

Maureen Hodgins, Water Research Foundation research manager

The risk of backflow is low at typical distribution system design and operating pressures of >20 psi. However, this risk increases when there are abrupt changes in flow conditions that cause low or negative pressures for brief periods of time (transient surges). While cross connection control devices are used in industrial/commercial accounts, they are not typically required for residential customers. The key findings of this research included identifying the most effective technology for rapidly detecting residential backflow events, determining the rate of residential backflow occurrence, and that backflow events occur in many areas other than those thought to be vulnerable to surges.

The research was done by American Water and the University of Southern California. In this study, the most effective technology for detecting backflows was a standard meter that was referred to as a backflow sensing meter. This meter has an electronic feature that determines if the net flow of water over a given time period is negative. The meter stores negative readings until retrieved by an automatic meter reading system.

Backflow occurrence was determined by taking advantage of backflow sensing meters that had already been installed at residential accounts in four distribution systems. Meter placement was either on each service connection, randomly scattered, or at locations susceptible to low or negative pressure transients as identified by hydraulic surge modeling. On average, backflow of at least 1 gallon, over a 15-minute period, had an occurrence rate of 1.6% each month (698 occurrences in 42,735 monthly meter reads) and approximately 5% of the meters recorded at least one backflow during the testing period (518 of 10,313 meters installed). Backflow was not consistently correlated to the locations susceptible to low or negative pressures identified by surge modeling. In contrast, backflow incidents were often detected in locations thought to be less vulnerable.

In this study, the water quality monitors were not recommended for backflow sensing because while they are capable of detecting very small changes in water quality, either from normal variation or backflow, data analysis techniques may not be powerful enough to differentiate them. This research also explored sensor response to spiked surrogates and the care and maintenance of water quality platforms, which can be found in the report.

This study showed that residential backflow does occur and utilities may be able to determine the occurrence rate in their system. Utilities may consider installing backflow prevention devices on service connections where backflow could present a potential public health hazard as determined by a sanitary survey for cross connection control.

A Webcast covering the results of this project was held in November 2009 and is archived on the WaterRF Website. The final report, ***Determining Vulnerability and Occurrence of Residential Backflow*** (2010, order/project #3022) can be downloaded at www.WaterRF.org/search/detail.aspx?Type=2&PID=3022&OID=3022.

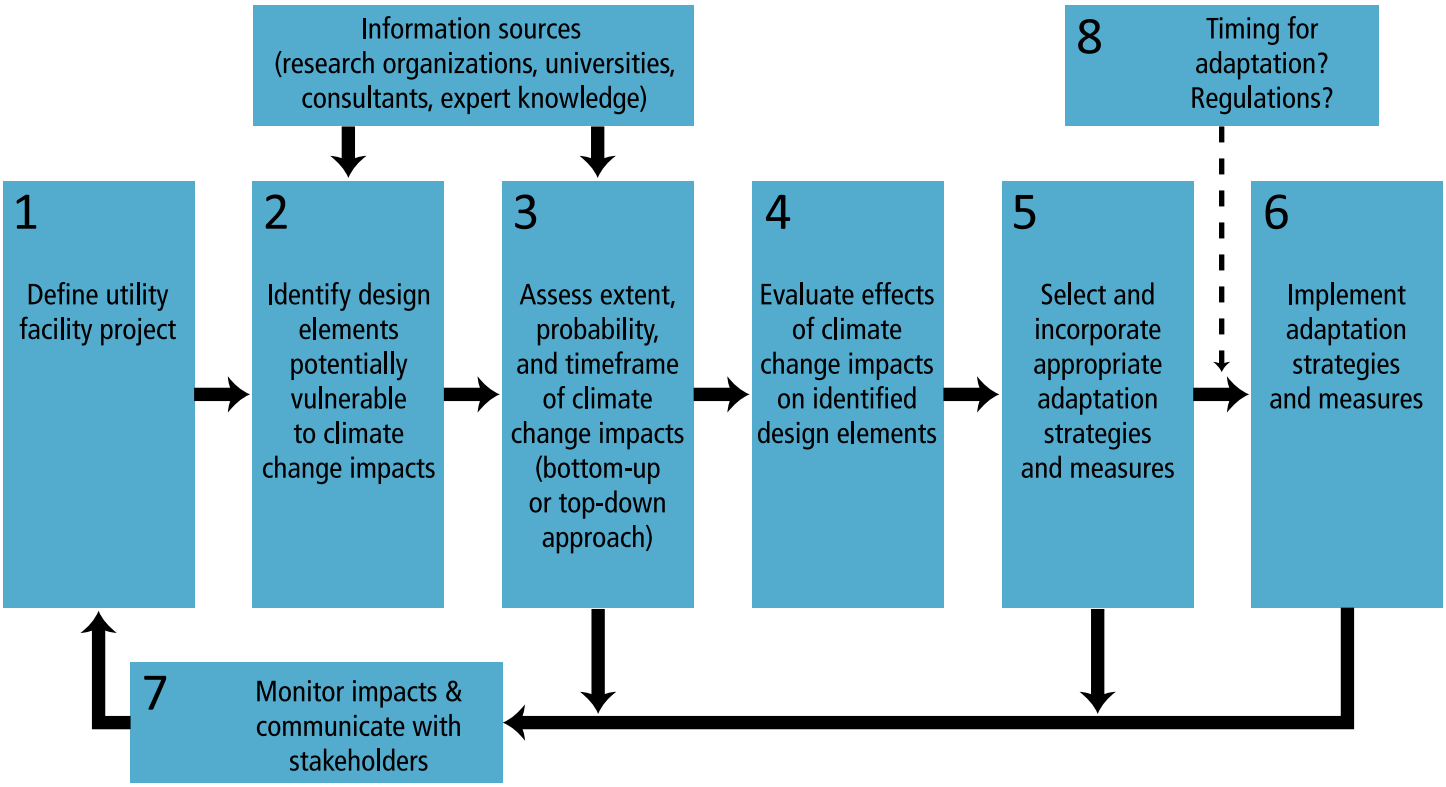
Effects of Climate Change on Water Utility Planning Criteria and Design Standards

Linda Reekie, Water Research Foundation research manager

Effects of Climate Change on Water Utility Planning Criteria and Design Standards (order/project #4154) was designed to investigate how utilities evaluate, respond, adapt, and prioritize risk to climate change. This was a tailored collaboration project sponsored by Contra Costa Water District, Seattle Public Utilities, Los Angeles Department of Water and Power, and San Diego County Water Authority.

Climate change impacts are interrelated and complex. They can affect water quantity and quality within the watershed, and result in effects on water utilities, their infrastructures, operations, and energy. The report presents a comprehensive array of climate impacts and available and pertinent adaptation strategies for various components of a water system. For example, climate change impact adaptation strategies for the distribution system might include selection and installation of pipe materials to withstand stress and strain and protect buoyant pressures on pipe during flooding periods, which are expected to increase in frequency and intensity in some regions. Design standards for distribution systems that may need modification (i.e., to include information on climate adaptation strategy implementation) include groundwater, pipe and accessories, valves and hydrants, meters,

Framework for evaluating effects of climate change on water utility facility planning and design



service lines, plastic pipe, plant equipment, infrastructure and equipment, and material design and installation.

A review of *AWWA Design Standards and Manuals of Water Supply Practices* indicated that all AWWA Standards and many of the AWWA Manuals could be impacted in some way by the effects of climate change; however, fundamental changes to these documents are not necessary because they are based on physical well-understood principles. Instead, in order to consider the impacts of future climate change on current planning criteria, utilities should consider modifying the following:

- Water demand forecasting to include more complex methods that consider potential climate change effects on local weather patterns
- Hydrological modeling to extend planning horizons for future planning purposes
- Evaluation of water sources to result in diversification of supply sources to manage risk

The report presents case studies that document the efforts of the four sponsoring utilities to evaluate the potential impacts of climate change and to modify the existing planning criteria and design standards to provide flexibility to manage the wide range of projected climate changes.

The report also presents a framework to help water utility managers, planners, and engineers assess which facets of their designs may be sensitive to climate change and identify what options are available to reduce the risks. The framework is adapted from a risk assessment framework based on Australian/New Zealand Standard 4360, which incorporates concepts of climate change vulnerability and adaptations. It is intended to assist water utility staff with the assessment of climate change impacts on their utility, identify changes to design elements, and consider adaptation strategies and measures, as shown on the previous page.

Examples of the framework step application for each of the participating utilities are described in the detailed case studies contained on the CD-ROM that accompanies the final report.

Minimizing Backwash Volume From Coagulation/Filtration for Arsenic Removal

Hsiao-wen Chen, Water Research Foundation research manager

Coagulation/filtration (C/F) with conventional anthracite–sand media in pressure vessels is an established, economical technology for removing contaminants from groundwater. However, one drawback of this process is the production of a rather high volume of spent filter backwash water. The disposal and/or treatment of this much water can be burdensome for some water utilities, especially small systems. ***Minimizing Backwash Volume From Coagulation/Filtration for Arsenic Removal*** (2010, order/project #3164) is a revolutionary study that demonstrated that ultra-light filter media could potentially replace sand–anthracite media to significantly decrease the required volume of filter backwash water while effectively and consistently removing arsenic from groundwater in a C/F process.

The required filter backwash water volume depends on the backwash velocity that is sufficient to fluidize the media. Thus, it requires less water to backwash ultra-light filter media with a specific gravity less than 1.3 than to backwash sand (specific gravity ~2.63) and anthracite (specific gravity ~1.65). The research team at Water Quality and Treatment Solutions, Inc. tested polystyrene (specific gravity 1.05) and PFC100E strong-acid cation exchange resin (specific gravity 1.27) ultra-light media at pilot and demonstration scale. The key conclusions from the testing are as follows:

- The ultra-light media effectively and consistently removed arsenic from groundwater to below the maximum contamination level of 10 µg/L.
- Feedwater recovery with the ultra-light media was approximately 99%.
- The maximum backwash rate of the ultra-light media was <20%, as high as that typically used for conventional sand–anthracite media.
- The backwash regime tested in the study effectively and consistently cleaned the ultra-light media. Air scour was critical for effective backwashing. It provided the energy necessary to break up floc/media agglomerates and small mudballs.
- The low unit backwash volume (30–35 gal/ft^2 or 1.2–1.4 m^3/m^2) made it possible for small systems to accommodate the spent backwash water with an on-site septic system or leach field. The backwash flow rate of 3.3 gpm/ft^2 (8.1 m/hr) was low enough to be directly routed to a sewer with no equalization basins.
- Given that a typical filtration rate is on the order of 5 gpm/ft^2, the backwash flow rate of 3.3 gpm/ft^2 could be provided by the production rate of a parallel filter, thereby eliminating the need for a dedicated backwash pumping system.

North American Residential Water Usage Trends since 1992

Maureen Hodgins, Water Research Foundation research manager

The purpose of this research was to quantify the residential water use changes across North America observed during the past 30 years and try to understand water usage behavior patterns and trends. The results may be correlated with future trends for planning purposes. Or utilities may want to replicate the research at their own utility.

The research was done by Dr. Paul Coomes and Dr. Tom Rockaway, University of Louisville. The study had 3 tasks: a national survey of 43 utilities, case studies of 11 utilities, and a more in-depth examination of residential water use in Louisville, Kentucky. The main finding of the research was that water use declined by about 0.44% annually (381 gallons) per residential customer account. This equals 13.2% compounded over 30 years, implying that a residential customer would use 11,673 gallons less in 2008 than it did in 1978.

The other main findings were related to the Louisville study, which consisted of a customer survey, data logging water use of 59 residential customers, and developing an econometric modeling. The econometric model (a statistical model) was developed to investigate the independent impacts of weather, demographics, economics, indoor appliances, and outdoor water features. The resulting coefficients for the variables were combined with historical billing dates to try to explain declining water use over time. The econometric model showed that weather and temperature affected water use. Wetter soil conditions resulted in less water use and a one-degree increase in temperature led to more water use. Residential water usage increased with outdoor uses like a swimming pool (+65 gpd), outdoor spa (+13 gpd), and landscape watering (+10 gpd). The average indoor use was 151 gpd, with roughly 60% of that usage for toilets, showers, and clothes washers. The econometric model determined that the biggest factors for declining water use in Louisville were increased use of low flow appliances (-19 gpd) and fewer people per household (-5 pgd).

The research and two utility responses to declining water use were presented in a Water Research Foundation Webcast in December 2010. Greg Heitzman, Louisville Water Company (LWC), described how this research helped explain the paradox of a water rich area experiencing a decline in water use. As a result, LWC decided to provide new services to generate revenue, such as offering a customer service line protection program. Ray Quay and Adam Miller described the City of Phoenix's analysis of declining water use. Unlike LWC, Phoenix produces drinking water and treats wastewater, so is able to balance the reduced water demand with reduced sewer water flows and subsequently delayed capital investments for wastewater treatment.

CONTINUED NEXT PAGE

More Information:

- "End Uses of Delivered Water," by Jennifer Warner, *Drinking Water Research*, volume 20, number 3 (July-September 2010): page 3. Login, go to www.WaterRF.org/Resources, and then click on Drinking Water Research Magazine.
- To replay the archived Webcast, "North American Residential Water Usage Trends and Applications for Utilities," login then go to www.WaterRF.org/Resources/Webcasts. The Webcast includes 3 presentations:
  - North American Residential Water Usage Trends and Applications for Utilities by Thomas D. Rockaway, PhD, PE and Josh Rivard, Center for Infrastructure Research at the University of Louisville.
  - Strategic Business Implications of Water Consumption Trends in Louisville from 1975 to 2009 by Greg Heitzman and Ed Chestnut, Louisville Water Company.
  - Phoenix: What is the Impact of Water Conservation on Utility Finances? by Ray Quay, Arizona State University and Adam Miller, Water Services Department, City of Phoenix.
- Download the final report, ***North American Residential Water Usage Trends since 1992*** (2010, order/project #4031) at www.WaterRF.org/search/detail.aspx?Type=2&PID=4031&OID=4031.

Sample Preparation Methods for Molecular Techniques for Drinking Water

Grace Jang, Water Research Foundation research manager

A wide array of molecular techniques has been applied to the study of microbiological water quality issues. These techniques are more sensitive and rapid compared to other analytical methods, such as conventional culture and microscopic methods used by water utility laboratories. In addition, they may be broadly reactive to a large number of organisms or specific strains, if designed properly. Although the application of molecular techniques, such as polymerase chain reaction (PCR) and reverse transcription-PCR (RT-PCR), has generated a great deal of valuable information on the occurrence, diversity, and ecology of pathogens in water, these techniques have not been accepted for routine use within the water industry and are largely limited to research application. One of the main reasons for this is the lack of a validated, easy to use, unified sample extraction protocol that effectively removes inhibitors of molecular detection assays found in water concentrates with minimal loss of nucleic acid. ***Sample Preparation Methods for Molecular Techniques for Drinking Water*** (2010, order/project #3108) evaluated different nucleic acid extraction techniques to detect different microbial pathogens in drinking water using molecular techniques. It also developed a single nucleic acid extraction method that could be readily implemented by any water utility laboratory to extract DNA and RNA from diverse microbes of interest for water quality monitoring.

The project method was systemically developed by taking the following steps: (1) a literature review and utility survey, (2) extensive experimental work to develop a nucleic acid lysis buffer for total nucleic acid extraction and recovery, (3) evaluation of non-commercial nucleic acid extraction techniques, (4) evaluation of nucleic acid separation and inhibitor removal techniques, (5) validation of developed sample preparation protocol with commercial kits, (6) valuation of sample preparation techniques for membrane filters, (7) validation of developed sample preparation protocol with variety of water types, and (8) inter-laboratory validation with utility participants. This project method can be performed within a short time frame (less than 1 hour) to effectively extract and recover DNA and RNA from a diverse array of microbes types. Another advantage of this method is that it is "open source" and can be readily optimized or modified as desired by laboratories to meet their specific needs.

The intent of this project was not to develop a method that was superior to commercially-available kits, but to provide evidence-based recommendations for nucleic acid extraction, inhibitor removal, and PCR facilitator techniques. The results of this project provide water utility laboratorians with data and techniques that can be readily implemented to facilitate new molecular testing initiatives or improve an established molecular testing program.

Treating Algal Toxins Using Oxidation, Adsorption, and Membrane Technologies

Jonathan Cuppett, Water Research Foundation research manager

Cyanobacteria and other toxin producing algae are topics of recent interest for drinking water utilities. In large numbers, their presence can negatively impact drinking water unit operations and their production of toxins can have an adverse affect on human health. They can also reduce the aesthetic quality of the water. As demand for water grows and current water sources are exhausted, some utilities are turning to previously unused source water supplies. With increased surface water use, the risk of contact with cyanobacterial toxins such as microcystin increases. ***Treating Algal Toxins Using Oxidation, Adsorption, and Membrane Technologies*** (2010, order/project #2839) identified and assessed viable control and treatment methods, including design and operating criteria and estimated treatment costs, to mitigate algal toxins in finished water. Capital and operating cost estimates were prepared for five treatment technologies based on construction of a 20 million gallon per day (mgd) treatment facility. The following bench scale microcystin-LR (m-LR) removal technologies were investigated.

Ultraviolet/hydrogen peroxide (UV/H_2O_2)

UV/H_2O_2 was found to be an effective treatment for m-LR. However, by itself, UV photolysis was not effective for m-LR destruction. The effectiveness of the process depends on the UV and hydrogen peroxide dose as adjusted for a specific raw water quality.

Ozone

Ozone doses and contact times typically used for disinfection can be adequate for m-LR removal under most water quality conditions encountered in the treatment of drinking water.

Powdered activated carbon (PAC)

Given sufficient reaction time, PAC provided reasonably effective treatment of m-LR. Results from this study showed that adsorption of m-LR onto PAC is relatively rapid (roughly 50% removal within 5 minutes). Therefore, long contact times may not be needed for many treatment scenarios.

Granular activated carbon (GAC)

GAC adsorption was very successful at removing m-LR. However, the required GAC replacement frequency might be an obstacle for implementation.

Nanofiltration (NF) and reverse osmosis (RO) membranes

The membranes tested in this study removed the m-LR algal toxin efficiently, regardless of flux and recovery. All of the tested membranes removed at least 95% of the algal toxin under any condition.

The Water Research Foundation also presented a Webcast in September on algal toxins, titled "Algal Toxins—Source Water Management and Treatment." This Webcast presented research on (1) source water management strategies for cyanobacteria and (2) drinking water treatment processes to control cyanobacteria, such as GAC, ozone, and membrane treatment, and is available on the WaterRF Website.

Water Conservation: Customer Behavior and Effective Communications

Linda Reekie, Water Research Foundation research manager

What communication approaches are most effective in influencing customer behavior to conserve water? What is social marketing? What are water utilities doing to influence customer behavior? What are the linkages between demographics and communications to design an effective communication campaign? ***Water Conservation: Customer Behavior and Effective Communications*** (order/project #4012) provides some insights to these questions.

The report provides a summary of a literature review that focused on investigating the state of knowledge on residential water use and the impact of conservation programs, and a range of resource conservation strategies and tools that are practiced. The review provides good references and examples of water conservation campaigns and social marketing efforts and the effects of various strategies on customer participation in programs and water consumption.

The report documents full case studies for the City of Durham, North Carolina; City of Phoenix Water Services Department, Arizona; JEA, Jacksonville, Florida; Orange County Utilities, Florida; and Seattle Public Utilities, Washington. The case studies include analysis of historic water billing records, mail surveys of customers, and an evaluation of the utility conservation communication program impacts.

In evaluating the literature and the case study results, the researchers recognize the following:

- It is still not clear which media constitutes the best channel for social marketing.
- It is difficult to measure the effect or value of any one message.
- It is not clear which market segments to target for the most effective outcomes.
- Most utility programs lack good customer benchmarks to convey what the average customer is doing, thus minimizing the power of the norm message for water conservation.

The research results suggest the following:

- There is a high level of awareness about conservation practices.
- Saving money is the most frequently cited motivation factor for conservation behavior.
- Most frequent conservation actions are repair of leaking plumbing and purchase of major appliances that use less water.
- Least practiced measures are water wise landscaping and tracking usage with the water bill.
- External pressures such as local government mandates and other enforcement actions reduce water use.
- Residents with automatic sprinkler systems use more water than those without.
- Message dosage is inversely proportional to water use: the more messages communicated, the less water used.
- It is difficult to measure the effect or value of any one message. A broad multimodal communication approach to conservation messaging may be more effective in the long run than short sharply focused messages.
- Conservation is less a series of behaviors and more a lifestyle perspective.

A Foundation Webcast, "Water Conservation—Customer Behavior and Effective Communications," was presented by Tony Silva, ICF International and Peter Mayer, Aquacraft on March 2, 2010. It can be viewed from the Foundation Website: www.WaterRF.org/Resources/Webcasts/Pages/default.aspx.

Water Sector Workforce Sustainability Initiative

Linda Reekie, Water Research Foundation research manager

Future workforce challenges for the water industry remain despite the recent recession temporarily increasing the available labor market for water utilities. A large percentage of the workforce comprised of baby boomers will still retire in the next 15 years. Utilities will feel the impact of these retirements, compounded by the declining number of science and technical students receiving degrees, most severely in areas requiring technical skills and knowledge such as engineering and operations. To help address current and upcoming workforce challenges, the Water Research Foundation and the American Water Works Association (AWWA) jointly funded a project to frame the challenges in the water industry and to identify opportunities to address these challenges. The final report, ***Water Sector Workforce Sustainability Initiative*** (order/project #4206), provides a review of utility and other industry collaborative programs that have been successful in mitigating workforce challenges and proposes recommendations for moving the utility industry forward in designing and implementing the collaborative initiatives.

A variety of collaborative initiatives are highlighted that can serve as models or resources in defining collaborative water sector initiatives. The examples are presented in the categories of industry sector, regional, utilities, public sector, and national. A regional initiative that is highlighted is the *Employ Florida Banner Center for Energy,* which is a partnership of industry, education, and the Florida Workforce Development center. It is one of ten Banner centers created by Workforce Florida to provide curriculum, training, and support to develop employees for energy utilities. A national collaboration that is highlighted is *The Center for Energy Workforce Development and Get Into Energy*. This is a collaboration between private industry, educational institutions, public utilities, and unions that was created to "build alliances, processes, and tools to develop tomorrow's energy workforce." There are numerous other examples provided in the report.

The recommendation to implement a water workforce resource clearinghouse was undertaken by AWWA and the Water Environment Federation (WEF). They developed a Website, Work for Water! (www.workforwater.org), where students and job seekers can explore green careers in the water industry, and utilities can find a clearinghouse of resources for recruiting. A second recommendation to define water sector career pathways was also undertaken by AWWA and WEF (with the USEPA), and resulted in the development of a Water Sector Competency Model (www.careeronestop.org/COMPETENCYMODEL/pyramid.aspx?WS=Y) to identify the occupation specific competencies required for workers in the water sector. WaterRF is further developing detailed competency models for specific positions within the water industry through ongoing project #4244, **"Competency Model Development and Application to Meet Water Utility Workforce Needs."**

A Foundation Webcast was presented on this project by Denise O'Berry, EMA, Inc. on Feb. 4, 2010, titled "Workforce Sustainability—Strategies for Partnership in Workforce Planning and Development." It is available to view on the Foundation Website at www.WaterRF.org/Resources/Webcasts.

2010 Lead Corrosion Reports

Jonathan Cuppett, Water Research Foundation research manager

Impact of Chloride: Sulfate Mass Ratio (CSMR) Changes on Lead Leaching in Potable Water **(order/project #4088).**

Lead leaching in potable water can be severely impacted by seemingly innocuous changes in water treatment, including changing from one coagulant type to another. Prior research and case studies documented instances where coagulant changes produced higher CSMRs that were linked to the onset of lead leaching problems. This project was funded to determine the potential effects of coagulant changeover on lead release from plumbing components. This project evaluates the impacts of CSMR on lead leaching from plumbing materials, as well as the roles of alkalinity, pH, and corrosion inhibitors in potentially mitigating corrosion in high CSMR waters. CSMR values can fluctuate due to a variety of causes including desalination, road salt runoff, and on-site chlorine generators. A key finding was that problems that occur in coagulant changeovers could usually be mitigated by controlling the type of coagulant and keeping CSMR below about 0.5. However, this is not always an option. A Webcast on this project was presented on March 16, 2010.

Contribution of Galvanic Corrosion to Lead in Water After Partial Lead Service Line Replacements **(order/project #4088b)**

This project is an extension of project #4088 and examined effects of CSMR and galvanic corrosion on lead leaching to potable water after partial lead service line replacements. Due to property ownership issues, partial lead service line replacements (and not full replacements) are widely implemented in the United States, with a primary goal of reducing lead exposure at the tap. During a partial-pipe replacement, a portion of the lead service line is typically replaced with copper pipe. These dissimilar metallic pipe materials are then connected to restore drinking water service. This process creates an electrochemical or galvanic cell, which can accelerate corrosion of the lead pipe. In this work, the adverse effects of such connections in the context of lead leaching were confirmed in experiments of simulated lead service line replacements. Under stagnant water conditions, galvanic connections between lead pipe (either new or old) and copper pipe increased lead release into the water, compared to a full length of lead pipe alone. The extent of galvanic corrosion observed was dependent on drinking water quality. High CSMR increased lead release, compared to low CSMR water. Key aspects of this study are also available in the March 16, 2010 Webcast.

Influence of Water Chemistry on the Dissolution and Transformation Rates of Lead Corrosion Products **(order/project #4064)**

Lead concentrations in drinking water are affected by chemical reactions that occur within lead service lines and premise plumbing. Lead may be released directly from pipe, lead containing corrosion products on the pipe surface, and from brass and solder that contain lead. Solubility and dissolution rates of corrosion products are affected by water chemistry parameters including pH, dissolved inorganic carbon, orthophosphate, and the concentration and type of disinfectant residual. The primary objective of this project was to provide new information to the water supply community that advances understanding of lead corrosion product dissolution and transformation rates. This study found that the effectiveness of corrosion control strategies will vary depending on the source water chemistry and the composition of the pipe scales. When collecting samples for compliance with the Lead and Copper

Rule (LCR), utilities could gain insights into processes controlling lead concentrations by measuring pH, dissolved inorganic carbon concentrations or alkalinity, free and/or combined chlorine concentrations, and orthophosphate concentrations. A Webcast on this project was presented on April 29, 2010.

An Investigation of the Mode of Action of Stannous Chloride as an Inhibitor of Lead Corrosion (order/project #3174)

One alternative to phosphate for lead corrosion control is stannous chloride. Stannous chloride has a wide variety of industrial uses including as a preservative in food products. Stannous chloride has also been approved for use as a water treatment chemical by NSF International under Standard 60. Laboratory experiments were performed to investigate whether stannous chloride is an effective lead corrosion inhibitor and its mode of action. In previous pipe loop studies, stannous chloride showed some benefit with respect to reducing lead and bacterial levels, but the chemical did not decrease lead release or biofilm accumulation in the batch experiments with lead coupons performed in this work. Utilities considering use of stannous chloride for lead corrosion control should proceed slowly and with caution. Coupon and possibly pipe loop studies are recommended for utilities considering use of stannous chloride to evaluate whether the chemical might be effective for the given water quality conditions.

Effect of Changing Disinfectants on Distribution System Lead and Copper Release: Part 2—Research Results (order/project #3107)

Part 1—Literature Review of this project was published in 2006 (order #91152). Part 2—Research Results was published in 2010 (order #3107). This investigation produced a body of data regarding metal release and passivation under a variety of conditions that provides valuable guidance for engineers and utility operators seeking to make disinfectant conversions without endangering public health. The objective of this research was to determine effects of changing disinfectants from free chlorine to chloramines and vice versa on metals leaching rates and leaching levels from lead, brass, and copper components in the distribution system. While the results of this project are especially applicable to distribution systems with lead components, the implications of this research extends to newer distribution systems containing other lead-bearing materials. This study demonstrates the importance of passivating scales, notably the presence of lead dioxide and possibly other lead (IV) phases, for the occurrence of lead release changes in systems undergoing chlorine/chloramines conversion. Additionally, based on the findings of this research, guidelines for before and after the disinfectant change were developed for utilities faced with potential consequences of lead and copper release.

U.S. Drinking Water Regulations: A Look Back on 2010

Shannon Diederich, Water Research Foundation writer

Drinking water researchers and U.S. regulators were busy in 2010 scrutinizing the current state of science and risks related to a number of contaminants. The USEPA completed its second six-year review of 71 existing drinking water regulations. The agency also shifted its strategy for setting future drinking water standards, announcing plans to regulate drinking water contaminants in groups rather than individually. Contaminant groups initially under consideration include carcinogenic volatile organic chemicals (VOCs), nitrosamines, and disinfection by-products (DBPs) resulting from chlorination.

In 2010, the Water Research Foundation continued to provide research to help subscribers comply with existing and future regulations. At the same time, the organization served as an industry partner to USEPA and other regulators, ensuring that utilities' needs and perspectives were considered in rulemaking and policy development.

The primary regulatory announcements, their implications, and an overview of the Foundation's related studies are described below:

Revised Total Coliform Rule (RTCR)

After completing its six-year review of the Total Coliform Rule, the USEPA in 2010 proposed a Revised Total Coliform Rule (RTCR), which will apply to all water systems. This regulation is designed to ensure distribution system integrity and requires ongoing monitoring of microbial contamination. To aid utilities with finding and fixing associated contamination, the agency also drafted an *Assessment and Corrective Action Guidance Manual.*

The revised rule calls for

- removing the current maximum contaminant level goal (MCLG) and maximum contaminant level (MCL) of zero for total coliform,
- maintaining a zero MCLG and MCL for *E. coli*,
- specifying microbial testing frequency based on population served, and
- notifying the public of monitoring results.

WaterRF, utilities, and industry groups collaborated with regulators to identify and prioritize distribution system research. USEPA and WaterRF continued their collaborative effort to identify distribution system research needs through the Research and Information Collection Partnership (RICP), which was formed in early 2009. A priorities document outlining the results of the partnership's planning efforts was published in May 2010. The organization's participation will allow utility needs to be considered in future risk management actions.

The studies were heavily referenced throughout the RTCR revision process:

- Guidance and decision support tools were developed to aid in rule compliance.
- Related Foundation projects were cited more than 240 times in the 10 white papers and 9 issue papers developed to support the Federal Advisory Committee.
- Order/project #4024, ***Significance of Methods and Sample Volumes for* E. coli *and Total Coliform Measurements,*** provided regulators with more accurate

methods for detecting coliform bacteria and *E. coli* in drinking water.

- ***Strategies for Managing Total Coliform and* E. coli *in Distribution Systems*** (2009, order #91259/project #3116), guides utilities in managing and responding to total coliform and *E. coli* occurrences in their distribution systems.
- Current coliform detection methods and techniques were evaluated, and WaterRF researched ways to improve monitoring effectiveness and avoid false positives.

Carbon Sequestration

Geologic carbon sequestration (sequestration) promises to control the release of greenhouse gases, and its use is expected to increase substantially in coming decades. Yet the injection of carbon dioxide (CO_2) into deep aquifers may cause geochemical changes, add contamination from the injection stream, and produce volumetric changes.

In December, the USEPA published its final rule governing the injection of CO_2 for sequestration to protect underground sources of drinking water.

Two WaterRF reports address possible water quality impacts on groundwater quality, as well as provide recommendations for minimizing or mitigating those impacts:

- In the Rapid Response project, ***Potential Groundwater Quality Impacts Resulting from Geologic Carbon Sequestration*** (2009, order/project #4203), WaterRF researchers characterized the potential impacts on groundwater quality, developed recommendations for assessing and mitigating those impacts, and developed a monitoring guideline. They also performed a comprehensive evaluation to determine knowledge gaps and needs.
- Based on those projects' findings, WaterRF funded another study, **"Impacts of Geologic Carbon Sequestration on the Water Quality of Groundwater"** (project #4265). Researchers are currently identifying impacts from the migration of CO_2 from sequestration projects, as well as associated physical and chemical changes.

Perchlorate

The USEPA recently decided to regulate perchlorate as a drinking water contaminant, reversing an earlier decision by the agency. Perchlorate is both naturally occurring and manmade, and regulators are concerned that elevated levels can impact human thyroid function.

The agency published an interim health advisory level of 15 parts per billion (ppb) in January 2009, but some speculate the new MCL could go as low as 2 ppb. California and Massachusetts have already set limits at 6 and 2 ppb, respectively.

The agency is now assessing the feasibility and costs of treatment technologies and compliance with proposed federal standards. A new standard is expected in about two years.

Two Foundation studies are helping to inform the drinking water industry and

decision makers on the prevalence of perchlorate in drinking water: ***National Assessment of Perchlorate Contamination Occurrence*** (2002, order/project #90902), and ***Hypochlorite: An Assessment of Factors that Influence the Formation of Perchlorate and Other Contaminants*** (2009, order/project #4147).

Another study, ***Biological Destruction of Perchlorate and Nitrate in Ion Exchange Concentrate*** (2010, order/project #3137), characterized biodegradation parameters to improve perchlorate destruction rates. It also demonstrated the recycle and reuse of treated brine, and assessed water quality impacts.

Currently, researchers on a Foundation Rapid Response project are developing the **"State-of-Science on Perchlorate Treatment Technologies and Regulations"** (project #4359). This white paper will include information on, among other things, available treatment technologies and the feasibility of treating perchlorate at the potentially very low concentrations anticipated for the new MCL.

More about perchlorate can be found in the Foundation's ***Perchlorate in Drinking Water Regulatory Update and Treatment Options*** state-of-the-science report, which was prepared in 2010 and updated in early 2011.

Hexavalent Chromium

While total chromium has long been regulated in drinking water (the USEPA MCL is 100 ppb), studies have raised concerns about the potential carcinogenicity of hexavalent chromium, a highly oxidized form of the metal.

Last September, the USEPA issued a draft risk assessment of its Integrated Risk Information System database, which specifically addressed the health risk of hexavalent chromium. The results of this assessment will likely lead to setting a national standard. California is the only state with a regulatory standard for hexavalent chromium; it recently set a public health goal of 0.02 ppb.

More about USEPA's risk assessment and next steps in the regulatory review can be found in the Foundation's ***Hexavalent Chromium in Drinking Water Regulatory Update and Treatment Options*** state-of-the-science report, which was prepared in 2010.

Additionally, WaterRF collaborated with California utilities and the USEPA to better understand and address hexavalent chromium removal. Research conducted by a collaboration of southern California drinking water utilities, USEPA, and the Foundation found that weak base anion exchange and reduction-coagulation-filtration could remove hexavalent chromium to below 5 ppb for the utilities' particular groundwater source.

Volatile Organic Compounds (VOCs)

As part of its six-year review, the USEPA announced in early 2010 that it will revise standards for two VOCs: trichloroethylene (TCE) and tetrachloroethylene (PCE). At elevated levels, both compounds may potentially cause cancer and other health effects. More recently, USEPA has announced that it will regulate 16 carcinogenic VOCs as a contaminant group, and will include TCE and PCE in this grouping.

The USEPA limits concentrations of both TCE and PCE in drinking water to 5 ppb, with a MCLG of 0 ppb. With improved analytical techniques, the current MCL could drop significantly.

CONTINUED NEXT PAGE

WaterRF has completed VOC occurrence studies and developed a model for estimating impacts of control strategies for fuel-derived VOCs on individual reservoirs. Its research also found that air stripping, and various oxidization and activated carbon processes, are more effective than ultraviolet disinfection in removing selected VOCs. The organization is currently studying the cost and performance considerations of these treatment methods.

Hydraulic Fracturing

Hydraulic fracturing enhances natural gas extraction by injecting water and chemicals into wellbores to create and enhance fractures, which make removing gas easier. The USEPA plans to study the groundwater and surface water impacts of hydraulic fracturing in mid-2011. Neither the agency nor states yet regulate this practice.

Last October, WaterRF hosted workshops to identify potential impacts of hydraulic fracturing on water quality and water supply. Utilities need more information on the potential water supply impacts of hydraulic fracturing. The workshops helped to raise awareness and share existing knowledge of hydraulic fracturing with utilities and other stakeholders, and also identified 14 research ideas aimed at closing knowledge gaps related to impacts of hydraulic fracturing.

Lead & Copper Rule (LCR)

Pipes and plumbing systems, in particular service lines and premise plumbing components, can contribute trace amounts of lead and copper in the water supply. While the USEPA won't propose long-term revisions to its LCR until 2012, it is discussing with drinking water authorities and researchers the need for revisions. Additionally, the Obama administration signed into law the *Reduction of Lead in Drinking Water Act* in January. This new law will eventually require utilities and manufacturers to comply with more stringent standards for allowable lead concentrations in plumbing materials.

To help utilities minimize lead and copper exposure at the tap, WaterRF has completed numerous studies (see the WaterRF state-of-the-science report, ***Lead and Copper Rule and Distribution System Corrosion: An Overview of Foundation Research***). In 2010, the organization allocated $1.5 million for three new studies addressing current issues with lead in drinking water:

- **"Impact of Galvanic Corrosion on Lead Release Following Partial Lead Service Line Replacement"** (project #4349)
- **"Non-Intrusive Methodology for Assessing Lead and Copper Corrosion"** (project #4317)
- **"Evaluation of Lead Service Line Lining and Coating Technologies"** (project #4351), which is funded through a USEPA Science to Achieve Results (STAR) Grant

Additionally, the Foundation is assessing performance of non-leaded brass drinking water distribution system components in project #4191, **"The Performance of Non-Leaded Brass Materials."**

Nitrogenous Disinfection By-Products

Recent epidemiological studies suggest nitrogen-containing DBPs (N-DBPs) are more toxic than other DBPs, so the USEPA is considering regulating nitrosamines

(a class of N-DBPs) as a contaminant group. Currently, no MCLs exist for N-DBPs, but five nitrosamines are on the agency's Contaminant Candidate List.

WaterRF studies have revealed that formation, fate, and effective control of N-DBPs differ from that of non-nitrogenous DBPs, and that efforts to control the former may increase the formation potential of the latter. By better understanding this trade-off, researchers can help utilities design more effective disinfection systems.

Two projects are underway to better understand and reduce N-DBP occurrence and formation: **"Development of a Protocol to Predict the Formation of Nitrosamines While Minimizing the Formation of Regulated DBPs"** (project #4180), and **"Fate of Non-Regulated DBPs in Distribution Systems"** (project #4242).

Long-Term 2 Enhanced Surface Water Treatment (LT2) Rule

While source water protection (SWP) is important to delivering safe drinking water, no federal mandate or coordinated framework currently exists, leaving water utilities on their own to develop and advocate effective SWP programs.

The USEPA has until 2015 to revise its LT2 Rule, and many industry insiders expect increased emphasis on source water monitoring and protection.

WaterRF's ***Developing a Vision and Roadmap for Source Water Protection for Drinking Water Utilities,*** (order/project #4176), is intended to serve as a feasible, focused path for promoting SWP for drinking water utilities.

Additionally, ***Watershed Pathogen Modeling for Risk Management and Load Estimations*** (2010, order/project #3124), developed an online, event-based model that allows utilities to estimate likely ranges of concentrations and loads for key pathogens. WaterRF is presenting the model to key USEPA staff in 2011.

The Foundation's most recently published study related to SWP, ***Selecting and Standardizing the Most Appropriate Tool for Regulatory* Cryptosporidium *Genotyping (Genotyping Tools)*** (order/project #4179) developed simple, sensitive, specific, and validated *Cryptosporidium* genotyping tools to allow the water industry to assess human infective *Cryptosporidium* oocysts in source water and to then track the contamination to host groups in the environment.

Conclusion

As the USEPA continues to evaluate existing and potential new regulations that impact water utility operations and compliance costs, WaterRF will participate in the dialogue, bringing relevant science to regulators in an effort to promote pragmatic rulemaking on behalf of its subscribers, and will continue to provide utilities with the most cost-effective compliance strategies and tools.

Drinking Water in the News 2010

Shannon Diederich, Water Research Foundation writer

The media in 2010 shined a spotlight on global drinking water challenges, from new regulatory standards to ongoing water quality and supply concerns. Articles on dwindling fresh water supplies, hexavalent chromium, algal toxins, and degrading infrastructure alarmed utility managers, customers, and oversight agencies, underscoring the need for swift, research-based solutions. The following round-up of 2010's top drinking water stories will help utility managers stay abreast of current events and be prepared for 2011's headlines.

Water Quality

Delivering safe drinking water has been a global challenge for centuries and certainly remained a concern in 2010. Stories about lead, hexavalent chromium, and other drinking water contaminants permeated mainstream and trade media alike.

In May, the USEPA announced it would overhaul drinking water regulations to better monitor dozens of contaminants simultaneously.

Lead

Perhaps one of the year's most contentious water quality articles—the *Washington Post's,* "Drinking water debacle deals a blow to CDC and EPA,"—focused on a U.S. Centers for Disease Control and Prevention study on lead exposure. The study found exposure risks to lead from pipes and other water fixtures were greater than previously believed.

These findings countered a USEPA directive in 1991 that partial pipe replacement was effective in reducing lead exposure. Lead pipes remain in an estimated 3 million to 6 million households nationwide.

Hexavalent Chromium

USA Today was one of several news agencies that reported about the prevalence of hexavalent chromium in drinking water.

While the federal government currently restricts the amount of total chromium in drinking water, the USEPA is considering setting a limit for hexavalent chromium (or chromium-6) in tap water.

Late last year, California proposed a public health goal of 0.02 parts per billion, which was more stringent than anticipated by many industry insiders. The goal was lowered from the 2009 proposal of 0.06 parts per billion due to potential health risks.

Algal Toxins

Unwanted blue-green algae blooms made several appearances in water bodies last year, sparking health advisories and closing recreational areas in California, Ohio, Australia, and even Cape Town, South Africa—among other locales. The naturally occurring blooms contained cyanobacteria, which can

cause skin rashes, nausea, or tingling and numbness around the mouth or fingertips.

Perchlorate

California's San Bernardino County declared a state of emergency briefly last year after the city of Barstow's water was found to be contaminated with perchlorate, a toxic chemical used to make explosives and rocket fuel. The *Los Angeles Times* reported in "Governor declares emergency over water contamination in Barstow," that some 40,000 residents stocked up on bottled water. The contaminant has been found in water in more than 30 U.S. states.

As with hexavalent chromium, the USEPA is considering setting a drinking water guideline for perchlorate. The agency published an interim health advisory level as 15 parts per billion (ppb) in January 2009, but some speculate the new maximum contaminant level (MCL) could go as low as 2 ppb. The final regulatory determination is slated to be published in early 2011.

Fluoride, Manganese, and Radon

The *Associated Press* reported the federal government plans to lower the recommended limit for fluoride in water supplies—as the compound allegedly causes streaking or spottiness on some children's teeth. The 1962 regulatory standard was set between 0.7 to 1.2 milligrams of fluoride per liter of water.

Environmental Health Perspectives reported that excess fluoride and manganese may lower IQ levels in children as well. While manganese in drinking water is not currently regulated, the USEPA suggests a limit of 0.05 milligrams per liter.

As for radon, nine states took matters into their own hands and set guidance limits for the compound out of concern that there may be elevated levels of radon in drinking water. To date, the USEPA has not published a maximum limit for radon in water. The agency proposed in 1999 that states adopt different radon mitigation programs that reduce exposure from air and water.

Infrastructure Sustainability

While the global economy reels from ongoing deficits and recessionary shocks, water suppliers are struggling with a huge unfunded need to replace aging infrastructure.

USA Today's "Pipes, pumps trouble Big Easy" story reported in the U.S. alone, more than 1,000 aging water and sewer systems need urgent upgrades—at a cost of $500 billion to $1 trillion—according to Ken Kirk, executive director of the National Association of Clean Water Agencies.

And each day, some 7 billion gallons of treated drinking water—15% of the nation's total water production—are lost from pipeline leaks, according to the American Society of Civil Engineering.

American Water piloted a new acoustic leak detector in 2010, which can relay daily leak data back to a utility, revealing information about pipe conditions and factors contributing to new leaks. The tool significantly reduced water loss within six months, saving an estimated $140,000 in

lost revenue and generating a return on investment within two years.

Also last year, the USEPA issued a Clean Water and Drinking Water Infrastructure Sustainability Policy to provide technical assistance and $3.3 billion in funding in hopes of jumpstarting infrastructure construction. The agency instructed states to adopt smart-growth principles and invest in existing infrastructure first, but some municipalities want more control over how the monies are spent.

The Federal Emergency Management Agency also began funding a four-year, $375 million project to replace drinking water and sewer lines, storm drains, and roads that were under water and damaged solely by Hurricane Katrina.

Hydraulic Fracturing

As demand for natural gas increases, so has scrutiny of the environmental impacts of hydraulic fracturing, a form of extracting natural gas, on nearby watersheds. In fact, "more than two out of three Americans (69%) are concerned about the drilling technique's possible threat to clean drinking water," according to a 2010 Infogroup/Opinion Research Corporation survey.

The USEPA announced in March that it would study the potential human health and water quality effects of fracking. The agency might also outline best management practices and provide other guidance.

Source Water Protection

While source water protection is important to delivering safe drinking water, no federal mandate or coordinated framework currently exists, leaving water utilities on their own to control related impacts.

In *Science Daily's* "Large Number of Public Wells in U.S. Have Potentially Harmful Contaminants in Source Water, Study Finds," the article said that a 2010 U.S. Geological Survey study found that more than 20% of untreated water samples from 932 public wells across the nation contained at least one contaminant at levels of potential health concern—affecting about one-third of the nation's population.

In this regard, the United States joins other large, geographically diverse countries such as Brazil, which found up to 30% of that nation's water sources were of poor quality.

The Water-Energy Nexus

Curbing energy use not only shrinks the global carbon footprint, it saves a tremendous amount of water. Efforts are underway worldwide to continue this trend.

In Dubai, officials raised electricity and water bills 15% in 2010 in hopes of reducing unnecessary consumption, *Bloomberg* reported in its "Dubai to Raise Water, Power Prices, Emarat Alyoum Reports" feature.

Residents of this Gulf country consume a staggering 132 gallons of water each day, compared to 70 gallons daily in the United States. Dubai's Energy Council also passed a green building regulation that is expected to reduce water and power consumption by one-fifth.

Here in America, a $1,500 federal tax credit was awarded to homeowners who installed more efficient appliances to reduce energy and water use. States are making inroads as well.

In 2010, North Carolina saw big returns on a program it launched years ago. The Utility Savings Initiative, a multi-programmed approach to reduce utility expenditures and resource use in public buildings, cut water use by 31% and avoided $17 million in water bills. And California released its final report on ways to achieve a 20% reduction in per capita water use by 2020.

Water Scarcity

A staggering 884 million people in the world lacked access to safe drinking water in 2010, according to *Environmental Leader*. And with less than 1% of the planet's water available to an ever-expanding population of nearly 7 billion, water scarcity remains the primary global water challenge.

Some of the hardest-hit regions included:

- India—After suffering from chronic rainfall shortages, hydrologists mined water from underground aquifers to meet the needs of this highly populated and intensely irrigated region.
- Middle East—The Arab Forum for Environment and Development called for urgent policy reforms and published a water efficiency manual to help the region use water more resourcefully in homes, offices, and industry. Syria also piloted an innovative water scarcity park to harvest rainwater. The park deploys solar power to generate electricity to pump water for irrigation. If successful, similar parks will be built throughout the Arab region.
- Brazil—The Amazon Basin dropped to record lows, forcing thousands to go hungry as low water levels halted transport and fishing.

In the United States, water engineers were forced to tunnel under Nevada's Lake Mead to install an intake valve to continue water delivery despite dramatically reduced water levels. According to the *New York Times* piece, "Water Use in Southwest Heads for a Day of Reckoning," if volume continues to drop, it could alter the state water distribution plan, cease the flow of electricity generated from the Hoover Dam, and put the city of Las Vegas' water supply at grave risk.

Altering the Business Landscape

Sustainability experts are predicting the lack of fresh water also will radically transform global industrialization and business models, as water shifts from being a commodity to a precious resource.

According to a 2010 study by GlobeScan, a public opinion and research firm, businesses must develop and market improved water-conserving production and irrigation practices to keep doors open in the 21st century.

Continued Strain

National Geographic reported in a special edition on water that 1.8 billion people will

live in areas plagued by water scarcity, and two-thirds of the world's population will live in water-stressed regions as a result of use, growth, and climate change by 2025.

Desalination

National Geographic reported 300 million people get their water from the sea or from brackish groundwater, double the number a decade ago. In the next six years, desalination plants will treat about 13 billion gallons a day—thanks to $88 billion that will be invested in new technologies.

Israel became home to the world's largest reverse-osmosis desalination plant in 2010, which is expected to supply 20% of the country's annual household consumption.

Looking Ahead

WaterRF expects these drinking water challenges to linger for years to come. It is incumbent on our industry to innovate new treatment technologies, share best practices and rebuild a global distribution and storage system to ensure a plentiful and healthy drinking water supply for future generations.

2010 Webcasts

Adam Lang, Water Research Foundation publishing manager

The Water Research Foundation hosted or co-sponsored a record 19 Webcasts in 2010, all free to Foundation subscribers. Webcasts were conducted on a wide variety of topics and projects, ranging from managing total coliform and *E. coli* to the accuracy of in-service water meters. A few of the Webcasts from 2010 are described in this article. A full list of the 2010 Webcasts are included on the next page along with a list below of the Top 5 2010 Webcasts by attendance. All Foundation hosted Webcasts and/or the slides, audio, and Q&A are available to subscribers to view or download from the Foundation Website.

The first Webcast of 2010, "Criteria for Optimized Distributions—Recommended Metrics and Approach," provided preliminary results for a very popular report and software tool published at the end of the year, ***Criteria for Optimized Distribution Systems*** (order/project #4109). This Webcast and project presented a practical set of easily measured parameters that, when actively and effectively managed, drive excellence in overall distribution system water quality, operations, and infrastructure management. A detailed description of the project is provided on page 14 of this issue.

The most watched Webcast of 2010 was held in December and titled, "North American Residential Water Usage Trends and Applications for Utilities." This Webcast focused on understanding residential water-usage behavior patterns and trends, assessing the impact of those patterns on water utility operations, and providing data that can be correlated with future trends for planning purposes. The Webcast was based on the report, ***North American Residential Water Usage Trends Since 1992*** (order/project #4031), which was published in January 2010. This project is discussed on page 19.

While the aforementioned Foundation Webcasts were focused on specific projects, the second most viewed Webcast of the year, "Algal Toxins: Source Water Management and Treatment," combined results from multiple reports as well as the researcher's knowledge to provide a comprehensive overview on how to control algal toxins. This Webcast presented information on source water management strategies for cyanobacteria and drinking water treatment processes to control cyanobacteria, such as granular activated carbon (GAC), ozone, and membrane treatment. Further, this Webcast connected two experts on algal toxins from Australia with subscribers to discuss these issues. In the future, we plan on holding more Webcasts that focus on general topics instead of specific projects, so that our subscribers can receive all the latest information and research on important issues.

We would also like to note that the last two Webcasts of 2010 were two of the top five attended Webcasts for the year. While these two Webcasts covered important issues, that rise in viewership also likely reflects the desire of our subscribers to view presentations remotely, without having to tap declining travel budgets. Therefore, our goal is to hold more Webcasts in 2011 than ever before.

Top 5 Webcasts of 2010 (by number of viewers)

1. North American Residential Water Usage Trends and Applications for Utilities
2. Algal Toxins: Source Water Management and Treatment
3. Strategies for Managing Total Coliform and *E. coli*
4. Criteria for Optimized Distributions: Recommended Metrics and Approach
5. Accuracy of In-Service Water Meters at Low and High Flow Rates

2010 Webcasts

January	January 21—Criteria for Optimized Distributions: Recommended Metrics and Approach (based on project #4109)
February	February 4—Workforce Sustainability: Strategies for Partnership in Workforce Planning and Development (based on project #4206)
	February 11—Localized Treatment for Disinfection Byproducts (based on order #91254/ project #3103)
March	March 2—Water Conservation: Customer Behavior and Effective Communication (based on project #4012)
	March 16—Chloride to Sulfate Mass Ratio and Galvanic Connection Changes: Impact on Lead Leaching (based on project #4088)
April	April 22—Nitrosamines and other Emerging Nitrogenous Disinfection By-Products: Formation, Occurrence, and Control (based on projects #3014, #4209, #4180)
	April 29—Managing Lead in Pipe Scales: Understanding How Water Quality Affects Lead Release (based on project #4064)
May	May 25—Assessment of Inorganics Accumulation in Drinking Water System Scales and Sediments (based on project #3118)
June	June 15—Groundwater Reserves—Conditions, Trends, and Sustainability (hosted by the Groundwater Foundation)
July	July 8—Water Well Research Priorities Workshop (based on project #4240) (hosted by the National Ground Water Association)
	July 27—Emerging Contaminants in the Environment (hosted by the Groundwater Foundation)
September	September 9—Algal Toxins: Source Water Management and Treatment
	September 14—Accuracy of In-Service Water Meters at Low and High Flow Rates (based on project #4028)
	September 30—Simultaneous Compliance Decision Tool for Small and Large Systems (based on project #3115)
October	October 7—Best Practices for Energy Efficiency in the Water Supply Industry (based on project #4223)
	October 12—Engineered Biofiltration for Enhanced Hydraulic and Water Treatment Performance (based on project #4215)
	October 21—Applied Research Successes in Leakage Management (based on order #91180/project #2928)
December	December 2—Strategies for Managing Total Coliform and *E. coli* (based on project #3116)
	December 14—North American Residential Water Usage Trends and Applications for Utilities (based on project #4031)

2010 FUNDED PROJECTS

Project Title	Project #	Research Program
2010 Groundwater Foundation Webinar Series	4330	Co-sponsored
2010 Water Quality Conference (Perchlorate, Pharmaceuticals, DBPs)	4328	Co-sponsored
5th AWWA International Symposium on Waterborne Pathogens	4329	Co-sponsored
Acute Health Effects of Chloramine Use in Drinking Water	4320	Strategic Research Initiative: Distribution System Water Quality
Advanced Condition Assessment and Failure Prediction Technologies for Optimal Management of Critical Water Supply Pipes	4326	Partnership
Altering Environmental Conditions to Enhance Non-mechanical Dewatering of WTP Residuals	4338	Tailored Collaboration
Analysis of Reservoir Operations Under Climate Change	4306	Strategic Research Initiative: Climate Change
Assessing the Gap Between AWWA J100-10 Standard and Existing RAMCAP-Compatible Vulnerability Assessment Tools	4358	Rapid Response
Business Continuity Plans for Water Utilities	4319	Partnership
Case Studies on Utility Pressure Management, Baseline to Optimized Monitoring	4321	Strategic Research Initiative: Distribution System Water Quality
CFRP Renewal of Prestressed Cylinder Concrete Pipe	4352	EPA/WERF Aging Water Infrastructure Partnership
A Comprehensive Field-Scale Distribution System Network Model Assessment and Analysis: Hydraulics and Water Quality	4345	Unsolicited
Constructed Wetlands for Treatment of Organic and Nanomaterial Pollutants	4334	EPA/WERF Aging Water Infrastructure Partnership
Consumer Perceptions and Attitudes towards EDCs and PPCPs in Drinking Water	4323	Strategic Research Initiative: Endocrine Disruptores/ Pharmaceuticals and Personal Care Products
Defining and Enhancing the Safe Yield of a Multi-Use, Multi-Reservoir Water Supply	4304	Tailored Collaboration
Drinking Water Pump Station Design and Operation for Maximum Life Cycle Energy Efficiency	4308	Strategic Research Initiative: Climate Change
Effective Microbial Control Strategies for Main Breaks and Depressurization	4307	Partnership

Project Title	Project #	Research Program
Engineered Biofiltration: Enhancing Hydraulic and Water Treatment Performance	4346	Tailored Collaboration
Evaluation of Lead Service Line Lining and Coating Technologies	4351	Partnership
The Future of Research on Climate Change Impacts on Water: A Workshop Focusing on Adaptation Strategies and Information Needs	4340	Strategic Research Initiative: Climate Change
Groundwater Sustainability Under Climate Change	4325	Strategic Research Initiative: Climate Change
Identifying Meaningful Opportunities for Health Risk Reduction	4310	Partnership
Impact of Galvanic Corrosion on Lead Release Following Partial Lead Service Line Replacement	4349	Tailored Collaboration
Information Optimization for Water Utilities: Strategic Vision, Integration, and Investments	4316	Partnership
Integration of Cost of Failure with Asset Risk Management	4332	EPA/WERF Aging Water Infrastructure Partnership
Investigating the Use of Algaecides for Removal of Geosmin and Methylisoborneol	4347	Tailored Collaboration
Legacy of Manganese Accumulation in Water Systems: Assessment, Consequence, Remediation and Prevention	4314	Partnership
Long-term Performance Prediction of Steel Pipe	4318	Partnership
Matrix Effects in the Bull Run Watershed on Cryptosporidium Oocyst Recovery	4348	Tailored Collaboration
Monochloramine Cometabolism: the Missing Link in Understanding Disinfectant Loss During Nitrification Episodes in Distribution Systems	4341	Unsolicited
Non-Intrusive Methodology for Assessing Lead and Copper Corrosion	4317	Partnership
An Operational Definition of Biostability in Drinking Water	4312	Solicited Research
Opportunities and Challenges of Nanomaterials in Drinking Water	4311	Solicited Research
Optimizing Conventional Treatment for Removal of Cyanobacteria and Their Toxins	4315	Partnership
Perfluorinated Compound Removal By North American Water Treatment Practices	4322	Strategic Research Initiative: Endocrine Disruptores/ Pharmaceuticals and Personal Care Products

Project Title	Project #	Research Program
Process Benchmarking for the Ten Attributes of Effectively Managed Water Utilities	4313	Solicited Research
Removal of Perfluorinated Compounds by Powdered Activated Carbon Blends, Superfine Powdered Activated Carbon, and Magnetic Anion Exchange Resins	4344	Unsolicited
Retrospective Analysis of Performance of Dual Distribution Systems	4333	EPA/WERF Aging Water Infrastructure Partnership
Sources and Characterization of Organic Carbon in the Clackamas River Basin, Oregon, and their Effects on the Formation of Disinfection By-products in Finished Drinking Water	4336	Tailored Collaboration
Transformation of Amines to Nitrosamines on Activated Carbons: Implications for Nitrosamines Analysis and Water Purification	4343	Unsolicited
Update and Expand Residential End Uses of *Water (1999, Project* 241)	4309	Solicited Research
Water Quality Impacts of Extreme Weather-Related Events	4324	Strategic Research Initiative: Climate Change
Water Utility Executive Leadership for the 21st Century	4342	Unsolicited
WateReuse Foundation Research Conference	4327	Co-sponsored
Workshop on Natural Gas Development Issues for Drinking Water Utilities	4301	Rapid Response

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