WATER RESOURCES

IMPACT

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CONTAMINANTS OF EMERGING CONCERN

AWRA
Community, Conversation, Connections
AMERICAN WATER RESOURCES ASSOCIATION

CONTAMINANTS OF EMERGING CONCERN

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Contaminants of Emerging Concern (ECs) are being found with increasing frequency in the world's streams, lakes, and ground water. Are some ECs potentially harmful to ecological or human health? Are there safe limits of exposure or ingestion? How do we allocate scarce funds to study or control EC exposure when the risks are poorly defined? This issue of *Water Resources IMPACT* starts the process of finding answers to these questions. We will continue that communication process at the AWRA meeting in Vail, Colorado, on June 25-27, 2007, but we also realize that the professional challenges that face this group of researchers and interested stakeholders will take time to solve.

INTRODUCTION

FEATURE ARTICLES

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(Opinions expressed by our columnists are their own and do not represent the opinion or position of AWRA.)

Learn more about AWRA's Summer Specialty Conference
"Emerging Contaminants of Concern in the Environment: Issues, Investigations, and Solutions"
June 25-27 ~ Vail, Colorado
Check out the special 4-page center tear-out section featuring Conference Themes ... Who Should Attend? ... Program Highlights ... Program-at-a-Glance ... and a Registration Form for your convenience

Scheduled Topics for Future Issues ...

JULY 2007
INSTREAM FLOWS
CLAY J. LANDRY (LANDRY@WATEREXCHANGE.COM)

SEPTEMBER 2007
MEASURING MONITORING PERFORMANCE BY LOCAL WATERSHED GROUPS
WINFIELD G. WRIGHT (GUEST EDITOR)
LAUREL E. PHOENIX (PHOENIXL@UWGB.EDU)

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WATER RESOURCES DISASTER RECOVERY
ERIC J. FITCH (FITCHE@MARIETTA.EDU)

All of the topics listed above are subject to change. For information concerning submitting an article to be included in the above issues, contact the designated Associate Editor or the Editor-In-Chief N. Earl Spangenberg at (espangen@uwsp.edu).

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Community Conversation Connections

WATER RESOURCES
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INTRODUCTION: CONTAMINANTS OF EMERGING CONCERN IN THE ENVIRONMENT

William Battaglin, Jörg Drewes, Bret Bruce, and Mike McHugh

The focus of this issue of *Water Resources IMPACT* is contaminants of emerging concern in the environment. Identifying sources of contaminants of emerging concern (ECs), determining their fate in engineered systems and in the environment, and understanding their potential effects on wildlife and humans is a complex topic requiring research and insights provided by multidisciplinary fields including chemistry, hydrology, biology, and engineering. Research will help wastewater and drinking water treatment plant managers, regulators, and public health officials to make informed decisions regarding ECs.

What are ECs and why are we convening a national meeting to discuss them? ECs can be broadly defined as any synthetic or naturally occurring chemical or any microorganism that is not commonly monitored in the environment but has been recently detected in the environment. Once in the environment, ECs are a potential ecologic or public health risk, however, adequate data often do not exist to determine their risk (USGS, 2007; Younos, 2005). Typically, synthesis of new chemicals or changes in use and disposal of existing chemicals creates a source of ECs, but in some cases, the release of ECs to the environment has likely occurred for a long time, but may not have been recognized until new detection methods were developed.

Advances in analytical chemistry, hydrology, and engineering have greatly improved our ability to identify and study ECs in the environment. Over the last three decades, our analytical capabilities have generally improved from parts per thousand, to parts per trillion, and in some cases parts per quadrillion. Correspondingly, our ability to investigate and understand environmental contaminants also has improved.

As science leads to the discovery of trace (e.g. sub-part-per billion) concentrations of ECs in streams, ground water, drinking water, air, food, and in the products used every day, there is a concern about the long term effects of public health or ecological exposure. However, our ability to detect ECs in the environment often may exceed our ability to understand their risks.

Initial studies of EC occurrence focused on locations where ECs were expected to occur, such as those downstream from intense urbanization or livestock production (Kolpin *et al.,* 2002). Recent research documents that ECs are present in the environment on a global scale and can occur in relatively undeveloped areas (Ashton *et al.,* 2004; Bendz *et al.,* 2005; Kim *et al.,* 2007).

What, then, is our public policy regarding these substances? Are some ECs potentially harmful to ecological or human health? How do we allocate scarce funds to study or control EC exposure when risks are poorly defined? Are there safe limits of exposure or ingestion? How do we respond to new compounds, new modes of action, or new research findings? What recommendations should water-resources professionals give to policy makers? Finding answers to these questions is the professional challenge that faces this group of stakeholders.

This issue of *Water Resources IMPACT* begins the dialog process with seven articles on EC-related subjects. Susan Glassmeyer provides an overview of ECs sources. She then focuses on how wastewater and drinking water treatments effect ECs occurrence, transport, and fate in the environment. Steve Frank writes about ECs from a wastewater-treatment plant operator's perspective and indicates how operators must balance their desire to be forward looking with the realities of supporting aging infrastructure and addressing pressing water-quality issues. Tamim Younos and his co-authors describe how pathogens can be ECs and their potential threats to human health. They argue that improvements in detection capability and fate and transport modeling are needed to help protect the public from the potential effects of pathogens in America's water resources. David Norris and his co-author describe the effects that endocrine active chemicals can have on wildlife and humans. They suggest that there is extreme fetal sensitivity (rodent or human) regarding exposure to endocrine active ECs. Laurie Peterson-Wright summarizes results from recent national-scope biomonitoring surveys. She describes how biomonitoring can be used as a public health tool that can provide answers to questions about EC exposure and accumulation in humans. Brenda Bateman and her co-authors highlight the issues and obstacles involved in designing effective and sustainable community pharmaceutical "take-back" programs. They provide examples of programs from across the U.S. Finally, Juliane Brown and her co-author relate how the Consortium for Research and Education on Emerging Contaminants (CREEC) was formed by a group of forward thinking Colorado and Wyoming stakeholders. These individuals and the organizations they represent are interested in being informed and proactive about EC issues and are willing to work together to address those issues.

The AWRA Summer Specialty Conference in Vail, Colorado, on June 25-27, 2007, promises to be a very thought-provoking three days, with more than 120 presentations scheduled. Topics of the 24 oral sessions include: analytical methods (3), EC sources (3), drinking and wastewater treatment technologies (3), EC fate and transport (5), ecosystem effects and exposure monitoring (3), policy and legal issues (2), engineering and source control solutions (2), and policy and communication (3). Plenary speakers will include: Theo Colborn, Dana Kolpin, Christian Daughton, Kim Linton, Hal Zenick, Rula Deeb, and Peter Stoks.

So please join us in Vail to hear and discuss what we know and do not know, and to learn what we can. The Vail valley and surrounding mountains are an appro-

priate setting for a great intellectual challenge. We hope to see you there.

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William A. Battaglin received a B.A. in Geology from the University of Colorado-Boulder in 1984 and an M.E. in Geological Engineering from the Colorado School of Mines in 1992. Bill is currently working on investigations of the occurrence of glyphosate in National Parks and National Wildlife Refuges, chlorothalonil and other fungicides in surface and ground water, hypoxia in the Gulf of Mexico and its relation to nutrient flux of the Mississippi River, emerging contaminants in Colorado's water resources, and the decline of amphibian populations in North America.

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NOTICE OF PROPOSAL TO AMEND THE BYLAWS OF THE AMERICAN WATER RESOURCES ASSOCIATION

At its July 31, 2007, conference call meeting the Board of Directors of the American Water Resources Association will consider the following amendment to the Association's Bylaws.

CURRENT BYLAWS

Article V, Section 3. Types of Member

e. **Corporate Member**. Business firms, corporations, or associations are eligible for Corporate Membership.

f. **Institutional Member**. An educational institution or one of its departments, a Federal, State, Provincial or local government agency or body, or nonprofit organization is eligible for Institutional membership.

g. **Emeritus Member (Retired Member)**. Retired persons who have been regular members of the Association for at least 10 years may petition to the Executive Vice President for Emeritus (Retired) Member status. If granted, Emeritus Member dues will be one-half the amount of regular membership dues. Emeritus (Retired) status will continue from year to year upon payment of dues unless rescinded by the Executive Vice President or the Executive Committee.

Article V, Section 4. Voting

All members of the Association are eligible to vote and hold office, except for Corporate and Institutional Members.

PROPOSED CHANGES

Article V, Section 3. Types of Member

~~e. **Corporate Member.** Business firms, corporations, or associations are eligible for Corporate Membership.~~

~~f. **Institutional Member**. An educational institution or one of its departments, a Federal, State, Provincial, or local government agency or body, or nonprofit organization is eligible for Institutional membership~~.

e. **Associate Member.** Business firms, corporations, associations, educational institutions, and federal, state, provincial, local or tribal governments are eligible for Associate Membership. Associate Members may choose to join as a single office, department, or location, or they may choose to join enterprise-wide.

~~g.~~ f. **Emeritus Member (Retired Member)**. Retired persons who have been regular members of the Association for at least 10 years may petition to the Executive Vice President for Emeritus (Retired) Member status. If granted, Emeritus Member dues will be one-half the amount of regular membership dues. Emeritus (Retired) status will continue from year to year upon payment of dues unless rescinded by the Executive Vice President or the Executive Committee.

Article V, Section 4. Voting

All members of the Association are eligible to vote and hold office, except for ~~Corporate and Institutional Members~~ Associate Members.

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THE CYCLE OF EMERGING CONTAMINANTS

Susan T. Glassmeyer

The best wine is the oldest, the best water the newest.
William Blake (1757-1827)

For the past decade, so-called "emerging contaminants" (ECs) have become an increasing area of interest for environmental research. This is because of concern about potential impacts of these chemicals on human health and the environment. In 1998, there were approximately 100 papers published in the scientific literature on ECs. In 2006, the number of papers increased to over 300, including a special issue dedicated to the topic in the journal *Environmental Science and Technology*. But, what are these "emerging contaminants?" ECs are broadly defined by the scientific community as pollutants that are currently not included in routine monitoring programs, and which may be candidates for future regulation, depending on research on their toxicity, potential health effects, occurrence in various environmental matrices, and public perception. The term has come to encompass a wide variety of chemicals – pharmaceuticals and household chemicals such as fragrances, antimicrobials, surfactants, and fluorescent whitening agents. Some definitions of ECs include newer classes of compounds, such as nanomaterials and genetically modified food items. The majority of the ECs differ from the "conventional" environmental pollutants, such as pesticides, metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and dioxins because many ECs are used in typical households. The use of the term "emerging" has led to a common misconception: that ECs are chemicals that have only recently been released into the environment. In reality, these chemicals have likely been entering the environment as long as they have been in use. What is "emerging" is the awareness in both the scientific community and general public that these chemicals are being released into the environment through household wastewater, and can be detected in water, sediment, soil and biota.

Recently, the practice of flushing unused or expired medications has come under scrutiny because pharmaceuticals have been detected in wastewater treatment plant (WWTP) discharges. Several Federal agencies have published guidelines advocating the disposal of unused medications in the trash, rather than the toilet, to minimize their potential environmental impact (http://www. whitehousedrugpolicy.gov/news/press07/022007.html; http://www.fws.gov/news/NewsReleases/showNews.cfm?newsId=708A991D-F915-7BD0-085DE68425ABF68B). In addition, some communities have begun working with local pharmacies on "take back" programs, as well as adding pharmaceutical collections to their household hazardous waste collection programs. While these "take back" programs have obstacles, particularly when dealing with pharmaceuticals that have the potential for abuse, the efforts reflect the growing awareness of the need to limit the environmental release of these chemicals.

What is "emerging" is the awareness in both the scientific community and general public that these chemicals are being released into the environment through household wastewater, and can be detected in water, sediment, soil, and biota.

The level of treatment that household wastewater receives varies throughout the United States (U.S.). Approximately one-quarter of the homes in the U.S. use onsite septic systems to process household wastewater. These septic systems depend on the homeowners' diligence for maintenance, thus, treatment efficiency may decrease over time. The remaining 75 percent of household wastewaters are discharged to municipal WWTPs. WWTPs are designed to remove solid materials and reduce metal, bacteria, and other pathogen levels, but are not designed to specifically destroy chemicals (see Figure 1 for a description of typical wastewater treatment processes). During wastewater treatment, the solid materials are settled out, forming biosolids (commonly referred to as sludge). The concentrations of several ECs have been measured in these biosolids. The concentrations are typically in the range of milligrams of chemical per kilogram of biosolid, or parts per million (ppm). Biosolids can be incinerated, disposed of in landfills, or spread on land as a fertilizer for agricultural crops or a soil amendment. These land applications potentially allow the ECs to leach from the biosolids into the soil and surface and ground waters, depending on the fate and transport properties of the chemicals. Human waste streams are not the only route of environmental introduction for these chemicals. While this paper has primarily discussed the chemicals used in households, ECs also have veterinary applications. Chemicals such as antibiotics and insecticides are often used in concentrated animal feeding operations (CAFOs). The urine and feces from the animals can contain traces of these prophylactic chemicals. As with human biosolids, if these wastes are not suitably contained, the ECs can seep from the fecal material and enter the soil and surface and ground waters.

Returning to the WWTP process, after removing the solids, the liquid portion of the wastewater is further subjected to disinfection to reduce the level of pathogens. The concentrations of ECs may be reduced, but are typically not completely removed, by these steps. In a recent collaborative study between the U.S. Environmental Protection Agency (USEPA) and the U.S. Geological Survey (USGS), the discharges from 11 WWTPs were examined (Glassmeyer *et al.*, 2005). Of the 110 chemicals that were tested, 68 were found in at least one effluent sample and 34 were found in at least half of the effluent samples.

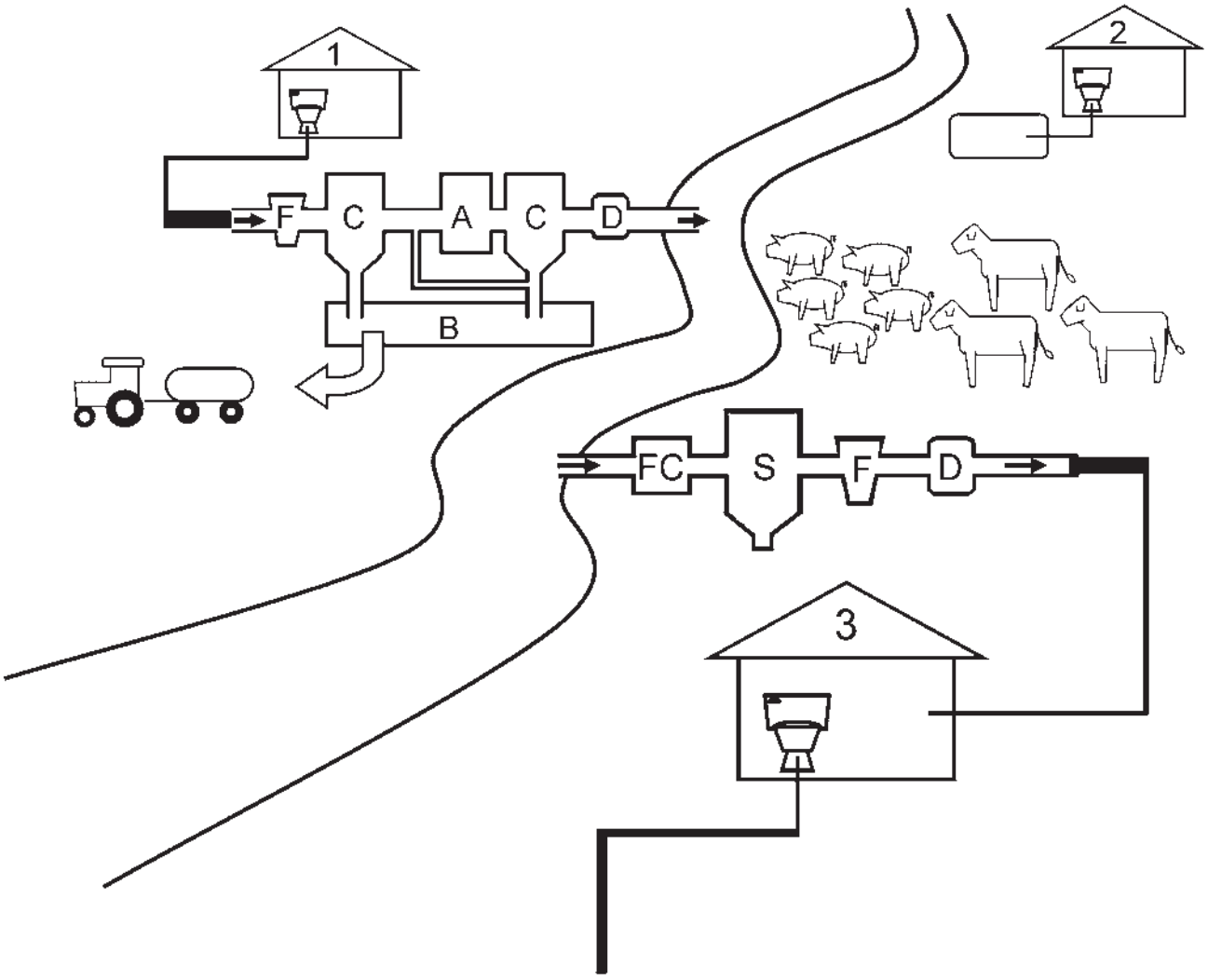

Figure 1. A Tale of Three Houses. House 1 is connected to a municipal wastewater treatment plant (WWTP). In this example, the WWTP's secondary treatment is an activated sludge system. After entering the WWTP, the waste is filtered (F) to remove debris. In the primary clarification tank (C), the solids separate by gravity, and are transferred into a biosolid digester (B). In secondary treatment, the waste passes though an aeration tank (A) and undergoes secondary clarification (C). Part of the separated solids are re-introduced into the treatment train to keep a constant solids concentration in the aeration tank. The remainder of the solids are removed as biosolids (B). The liquid portion remaining after clarification is disinfected (D), typically using chlorine, ozone or ultraviolet light. The disinfected effluent can be discharged into surface waters, or used to recharge ground water aquifers. The biosolids from the WWTP can be incinerated, landfilled, or land applied as a soil amendment or a fertilizer for certain agricultural crops. Household chemicals that bind to the biosolids can be introduced into the soil, surface or ground waters through runoff or percolation through the soil. House 2 disposes of their waste in an on-site septic tank treatment system. The effluent from these types of systems can discharge into soil, surface waters, or seep into ground water. Concentrated animal feeding operations (CAFOs) can also be a source of ECs such as antibiotics and insecticides. Similar to biosolids, the ECs contained in the animals' fecal material can be leached from the waste and end up in soil, surface and ground waters. House 3 is downstream from houses 1, 2 and the CAFO, and the source of its drinking water is the same water body into which the treated wastewater from houses 1 and 2 is discharged. During drinking water treatment, chemicals such as alum, lime, potassium permanganate, and activated carbon may be added to source water in the flocculation/coagulation step (FC) to remove solids, soften the water, oxidize metals, and improve the taste of the water. The solids in the water are separated in a settling basin (S), and any remaining particulates are filtered out (F). The water is disinfected using chlorine, chloramines, ozone or ultraviolet light (D), and distributed to households. Once the drinking water is used in house 3, the water enters the wastewater pathway, and the cycle begins again.

Nine chemicals – including the fragrances benzophenone, ethyl citrate, galaxolide, tonalide and antimicrobial triclosan – were found in every WWTP effluent sample. The number of chemicals found in any given effluent sample ranged from 27 to 50; the median number of chemicals was 35. The concentrations of the ECs in these effluents were typically in the high nanogram per liter (ng/L) to low microgram per liter (µg/L), or high parts per trillion (ppt) to low parts per billion (ppb) range.

Through the effluent of WWTPs, outlets from individual septic systems, and runoff from land applied biosolids, ECs can enter surface and ground waters. Because ECs have been measured in surface waters, there are concerns regarding their impact on the environment. For example, some ECs can act as endocrine disrupting chemicals (EDCs). EDCs have the potential to affect hormonal driven processes, such as reproduction. Aquatic organisms are particularly susceptible to EDCs, because their entire life cycles are spent in continuous contact with water. A variety of different physical, chemical, and biological processes, such as photolysis, hydrolysis, biodegradation, volatilization, sorption, and simple dilution, work to decrease the concentration of ECs that are ultimately detected in the water. These removal and transformation processes are compound-specific, and some chemicals can remain at detectable levels miles downstream from their environmental introduction. In the USEPA/USGS study, 54 of the 110 chemicals were detected in at least one sample downstream from the WWTPs. However, there were fewer chemicals detected in the downstream samples, as compared to the effluent samples. The numbers of chemicals detected ranged from 12 to 35 (median 24). The nine chemicals that were found in every effluent sample were also less frequently detected in the downstream samples, decreasing from 100 percent to a range between 50 and 90 percent. The median concentrations of the chemicals in the downstream samples similarly decreased. For the nine, the declines in median concentrations ranged from 44 to 86 percent.

Humans may also be exposed to ECs in the environment. Waters downstream of WWTP effluent outfalls, or those receiving runoff from land where biosolids have been applied, may be used as source water for drinking water supplies, and hence are potential routes of human exposure to ECs. Figure 1 depicts the processes that are typically used in drinking water treatment. Several studies in Europe and the U.S. have examined the concentrations of ECs in finished drinking water. For the chemicals that are detected, the concentrations are normally less than 100 ng/L, with many of the detections reported at levels less than 10 ng/L. It should be noted that frequency of detection of ECs in drinking water is far less than that found in surface water and wastewater, and the concentrations in drinking water are a hundred to a thousand times lower.

While the disinfection steps in both drinking and wastewater treatment are primarily designed to remove pathogens, they can also affect chemicals, forming disinfection by-products (DBPs). Researchers and regulators are aware of formation of chemicals such as trihalomethanes (THMs) and haloacetic acids (HAAs), and drinking water treatment plant operators are under strict rules to keep these chemicals to safe levels. But the ECs may also be forming by-products. Laboratory studies have shown that several pharmaceuticals, including acetaminophen, can become halogenated when treated with a chlorine disinfectant. Little is known about the toxicity and the dose-responses of these by-products. Most of the published environmental monitoring studies only report the removal rate of ECs during wastewater and drinking water treatment. These studies have not looked for, and therefore have not found, any by-products that may be forming during the disinfection process. To fully understand the potential for human and environmental exposure to ECs, additional studies need to be conducted to determine the concentrations of both the intact chemicals, as well as any metabolite and DBPs that may be formed during wastewater and drinking water treatment processes. This information may assist state and federal regulators in deciding how to improve the treatment of human and animal wastes and maintain a safe drinking water supply for the public.

Disclaimer: The U.S. Environmental Protection Agency through its Office of Research and Development funded and managed the research described here. It has been subjected to Agency's administrative review and approved for publication. The conclusions and opinions drawn are solely those of the author and should not be construed to reflect the views of the Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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A BALANCING ACT: DEALING WITH INFRASTRUCTURE NEEDS

Stephan D. Frank

An average citizen pours a cup coffee and opens his morning paper. In it, he sees a story about how male fish downstream from a wastewater treatment plant (WWTP) are turning into females.

To make the story easier for readers not accustomed to dealing with science information, a reporter (who himself might not have fully understood all the complexities and conditions in the findings) has reduced a complex set of facts that say the apparent sex change in the fish could be caused by untreated chemicals in the discharge from the WWTP to simpler language. Now readers could easily conclude a sex change is occurring and is being caused by untreated chemicals in the water from the WWTP. The article also does not make it clear that the WWTP is not adding chemicals to its effluent.

The researcher who discovered the apparent sex change speculates the cause is a chemical most people have never heard of at an incomprehensibly small concentration. In the newspaper article, the reporter has posed the rhetorical question: If this is happening to fish, what's happening to you or members of your family?

Let's face it ... we live in a 30-second society. Every problem, from bad breath and body odor to serious, complex problems, has to have a 30-to-90-second solution. The public, by and large, does not know what WWTPs do or how they do it. But now their daily paper says they are discharging "hexachloro-badstuff" in incomprehensible amounts, and it might be making fish change their sex and, by extension, might be harming people. The problem sounds critical. The public wants something done, and they want it done now.

The quote in the paper from the WWTP representative tells readers the WWTP doesn't know for sure whether a chemical caused the sex change in the fish and – if it was, indeed, a chemical – at what concentration the chemical causes the sex change. The WWTP representative tells the newspaper there are no standard, approved analytical methods for finding many of the chemicals that have been speculated to be causing the sex change. There are also no regulations in place from the state or the U.S. Environmental Protection Agency (USEPA) that limit the concentration of most of the suspected chemicals in the plant's effluent. To complicate things further, removal technologies for the suspected culprit chemicals have only begun to be developed. Known removal technologies are very expensive and are far from being well proven and widely accepted.

The WWTP representative does know that his facility is under a compliance order to build 12 miles of new sewers and to rehabilitate another 20 miles of sewers within the next two years. He also knows new nitrogen or nutrient standards will force his utility to spend tens – perhaps hundreds – of millions of dollars to construct the new facilities needed to remove these pollutants to the levels required by the regulations. And he also knows, as do many wastewater treatment managers across the United States (U.S.), that his agency does not have the money to do this work.

Much of the water and wastewater infrastructure in the U.S. – the systems that treat, distribute, collect and clean water – was built nearly a century ago for a smaller population. It is aging and overburdened now. Even with newer facilities and innovative alternatives, upgrades are required to keep pace with growing needs and environmental challenges. These upgrades do not include upgrades required to remove newly discovered chemicals at exceedingly small concentrations that may or may not be causing harm to people or the environment. The science on many of these is still unresolved.

Chemicals of emerging concern certainly pose potential harm to people and the environment, but chemicals and other pollutants that pose well-known, well-understood dangers are real threats to people and the environment and should be dealt with now

The level of investment by governments in maintaining water and wastewater infrastructure has declined dramatically, and in many areas sewer and water rates do not reflect the true cost of service. The U.S. is at a critical point for sustainable water and wastewater infrastructure across the country.

The USEPA reports that by 2016 water pollution levels may deteriorate to those observed in the 1970s if we do not reinvest in our water and wastewater infrastructure. If steps are not taken to reinvest in this infrastructure, the U.S. risks reversing decades of progress in public health, environmental protection, economic development, and quality of life.

The U.S. General Accounting Office (GAO) says there are more than 800,000 miles of water pipe in the U.S. and more than 600,000 miles of sewer lines. The vast majority of this infrastructure network was installed after World War II and is at or near replacement age. Many of the nation's water and WWTPs, some built in the early 1900s, are reaching the end of their useful lives as well. Infrastructure also includes natural solutions to managing and cleaning stormwater, such as constructed wetlands and retention ponds where plants and soil filter pollutants from street and building runoff. These "green" infrastructure systems can be overburdened as well and many need to be improved and expanded. Drinking water and wastewater utilities must plan to invest hundreds of billions of dollars in capital infrastructure over the next 20 years, according to estimates from the USEPA and the

Congressional Budget Office. Nationally, the projected costs of revitalizing and expanding our water systems range from $485 billion to nearly $1.2 trillion. Each community will need to determine how to pay for these necessary improvements.

This issue is vitally important because water affects every aspect of the quality of life in America. The availability of clean water is crucial to public health. The Centers for Disease Control and Prevention credit treatment of drinking water in the U.S. since 1900 for the virtual elimination of waterborne diseases such as typhoid, cholera, and hepatitis A and for helping to increase life expectancy by 30 years.

Wastewater treatment plants must be careful not to rush into spending scarce resources on courses of action that offer unacceptably small return on their investment. For example, various chemicals – now frequently lumped together as contaminants of emerging concern – have been found in wastewater, many at very low concentrations. These chemicals – endocrine disruptors, pharmaceuticals, and personal care products – are ubiquitous by-products of daily living. But maximum safe levels of these chemicals are still being developed, as are standard analytical methods and proven removal technologies.

Is a wastewater treatment authority behaving responsibly if it devotes significant resources to an effort to fund and support capital construction, operations, and societal programs that provide a return whose value has not been established when the same level of effort might be better invested in funding a capital program that could help solve problems of proven magnitude and seriousness?

One might argue that a program to limit the discharge of contaminants of emerging concern would be a cooperative community effort and the wastewater treatment plant would surely garner visibility and goodwill among its ratepayers for supporting such efforts, especially when the public thinks those efforts are needed. But what if the same effort produced public education and understanding about what is truly needed? And what if that understanding yielded a capital improvement program that helped the utility repair or rehabilitate crumbling sewers or add a state-of-the-art standard process to remove a well understood pollutant such as ammonia instead of a process to remove poorly understood chemicals present at tiny concentrations? Would the capital improvement program not yield more immediate, tangible rewards for the utility's customers? While this dilemma is in some cases a political question, the logic of the argument must also be taken into account during the decision-making process.

Questions such as these keep wastewater system managers awake at night. It is not a case of deciding that some of the ubiquitous chemicals that are now being found at very low concentrations are unexciting or unimportant. Such chemicals are being found. Analytical methods are being developed. Safe exposure levels are being explored. And removal technologies are being developed. This research needs to continue and is being supported by the wastewater treatment community.

With scarce resources at hand, however, the question is the extent to which serious, well-understood problems – problems the wastewater community knows how to solve – are more pressing and require immediate actions to resolve.

Chemicals of emerging concern certainly pose potential harm to people and the environment. But chemicals and other pollutants that pose well-known, well-understood dangers are real threats to people and the environment and should be dealt with now. The hard question thus becomes how to balance the need to energize citizens to solve the problem of crumbling infrastructure

with the problem of dealing with exotic, newly found chemicals in the water.

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Photos Courtesy of the Metro Wastewater Reclamation District.

▲ Candidates for AWRA Officers and Directors – 2008

The Nominating/Awards Committee of the American Water Resources Association, chaired by Past President Melinda M. Lalor, announces the following slate of candidates for the positions of Officer and Directors for terms commencing January 1, 2008.

PRESIDENT-ELECT (1-YEAR TERM)

GERALD SEHLKE
Idaho National Laboratory ~ Idaho Falls, Idaho

DIRECTOR (3-YEAR TERM)

MICHAEL CAMPANA
Oregon State University
Corvallis, Oregon

MARTHA CORROZI
University of Delaware
Newark, Delaware

JOHN HINES
Pennsylvania DEP
Philadelphia, Pennsylania

MAC MCKEE
Utah State University
Logan, Utah

As set forth in Article III, Section 5D of the American Water Resources Association's Bylaws "members may nominate additional candidates by submitting a written petition to the Association Headquarters signed by not less than 25 association members in good standing. A letter signed by the nominee expressing a willingness to accept the nomination and to serve if elected and a brief biographical sketch must accompany the petition. Such petition with the requisite signatures, the acceptance letter, and the biographical sketch must be received no later than June 11."

WATER RESOURCES IMPACT

PATHOGENS IN NATURAL AND ENGINEERED WATER SYSTEMS: EMERGING ISSUES

Tamim Younos, Valerie J. Harwood, Joseph O. Falkinham III, and Hua Shen

With increased water demand, it is expected that by the year 2025 humans will tap 100 percent of available global fresh water resources. However, assessment and improvement of water quality for various uses remains a serious challenge because of the detection of increased levels of pathogens and nonbiological contaminants such as estrogens and pharmaceuticals in the natural and engineered water systems. Recreational water quality issues are also increasing, with many of the etiological agents emerging or unknown because of the difficulty of contaminant and source identification.

PATHOGENS IN NATURAL WATERS

Pathogenic microorganisms (bacteria, viruses, and protozoa) in natural waters are contributed from agricultural and domestic animals (animal waste), urban runoff, sewer and septic system (human waste) inputs, and wildlife. Some are normal inhabitants of natural waters. Fecal indicator bacteria such as fecal coliform, *Escherichia coli* and enterococci, are a major cause of water contamination in the United States (U.S.). Microbial source tracking (MST) is a thriving scientific field that traces bacterial contamination from its source to surface waters (Keeling *et al.*, 2005). Recognized indicator bacteria such as *E. coli* and *Enterococcus* spp. are used for many MST methods, while alternative indicators such as *Bacteroides* sp. are also employed.

Emerging pathogens are newly discovered microorganisms and/or newly recognized pathogens. Typically, little data are available about their transmission routes, virulence, minimum infective dose, survival outside of host, or disinfectant susceptibility. The U.S. Environmental Protection Agency (USEPA) periodically updates the drinking water Contaminant Candidate List (CCL) and it was last updated in February 2005 (USEPA, 2005). Several examples of candidate microbial pathogens are listed in the left column of Table 1, and scientists have identified several other emerging pathogens (right column of Table 1) for which limited information is available (Egli and Rust, 2002).

... utilities are required to identify the best available technology for the treatment of contaminated source waters; however, while treated water is considered safe, less is known about microbial pollution in water distribution systems

PATHOGENIC HEALTH THREATS

Pathogens pose a risk to human health through various uses of water, particularly drinking water (Figure 1). Water treatment technologies for disinfection were generally considered effective for removing pathogens from water, but in 1993, *Cryptosporidium parvum*, a disinfectant-resistant protozoan pathogen, was the cause of the largest waterborne (drinking water) disease outbreak in U.S. history. This outbreak affected more than 400,000 people in Milwaukee, Wisconsin, and caused more than 100 deaths (Lindquist, 1999). *Giardia intestinalis* (previously named *Giardia lamlia*) is a frequent

Table 1. Some Candidate Emerging Pathogens.

Pathogen	Cited by USEPA (2005)	Listed by Egli and Rust (2002)
Bacteria	*Aeromonas hydrophila* *Helicobacter pylori* *Mycobacterium avium* complex	*Pseudomonas aeruginosa* *Legionella pneumophila* *Aeromonas hydrophila* *Campylobacter jejuni* *Yersinia enterocolitica* *Chlamydia*
Viruses	Caliciviruses Adenoviruses Coxsackieviruses Echoviruses	Caliciviruses, i.e. Norwalk virus Other small round structured viruses Rotaviruses *Hepatitis A*
Protozoa	Microsporidia, i.e., *Enterocytozoon* and *Septata*	

Figure 1. Uses of Water and Pathogen Pathways in Natural and Engineered Water Systems.

cause of waterborne outbreaks of acute gastroenteritis (symptoms include diarrhea, cramps and fatigue). Both of these obligate parasites produce cysts (or oocytsts) that are resistant to disinfection.

The USEPA recommends a multiple barrier approach for drinking water treatment to reduce the impact of pathogenic and chemical contaminants in the drinking water and has enacted a number of rules that specifically address pathogens and source water quality (USEPA, 2007). Current USEPA regulations under the Safe Drinking Water Act require that drinking water utilities identify and quantify a specific set of microbial contaminants in source waters. In addition, utilities are required to identify the best available technology for the treatment of contaminated source waters. However, while treated water is considered safe, less is known about microbial pollution in water distribution systems. As discussed later, recent research indicates the potential for adverse health effects associated with bacterial growth in water distribution pipes and home plumbing systems. Aerosolization of some types of pathogenic bacteria, such as *Legionella pneumophila*, in home-heated water system (bathing showers and hot tubs) are also considered a health risk factor (pulmonary disease).

Pathogens pose a risk to human health through various uses of water as well. Waterborne disease outbreaks associated with recreational water are attributed to the use of public pools, hot tubs, rivers, lakes, beaches, and water fountains (Dzuiban *et al.,* 2006). Many outbreaks occur in pools and hot tubs that have been chlorinated. Shellfish contaminated via waterborne routes can impact human health through the food chain. For example, a recently reported outbreak of hepatitis A was caused by oyster consumption (Bialek *et al.,* 2007). Also recently, contaminated irrigation or runoff water was speculated as possible pathways to a recent, nationwide outbreak caused by *E. coli* O157:H7 (CDC, 2006).

PATHOGENS IN ENGINEERED SYSTEMS

Bacterial growth in water distribution systems has been investigated for several decades. For example, Baylis (1930, cited in van der Kooij, 2003) reported coliform growth in sediments accumulating in water distribution pipes. Researchers have found that mycobacterial numbers were substantially higher in the water distribution systems (on average 25,000-fold) than those collected immediately downstream from the water treatment facilities, indicating that mycobacteria grow in the distribution system (Falkinham *et al.* 2001). In recent years, there has been great concern about the presence of emerging pathogens such as *Legionella spp.*, *Mycobacterium* spp., and *Aeromonas* spp. and other opportunistic pathogens in water distribution pipes and home plumbing systems. It should be noted that both Legionnaires' disease (a serious, life-threatening pneumonia) and Pontiac fever (a mild, flue like illness) are caused by members of the genus *Legionella*. Two pathogens of concern in water systems are discussed below.

Mycobacterium avium (*M. avium*) is an environmental opportunistic bacterial pathogen, a normal inhabitant of natural waters and drinking water distribution systems, and has been listed on the USEPA's Candidate Contaminant List (CCL) (Table 1). They are opportunistic pathogens of humans, animals, and fish and are very slow growing organisms, reproducing, at the most, 1 generation/day. Slow growth makes them poor competitors for resources against other microorganisms; however, their die-off rates are lower and they show evidence of adaptation to harsh conditions. Mycobacteria are very hydrophobic, which makes them resistant to antimicrobial agents. Their hydrophobicity leads to their attachment to surfaces and proliferation on them, i.e. biofilm formation (attached populations of microbial cells and polysaccharide that form at interfaces and surfaces such as pipe walls) because they can grow in waters with relatively low organic nutrient concentrations (> 50 µg assimilable organic carbon per liter). Biofilm formation increases *M. avium* persistence in drinking water distribution systems. Hydrophobicity is also a major contributor to *M. avium*'s aerosolization and concentration in aerosols above waters. *M. avium* numbers increase in recirculating hot water distribution systems in hospitals, office buildings, and apartment houses. The use of showers and hot tubs (spas) are risk factors for development of *M. avium* pulmonary disease because of *M. avium* aerosolization potential and the entrainment of *M. avium*- rich biofilms into aerosols upon water flow.

Legionella pneumophila (*Legionella)*, an emerging bacterial pathogen (Table 1), was discovered following an outbreak of pneumonia amongst attendees at the 1976 American Legion convention in Philadelphia, Pennsylvania. It is a Gram negative bacterium, commonly found in fresh water environments and replicates in protozoa as intracellular parasite. The bacterium *Legionella* exists in low numbers in natural waters. However, higher water temperatures in engineered water systems promote rapid growth of *Legionella* (Fields *et al.,* 2002).

Legionnaires' disease has been linked to aerosols generated from air conditioners, humidifiers, decorative fountains, whirlpool spas, and industrial or residential cooling towers. An opportunistic pathogen, the bacterium causes disease in individuals with weakened immunity. Large outbreaks of disease have been reported in news media. For example: in Virginia, September 1996, a whirlpool spa display at a home improvement store caused 23 cases of the disease, and killed 2; in Spain in 2001, a hospital cooling tower caused 449 cases of the disease and killed 2; in September 2005, a Toronto outbreak in an assisted living facility killed 17 people. The majority of *Legionella* pneumonia cases, however, are sporadic community infections which are possibly-under diagnosed and underestimated. In the U.S., it is estimated that up to 20,000 cases occur annually, and mortality of the disease is up to 26 percent (Benin *et al.,* 2002). In 2003, the Centers for Disease Control (CDC) reported increased cases in the Mid-Atlantic region, increasing to 178 cases versus 48 cases in 2002. Disease control and prevention depends on a rapid, sensitive, and quantitative detection method. Also, since the bacterium is common in engineered systems, it is important to establish an acceptable level of the bacteria in these water systems.

Maintaining a disinfectant residual in water distribution systems can be an effective way to prevent bacterial growth of some pathogens in water distribution pipes. However, the challenge is how to balance the need for adequate disinfection while reducing the potential chronic health effects of chlorination without selecting for other potential pathogens. Also, it should be noted that some pathogens are resistant to chlorination (*M. avium* is resistant to chlorine, chloramines, chlorine dioxide, and ozone). Recently, across the U.S. there is a trend to use chloramines instead of free chlorine as disinfectant, since there is less potential for generating harmful by-products. However, little is known about potential health effects of switching to chloramines that could arise from increased microbial survival or growth in the drinking water distribution system. Furthermore, a recent study indicated that a switch from free chlorine to chloramines disinfectant triggered lead release from home plumbing pipes (Edward and Dudi, 2004). Exposure to high levels of lead in drinking water can pose significant health risk to society.

FUTURE DIRECTIONS AND RESEARCH NEEDS

Water quality monitoring and public health assurance is routinely performed through enumeration of fecal indicator bacteria in both potable and recreational waters. Fecal coliforms are used as indicators based on the expectations that the only source of these organisms is directly from fecal contamination, and that the fate and transport of fecal coliforms reflects that of waterborne pathogens. Furthermore, environmental water standards are based on risk to human health from human sewage contamination. However, conventional indicator organisms such as fecal coliforms and enterococci have many drawbacks in terms of recreational water quality assessment. Fecal indicator bacteria have many sources, including storm water runoff and environmental reservoirs such as sediments. Many waterborne pathogens do not have the same fate and transport characteristics as fecal indicators, and these relationships are unknown for other pathogens.

To help understand the sources, fate, and predictive relationships of waterborne pathogens, efforts are being made in mathematical modeling for prediction, and microbial and fecal source tracking. The latter involves tracking target chemicals found exclusively in sewage instead of pathogens or indicator microorganisms. The microbial source tracking target requires the following characteristics: (1) unique to a particular host species or group, (2) all host individuals are carriers of the target, (3) it has wide geographic range and it is temporally stable, (4) the assay is inexpensive but reliable, and (5) quantitative data can be generated.

A new candidate indicator for human fecal source detection is the human polymavirus, which can be detected by polymerase chain reaction (PCR). To date there has been too little work at exploring the challenges posed by

waterborne pathogens that are normal inhabitants of water (e.g., pathogenic *Vibrio* species) and drinking water distribution systems (e.g., *M. avium*). Here, the environment or the water system is the source and the presence of the pathogen does not represent contamination from a fecal source. Achievement of the goal of providing rapid, accurate identification of emerging waterborne pathogens pose the following challenges to microbiologists and epidemiologists: (1) measure risks ascribed to different host sources, (2) measure risks posed by different pathogens, (3) accurately describe the ecology of indicators and pathogens, and (4) develop more sensitive and more rapid detection technologies for indicators and pathogens.

Some candidate detection or measurement methods for these emerging pathogens include quantitative PCR (polymerase chain reaction), RT-PCR (reverse transcriptase-PCR), multiplex PCR, NASBA (nucleic acid based sequence amplification) (isothermal method), transcription mediated amplification (isothermal and reverse transcriptase), and micro arrays. An incomplete list of potential research needs include: (1) quantitative risk assessment for a wide variety of waterborne pathogens, (2) identification of suitable indicators for waterborne microbes and viruses, (3) epidemiology studies of the relationship between pathogens and human health outcomes in recreational waters that are not impacted by point sources, (4) methods for rapid detection of pathogens and indicators, (5) quantitative microbial source tracking methods for human and other sources of fecal contamination, (6) linkage of indicator bacterial numbers with risk of human disease, (7) linkage of microbial source tracking results with the different indicators, (8) understanding indicator organism and pathogen survival and growth in sediments and sands, (9) improved modeling of microbial transport and fate in the environment, (10) improved methods to determine the causes of increased antibiotic resistance due to chemical contamination in the environment, (11) rapid detection methods for recreational marine waters to be able to update swimming advisories accurately, (12) identification of pipe surface treatments to reduce *M. avium* and *Legionella* numbers in biofilms, and (13) identification of cost-effective methods for reducing the number of emerging pathogens in waters

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WATER RESOURCES
IMPACT

ENDOCRINE ACTIVE CHEMICALS (EACs) IN WASTEWATER: EFFECTS ON HEALTH OF WILDLIFE AND HUMANS

David O. Norris and Alan M. Vajda

Endocrine active chemicals (EACs) are natural and synthetic molecules that can interfere with hormone systems in the bodies of animals. Recognition and regulation of adverse impacts by estrogenic pesticides and pharmaceuticals (xenoestrogens) in wildlife, domestic animals, and humans began in the mid 1900s, but ample evidence of endocrine disruption of reproduction related to nanoquantities (parts per billion and parts per trillion) of human-based xenoestrogens in wastewater effluents appeared in the late 1980s and early 1990s (see Guillette and Crane, 2000; Norris and Carr, 2006). Numerous studies have documented disruption of sex determination and sex ratios, feminization or demasculinization of adult males, and alterations in reproductive behaviors, as well as contraceptive-like actions in both male and female fishes. Similar disruptions are reported for amphibians, reptiles, birds, and mammals exposed via various routes. Studies of accidental exposures as well as correlative studies of exposure to estrogenic chemicals present in diets, plastics, personal care products, etc., have appeared for cultured cells, rodents, and humans. Developing animals, including the human fetus, are much more sensitive to exogenous estrogenic chemicals than are adults (see Colborn and Clement, 1992). Observations in rodents and humans show that a single exposure to an estrogenic chemical during development not only affects that generation but also induces permanent changes that are passed to the next and the next and the next generation without additional exposures (Anway *et al.*, 2005).

Because many estrogenic chemicals operate through estrogen receptors in their target cells, their effects are additive. This means that there is no minimally safe exposure because (a) any dose adds to natural estrogens already present and (b) any mixture of "ineffective" doses measured in isolation can sum in a mixture to produce an effect. Other environmental chemicals also can affect reproduction through altering rates of synthesis or rates of metabolism (inactivation) of steroids, producing changes in the availability of estrogen receptors, and enhancing or reducing the availability of various cofactors necessary for activated estrogen receptors to produce their effects in a target cell (Tabb and Brumberg, 2007).

Are current levels of estrogenic chemicals in wastewater effluents and drinking water "safe"? Clearly, not for some wildlife that live immediately downstream of effluent discharges. Current levels of estrogenic chemicals in drinking water may not be sufficient by themselves to induce measurable effects in adult humans, but they add to the many other sources to which we are subjected through diet and use of plastics, personal care products, pharmaceuticals, etc. Recycling of wastewater effluents as drinking water may increase these concentrations if efforts are not made to reduce them. Studies demonstrating effects in rodent and human fetuses exposed during pregnancy to estrogenic compounds (Swan *et al.*, 2005) highlight the extreme sensitivity of the fetus and perhaps should be the focus for development of future regulations.

Estrogenic chemicals in wastewater have alerted us to the greater concern for exposure to exogenous estrogens from many sources and to their additive effects. However, these are not the only EACs of concern for endocrine disruption. Thyroid (e.g., PCBs, perchlorate) and adrenal disrupters (e.g., cadmium) can alter reproduction as well. Deficiencies in thyroid function during fetal life can disrupt nervous system development resulting in permanent mental retardation. In addition to EACs, some pharmaceuticals present in wastewater are neuroactive agents, such as antidepressants (e.g., fluoxetine) and beta-blockers, whereas others are metabolically active agents such as anticholesterol drugs. Published studies of the possible biological effects of these pharmaceuticals on wildlife are just beginning to appear. Antibiotics in wastewater are another major chemical concern to be addressed with respect to their potential effects on microbial populations including potential human pathogens.

Observations of estrogenic chemicals in wastewater on wildlife now have provided an alert to potential disruptions by trace chemicals throughout our environment

We have noted, but at the same time disregarded, disturbing health trends in human populations (e.g., earlier puberty, increases in diseases and developmental abnormalities, changes in sex ratios at birth). Observations of estrogenic chemicals in wastewater on wildlife now have provided an alert to potential disruptions by trace chemicals throughout our environment. Perhaps this has unfairly spotlighted the water treatment industry since present wastewater processing technologies are not the cause of the disruptive effects being documented in wildlife, domestic animals, and humans. Instead, we should look at the increased reliance on the uses of chemicals to improve human health and comfort (e.g., pharmaceuticals, personal care products, convenience foods, detergents, plastics, pesticides) and how we dispose of them. These chemicals appear through natural excretion by each of us and by inappropriate disposal procedures from domestic, commercial, and industrial sources. They.are transferred to wastewater systems and they are appearing in our drinking water. It is a problem we are all creating, and we all need to work together to find solutions.

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▲ President's Message ... Gerry E. Galloway, AWRA President, 2007

It has been a busy spring for AWRA. The Association and its members have been hard at work discussing water resources issues challenges around the nation. State sections have been very active in bringing local, regional, and national issues before their members. I have been fortunate enough to get to the state section annual meetings in Wisconsin and Colorado and was very impressed by the high quality of presentations and the superb networking that was taking place. AWRA members are dealing with the important issues in their regions and the opportunity to share ideas at annual meetings and monthly gatherings continues to be very helpful to them. In my visits to these states, I emphasized the need for those at the state level to also pay attention to national policy issues that will drive, in many cases, state actions. I also urged many the meeting attendees, who were not members of AWRA, to consider joining the National Association. Professionals belong to professional organizations and ours certainly represents professionalism at the highest level.

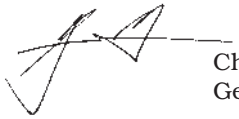
Chairperson Michael Campana's planning committee for AWRA's annual meeting in Albuquerque is hard at work and is putting together a superb conference. It not only will be professionally rewarding, but also a lot of fun. I would urge all of you to make plans now to attend and to get an abstract submitted for presentation of a paper.

The agenda for AWRA's June 25-27 Summer Specialty Conference in Vail on emerging contaminants has been locked in, and like the annual meeting will be filled with high-quality presentations. Emerging contaminants is a subject that should be of concern to all. Chairperson Bill Battaglin and his committee have ensured that attendees will leave with a solid understanding of the challenges we face and the actions we must take to deal with these new threats to our environment.

As you will see elsewhere in this issue (pg. 4), we have also reviewed our membership structure and are proposing changes that, in the view of your Board, will enable the Association to remain competitive in a very busy professional association market. Please take time to read the proposed changes to our Bylaws and, if you have questions, email me (gegallo@umd.edu), Ken Reid (ken@awra.org), or Terry Meyer (terry@awra.org).

Ken Reid, Jane Rowan, and I had the opportunity in March to attend a seminar for association elected officers and chief staff executives and to gather with a mix of volunteers and professional organization personnel to discuss the changing nature of associations. At the heart of the discussion was a review of 21st-Century communication methods, ranging from blogs, RSS, and Wiki's to mashups and podcasts and what each of these technologies will mean to associations and their members. We are working hard to ensure that the information we have is readily available to you, and that in turn, we can hear from you about those issues of concern to you and those with whom you work.

I would hope that if you have ideas about how to make AWRA a better organization, you would share them with us. Don't hesitate to send me an email at gegallo@umd.edu. Thank you for what you're doing for the Association and our nation's water.



Cheers
Gerry Galloway

WATER RESOURCES
IMPACT

IS YOUR BODY A HAZARDOUS WASTE SITE?

Laurie Peterson-Wright

Scientists have been identifying and measuring pollutants in air, water, soil, food, and commercial products for decades and using that information to predict levels of pollutants in people. Now scientists have the ability to actually measure these pollutants in the human body through biomonitoring. As a result, many industrial chemicals have been found in every individual tested in the biannual National Health and Nutrition Examination Survey administered by the Center for Disease Control (CDC).

Does the fact that our bodies have detectable levels of insecticides, pesticides, herbicides, plasticizers, estrogen-mimickers, and metals mean anything? Does a lifetime of chemical exposure because of an industrial lifestyle explain the wide range of health trends confronting us today, including declining sperm counts, hypospadias, early puberty in girls, endometriosis, miscarriages, birth defects, increased cancer rates, declining ratio of boys to girls, autoimmune diseases, autism, learning difficulties, obesity, mental illness, and childhood asthma?

No one is certain environmental toxins play a role in current health trends, but by examining chemicals in the blood and urine, biomonitoring may be the public health tool that provides answers.

The CDC's biomonitoring work began nearly 30 years ago with the development of analytical tools to measure chemicals in humans. The Third National Health and Nutrition Examination Survey, conducted in 2000-2001, analyzed samples from 2,500 Americans for 148 chemical compounds suspected of causing health problems. Biomonitoring determined that children's exposure to lead and both children's and adults' exposure to secondhand cigarette smoke have dropped over the last 10 years. Likewise, exposure to banned organic pesticides such as aldrin, endrin, and dieldrin has declined.

Conversely, the results show that children are carrying in their bodies higher levels than adults of some chemicals, insecticides, and plasticizers. Five percent of women more than 20 years old have high enough levels of cadmium in their systems to be associated with kidney injury and an increased risk for osteopenia. That data also showed that 8 percent of women of childbearing age have levels of mercury above the level the government considers safe.

Since the release of this report, the CDC has continued to perform biomonitoring for emerging contaminants using the samples previously collected. Perfluorinated compounds were found in all 1,562 serum samples collected from the 1999-2000 National Health and Nutrition Examination Survey, which suggests common exposures. Perfluorinated compounds bioaccummulate and are found in such common products as floor polishes, shampoos, carpets, upholstery, and fire-fighting foams. Detectable levels of perchlorate, a powerful oxidant used in solid rocket fuels, were found in all 2,810 samples collected from the 2000-2001 National Health and Nutrition Examination Survey, indicating broad human exposure. Perchlorate impairs normal thyroid function because it is taken up preferentially by the thyroid gland in place of iodide.

No one is certain environmental toxins play a role in current health trends, but by examining chemicals in the blood and urine, biomonitoring may be the public health tool that provides answers

Most states and local health departments currently lack the ability to perform biomonitoring testing. In 2001, the CDC's Environmental Health Laboratory distributed approximately $10 million for biomonitoring planning to 25 state and regional programs, supporting 33 states in biomonitoring planning. In 2003, the CDC funded New Hampshire, New York, and the Rocky Mountain Biomonitoring Consortium (Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming) to implement biomonitoring programs. California is the first state to pass a human biomonitoring bill that sets rules for measuring people's exposures to pollution. Many other states including Indiana, New York, Arizona, and Washington also are proposing bills.

The motto of a large chemical manufacturer once was "Better Things for Better Living ... Through Chemistry" until the tagline "through chemistry" was removed in the 1980s. Although the advances realized by our industrial country should not be discounted by unnecessarily alarming people about products that protect our health and contribute to our well being, further investigation of synergistic or long-term effects and human exposure must be undertaken. A biomonitoring surveillance program may be the public health and epidemiological tool that can identify long-term exposure and provide data to set regulatory limits or levels for initiating public health interventions.

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WATER RESOURCES
IMPACT

CONFLICTING PUBLIC POLICIES: WHY IS IT SO DIFFICULT TO KEEP PHARMACEUTICALS OUT OF THE WATER?

Brenda Ortigoza Bateman, Ralph Thonstad, and Daniel Danicic

INTRODUCTION

In what has become a national wake-up call, researchers across the United States (U.S.) are finding pharmaceuticals and other chemicals at very low concentrations in most waterways that receive discharges from municipal wastewater treatment plants (WWTPs) (Kolpin *et al.*, 2002). One researcher warns that "the continual environmental introduction of drugs ... makes them 'pseudo-persistent' pollutants with ramifications for aquatic organisms" (Daughton, 2002).

Many of these pharmaceuticals find their way into WWTPs, having been excreted from our bodies. But others have made their way into WWTPs because for decades, Americans have been told to flush their unwanted and expired pharmaceuticals down the drain as a quick and safe method of disposal. However, most of the municipal WWTPs in the U.S. use biological treatment methods that were not designed to remove pharmaceuticals or other chemicals from municipal wastewater. (To clarify, this discussion focuses on wastewater treatment plants and not drinking water plants, which have more sophisticated treatment processes in place designed to remove chemical compounds and other contaminants of concern.) Increasingly, local officials are urging the public not to use the water system as a garbage dump for pharmaceuticals.

Communities across the U.S. have identified an alternative to flushing pharmaceuticals down the drain. They are designing "take-back" programs to collect and destroy unused pharmaceuticals in a safe and environmentally responsible manner.

These take-back programs have created an exciting coalition of organizations. The poison control centers and child advocacy groups are spearheading efforts to decrease accidental poisoning of children and pets in households. The Drug Enforcement Administration, law enforcement, and healthcare industries are leading efforts to prevent intentional drug abuse. The environmental and public health communities are focused on protecting water quality. All of these groups can use pharmaceutical take-back programs to further their goals.

Communities that are trying to protect their streams and rivers from discarded pharmaceuticals are spending an inordinate amount of time and resources sorting, handling, and documenting these unwanted medicines ... this creates programs that are expensive for participants, and cumbersome for program coordinators

OBSTACLES

Communities designing their own programs have been hampered by the very web of laws and regulations that were originally designed to protect our communities and environment.

The design of pharmaceutical take-back programs must take into account the different perspectives in which pharmaceuticals are categorized – and subsequently regulated. In general, members of the public recognize their household pharmaceuticals as either "prescription" or "over-the-counter" (see Figure 1).

Secondly, however, the U.S. Drug Enforcement Administration (DEA), an important regulatory agency in this arena, categorizes some prescription drugs as "controlled substances." Finally, the U.S. Environmental Protection Agency (USEPA) categorizes yet a different category of pharmaceuticals as "hazardous." Ensuring the proper collection and destruction of pharmaceuticals, therefore, requires program designers to account for all three of these perspectives. It also requires much more information than is typically available on the product label.

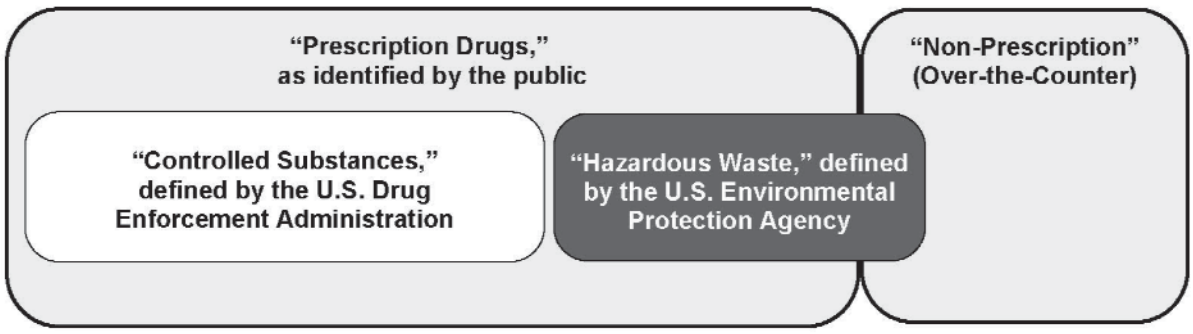

Figure 1. Pharmaceutical Categories: Three Different Perspectives.

Controlled Versus Noncontrolled Substances

Within the family of prescription medicines, some are considered "controlled" substances, so defined by their potential for abuse and addiction (http://www.usdoj.gov/dea/pubs/scheduling.html is a representative schedule of controlled substances). Well known examples include tranquilizers like Valium, stimulants like Ritalin, and painkillers like Codeine, Oxycodone, and Percocet. This category of medications is significant, as controlled substances typically comprise between 5 and 15 percent of the items collected in a take-back program.

The Controlled Substances Act of 1972 not only defines controlled substances, but also represents the most formidable obstacle to the design of pharmaceutical take-back programs in the U.S. The Controlled Substances Act prohibits the transfer of dispensed, controlled substances, except between DEA registrants (entities registered with the DEA to handle or manage controlled substances) [21 Code of Federal Regulations §1301.11(a), §802.11, and §841(a)]. This means that once controlled substances are prescribed and dispensed, the patient cannot legally give them to friends, family, a doctor, the pharmacist, or anyone else.

The sole exception to this rule allows law enforcement personnel to accept controlled substances from the public (21 Code of Federal Regulations §1301.24). Law enforcement officials are then supposed to ensure that these controlled substances are destroyed beyond recovery. Usually, this means taking the collected items to a local incinerator and staying on site long enough to witness "the burn." However, this method of destruction is not formally required by Federal law, and some law enforcement departments have hired contractors to haul controlled substances to far away incinerators on their behalf. Regardless of the ultimate destruction destination, any successful, comprehensive take-back program must rely on the participation of local law enforcement officials to accept controlled substances from the public.

Hazardous Versus Nonhazardous Pharmaceuticals

Another important perspective for categorizing pharmaceuticals comes from the USEPA, whose most relevant regulation in this case is the 1976 Resource Conservation and Recovery Act (RCRA). The RCRA defines a substance as "hazardous" if its chemical properties are ignitable, toxic, corrosive, or reactive [40 Code of Federal Regulations §261(c)], and categorizes six, noncontrolled pharmaceuticals as hazardous – these are: (1) Arsenic Trioxide (a chemotherapeutic agent), (2) Epinephrine (adrenaline), (3) Nicotine and Nicotine patches, (4) Nitroglycerin (controls chest pain), (5) Physostigmine (a glaucoma treatment), and (6) Warfarin/Coumadin (blood thinners). These six pharmaceuticals may constitute up to 10 percent of the items found among the unwanted or expired medications in residential medicine cabinets.

Individual households are exempt from RCRA regulations and are legally allowed to throw these items into household trash. But households that are trying to be environmentally responsible and community programs that are collecting and consolidating medications will need to transport these items to a household hazardous waste facility that ensures destruction by incineration.

Lack of Local Incinerators

USEPA-approved incinerators, with all their appropriate environmental controls, are the backbone of any good medication disposal program. Unfortunately, they are few and far between, making it somewhat difficult and expensive to design good medication disposal programs for the public.

Complicating the issue are the customary law enforcement protocols requiring law enforcement officials to be physically present to witness the destruction/incineration of controlled substances. Some communities that are designing medication disposal programs have found themselves in a situation where the local incinerator will accept controlled substances from law enforcement agencies, but refuses to accept noncontrolled substances that are defined as "hazardous" under RCRA. While other incinerators do accept these "hazardous" substances, the trip may too far for law enforcement officials to personally deliver controlled substances and witness their destruction. Therefore, program coordinators are obliged to expend time and labor sorting collected medications into two waste streams going to two separate incinerators.

HOW ARE COMMUNITIES COPING?

There is a growing community of professionals working on the design of pharmaceutical take-back programs. These professionals represent a wealth of experience in law enforcement, public health, community education, coalition building, advertising, and best practices in take-back programs. One of the best resources for the design of community programs is a "pharmwaste" listserve administered by Florida's Department of Environmental Protection (see http://lists.dep.state.fl.us/cgi-bin/mailman/listinfo/pharmwaste and http://www.dept.state.fl.us/waste/categories/medications/default.htm).

Asking the Public "Not to Flush"

The most immediate priority is to keep the public from flushing unwanted and expired medications down the drain. The easiest alternative, employed by most poison control centers and state environmental agencies, is to advise residents to destroy any patient identifiers printed on the medication, mix the contents with kitty litter or something equally unpalatable, and then encase the bottle or package in a water-tight plastic bag before dropping it into the garbage. While this method prevents the medication from entering the water system right away, it does pose health and safety problems for children, pets, or animals that may have access to garbage cans or landfills.

When the packaging decomposes, the medications will ultimately reach the water. In older, unlined landfills, the leachate (liquid produced from the decomposition of

waste) leaks into local ground water supplies (Slack *et al.*, 2005). In modern landfills, the leachate is collected and sent to municipal wastewater treatment plants, which, as previously mentioned, typically are not designed to handle these wastes.

Don't Ask, Don't Tell

Time and again, household hazardous waste (HHW) facilities are receiving calls or visits from residents who want to dispose of unwanted medications in an environmentally responsible manner. The current web of regulatory and infrastructure limitations has spawned HHW programs that are trying to be responsive to the public, while operating in a legal gray area.

Under today's regulatory atmosphere, many HHW facilities accept "all medications" from households without inquiring whether they include controlled substances or not. The facilities then package everything together in steel drums and ship them off for incineration. Residential customers have no idea whether their bag of unwanted medications includes "controlled" substances or not, and local HHW programs accept these bags knowing that controlled substances may well be included. This "don't ask, don't tell" approach is getting unwanted medications out of medicine cabinets, while keeping them off the streets, out of landfills, and out of the nation's water supplies. Strictly speaking, however, this transfer is outside the law if facilities knowingly accept controlled substances.

Without a change in the Controlled Substances Act, communities that want to design formal programs to collect and consolidate unwanted medications from their residents cannot plan to use local HHW facilities to dispose of controlled substances. The formal protocols necessitated by such a program will require HHW facilities to identify and reject any controlled substances. Communities must come up with a better plan.

Pharmaceutical Take-Back Programs

Some communities across the U.S. have been conducting pharmaceutical take-back programs for years, but most have not hit upon the right combination of infrastructure, staffing, and resources to create sustainable programs. Figure 2 shows a sampling of programs currently underway in the U.S.

Most programs involve day-long or week-long take-back "events" that are expensive to advertise and staff, because of the need for pharmacists to identify controlled versus noncontrolled substances, law enforcement officers to take possession of controlled substances, and garbage haulers to take the noncontrolled substances. Typically, these events also have staff to control traffic, "greet" participants, collect data, take surveys, and serve as support staff. Such events accept both controlled and noncontrolled substances (see www.nerc.org/adopbe/setting.up.draftFINAL,pdf for holding stand-alone collection events and www.nerc.org/adopbe/hhw.setting.up.draftFINAL.pdf for collecting pharmaceuticals as part of a larger HHW event). Perhaps one of the most extensive events took place during May 2006 in the San Francisco Bay area. With participation from 17 agencies, the program partners collected 3,634 pounds of pharmaceuti-

Location	Accepts Both Controlled & Non-Controlled Substances?	Year-Round Program?	How the Program Works
California (Palo Alto) Illinois (Cook County) Indiana (Monroe County) Maine (Mid Coast Region) Wisconsin (several counties)	✓		**Events:** Every year, week-long or day-long collection events accept both controlled and non-controlled substances.
California (Marin County, Palo Alto, San Francisco) Florida (Alachua County) Michigan (Macomb County) Oklahoma (Tulsa) Washington State Pilot (Puget Sound Area)		✓	**Partial program:** Residents can bring only non-controlled substances to participating drop-off sites during business hours.
Indiana (Monroe County) Washington (Clark County)	✓	✓	**Two, year-round, simultaneous programs:** Residents can bring: (1) controlled substances to law enforcement facilities, and (2) non-controlled substances elsewhere. The Indiana drop-off site is a HHW facility; Washington sites are participating pharmacies.
California (San Mateo County & City of Vacaville) Iowa (Statewide)	✓	✓	**One, year-round, consolidated program:** Program accepts all pharmaceuticals from residents. In California, drop-sites are law enforcement offices; the Iowa site is the state's household hazardous waste (HHW) facility.
Oregon (City of Newberg)	✓	✓	**Adult care facilities only:** Law enforcement holds the only key to disposal containers and collects controlled substances on a quarterly basis; garbage collection service takes non-controlled substances to HHW facilities.

Figure 2. Sampling of Pharmaceutical Take-Back Programs in the U.S.

cals from 1,500 residents or about two pounds per person (Jackson and North, 2006).

Other programs run year-round and their successes hinge on the use of a locked collection container. These containers have the same basic design as a curbside mailbox, in that items go into a depository door at the top, and are inaccessible thereafter – except through a locked door at the bottom of the container. Some programs have placed these drop-boxes in law enforcement facilities so that they can accept controlled substances under supervised conditions. Other programs have placed the drop-boxes in retail settings (pharmacies and health clinics), and can only accept noncontrolled substances because no law enforcement officers are stationed on-site. This approach poses some logistical problems, because unless someone stands there to supervise and sort the waste stream, the public has no idea whether the pharmaceuticals are "controlled" substances or not.

Still other programs have focused on residential situations, such as nursing homes or assisted living centers, where pharmaceuticals are found in more concentrated numbers.

To date, local governments have led the way in the design and funding of pharmaceutical take-back programs. However, several efforts are also underway to develop state-wide solutions. Maine passed legislation in 2004 allowing residents to mail unwanted controlled substances to the state's Drug Enforcement Agency, although the state has not yet funded or implemented a program. California, Iowa, and Massachusetts have introduced legislation about pharmaceutical take-back in their 2007 Legislatures. Oregon has a state-wide stakeholder committee evaluating designs for a take-back program as well.

CONCLUSION

In the current regulatory environment, law enforcement must physically accompany controlled substances to incinerators for "witnessed destruction." HHW facilities are not allowed to knowingly accept controlled substances from the public, and many incinerators will accept controlled substances or hazardous pharmaceuticals, but not both. Communities that are trying to protect their streams and rivers from discarded pharmaceuticals are spending an inordinate amount of time and resources sorting, handling, and documenting these unwanted medicines. This creates programs that are expensive for participants, and cumbersome for program coordinators.

The policies originally designed to protect our environment and communities are unintentionally damaging our nation's water resources. Unless these rules are modernized, the public will continue to find it more convenient, affordable – and legal – to continue flushing expired and unwanted medications down the drain. However, protection of our nation's water resources need not conflict with prudent drug disposal policy. We must develop integrated public policies that facilitate the design and proliferation of pharmaceutical take-back programs.

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▲ Student Opportunities

WATER RESOURCES
IMPACT

STRIVING FOR COLLABORATIVE SCIENCE AND COMMUNICATION THROUGH THE CONSORTIUM FOR RESEARCH AND EDUCATION ON EMERGING CONTAMINANTS (CREEC)

Juliane B. Brown and William A. Battaglin

Current analytical capabilities are allowing scientists to identify possible contaminants in the environment that were previously unmonitored or were present at concentrations too low for detection. New scientific evidence about the exposure pathways and potential impacts of some of these compounds on human or environmental health is regularly being published (Woodling *et al.*, 2006; Drewes *et al.*, 2005; Kinney *et al.*, 2006; Gibs *et al.*, 2007; Veldhoen *et al.*, 2006). Recent news headlines have declared potential human health and ecological concerns regarding the occurrence of personal care products and pharmaceuticals in our environment. These are products that we regularly use (or create) in our homes, businesses, farms and industry, including plasticizers, flame retardants, detergents, pesticides and herbicides, antibacterial agents, steroids, antibiotics, and disinfection byproducts. These 'emerging contaminants' (ECs) are compounds that have recently been shown to occur widely in one or more environmental media, have been identified as being a potential public health or ecological risk, and yet adequate data are lacking to determine their actual risk (Younos, 2005; Soin and Smagghe, 2007; Hutchinson, 2007).

In response to the headlines, and recognizing the need for and benefits of multidisciplinary, collaborative research and expanded analytical capabilities, a group of proactive stakeholders from the mountain states of Colorado and Wyoming (Table 1) formed the Consortium for Research and Education on Emerging Contaminants (CREEC) (see http://co.water.usgs.gov/CREEC/). This consortium includes scientists and engineers from the local, state, and Federal government and from several universities with expertise ranging from hydrology and environmental geochemistry to wildlife toxicology, as well as drinking-water and wastewater treatment technology. Regional stakeholders also include regulators, policy makers, consultants, drinking water and wastewater treatment plant representatives, and concerned individuals.

Through collaboration, communication, and education, CREEC seeks scientifically sound answers to human, ecological, and environmental questions and concerns regarding emerging contaminants that are applicable to the Colorado and Wyoming Rocky Mountain region and transferable worldwide

CREEC's purpose is to share research ideas, resources, and expertise and to create a mechanism for channeling financial support to advance EC research in the Colorado and Wyoming Rocky Mountain region. CREEC provides a forum to discuss study plans, research ideas, and scientific results, and strives to communicate results to policy makers and the public to enhance understanding without producing unwarranted alarm.

Table 1. List of CREEC Stakeholders.

Water and Wastewater Utilities, Consultants, and Universities	State and Federal Government Agencies*
CH2M Hill	CDPHE – Water Quality Control Division
City of Aurora, Colorado	CDPHE – Colorado State Environmental and Clinical Chemistry Program
City of Boulder, Colorado	Colorado Division of Wildlife
City of Englewood, Colorado	USEPA – Region 08 – Industrial Pretreatment Program
City of Thornton, Colorado	USEPA – Region 08 – Office of the Regional Administrator
Colorado School of Mines	USEPA – Region 08 – Water Quality Unit, Ecosystems Protection
Colorado State University	USEPA – Region 08 Laboratory
Denver Water	U.S. Fish and Wildlife Service
Metro Wastewater Reclamation District	USGS – Colorado Water Science Center
Richard P. Arber Associates	USGS – Toxic Substances Hydrology Program
University of Colorado at Boulder	USGS – National Research Program
University of Wyoming	USGS – Biological Resources Discipline

*CDPHE, Colorado Department of Public Health and Environment; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey.

CREEC members are focusing their research efforts in the Colorado and Wyoming Rocky Mountain region, which provides an 'ideal field laboratory setting,' for research and education on emerging contaminants. The region includes a unique hydrologic gradient of exposure, identified EC occurrence and effects, and an established network of scientists and other key stakeholders from institutions and facilities at the forefront of EC research, who are willing to collaborate on the issue. Most streams in the region originate high in the Rocky Mountains, initially flow through relatively pristine forests and open space with varying levels of recreational use, then traverse rapidly growing urban and suburban areas, and finally pass through intensively farmed agricultural areas. Once the streams leave the mountains, their water is used and reused by agriculture and urban populations, resulting in streamflow and water quality that are highly dependent on treated wastewater, nonpoint discharges, and agricultural return flows. As a result of this combination of factors and mounting pressures on this relatively limited resource, the Colorado and Wyoming Rocky Mountain region has a unique gradient of water quality, land use, and demographic conditions where the source, fate, transport, and effects of ECs can be effectively studied.

Consortium goals include the following:

- *Advance the state of knowledge* of occurrence, fate, transport, ecological relevance, and potential effects on human and environmental health of ECs by facilitating cooperative, multi-institution, interdisciplinary research and monitoring projects.
- *Foster collaborative research* by linking consortium researchers with field sites, pilot facilities, and laboratory resources available at Federal, state and academic institutions as well as several local and regional water, wastewater, drinking water, and agricultural organizations and agencies.
- *Share information* on current and proposed research among scientists, regulators, and stakeholders in an open environment for discussion and educational purposes.
- *Coordinate, facilitate, and share limited resources* to acquire funding and maximize resources to conduct transferable EC research at laboratory and/or field scales in the Colorado and Wyoming Rocky Mountain region.
- *Advance knowledge* concerning the ability to reuse waters that contain ECs.
- *Investigate options for EC removal* from the environment by treatment or source control.
- *Synthesize and communicate results* of current and future EC research to regulators, policy makers, drinking-water and wastewater treatment plant operators, other scientists, and the public.

Recent CREEC activities include an EC-focused workshop held in conjunction with the 2005 South Platte Forum, application for state and Federal nonprofit status, and ongoing collaborative development of a regional water quality study on nonylphenol and selected organic compounds. CREEC also will be a sponsor of the American Water Resources Association Summer Specialty Conference, "Emerging Contaminants of Concern in the Environment: Issues, Investigations, and Solutions" in Vail, Colorado, June 25-27, 2007. If you are interested in participating in CREEC activities, or if you want to be informed of CREEC-sponsored events and products, please contact us by email at creec@usgs.gov.

Through collaboration, communication and education, CREEC seeks scientifically sound answers to human, ecological, and environmental questions and concerns regarding emerging contaminants that are applicable to the Colorado and Wyoming Rocky Mountain region and transferable worldwide.

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SELECTED LINKS TO MORE INFORMATION

http://co.water.usgs.gov/CREEC/index.html – Homepage of the Consortium for Research and Education on Emerging Contaminants (CREEC)

http://toxics.usgs.gov/regional/emc/index.html – U.S. Geological Survey Toxic Substances Hydrology Program

http://www.epa.gov/esd/chemistry/pharma/index.htm – Pharmaceuticals and personal care products (PPCPs) as environmental pollutants historically hosted by the U.S. Environmental Protection Agency National Exposure Research Laboratory Environmental Sciences (no longer being updated)

http://www.awwarf.org/research/TopicsAndProjects/topicSnapshot.aspx?topic=EDCS – AWWA Research Foundation's featured topic snapshot on emerging contaminants

http://e.hormone.tulane.edu/ehormone.html – Gateway to information on the environment and hormones hosted by Center for Bioenvironmental Research at Tulane and Xavier Universities

http://www.chbr.noaa.gov/peiar/ – A database of available information on the general chemistry and toxicology of potential environmental levels of pharmaceuticals hosted by the National Centers for Coastal Ocean Science, Center for Coastal Environmental Health and Biomolecular Research

http://www.endo-society.org/ – The Endocrine Society whose mission is intended to advance endocrinology and promote its critical role in integrating scientific research and medical practice, hosted by The Hormone Foundation

http://www.ourstolenfuture.org/ – A website that tracks the most recent developments regarding endocrine disruption and related scientific findings, based on the book "Our Stolen Future" by Theo Colborn, Dianne Dumanoski, and John Peterson Myers

http://bcn.boulder.co.us/basin/topical/haa.html – Boulder Area Sustainability Information Network (BASIN) sponsored web site that contains a summary of research on the impacts of hormonally active agents in Boulder Creek, Colorado

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IN MEMORIAM

The AWRA Board of Directors, staff and membership extend their deepest condolences to the families and friends of the victims of the tragedy at Virginia Polytechnic Institute and State University. Words cannot express the pain and sorrow these people are going through right now. It touches so many of us across the country and indeed the world. Even in our own little corner of that world, the AWRA Virginia Tech Student Chapter has been affected and altered forever. Not just by the loss of Matthew Gwaltney, the chapter's Vice President, but also by the loss of the members of the Environmental and Water Resources Engineering Program, the students who participated in chapter's activities, and faculty members such as Dr. G. V. Loganathan, who supported their efforts. We honor their memories and trust that their spirit and dedication will live on in the Chapter and the University.

WATER POLICY ANNOUNCEMENT
Guatemala will be the venue for the SIXTH WATER DIALOGUE

The Sixth Dialogue will take place in Guatemala City, on August 12-17, 2007. The Sixth Inter-American Dialogue on Water Management is the most prominent regional event that gathers a wide array of stakeholders and practitioners in the theme of water management in the Americas. Organized by the Inter-American Water Resources Network and the Government of Guatemala, with the collaboration of many international agencies, civil society organizations, academic institutions, and the private sector, the Sixth Dialogue will take on the need to evolve "From Dialogue to action – Strengthening partnerships and building the basis for meeting the Millennium Development Goals." The Dialogue is built around the foundation of wide participation to come up with a set of recommendations that will be sent to the decision-makers and opinion drivers in water issues in the region – regardless of the sector in which they act. Building such a partnership means more than just agreeing in how to split chores to work together for an objective, like water and sustainable development. It also means making a call to everyone to be part of the crusade to manage responsibly the most precious resources that our countries have: water and their people. **For additional information, please visit the webpage http://www.iwrn.net.**

HAVE SOME COMMENTS ABOUT THIS ISSUE OF IMPACT?
SEND US YOUR FEEDBACK

Water Resources IMPACT is in its ninth year of publication and we have explored a lot of ideas. We hope we've raised some questions for you to contemplate. "Feedback" is your opportunity to reflect and respond. We want to give you an opportunity to let your colleagues know your opinions ... we want to moderate a debate ... we want to know how we are doing. For this issue send your letters by land-mail or e-mail to

William A. Battaglin (wbattagl@usgs.gov)
Jonathan E. Jones (jon.jones@wrightwater.com)

Comments may also be sent to

Earl Spangenberg (espangen@ uwsp.edu)

Either way, please share your opinions and ideas. Please limit your comments to approximately 350 to 400 words. Your comments may be edited for length or space requirements.

THE NEW ECONOMY OF WATER

Clay J. Landry and Christina Quinn

CHINA'S WATER SUPPLY CRISIS OPENS DOORS FOR PRIVATE FOREIGN INVESTMENT

China's water market was ranked by the *Global Water Intelligence* in 2006 as having high potential for investors. The rapid development of the industrial sector and the continuing rise in population in China has added to the derogation and deterioration of water supply in China's urban centers. The limited supply struggles have created conflict between industrial, municipal, and agricultural water users. The Chinese government has responded by investing billions of dollars on new water recycling facilities, dams, and pipelines to bring water to all users. The daunting task has also led the country to open the water market to both domestic and foreign private investors.

Private Investment

In particular, the Chinese government has opened the entire municipal service sector to domestic and foreign companies. From 2003-2005, 50 state-owned water and sewer enterprises contracted management and investment decisions to private entities in concession agreements, according to the World Bank. Four state-owned enterprises leased the management operations to private entities. The country also had 53 greenfield projects allowing private companies or private-public partnerships to build and operate new water and wastewater facilities. Two other state-owned water facilities were divested to private companies. The total private investment from 2003 to 2005 equaled more than $4.14 billion, according to the World Bank (see below).

Private Foreign Investment

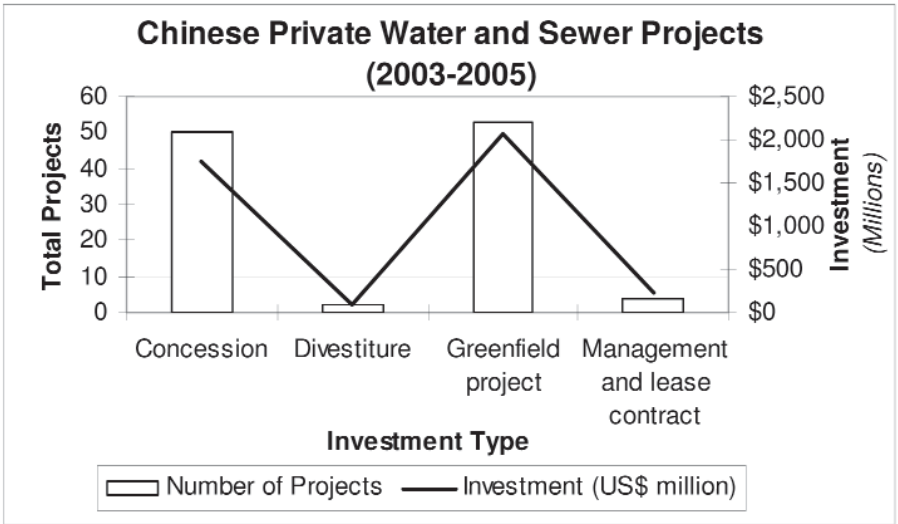
China wants to continue to tap private capital and technology, especially from overseas, to address the water supply shortage. "We welcome water companies from all over the world to participate in the Chinese market," the Deputy Minister for Construction Qui Baoxing told the *Bloomberg News* in August 2006. "Companies including Veolia and Suez have already done very well in China's water treatment and recycling sector. This is proof that China's water sector is open."

The French firm Veolia Water was the first foreign water company to penetrate the Chinese market. Most recently, Veolia Water won a $2.07 billion, 30-year contract to manage four water treatment plants in northwestern China. The French company was able to obtain this contract by buying 45 percent of China's Lanzhou Water Supply Co. Altogether, the company serves 14 million people in China ranging from an industrial customer to 11 municipalities.

Another French company, Suez, provides drinking water and wastewater to 13.5 million people in China. Its water projects include 30-year contracts with wastewater treatment plants and a concession contract for a water facility. The company also has an industrial wastewater reuse program in China.

Hyflux, headquartered in Singapore, is another prominent private company venturing into China's water market. The company has multiple municipal water projects and also specializes in the desalination of seawater and the purification of well water. In March, the company won three water treatment projects in China worth $70 million.

Generally these private foreign investments target small water projects; however, the private investments are also a part of larger Chinese water projects. The



South-to-North Water diversion is a multi-billion dollar project to divert 11.88 trillion gallons of water from the lower, middle, and upper Yangtze River through the eastern, central, and western routes to Northern China. The project is expected to be completed in 2050. Within this project, the government has hired private companies including U.S. engineering firms.

The Challenges to Investing in China

The continued growth in private investment in water is tied to water and wastewater prices and the regulatory environment. The Chinese government can cap the amount of foreign investment. Moreover, the government has control over municipal water and wastewater prices. Water prices signal a potential return to investors around the world.

Urban water delivery and wastewater treatment prices are determined by municipal governments but are generally too low to cover costs and finance facility upgrades or expansion. In some regions the prices are low enough relative to household income to absorb a rate increase. The average household water expenditure in 2004 in Beijing accounted for 1.8 percent of the household income, according to a report by China Economic Net.

Currently foreign financing in the water industry in China is less than 10 percent, China's Deputy Director General for Urban Construction at the Ministry Zhang Yue told *Bloomberg News* in August 2006.

The Incentive for an Open Market

China has strong incentives to increase private foreign contribution to its water supply projects. Reports from the Chinese Water Congress in 2007 showed that 400 of China's urban cities do not have adequate domestic or industrial water supplies. In addition, much of the wastewater is not treated. As a result, the county has an investment need of $30 billion by 2010. More than 1,000 treatment plants will be built throughout China by 2010 and the market for wastewater treatment will reach $50 billion, according to the Water Congress reports. Part of the financing is expected to come from foreign companies.

To spur foreign private investment, the Chinese government has approved a nationwide increase in water supply and treatment fees. The Chinese government has called for water prices to reflect costs by 2010. The announcement signals to private firms a potential investment opportunity in China.

E-Mail Connection

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Christina Quinn (Quinn@waterexchange.com)

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▲ AWRA Future Meetings

2007 MEETINGS

June 25-27, 2007
AWRA's Summer Specialty Conference
"EMERGING CONTAMINANTS OF CONCERN IN THE ENVIRONMENT: ISSUES, INVESTIGATIONS, AND SOLUTIONS"
Vail, Colorado ~ Vail Cascade Resort
(FOR ADDITIONAL DETAILS, SEE THE CENTER SECTION IN THIS ISSUE)

November 12-15, 2007
AWRA's
ANNUAL WATER RESOURCES CONFERENCE
Embassy Suites Hotel Albuquerque
Albuquerque, New Mexico

Additional Info – www.awra.org

WHAT'S UP WITH WATER?

Eric J. Fitch

DO THE 'EYES' REALLY HAVE IT?

There is a possibly apocryphal story that has circulated for several years that once when NOAA was asking Congress for funding for a new Geostationary Operational Environmental Satellite (GOES), a member of Congress reportedly asked "Why do we need weather satellites when we have the Weather Channel?" Needless to say, after they were informed by their staff about why that was a 'dumb' question on a variety of levels, the question and response was redacted and removed from the committee meeting transcript. True story or not, it is reflective of the seeming de-emphasis of the U.S. government toward collection, analysis, and dissemination of remotely sensed data on the Earth's environment, including its water resources. NASA no longer has a "Mission to Planet Earth," now it's "Destination Earth." The name change may be subtle, but the facts on the ground and in space are much different. We've moved earth and environmental science missions at NASA back from the critical concept of mission to a destination; like a "destination resort" as in "Oh, no, we don't live here, we're just visiting!" Hello! We do live here and unfortunately we're cutting back on funding for the help line on planetary maintenance ("now how much CO_2 and methane can we add before we have negative feedback?").

Science as a whole has done poorly in recent federal budgets and even worse in the current federal budget. Space science fares better at first glance until one sees that moneys are being shifted away from satellites, probes, and unmanned science to the manned missions, especially the Orion Moon-Mars launch vehicle. Climate and other earth oriented data missions have been especially hard hit. Some of this has to do with other federal expenditures like the war in Iraq, but much has to do with the decrease in revenue streams available after the major tax cuts of the last six years. Some of it has to do with the lack of understanding and foresight necessary on the part of decision-makers, and some of it has to do with (surprise, surprise) politics.

One great example of a perfect storm for budget cutting was what came to be called the Triana (named after the sailor who first spotted the New World from Columbus' ship) project and later named DSCOVR. Back in 1998, then Vice-President Gore promoted NASA's Mission to Planet Earth and even suggested his own idea. A satellite would be launched and sent to Lagrange-1, or L1 (the neutral gravity point between the Sun and the Earth) that would constantly view the entire lighted side of the Earth, transmit that image back home and distribute it across the internet in real time. For his rationale, he referred to an image that many of us of a certain age remember vividly; the photo taken from Apollo 8 of Earthrise. Mr. Gore recounted the fact that this is the most reproduced photograph in the world because of its profound symbolism. Here for the first time human eyes could look back at our world and see not only the entirety of the Earth, but see it as the home of every living being past and present we have ever known and of all human accomplishment. All that, on this little blue marble. It was initially dubbed Goresat and opposition politicians in Congress derided the idea as the "worlds most expensive screen saver." NASA and her university partners however took the idea and ran with it. They tweaked the task and created a project that had strong scientific merit while still providing for Mr. Gore's idea of having a constant reminder of our world's fragile nature. The satellite was built and renamed the Deep Space Climate Observatory (DSCOVR). It's primary scientific mission is to measure the albedo of the Earth's atmosphere as a whole over time. Albedo, if one needs reminding, is the coefficient of reflectivity of the atmosphere, or how much of the visible spectrum of light is being reflected back into space. This is a critical piece of information for the scientific community in its study of climate change, global brightening/dimming, and the changing nature/composition of the atmosphere. Today, with the inextricable links between weather, climate, and the dynamics of global hydrological systems, more and better information is essential. So, are we benefitting from scientific data coming from DSCOVR? No. After spending $100 million to build it, it is warehoused and costing taxpayers $1 million/year to maintain it. Why? Budget cuts.

The loss of DSCOVR as a functioning resource is bad enough. The loss and delay of many other projects to help in our continuing quest to understand our own planet and its dynamics borders on the criminal. Yet underfunding of NASA and NOAA is creating that reality today. The National Research Council has recommended a 10-year plan to bring 15 new missions on line at a cost of $7.5 billion dollars. These moneys along with increasing the half billion dollar shortfall for existing projects and partnerships with other nations will help to create an earth sensing network that can do the job at this critical time. So far, not having an "owners manual" for the planet hasn't caused us to make a fatal mistake (at least for our own species). To paraphrase and sanitize one of the more memorable lines by Billy Bob Thorton in Armageddon, "it's a pretty big (blank) planet." Science tells us that humans have gravely impacted the Biosphere already. Tracking, analyzing, and successfully adapting to these changes will take our best science and we know that science is only as good as the data it is based upon. Let's make sure that we have the tools to collect that data and not rely on the judgement of those who can't differentiate between what the Weather Channel does and what our satellites and other scientific instruments and programs do for us, and our ability to manage water and other critical aspects of the global environment.

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WATER RESOURCES
IMPACT

ATTRACTION: GETTING WHAT YOU WANT TO COME TO YOU

Marshall Brown

Paul is one of those people at work you just love to hate – but can't, really, because he's so darn nice. Things seem to go so easily for him. He lands contracts, the head of the company pops in with interesting projects, customers call him with huge orders. It's as if he's just kicking back on an inner tube and being carried along in a current of good luck.

Contrast that with Sean who puts in twice as many hours at work – super-long, hard hours every day, plus more on weekends. He exerts huge effort with every deal he puts together, every project he takes on. Yet he rarely achieves exactly what he's striving so hard to create. Rather than floating down a river, Sean feels like he's slogging through mud.

What's the difference? On the outside, things look relatively equal. Both men have master's degrees from well-respected universities. They're competent and well-liked by co-workers and those they supervise.

Hint: It's in the river image. When Paul works hard, it doesn't feel like struggle, for he's "in the flow." He's in tune with his life purpose, his passions, and his vision for himself and the work he does in the world. As a consequence, he's just naturally able to attract what he wants, with an enviable ease.

The law of attraction. It's not just some woo-woo theory, it's scientific: like matter attracts like. It's similar to a radio broadcast: when tuned into a particular station, you will only hear (attract) the frequency of radio waves that match that station's signal. And when that happens, everything seems easy, like it does for Paul, not a struggle, like it does for Sean.

"Once you change the way you are inside, the outer world changes," writes Joe Vitale, author of the recent bestseller *The Attractor Factor*.

Vitale is one of dozens of authors who write persuasively on this seemingly mysterious subject. Call it synchronicity, coincidence, chance, or what have you. Attraction is a phenomenon that, as author Julia Cameron puts it, some of us might prefer to ignore: the possibility of an intelligent and responsive universe, acting and reacting in our interests.

Below are some of the key ingredients for attracting into your life and work what you want from some of the foremost writers on the subject.

- Get **clear on what you want and why**. It's not enough to know what you *don't* want. You can't get what you want until you know what that is!

Napoleon Hill, whose classic *Think and Grow Rich* has inspired several generations now, wrote that a *burning* desire is essential to personal success. It was as true in 1937 during the Depression, when he wrote the book, as it is now that "there is one quality which one must possess to win, and that is definiteness of purpose – the knowledge of what one wants and a burning desire to possess it."

What do *you* want? A job with flex time so that you can go to your daughter's soccer games? To have the financial freedom to be able to take on a pro-bono nonprofit client? To indulge your passion for chocolate (and inflame others with it) by opening a chocolate café downtown?

Many of us have forgotten how to dream. We're more connected to our To-Do lists than to what we really want. But getting crystal clear is where the "magic" of attraction all begins. When you know the *what*, then the *how* can begin to fall into place.

- Imagine **it**. Act as if what you want to happen is already happening and see how that changes your thoughts. "Conscious change is brought about by the two qualities inherent in consciousness: attention and intention," writes Deepak Chopra in his book *The Seven Spiritual Laws of Success*. "Attention energizes, and intention transforms. Whatever you put your attention on will grow stronger in your life."

- **Commit**. The quotation often attributed to Goethe but actually written by W.H. Murray in his 1951 book *The Scottish Himalaya Expedition*, speaks eloquently to the power of commitment: "Until one is committed, there is hesitancy, the chance to draw back, always ineffectiveness. Concerning all acts of initiative (and creation), there is one elementary truth the ignorance of which kills countless ideas and splendid plans: that the moment one definitely commits oneself, then providence moves too. A whole stream of events issues from the decision, raising in one's favor all manner of unforeseen incidents, meetings, and material assistance, which no man could have dreamt would have come his way."

Commitment, by its very nature, implies choice. And choosing something means not choosing something else, a prospect that some of us find daunting. But "keeping all our options open" too often results in no choice at all, the death knell of dreams.

- Keep **yourself receptive**. Exercise, eat healthily, play, and relax. Stress, exhaustion, sluggishness, etc., can all interfere with attraction. In the radio station analogy, they become the "static" that interfere with the "frequencies" of that which you want to attract. Though taking a day off to relax rather than working frantically may seem as difficult as stepping off a precipice, it can be just what is needed. As novelist Toni Morrison says, "We are traditionally rather proud of ourselves for having slipped creative work in there between the domestic shores and obligations. I'm not sure we deserve such big A-pluses for that."

When we're too busy with all our daily to-do's, we effectively tune out and turn off the frequency that broadcasts inspirations and hunches and new ideas. As economist Paul Hawken says, "Always leave enough time in your life to do something that makes you happy, satisfied, and even joyous. That has more of an effect on economic well-being than any other single factor."

- Listen **to your intuitive nudges**. Attraction isn't about sitting back and waiting for it all to come to you. Action is always required to meet goals and make dreams come true. Vitale writes: "Your job is to ask for what you want, and then to act on the inner nudges you get to do things, like make phone calls, write letters, visit a certain person, or whatever." Don't worry if your "nudges" don't make immediate sense. The "why" will reveal itself later.

- **Change your thoughts**. Consider the possibility that you can change what is by simply changing the way you see it. The axiom that Dr. Wayne Dyer uses daily to remind himself of this truth is: *Change the way you look at things, and the things you look at change.*

In his book *The Power of Intention*, Dyer recommends a 10-step program for attracting what you want. His steps include: see the world as an abundant, providing, friendly place; affirm that you attract success because that is who you are; remember that your prosperity and success will benefit others; monitor your emotions as a guidance system for when you are connected and not to the energetic "flow" that happens when you are in sync with inspiration; and be grateful and filled with awe for all that manifests into your life.

- Surrender **control**. Detach from the outcome. This means to let go and trust. Let go of the particular way in which things will happen. Let go of fear, doubt, worry, and disappointment. Let go of the notion of struggle. Like Paul, when you're working hard in something you love, it doesn't feel like struggle.

Julia Cameron, whose book *The Artist's Way* has helped countless people attract and successfully live the creative life they desire, calls this notion of struggle "rubbish." She contends that we can count on so-called lucky breaks, what Joseph Campbell called "a thousand unseen helping hands."

"We like to pretend it is hard to follow our heart's dreams," Cameron writes. "The truth is, it is difficult to avoid walking through the many doors that will open. Turn aside your dream and it will come back to you again. Get willing to follow it again and a second mysterious door will swing open ... Take a small step in the direction of a dream and watch the synchronous doors flying open."

So whether your dream is a job promotion, landing that huge client, or buying a new house, claim it. It's yours if you want it.

Marshall Brown, a certified career and executive coach has always had a passion for helping people find ways to live more fulfilling lives. He found that a personalized, "no nonsense" approach to coaching was the most efficient and effective way to get people on a successful life course. As a coach, Marshall helps individuals to find their passions and encourages them to move ahead in reaching their goals. His new book, *High Level Resumes*, reflects his successful work with hundreds of job candidates.

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www.mbrownassociates.com (202.518.5811)

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Have Questions About IMPACT?

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Check Out Our Home Page At www.awra.org

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2007 REQUEST FOR APPLICATIONS – SCIENCE FELLOWS PROGRAM

CALFED Science Program
California Sea Grant College Program

"FELLOWSHIPS for Predoctoral Students and Postdoctoral Researchers"

The Science Fellows Program brings together young scientists, CALFED agency scientists and senior research mentors in collaborative data analysis and research projects relevant to ecosystem management and water supply reliability questions. The CALFED Science Program, in collaboration with California Sea Grant, is seeking applications from qualified individuals to compete for fellowship opportunities in 2007.

The 2007 CALFED Science Fellows Program will be sponsoring at least seven Science Fellows (predoctoral and postdoctoral) in all disciplines of environmental science addressing the following 2007 priority topics:

•Environmental Water
•Aquatic Invasive Species
•Population Trends and Patterns of Key Species
•Habitat Availability and Response to Change

or CALFED Implementing Agency Science Needs.

For further information about the 2007 Request for Applications - Science Fellows Program, please visit:

http://www.csgc.ucsd.edu/EDUCATION/SgEducationIndx.html

All applications are due by June 1, 2007, 5:00 pm at the California Sea Grant College Program Office

CALFED BAY-DELTA PROGRAM

Sea Grant California

LEGAL ISSUES: BLACK CANYON OF THE GUNNISON: THE BEGINNING OF THE END FOR NEGOTIATED AGREEMENTS?

Michelle Henrie and Kyle S. Harwood

New Mexico's "Year of Water" is 2007. This designation commemorates 100 years of New Mexico water law, which was first enacted as territorial laws in 1907. Who would have guessed that in 2007, after 100 years of water law, New Mexico would still be largely unadjudicated? Only about 20 percent of New Mexico has been adjudicated.

In the meantime, however, until New Mexico becomes fully adjudicated through its courts, we here in New Mexico must agree among ourselves or fight among ourselves. Mostly, we have found ways to agree. For example, Shortage Sharing Agreements are becoming increasingly common as a means of gaining certainty and predictability – that are essential to business – in an unadjudicated system.

However, a recent federal court decision could affect our ability to agree among ourselves. The case involved water in Colorado's Black Canyon of the Gunnison, a National Park. The applicable law of "federal reserve water rights," also called "Winters doctrine," states that when Congress sets aside land for a particular purpose, it impliedly sets aside water in an amount sufficient to fulfill this purpose. Examples of lands set aside by Congress include Indian reservations, National Parks, National Forests, and military reserves such as the White Sands Missile Range. In New Mexico, these federal reserve lands total approximately 40 percent of the state.

With regard to the Black Canyon of the Gunnison, the federal government had trouble quantifying the federal reserve water rights for the Black Canyon because its purpose was different than the purpose of other federal projects on the same river system: reservoirs, including reservoirs producing hydroelectric power. Finally, in 2001 the federal government filed the paperwork in a Colorado Water Court to quantify its water rights. However, 380 different parties then filed protests opposing this quantification. Over the next two years, the federal government worked with key protestants such as the State of Colorado to develop a compromise settlement agreement.

However, the federal court determined that negotiated compromise of the Black Canyon's federal reserve water right was an unlawful disposal of federal property without Congressional approval. Further, even though a Colorado State entity was willing to take upon itself the task of protecting the Black Canyon's water resources, the federal government cannot delegate this task. Finally, the compromise was subject to NEPA.

Long story short: the federal government cannot compromise its federal reserve water rights easily. Once those federal reserve water rights have been articulated (even in an "application"), such a compromise must go through NEPA and be authorized by Congress. Further, the federal responsibility to protect reserved lands cannot be delegated to anyone.

What does this mean for a place like New Mexico?

- It may mean that federal reserve water rights claims asserted in adjudications cannot be settled and compromised without a NEPA process and Congressional authorization.

- It may mean that water users on an unadjudicated river system cannot enter into Shortage Sharing Agreements involving federal reserve water rights without a NEPA process and Congressional authorization.

- It may mean that in the face of emergency such as drought, everyone else will need to tighten their belts. The federal government may not be able to compromise its federal reserve water rights in an emergency time frame.

What can be done? A change may need to occur at the Congressional level to authorize and specifically allow federal agencies to enter into negotiated settlements without triggering NEPA or case-by-case Congressional authoritzation.

Please contact Michelle Henrie at mhenrie@bhfs.com for a copy of the court's order.

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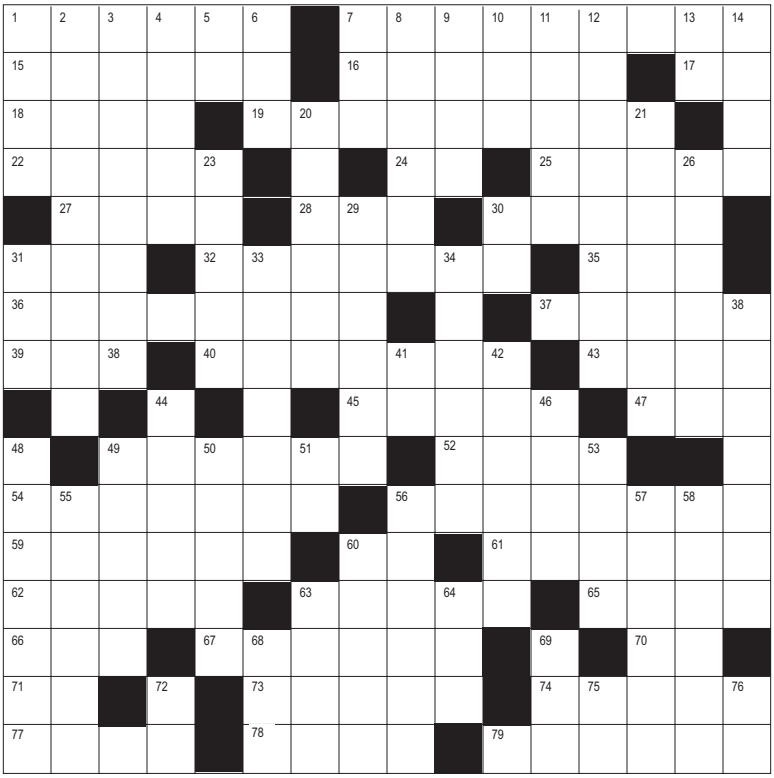
▲ Water Resources Puzzler (answers on pg. 32)



ACROSS

1 force * distance
7 part of baseball calendar
15 lack of vigor
16 to dedicate
17 Derek or Jackson
18 prong
19 want ads?
22 MONOPOLY piece
24 printer's space
25 coin flips
27 none
28 place to relax
30 sesame
31 followed by -American
32 narrow strip of land
35 trig function
36 gun attachment
37 type of machine
39 followed by light or marshal
40 spotted ruminant
43 fodder trough
45 wax impressions
47 Capone and Gore
49 a game of _____
52 bright light?
54 beat soundly
56 followed by hunt or Island
59 _____ Mame
60 Latin diagraph
61 New York island
62 to extol as holy
63 anagram of stern
65 _____ vaulter
66 Baxter or Aspin
67 dinner option
70 circumference / diameter
71 hospital rm.
73 anagram of eater
74 long poems
77 fast fliers
78 _____ and means
79 frightened

DOWN

1 h.s. subject
2 leek, garlic, or shallot
3 intellectually
4 Arabian chieftan
5 atomic no. 28
6 followed by room or dance
7 scratch
8 pants line
9 _____ and gloom
10 transgression
11 related on mother's side
12 followed by salmon or City
13 Siberian river
14 auction motions
20 followed by egg or lily
21 Ol' Blue Eyes
23 example of 10 DOWN
26 a legume
29 a syntactic unit
30 undergraduate deg.
31 cousin of a donkey
33 type of fiction
34 biased
38 lewd
41 Santa _____
42 first born
44 closes
46 follows back or county
48 homes for horses
49 photoreceptors in the retina
50 parsley kin
51 coll. major
53 on the double
55 czars
56 principles
57 place of perfection
58 keepsakes
60 matrix
63 Italian spewer
64 view
68 followed by Deal or moon
69 to solicit alms
72 part of N. A.
75 acid indicator
76 ave. crosser

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▲ JAWRA Technical Papers ... April 2007 • Vol. 43 • No. 2

TECHNICAL PAPERS

- A Comparison of Gauge and Radar-Derived Rainfall in a Land Falling Typhoon in Taiwan
- Development of an Index of Biotic Integrity for a Southeastern Coastal Plain Watershed, USA
- Water, Adaptation, and Property Rights on the Snake and Klamath Rivers
- Comparative Evaluation of Three River Water Quality Models
- Estimating Hydraulic Properties of Volcanic Aquifers Using Constant-Rate and Variable-Rate Aquifer Tests
- Multi-Criteria Decision Support Systems for Flood Hazard Mitigation and Emergency Response in Urban Watersheds
- Demonstrating Floodplain Uncertainty Using Flood Probability Maps
- New Criteria for Sustainable Water Quality Management
- Sound Survey Designs Can Facilitate Integrating Stream Monitoring Data Across Multiple Programs
- Dry Weather Water Quality Loadings in Arid, Urban Watersheds of the Los Angeles Basin, California, USA
- Modeling Stream Channel Characteristics From Drainage-Enforced DEMs in Puget Sound, Washington, USA
- Resident's Assessment of an Urban Outdoor Water Conservation Program in Guelph, Ontario
- Stream Temperature Surges Under Urbanization and Climate Change: Data, Models, and Responses
- Developing Nutrient Criteria for Streams: An Evaluation of the Frequency Distribution Method
- Generalized Nondimensional Depth-Discharge Rating Curves Tested on Florida Streamflow
- The Sensitivity of California Water Resources to Climate Change Scenarios
- Alluvial Sedimentation and Erosion in an Urbanizing Watershed, Gwynns Falls, Maryland
- Minimum Wet-Season Flows and Levels in Southwest Florida Rivers
- Developing a Standardized Water Quality Index for Evaluating Surface Water Quality
- Simulation of Surface Water for Un-Gauged Areas With Storage-Attenuation Wetlands

▲ Water Resources Continuing Education Opportunities

JULY 2007

24-26/2007 UCOWR/NIWR Annual Conference Hazards in Water Resources. Grove Hotel, Boise, Idaho. www.ucowr.siu.edu

AUGUST 2007

5-14 / 33rd International Geological Congress (IGC). Oslo, Norway. Prof. Arne Bjorlykke, President of the 33rd International Geological Congress (arne.bjorlykke@ngu.no) or Scientific Program Committee (secretariat@33igc.org) (www.33igc.org)

13-17 / Shortcourse – Geomorphic and Ecological Fundamentals for River and Stream Restoration. Lake Tahoe, CA. **Contact** restoration.ced.berkeley.edu/shortcourse. Also restoration_shortcourse@yahoo.com

SEPTEMBER 2007

5-7 / Alabama Water Resources Conference. Orange Beach, AL. **Contact** www.auei.auburn.edu/conference or 334.844.4132

Solution to Puzzle on pg. 31

AMERICAN WATER RESOURCES ASSOCIATION MEMBERSHIP APPLICATION – 2007

MAIL THIS FORM TO . . . AWRA • 4 West Federal St. • P.O. Box 1626 • Middleburg, VA 20118-1626
FOR FASTEST SERVICE . . . FAX this form (credit card or P.O. orders only) to (540) 687-8395
QUESTIONS? . . . CALL AWRA HQ at (540) 687-8390 or E-MAIL at info@awra.org

➤ Complete All Sections (please print)

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TITLE

COMPANY NAME

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IS THIS YOUR ❑ HOME OR ❑ BUSINESS ADDRESS?

PHONE NUMBER FAX NUMBER

E-MAIL ADDRESS

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➤ Student Members Must Be Full-Time And The Application Must Be Endorsed By A Faculty Member.

PRINT NAME SIGNATURE

ANTICIPATED GRADUATION DATE (MONTH/YEAR): _____

➤ Key For Membership Categories:

JAWRA – Journal of the AWRA (bi-monthly journal)
IMPACT – Impact (bi-monthly magazine)
PROC. – 1 copy of AWRA's annual symposium proceedings

ENCLOSED IS PAYMENT FOR MEMBERSHIP (PLEASE CHECK ONE)

❑ Full Year ❑ Half Year

- ❑ Regular Member (JAWRA & IMPACT).....$150.00
- ❑ Student Member (IMPACT) FULL YEAR ONLY $30.00
- ❑ Institutional Member (JAWRA, IMPACT, & PROC.) $325.00
- ❑ Corporate Member (JAWRA, IMPACT, & PROC.) $425.00
- ❑ AWRA Membership Certificate.....$11.00

➤ Foreign Airmail Options: Contact AWRA for pricing.

➤ Please Note

* Membership is based on a calendar-year; after July 1st regular, institutional, or corporate members may elect a 6-month membership for one-half of the annual dues.
* Students do not qualify for half-year membership.
* Remittance must be made in U.S. dollars drawn on a U.S. bank.

➤ Payment Must Accompany Application

PAYMENT MUST BE MADE BY CHECK OR ONE OF THE FOLLOWING CREDIT CARDS:

❑ VISA ❑ MASTERCARD ❑ DINERS CLUB ❑ AMEX ❑ DISCOVER

CARDHOLDER'S NAME _____

CARD # _____ EXP. DATE _____ CSC # _____

SIGNATURE (REQUIRED) _____

➤ Your Primary Reason For Joining? (check one)

- ❑ To Receive Information Through JAWRA and Impact
- ❑ Networking Opportunities
- ❑ Technical Committee Interactions
- ❑ Conference Discount
- ❑ Employment Opportunities
- ❑ Other: _____

➤ How Did You Learn Of AWRA? (check one)

- ❑ Promotional Mailing
- ❑ Internet Search
- ❑ Journal (JAWRA)
- ❑ IMPACT
- ❑ Boss/Friend/Colleague
- ❑ Email Received
- ❑ Other: _____

AWRA
Community, Conversation, Connections

DEMOGRAPHIC CODES

(PLEASE LIMIT YOUR CHOICE TO ONE IN EACH CATEGORY)

JOB TITLE CODES

JT1	Management (Pres., VP, Div. Head, Section Head, Manager, Chief Engineer)
JT2	Engineering (non-mgmt.; i.e., civil, mechanical, planning, systems designer)
JT3	Scientific (non-mgmt.; i.e., chemist, biologist, hydrologist, analyst, geologist, hydrogeologist)
JT4	Marketing/Sales (non-mgmt.)
JT5	Faculty
JT6	Student
JT7	Attorney
JT8	Retired
JT9	Computer Scientist (GIS, modeling, data mgmt., etc.)
JT10	Elected/Appointed Official
JT11	Volunteer/Interested Citizen
JT12	Non-Profit
JT13	Other

EMPLOYER CODES

CF	Consulting Firm
EI	Educational Institution (faculty/staff)
ES	Educational Institution (student)
LR	Local/Regional Gov't. Agency
SI	State/Interstate Gov't. Agency
IN	Industry
LF	Law Firm
FG	Federal Government
RE	Retired
NP	Non-Profit Organization
TG	Tribal Government
OT	Other _____

EDUCATION CODES

HS	High School
AA	Associates
BA	Bachelor of Arts
BS	Bachelor of Science
MA	Master of Arts
MS	Master of Science
JD	Juris Doctor
PhD	Doctorate
OT	Other _____

WATER RESOURCES DISCIPLINE CODES

AG	Agronomy	GI	Geographic Information Systems
BI	Biology	HY	Hydrology
CH	Chemistry	LA	Law
EY	Ecology	LM	Limnology
EC	Economics	OE	Oceanography
ED	Education	PS	Political Science
EG	Engineering	OT	Other
FO	Forestry		
GR	Geography		
GE	Geology		

PLEASE NOTE YOUR SELECTED CODE NUMBERS FROM ABOVE

JOB TITLE CODE .....
EMPLOYER CODE .....
WATER RESOURCES DISCIPLINE CODE .....
EDUCATION CODE .....

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