Colorado Water

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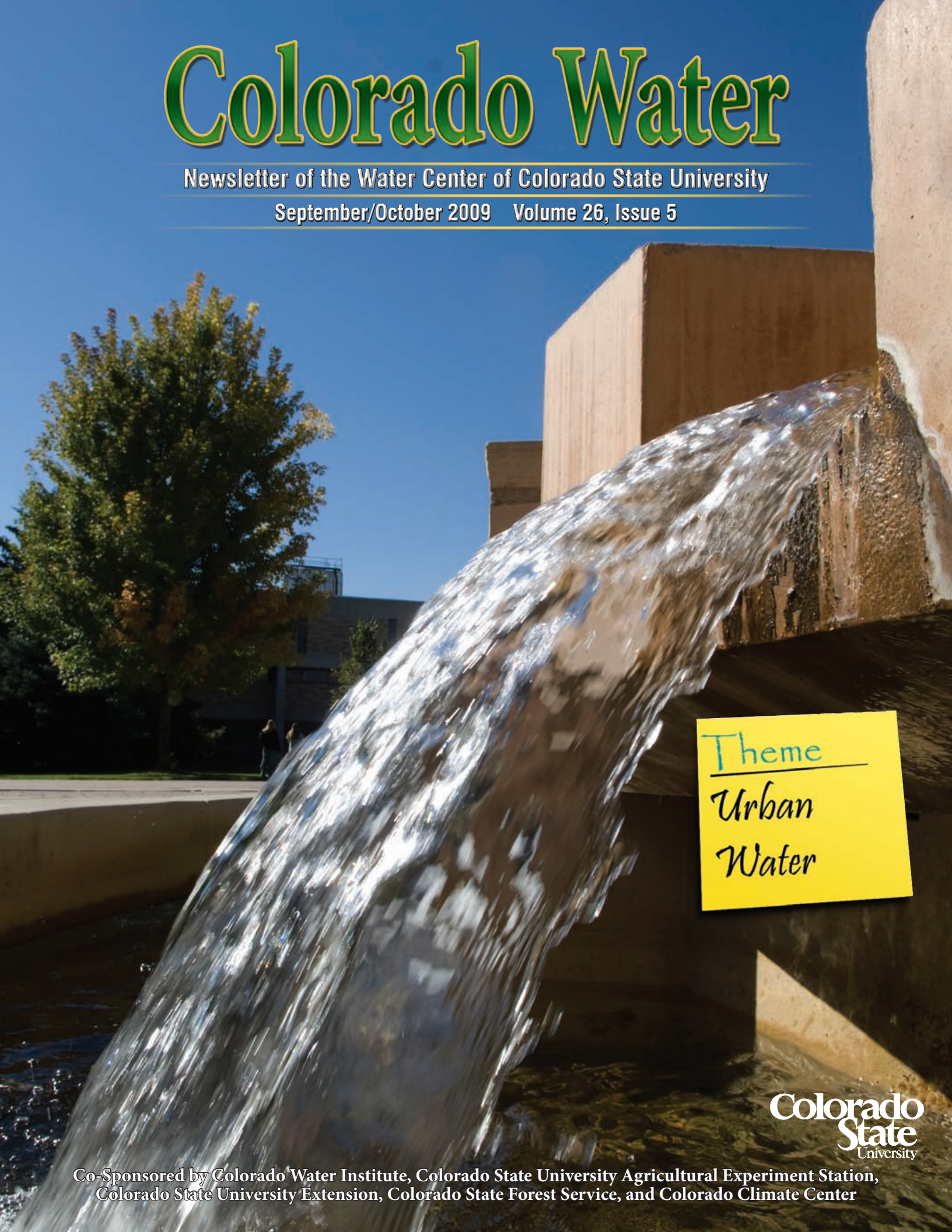

Colorado State University

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Highlights

In Every Issue

COLORADO WATER is a publication of the Water Center at Colorado State University. The newsletter is devoted to enhancing communication between Colorado water users and managers and faculty at the state's research universities. This newsletter is financed in part by the U.S. Department of the Interior, Geological Survey, through the Colorado Water Institute. The contents of this publication do not necessarily reflect the views and policies of the U.S. Department of the Interior, nor does mention of trade names or commercial products constitute their endorsement by the U.S. Government.

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Front Cover: A replica of the Parshall Flume, which became the standard water flow measuring device throughout the world, is part of the Water Plaza on the Colorado State University campus. (Photo by William A. Cotton)

Editorial

by Reagan Waskom, Director, Colorado Water Institute

Urban water encompasses the supply and management of drinking water, wastewater, stormwater, and floodplain management in our cities and adjacent urbanizing areas. Since the beginnings of civilization, humans have settled close to water for access to food, transportation, and protection, as well as for aesthetic and cultural reasons. In doing so, we have created the built environment, often in spite of hydrologic realities. Engineers have long been employed to solve the problems caused by human settlement—bringing clean water to cities and removing excess water and waste. Although it has sometimes been lost in the equation, our urban areas are always part of a watershed, and maintaining the functions of urbanizing ecosystems is a challenge.

The United States is a highly urbanized nation, with 81% of its 305 million people residing in cities and suburbs (the worldwide urban rate is 49%). Colorado and the rest of the West are also highly urbanized, with over 80% of the population residing in urban areas. The West continues to grow faster than the nation as a whole, with expectations for the region to increase from the current 65 million to 101 million people by the year 2040. During that time, Colorado is also expected to increase by 65% to almost 9 million people. That should come as no surprise—people are mobile and the region is highly attractive to both people and capital investment.

The Colorado Water Conservation Board estimates the state will need an additional 630,000 acre feet of water supply by 2030 to meet the needs of growing urban and suburban communities, most of which are located on the Front Range. Aside from the impact of our periodic droughts on environmental and recreational flows, it could be argued that virtually all of our new water needs, or at least all of our water problems, are related to urbanization. After all, even the water required for agriculture is to feed those who live in the city. The same might also be said for the water used to produce energy.

A critical issue associated with urban growth and climate variability is the development of more resilient urban water systems. Our vision should be to develop holistic and systemic approaches for water and wastewater systems. This includes the science and engineering behind the development of more efficient homes and businesses, conservation programs, water reuse and dual systems, stormwater BMPs, flood and drought modeling, graywater, and rainwater management systems. This issue of *Colorado Water* focuses on recent urban water research and education programs in Colorado. Drs. Larry Roesner and Sybil Sharvelle describe the work of the Urban Water Center at CSU on graywater systems. Dr. Chris Goemans and his graduate student Casandra Kanable report on recent water conservation studies in Aurora. We are also pleased to have updates on urban water programs from the Water Research Foundation, the Waterwise Council, Fort Collins Utilities, and the Urban Drainage and Flood Control District.

Expanding urban populations will continue to place increasing demands on limited water resources—not just in Colorado, but across the globe. Infrastructures continue to age, and extreme flood and drought events will test the robustness of our systems. Urban water managers are going to need the best science, engineering, and information systems to meet these challenges.

The Urban Water Center at CSU

by Larry Roesner, Professor, Civil and Environmental Engineering, Colorado State University

The Urban Water Center at CSU was created at the dawn of the new millennium to foster education and research, as well as to provide municipalities with information to help them better manage their urban water systems. Co-directed by Drs. Larry A. Roesner and Sybil Sharvelle, the Urban Water Center is financially supported by the Harold H. Short Endowed Fund for Urban Water Infrastructure Systems and by client projects.

The mission of the Urban Water Center is to develop better methods to manage water use in the urban environment through teaching and research in two main areas:

- Analysis of urban water systems to determine the efficacy of new management approaches that minimize the import of water into the system and the export of wastewater from the system. A major thrust of this program is the reduction of urban water supply demands through the use of household graywater for residential landscape irrigation and toilet flushing.
- The development of protocols for control of urban runoff to create sustainable urban stream systems in terms of hydrology, geomorphology, and ecology.

The education aspect of the Urban Water Center includes three graduate-level courses. *Analysis of Urban Water Systems* introduces students to water management within the urban setting and guides them in examining ways to improve water use within the current system so that import of water and export of wastewater from the system is minimized. *Urban Stormwater Management* educates students in the state-of-practice of urban drainage systems design and illustrates how damaging this practice is to urban stream systems; students are then taught how to design these systems in a manner that is hydrologically, geomorphically, and ecologically stable. *Water Quality Modeling* gives students a real waste load allocation problem to solve, through which they learn the fundamentals of in-stream water quality modeling, including hydrologic, hydraulic, and water quality simulation.

Research on *Integrated Urban Water Systems* seeks to reform urban water services with an overall goal of providing information and analytical tools that enable urban water managers to make informed decisions on the viability and configuration of decentralized, integrated water and wastewater management. This goal is based on the hypothesis that distributed water management will provide an improved framework for ensuring a safe drinking water supply and increasing water conservation capabilities, even while providing economic benefits. Current projects include the development of a simple water balance/cost model for the U.S. Environmental Protection Agency (EPA) that permits a user to examine various scenarios for urban water management, including conservation, reuse, graywater reuse, and rainfall harvesting at various geographic scales to determine the water savings and economics of each created scenario. In a second project, the Urban Water Center is

Larry Roesner stands next to a peak-shaving slot weir. (Courtesy of Larry Roesner)

This free water surface wetland is in operation on the Colorado State University campus. (Courtesy of Jesse Spear)

working jointly with CDM, an international environmental consulting firm, to improve the economic algorithms used in the model for calculating costs and benefits.

An important research component of the Integrated Urban Water Systems program is the study of graywater and its viability for use in landscape irrigation and toilet flushing. This research began in 2000 with an Urban Water Center-funded project on an individual household graywater system. Various research projects have evaluated the use of treatment technologies such as aeration, filtration, UV, and peroxide to condition water for reuse. A second study, funded jointly by CSU Facilities, the EPA, and the Urban Water Center, began in 2008 and is examining the effectiveness of using two types of constructed wetlands to treat graywater: a free-surface wetland and a subsurface gravel wetland. A current three-year study for the Water Environment Foundation is the first to evaluate the effects of graywater reuse for outdoor irrigation. The study involves collecting plant and soil samples from several locations that have been (or will be) irrigated with graywater, and analyzing those samples for constituents that may be of concern for human health and the environment.

The other major thrust of the Urban Water Center is researching better ways to control urban runoff so that urban stream courses are preserved as development occurs in a watershed. Research involves using urban runoff simulation models to find ways to control runoff from developed sites so that the pre-development flow-frequency and the flow-duration curves are preserved. A more recent study, funded by the Water Environment Research Foundation, focused on containing post-development streambed erosion rates to pre-development rates, and on discovery of stream metrics that reflect the health of stream benthic communities and how to relate these metrics to urban runoff control alternatives. Currently, in another study funded by the Water Environment Foundation, the Urban Water Center is examining the linkage of BMPs to receiving water quality. This study includes: (1) creating better algorithms to simulate pollutant removal in BMPS, (2) developing a simple screening model to determine the cost effectiveness of alternative BMP scenarios to meet a stream TMDL allocation, and (3) building a "Framework for Urban Stormwater" that allows an analysis to link any land-based runoff model (urban or rural) to any receiving water model, and to apply decision support tools to the model results.

In a research project for the (Denver) Urban Drainage and Flood Control District, the Urban Water Center is building a BMP screening model similar to that described above, but using data on BMP pollutant removals and costs specifically applicable to Front Range communities. The model will allow geographic data on watershed size and land use to be input directly through Google Maps™ routines. Finally, the Urban Water Center is under a three-year contract with the City of Fort Collins to assist the stormwater utility with construction and testing of Low Impact Development (LID) BMPs. This project includes assisting the utility in design of LID sites and, after installation, monitoring the performance of the sites in terms of reduction of stormwater flows and removal of pollutants.

Greening CSU: Graywater Use in Academic Village

by Laurie Schmidt, Colorado Water Institute

Who says murky water in your toilet is a bad thing? Sure, it might not be visually attractive, and you might have to do a bit of explaining before your friends use the restroom at your house. But that's a small price to pay for participating in cutting-edge water conservation. Within the next two years, CSU students who sign up to live on the first floor of residence hall "D" in the new Academic Village will play a small role in a study that involves using graywater for toilet flushing and landscape irrigation.

The Academic Village, which currently houses 420 students, is billed by CSU as a state-of-the-art living environment that integrates learning into the living area. It was also designed to be eco-friendly, with low-flow water fixtures, a "green" dining hall that produces a compostable by-product from food and paper waste, and a future graywater reuse system.

Graywater refers to the water that drains from bathroom sinks, showers, and clothes washing machines in a typical household. It does not include water that drains from kitchen sinks, dishwashers, and toilets, which typically contains higher levels of organic waste. In most residential dwellings, potable—or fully treated—water is used to flush toilets and irrigate outdoor landscapes. But growing water supply demands have prompted researchers to ask whether water used for toilet flushing needs to be treated to the same standards as drinking water.

"Approximately 50% of water generated in a household is graywater, so if you can conserve and reuse it, that's 50% less water you need from the municipal plant," said Sybil Sharvelle, assistant professor in the Department of Civil and Environmental Engineering and co-director of the Urban Water Center at CSU. "This presents both a financial savings to consumers, as well as environmental savings, since less wastewater is flowing to the treatment plant."

Potable water, which is supplied by a municipality, meets federal safe drinking water standards and is typically used for all household purposes. "We're working on changing things so that when houses are plumbed, the graywater exits the house in one line and the blackwater (water containing fecal matter or urine) exits in another line," said Sharvelle. In a graywater reuse system, after the water enters the drains, the graywater is collected and stored in a container until it is needed for toilet flushing and irrigation.

As of 2000, the Universal Plumbing Code (UPC) provides for houses to be dual plumbed with both a graywater system and a blackwater system, according to Larry Roesner, professor in the Department of Civil Engineering and co-director of the Urban Water Center. "The City of

Dr. Sybil Sharvelle (left), recent CSU graduate Adam Jokerst, and Dr. Larry Roesner pose with the first stamped graywater manhole in the United States. (Courtesy of Larry Roesner)

A 500-gallon tank is filled with graywater from dormitories on the Colorado State University campus. (Courtesy of Jesse Spear)

Fort Collins uses the UPC as the basis for its code, so dual plumbing for houses is permittable here," he said.

According to Roesner and Sharvelle, the city of Tucson, Arizona, is strongly considering a requirement that any new homes built have separate plumbing lines for graywater and blackwater. "I think it's a good idea, because while we're waiting for the technology to ramp up to perfection, the houses will already be plumbed," said Roesner. "It's fairly expensive to go back and re-plumb a house."

At CSU's Academic Village, the intention is to capture the sink water, shower water, and laundry water and reuse it on site. "They've plumbed that building in a way that we can put in a treatment system and reuse that water for toilet flushing on the first floor," said Sharvelle.

The collected graywater will also be used to irrigate landscape near the residence hall building. "There's a plot of landscape that has already been allocated for the project, and graywater could be used for irrigation there as early as next year," said Sharvelle.

But before the graywater supply is tied into the residence hall's toilet system, the project will need to be approved by both the City of Fort Collins and CSU's Environmental Health Services. "It's not a trivial approval process we need to go through," said Sharvelle. "At that point, we'll be certain that there are no potential health risks."

Most concerns about using graywater relate to the gray, murky appearance of the water. "It's primarily a perception issue," said Sharvelle. "People want to feel that the water coming into their toilet is clean, and the perception of clean has to do with both visual appearance and the potential presence of pathogens."

"The systems we're using at this point have complete disinfection, so the possibility of pathogenic contamination is very remote," said Roesner. "I can say categorically that there is no documented incident anywhere in the United States where graywater has had a negative effect on humans or the environment."

Although the Academic Village residence hall opened in Fall 2009, Sharvelle says the team is just beginning its experiments, so students won't really see anything new right away. "They'll initially be on potable water," said Roesner.

Once the graywater system is in place, students living in that section of the residence hall will be informed about the process and any precautions they need to take. "They need to know that they're moving into a different situation where we collect water from their showers and it ends up back in their toilet system," said Sharvelle.

The CSU graywater system is part of the Urban Water Center's multi-disciplinary graywater research project, which includes evaluating various treatment technologies to reduce bacteria and pathogens in graywater, evaluating the effectiveness of constructed wetlands to treat graywater, and examining the effects of graywater on irrigated vegetation. "We're teamed with CSU's Department of Horticulture & Landscape Architecture, as well as with economists, social scientists, and construction management folks," said Roesner.

"What we can do with this project is provide data and information that allow regulatory agencies to make decisions that make sense, based on the science," said Sharvelle.

Understanding Weather's Impact on Household Water Demand

by Casandra Kanable, Graduate Research Assistant
Christopher Goemans, Assistant Professor
Department of Agricultural and Resource Economics, Colorado State University

The effect of climate on residential water demand is undeniable. Most obvious is the seasonal shift in demand from winter to summer. During the summer months, households irrigate lawns and gardens, fill swimming pools, and wash their cars. These types of additional activities result in per capita demands that are two to three times higher than typical consumption during winter months. Nevertheless, within-season variations in weather conditions can have just as large an impact on water use. This year's cool, rainy conditions during most of the spring and summer along Colorado's Front Range are a strong reminder that cool/wet conditions can significantly influence a household's water use. Figure 1, which illustrates projected and actual water demand, provides an illustration of the effect that these conditions have had on residential water use in Fort Collins, Colorado.

Figure 1 also highlights the difference between seasonal shifts in demand and those corresponding with daily fluctuations in weather. Despite the fact that Fort Collins received more than twice as much precipitation in May and June than it did in March, water demand still increased during the summer months.

Previous residential water demand studies have focused largely on aspects of household behavior that are under control of the utility; namely, the effectiveness of price and non-price demand management programs. While there is wide consensus that, for example, water use tends to increase during hot and dry periods, relatively little is known about how people actually respond to changes in climate (i.e., the behavioral process).

Do households respond to daily fluctuations in temperature and precipitation or severe weather events? Are basic weather variables better predictors of household demand than more complex weather indices? Questions such as these have largely been ignored in the literature. Moreover, unlike with price, little or no theoretical guidance exists as to how people respond to weather. Not coincidentally, numerous approaches to modeling climate's effect on water demand have emerged. Below, we provide a summary of the different approaches taken in previous studies, broken down into three categories: climate, weather, and seasonal.

Table 1 provides a list of the most common approaches used to capture the influence of climate on water use. The

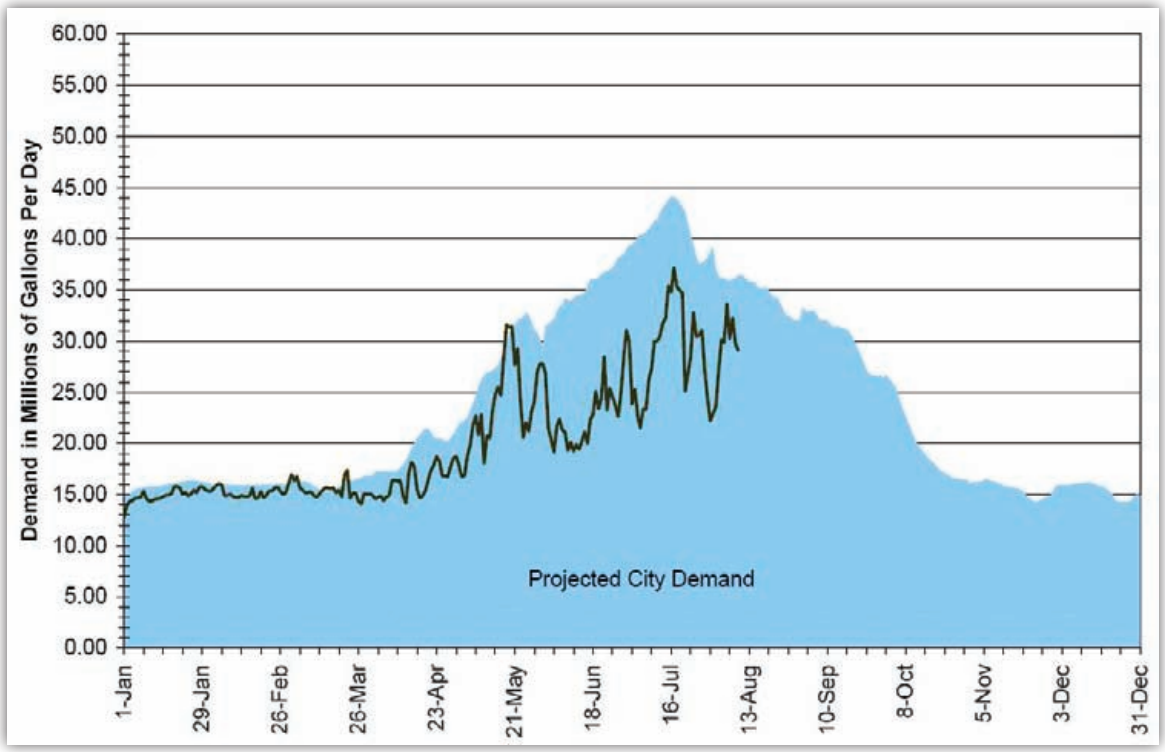


Figure 1. Fort Collins Utilities Projected and Actual Treated Water Demand, 2009 (Courtesy of Dennis Bode, Water Resource Manager, Fort Collins Utilities)

Table 1: Climate	
Approach	Example
Drought vs, Non-Drought	Restrict data (during drought) or include a drought dummy variable in the regression analysis
Weather across Regions	Cross-region comparisons of water demand

term "climate" refers to the generally prevailing weather conditions of a region, throughout the year, averaged over a series of years. Varying climate conditions across different locations influence people's choice of activities (water intensive or not) and the amount of water used in those activities, which in turn help to explain differences in their long-term water use. Periods of drought represent deviations from normal climatic conditions.

Table 2 presents the most common approaches used to capture seasonal differences in water demand. The term "season" refers to different periods within a year that share similar climate conditions. Most water demand studies assume two different seasons: irrigation and non-irrigation.

Table 2: Season	
Approach	Example
None	Ignore differences in household water demand across seasons
Restrict Data	Control for differences in water use across seasons by studying water use during only one period
Separate Regressions	Analyze both seasons by conducting separate analyses for water use during the summer versus the winter
Seasonal Dummies	Include an irrigation season, peak, or monthly dummy in the regression analysis

"Weather" refers to the state of the atmosphere at a given time and place with respect to variables such as temperature, precipitation, etc. Table 3 provides a summary of the most common approaches used to capture the influence of weather on demand. The water demand literature generally does not clearly distinguish between weather and climate. For example, many studies consider temperature and precipitation as climatic factors when they are actually a measurement of daily fluctuations in weather.

Each of these three variables likely influences demand in different ways. Some households may turn off their sprinklers every time it rains; others may only adjust the settings on their sprinkler systems at the beginning of the irrigation season or during periods of extreme drought.

Table 3: Weather	
Approach	Example
Basic Weather Variables	For example, assume that people respond to daily temperature and precipitation, Crop Water Requirements (Net ET), etc.
Weather Events & Deviations from the Mean	Days with little or no rainfall (<0.25 inches)

Most studies use a combination of the approaches listed above. What is not clear is (1) the extent to which these different approaches produce different forecasts of water demand and (2) whether estimates of the effectiveness of price and non-price demand management programs differ depending on how you model climate, weather, and seasonality.

The question then becomes: does it matter which combination of the above approaches we take when estimating residential water demand?

As part of ongoing research with the city of Aurora, we are addressing this question. Using data from Aurora, Colorado, covering the period 2000-2005, we estimated a series of residential water demand models corresponding to each of the approaches listed in Table 1. Not only did each of the models produce forecasts that were significantly different from one another, the estimates of household responsiveness to price (price elasticity: the percentage change in quantity divided by the percentage change in price) and restrictions also differed significantly across each of the different models.

Table 4 provides an example of the results. Estimates of household responsiveness to price and restrictions during the period of study are presented for three models: model 1, which does not include any controls for weather; model 2, which controls for weather using temperature and precipitation; and model 3, which controls for weather using net evapotranspiration (ET).

Table 4: Model			
	1. No Controls	2. Temp and Precip	3. ET
Price Elasticity of Demand for Water	-0.67	-0.63	-0.71
% Change in Demand due to Restrictions	-3.23	-69.87	-38.27

The resulting estimate of price elasticity when using temperature and precipitation to control for the influence of weather is 6% lower than when there is no control for

Table 5:	Low Water Users		High Water Users	
	No Control	ET	No Control	ET
Price Elasticity of Demand for Water	-0.47	-0.49	-0.70	-0.79
% Change in Demand due to Restrictions	-0.76	-0.87	0.87	0.20

weather. By comparison, the estimate of price elasticity using ET is 6% greater relative to the no control model. These differences by themselves are not that alarming, given the range of price elasticity estimates found in previous studies (note: other combinations of the approaches taken above produced differences that were significantly larger than those presented here; however, temperature/precipitation and ET are the two most common approaches used). However, when combined with the estimates of the effectiveness of restrictions, these results highlight the need for a better understanding of how climate/weather/seasonality influences consumer behavior, as choosing the "wrong" approach can produce significantly different estimates.

It is likely that climate, weather, and seasonal factors have the most influence on households that have substantial outdoor water demands. If this is the case, then choosing the correct approach would be most effective in areas with a greater proportion of households with significant outdoor water use. To test this hypothesis, we segmented the population into three groups based on their pre-2000 water use: low water users, "average" water users, and high water users. While we are unable to identify the percent of each household's water use that corresponds to outdoor use, analysis of the water use patterns across each of the three groups suggests that the difference between "low" and "high" water users is their outdoor water use. Table 5 provides an example of the results from this analysis for models 1 and 3.

Again, our focus is on the difference in the estimates across the two models, not the level of the estimates themselves. For "low" water use households, the difference between the two models is small, which is not surprising. By comparison, the difference in estimates across models for "high" water use households is substantially higher, with the estimated effect of restrictions actually being positive.

The above highlights a need for research that develops a better understanding of how households incorporate climate, weather, and seasonal factors into their water use decisions. Not only is it important in terms of forecasting water use, but, as illustrated above, it is also necessary so that we can get consistent and accurate estimates of the effectiveness of various demand management programs.

Everything Old is Still Old: Reflections on 40 Years of Studying Urban Water Issues

by Loretta Lohman, Nonpoint Source Outreach Coordinator, Colorado Water Institute

This issue's urban water theme happened to coincide with the July 13, 2009, White House announcement of an urban policy outreach that solicits ideas from political leaders, city advocates, and policy experts to remediate and alleviate policies that create sprawl and place burdens on basic infrastructure.

Water was not mentioned. By extrapolation, one might assume that discussions of water, in this context, will be heavily focused on infrastructure, although the American Recovery and Reinvestment Act appears to be heavily weighted toward transportation infrastructure. Nonetheless, the *Colorado Water* newsletter's focus on urban water, coupled with the White House interest in things urban, sent me to my library. Collected over 40 years, the publications on those shelves reflect an approximate 5- to 7-year cycle of interest in urban water among Colorado water managers and researchers.

The cycle began at the 1970 Western Resources Conference entitled *Urban Demands on Natural Resources*. Conferees examined water, air, energy, and land concerns separately and as part of urban resource decision making. Before the Environmental Protection Agency (EPA) was created, and before stormwater was considered a major pollutant, this conference addressed the collection and conveyance of stormwater as wasteful; land use management in terms of protecting natural resources; and comprehensive river basin planning. Throughout the 1970s, studies about water supply—particularly for the Denver area—were plentiful. There also was a comprehensive Colorado Water Policy study completed, although it was never released to the public.

This pattern of studying Colorado's water supply and management continued through the 1990s and into this century. The issues remain much the same, although some of the language has changed. A keyword search on Colorado urban water reveals page after page of results related to how to get and stretch water supplies.

On July 27, 2009, the *Pagosa Sun* published an opinion piece that said:

> *To grow, you must have adequate water. Those who advocate growth must, if they are to remain coherent, support use and protection of the maximum of the water resource allowed.*

However, growth does not follow water in the West. Instead, water tends to follow the money that comes with growth. Nearly 25 years ago, the Denver Research Institute, as part of a study for Denver Water, analyzed the role of water as a growth management tool. The study concluded that, while sufficient available water makes growth easier, it is not an absolute prerequisite for urban expansion.

Other than a total absence, research shows just two ways that water can play a major role in growth. In one instance, water management decisions are an integral part of the decision process through an authoritative regional agency that also oversees land use decisions, traffic and transportation, schools, power, sewers, police, and all other public services. The other way is to price water at its true cost, which would reduce demand and likely change the pattern and configuration of new development.

Water is not a defining factor in our urban development. Land-use decisions are in the hands of a variety of local and county governments, special districts for water or other services are simple to create, and physical growth is considered necessary for economic growth. With this paradigm, water too often is a late addition to the equation.

A "green roof" is seen from the terrace above the 9th floor of the U.S. EPA Region 8 office in Denver. (Courtesy of U.S. EPA)

In fact, the issues studied at Colorado universities during the past 40 years are the same ones discussed and studied today. What can be done about recurring drought? Where can new water supplies come from? Can conservation and water reuse fill some of the supply gap? Will transfers from agriculture to urban use serve the state? And, incidentally, what might any or all these of these things do to water quality?

Pervious pavement is demonstrated at the Greenwood Village city office in the Denver metro area. (Courtesy of Joe Chaplin, City of Loveland)

The basic paradigm has not changed in 40 years. Western water management essentially remains as developed as it was during the settlement of the West. Land use is still in the hands of localities and disconnected from many constraints of infrastructure, transportation, water, or other resources. Even stormwater, regulated in the last quarter century, still primarily addresses the early 20th-century model of collect and convey, represented by curbs and gutters rushing water to the nearest watercourse. In a paper presented at the 1970 Conference, CSU's Maury Albertson suggested that

> *perhaps excess storm runoff could be either diverted back to the water supply system, or to a storage area where it could be used for recreational purposes, of both. . . Also, in lieu of constructing storm sewers, drainage channels can be left in their natural state to add to the aesthetic qualities of a city.*

Although Albertson was a systems engineer, he was prescient in addressing the ways in which stormwater was wasted. Remarkably, although not recognizing the water quality problems presented with normal stormwater measures, he addressed the aesthetic sterility of collect and convey.

Arguably, conservation is one way of achieving water quality by reducing runoff that picks up contaminants. However, that is rarely the intent of the conservation discussed by urban planners and water managers. Conservation is a way to stretch a limited supply of water for increasing numbers of users and uses. Sometimes it is called "efficiency."

Making Old Tools New: Low Impact Development and Water Quality

In 2004 the United States had 3,200 square feet of impervious surface for each resident, compared to 1,109 square feet in England and 721 square feet in China. These surfaces intensify urban heat island effects and increase the damages caused by additional stormwater runoff. The EPA promotes smart growth and low impact development techniques as a way to protect water resources (see www.epa.gov/dced/publications.htm#water). These techniques help reduce the negative effects of impervious surfaces in urban areas—roads, roofs, parking lots, driveways, patios—that increase runoff quantity, degrade water quality, and greatly disturb the predevelopment hydrology and receiving waterways.

Some typical urban design elements that continue to negatively affect waterways and miss opportunities for impacts include:

- elevated landscape islands in commercial parking areas
- solid, elevated curbs that prevent runoff from flowing off a street or parking lot and onto landscaped areas
- roof drains directly connected to an under drain storm sewer system
- minimum parking requirements that create large, impervious parking areas with vacant spaces much of the time

Curb and parking lot design and size are often mandated by city codes. Roof drains leading directly to the collect and convey curb and gutter system may also be enshrined in code that is years old. Conversely, these design elements are easily adjusted and can become part of the stormwater solution. For example, elevated landscape islands in parking areas can be constructed as sumps. Raised curbs can be constructed as flush curbs with bollards, wheel stops, or curb cuts to allow stormwater to flow into sumped landscape areas. Architects and civil engineers can collaborate on building designs so that roof drains discharge into porous landscape detention areas instead of an underdrain that discharges to a detention facility or storm sewer system.

The Urban Drainage and Flood Control District, the Colorado Association of Stormwater Floodplain and Managers, and the Rocky Mountain Land Use Institute have been working toward making some of these low impact development techniques more available to Colorado cities and counties. Adopting more up-to-date codes that address water quality and supply as part of land use decisions is one way that urban water issues might move beyond the basic question of supply.

Water conservation or efficiency is a mantra in drought-stricken California and Texas this year, just as it was in Denver a few years ago. The degree of community acceptance largely depends on the language in which conservation is presented. In San Diego, conservative conservation measures are referred to as "rationing" in the newspapers (rationing means lawn watering only three days a week, and fountains and ponds are permitted as long as they do not shoot water in the air). San Diego has a history of assuming that water will follow growth. Twenty-five years ago, the City and County were exploring water reuse and the possibility of using water to control growth. Because the water leadership opposed most control efforts, nothing changed, and today they are once again exploring reuse. Growth is just a given.

The greater Las Vegas metropolitan area has somewhat standard rules that include measures with which Colorado is familiar—assigned watering days, seasonal watering restrictions, and other water-efficiency improvements. Rules unique to the desert area include tightly controlled water budgets for golf courses; limits on decorative fountains and driveway car washes; development codes that prohibit turf grass in front yards and restrict it in backyards; and incentive programs that provide rebate money to people who replace their lawns with desert landscaping or install swimming pool covers. Considering that Las Vegas has one of the nation's highest per capita water consumption rates—254 gallons per capita per day in 2008—these are not onerous rules.

One must dig deep into the strata before encountering a mention of water quality in a search about urban water in Colorado, or anywhere. The first mention is stormwater management, and the next one is typically wastewater quality. Despite more than 20 years of activity from the Nonpoint Source Pollution program, including several significant public education campaigns, water quality protection does not register in the continuing search for water supplies.

What this tells us is that any effort to tie water supply and water quality together is unfulfilled. Although public opinion surveys tell us that urban dwellers care about their water quality—as long as the supply is sufficient in quantity and quality to support a chosen lifestyle—the cause and effect of specific actions on water quality will often be disregarded.

Forty years later, we in Colorado are still asking the same supply questions and generally using the same tools to address both supply and limited quality issues. Curb and gutters remain the design standard for most areas. Land use decisions rarely, if ever, include consideration of water—either supply or impacts on quality. Water management decisions remain disconnected from any geographic markers and are as fragmented politically and institutionally as ever.

Twelve Steps to Save Our Urban Lakes and Streams

by Ken MacKenzie, Master Planning Program Manager, Urban Drainage and Flood Control District

"Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land."

-Luna Leopold (1915–2006), renowned hydrologist

The Federal Clean Water Act, enacted 32 years ago, sought to improve the conditions of the nation's waters primarily by regulating industrial and wastewater dischargers. The initial impact was dramatic improvement, as rivers that had become open sewers were gradually rehabilitated to the point of supporting aquatic life and human recreation. Since those initial improvements, however, the health of our urban lakes and streams has not been getting better. There are a multitude of reasons for this that can all be directly tied to the way we are developing and living on the land. Until we change our habits, our urban water environment will continue to get worse.

The Urban Drainage and Flood Control District (UDFCD) is an independent agency that was established by the Colorado legislature in 1969 to assist local governments in the greater Denver metropolitan area with drainage and flood control problems. UDFCD conducts research and develops design criteria for stormwater quality management techniques. We believe these methods and tools, if implemented regionally, will reverse the current trend of worsening health and natural function of our urban lakes and streams. Toward this goal, we have published a manual for stormwater quality management techniques known as Best Management Practices (BMPs). These are steps that can be taken in conjunction with new development or when redeveloping an urban area to minimize harm to the environment.

This harm originates from two sources: the first is called increased imperviousness. Roofs and paved surfaces like parking lots increase imperviousness, which increases the amount of water that runs off when it rains. Rain that used to soak into the ground rushes to the nearest stream, carrying sediment and pollutants with it. Once in a stream, this extra water erodes the stream's banks and bottom, throwing it out of equilibrium. Many urban streams that used to be shallow and full of grasses and native plants are now deeply cut with sloughing banks and are full of weeds.

This rain garden in Denver, Colorado, helps runoff collect and filter through the sandy soil. (Courtesy of Ken MacKenzie)

The second source of harm to surface waters is pollution. Toxic metals from automobile exhaust, brakes, and wearing parts wash off roads when it rains. There they are joined by trash and litter; fertilizers and pesticides from lawns and landscaping; viruses and bacteria from pet waste, urban wildlife, and leaky sewer pipes; sediment from construction sites; atmospheric dust and dirt (over 300 pounds per acre every year); and a variety of harmful chemicals from automobiles and roadway maintenance. The roads, gutters, and storm sewers we build are designed to efficiently carry the storm runoff—and all of these contaminants—directly into our lakes and streams.

There is a solution. The following 12 BMPs can help reverse the degradation of our receiving lakes and streams:

1. **Better Land Use Planning.** Plan new development with less imperviousness. We need to change the way we create new communities. Narrower roads, shared driveways, clustered and higher-density development do less harm to the environment per capita than our traditional methods. Isolate paved surfaces where possible to force the rain runoff over green surfaces. This removes pollutants and reduces the amount of runoff that gets to the stream.
2. **Grass Buffers.** Plant strips of grass between paved surfaces and areas downstream of those surfaces. The grass will filter out pollutants while absorbing some of the extra rainfall, decreasing the volume of runoff.
3. **Grass Swales.** Replace conventional curb and gutter with very shallow, grassy ditches. These can be designed to be easily mowed, and they filter and absorb rainwater as effectively as grass buffers while reducing the cost of curb, gutter, and storm sewers.

4. **Green Roofs.** Researchers at CSU and the Environmental Protection Agency (EPA) are working together to identify plant species that can survive the harsh conditions on roofs in the arid West without extensive irrigation. In other parts of the country, green roofs are being used to reduce runoff, remove pollutants, reduce cooling requirements of buildings, and extend the life of roofs by decreasing their exposure to ultraviolet radiation.

5. **Rain Gardens.** Create depressed areas where runoff can collect and filter through a special sandy soil mixture and either soak in to reduce runoff, or slowly drain away. Plant these areas with ornamental plants that will help the rain garden function for a long time.

6. **Permeable Pavements.** Replace traditional parking lots, sidewalks, driveways, and low volume/low speed roadways with permeable pavements. These can be special mixes of concrete or asphalt that allow water to flow directly through them, or special concrete paver blocks that allow water to flow between them. Build these new pavements with a sand filter layer below to filter and then soak in or slowly drain away the filtered runoff. For areas that are rarely used, specially designed gravel pavement or a pavement made with a grid that allows grass to grow through it is all you really need.

7. **Sand Filters.** The big brother of the rain garden, sand filters collect storm runoff from a large site or an entire neighborhood, store and filter it, and either soak it in or slowly drain it away over many hours.

8. **Extended Detention Basins.** Use these for larger areas. These ponds are multi-taskers, providing stormwater quality improvement, runoff volume reduction, and flood control. They are empty between storms, providing opportunities for open space and parks.

9. **Wetland Ponds.** Build these where there is sufficient water to sustain them. In addition to removing pollution from storm water, wetland ponds create essential habitat for a variety of wetland plants and aquatic life.

10. **Wetland Channels.** Use these to convey large amounts of stormwater slowly through a natural filtering stand of wetland plants that will remove the pollutants from the water.

11. **Retention Ponds.** When you have the legal right to the water, retention ponds create water features and are used by golf courses everywhere. Sediment and pollutants settle out of storm water quickly in these attractive ponds.

12. **Good Housekeeping and Public Education.** There are plenty of things you can do (or avoid doing) every day that will make a big difference in the quality of your local lake or stream.

    - ✓ Wash your car on your lawn, not on the driveway or street.
    - ✓ Don't hose down your driveway into the street, and don't blow your lawn clippings and leaves into the street. In fact, compost your yard waste—added to your soil, it will improve its ability to hold water and you'll grow better plants.
    - ✓ Be careful not to over-water your lawn and garden, and go easy on that fertilizer and weed killer, especially near paved surfaces.
    - ✓ If you work on your car, clean up the spills with kitty litter and throw it in the trash. If your car leaks, fix it. Even small leaks from thousands of cars add up fast, and it all ends up in our streams.
    - ✓ Pick up after your pets at home and on walks, even when no one is looking. Bag it and throw it in the trash.
    - ✓ Never, ever litter. Our urban streams are full of trash from people who didn't think it mattered.
    - ✓ Use common sense housekeeping measures at your business, such as covering chemical handling areas and loading docks, and not hosing down equipment and pavement into storm drains. If you wouldn't drink it, don't send it down the gutter or drain.
    - ✓ Plant trees. Tree roots keep the soil loose and improve absorption of rain water.

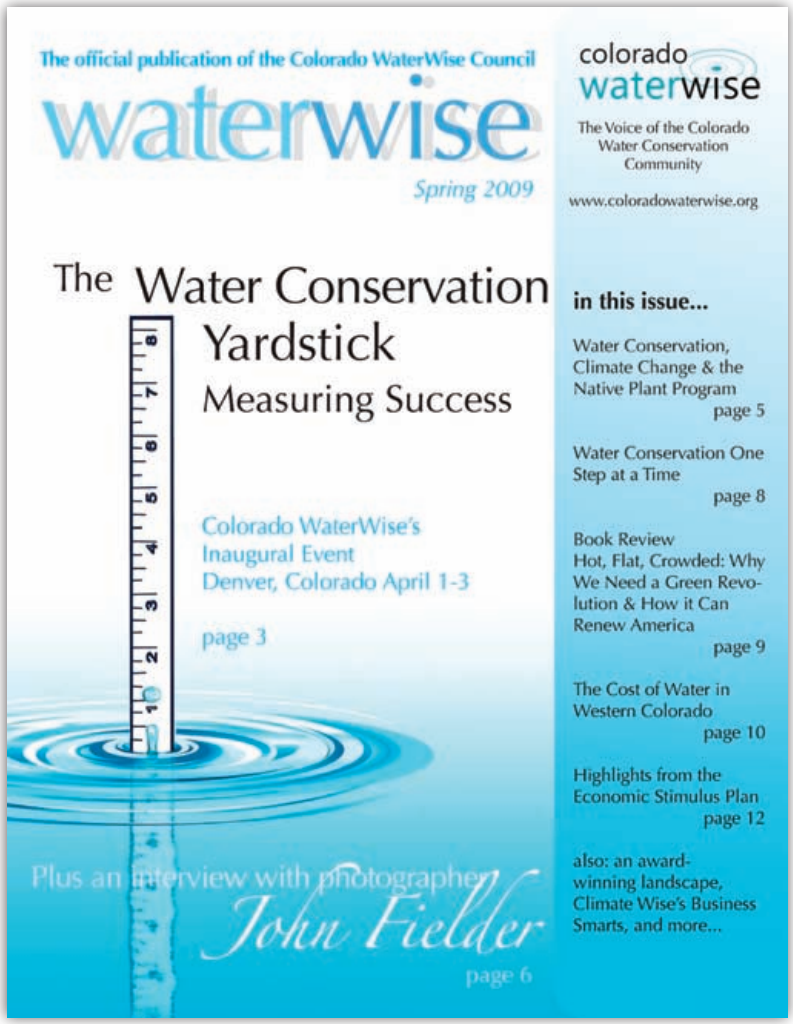
Specific guidance on these BMPs can be found on our web site at www.udfcd.org. Some of these steps will take planning and money, while others can be implemented at no cost starting today. They will all help, by reducing the amount of rainfall that runs off developed land and by reducing the amount of pollutants that wash off paved surfaces into our urban lakes and streams. If you develop land, implement as many of these BMPs as possible; the city or county should be eager to work with you. If you work for the city or county, help developers minimize the environmental harm caused by development. If you own a business, practice good housekeeping, and when it's time to replace your roof or resurface your parking lot, consider green alternatives. If you own a house, build a rain garden or a swale. There are things you can do every day to minimize harmful effects to our urban lakes and streams.

Colorado WaterWise Gets Busy

by Scott Winter, Chair, Colorado WaterWise

Colorado faces a complex water future as its water professionals—those who manage water resources either directly or indirectly—wrestle with uncertainty related to resource availability, reliability, quality, and cost. For this reason, water conservation measures and strategies are becoming increasingly valuable components of overall water resource management, particularly for municipal and industrial professionals. Municipal and Industrial (M & I) water conservation has tremendous potential to improve supply reliability and quality while saving money for everyone.

Whether or not water conservation and efficiency is an important aspect of our water resource future is not a matter for legitimate debate. Conservation is an undeniable—and inevitable—piece of the water puzzle. The more pertinent questions to answer are, which conservation strategies and at what cost? Colorado WaterWise (CWW) exists to assist M & I water professionals who strive to answer these questions.



The mission of CWW is to promote and facilitate the efficient use of Colorado's water. CWW became the voice for water conserva¬tion in Colorado in 2000 when it was formed by combining Metro Water Conservation, Inc., and Xeriscape Colorado, two water conservation non-profits established in the mid-1980s. CWW supports water professionals, water providers, and communities across Colorado, empowering them to offer more responsive and effective programs to their own customers, clients, and citizens. In this role, CWW has always been committed to enabling proactive conservation as well as collaboration and partnerships that leverage resources, learning, and change. But, for the past couple of years, CWW has been extremely busy transitioning into a new era of conservation practice.

Water conservation activities, in the state of Colorado and nationally, have changed significantly in recent years from somewhat "soft," albeit critical, education-based efforts to more strategic, science-based practices that involve detailed and ongoing measurement and analysis. As a collection of water professionals, CWW has taken steps to keep up with the changing face of conservation so we can continue to fulfill our mission and support the changing needs of our members. Collectively, we have embarked on several ambitious projects, including developing a Water Conservation Best Practices Guidebook, forming an annual water conservation event for Colorado, creating an industrial, commercial, and institutional water conservation toolkit, and designing a new more interactive web site.

Water Conservation Best Practices Project

CWW obtained a grant from the Colorado Water Conservation Board (CWCB) in March, 2008, to develop a detailed *Water Conservation Best Practices Guidebook* (BP Guide) for use throughout the state. Aquacraft Water Engineering has subsequently been contracted to complete the development of the BP Guide. The BP Guide will be used by water professionals to help select the most sensible and cost-effective water conservation measures and programs to implement. Municipal and Industrial water providers will use the BP Guide to help select water conservation program options to include in their conservation plans to be submitted to the CWCB. Building trade professionals may use the BP Guide to determine the best water efficiency practices to implement in new construction projects and existing buildings. Others

may find the BP Guide a useful tool to increase water efficiency in their local communities.

The BP Guide will:

- Review urban water conservation best management practices (BMPs) and best practice guidance documents developed elsewhere. Where appropriate, elements will be incorporated into the BP Guide.
- Provide a summary of all appropriate customer-side indoor and outdoor best practice options for urban water conservation in Colorado.
- Provide a summary of all appropriate utility-side best practices for water management, including enhanced demand forecasting tools, conservation-oriented rate structures, and utility water loss programs.
- Provide detailed information on each best practice option, including implementation approach and methods, likely costs, anticipated water savings, and barriers and challenges.
- Provide guidance on prioritizing and selecting appropriate water conservation program tools and measures for different communities and situations.
- Include a resource guide for anyone seeking water conservation information, assistance, and financing in Colorado.

A project advisory committee of Colorado water conservation professionals will help Aquacraft develop ideas for the BP Guide and provide valuable peer review input. Once the BP Guide is complete, it will be showcased through a series of three workshops held across the state.

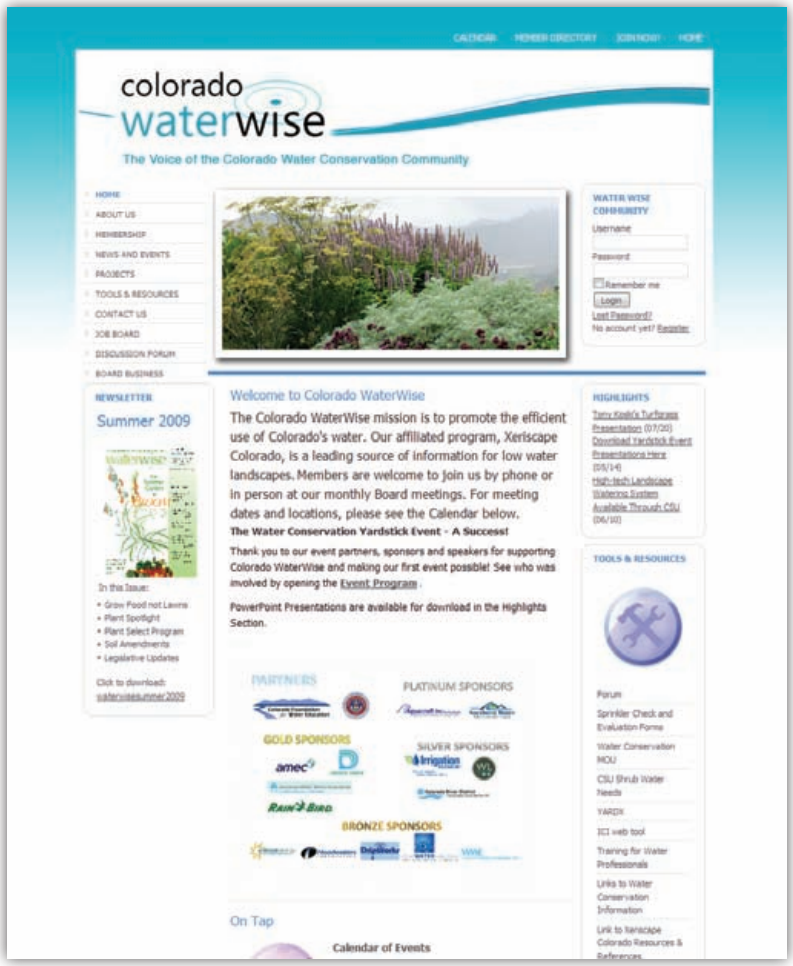
Water Conservation Yardstick: Measuring Success

CWW's first annual event entitled "Water Conservation Yardstick: Measuring Success" was held April 2–3, 2009. Thanks to the tremendous support of volunteers and sponsors, the event was a rousing success. About 130 attendees included water providers and conservation districts, conservancy groups, researchers, and consultants.

Harris Sherman, director of the Colorado Department of Natural Resources, and Denver Mayor John Hickenlooper gave powerful keynote addresses, encouraging water professionals to help provide proactive solutions to future water shortages in Colorado and the West. Other presenters and panelists addressed a wide variety of important water conservation topics, including the nexus of water and energy, the importance of conservation in today's economy, benefit-cost analyses, irrigation audits, changing water use behavior, and promoting conservation on the West Slope. Planning is under way for the 2010 annual event, and we will be seeking volunteers and sponsors to help make it a success.

ICI Water Conservation Committee

CWW's Industrial, Commercial, and Institutional (ICI) Water Conservation Committee is continuing the work of the Northern Colorado ICI Water Conservation Workgroup. The committee has developed an ICI Water Conservation Resource Guide and Toolkit, which is targeted at water users and water providers aiming to achieve conservation in these often overlooked sectors. The goal of the toolkit is to provide information and tools that will make the water conservation process, from assessment through implementation, more accessible to all water users. The toolkit helps guide users through a water conservation assessment and addresses available technologies for water conservation that may apply in new and existing buildings. It is written in language accessible to those unfamiliar with water conservation assessments and is generalized to apply to a number of ICI sectors.



With the support of a Pollution Prevention Advisory Board grant, Northern Colorado water providers also developed water use benchmarks for select ICI sectors to inform the water conservation process. The sectors studied included restaurants, schools, hotels/motels, and nursing/assisted living facilities. The group is currently in the process of disseminating the results of this effort.

New Web Site

The internet provides tremendous opportunities to educate, learn, interact, and collaborate. It is important for an organization like CWW, made up of a geographically and professionally diverse membership, target audience, and volunteers, to have a significant web presence that affords these opportunities. CWW's new web site was launched in the summer of 2008 and continues to evolve. It features greater access to various tools and resources, including the ICI Water Conservation Toolkit, Sprinkler Check and Evaluation Forms, and our informative newsletter. Visitors to the web site can sign up to receive the electronic newsletter for free. For members, the web site also provides the ability to:

- Sign up and renew membership
- Add a listing to the Directory of Members
- Share press releases
- Add events to the calendar
- Manage newsletter subscription
- Access all articles and archives
- Participate in a discussion forum

Moving Forward

CWW is an organization built on collaboration and partnerships; we are and will always be dependent on the work of many volunteers and the support of a growing member base. We continue to support water professionals and communities state-wide to push for more effective conservation efforts. Comments and suggestions to improve our work are always welcome. For more information about our activities, visit www.coloradowaterwise.org.

USGS science for a changing world

Recent Publications

Analytical Results for Agricultural Soil Samples from a Monitoring Program Near Deer Trail, Colorado (USA) by J.G. Crock, D.B. Smith, and T.J.B. Yager http://pubs.usgs.gov/of/2009/1111/

Geochemical Data for Upper Mineral Creek, Colorado, under Existing Ambient Conditions and During an Experimental pH Modification, August 2005 by R.L. Runkel, B.A. Kimball, J.I. Steiger, and K. Walton-Day http://pubs.usgs.gov/ds/442/

Recharge Rates and Chemistry beneath Playas of the High Plains Aquifer—A Literature Review and Synthesis by J.J. Gurdak, and C.D. Roe http://pubs.usgs.gov/circ/1333/

Redox Conditions in Selected Principal Aquifers of the United States by P.B. McMahon, T.K. Cowdery, F.H. Chappelle, and B.C. Jurgens http://pubs.usgs.gov/fs/2009/3041/

Salinization of the Upper Colorado River—Fingerprinting Geologic Salt Sources by M.L. Tuttle, and R.I. Grauch http://pubs.usgs.gov/sir/2009/5072/

Spatially Referenced Statistical Assessment of Dissolved-Solids Load Sources and Transport in Streams of the Upper Colorado River Basin by T.A. Kenney, S.J. Gerner, S.G. Buto, and L.E. Spangler http://pubs.usgs.gov/sir/2009/5007/

Water Quality in the High Plains Aquifer, Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, 1999-2004 by J.J. Gurdak, P.B. McMahon, K. Dennehy, and S.L. Qi http://pubs.usgs.gov/circ/1337/

Groundwater Quality, Age, and Probability of Contamination, Eagle River Watershed Valley-Fill Aquifer, North-Central Colorado, 2006-2007 by M.G. Rupert, and L.N. Plummer http://pubs.usgs.gov/sir/2009/5082/

Occurrence of Selected Organic Compounds in Groundwater Used for Public Supply in the Plio-Pleistocene Deposits in East-Central Nebraska and the Dawson and Denver Aquifers near Denver, Colorado, 2002-2004 by J.B. Bails, B.J. Dietsch, M.K. Landon, and S.S. Paschke http://pubs.usgs.gov/sir/2008/5234/

U.S. Geological Survey Colorado Water Science Center: http://co.water.usgs.gov

A Utility for the 21st Century

by Laurie D'Audney, Water Conservation Specialist, Fort Collins Utilities

Fort Collins Utilities is municipally owned and provides water, electric, wastewater, and stormwater services to the community. In 2007, the Utilities began an initiative to turn itself into a leader of natural resource stewardship—"Utility for the 21st Century." Using "triple bottom line" thinking, a sustainability plan was rolled out in 2009 that integrates economic, environmental, and social considerations. The plan sets a vision and will guide the Utilities for the coming decades.

Although energy has garnered much of the attention surrounding sustainability, Fort Collins Utilities also considers the stewardship of our water resources to be of key importance. The Utilities has provided residents and businesses with a safe and reliable supply of water for 127 years. The water comes from surface water, primarily from direct flow rights in the Poudre River, and water from the Colorado-Big Thompson Project that transports water from the Western Slope.

With an average precipitation of just 15 inches a year, Fort Collins has experienced water crises throughout its history. Restrictions have occasionally been enacted in response to a water shortage. However, it wasn't until the late 1970s that water conservation was recognized as having a valuable role in meeting water needs. Over the past 30 years, the City's conservation program has evolved and grown.

Conservation Begins

Faced with a drought in 1977, the Utilities created a part-time position dedicated to water conservation. During the 1980s, federal and state legislation mandated conservation as part of water supply planning. Locally, a move to build a series of dams on the Poudre River brought home the discussion of water conservation. Opponents of the dams argued that by implementing water conservation measures, the project would not be necessary.

In 1990, the water conservation position expanded to full-time, and conservation projects and educational efforts increased. The Fort Collins City Council adopted the *1992 Water Demand Management Policy*, setting two goals for lowering demand and 12 measures for achieving those goals.

The effects of a recent drought in 2002-2003 greatly impacted water use, and the City's water conservation program expanded again. As awareness of the drought grew, the City's outreach efforts expanded, restrictions were put in place, and regional media coverage affected how customers used water. In 2003, a *Water Supply and Demand Management Policy* was adopted by City Council, combining and updating the *1992 Water Demand Management Policy* and the *1988 Water Supply Policy*. The resolution provides general criteria for decisions regarding water supply projects, acquisition of water rights, and demand management measures. Demand management tools include educational programs, rate structures, incentive programs, and regulatory and operational measures.

Mary Young of Fort Collins Utilities assists students with the "Bucket Brigade" at the Children's Water Festival, an all-day water festival for third grade students in Fort Collins. (Courtesy of City of Fort Collins)

Current Program

Fort Collins Utilities' water conservation program offers a diverse range of activities targeted at all customer sectors:

Educational Programs

- **Conservation Assistance and Outreach** Staff respond to residential and commercial customers with water use or billing questions and requests for water conservation information. Water conservation information is disseminated via a wide range of media, including bill inserts, bus benches, and brochures. Displays are set up at various community events, including the Sustainable Living Fair, Thursday Night Music and More, and others. Topics include water-saving tips, technology and techniques, Xeriscape, and lawn watering.
- **Adult Education** The Utilities provides programs about Xeriscape landscaping, watering techniques and practices, and general water conservation. Staff oversees maintenance of the City's Xeriscape

Demonstration Garden and provides tours at organized events and upon request. A daily *Lawn Watering Guide* is published in the local newspaper and on the City's web site during the watering season.

- **Youth Education** Presentations and hands-on activities are provided to school classes on water topics, including the history of water in Fort Collins, water use and conservation, water chemistry, and watersheds. Dr. WaterWise is a water conservation curriculum introduced in 2003 to classrooms during the drought. Fort Collins Utilities is a co-sponsor of the annual Children's Water Festival.
- **Commercial Outreach** The Utilities offers an annual business program series on a variety of environmental topics, including water conservation. Staff performs facility water audits to assess water use and make recommendations for improved efficiency. Materials are distributed to hotels and other lodging establishments to inform guests about the importance of water conservation to our area and to encourage the reuse of towels and linens.

Water Rate Structures

- **Tiered Rates** Tiered rates for single-family residential customers are designed to charge an incrementally higher amount for higher water use.
- **Seasonal Rates** Commercial and multi-family customers are billed with a seasonal block rate structure, with higher rates from May through September. Commercial rates have a second tier for higher water use.

Incentive Programs

- **Clothes Washer Rebates** The Utilities offers a $50 rebate for customers who purchase high-efficiency clothes washers. Rebate costs are split between water and electric utility funds. Approximately 900 rebates are given each year.
- **Dishwasher Rebates** New in 2007, this program offers a $25 rebate when a qualifying dishwasher is purchased. The cost of the rebates is shared with the electric utility fund.
- **Zero-interest Loan Program (ZILCH)** Loans are provided at no interest to residential customers for water conservation improvements. Loans are available for water service line replacements and high efficiency clothes washers.
- **Sprinkler System Audits** Available to homeowners and homeowner associations, Utilities auditors perform a sprinkler system assessment and show sprinkler operators how to water more efficiently. Approximately 275 audits are completed each year.
- **Conservation Giveaways** Free water conservation kits with indoor or outdoor water-saving devices are offered periodically through coupons in utility bills.

Regulatory Measures

- **Wasting Water Ordinance** Staff enforces the section of the City Code that prohibits wasting water. Wasting water complaints are investigated. Complaints are used as an education tool, but enforcement by ticketing is also an option.
- **Restrictive Covenants Ordinance** In 2003, City Council adopted an ordinance that prohibits homeowner association's covenants from banning the use of Xeriscape or requiring a percentage of landscape area to be planted with turf.
- **Soil Amendment Ordinance** This ordinance requires builders to amend the soil for new landscaping.
- **Water Supply Shortage Response Plan** This plan has a series of measures to be enacted, including water restrictions, for four levels of water shortage.
- **Landscape and Irrigation Standards** New development landscape and irrigation plans are reviewed for compliance with the Land Use Code's water conservation standards. The standards were revised in 2009 as part of the annual Land Use Code updates.

Laurie D'Audney and Steve Strickland, City of Fort Collins, perform an audit of water use as part of the Climate Wise program. (Courtesy of City of Fort Collins)

Master gardener Kay Nason performs a sprinkler system audit. Water catch devices calculate the precipitation rate of the sprinkler system and determine an accurate run time for the zone. (Courtesy of City of Fort Collins)

Operational Measures

- **Water Reuse** Treated wastewater from the Drake Water Reclamation Facility is pumped to Rawhide Power Plant for landscaping and cooling water.
- **Backwash Water Recycling** Equipment at the water treatment facility treats backwash water and recycles it to the beginning of the treatment process.
- **Utility Water Loss Program** Utilities "lose" water to leaks in the distribution system, meter inaccuracy, billing errors, and other conditions. The Utilities' water loss program entails listening for leaks and pinpointing their locations using sonar equipment. It takes crews two years to survey the 500 miles of water mains. Catching leaks before they have surfaced saves water and costs of excavation and repairs.
- **City LEED Buildings** The City is committed to building new City buildings to the Leadership in Energy and Environmental Design (LEED) Gold standard (Silver standard in some cases). Water conservation upgrades are part of this commitment.
- **WaterSense Partner** Fort Collins Utilities is a partner in EPA's WaterSense program, a national water efficiency effort. WaterSense's mission is to protect the future of our nation's water supply by promoting and enhancing the market for water-efficient products and services. As the water counterpart to the EnergyStar program, WaterSense has begun labeling products that offer a 20% efficiency improvement to help consumers conserve water when they install new plumbing fixtures and appliances.

Future Conservation Efforts

The State of Colorado's *Water Conservation Act of 2004*, which required an approved water conservation plan, prompted the Utilities to develop a plan. The draft plan recommends a water use goal of 140 gallons per capita per day (gpcd), a decrease from the current 185 gpcd goal. The recommended program continues the existing programs and adds about 20 new or expanded measures targeting all customer classes and indoor and outdoor water use. Due to budget constraints, the new programs will be phased in more slowly than initially planned.

Fort Collins is fortunate to have a plentiful water supply. Regardless, Fort Collins Utilities believes water conservation is of vital importance for many reasons, including to:

- Foster a conservation ethic and eliminate waste
- Demonstrate a commitment to sustainability
- Provide water for multiple beneficial purposes
- Reduce costs for the Utility and for customers
- Prepare for periodic drought and future climate change

It makes economic, social, and environmental sense to promote water conservation. Fort Collins Utilities is moving aggressively to give substance to its vision of a "Utility for the 21st Century" and could well emerge as a national leader in sustainability.

Virtual Aquifers: Visualizing the Invisible in Douglas County

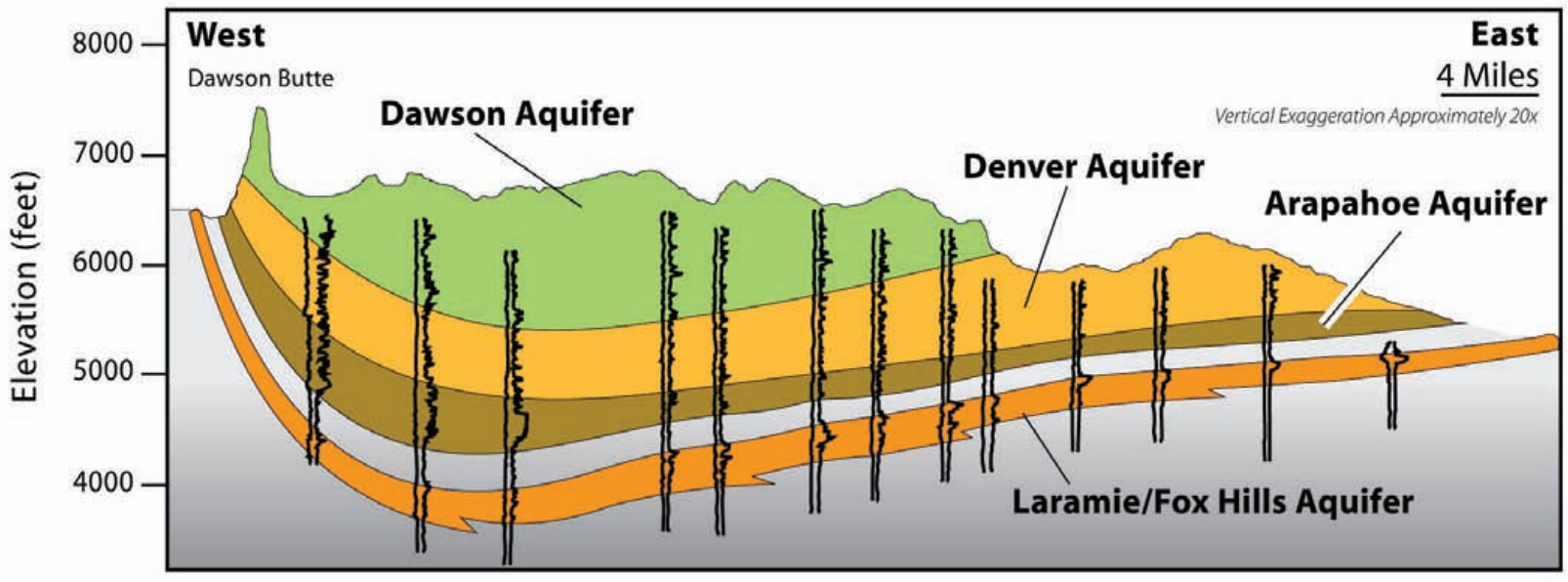
by Carol Hutton Lucking, M.A. Candidate, Department of History, Colorado State University

Deep groundwater aquifers are an admittedly abstract concept, even to the geologists who study them. A saturated rock that can produce mind-boggling amounts of water from 2,000 feet below the surface is a difficult idea to grasp, so geologists and writers use models and metaphors to help people understand the water resources that lie deep underground. Because scientists will never see a deep aquifer *in situ*, they must use what they know from well cores and surface outcrops to create maps, images, and simulations of how a deep water aquifer works. They explain aquifers using terms like underground reservoirs and bathtubs, and even liken the pressure of a confined aquifer to champagne spilling out of a bottle.

While this imagery may help citizens understand their water resources, it can also be misleading. Unlike bathtubs or champagne bottles, deep aquifers cannot be manipulated so easily by people, and the implication of human control provides a false sense of security to water users. Even experts argue about the quantity of water in aquifers and how much of that water is accessible to humans. For the citizens of Douglas County, Colorado, questions about the behavior and nature of the heavily mined Arapahoe Aquifer are increasingly pressing, as scientists predict that the useful life of the aquifer is finite.

For nearly 100 years after its incorporation as a county, Douglas County grew slowly, and life in the small communities centered on ranching and cattle. Rural ranchers and towns got the water they needed from minimal surface water rights and shallow ground water wells. The population began to grow significantly in the 1970s as people escaped Denver and its suburbs, preferring the rural feel of 35-acre ranchettes that were springing up across the county. Technology that allowed residents and municipalities to tap into the deep aquifers enabled much of this growth and gave the county access to an enormous water supply to sustain its burgeoning population. Private and municipal wells tapped into the Arapahoe Aquifer, and large city wells producing hundreds of gallons per minute created the illusion of an endless supply of water.

Currently, Douglas County is home to an estimated 290,000 people, the majority of whom rely on the non-renewable Arapahoe Aquifer for water. Unlike shallow aquifers that are recharged seasonally by rivers and snow melt, the Arapahoe Aquifer is 2,000 feet below the surface and is bounded by impermeable layers of shale. These layers make the Arapahoe Aquifer non-renewable on a human time scale, and they create what is known as a confined aquifer. The layers of shale put the water in the aquifer under pressure so that when a well is drilled into the aquifer, the water naturally pushes upward toward the



This graphic shows a cross section of aquifers within the Denver Basin. (Source: Citizen's Guide to Denver Basin Groundwater)

surface. The confined status and high quality water of the Arapahoe Aquifer make it very attractive for extensive mining. Scientists are still unsure what will happen to the water level of the Arapahoe Aquifer in the future as more wells are drilled, and the growing population places more demands on this inherently limited water resource. If the aquifer loses its confined status, it could make pumping prohibitively expensive—even if there is still water available.

Aware that they were tapping into a largely non-renewable water source, county officials created the Douglas County Water Authority Board in 1987 to gather information about water sources for the county. In studies commissioned by the Board, estimates on the useful life of the Arapahoe Aquifer varied from 10 to 400 years. But some residents on the western edge of Douglas County have already found that their wells are drying up, and estimates have been revised downward to 10 to 20 years of remaining productivity for the Arapahoe Aquifer. Realizing that many citizens of Douglas County are unaware of the coming water situation, geologists use metaphors to help the public understand their limited water resources.

The most frequently used description of an aquifer is an underground reservoir. A 1994 *Rocky Mountain News* article titled "Reservoirs Go Underground" opened with the following sentence: *You can't sail or water ski on it, but water banked deep in underground reservoirs will be the cheapest, most efficient water supply for one thirsty community*. The idea of sailing and waterskiing as primary functions of a reservoir illustrates the dominance of recreational ideals associated with reservoirs. Many Coloradans, and indeed Westerners, forget that the main purpose of the reservoirs they enjoy on hot desert days is to store water for municipal, domestic, agricultural, and industrial uses. Most reservoirs also provide a renewable source of water—something the deep Arapahoe Aquifer does not do. Describing aquifers as reservoirs leads to misperceptions not only about the physical nature of the aquifer, but also about the quantity of water available for consumption.

The idea of banking water is another revealing metaphor. In addition to the monetary value of water, a water bank implies that people or municipalities could deposit water in an aquifer and that its safety would be insured until they need to withdraw the water. While many scientists are interested in the idea of using aquifers for water storage, there are many uncertainties. There is no guarantee the water will stay where it was deposited; it could also be polluted by underground contaminants or pollute the water that is already in the aquifer. Water banked underground may be safe from evaporation, but the amount deposited may not be available for withdrawal by the people who put it there.

Describing an aquifer as a bathtub implies that the aquifer is under complete human control, being drained and filled as humans see fit. CH2M Hill hydrologist Courtney Hemenway used this analogy to explain Highlands Ranch's plans to store water in the emptied aquifer below the development. According to Hemenway, the bathtub would be filled in the winter months by treated surface water. When water demands rise in the summer due to swimming pools and sprinklers, the water would be slowly drained from the tub. Of course, like the reservoir analogy, this idea is problematic as it implies that the water humans put in the aquifer will be available for withdrawal. The bathtub also oversimplifies the complex workings of an aquifer: access to water can be inhibited by cones of depression or non-permeable lenses of rock within the aquifer.

In 2004, the *Rocky Mountain News* ran a four-part series on water in Douglas County and stated: *Hydrologists liken the [confined status of the] aquifer to a champagne bottle. Once the cork is popped, or a well is drilled, the fizz pushes water close to the surface*. The way champagne comes spilling out of a bottle indicates just how easy it is to pump the water, but it also gives the impression of a very lavish extravagant lifestyle. Dr. Robert Raynolds of the Denver Museum of Nature and Science argues that the residents are living a lifestyle that is not sustainable. Like the fizz of the champagne, the water is not the only thing that will disappear—the lifestyle supported by that water will go as well. The *Rocky Mountain News* went on to report that not even the experts agree on what will happen once multiple wells have tapped out the artesian pressure. Some argue that the water level will stabilize, while others maintain that it will slowly drop, and the direst predictions estimate that the water level will continue plummeting rapidly, leaving residents without a water source in the future.

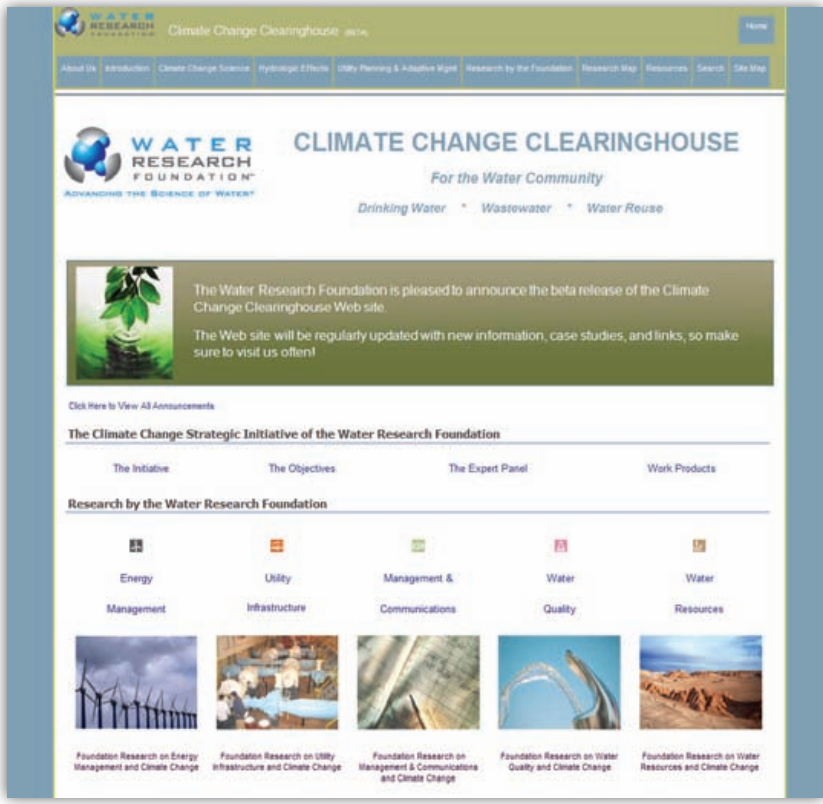
Whether the Arapahoe Aquifer fails to supply the residents of Douglas County with water next year or in 20 years, it is clear that the county must look elsewhere for a renewable source of water. Water suppliers have already purchased more surface water rights and are negotiating for water storage in Parker's new Rueter-Hess Reservoir. Scientists are looking at the possibility of using emptied or partially emptied aquifers for water storage. Regardless of where the new source or sources of water come from, the way residents perceive the water will be very important to the way it is used. Historically, the need for water in the semi-arid West forced people to organize, commonly around agriculture. Yet in Douglas County, the domestic and municipal need for water will compel citizens to work together to bring a new source of water to the county.

Climate Change Clearinghouse

by Kenan Ozekin, Senior Project Manager, Water Research Foundation

Climate change information for water utility staff, managers, and executives is now easily accessible through a new web site. The site offers a one-stop shop that will help facilitate and enhance the integration of climate change into water utility planning. The Climate Change Clearinghouse (www.TheClimateChangeClearinghouse.org) was developed and officially launched on April 13 by the Water Research Foundation (Foundation). The beta version offers an overview of the fundamentals of the science, existing knowledge, and effects of climate change on the water cycle.

Staying abreast of climate change information is critical, as scientists agree that ongoing changes in our global climate will impact the environment and freshwater resources. Climate change is likely to trigger unpredictable rains and floods in some areas, making it more challenging to treat and store water. In other areas, hotter weather and decreased precipitation will likely reduce water supply and increase consumer demand. Ultimately, these effects may impact the sustainability of our communities, agricultural production, and economic development.



Homepage for the Climate Change Clearinghouse (www.TheClimateChangeClearinghouse.org)

Managing the Challenges of Climate Change

The Climate Change Clearinghouse provides utilities with available information and data being developed by the climate change planning community. The right information in the right format can help water utilities in their strategic planning and decision making so they can plan for, adapt to, and manage the imperatives, risks, and challenges of climate change.

Information on the web site is organized into specific categories, making climate change information for utilities easy to find. Here are just a few of the topics found on the site:

- Assessing vulnerabilities
- Identifying and analyzing adaptation options
- Infrastructure investment and associated financial structuring
- Water market options and transfers
- Conservation (demand management) needs and program options
- Water storage needs and options
- Water quality treatment, storage, and distribution issues
- Source water protection and watershed management
- Coastal zone planning
- Snowpack and seasonal runoff management
- Emergency response and business continuity planning

RSS feeds allow users to subscribe and receive notices when the site is updated with new information. A search function makes it easy to find specific information within the site. A blog and discussion forum will also be added to the site so that water professionals

can share information on climate change-related topics.

The case studies section of the site is where the Foundation is seeking your help. Here, we will post case studies conducted by water utilities so that other utilities dealing with similar issues can learn from their peers. To submit a case study to the clearinghouse site, visit the "Case Studies" page under the "Resources" tab on the home page.

Keeping Up With Climate Change Information

Climate change is fraught with uncertainties, including unknown impacts on water supplies. It is difficult to predict future emissions, and it is important to consider climate modeling of complex atmospheric processes, changes in storm tracks, and other important processes. Decision makers and planners need to know how to assess and assure secure water supplies. Important associated capital investment decisions on planning horizons range anywhere from 10 years to more than 100. When confronted with the prospect of such uncertainty, a utility manager might feel overwhelmed and unsure of how to evaluate the risks and available options.

The continual evolution of climate change poses a challenge for all involved in the water industry. The new web site will deliver critical, up-to-date climate change information to the water community, including current research, assessment and policy analysis, and climate change-related tools, applications, decision aids, and planning templates.

The Foundation, through its solicited RFP program, has also recently hired a consulting company to identify and compile readily available climate change information relevant to water utilities. Through this 18-month contract, information generated through the project will continually be posted to the site, allowing users access up-to-date information on climate change.

Clearinghouse Organization

Information on www.TheClimateChangeClearinghouse.org web site is organized into eight major categories, each featured as a tab at the top of the home page. The categories include:

About Us: Information about the Foundation and its climate change strategic initiative is available under this tab.

Introduction: Climate change processes and summaries about climate change impacts on water are posted here, along with a glossary that contains major climate terminology.

Climate Change Science: Current information on climate change science, climate change throughout geologic time, greenhouse gases, future uncertainties, time scale for water utilities, and global climate models is located under this tab.

Hydrologic Effects: The hydrological effects of climate change are featured under this tab and include extensive information on precipitation amount, precipitation frequency and intensity, evaporation and transpiration, changes in average annual runoff, natural variability, effect on coastal zones, water storage issues, water demand issues, and effect on water quality.

Utility Planning and Adaptive Management: This section describes integrated water resources management approach, a systematic approach to planning and management that considers a range of supply-side and demand-side processes and actions. Also planned for the future is information on vulnerability assessments.

Research by the Foundation: Past and current climate change research, funded by the Foundation, is organized using five major topic areas: water utility energy management, infrastructure, water utility management and communications, water quality, and water resources.

Research Map: This area is yet to be developed, but plans for this page include summarizing summary of climate change research conducted by the Foundation and other U.S. and international organizations.

Resources: The resources page is designed to help users to find additional information about climate change. This is where users can find case studies about how leading water utilities have incorporated climate change into their strategic planning, links to relevant information and activities being undertaken by federal agencies and other organizations, and upcoming climate change activities.

CSU Professor Honored by Interior Secretary Ken Salazar

Interior Secretary Ken Salazar recently honored Jose 'Pepe' Salas, a Colorado State University civil and environmental engineering professor, with the U.S. Department of the Interior Partners in Conservation Award. Salas and his colleagues at three other universities received the award for helping to develop new operational guidelines for the Colorado River.

Honored with Salas were representatives of the University of Colorado, the University of Arizona, and the University of Nevada, Las Vegas. Together with the U.S. Bureau of Reclamation and a variety of other government agencies, Salas and his partners helped develop Colorado River Interim Guidelines, which has been praised as the most important agreement among the seven basin states since the original 1922 compact. States signing the agreement were Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming.

Salas has served as principal investigator on two projects funded by the U.S. Bureau of Reclamation in connection with the Colorado River Basin. His activities on these projects included:

- Using innovative record extension techniques for updating the data base of naturalized flows of the Colorado River system
- Developing new approaches for reconstructing streamflows of the Colorado River based on tree-ring indices
- Developing potential scenarios of streamflows that may occur in the Colorado in future years
- Characterizing multi-year droughts using simulation and mathematical techniques
- Testing the effects of stochastic streamflows on the operations of the Colorado River system, particularly the effects on reservoir levels and outflows of the two major lakes, Lake Powell and Lake Mead

**This article was adapted from a June 30, 2009, CSU news release.*

Upper Yampa Water Conservancy District John Fetcher Scholarship Awarded

The Upper Yampa Water Conservancy District (UYWCD) funds an annual scholarship named in honor of John Fetcher in support of CSU students preparing for careers in water-related fields. The scholarship program is administered by the CSU Water Center and provides financial assistance to committed and talented students who are pursuing water-related careers at CSU. The UYWCD $3,000 scholarship is open to any major at CSU. Criteria require the recipient to be a full-time student enrolled at CSU with a minimum GPA of 3.0. The scholarship duration is one year.

The UYWCD John Fetcher Scholarship recipient for the 2009-10 academic year is Luke Javernick. Luke is a senior in the Department of Civil and Environmental Engineering at Colorado State University and plans to pursue a master's degree in hydrology. He is currently the vice president of the CSU chapter of the American Society of Civil Engineers (ASCE), is a member of the American Concrete Institute, and is involved with Tau Beta Pi.

Luke's interest in engineering developed at an early age—while most five-year-olds were playing, he spent his days landscaping with his father. After many years of pursing an aviation career, Luke realized how much he missed the challenges and unique projects that landscaping offered. So he began researching his options and decided to study civil engineering, which he says has proven to be the best decision he ever made.

Luke is a nontraditional student and has been married to his wife, Tiffany, for over three years. Both Luke and Tiffany grew up in Canon City, Colorado, and they hope to stay in Colorado and raise a family. In the future, after developing a solid engineering foundation and passing the Principles and Practice of Engineering (PE) exam, Luke aspires to one day become a city or county engineer.

The CSU Water Center and Colorado Water Institute congratulate Luke and wish him success in his future academic studies and career. The ongoing support of CSU students by the UYWCD is acknowledged and greatly appreciated.

Water and Land Use Planning for a Sustainable Future: Scaling and Integrating

September 28–30, 2009
Denver, Colorado

Western States Water Council 2009 Symposium on Water and Land Use Planning for a Sustainable Future is just around the corner.

In partnership with the Colorado Department of Natural Resources, the symposium will explore integrating water and land use planning at different scales. This topic is increasingly important as we strive to meet challenges related to growth, change, and sustainability in the arid West. Land use impacts water demands, and water availability limits land use options. Sound planning requires taking both into consideration. We cannot define and achieve sustainability without understanding the limits of our land and water resources and the present and future demands on those resources.

This symposium will bring together diverse participants from special districts, cities and counties, state and federal agencies, and nongovernmental organizations, including policy and decision-makers, planners, developers, and regulators, to look at water and land use patterns, share experiences and concerns, identify problems and potential solutions, discuss obstacles and opportunities, and develop recommendations to better integrate and scale water and land use planning for a sustainable future.

When:

Monday, September 28 through
Wednesday, September 30, 2009

Registration Fee:

Received before September 14	$175
Received after September 14	$200
At the Door	$225

Where:

The Red Lion Hotel, (303-321-6666)
4040 Quebec Street
Denver, CO 80216

The Red Lion Hotel/Denver Central located at 4040 Quebec Street, Denver, Colorado has reserved rooms for September 28-29 at the rate of $109 per night (single/double occupancy). Reservations can be made by calling the hotel directly at (800) 733-5466. Please specify that you are with the Western States Water Council room block. The deadline for room reservations at the discounted rate is Friday, September 18.

To register for the symposium, please go to http://www.westgov.org/wswc/awms.html.

Seventh National Monitoring Conference: Monitoring from the Summit to the Sea

April 25–29, 2010
Denver, Colorado

The National Water Quality Monitoring Council (NWQMC) will host its Seventh National Monitoring Conference, Monitoring From the Summit to the Sea, on April 25-29, 2010. The conference will focus on the many facets of water quality and water quantity monitoring for improved understanding, protection, and restoration of our natural resources and communities. It will also provide a unique forum for water practitioners from all backgrounds, including governmental organizations, volunteers, academia, watershed and environmental groups, and the private sector, to exchange information, develop skills, and foster collaboration and coordination. USGS, EPA, NOAA, state scientists, and others will showcase new findings on the quality of the nation's streams and groundwater, and highlight recent innovations and cutting-edge tools in water-quality monitoring, assessment, and reporting. The conference's location in Denver, Colorado, will also provide a forum to showcase western water monitoring issues, including sustainable water management, effects of wildfires, and efforts to evaluate the effects of climate change on water quality, quantity, and aquatic ecosystems. Especially integral to effective monitoring networks are the "3C's" of the Council's Framework for Monitoring—Communication, Collaboration, and Coordination.

Instructions for Submitting Abstracts

Abstracts should be submitted online by logging onto acwi.gov/monitoring/ and clicking on "2010 National Monitoring Conference." Follow the instructions provided on the abstract submittal page.

All abstracts must be received no later than September 19, 2009.

Authors of abstracts accepted for oral and poster presentations will be notified by January 8, 2010, and will receive further guidelines for preparation of presentations, papers, and posters. All presenters must register for the conference.

Conference Themes

- Applying Innovative Monitoring, Assessment, and Modeling Tools and Approaches
- Integrating Monitoring to Cost Effectively Support Water Resource Management
- Exploring New Technologies and Analytical Methods
- Addressing Climate, Energy, Water Availability, and other Emerging Water Issues
- Communicating Science to Decision Makers and the Public
- Strengthening Collaboration and Partnerships at all Scales

Registration Information

Registration includes breakfasts and lunches and one evening reception. Attendee scholarships may be available.

- Attendee: $400 (early registration); $450 after February 15, 2010
- Oral or Poster Presenter: $350 (early registration); $400 after February 15, 2010

For exhibitor and sponsorship information please contact surbas@nalms.org . For questions related to programming or to be placed on a NWQMC conference mailing list, please contact the 2010 National Monitoring Conference Coordinator at gglysson@usgs.gov. For more information, visit: http://acwi.gov/monitoring/.

The NWQMC invites you to join us in Denver, CO, a cosmopolitan city nestled at the base of the Rockies, and known for its outdoor beauty and urban sophistication. With snow-capped peaks providing a spectacular backdrop, Denver is as refined as it is laid back. The newly revitalized and walk-able downtown offers plenty of world-class cultural arts, entertainment, nightlife, nationally recognized restaurants and abundant outdoor recreation found in the largest city park system in the country.

Surprise...More Water Than Expected!

by Nolan Doesken, Colorado State Climatologist, Colorado Climate Center

We got more water than we expected have been rare words here in Colorado in the past ten years or so. Beginning in 2000 and continuing for most of this decade, many spring seasons have been warm and dry (compared to previous decades). We've also had some of our hottest summers in history this decade. To go with that, mountain snowpack just hasn't seemed to yield as much water as expected, based on the amount of winter snowpack that we've measured.

But this year has surprised us. The dirty snowpack from several large spring dust storms and warm weather in mid-May worked together to produce unusually early peak flows. The early rush of water was great, but it looked like a sure indicator of disappointing water supplies later in the summer—again. And then things changed.

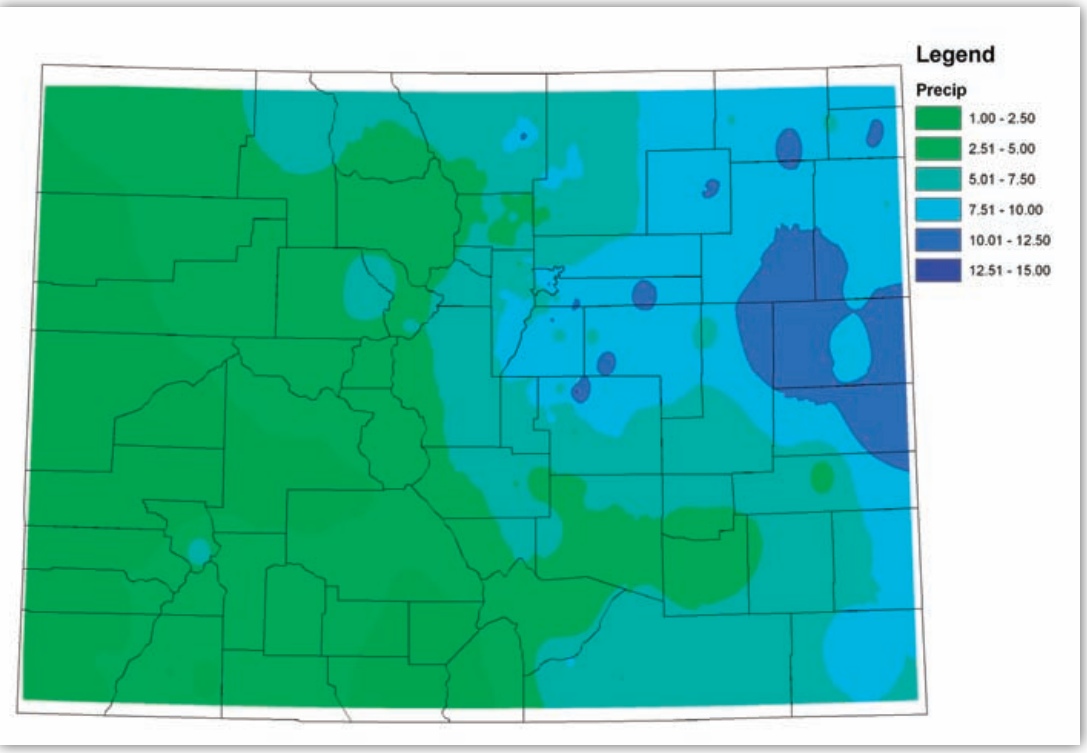
Starting on May 19, 2009, temperatures soared into the 90s. But in the weeks that followed, moist air found its way into Colorado from the east, south, and occasionally even from the west and northwest. Late May and early June storms are common, but this year they continued through June, accompanied by more clouds, higher humidity, lower temperatures, lower wind speeds, and lower evapotranspiration rates. Instead of slowing down, many of Colorado's rivers continued to flow high well through June. Reservoirs filled and sometimes spilled.

On the eastern plains, and especially over northeastern Colorado, huge thunderstorms developed day after day, and sometimes even late at night. The moisture has been great, but some farmers have gotten too much. Since mid-April, the town of Julesburg has received over 20 inches of rain, and hail storms have been devastating in some areas.

With generous rains from the Front Range eastward, the demand for summer irrigation water has been reduced, leaving more water in many reservoirs. In addition, several large thunderstorm systems over Denver have caused considerable urban runoff—sending even more water down the South Platte River.

As usual, not all areas of the state have experienced the same weather patterns. While most of us were cool and damp in June, the late summer monsoon has been slow to arrive, and parts of southwestern Colorado have dried out.

So don't get to thinking that just because things look good now, we won't have to be concerned and careful in the future. Remember 1999? We seemed to have more water that year than we knew what to do with. But starting that fall, patterns changed and we started drying out. By the spring of 2000, northeast Colorado was calling for water, and in 2001 the mountains and western valleys dried out quickly. This was all a precursor to the devastating drought of 2002. It took less than three years to go from one extreme to the other.



Precipitation levels for the state of Colorado, June 1–August 11, 2009. (Source: Community Collaborative Rain Hail, & Snow Network)

It is wonderful that the grass turned green this year and that reservoirs have been full. Enjoy it. It probably won't last. And remember that all the extra green grass and vegetation we grew this year may be fuel for future wild fires. Oh well…just another year in the life of Colorado climate.

Negotiating Implementation of the Endangered Species Act in the Platte River Basin

by David M. Freeman, Professor Emeritus, Department of Sociology, Colorado State University

The language of the Endangered Species Act (ESA, 1973) has compelled an extended and sometimes torturous set of negotiations among representatives of the three Platte River Basin states (Colorado, Nebraska, and Wyoming), the federal Department of Interior, and the environmental community. The talks began in the mid-1970s during the course of scattered collisions between ESA requirements and water user operations—and proposals—across basin landscapes. Negotiations continued for over 30 years and finally culminated in an agreement (effective January 1, 2007) to re-organize about 11% of the average annual surface flow of the Platte River, as measured near Grand Island, Nebraska.

What Is To Be Done?

The program's primary objective is to sustain and restore habitats along a 70-mile main-stem river reach in central Nebraska for three species listed under the terms of the ESA: the whooping crane, interior least tern, and the piping plover. In addition, the parties agreed to test the hypothesis that program actions would demonstratively serve needs of the ESA-listed pallid sturgeon farther downstream near the mouth of the Missouri River. Another objective is to provide regulatory certainty to basin water users on the condition that their pledges be fulfilled by providing the habitat recovery program an average annual supply of 130,000-150,000 acre feet of re-organized water, 10,000 acres of land habitat fulfilling specific quality requirements, money, and partnership in on-going adaptive management over the course of the first 13-year program increment.

The traditional river flow regime has been impacted during the 19th and 20th centuries by 15 major dams and reservoirs, supplemented by over 100 dam and storage projects on the Colorado-Nebraska South Platte and by over 80 storage works on the Wyoming-Nebraska North Platte (upstream of Lake McConaughy in Nebraska). This much impounded water has meant lower and less frequent spring and summer flood pulses with negative consequences for wet meadow habitats, river bank water storage, and recycling of nutrients in the riverine biotic web. It has also meant straighter, deeper, more incised channels—a product of clear water releases from sediment-trapping dams. These changes have resulted in loss of wide, sandbar-braided, shallow river channels, and a marked increase in densely vegetated river banks and islands. The listed target species have thereby been crowded into ever-smaller reaches of viable habitat, along with millions of other migratory birds that press into the shrinking remaining segments of usable quality. Potential for disastrous disease outbreaks has increased. Therefore, the negotiated habitat recovery program is focused on sustenance and restoration—at least to a modest extent—of critical habitat characteristics associated with the traditional flow regime.

How Is It To Be Done?

Negotiators struggled for years to forge a multi-level (local, state, federal), multi-state, federal multi-agency (Bureau of Reclamation, Fish and Wildlife Service (USFWS), Forest Service), multi-species, river-basin scale habitat recovery program. The essence of the federal negotiating approach was to offer the promise of long-term regulatory certainty

Threatened and endangered species on the Platte River.

to state water providers (who need predictability regarding the terms and conditions under which their various federal licenses and permits would be approved) in return for water user organization willingness to provide for target species habitat needs. This involved blending in the concept of "milestones" fulfillment (action X will be completed by time Y at site(s) Z), along with a willingness to engage in a mutually collaborative learning process called "adaptive management"—scientifically disciplined data gathering and analysis to mutually learn about what is effective.

Negotiators grappled with highly charged issues. They needed to devise means to replace historic depletions to the river system, replace "new" (post-1997) depletions, track water diverter depletions, organize species and pulse flow deliveries to the top of critical habitat, organize a viable research and monitoring program, and develop a mutually acceptable framework for conduct of adaptive management. Some conflicts were bitter and protracted, and at times they threatened to abort negotiations as states wrestled with one another over divisions of flows (with an unwelcome intruding federal agenda), and with environmentalists who represented potential recourse to courts should any deal fail to sufficiently serve species habitat requirements.

A core challenge was to reconcile two incompatible visions of habitat restoration. On the one hand, states and their water providers consistently advanced a vision centering on protection of their project water yields. They serve demanding agricultural municipal and industrial customers who expect their supplies to be sufficient, cheap, and reliable. Water providers have no mandate to seriously question the economic growth games that their customers play, and they fought to protect themselves from endless unpredictable claims on their storage and treasuries. In an arid environment, water managers must capture more water than needed in wet years to serve demands in dry ones. It was difficult for them, and their constituents, to envision fractions of flows surging by at less than optimum times in the name of improved habitat for three birds and a fish far downstream. They, therefore, insisted that the program deliver them regulatory certainty via an adaptive management program that would function within defined contributions of water, land, and money.

On the other hand, the USFWS consistently advanced its vision centered on restoration of some natural and variable river flows to help restore and sustain essential habitat characteristics. Diversity in flow patterns is what distinguishes a river from a canal and is viewed as essential to generate the dynamic mosaic of habitat types necessary to meaningful restoration. In the agency's view, the adaptive management path toward the grant of regulatory certainty was to introduce not only minimum flows but also pulse flows while protecting wild and uncontrollable peak flows as much as possible. In combination, the several flow types do the work of scouring vegetation, creating ephemeral barren sandbars and maintaining wide, shallow, braided river channel characteristics.

These two conflicting visions were pitched against each other for years and would drive the discussions of many program particulars. In the end, states and water providers never accepted any portion of the federal natural flow vision, but a cooperative program for habitat restoration was finally adopted. The deal was based on a carefully crafted distinction. On the one hand, the grant of regulatory certainty would be conditioned upon fulfillment of program milestones achieved within the constraints of defined contributions. On the other hand, explorative steps conducted in accordance with adaptive management principles will be undertaken in a domain independent of milestones fulfillment. The failure of any set of adaptive management actions will not be cause for withdrawal of regulatory certainty. The greater the distinction between the two domains, the greater the state water providers' tolerance for USFWS natural flow explorations.

Significance

From a policy perspective, the Platte basin habitat recovery negotiations demonstrate that it is possible to implement the ESA across huge landscapes divided by state lines, mutually wary state river administrations, and conflicting local, state, and federal agendas. A collaborative approach to habitat restoration that accepts local knowledge along with national mandates and that addresses incompatible visions can work even in situations characterized by much private land ownership. However, it takes an unyielding ESA that meaningfully compels the discussion, and leaders—local, state, and national—with patience to work through perplexing and tangled issues.

The negotiations provided an opportunity to study mobilization of water providers to transcend their individual organizational rationalities in order to install an enhanced water commons. Negotiators constructed a new system of river basin governance to produce and manage that public good. The peoples of the basin are, thereby, learning how to better govern themselves more along the lines once envisioned by John Wesley Powell. The fuller story, and an analysis of what it takes for such a mobilization for better governance, is now in preparation.*

*Material for this essay is based on the author's study of Platte River negotiations from 1997 to 2007. A manuscript documenting and analyzing these negotiations is currently under review by the University Press of Colorado. It is tentatively titled: *Negotiating New Environmental Governance on the Platte River Basin Water Commons: Mobilizing Water Users to Implement The Endangered Species Act*.

Colorado Water Congress 2009 Summer Conference

The Colorado Water Congress (CWC) met on August 19-21, 2009, in Steamboat Springs for its annual summer conference. This year's theme was "A Change in the Financial Climate," reflecting the concerns about the state budget and the funding challenges facing water management agencies.

Two pre-conference forums were held: one that focused on how the state budget process works and a second for CWC members on developing better writing for advocacy skills. In addition, the Colorado Legislator's Interim Water Resources Review Committee met to discuss upcoming water legislation.

The conference kicked off on Thursday morning with about 200 CWC members in attendance. Congressman John Salazar opened the conference by describing federal water project funding that has been recently appropriated, including the Arkansas Valley Conduit and a number of much-needed rehabilitation projects around the state. He also read a tribute to former CWC Executive Director Dick MacRavey, noting many of Dick's accomplishments.

Congressman Salazar discussed the proposed Clean Water Restoration Act and the amendments being offered to limit jurisdiction. He remarked on the proposed Cap-and-Trade Bill, the need for clean coal technology, and the cost of the current proposals on household utility bills. The current health care debate is likely to capture most of the attention and energy for the next six months, he said.

A legislative panel discusses upcoming water legislation.

A panel of state water leaders from Utah, Colorado, and Wyoming discusses regional perspectives.

Attendees John McClow, Senator Bruce Whitehead, and Erin Light enjoy a break at the conference.

A panel of state legislators, including Rep. Kathleen Curry, Rep. Wes McKinnley, Rep. Randy Fischer, Sen. Al White, Sen. Grant Schwartz, Sen. Mary Hodge, Rep. Sal Pace, Rep. Jerry Sonnenberg, Rep. Randy Baumgardner, and new state Senator Bruce Whitehead reviewed last year's legislation and next year's budget and potential legislation. Their focus is on preserving the state's core mission while searching for long-term funding solutions.

Regional perspectives on water issues were provided by Pat Tyrrell, Wyoming State Engineer; Dennis Strong, director of the Utah Division of Water Resources; and Jennifer Gimbel, executive director of the Colorado Water Conservation Board. Although Utah has never built a state water project, it has recently directed work on two state water supply projects: one on the Bear River and one on the Colorado River. The State of Wyoming has one water project: the High Savery Project. In general, the three state governments are not in the business of water development, but they attempt to facilitate the development of water by other entities. All three state leaders expressed concern about meeting delivery obligations on the Colorado River and that additional development would further deplete the river, jeopardizing endangered species recovery.

Other program highlights included Harris Sherman, executive director of the Colorado Department of Natural Resources, who addressed the need for the water community to unify its voice and help address the state budget crisis as a whole, not just the funding shortages for water. John Fetcher, deceased director of the Upper Yampa Water Conservancy District was honored during a reception for CWC members and guests. The Colorado Water Congress Annual Winter Meeting will be held on January 27-29, 2010, in Denver. For further information on the CWC, visit www.cowatercongress.org.

34th Annual Colorado Water Workshop
July 22-24, 2009

by Laurie Schmidt, Colorado Water Institute

Members of the state's water community gathered at the Colorado Water Workshop on July 22-24 to investigate and discuss issues related to non-consumptive water use in Colorado. Due to renovations on the Western State College campus in Gunnison, the Workshop was held "up valley" in Mt. Crested Butte.

The meeting opened on Wednesday, July 22, with lunch and a welcome by new director Jerritt Frank, who provided a rationale for this year's theme. "We have become a nation of recreators," he said. "America used to know nature through labor; now we know nature through play." Lunch was followed by two afternoon sessions, the first of which focused on water and democracy in modern America. George Sibley, retired Western State College faculty member and former director of the Workshop, discussed the tradition of "hydraulic democracies" in the West. Justice Gregory Hobbs then provided an overview of the decision-making process in Colorado water court.

Taylor Hawes, director of the Natural Conservancy's Colorado River Program, began the second afternoon session, titled *Diverse Voices: Managing for Multiple Missions*, by explaining the Colorado River's "math" problem:

	30 million people
+	3.5-4 million acres of irrigated agriculture
+	non-consumptive needs
+	tribal settlements
+	Mexico
+	hydropower releases
=	**Deficit Spending**

This problem, she said, is compounded by the projected addition of 12-15 million more people by 2035, as well as by future climate variability.

Rick Cables of the U.S. Forest Service addressed managing forests for non-consumptive uses and "The New Water Project"—protecting forest headwaters while sustaining non-consumptive uses. Harris Sherman, executive director of the Colorado Department of Natural Resources, wrapped up the session with a discussion on how Colorado's economic future depends on the health of non-consumptive uses. "Companies often come here for the outdoor recreation opportunities that will attract employees," he said.

On Thursday morning, speakers during a session focused on environmental challenges included Angela Kantola, who provided an overview of the Upper Colorado River Endangered Fish Recovery Program and a status report on endangered fish in the Colorado and efforts to remove non-native fish species. Brad Taylor, a professor at Dartmouth College, discussed the nuisance blooms of *Didymosphenia geminata* (didymo) throughout western Colorado rivers that is particularly common below dams and reservoirs. Taylor's study on didymo's impacts to invertebrate populations showed a higher density of bugs where didymo is present. Finally, Mark Anderson of Glen Canyon National Recreation Area discussed efforts by the National Park Service to address the increasing threats posed by Zebra mussels to western waterways. Although Lake Mead was declared infested in 2007, the invasive species has—so far—been kept out of Lake Powell and Glen Canyon. Continued success, however, depends greatly on future funding. "With no suitable eradication options currently existing for most locations, prevention is the only hope," he said.

In a session on past, present, and future climate change, topics of discussion included impacts of reduced snowpack on Colorado's ski industry, by Matthew K. Reuer of Colorado College; effects of climate change on stream insects, by Bobbi Peckarsky of the University of Wisconsin; and hydroclimatic variability in the Upper Colorado River Basin, by Margaret Matter, Ph.D. candidate at Colorado State University.

Thursday afternoon included a lively discussion on the public's "right to float" on Colorado rivers. Attorney John Hill educated attendees on Colorado law regarding the issue, which holds that the public has no right to float through private property without the consent of the landowners. Attorney Lori Potter followed Hill with an overview of how other western states approach the "right to float" issue and posed the question of whether Colorado has laid the legal foundation necessary to support the public's right to float. The session concluded with a talk by Greg Felt, co-owner of a fly-fishing guide service on the Arkansas River, who asserted that lawmakers are not willing to stand for public access. "If an amendment were left up to Colorado voters, I believe it would pass because most people think it's the law already," he said.

On Thursday evening, a reception and dinner banquet were followed by a keynote address by Steve Martin, superintendent of Grand Canyon National Park. Martin, who has worked at Grand Canyon since 1973, discussed the recreation plan for the canyon, as well as the growing concerns about Glen Canyon Dam and its impacts on the canyon downstream. Speaking in terms of Grand Canyon's future, he said, "Change is going to be the constant."

The Workshop concluded on Friday morning with two sessions that focused on collaborative solutions and consensus. After lunch, director Jerritt Frank invited the Workshop Advisory Committee, speakers, and attendees to discuss themes and topics for next year's Workshop. Make plans to attend the 2010 Colorado Water Workshop, which will return to its regular venue on the Western State campus in Gunnison.

Rio Grande Basin Tour
June 18-19, 2009

by Troy Lepper, Colorado State University Sociology Water Lab
Julie Kallenberger, Colorado Water Institute

For a number of water users, managers, state representatives, and academics, mid-summer in Colorado means it is time for the Colorado Foundation for Water Education's (CFWE) annual river basin tour. The CFWE's basin tours combine visits to basin sites with talks by expert speakers who focus on past, present, and future problems and solutions facing Colorado's river basins. The annual event serves not only as an educational opportunity for the state's water users and managers, but also as a fundraiser for the foundation's non-partisan educational work.

This year's tour took place on June 17-19 and visited the Rio Grande Basin. Located in south-central Colorado, the Rio Grande Basin is nestled between the Sangre de Cristo and San Juan Mountains and covers 7,700 square miles of land. Although its primary water use is agriculture, the basin is characterized by multiple uses, including recreation, wildlife preservation, and municipal use, that are all important to the successful and sustainable operation of the basin. This year's tour began on Wednesday, June 17, with two field trip options: (1) a whitewater rafting trip on the headwaters of the Rio Grande with speakers Brent Woodward (Colorado Division of Wildlife) and Dan Dallas (U.S. Forest Service), or (2) a walking tour of the historic Costilla County acequias hosted by former county commissioner Joe Gallegos.

The day closed with a dinner and reception hosted by the Rio Grande Watershed Association of Conservation Districts *Teachers Workshop* at the Trincherra Ranch in Fort Garland. On Thursday, the tour officially started when the bus departed Alamosa for our first stop at the Native Aquatic Species Restoration Hatchery, where Steve Vandiver (Rio Grande Water Conservation District) and Dave Schnoor (Colorado Division of Wildlife) spoke about water management issues on the Rio Grande, as well as the challenges of protecting endangered species. The tour then turned west to the Rio Grande Reservoir, where Travis Smith (San Luis Valley Irrigation District), Dan Dallas, Tom Spezze (Colorado Division of Wildlife), and Kelly DiNatale (DiNatale Water Consultants, Inc.) spoke about the rehabilitation of the Rio Grande Reservoir and the potential for collaboration between multiple agencies and organizations for a multi-purpose reservoir project on the Rio Grande.

After lunch we boarded the bus for our next stop at the Rio Oxbow Ranch, which included a panel discussion focused on the Rio Grande restoration and conservation project. Rio de la Vista and Nancy Butler (Rio Grande Headwaters Land Trust), Mike Gibson (San Luis Valley Water Conservancy District), Dale Pizel and Greg Higel (Rio Grande Water Conservancy District), and Karla Shriver

Rio Grande Basin Tour attendees gather at Rio Oxbow Ranch near Creede, Colorado. (Courtesy of Colorado Foundation for Water Education)

Zeke Ward discusses floodplain reclamation and watershed protection with Rio Grande Basin Tour attendees in the Creede Mining District.

(Great Outdoors Colorado) discussed the in-progress efforts to preserve the natural flows of the Rio Grande for species protection, recreation, and conservation. After visiting the private Rio Oxbow Ranch, we travelled to Creede to look at the Willow Creek Reclamation Project, which is focused on improving water quality on Willow Creek following years of mining in Creede. At the base of the old mine, we were greeted by Zeke Ward and Kathleen Murphy (Willow Creek Reclamation Committee), who updated us on water quality improvements on Willow Creek. The evening ended with dinner and entertainment at the La Garita Ranch in South Fork. Evening speakers included Nicole Seltzer and Matt Cook (Colorado Foundation for Water Education), Mike Gibson, and Doug Shriver (Rio Grande Water Users Association) representing the Rio Grande Basin Roundtable, and Colorado State Senator Gail Schwartz, who gave the keynote address on a vision for sustainable water management for the San Luis Valley.

Day three began with speeches by Ray Wright (Rio Grande Water Conservation District) and Allen Davey (Davis Engineering Service, Inc.) on groundwater management issues in the San Luis Valley. The tour then headed to the Alamosa National Wildlife Refuge, where we heard from Clark Dirks (U.S. Fish and Wildlife Service) on preserving habitat and conserving water resources on the refuge. After touring the wildlife refuge we stopped at Entz Farm, where former Colorado State Senator Lewis Entz and his son Mike Entz spoke about the history of agricultural water in the Closed Basin and the viability of agriculture in the San Luis Valley. After a short stop at the Alamosa Photovoltaic Solar Plant, we headed to our final two stops of the tour. Following lunch at the Zapata Ranch in Mosca, Paul Robertson and John Sanderson (The Nature Conservancy) spoke on water management at the ranch and the non-consumptive water needs of the San Luis Valley. This stop was highlighted by a photo presentation of the Rio Grande River Basin by freelance photographer Michael Lewis (National Geographic). Finally, we boarded the buses one last time and headed to Colorado's newest national park: Great Sand Dunes National Park and Preserve. Here we were met by Art Hutchinson and Fred Bunch (National Park Service) who explained the importance of hydrology to the creation of the sand dunes and the park. We arrived back in Alamosa late Friday afternoon where we parted ways with our new and old friends and headed back to our various institutions and organizations.

The quality of the Rio Grande Basin Tour is a testament to the hard work and attention to detail by the staff of the Colorado Foundation for Water Education. Their continued efforts to provide Colorado water users and managers with educational opportunities helps focus management on the challenges related to sustainable water management in the 21st century. For more information about the CFWE, please visit www.cfwe.org.

GRAD 592
Interdisciplinary Water Resources Seminar

Fall 2009 Theme:
Environmental Protection and Water Management: Are They Compatible?
Mondays at 4:00 PM, Clark A 206

The purpose of the 2009 Interdisciplinary Water Resources Seminar (GRAD 592) is to examine how the environment is protected as water supplies are developed and managed in Colorado. More specifically, the seminar will:

- Examine environmental laws, institutions and policies that affect water development
- Understand current approaches to environmental protection and water management
- Discuss the evolution of environmental protection and public participation in water management
- Examine current Colorado water case studies to understand the management of public water supply, growth, environmental mitigation, endangered species needs, water quality protection and other topics.

Aug. 24 **Organizational Meeting**—First Day of Class

Aug. 31 **Environmental History as a Tool in Water Resource Protection and Management**—Mark Fiege and Jared Orsi

Sept. 7 *Labor Day*—No class

Sept. 14 **U.S. Department of Interior and Bureau of Reclamation's Role in Water and Environmental Management**—Bennet Raley

Sept. 21 **Conservation Priorities and Environmental Flow Quantification: Colorado's Non-Consumptive Needs Assessment**—John Sanderson

Sept. 28 **State's Role in Water Quality Protection and Management**—Steven Gunderson

Oct. 5 **Resolving Transboundary Environmental Issues**—Jennifer Pitt

Oct. 12 **Negotiating Better Environmental Governance in the Platte River Basin: Implementing the Endangered Species Act**—David Freeman

Oct. 19 **Holistic Management of the Colorado River System**—Taylor Hawes

Oct. 26 **Public Participation in Water Management--Case Study: Bear Creek Watershed**—Russ Clayshulte

Nov. 2 **Water Management and the Environment: Programs and Priorities for the Western Governors**—Tom Iseman

Nov. 9 **Legal Tools and Legal Constraints in Environmental Protection**—Melinda Kassen

Nov. 16 **35 Years of The Clean Water Act--Are We There Yet?**—Ayn Schmidt

Nov. 23 *Thanksgiving Break*—No class

Nov. 30 **Instream Flow Protection Program and Wild and Scenic Designations to Protect Colorado Waters**—Ted Kowalski

Dec. 7 **Student Discussion and Participation**—Final Class

Dec. 14 *Final Exams*—No class

Presentations will be posted online each week if available. http://www.cwi.colostate.edu/grad592.asp

All interested faculty, students, and off-campus water professionals are encouraged to attend.
For more information, contact Reagan Waskom at reagan.waskom@colostate.edu or visit the CWI web site.

Faculty Profile

William Bauerle, Associate Professor, Department of Horticulture & Landscape Architecture

A career in horticulture was always on my horizon; my family tree is steeped in all aspects of the horticulture discipline. As a child, I was very involved in my grandparents' garden center and was quickly drawn to developing my own business—raising pumpkins for Halloween. This experience gave me an appreciation for the importance of water in crop production and for the economic decisions involved in resource input costs versus variable returns on yield.

After high school, I enrolled at Ohio State University and later transferred to Colorado State University (CSU) to major in landscape horticulture. Upon arriving at CSU, I quickly realized that working with trees appealed to me as a career. Therefore, I opted for the landscape and nursery concentration within the Department of Horticulture and Landscape Architecture. When I finished my bachelor's degree in 1995, I chose to continue my exploration of the West and headed to the University of Washington to begin a M.S. program in horticulture.

It was during these initial graduate student years that I decided to focus on plant physiology and, more specifically, tree physiology. My former principal advisor, Dr. Tom Hinckley, mentored me as a tree physiologist in the area of water relations of Douglas fir trees. He had a lot to do with cultivating my interest in plant water relations, and his awe-inspiring character greatly influenced my decision to pursue a career in academics. After completing my M.S. in 1997, I headed to Cornell University to begin a Ph.D. program. For my doctoral research, I focused on the water relations of red maple ecotypes from contrasting hydrologic habitats. Consequently, a career in plant water relations now seemed inevitable. However, during those cloudy days in Ithaca, New York, (which shadowed similar conditions in Seattle, Washington), I began to really long for Colorado.

Upon completion of my dissertation in 2001, all of the primary tenure-track university jobs in my area of expertise happened to be located in the Southeast. I began a job as an assistant professor at Clemson University only two weeks after graduating from Cornell. There, my program focus was on tree physiology and modeling the interactions of multiple plant stress responses—specifically, water and carbon exchange. During my six-year tenure as a faculty member in the Department of Horticulture at Clemson University, I developed my program in plant ecophysiology and integrated the development of mechanistic models in order to predict plant responses to environmental stress. In so doing, the outcome of my water and temperature stress physiology research program helps provide the data for model development and validation. The spatially explicit scaling of the model estimates, however, does not always lend itself to comparison with off-the-shelf instrumentation. Therefore, I experiment in the area of instrumentation development to overcome the limitations of commercially available devices. Process modeling allows me to scale the research findings from the molecular to the ecosystem level and to connect species or genotypes genetic predisposition with the atmosphere.

When a job in this area of expertise opened up at CSU, the decision to transfer was not at all difficult. I joined the Department of Horticulture & Landscape Architecture in the fall of 2007 with an appointment that primarily includes research and teaching in the area of plant stress physiology, with a focus on drought tolerance. Here, my research program has expanded to scale stress responses from the cellular to the ecosystem level. In the future, my program will continue to investigate the link between the molecular, cellular, and whole-plant mechanisms of drought and thermal stress tolerance. The primary plant physiological methods used in my research program include sap flow sensors to measure whole-plant and branch water loss; infrared gas analysis for determining rates of photosynthesis and transpiration at the organ and whole-plant level; enzyme linked immunosorbent assay analysis and molecular imprinting to determine pico scale plant hormone sensitivity; stable isotope labeling using $^{13}CO_2$ with mass spectrometry to trace isotope composition; chlorophyll fluorometry to quantify photochemical quantum yield; and process-based modeling to scale stress responses from the leaf to the ecosystem level. Overall, this approach allows us to understand the precipitation and temperature effects on growth, survival, and physiological processes so that we can improve water use efficiency and predict the impact of water deficits in managed and natural terrestrial ecosystems.

Colorado water issues, coupled with the abundant water-related expertise at CSU, make this an incredible place to develop new methodology to overcome water limited situations. In addition, my family and I love Fort Collins and the surrounding community. In the future I will continue to develop physiologically and genetically constrained models using the above techniques, which are well-suited to confronting the challenges related to predicting the effect of water and temperature stress on genetically diverse landscape plant species, ecotypes, and genotypes.

William Bauerle, Ph.D.
Associate Professor

Colorado State University

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Water Research Awards

Colorado State University (June 15 to August 14, 2009)

Anderson, David G, DOI-Fish and Wildlife Service, Monitoring Non-Native Species & Native Species; Native Species Taxonomy Studies, $35,000

Bartolo, Michael E, Colorado Onion Association, Biology of Onion Thrips, Alternative Production Practices and Irrigation Practices-Arkansas Valley, $2,500

Bauerle, William L, Horticultural Research Institute, A Systematic Approach to Solve Nursery and Landscape Water Management: Initial Industry Application, $25,000

Bestgen, Kevin R, DOI-Bureau of Reclamation, Floodplain Inundation and Entrainment Studies, $31,800

Bestgen, Kevin R, DOI-Bureau of Reclamation, Population Estimate of Humpback Chub in Black Rock, $4,000

Brown, Cynthia S, DOI-Geological Survey, Temperature Effects on the Southern Limit of Russian Olive (Elaeagnus angustifolia) in Western North America, $44,511

Chavez, Jose L, Central Colorado Water Conservancy District, Wireless In-field Soil Water Content Monitoring Project, $39,703

Cotrufo, Maria Francesca, USDA-USFS-Rocky Mountain Research Station, Salt Cedar and Russian Olive Demonstration Act (HR2720) Science Assessment and Ongoing Invasive Species (Salt Cedar and Russian Olive)-Related Research, $123,500

Culver, Denise R, Colorado Water Conservation Board, Identification and Assessment of Important Wetlands in the North Platte River Watershed, $37,000

Demott, Paul J, National Science Foundation, Ice Nuclei and Ice Initiation in Mid-Latitude Clouds in Springtime: Background and Dust-Affected, $28,472

Fontane, Darrell G, Water Resources University (Vietnam), Presentation of an Introduction to Civil Engineering Course for the Water Resources University, Hanoi, Vietnam, $12,519

Gao, Wei, USDA-CSREES, Global Change/ Ultraviolet Radiation, Colorado, $1,312,660

Goemans, Christopher G, FRICO-Farmers Reservoir and Irrigation C, Alternatives to Water Transfers in the South Platte Basin using the Farmers Reservoir and Irrigation Company System, $57,689

Kummerow, Christian D, NASA, Optimal Estimation of Precipitation Profiles with Multiresolution Overlapping Radiometer and Radar Observations, $30,000

Kummerow, Christian D, DOC-NOAA, Development of an Improved Climate Rainfall Dataset from SSM/I, $109,817

Lemly, Joanna, Colorado Division of Wildlife, Basinwide Wetland Profile of the North Platte River Basin in Colorado, $180,568

Liston, Glen E, NASA, Improving the Representation of Global Snow Cover, Snow Water Equivalent, and Snow Albedo in Climate Models by Applying EOS Terra and Aqua Observations, $124,989

McDonald, Sandra K, Colorado Department of Agriculture, Regional Pilot-Aquatic Pesticide Applicator Guide, $83,096

Myrick, Christopher A, DOI-Bureau of Reclamation, Barrier Design Criteria for White Sucker and Burbot, $46,499

Nissen, Scott J, Colorado Water Conservation Board, New Methods for Sago Pondweed Management, $20,000

Poff, N LeRoy, DOI-Geological Survey, Effects of Water Management and Climate Change on the Dynamics of Native and Invasive Wetland and Riparian Plants in the Western US, $86,316

Roesner, Larry A, Water Environment Research Foundation, Linking Stormwater BMP Systems Performance to Receiving Water Protection to Improve BMP Selection and Design, $244,789

Sibold, Jason Scott, DOI-National Park Service, Investigation into Relationships between Disturbance History and Mountain Pine Beetle Outbreak Severity and Consequences in the Lodgepole Pine Forest Type of Rocky Mountain National Park, Colorado, $13,991

Stednick, John D, Northern Colorado Water Conservancy District, Willow Creek Water Quality Study, $21,010

Theobald, David M, USDA-USFS-Forest Research, Western Riparian Threats Assessment, $20,000

Thornton, Christopher I, Erosion Prevention Products, Overtopping Tests on Two Articulating Concrete Block Systems, $4,800

Waskom, Reagan M, Colorado Water Conservation Board, Agricultural Water Conservation Clearinghouse, $10,000

Willson, Bryan D, Solix Biofuels, Inc., Algae to Biodiesel-Phase One; Lab and Reactor Development, $205,359

Winkelman, Dana, DOI-Bureau of Reclamation, Population Dynamics Modeling of Introduced Smallmouth Bass, Upper Colorado River Basin, $32,424

Zabel, Mark D, DOI-National Park Service, Evaluation of Water and Soil Samples from Rocky Mountain National Park for Chronic Wasting Disease Prions, $54,027

Calendar

September

12 **Ag Day 2009; Fort Collins, Colorado**
The 28th Annual Ag Day at Hughes Stadium, hosted by agricultural organizations and associations.
http://agday.agsci.colostate.edu

13-16 **24th Annual WateReuse Symposium; Seattle, Washington**
The world's preeminent conference devoted to water reuse and desalination.
http://www.watereuse.org/conferences/symposium/24

14-16 **From Dust Bowl to Mud Bowl; Kansas City, Missouri**
Ties current or ongoing research directly to the health and sustainability of reservoirs.
http://www.swcs.org/en/conferences/dust_bowl_to_mud_bowl_sedimentation_

18 **Colorado River District Annual Meeting; Grand Junction, Colorado**
Discuss Colorado River operations by the Bureau of Reclamation in the Lower Basin.
http://www.crwcd.org/page_305

22 **The Big Thompson Watershed Forum's 11th Annual Meeting; Fort Collins, Colorado**
Theme is "Protecting Our Watershed, Preserving Our Future."
http://www.btwatershed.org

26 **Tunnel Days; Gunnison, Colorado**
Centennial celebration of the Gunnison Tunnel.

28-30 **Western States Water Council 2009 Symposium; Denver, Colorado**
This year's theme is "Water and Land Use Planning for a Sustainable Future."
http://www.westgov.org/wswc/awms.html

October

2-5 **2009 Theis Conference; Boulder, Colorado**
This conference addresses groundwater and climate change.
https://info.ngwa.org/servicecenter/Meetings/Index.cfm?meetingtype=cf

6-8 **H_2O-XPO for Water and Wastewater; Louisville, Kentucky**
http://www.h2o-xpo.org/

7-9 **Sustaining Colorado Watersheds Conference; Vail, Colorado**
This year's theme is "Thriving in Challenging Times."
www.coloradowater.org

14-15 **Platte River Symposium; Kearney, Nebraska**
A review of research and innovative programming related to the Platte River.
http://watercenter.unl.edu/Platte2009/Platte.asp

21-22 **20th Annual South Platte Forum; Longmont, Colorado**
"1989 to 2029: A River Odyssey" is this year's theme.
www.southplatteforum.org

28-30 **NALMS Annual Symposium; Hartford, Connecticut**
Provides the latest information on lake management issues.
http://www.nalms.org

November

4-7 **Fifth International Conference on Irrigation and Drainage; Salt Lake City, Utah**
This conference is a premier international event for water resources professionals.
http://www.uscid.org/09intconf.html

8-12 **American Water Resources Association Annual Conference; Seattle, Washington**
Explore the many multidisciplinary aspects of water resources research, policy, and management.
http://www.awra.org/meetings/Seattle2009

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Cottonwood trees reflect in the Cache la Poudre River in northern Colorado. (Image courtesy of John Bartholow)