

# Colorado Water

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Front Cover: Sun sets near Bingham Hill in Fort Collins. Photo by David Kingham  
This Page: Grizzly Creek, Glenwood Springs, Colorado. Photo by halseike

# Editorial

by Reagan Waskom, Director, Colorado Water Institute

Each year we look forward to the renewal of streamflows as warmer weather begins the annual cycle of snowmelt, bringing the anticipated spring rise. Linger drought portends 2013 will be a second consecutive year of below average streamflows, reducing our ability to store water in reservoirs and to adequately water our farm fields. Drought happens in Colorado. We will get through it as we always do—by implementing conservation measures and the priority based water allocation system, which is particularly efficient in managing water scarcity. But what about the water needs of the environment? How do we keep our streams and aquatic ecosystems functioning during times of low flow?

Newcomers from wetter regions often express dismay at how Western rivers and reservoirs drop in late summer and remain low during the fall and winter. Part of this is due to diversions for irrigation and other uses, but low flows are also a hydrologic reality of aridity and cyclical drought. Most historical accounts by explorers and settlers from the East noted that late-season streamflows often were negligible or non-existent, and travelers sometimes had to dig into the riverbed sands to find drinking water for themselves and their livestock. Post-settlement development of irrigation canals, reservoirs, transbasin diversions, and groundwater wells caused return flows to occur later in the season and lower in the basin, allowing for the perennial flows that people from back East were more familiar with. Over time we have altered the hydrology of our rivers, introduced game fish, and facilitated the introduction of nonnative and invasive species, changing society's expectations of what Colorado's rivers should look like.

It is clear that the needs and desires of modern civilization will not permit a return to pre-settlement stream conditions, no matter how much that goal may be desired. However, scientific understanding of flow requirements for maintaining stream function has evolved along with public value placed upon healthy ecosystems. We know that fish populations need spatial connectivity above and below diversion points to remain vibrant. We know that flood flows are needed to mobilize bed sediment, renew channel morphology, and allow interchange between the river and its floodplain. We know that adequate base flows are needed for certain species' survival. But



how do we apply this knowledge in a market-based prior appropriation system? Established in our 1876 state constitution to allow water diversion to where it is needed, and to prevent monopoly and speculation, prior appropriation has evolved to encompass changing societal value for non-consumptive beneficial uses, such as instream flows and recreational in-channel diversions.

The Colorado Water Conservation Board (CWCB) is the state agency charged with managing (among other things) an instream flow program that now preserves over 9,000 stream miles in Colorado through protection of environmental flows. CWCB is the only entity in Colorado legally empowered to hold designated instream flow rights acquired through gift, lease, or purchase of increasingly expensive water. The State Engineer and river commissioners are charged with shepherding these flow rights. The research and engineering communities play the role of providing the data, models, and sound, non-advocacy science needed to quantify the flow levels required for a reasonable degree of environmental protection. Colorado State University has a developed strong and growing program in the emerging science of ecohydrology, spanning several colleges and disciplines to provide research-based information on eco-flow needs. Many actors must work together to quantify, designate, protect, and administer instream flows, a great example of collaboration at multiple levels of the water and environmental communities.

# Colorado's Instream Flow and Natural Lake Level Program Celebrates 40<sup>th</sup> Anniversary

*Linda Bassi, Chief of Stream and Lake Protection Section, Colorado Water Conservation Board*

## In a Nutshell

- The four main Instream Flow Program areas are: New ISF Appropriations, Water Acquisitions, Legal Protection, and Monitoring and Enforcement
- The Colorado Water Conservation Board administers the program
- Over the past 40 years, the Instream Flows Program has appropriated and acquired water rights within every Colorado river basin

Colorado's Instream Flow and Natural Lake Level Program (ISF Program) turns 40 years old this summer. During the last 40 years, the ISF Program, administered by the Colorado Water Conservation Board (CWCB), has achieved permanent protection of valuable stream habitat in every river basin in Colorado by appropriating and acquiring water for ISF water rights to preserve the natural environment of Colorado's streams to a reasonable degree. ISF water rights help to support the state's recreation-based economy, preserve habitat of numerous fish species in Colorado, and can help prevent Endangered Species Act listings of declining native fish species.

The CWCB works with federal and state agencies, local governments,

and other stakeholders to achieve their resource protection goals using the ISF Program. Recent examples include: (1) a trust agreement with Pitkin County allowing the CWCB to use certain water rights owned by the County for ISF use on Maroon Creek and the Roaring Fork River; (2) the appropriation of ISF water rights in the Dominguez Canyons Wilderness Area; and (3) the appropriation of ISF water rights on three reaches of the Colorado River as a key part of the Upper Colorado River Wild and Scenic Stakeholder Group's proposed alternative to a potential federal finding by the Bureau of Land Management that those reaches are suitable for Wild and Scenic designation.

Colorado's lawmakers created the ISF Program by passing Senate Bill 97, which became effective on July 1, 1973. The legislature, recognizing the need to "correlate the activities of mankind with some reasonable preservation of the natural environment," authorized the CWCB "on behalf of the people of the state of Colorado, to appropriate or acquire... such waters of natural streams and lakes as the board determines may be required for minimum stream flows to preserve the natural environment to a reasonable degree." The CWCB, established in 1937, is an agency within Colorado's Department of Natural Resources whose mission statement is "To conserve, develop, protect, and manage Colorado's water for present and future generations." In giving this 15-member citizen board authority over the ISF Program, proponents of Senate Bill 97 hoped to assure the water development community that the ISF Program would be implemented in a fair and

balanced manner. Over the years, the law governing the ISF Program has evolved, clarifying, limiting, and expanding various aspects of CWCB's authority over the Program. Seven CWCB staff members work on daily implementation of the Program and receive direction from the Board at its regularly scheduled meetings.

ISF water rights are in-channel appropriations of water for specified flow rates between two points on a stream. Natural lake level water rights are appropriations of water in a natural lake for a specified lake level or volume. ISF and natural lake level water rights are adjudicated in water court, decreed to preserve the natural environment to a reasonable degree, and administered within the state's water rights priority system. The CWCB has exclusive authority to obtain water court decrees for such water rights in the state of Colorado. As of 2013, the CWCB has appropriated ISF water rights on more than 1,500 stream segments covering more than 9,000 miles of stream, and has appropriated 480 natural lake level water rights. The CWCB also has acquired water for ISF use through over 25 transactions, including donations and long-term contracts, for approximately 500 cfs and 9,300 acre-feet. The four main ISF Program areas are: (1) New ISF Appropriations, (2) Water Acquisitions, (3) Legal Protection, and (4) Monitoring and Enforcement.

## New ISF Appropriations

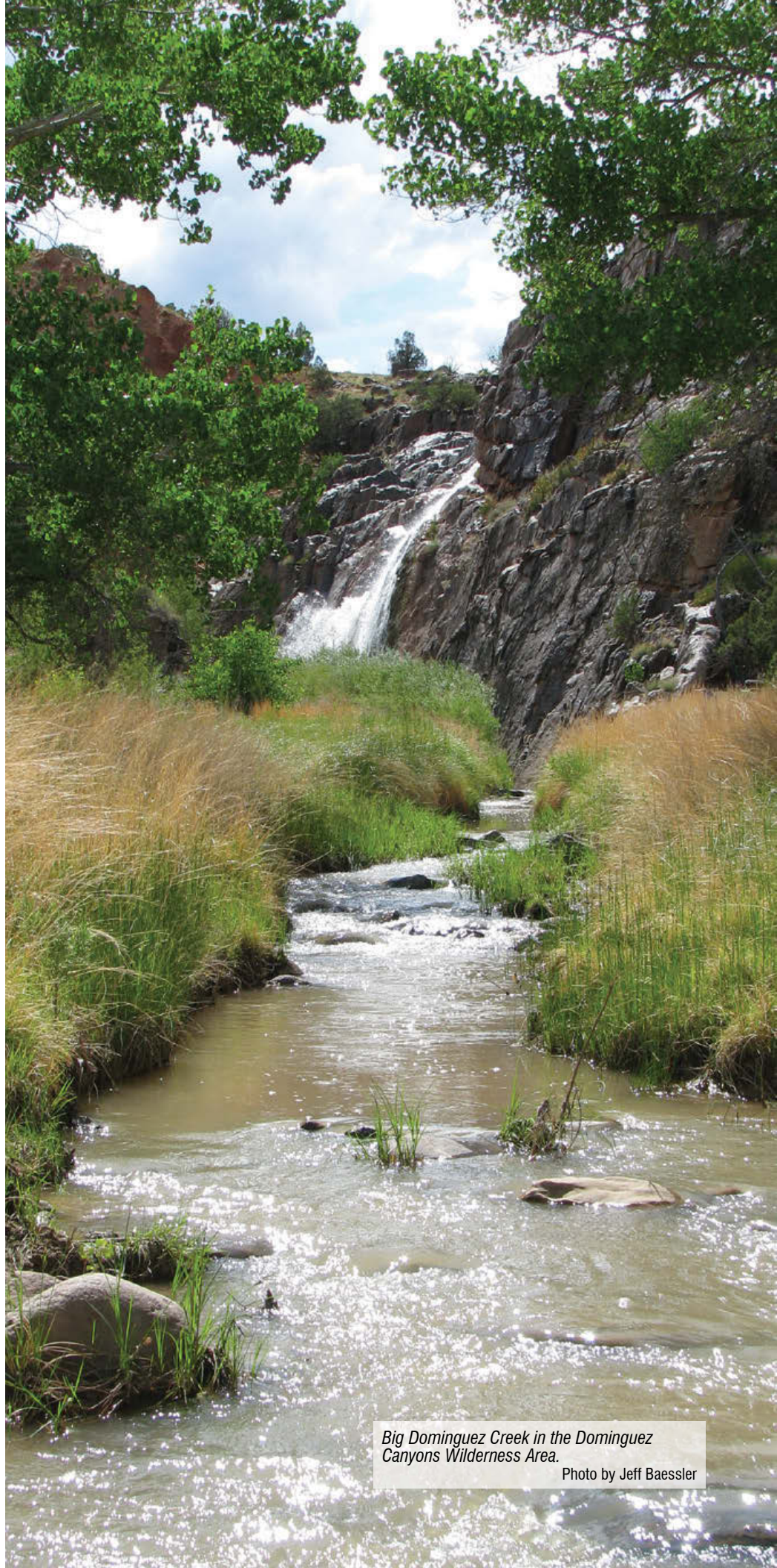
The CWCB appropriates and adjudicates new ISF water rights based upon recommendations received from Colorado Parks and Wildlife, the U.S. Bureau of Land Management, local governments, nonprofit organizations,

and other entities. These recommendations must be submitted in writing and with specificity, including identification of the proposed stream reach and the aspect of the natural environment to be preserved on the reach (such as a cold water fishery), and a scientific quantification of the biological flow requirements using R2Cross or another standard methodology. Before applying to water court for an ISF water right, the CWCB must make three determinations required by statute: (1) there is a natural environment that can be preserved with the ISF water right; (2) the natural environment will be preserved to a reasonable degree by the water available for the ISF appropriation; and (3) the natural environment can exist without material injury to water rights.

The CWCB holds an annual public ISF Workshop at which it receives ISF recommendations and provides an update on the status of recommendations in process. For each recommendation, CWCB staff then conducts additional field work as needed, performs a water availability analysis, holds public meetings to get input on the recommendations, and consults with the Division of Water Resources. After compiling information that forms the basis for the CWCB's determinations, CWCB staff brings the recommendations to the CWCB for appropriation. The CWCB uses a public notice and comment procedure for ISF appropriations that can include a hearing if a party objects to the proposed appropriation. Upon completing that procedure, the CWCB takes final action on the ISF appropriation and decides whether to file a water court application for the ISF water right.

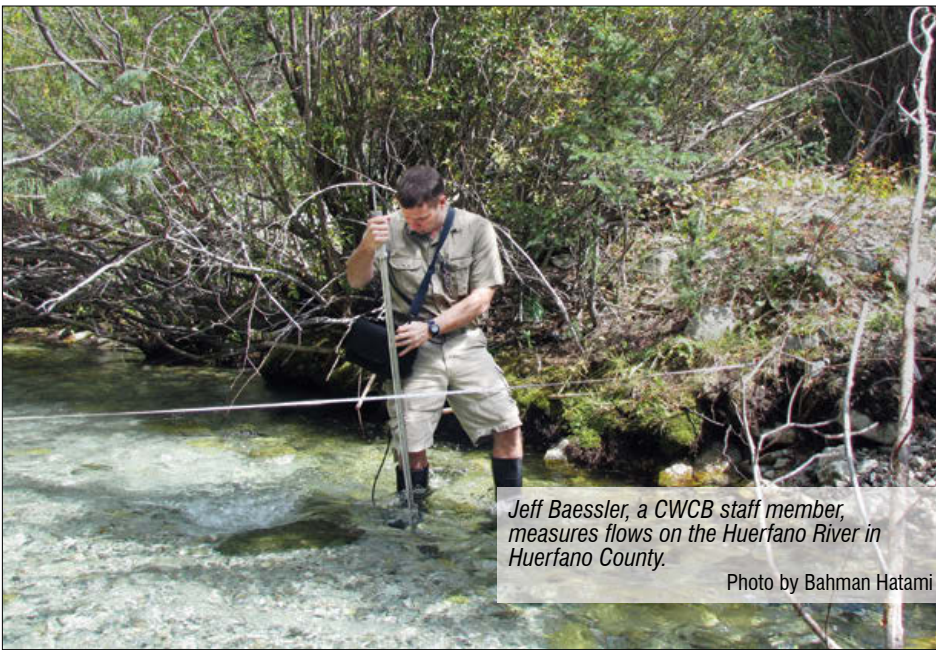
## Water Acquisitions

The CWCB can acquire water, water rights, or interests in water for ISF use by donation, purchase, lease, or other



*Big Dominguez Creek in the Dominguez Canyons Wilderness Area.*

Photo by Jeff Baessler



*Jeff Baessler, a CWCB staff member, measures flows on the Huerfano River in Huerfano County.*  
Photo by Bahman Hatami

contractual arrangement, in amounts that it determines appropriate to preserve or improve the natural environment to a reasonable degree. In 2001, the legislature authorized the CWCB to use acquired water to improve the natural environment, which typically means protecting flows at higher rates than the minimum necessary to preserve the natural environment. The CWCB works with willing donors, sellers, and lessors of water to incorporate acquired water into its portfolio of ISF water rights. There are several factors that the CWCB considers when evaluating and accepting an offer of water for ISF use, including, but not limited to:

1. Historical use and return flows
2. Location of other water rights on the stream reach
3. The potential for material injury to existing decreed water rights
4. The natural environment that may be preserved or improved by the proposed acquisition (based on biological analysis provided by Colorado Parks and Wildlife)
5. Availability of the water for subsequent use downstream

6. Water rights administration issues, if any
7. The potential effect of the proposed acquisition on interstate compact issues and maximum utilization of the state's waters

Most of the CWCB's acquisitions of water ISF use require the CWCB to obtain a water court decree confirming its right to use the acquired water right to preserve or improve the natural environment. However, a water rights owner can lease or lend a water right to the CWCB for ISF use under what is referred to as a temporary lease. ISF use of a water right under a temporary lease is limited to a period not to exceed 120 days in any one year, and may not be exercised for more than 3 years in a 10-year period. Such leases can occur on any stream where CWCB currently holds an ISF water right, up to the decreed flow rate of that right. Temporary leases do not require water court approval; the State and Division Engineers can approve a temporary ISF lease under an expedited notice and comment procedure, provided that no injury to other water rights will result. Last year, the CWCB worked closely with

the Colorado Water Trust on the Request for Water 2012 Program, implementing four temporary leases for ISF use that provided multiple benefits to Colorado's citizens and the natural environment.

## Legal Protection

To ensure that proposed water uses do not injure decreed ISF water rights, CWCB staff reviews the water court resumes each month for applications that could injure ISF water rights, and files statements of opposition to such applications. Proposed plans for augmentation, changes of water rights, and on-channel reservoirs that inundate an ISF water right can result in injury to ISF water rights. CWCB staff and the Attorney General's Office work with applicants to negotiate terms and conditions to include in their water court decree that protect ISF water rights while allowing proposed uses to move forward.

## Monitoring and Enforcement

The CWCB participates in new stream gage installations and cooperates with the USGS, Division of Water Resources (DWR), and others on existing stream gages. Real-time monitoring is available from over 125 gages via the DWR/CWCB flow alert system, which sends email and cell phone alerts to CWCB staff when flows dip below decreed ISF rates. Additionally, interested stakeholders alert staff to observed or suspected low flow conditions, and staff relies on staff gages and other verifiable methods of measuring stream flows. CWCB staff coordinates with the DWR on low flow conditions and places administrative calls for ISF water rights.

For more information on the ISF Program, go to <http://cwcb.state.co.us/environment/instream-flow-program/Pages/main.aspx> ●

# Managing Connections

## Applications of Fish Physiology Research to Stream Connectivity and Instream Flows

*Christopher Myrick, Associate Professor, Department of Fish, Wildlife, and Conservation Biology*

### In a Nutshell

- The Fish Physiological Ecology Laboratory (FPEL) at Colorado State University is addressing the biological component of instream flows by researching fish movement and connectivity, helping train future fisheries biologists, and making suggestions to improve river systems
- Many fish species not considered gamefish in local regions have not yet been the subject of study for such matters; this project has been taken on by FPEL

The Instream Flow Council has underscored the importance of including the full spectrum of components as part of a well-orchestrated instream flow program, including a careful assessment of the biological needs of the system in question. That biological component in turn contains a variety of subtopics

that should be addressed as part of the program, and one of particular interest to the Fish Physiological Ecology Laboratory (FPEL) at Colorado State University (CSU) is that of managing the ecological connectivity within riverine systems. Our laboratory has specialized in studying the swimming physiology



*Eric Gardunio and some CSU Fish, Wildlife, and Conservation Biology undergraduate students sample the Poudre River for white suckers.*


*Photo by Chris Myrick.*

of fishes in the region, and through the application of physiological techniques to applied management questions, we have begun to help resource managers develop better tools for managing the movement of fishes. The reasons why fish move and why this movement is important in the intermountain region were the subject of an article in 2009—a quick summary of that discussion will be presented here, followed by two examples of FPEL research that addresses this topic.


The diverse array of streams and rivers in Colorado and other intermountain states are home to a number of stream- and river-adapted fishes that can make extensive movements in both upstream and downstream directions. Some of these movements appear obligatory, as fish like flathead chub (*Platygobio gracilis*) and brown trout (*Salmo trutta*) move to spawning areas, while others seem more exploratory in nature, such as those of invasive burbot (*Lota lota*) colonizing new areas of the Green River system. Regardless of the reason behind the movements, the underlying necessity is the presence of a stream or river system that has not been longitudinally or temporally fragmented. Unfortunately, as we have developed our agricultural, industrial, and urban centers and the streams and rivers upon which they depend, we have necessarily modified these systems with dams, diversions, and other structures that alter, and often sever that connectivity.

Fisheries biologists are well-aware of the short- and long-term impacts that result from changes in connectivity, and a large amount of effort has been expended to devise methods of restoring or at least mitigating those losses. Much of this effort has been focused on coastal streams and rivers that have populations of strong-swimming migratory fishes such as Atlantic salmon (*Salmo salar*), Pacific

salmon (*Oncorhynchus spp.*) and American shad (*Alosa sapidissima*). The solutions chosen by resource managers in these systems tend to follow one of two paths—either mitigating for the lost productivity of upstream habitat through the use of downstream fish hatcheries, or developing fish passage structures (sometimes referred to as fishways) to assist fish in moving past the structures. Despite literally millions of dollars spent on the design, evaluation, and implementation of these strategies, they have not been wholly successful, but they are better than doing nothing. The situation in the intermountain region is similar, but there are some key differences.



Results from Ficke's work will represent the most comprehensive body of work on the swimming ability and passage requirements of fishes from Colorado's Front Range.



The first key difference is that unlike the coastal rivers that are often populated by large-bodied (more than two feet long) and strong-swimming species, many of our native fishes are relatively small-bodied (less than two feet long) and have not been considered candidates for captive rearing in mitigation hatcheries below dams or diversion structures. This small body size becomes a factor because of the second key difference—it does not take an instream structure of great height to form a barrier to the movement of fishes; in the case of the native fishes in Spring Creek, Larimer County, a three-foot vertical drop was sufficient to bar the movement of essentially all the fish species in the system. The final difference is that many of the species in the region, particularly

those not considered gamefish, have not been the subject of an exhaustive set of studies of behavior and swimming performance, so data that might be used to help design fishways or even evaluate the barrier potential of existing structures just did not exist. The FPEL took up the challenge of collecting data on the performance of non-traditional fish species so that regional resource managers could use more applicable data in their efforts to enhance or restrict fish movements.

As with many research programs, each project builds upon the lessons learned in prior projects. The groundwork for the two examples that will be presented here was laid by Matthew Kondratieff, who developed an apparatus for measuring the volitional jumping ability of fishes during his Master of Science project on building better brook trout (*Salvelinus fontinalis*) barriers, and by Ashley Ficke, who improved the FPEL ability to measure swimming performance variables relevant to the design of fishways, along with refining techniques to track fish movements in the field.

The first example of FPEL research is a project tasked with developing better fish passage guidelines for fish native to transition zone and plains reaches of Front Range streams and rivers. The Ph.D. student on the project, Ashley Ficke, has used a three-phased approach to tackle the problem. In the first phase, she conducted an extensive field study on whether fish such as brown trout and longnose suckers (*Catostomus catostomus*) are successfully using existing fishways on South Boulder Creek. We installed a set of remote antenna arrays above and below the existing fishways; a second set of arrays were installed in representative control reaches. We then monitored the movement of 1,153 PIT-tagged fishes from May 2010 through July 2011 and are using the resulting





One of the diversion structures that was studied on South Boulder Creek.

Photo by Matt Kondratieff

data to evaluate the efficiency of the fishways and compare movement rates in stream reaches with and without the structures. The preliminary analyses of the results suggest that while both fishways are capable of passing fish, the design of the structure does have a substantial effect on the numbers of fish that successfully move upstream.

The second phase of the study is an attempt to better understand the swimming performance of a diverse suite of small-bodied native fishes to determine if the species could be grouped into swimming 'guilds' based on their performance, morphology, and physiological characteristics. If successful, this approach will reduce the amount of time and effort needed

to develop passage guidelines for specific fish assemblages. These experiments involved measuring the swimming performance of more than 10 species of native fish,

**It does not take an instream structure of great height to form a barrier to the movement of fishes.**

including creek chub (*Semotilus atromaculatus*), plains topminnow (*Fundulus sciadicus*), and flathead chub. We used constant acceleration swimming trials to identify the speeds at which these species switched to a burst or sprinting swimming gait and

to generate a conservative estimate of their maximum swimming speeds. These trials were then followed by fixed velocity trials to measure the swimming endurance of the tested species. The results of these experiments are still being analyzed.

The final phase of the study took advantage of the capabilities of the hydraulics laboratory in CSU's Engineering Research Center, where we collaborated with Chris Thornton to design and build a test rock ramp fishway. This apparatus was then used to evaluate the ability of white suckers (*Catostomus commersonii*), longnose dace (*Rhinichthys cataractae*), and Iowa darters (*Etheostoma exile*) to successfully negotiate the fishway when faced with different

configurations of rocks within the channel. The results of this study are still being analyzed, but it appears that the stronger swimming species (suckers and dace) were not overly affected by the layout of the rocks, while the darters were.



The head of a burbot captured on Flaming Gorge Reservoir for fish barrier work.

Photo by Eric Gardunio

Taken together, the results from Ficke's work will represent the most comprehensive body of work on the swimming ability and passage requirements of fishes from Colorado's Front Range rivers and streams. The recommendations derived from those results should help engineers and fisheries biologists develop more fish-friendly instream structures and effective fishways, thus helping restore the connectivity that is a key part of the instream flow paradigm.

In general, restoring or maintaining longitudinal connectivity in a river or stream is considered beneficial, but there are some instances when biologists aim to intentionally sever that connectivity. One scenario in which this is a considered management option is when an upstream community of native fishes is threatened by downstream populations of nonnative fishes. The second example of FPEL work in the stream connectivity arena deals with just such a situation. Burbot (*Lota lota*), the only freshwater member

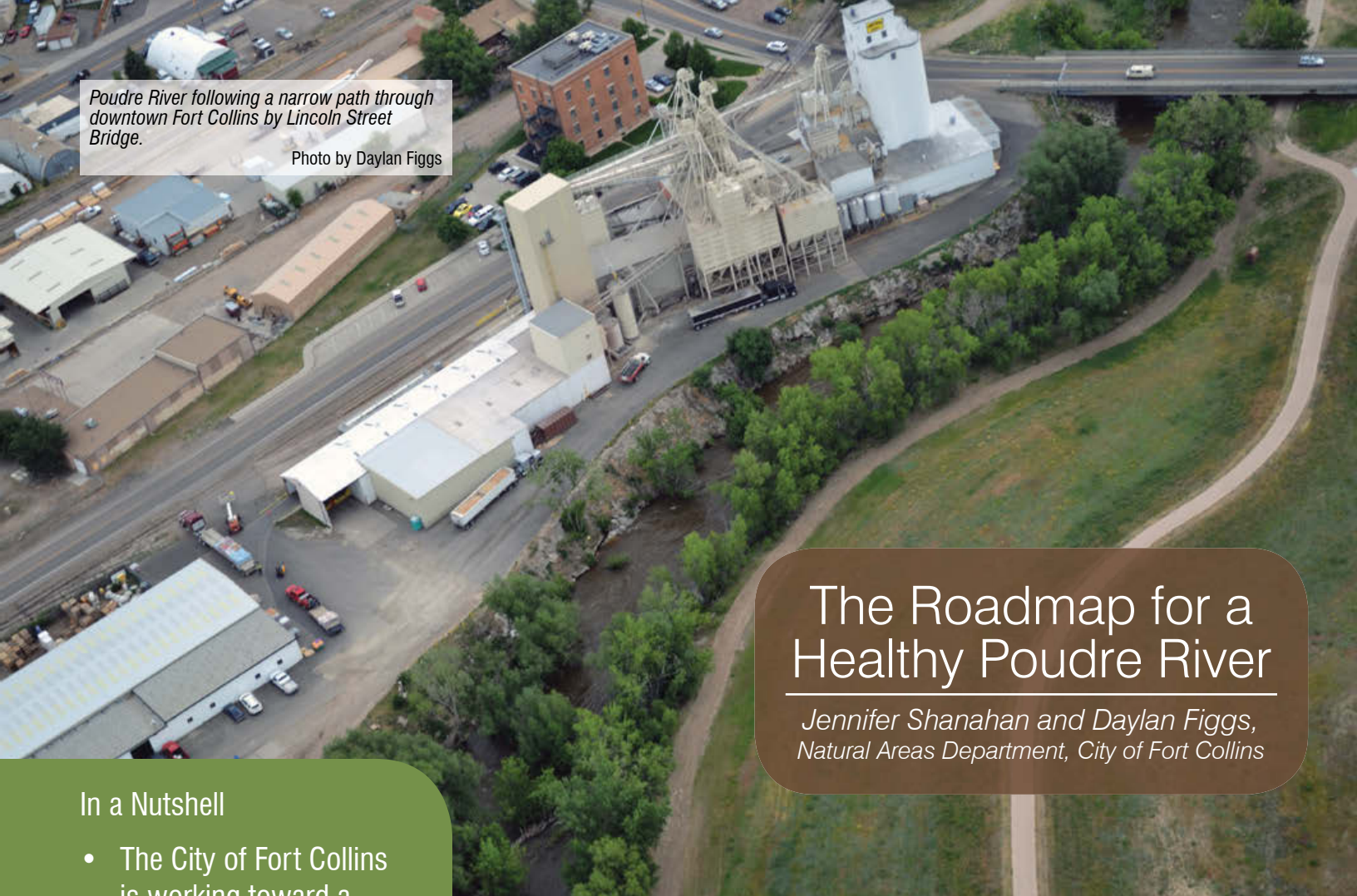
of the cod family, were illegally introduced into lakes that drain into tributaries of the upper Green River (Wyoming). Since their introduction, the burbot have spread downstream, rapidly colonizing new habitat. Where the habitat is particularly suitable, such as in Flaming Gorge Reservoir on the Wyoming and Utah border, the invasive burbot have flourished. Burbot are predators, and they pose a serious threat to native and sport fishes within the Green River system, including the bluehead and flannelmouth sucker (*C. discobolus* and *C. latipinnis*) and the roundtail chub (*Gila robusta*). The regional natural resources agencies, such as the Wyoming Department of Game and Fish, are very interested in developing barriers to the upstream movement of burbot to protect remaining populations of these fishes.

Eric Gardunio, a Master of Science student in the FPEL, is working on developing guidelines for effective barriers to the upstream movement of burbot and of another invasive species in the Green River system, the white sucker. He is using an interesting combination of techniques that are based upon earlier FPEL work—the jumping ability of the invasive species is being tested using the same artificial waterfalls that were developed by Matt Kondratieff for brook trout barrier design, and the swimming ability of the fish is being measured using a similar combination of constant acceleration and fixed velocity experiments as those used by Ficke. The burbot experiments require a slightly different approach than other fish tested in the FPEL because they are nocturnal and only become active after sundown. Thus, Eric and his technicians have essentially adopted the 'vampire shift,' arriving at the lab late in the afternoon, setting up the experiments as the sun goes down, and using cameras capable of recording under low-light conditions

to monitor the performance and behavior of the burbot. The results of this nocturnal effort have been promising, and it does look like there are combinations of vertical drop (e.g., artificial waterfalls) and high velocity streams that could be used to effectively protect upstream areas from invasion by burbot and white suckers.

Hopefully the two examples presented above provide a greater understanding of the FPEL's contributions to the development of tools for managing stream connectivity, and in turn, contribute to a well-designed instream flow program. The final, and perhaps most important, contribution of the FPEL to instream flow science in Colorado and the intermountain region is in introducing future fisheries biologists and resource managers to key tools and concepts. Every graduate project in the FPEL includes a number of undergraduate research assistants who are integral members of the field and laboratory research teams. At a broader scale, all of the undergraduate students in the Fisheries and Aquatic Sciences concentration of the Fish, Wildlife, and Conservation Biology major receive lectures on instream flows in sophomore and senior-level courses, and they gain experience measuring fish swimming and jumping performance in the hands-on laboratory sections of those courses.

Research on the movement of fishes has been and will continue to be a core mission of the FPEL, as will the training of future cohorts of fisheries biologists and resource managers. Projects such as those conducted at the FPEL have contributed to the knowledge used to make informed management decisions; our goal is to continue to do so in future years. ●



Poudre River following a narrow path through downtown Fort Collins by Lincoln Street Bridge.

Photo by Daylan Figgs

## The Roadmap for a Healthy Poudre River

Jennifer Shanahan and Daylan Figgs,  
Natural Areas Department, City of Fort Collins

### In a Nutshell

- The City of Fort Collins is working toward a healthier and more resilient Cache la Poudre River, including current projects like the Ecosystem Response Model to better understand river condition and a potential instream flow study segment

The City of Fort Collins (City) is situated along more than 10 miles of the Cache la Poudre River (River). The community has a high awareness and appreciation of the water supply and environmental amenities provided by the River, as well as concern for the River's long-term health and viability. The community's desire for a healthy river is expressed within the City's overarching

planning document, *Plan Fort Collins* (2011), through two key principles: "The City will support a healthy and resilient Cache la Poudre ecosystem and protect, enhance, and restore the ecological values of the River;" and the "City will work to quantify and provide adequate instream flows to maintain the ecological functionality, and recreational and scenic values of the Cache la Poudre River through Fort Collins."

A current priority for the City is to develop a roadmap to assure a healthy and resilient river ecosystem within the context of an increasingly urbanized landscape with increasing demands on the River for municipal water supply uses. To be successful, the map must link science to policy and deliver tangible benefits that address the public's expectations for a healthy and resilient river. One challenge for City staff is to understand what "river health" means

to the community. What can we do to maximize our understanding of that meaning through scientific and systematic investigations? How do we consistently combine community expectations for river health with scientific findings to inform management actions and policies? How do we balance those expectations with increasing water supply demands?

Ecologists hold extensive debates over the definitions of terms such as healthy, sustainable, and resilient. Municipalities, however, can approach these terms through the perspective of the community: Is the water clean? Are plants and animals thriving? Is the River taking care of itself now and through our grandchildren's generation? Does the River meet recreational needs of the community as well as its water supply needs?



*Natural Areas staff Rachel Steeves and Jen Shanahan explore the spring floods in the riparian forest.*

Photo by Rick Bachand

Responding to these interests on behalf of the community requires a comprehensive approach, from regional to local partnerships and across all disciplines of watershed management. On the landscape scale, and using science as a guide, we have initiated a study to help enhance our understanding of the drivers, threats to, and anticipated condition of indicator biota within the river system. The Ecosystem Response Model (ERM) under development for the Fort Collins reach of the River uses a multi-disciplinary approach to evaluating the system. It will foster a more informed dialog with a broad audience of stakeholders as to the current and anticipated use and condition of the River. Moreover, it will inform management and investment decisions. Built by a team of expert river scientists, the ERM is based on a wealth of accumulated knowledge of river science combined with local data. Expert knowledge

includes the overarching theory that flows are the master variable of the ecosystem, but there are a multitude of other variables related to the finer interactions occurring across the system, from microorganisms to cottonwood trees.

Preliminary results of the ERM indicate that the river system in Fort Collins has been changing for some time. Current flows, which reflect existing withdrawals for municipal and agricultural uses, are approaching the low end of flow thresholds that matter for scouring of algae, aquatic habitat, and channel maintenance. The modeling process also has shed light on other factors critical for the City to pay attention to, such as the poor functionality of hardened riparian habitats, water quality concerns related to contemporary land uses, and the connectivity of aquatic habitats.

Using the ERM to frame the issues, the City has charted a preliminary roadmap to move beyond an ecological framework into the operational “real” world. For example, two projects are in the works to evaluate and improve stream flows with respect to addressing both minimum flows and environmental flows. Additionally, the City is initiating a series of rehabilitation projects to enhance plant and wildlife communities within the river corridor.

The first streamflow project is intended to gain a better understanding of water management and administration of the River and how this management process influences the location and frequency of low flow and dry-up points as well as overall flow volatility. In the urban reach of Fort Collins, low flow concerns include dry up points, minimum flows required for survival

of aquatic organisms, volatility of low flows (or speed at which River flow changes), and optimal flow levels for aquatic wildlife to thrive through the seasons and reproductive cycles. The goal will be to identify management options that reduce or eliminate low flow conditions as well as moderate flow volatility.

In addition to low flows, high spring flows must be considered. Spring flows act as an annual detox by cleansing and refreshing aquatic habitat, scouring encroaching vegetation and providing critical overbank flooding and soil saturation of the riparian zone to ensure a productive forested corridor supporting recreational and habitat needs.

The second instream flow project has just begun, and entails a discussion with the Colorado Water Conservation Board about establishing an instream flow segment within Fort Collins. Within the defined segment, the City will use a combination of methods including R2Cross and perhaps the ERM to identify minimum flows necessary to sustain a healthy river and the environmental or “enhanced” flow needed to improve the ecological health of the River.

Obviously, without the engagement of the many actors in the basin, the City will not meet its goals. To this end, the City is participating in

a collaborative effort hosted by the Colorado Water Institute: the Poudre River Study Action Group. This group consists of multiple river stakeholders. The goal is to develop a dialog and working relationships across the spectrum of stakeholders and to identify common goals and actions beneficial for the River.

The City has begun to initiate other local projects to begin the long journey to improve river health by rehabilitating landforms, as well as improving aesthetics and connectivity of habitat. Projects are underway or are being planned to re-establish riparian forests and wetlands along the River. Additional projects are in the planning stages to make improvements to the river channel for recreation and aquatic wildlife species. Efforts include removing barriers to fish passage and improving in-channel habitat for fish and aquatic invertebrates. No one project or action will improve the River.

Progress will require many different actions. While the hope is that progress will not be centuries away, the success of this effort will need to be measured in decades and the level of effort required is significant.

The Poudre River, like any river, is a complex living system. Increasing its health and viability will be a complex and long-term project requiring a thoughtful, collaborative public-private process that mixes science, policy, and on-the-ground management. There is a tremendous amount of interest, energy, love, and knowledge of the River within the Fort Collins community. Understanding, designing, and implementing stream flows, in-channel, and bankside improvements that support the community’s goals of a healthy, resilient, and scenic Cache la Poudre ecosystem will not be accomplished without dedication and perseverance. ●



*Spring flows on the Poudre.*  
Photo by Natural Areas Department

# Impacts of Short-Term Rolling Average Diversion Limitations on Junior Water Rights

*Jordan Varble, Engineer in Training, Deere & Ault Consultants, Inc.*

## In a Nutshell

- **Study:** In the case of municipalities acquiring a ditch water right and adding water uses, this study looks into how junior water rights, which vary more year-to-year, are affected by a 20-year rolling average limit
- **Results:** Three scenarios with 10, 20, and 60-year rolling averages were evaluated—in the shorter two scenarios, diversions were less than the limit, but they reached the limit during the 60-year period, suggesting that a shorter time span decreases diversions

Municipalities commonly acquire shares of ditch company stock and change the use of the water rights represented by those shares in court to include additional uses, including municipal use. During this process, an outside consulting engineering firm that specializes in water rights cases is called upon to evaluate the historical and future uses, to develop future use terms and conditions to prevent injury to other water rights, and to serve as an expert witness in the court proceedings. One of the primary responsibilities of the engineer is to write an Engineering Report that describes the technical analysis of the

changes that the municipality (also referred to as the Applicant) seeks.

Twenty-year rolling average volumetric limitations on future diversions are very common in change-of-use cases, and the limitations have very different impacts on junior water rights than they do on senior water rights. This study addresses the impact of using 20-year rolling average volumetric limits on junior water rights.

## Engineering Reports

Engineering Reports contain a detailed history of the use of the subject water rights during a selected study period. This history typically includes ditch diversions, ditch losses, farm headgate deliveries, cropping patterns, farm irrigation efficiencies, crop consumptive use demands, soil moisture reservoir tracking, return flow amounts and timing, and an analysis of net stream depletions. These items are the ‘nuts and bolts’ of the analysis that are used to guide how the water rights can be used in the future by the Applicant.

Also included in the Engineering Report are proposed terms and conditions that are aimed at preventing injury to other vested water rights within the same river basin. Terms and conditions may include season of use, flow rate and volumetric limits (including monthly, annual and long-term limits), and return flow replacement obligations. The terms and conditions may be agreed upon by the objectors who have filed a formal opposition to the water rights application and have agreed to stipulate to entry of a decree, or else the application will be heard and decided upon by the judge.

A common term and condition found in the Engineering Reports is that during any consecutive twenty-year period, ditch diversions attributable to the water rights being changed to new uses by the Applicant shall be limited to a cumulative amount over a multi-year period. This is referred to as a rolling average volumetric limit. Typically the rolling average volumetric limit is equal to the average annual pro-rata ditch diversion or farm headgate delivery during the selected study period times some chosen number of years. The multi-year periods may be 10 years, 20 years, or longer. A 20-year rolling average volumetric limit is common. This term and condition began at a time when study periods were commonly 20 to 30 years in length. Therefore, it was appropriate that in any similar period of time, the municipal uses should not exceed the historical uses, and the length of the cumulative volumetric limit period was set to the length of the study period. However, it has also been common to simply adopt a 20-year period for the limit regardless of the length of study period. Study periods that are currently being used in expert engineering reports for pending court cases may be fifty, sixty, or even nearly 100 years long, while many terms and conditions continue to have a 20-year rolling average volumetric limit.

## Nature of Water Rights

Water rights in Colorado are commonly given the non-technical label of being either a “senior” or a “junior” water right. A senior water right may be able to provide a reliable water supply on a consistent basis, even during drought conditions. On the other hand, a junior water right may yield abundant water during wet

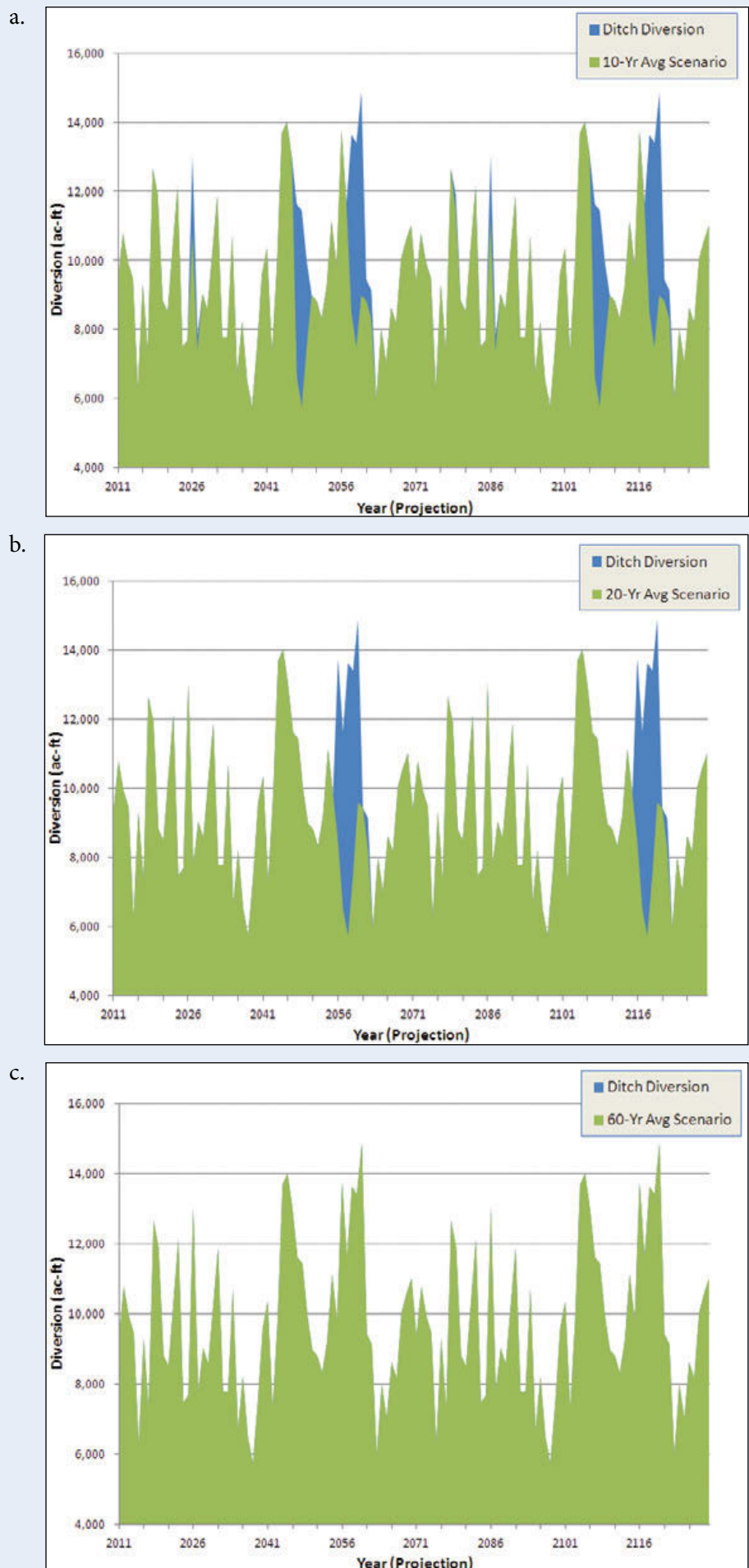
years but may have a very limited water supply available to it during dry years. When the senior right places a “call” on the stream in order to receive its decreed flow rate, it is the junior right that is “called out,” or shut off, so that the senior appropriation is satisfied.

Thus, the annual diversions of a senior water right may be nearly constant from one year to the next, while the annual diversions of the junior water right can fluctuate widely. Implementation of rolling average volumetric limits can have very different impacts on the future yield of junior water rights than on the future yield of senior water rights.

## Study Description

This study began by generating fictitious data of historical ditch diversions by a ditch that had wide swings in annual diversion amounts. Over a 60-year period, the average, minimum, and maximum annual diversions were 9,766, 5,751, and 14,862, acre-feet, respectively. As described previously, this wide range in annual diversions is typical of a junior water right. If this water right were being changed in water court, the applicant, or an objector, might recommend inclusion of a 20-year rolling average volumetric limit based on the previous 20 years times the 9,766 acre-feet per year average historical diversion. Under this limit, future diversions pursuant to the water right would not be allowed to exceed 195,320 acre-feet in any consecutive 20 years. Hence, the goal is that within any 20-year period, the future diversions would not average more than 9,766 acre-feet per year. Such a limit recognizes that yields vary from year to year and that yields in wetter years can make up for yields in drier years.

Figure 1. Hypothetical future river diversions by a ditch and river diversions limited by different scenarios: a. 10-year, b. 20-year, and c. 60-year.



To illustrate the impacts of this term and condition on a junior water right, future diversions were simulated using the same diversions as during the study period, but the years were rearranged and the time period was doubled to 120 years. Three scenarios were evaluated, with rolling average volumetric limit lengths of sixty, twenty, and ten years. In each scenario, the Applicant was allowed to divert an amount equal to the ditch diversion, with the exception that the average diversions could not exceed 9,766 acre-feet per year during the rolling average limit periods.

## Results

As shown in the graphs in Figure 1, there were many years where the Applicant's diversions under the 10- and 20-year scenarios were less

than the ditch diversion. Specifically, the illustration shows that on average, the future diversions as limited by the 10- and 20-year rolling average volumetric limits were six percent and five percent, respectively, less than the historical average ditch diversions. This occurs because a junior water right is supply-limited during dry years and needs the ability to divert large amounts during wet periods in order to achieve its average yield. However, the future diversions as limited by the 60-year rolling average volumetric limit were exactly the same as the historical average ditch diversions.

## Conclusions

The intent of terms and conditions on changes in water rights is to prevent injury to other vested water

rights. The goal of the rolling average volumetric limits is to limit the future uses of a water right to the average historical use of the right. This study has shown, however, that rolling average volumetric limits can unnecessarily restrict future amounts that the Applicant can divert from the stream if the period of time considered is too short. In the scenario that was run on a ditch with a relatively junior water right and wide swings in annual river diversions, the future diversions would be six percent less than would have otherwise been diverted if the rolling average period were the same length as that used in the historical study period. ●



## Recent Publications

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**The water cycle for kids; Neno, Stephanie; Morgan, Jim; Zonolli, Gabriele; Perlman, Howard; Gonthier, Gerard; USGS General Information Product: 146**

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**An economic value of remote-sensing information—Application to agricultural production and maintaining groundwater quality; Forney, William M.; Raunikar, Ronald P.; Bernknopf, Richard L.; Mishra, Shruti K.; USGS Professional Paper: 1796**

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**Application of sediment characteristics and transport conditions to resource management in selected main-stem reaches of the Upper Colorado River, Colorado and Utah, 1965-2007; Williams, Cory A.; Schaffrath, Keelin R.; Elliott, John G.; Richards, Rodney J.; USGS Scientific Investigations Report: 2012-5195**

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**Groundwater quality in the Colorado River basins, California; Dawson, Barbara J. Milby; Belitz, Kenneth; USGS Fact Sheet: 2012-3034**

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**Assessing the vulnerability of public-supply wells to contamination: Rio Grande aquifer system in Albuquerque, New Mexico; Jagucki, Martha L.; Bexfield, Laura M.; Heywood, Charles E.; Eberts, Sandra M.; USGS Fact Sheet: 2012-3138**

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**Groundwater quality in the San Francisco Bay groundwater basins, California; Parsons, Mary C.; Kulongoski, Justin T.; Belitz, Kenneth**

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**Hydrologic Data from the Piceance Basin, Colorado; Ficke, John F.; Weeks, John B.; Welder, Frank A.; Other Government Series: Colorado Water Resources Basic-Data Release - 31**



# Impact of Information on Household Water Use and Responsiveness to Utility Pricing Policies

## An Experimental Analysis

Liesel Hans, Ph.D. Candidate, Department of Economics, Colorado State University  
Christopher Goemans, Department of Agricultural and Resource Economics, Colorado State University  
Stephan Kroll, Department of Agricultural and Resource Economics, Colorado State University

### In a Nutshell

- Study: How do water users respond to increased access to daily use and/or pricing information?
- Hypothesis: Due to use uncertainty, households use less water to stay under budget—regular feedback would minimize uncertainty and potentially increase use
- Experiment: Participants interact with a computer interface, making decisions (with real money at stake) similarly to how they would make water-use decisions
- Results: Analysis suggests that more frequent feedback results in increased water use, regardless of the type of rate structure

In 2012, much of Colorado experienced severe drought and was reminded that even the most senior of water rights are ultimately at the mercy of Mother Nature. We can expect that increasing climate variability will continue to result in unpredictable water resources. At the same time, Colorado population is expected to increase by 30 percent with municipal and industrial (M&I) water demand to increase by 32 percent between 2013 and 2030. Climate and population pressures will require water providers to persist in their efforts to improve efficiency. Two opportunities are supply system efficiency and demand-side management (DSM) policies that promote households to use water more efficiently. Our research explores how developments in information technologies (IT) will impact consumer responsiveness to utility DSM policies.

The information technology (IT) development—advanced metering systems—creates a two-way stream of real-time information: utilities can monitor the supply system, and households can monitor their use. Utilities can use this “smart meter” technology to detect leaks, understand time-of-day consumption patterns, and improve demand forecasts, all of which can lead to a better understanding of consumer responsiveness to policies. A secondary impact that often lags these initial uses of smart meters is the communication of this data *back* to the households. Households can have access to more frequent information

on use and cost through an in-home display or a Web portal. This is the development that motivates our research: smart meter technology can enable participants to see how much water they are using throughout the billing period, information that is currently unavailable to most households. Customers need to be provided with regular and coherent information in order to understand the relationship between their actions, water use, and eventually their bill.

One popular DSM policy is the use of conservation-oriented rate structures, specifically increasing block rate structures (IBRs). These are rate structures and billing systems designed to encourage water conservation and promote efficiency in a fiscally responsible manner—one that still maintains stable and sufficient revenue for things like expensive capital maintenance projects. With an IBR, water consumption in a billing period beyond a threshold level results in a higher price for all gallons consumed beyond the threshold or “block boundary.” Effective use of this tool requires both the successful communication of the rate structure and an understanding of how households will respond to changes in prices. Surveys show that the average consumer has little knowledge of their own water use or the prices they face. This study investigates to what extent households will change their behavior if they are given more frequent information about their water use.

Photo by Rob K.

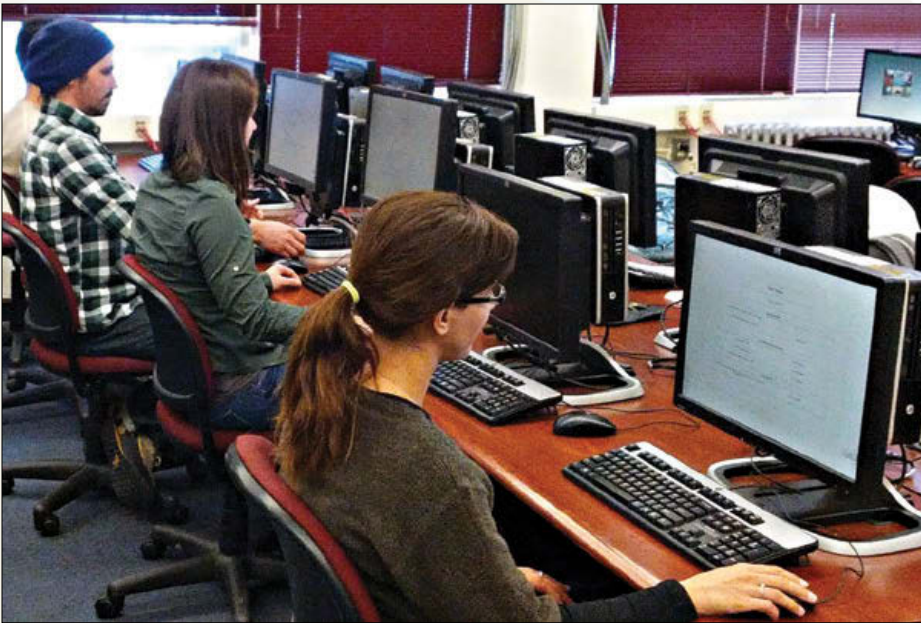


Figure 1. Subjects participating in experiment.

Photo by Chris Goemans

Trends show that water utilities are beginning to replace traditional meters with advanced metering systems. Examples exist in Colorado, including Aurora, Boulder, and Fort Collins. Surveys have shown that residential customers want more detailed information; households desire knowledge on how to be more efficient and how to reduce their utility bills. The question is: how will providing households with more frequent water use feedback impact their (a) consumption levels and (b) responsiveness to utility pricing policies?

We use an economic experiment to simplify the real world setting of interest: residential water use. The laboratory experiment allows us to isolate the effect of providing households regular feedback on their water use *within* a billing period

versus only providing information through a monthly bill.

Why use experimental techniques? Few utilities are already taking advantage of the utility-to-household smart meter communication opportunities, and even where these data exist, household level data are often protected for privacy. Beyond these barriers to accessing “real world” data, it is difficult and costly to apply different treatments (like different bill design, bill frequency, or prices) to different subsets of customers. A laboratory experiment is a great, low-cost way to avoid these complications and still study the question at hand. The experiment results give insight into how water consumers may respond to the additional information, and then provide guidance to actual utility demand-side policy construction and implementation.

Previous studies are mixed on the effect of increasing information to households through more frequent feedback.

Initial intuition might suggest that more frequent feedback would promote conservation. However, this doesn’t always appear to be the case—especially when households face complicated rate structures such as IBR. For example, while some electricity smart meter studies suggest that feedback reduces consumption, others show that households do not reduce but simply redistribute energy use away from peak-pricing periods of the day. Currently, only a few cities have invested in smart meters for water monitoring, resulting in very few studies on the effect of feedback on water use. However, one recent example in Aurora, Colorado shows that households having access to more frequent information through smart meter interfaces actually *increased* water use on average.

More research is needed in this area to better understand why information may encourage decreased consumption in some settings, but increase consumption in others. This research contributes by studying the effect of feedback across both conservation and non-conservation rate structures.

Using economic theory to guide our investigation, we explore how two types of households (low- and high-volume users) might respond to more frequent information. Low-volume users represent those households who would, under normal conditions, consume below the block boundary, whereas high-volume users represent those households whose water use would normally exceed the block boundary. Under the typical monthly billing system, households only receive information on their water use when paying their bill at the end of the period. The relationship between a month of varied water-consuming activities and the corresponding cost is not always obvious to households. Households are uncertain as to how much water they are using at any

Table 1. Price elasticity across low- and high-volume household types facing the non-conservation price schedule

User Type	Price Elasticity	
	No Feedback	Feedback
Low-Volume	-0.38	-0.26
High-Volume	-0.34	-0.20

point over the course of a billing period; we refer to this as “quantity uncertainty.” Without the ability to track water use within the period, we hypothesize that the risk of spending too much and going “over budget” causes households to consume less than they otherwise would. Providing households with regular feedback would minimize that risk and therefore potentially increase water use.

Furthermore, when facing a conservation-oriented rate structure, quantity uncertainty induces price uncertainty: the low-volume using household faces the risk of unintentionally consuming in a higher-priced block, while the high-volume using household has a chance that their consumption is less than expected, and in turn the marginal cost of water is less than expected. For the low-volume household, the presence of an IBR likely enhances the fear of going over budget, while muting the effect for high-volume users.

All of the above assumes households are fully aware of the price schedule they face and make decisions consistent with traditional economic theory. Another possibility is that, upon being able to monitor water use levels, households may instead give greater weight to the new information on quantity and in turn become less responsive to prices. They see block boundaries as “target” levels of consumption. If this is the case we would expect water use for both types of users to gravitate toward block boundaries. For low-volume users this would mean an increase in average water use; a decrease for high-volume users.

In the experiment, participants interact with a computer interface, making decisions (with real money at stake) similarly to how they would make water-use decisions.

The experiment is designed to illuminate how the participants’ choices change when they receive information similar to the current status quo monthly billing structure versus when they receive more frequent information, like what smart meter technology is capable of providing. We also study the effect of the information treatment under different price structures.

Preliminary analysis of the data suggests that more frequent feedback results in increased water use, regardless of the type of rate structure. When facing an IBR, consistent with our hypothesis, more frequent feedback increased water use, on average, by three percent for low-volume users and two percent for high-volume users. The effect of feedback on responsiveness to price was mixed. When facing non-conservation rate structures (a constant per-unit price), and for small price changes under an IBR, participants were significantly less responsive to price when they had access to the frequent within-period

water use information. Evidence of this can be seen in Table 1, which provides estimates of price elasticity across both household types when facing the non-conservation price schedule.

In treatments where participants faced an increasing block rate structure, the feedback caused participants to target the block boundary quantity: users that were below (above) the boundary increased (decreased) water use. For Figure 2 we calculated a normalized “distance” from each participant’s water use to the block boundary, with and without feedback—if the distance is negative, they consumed in the first block; if the distance is positive, they consumed in the second, high-priced block. Figure 2 shows how the distribution of water use moves toward the block boundary when participants had access to the within-period feedback. This behavior is consistent with our hypothesis that with feedback, participants would alter their behavior to focus on consumption levels rather than prices.

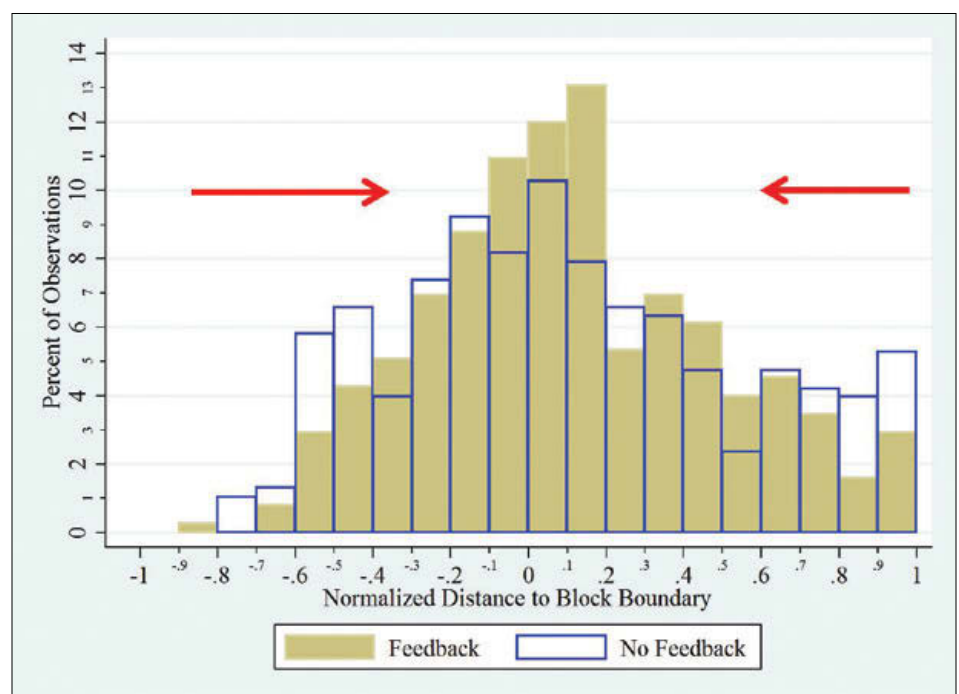


Figure 2. Difference between actual water use and block boundary for all participants normalized by the block boundary. Values represent consumption as a percent of the block boundary. Negative (positive) values indicate consumption was below (above) the block boundary.

# Putting Water Back Into the Rivers We Love



*Christine Hartman, Communications and Development, Colorado Water Trust*

## In a Nutshell

- Based on Colorado Revised Statute 37-83-105 and voluntary water leasing, Colorado Water Trust was able to ultimately package six water rights into four water leases during the 2012 water season
- The first approved water for the program reached the Yampa River in July of 2012

When my husband and I sat down a few years back to talk about where we would live, water availability was not a factor we considered. Understanding that I'm one of those people who moved to Colorado—30-40,000 or so have in each of the past seven years—I know I'm part of the growing population putting pressure on Colorado's water resources. But I don't ever want to live anywhere else, and I can't think of much I love more than being out on a river. When I shoehorned my way into a position at the Colorado Water Trust (CWT), I had no idea that my first year there, 2012, would be CWT's fastest-paced year to date.

My previous experience with water comes from working as a raft guide in Grand Canyon. When I moved to Colorado to leave the seasonal life, I wanted to do work that I thought would benefit rivers—I just wasn't sure how to do that until I met Amy

Beatie, executive director of the Colorado Water Trust.

The Colorado Water Trust was formed in 2001 by a group of water lawyers and water engineers. Our founding Board of Directors spent their working hours moving water out of rivers and streams, and in their spare time, some of those same people helped create the laws and mechanisms that would allow water to be moved back into rivers for environmental benefits. When I started volunteering at the Colorado Water Trust, I barely knew what an Instream Flow water right was, and I didn't realize that Amy had, in hand, an ambitious plan for CWT's future.

After playing chief cook and bottle washer for her first few years at CWT, Amy hired Zach Smith in 2010 with the help of Colorado Conservation Trust's Future Conservation Leaders fellowship program. As an attorney, Zach would help with the legal work involved in water rights transactions. Along with Ellen Olson, CWT's part time operations and communications coordinator, the CWT staff and Board underwent a strategic planning process. The message that came out of the process was clear: Grow. Do more, and do it faster.

Fast was the operative word. Amy grew the CWT staff with lightning speed. In September 2011, Scott Hummer joined CWT as the new projects manager. Twenty-five years of experience administering water in the Blue River Basin made him a natural fit for the position. I was hired in October as the full-time operations and communications coordinator. Amy figured that if, while guiding in Grand Canyon, I could tell stories about natural and human history,

keep guests safe and fed, and keep ice in my cooler for two weeks at a time, I could take care of CWT's needs.

Anne Janicki, water transaction specialist, formally joined the CWT staff in January 2012 after contracting with the Trust periodically over the years. Anne worked in the Colorado Water Conservation Board's Instream Flow Program for over 20 years, and CWT jumped at the opportunity to bring her skills in house. After CWT's success in evolving Zach from CCT fellow to full-time staff attorney, Colorado Conservation Trust agreed to grant us another fellow. CWT chose Edalin Koziol, a Vermont Law School grad with Master of Science in aquatic sciences, environmental policy, and conflict resolution, and experience in geographic information systems and publishing. Edalin joined in March.

While CWT was growing to meet demand, demand was staring back at us in the shape of bare mountains. In March 2012, after watching the Snotel Snowpack Update Maps turn from beige to yellow to orange to red, it became obvious that Colorado's spring snows weren't materializing. The newly assembled CWT staff felt that Colorado Water Trust had to have a plan for rewatering streams during the impending drought. If we didn't have a plan, we might as well all go home and close up shop.

Most anyone familiar with the Colorado's Instream Flow Program was aware of a state statute, C.R.S. 37-83-105, that would allow us to legally move water back into rivers under some circumstances. Although the statute had never been used before, it was the best tool we knew of for the job. After Colorado

suffered through extreme drought conditions in 2002 and 2003, state legislators crafted the statute to allow water practitioners to fill water-short instream flow rights quickly and administratively. In about six weeks' time, CWT staff studied the statute, met with our colleagues and partners at the Colorado Water Conservation Board and the Division of Water Resources, and lined out the screening and approval processes we thought we would need to utilize the statute.

Any water right we wanted to lease would have to meet the strict criteria laid out in the statute. We had to guarantee that the administrative approval would not injure other water users. We only wanted to lease water rights that would have water available in a dry year, so we were looking for the best direct flow and storage rights around. Ideally, we wanted water rights large enough to make an appreciable difference to flows in the local system. A leased water right would need to be able to be delivered

to fill an existing but water-short Instream Flow water right, so location and geography were major

considerations. And we would need to find a way to connect with the "right" water rights owners and offer a compelling reason to those people to offer their water for lease, voluntarily.

If you have experience with Colorado water law and water court, you know that most water lawyers and engineers are dealing with timelines on the scale of years rather than days or weeks. Those who live this work call it "Water Time." When rivers are reduced to a trickle, fish, bugs, and streams don't understand those timelines. Of course, some species have evolved to survive drought conditions. In most of the West, though, river and stream systems are elaborately plumbed, and some reaches are perennially dewatered. Stream ecosystems are forced to weather drought conditions in even wet years as water is diverted away from riffles and runs for beneficial use.

The prior appropriation water law system is all about seniority and priority, echoed in the adage, "first in time, first in right." CWT isn't trying to change that. On the list of things I respect most about CWT are the organization's methods—voluntary

and market-based—and its respect both for the current allocation system and private property rights. CWT works within existing water law and without conducting any advocacy. We raise money to buy or rent water to put back into rivers, and we believe that Coloradoans care about wet, flowing rivers enough to support them financially. This past year, CWT supporters proved us right.

When we started talking about the Request for Water 2012 pilot water leasing program as a way to help streams during the drought, we weren't sure exactly what would happen. Neither were the water rights owners who were courageous enough to pilot our program. We were raising money as we went, and irrigators who considered the program weren't always convinced that we had the money to lease their most valuable assets. We talked about water leasing as a way to provide another revenue option for water rights holders, and we were met with concerns about fallowing fields or losing commodity customers. People who were unfamiliar with



*On October 1, CWT received El Pomar's Robert V. Menary Award for Excellence in Environmental Issues. Pictured: Lee Rozaklis (CWT Board Vice President), Amy Beatie (CWT Executive Director), Michael Browning (CWT Board President), Zach Smith (CWT Staff Attorney), Peter Maiurro (Vice President, El Pomar Foundation).*

Photo courtesy of El Pomar Foundation



Left: Water is being released from Stagecoach reservoir. In an unprecedented contract among the Upper Yampa Water Conservancy District, the CWCB, and CWT, CWT leased 4,000 acre-feet of water from Stagecoach Reservoir upstream of Steamboat Springs to bolster flows in the Yampa River. This lease, formally approved on July 11, 2012, was our first Request for Water success. July 2012.

Photo by Scott Hummer

Below: Anglers fish in the Yampa River near Sarvis Creek, enjoying bolstered flows from a water lease. July 2012.

Photo by Scott Hummer



CWT didn't want us to look at their water rights portfolios because they didn't understand our motivation. Some were concerned about what we might unveil during the water rights screening process.

In spite of these stumbling blocks, the Colorado Water Trust was offered 87 water rights for lease, located in six of Colorado's seven Water Divisions. Initial screening left 56 water rights standing, which were then subjected to HCU (historic consumptive use) and groundwater modeling analyses. Thirteen water rights passed the engineering review and ultimately, we packaged six water rights into four water leases in the 2012 water season. The first drop of administratively approved water hit the Yampa River on July 11, 2012. Over 190 river miles saw additional water that would not have otherwise been in those reaches. When we talk to people who have worked in the Colorado water industry for years, they're astonished by how quickly the pilot program hit the ground. We're thrilled to have developed a new tool.

So what's next? The most recent issue of *Headwaters* magazine, published by the Colorado Foundation for Water Education, has an advertisement on the back that says, "Conservation works. Snow dances don't." In Colorado, this "conservation" piece is an ongoing conversation, and one I don't have the expertise to get into. But I do know that in a water rights system bound by priority, geography, injury, historic conditions, and litigation, the short-term leasing statute provides unusual flexibility. The statute allows CWT to offer some water rights owners an additional option for what they may do with their water in a given year and money if they decide to lease water to put instream. After piloting the program and testing the process, we're looking ahead to 2013.

Right now, Colorado's snowpack isn't accumulating in the way we'd hoped, especially after a dry year. Rivers and streams may see shortages for a second year in a row and for some in this state, the dry spell has been much longer. The CWT team wants to lease water again. We want bigger, more strategic leases that will keep Colorado rivers flowing. But this only happens if our Colorado community wants the same things. Do people across Colorado and the West care enough about the health of rivers to make them a priority? I think so. I'd still rather wake up on a boat, but I wouldn't trade that for my new position with CWT where I get to help put water into Colorado's rivers. ●

Colorado Mountain College partners with the USDA Forest Service to implement forest restoration surrounding Evergreen Lake, Leadville National Forest Hatchery.  
Courtesy of CSFS

## Forest Restoration Program Protects Watersheds, Reduces Wildfire Risk

*Naomi Marcus, Forest Stewardship Coordinator, Colorado State Forest Service*



Since 2007, a single grant program administered by the Colorado State Forest Service has helped mitigate threats to watershed health on more than 12,000 acres across Colorado, with more acres being treated every year.

The Colorado Forest Restoration Pilot Grant Program helps fund projects that demonstrate a community-based approach to forest restoration. The program first began in 2007 when the Colorado General Assembly, expressing interest and concern for the health of Colorado's watersheds, authorized funds to support forest restoration in Colorado communities to protect local watersheds and water supplies. The Colorado State Forest Service administers what is now referred to as the Forest Restoration Grant Program, which issues grant

awards that have resulted in the treatment of thousands of acres of forest land across all land ownerships.

Projects that receive funding mitigate threats that affect watershed health, such as the build-up of wildland fuels that increase the risk for a severe wildfire. Large, intense wildfires negatively impact watersheds through increases in runoff and erosion, diminished water quality, and accelerated loss of snowpack.

A primary purpose of the grant program is to encourage diverse local stakeholders to work together to develop forest restoration proposals that protect critical water supplies and address related forest health challenges such as wildfire risk reduction, community protection, ecological restoration, and woody biomass utilization.

### The Legislation Behind the Program

The Forest Restoration Pilot Program first emerged during the 2007 legislative session with House Bill 1130, the Colorado Forest Restoration Act. This act authorized funding to support the Forest Restoration Pilot Program, which responded to the Colorado General Assembly's interest in creating a pilot program to demonstrate community-based approaches to forest restoration. During the 2008 legislative session, Senate Bill 071 was authorized to sustain the pilot program, and in 2009, this pilot program continued through the Colorado Healthy Forests and Vibrant Communities Act of 2009.

Funded projects must meet specific criteria. The state share of the total project cost may not exceed 60 percent per project. Grant recipients are required to match at least 40 percent of the total project cost through cash, stumpage, or in-kind contributions. All projects must be associated with a completed Community Wildfire Protection Plan that has been approved by the Colorado State Forest Service. Additionally, projects that involve the Colorado Youth Corps Association or another accredited Colorado Youth Corps receive additional consideration. Approximately 50 percent of the awarded projects employed the Colorado Youth Corps Association in project implementation.

All funded projects address the program's primary objective of protecting water supplies and related infrastructure, and many of the projects also reduce the threat of large, high-intensity wildfires, preserve old and large trees where ecologically appropriate, and involve the replanting of trees in deforested areas. Some projects even support local communities and the timber industry by providing or selling forest products removed from the project areas.

The other criteria that projects are evaluated on include:

- Compliance with all applicable federal and state environmental laws
- Involvement of a diverse and balanced group of stakeholders in the design, implementation and monitoring of the project
- Incorporation of current scientific forest restoration information
- An assessment of existing ecological conditions of the proposed project area, as well as the desired future conditions

## Partnering to Accomplish Watershed Protection

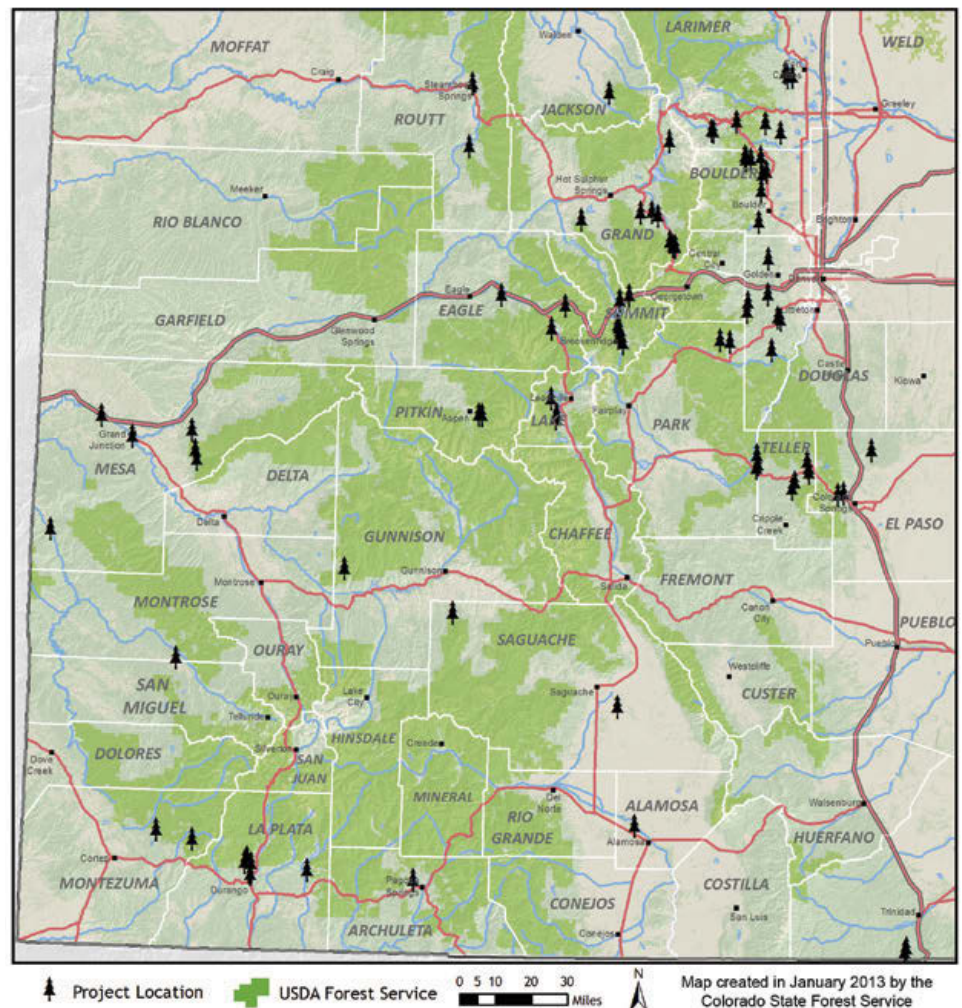
The accomplishments achieved through the Forest Restoration Pilot Grant Program are numerous. Projects have been implemented in 23 counties across the state. The program has awarded more than \$4.7 million of state funds and \$1 million of leveraged federal funds to 86 projects across the state, which additionally leveraged more than \$8 million to restore forests on over 12,000 acres. There are 17 projects currently in progress, and the CSFS anticipates these projects will treat an additional 1,200 acres. Projects range from ponderosa pine forest restoration to eradication of non-native tamarisk

and Russian olive trees in riparian ecosystems.

## More Watershed Protection to Come

Because this program has successfully brought dozens of communities together to protect forested areas from severe wildfire and other forest health concerns that ultimately impact water supplies, the Colorado General Assembly authorized an extension during the 2012 legislative session. House Bill 1032 will provide state funding for projects that continue the spirit of the original Forest Restoration Pilot Program. Stay tuned to learn more about riparian restoration and watershed protection efforts.

## Colorado Forest Restoration Grant Projects



Forest Restoration Pilot Grant Projects, 2007 to present.

Courtesy of CSFS



## Colorado Forest Restoration Pilot Grant Program: Funded Projects

Below is a list of awarded projects, organized chronologically by year of funding and the respective legislation:

### 2007 (HB07-1130):

- Dalla Park Fire Mitigation, La Plata County
- Forest and Community Protection Plan, Lake County
- Grand Junction Watershed and Fuel Reduction Program, Mesa County
- Grand Lake Beetle Kill Removal Project, Grand County
- Heil Valley Ranch 2008 Fuels Reduction–Unit 2, Boulder County
- Horsetooth Mountain Park Fuels Reduction, Larimer County
- Platte Canyon Fire/Forest Restoration and Water Protection Project, Park County
- Santa Fe Trail Ranch Fuel Break Project, Las Animas County
- Straight Creek Forest Restoration Project, Summit County
- Summit County Hazardous Fuels Reduction Project, Summit County
- Upper South Platte Watershed Forest Health Initiative, Park and Teller counties
- West Vail and Lower Gore Creek Fuel Reduction Project, Eagle County

### 2009 (SB08-071):

- Boulder Mountain Fire Mitigation, Boulder County
- Carter Lake Forest Restoration Project, Larimer County
- Collaborative Project for South Ridge Preservation, Routt County
- Cook Mountain Fuelbreak, Boulder County
- Dalla Park Fire Mitigation, La Plata County

- Elk Valley Estates HOA, Teller County
- Garden of the Gods Forest Restoration-Buckskin North, El Paso County
- Garden of the Gods Forest Restoration Program-Tag on Project, El Paso County
- Gordon Jackson Foundation, Teller County
- Grand County Hazard Tree Removal Along Road ROW, Grand County
- Homestead East, Jefferson County
- Horsetooth Mountain Open Space Forest Restoration, Larimer County
- Little Vasquez Creek Forest Health Project, Grand County
- Red Cliff Hazardous Fuel Reduction Project, Eagle County
- Rick Colyer Fuel Break, Teller County
- Santa Fe Trail Ranch/Wooton Ranch Shaded Fuelbreak, Las Animas County
- Snow Mountain Ranch Bark Beetle and Fuels Reduction, Grand County
- Straight Creek Watershed Protection Project, Summit County
- Streamside Forest Restoration Project, Jefferson County
- Summit County Fuels Reduction Project, Summit County
- Swan River Valley Protection Plan, Summit County
- The Meadows at Stagecoach, Routt County
- Tripp Gulch Fuels Treatment Project, La Plata County
- Upper Arkansas Watershed Hazardous Fuels Reduction and Pine Beetle Mitigation, Lake County
- Upper South Platte Forest Health Program, Teller and Park counties
- West Woodland Park Fuel Break, Teller County

- Woodland Park Healthy Forest Initiative, Teller County

### 2010 (HB09-1199, Round 1):

- Bellyache Ridge Hazardous Fuel Reduction Project, Eagle County
- Buffalo Creek Forest Health Plan, Jackson County
- Dalla Mountain Park Fire Mitigation, La Plata County
- Deer Creek Watershed Restoration, Park County
- Deer Mesa/Mailbox Subdivision Fuels Mitigation and Watershed Protection Project, San Miguel and Montrose counties
- Estes Park Center Fuels Reduction/Fire Mitigation, Larimer County
- Grand County Hazard Tree Removal Along Road ROW, Grand County
- Grand Junction Watershed Protection and Fuel Reduction Program-Phase II, Mesa County
- Greenbelt D Continued Firebreak, Grand County
- Heil PA5 Forest Restoration Project, Boulder County
- Palisade Watershed Fire Mitigation Project, Mesa County
- Ralph Price Reservoir Northwest Forest Thinning, Boulder County
- Shamrock Ranch Phase IV Mitigation, El Paso County
- Town of Breckenridge/Summit County Fuels Reduction and Watershed Protection Project, Summit County
- Watson Island Restoration Project, Mesa County
- White Ranch Open Space Park Forest Restoration and Watershed Protection, Jefferson County
- Upper Fraser Forest Health Project, Grand County

### 2011 (HB09-1199, Round 2):

- Arrowhead Project, Gunnison County

- Brook Forest Community/Stransky Ranch, Jefferson County
- Chimney Hollow Open Space, Larimer County
- Dolores River Partnership Project, Mesa County
- Heil Valley Ranch 2011 Forest Restoration/Fuels Reduction Project: PA5 and PA7, Boulder County
- Kerber Creek Restoration Project, Saguache County
- Rattlesnake Gulch, Boulder County
- Rock Springs Fuel Reduction and Timber Stand Improvement Project, Montezuma County
- Smuggler Mountain Open Space Forest Management, Pitkin County
- Town of Breckenridge & Summit County Fuels Reduction and Watershed Protection Project, Summit County

- Upper Fraser II Forest Health Project, Grand County
- WPHFI Forest Restoration Project & Hayman Recovery Project, Teller and Park counties

### 2012 (HB09-1199, Round 3):

- Watson Island Restoration Project, Mesa County
- North Fork Watershed Pilot Restoration Project, Jefferson County
- 2012 Alamosa County Riparian Improvement Project, Alamosa County
- West Ranch Forest Restoration Project, Jefferson County
- Dinero Mining Area Forest Restoration Project, Lake County
- Rock Springs/Little Carver Fuel Reduction and Forest Health Project, Montezuma County
- Cloman Park Restoration and Trail Project, Archuleta County

- Gold Basin WUI Forest Restoration, Saguache County
- Estes Park Center Fuels Reduction/ Fire Mitigation, Larimer County
- Bison Dr, Boulder County
- 2012 Lory State Park Fuels Reduction, Larimer County
- Cooper Creek Forest Health Project, Grand County
- KZ Ranch Mountain Community Forest Restoration & Wildfire Mitigation Project, Jefferson County
- Pinewood Reservoir County Park, Larimer County
- Pine River Valley Watershed Protection and Fuel Mitigation Project, La Plata County
- Powerline Fuelbreak, Boulder County
- Benedict Huts Forest Restoration, Pitkin County ●

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Colorado State University  
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Workshop participants were from throughout Afghanistan, and represented the best and brightest of the country's irrigated agriculture professionals. Here they discuss and practice soil moisture measurement techniques in an onion micro-spray demonstration at the Badam Bagh Farm.

Courtesy of Denis Reich



## Irrigation Outreach in Afghanistan Exposure to Afghan Water Resource Challenges

Extension

*Denis Reich, Water Resources Specialist (Western Slope), Colorado State University Extension,  
Colorado Water Institute*

*Calvin Pearson, Senior Research Agronomist, Fruita Research Center, Soil and Crop Science,  
Colorado State University*

In recent years, Afghanistan has emerged from the obscurity of its remote South Asian location to become one of the most scrutinized nations on earth. Perched on the southwestern corner of the Himalayas, its topography includes a range of elevations such as the remote valleys and steep peaks of the Hindu Kush range. As Afghanistan and its allies embark on an ambitious nation building effort, its agricultural sector is seen as the linchpin for hastening recovery and sustainable growth. As communities rediscover their entrepreneurial spirit after years

of being trapped in survival mode, local agriculture and reliable access to irrigation water has become the subject of increased attention and investment (TAF 2006).

That irrigated agriculture could be a key piece in the Afghan recovery puzzle was evidenced by the invitation extended to Colorado State University (CSU) Extension<sup>1</sup> and CSU Agricultural Experiment Station (AES)<sup>2</sup> to lead a six-day train-the-trainer workshop on irrigated agriculture for Afghan irrigation and agricultural professionals. CSU staff in cooperation with the U.S. Department

of Agriculture Foreign Service, and the Afghan Ministry for Agriculture, Irrigation, and Livestock (MAIL), organized a series of workshops at the Badam Bagh Farm in July of this year outside Kabul to train federal and provincial extension personnel on the latest techniques and science in irrigated agriculture.

Most of the workshop participants were serving farms of less than 20 hectares with the interest in irrigation focused on lower valley communities, where wheat is typically the dominant crop.<sup>3</sup> In the higher elevations, larger tracts of land are prepared for hardier

<sup>1</sup> Represented by Denis Reich – Water Resources Specialist, Colorado Water Institute.

<sup>2</sup> Represented by Dr. Calvin Pearson – Senior Research Agronomist, Fruita Research Center.

<sup>3</sup> Wheat is seen as the most suitable replacement for opium poppy. Illicit opium poppy production is proving hard to eliminate due to its drought tolerance, high returns, and low inputs.



*Workshop co-coordinator Denis Reich of CSU Extension observes a group of workshop participants delivering their final group project presentation. Denis is dressed in traditional Afghan jama and waistcoat.*

Courtesy of Denis Reich

small grains such as barley to be watered by snowmelt or spring rains. Fruits and nuts are also a common compliment to upland agriculture where tillage is not feasible. Livestock (mostly cattle and goats) management usually involves moving herds to summer grazing pastures and stalling over the winter (Barfield 2010).

In spite of the contrast between the insecurity of rural Afghanistan and the serenity of the inner mountain west here in the United States, it made good sense that irrigation expertise from Western Colorado was invited to assist with the educational aspect of Afghan on-farm water management. The irrigated areas of the Upper Colorado Plateau share many similarities with Afghanistan: extensive high altitude runoff irrigating dry, arid valley bottoms concentrated with alkaline, clay soils

(and plenty of bindweed); many hectares of wheat, orchard fruits, melons, onions, and alfalfa, with some corn, and a plentiful mix of livestock.

As the workshops progressed, the traditional roles of workshop instructor and participant were gradually replaced by a more collegiate atmosphere and open exchange of experience and knowledge. Field visits<sup>4</sup> enhanced this interaction, including hands-on examination of live systems. CSU representatives were able to learn more about the nuances of Afghan agriculture and the priority of concerns from within the four major basins. Maintaining effective programming despite onslaughts of persistent provincial violence was the primary concern for most attendees. Utilizing Afghanistan's water optimally is a key piece of the nation's

security status. Even with reprieves from the violence, water security problems (usually caused by conflict) also compromise efforts to permanently stabilize the region (Qureshi 2002). While few would dispute such a salient observation, it's a little harder to define "water security" in the Afghan context. Here in Colorado water users are often comforted by their own ambivalence to this "most precious resource," which perhaps explains why water in the Western United States often "evades institutional classification and eludes legal generalizations" (Wolf 1999). In

Afghanistan long and healthy lives are still a rare commodity, so most Afghans are yet to enjoy the luxury of academic debates over their water resources future. Small incremental improvements are often received with much joy and gratitude.

As the workshop progressed, additional hands-on sessions were used to strategize effective technology demonstrations, new methods for measuring crop water use, and effective irrigation scheduling. The workshop agenda focused on end users who are already benefiting from recent equipment upgrades. The objective for workshop participants was to ensure this group of irrigators translates these improvements into yield increases.<sup>5</sup>

<sup>4</sup> The MAIL Badam Bagh Research Farm (the workshop venue) was initially established and managed by the United Nation's Food and Agriculture Organization after the Taliban was removed from power.

<sup>5</sup> USDA ERS 2006 report on improving wheat yields in Afghanistan—the nation's most dominant crop—suggests that even with promising post-war yield recovery, there is still potential for further improvement.

At visit's end it wasn't clear who had benefited the most. The experience was undoubtedly eye opening and rewarding for both Coloradan and Afghani participants. Prior to their trip to Badam Bagh, the workshop attendants had already achieved much with little, and their ambition and resourcefulness were a lesson well learned by CSU representatives. Armed with more refined irrigation management tools, these inspiring extension professionals will no doubt quickly build on their prior outreach successes. Six days is a short time to make a lasting impact, but it did provide some insight into

Afghanistan's status as an agricultural nation, and how irrigation outreach is being delivered and supported.

## References

- Barfield, T., 2010. Afghanistan, A Cultural and Political History. Princeton University Press, 350 pp.
- Qureshi, A. S., 2002. Water Resources Management in Afghanistan: The Issues and Options. International Water Management Institute. Working Paper 49, Pakistan Country Series No. 14, 24 pp.

TAF, 2006. Afghanistan in 2006 – A Survey of the Afghan People. The Asia Foundation, 128 pp.

*This article is based on a longer article currently under review for publication in the Journal for Contemporary Water Research and Education.*  
[www.ucowr.org/journal](http://www.ucowr.org/journal). ●

*Below: The 55 hectare (135 acre) Badam Bagh facility was rebuilt by the U.S. Agency for International Development (US-AID) in 2006 and transferred to the Afghanistan Ministry for Agriculture Irrigation and Livestock in 2011. It is the most up to date research and demonstration facility at the disposal of Afghani agricultural academics and extension personnel.*

Courtesy of Denis Reich



Clarissa J. Trapp, Water Resources Archive, Colorado State University Libraries

Do you wonder what was it like to be in Big Thompson Canyon during the July 31, 1976, flash flood? Or maybe you want to know what engineers like Robert Glover did from day to day while working on large dam projects for the Bureau of Reclamation? The Water Resources Archive (Archive) is full of the personal experiences, opinions, and memories of hundreds of individuals from the last 150 years of Colorado's water history, all of whom can answer these questions and more—in their own words.

Patrons often want to know more about the people who created the data, reports, and other documents held in the Archive. Thanks to a \$50,000 grant from the Colorado Water Conservation Board, the Archive is in the midst of selecting and digitizing correspondence, diaries, speeches, and oral history interviews so that patrons can access the thoughts of historical water figures conveniently via the Internet. Some of the materials available online are highlighted below.

## Letters

One of the best ways to discover what concerned people fashioning Colorado's water laws, irrigation education, and water supply canals 100 years ago is through their personal papers, especially their correspondence. Daily minutia and larger concerns often rest side-by-side in these collections. One such example is found in the Papers of Louis G. Carpenter. Carpenter, a civil engineering professor at Colorado Agricultural College (CAC, now Colorado State University), simultaneously wrote quizzes, ordered equipment for experiments, and fought "stockmen" and others who wanted to devote land grant

universities exclusively to agricultural education and drop civil engineering as a course of study at CAC. In 1907, a group had some success with a similar campaign in Utah. Carpenter wrote to the U.S. Department of Agriculture in 1908 claiming his opponents had a malicious plan to besmirch the personal character of Carpenter and others. He wrote, "There has been a series of attacks on our College..., in which the reputation [sic] of individuals are destroyed if they are in the way." Carpenter's four year campaign to keep engineering at CAC ended in success, and his setbacks and victories—along with orders for office supplies—can be charted through his correspondence, which can be accessed online.

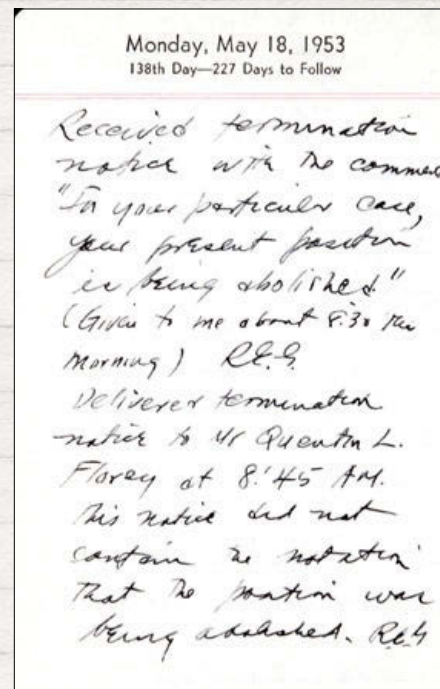
## Diaries

Several collections in the Archive hold diaries that will be digitized this year. These diaries are not repositories of personal confessions

but are instead records of engineers' and lawyers' daily activities. Reading these logs allows patrons to track the progress of projects—scientific tests, building projects, legislation—from beginning to end in many cases. Writers, such as Robert E. Glover, noted people they talked to, places they traveled, the main focus of daily work, and occasional personal details such as birthday reminders. For instance, Glover's 1953 diary documents his job transfer within the Bureau of Reclamation. On May 18, Glover received a notice of termination, which read, "In your case, your present position is being abolished." By May 20, Glover had accepted a transfer that allowed him to do similar work on salinity and concrete dam projects, and on June 9, Glover took annual leave, perhaps to recuperate after the unexpected employment change. "Gone fishin'!" he added.

## Speeches

The Archive is digitizing the speeches of some people documented in the Archive, such as Greeley businessman W. D. Farr. Farr tried to persuade public entities and private citizens of his views on water issues, and he used his talks to outline political and social trends and suggest frameworks for the future. W. D. Farr's talks concern two topics—water and the cattle industry. An enthusiastic booster for his hometown, Greeley, Colorado, Farr urged his listeners to aggressively develop a large and expansive plan for the city to ensure its continued growth and regional influence. For example, in an April 25, 2000, speech during a Greeley City Council work session, Farr declared that Greeley needed to annex all available land west of the city to Interstate 25. Farr also supported investing heavily



Robert Glover notes the termination of his position at the Bureau of Reclamation in a page from his 1953 diary.

Photo courtesy of the Water Resources Archive

in water infrastructure and city planning. “Think of the millions of dollars that can be saved in the planning and location of parks, storm sewers, and arterial roads, fire station locations, and proper sizing of sewer and water mains,” he proposed. The tone of Farr’s other speeches is much the same. Think big. Plan ahead. Act now.

## Oral Histories

Oral histories prove useful for capturing memories and opinions. Sometimes these are autobiographical reminiscences about events long past, but others record details right after a specific event. The Archive is making both sorts of interviews available online this year.

Interviews with former Water Supply and Storage Company board member Harvey Johnson cover his entire life. “I was born in Kansas in a sod house in 1895 in Cheyenne County,” Harvey Johnson told historian David McComb in 1973. In nearly 100 pages of interview transcripts, Johnson talked of his childhood on a beet farm near Fort Collins, Colorado and his life as a farmer, implement dealer, mayor of Fort Collins, and Water Supply and Storage Company board member. Johnson gave two interviews—one to McComb and another to James Hansen in 1986. In both cases, Johnson’s opinions, beliefs, and values are highlighted as much as the known facts of his professional achievements.

In the case of interviews collected in the wake of the 1976 Big Thompson Flood, multiple perspectives allow researchers to piece together a more comprehensive picture of the event. Shortly after the flood, David McComb sat down with more than 40 people, capturing the experiences of victims in the canyon and the response of officials during and after the event. In one such interview,

M: Does that mean that the price of water drops for the users once you got out of debt?

J: It meant that we didn't have to assess them quite as much.

M: I see.

J: But then the fact we have the inflation and the extra cost until we're back to our other assessment. Anyhow, we have not been able to use some of the transmountain diversion through the period of a year when there would be an excessive amount of water in the Poudre. Our storage would be taken care of. We'd have plenty of water on the side. So we have been doing some research and found out that we could improve the size of the Long Draw Reservoir. I might tell you it's been quite a job to meet with the environmental groups and to get what we have accomplished. A year ago we had accomplished a loan from the Small Loans Department of the Water Facilities, a million and three hundred thousand dollars for fifty years without interest, and a grant from the Wildlife and Game and Fish for \$350,000 to increase the size of Long Draw Reservoir to 11,000 acre feet, making it possible to bring more across and hold it at the time when we had an excessive amount of water here.

M: You said that was difficult to do, that is to get the permission to expand. You mentioned the environmentalists. What's the difficulty?

J: Oh, you've got a dozen different things. First place, the west slope says you can't take more water over. Our company filed on it in the 1880's with ditches laid into the

*A page from David McComb's 1973 interview with Harvey Johnson.*

Photo courtesy of the Water Resources Archive

Montrose Inn owners Mary and Charles Chappell recounted the noise of the flood in the canyon. “The rocks were bouncing off of each other like ping-pong [balls], and the roar was just incredible,” Mary remembered. She noted the “absolute black” silence that followed, as well. Like the Chappells’, other interviews discuss events in the canyon, but many others highlight the post-flood rescue and cleanup efforts of volunteers and officials such as Mennonite Disaster Service worker Sam Minter and Colorado Governor Dick Lamm. Together, these interviews tell the story of the Big Thompson Flood better than any single interview could.

## Now That You Know

The Water Resources Archive is excited to improve digital access to Colorado’s water leaders—and their words. The highlighted collections and more are available online, and additional items will be added this spring and summer. Researchers can find all digital materials through the Water Resources Archive home page, [lib.colostate.edu/archives/water/](http://lib.colostate.edu/archives/water/). Patrons can also research collections in person by visiting the Archive in Colorado State University’s Morgan Library. For further information contact Archivist Patty Rettig (970-491-1939; [Patricia.Rettig@ColoState.edu](mailto:Patricia.Rettig@ColoState.edu)), who is always happy to help. ●

# Richard Stenzel Discusses His Book on History of State Engineers

*Interview with Lindsey Middleton, Editor, Colorado Water Institute*

## *Tell me a little about the book, Water: Colorado's Real Gold.*

The Colorado we see today is totally different from what the first settlers found when they arrived. Today's environment would not exist if it weren't for the efforts of the early pioneers who constructed the irrigation systems, storage reservoirs, and transmountain diversions needed to irrigate their lands. Today we see extensive agricultural developments—reservoirs retime river flows to create more stable flow patterns, which can be relied upon during times of drought and at the same time support gold medal fisheries and river rafting.

After searching libraries throughout Colorado and talking to others interested in Colorado's water history and the future, Tom Cech and I tell stories of the development of Colorado's waters, the issues that ultimately resulted in the adoption of the Prior Appropriation Doctrine, and the administrative system that led to the creation of the State Engineer's

Office, also known as the Division of Water Resources, and its history.

## *What were some of the most interesting discoveries that you made while researching for the book?*

I think very few people realize that there was a period of time when the State Engineer was directed by the legislature and allocated funds for the building of wagon roads and bridges throughout Colorado to create a statewide system of roads. One the most significant projects was the construction of a wagon road through Glenwood Canyon in 1902. The State Engineer also constructed numerous state bridges throughout much of Colorado. A few of the bridges that were constructed during the turn of the century still exist today, and I have included photographs of them in the book. The State Engineer was responsible for the construction of wagon roads and state bridges between 1885 and 1910. In 1910, the Colorado Legislature created the

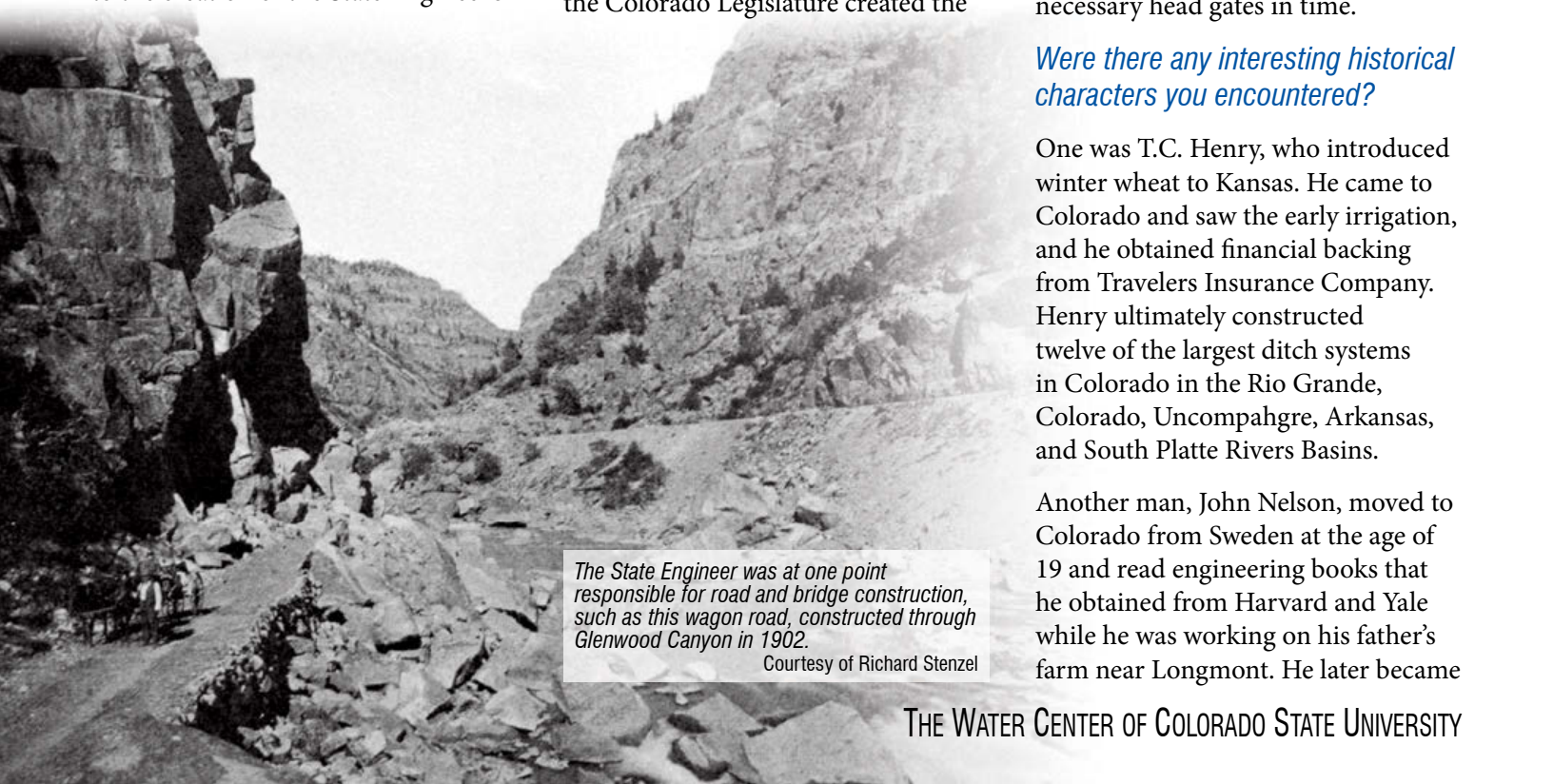
Colorado State Highway Commission and State Highway Engineer, and the Colorado State Engineer was released from any future responsibility of road construction.

Another discovery was the significant difficulty that the first Water Commissioners experienced administering water rights. The water users were told that they had to put in head gates, or diversion structures, and also install measuring devices. If they didn't comply, commissioners were responsible for installing the structures at their own cost and then seeking repayment from the water right owner. Many irrigators didn't want the head gates and measuring devices and would remove and throw them back into the river, refusing to pay the water commissioners. Commissioners had nobody to back them up or assist them in obtaining reimbursement. They were paid \$5 per day and could work a maximum of 90 days, and they could be fined up to \$500 if they did not construct the necessary head gates in time.

## *Were there any interesting historical characters you encountered?*

One was T.C. Henry, who introduced winter wheat to Kansas. He came to Colorado and saw the early irrigation, and he obtained financial backing from Travelers Insurance Company. Henry ultimately constructed twelve of the largest ditch systems in Colorado in the Rio Grande, Colorado, Uncompahgre, Arkansas, and South Platte Rivers Basins.

Another man, John Nelson, moved to Colorado from Sweden at the age of 19 and read engineering books that he obtained from Harvard and Yale while he was working on his father's farm near Longmont. He later became



*The State Engineer was at one point responsible for road and bridge construction, such as this wagon road, constructed through Glenwood Canyon in 1902.*

Courtesy of Richard Stenzel





*T.C. Henry was an important figure in early Colorado irrigation.*

Courtesy of Richard Stenzel

a very capable engineer without having the benefit of going to college. He built the Home Supply Diversion Dam on the Big Thompson River, Fossil Creek Dam and Reservoir, the Skyline Ditch, and many other irrigation systems.

A sad story was the story of Chief Black Kettle. He and his brother, White Antelope, were Cheyenne chiefs. They realized that with the Gold Rush and the arrival of the white man, their lives were going to change. Along with the Arapaho Indians, they worked out a treaty with the U.S. Government, which included a plan to have an irrigation ditch constructed for them near Fort Wise so they could learn about agricultural practices, and a large reservation was set aside for them in southeastern Colorado. Prior to the completion of the irrigation ditch, some of the Arapaho braves raided ranches in the surrounding area and killed some ranchers, which raised tensions between the settlers and the Indians. Chief Black Kettle and other Indian chiefs on the reservation tried to negotiate a peaceful solution by traveling to Camp Weld, located near Denver. However, the soldiers and other territorial officials had no real interest in reaching a solution. When the Native Americans returned

to the reservation, the commander told them it wasn't safe—they were told to move to the northeastern portion of the reservation, which included Sand Creek. Chief Black Kettle had been told that by flying a U.S. flag outside his tent would signify peace. Two months later Colonel John Chivington led 650 volunteer soldiers in an attack of the Arapaho and Cheyenne encampment at Sand Creek and killed 165 of the Indians, mostly women and children, and White Antelope. Black Kettle was wounded eight times but survived. The following year Chief Black Kettle and the surviving Cheyennes gave up any claims on the reservation lands and moved to Oklahoma. Three years later, General Custer led an early morning raid on their new location, and Chief Black Kettle and his wife were killed trying to escape.

*While you were looking through all these stories, were there any gaps—any documents you couldn't get a hold of?*

Along the way, I decided to try to find a photograph of all 19 State Engineers. It was very difficult, but eventually I was able to find photograph for all

but three of the men who served as State Engineers. One man I thought would be the easiest to find turned out to be one of those three. I did I find a lot of additional information on his activities—the man's name was Thomas William Jaycox. He went to Cornell University and in his senior year, he decided to leave college and join the Hayden expedition to Yellowstone. Later, he was also responsible for laying out the first sewer system for Washington, D.C. When he died, several national engineering publications wrote about him but never included any photograph.

*How has the role of the State Engineer changed over time?*

Early State Engineers were responsible for providing streamflow information and also rating the new measuring devices that were installed on irrigation ditch systems. This was necessary, because the water commissioners could not otherwise administer water rights or determine which water rights could continue to divert water during the irrigation season without this information. Communications were very



*Chief Black Kettle at Camp Weld.*

Courtesy of Richard Stenzel

limited—most water commissioners received information several times a week by mail or telegraph. Today, this information is available on a real time basis to not only the water commissioners, but also the general public via the Internet.

Later on, dam failures in other states became a concern, and the State Engineer's Office was made responsible for approving all new dam designs and for the oversight of dam construction. Previously, dams in Colorado were constructed without any engineering designs. We were fortunate in Colorado, but other states encountered major failures. At first the plans submitted for review to the State Engineer were inadequate and designed by people without any engineering background. This forced the State Engineer to provide design drawings.

Today, dam design reviews and dam inspections no longer have this issue. There are still instances of the State Engineer requesting changes in the final designs, but for the most part, designs are much less of a concern, and dam owners and the general public trust the process.

The State Engineer's Office also has responsibility for interstate compact administration, the issuance of well permits, data information regarding water rights tabulations, and historic diversion records.

*Did you come across another subject area you think should be explored with a future book?*

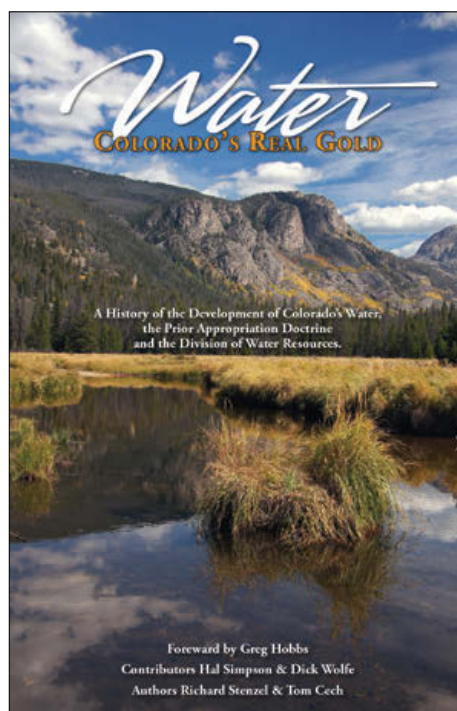
Tom Cech and I have discussed the possibility of writing a more detailed history of the activities of T.C. Henry. The current book only provides a more detailed history of water development in the South Platte and Arkansas River basins. I would like to possibly write about the history of water development in the Rio Grande

and the Colorado River and its tributaries in Colorado.

I am currently considering a coffee table book that would include photographs of Colorado's Water Projects. Photography is a passion of mine, and currently I photograph projects all over the state for use in a calendar that has been produced by the Applegate Group, Inc. since 2005. The book would discuss the history of dams throughout Colorado, why they're built, and the side benefits of them. The book would be intended for a general public.

*What is the intended audience for your book?*

Because of Water 2012, I wanted to write a book that tells the history of the State Engineer's Office, also known as the Colorado Division of Water Resource. However I also thought it was important to tell why the agency was created. I thought my audience would generally be water users, consultants, engineers, irrigation district personnel, and the general water community which includes farmers.



*What's the best way to get a copy of your book?*

The book is available, at a cost of \$30, by contacting Richard via email ([rstenz97@yahoo.com](mailto:rstenz97@yahoo.com)) or by telephone, (970) 222-5700. The book is not currently available in stores.

## About the Authors

Richard L. Stenzel retired after 25 years working for the State Engineer's Office. He served as an Assistant State Engineer and was the Division One



Engineer for the Colorado Division of Water Resources at the time he retired. For the past 10 years, he has been a consultant with the Applegate Group. His photographs of water projects have been used in the calendar produced by the Applegate Group called "Colorado's Historical Water Projects," which has been printed annually since 2005.

Thomas V. Cech is the owner of Cech Press, LLC. He was Executive Director of the Central Colorado Water Conservancy District in Greeley from



1982-2011, and is now Director of the One World One Water Center for Urban Water Education and Stewardship at Metropolitan State University of Denver. He has written three college-level textbooks on water resources with John Wiley & Sons, Cambridge University Press, and University Press of Colorado. ●

## Colorado State University (January 16, 2013 to March 15, 2013)

**Aldridge, Cameron**, Natural Resource Ecology Laboratory, DOI-NPS-National Park Service, Develop Spatially Explicit Gunnison Sage Grouse Winter Habitat Models, 3/14/2013, \$5,000

**Andales, Allan A**, Soil & Crop Sciences, USDA-ARS-Agricultural Research Service, Application of System Models to Evaluate and Extend Cropping Systems Studies at Different Great Plains/Northwest Locations, 2/6/2013, \$1,211

**Baker, Daniel W**, Civil & Environmental Engineering, Colorado Division of Parks and Wildlife, Cache la Poudre River Post-Fire Sediment and Aquatic Insect Monitoring: CPW, 1/22/2013, \$16,000

**Baker, Daniel W**, Civil & Environmental Engineering, City of Fort Collins, Ecological Response Model, 1/22/2013, \$29,947

**Bau, Domenico A**, Civil & Environmental Engineering, Colorado Water Conservation Board, Modeling the Influence of Conjunctive Water Use on Flow Regimes in the South Platte River Basin Using the South Platte..., 2/21/2013, \$37,224

**Bauder, Troy A**, CSU Extension, Colorado Department of Public Health & Environment, Tools to Address Agricultural Nutrient Nonpoint Source Contamination, 1/18/2013, \$219,026

**Berrada, Abdelfettah**, Southwestern Colorado Research Center, National Sunflower Association, Response of Two Sunflower Hybrids to Limited Irrigation and N rate, 3/13/2013, \$8,481

**Carlson, Kenneth H**, Civil & Environmental Engineering, Research Partnership to Secure Energy for America, Development of GIS-Based Tools for Optimized Fluid Management in Shale Gas Operations, 3/8/2013, \$1,092,083

**Clements, William H**, Fish, Wildlife & Conservation Biology, International Zinc Association, Effects of Zinc on Macroinvertebrate in the North Fork of Clear Creek, 2/15/2013, \$25,000

**Collett, Jeffrey L**, Atmospheric Science, NSF - National Science Foundation, Collaborative Research: Secondary Organic Aerosol Production in Real Atmospheric Waters, 2/5/2013, \$144,643

**Cooper, David Jonathan**, Forest & Rangeland Stewardship, DOD-ARMY-Corps of Engineers, Watershed to Local Scale Characterization & Functioning of Intermittent and Ephemeral Streams on Military Lands, 1/28/2013, \$272,340

**Fausch, Kurt D**, Fish, Wildlife & Conservation Biology, Colorado Division of Parks and Wildlife, Consequences of Climate Change for Mountain Lakes and Native Cutthroat Trout, 1/28/2013, \$59,862

**La Belle, Jason Mitchel**, Fish, Wildlife & Conservation Biology, Larimer County, Chimney Hollow Open Space Survey, 3/1/2013, \$13,104

**Ramirez, Jorge A**, Civil & Environmental Engineering, USDA-ERS-Economic Research Service, Integrating USDA Economic and Hydrological Projections in Assessing the Impacts of Climate Change on Agriculture, 2/12/2013, \$30,000

**Rocca, Jorge G**, Electrical & Computer Engineering, NSF - National Science Foundation, Engineering Research Center for Extreme Ultraviolet Science & Technology, 1/17/2013, \$195,539

**Thornton, Christopher I**, Civil & Environmental Engineering, Various "For Profit" Sponsors, Full Scale Product Evaluation during Wave Overtopping, 3/13/2013, \$39,870

**Waskom, Reagan M**, Colorado Water Institute, CDM Smith, Value of Water in Agriculture: Gathering Baseline Information, 1/28/2013, \$35,360

**Waskom, Reagan M**, Colorado Water Institute, Colorado Department of Public Health & Environment, NPS Outreach Coordinator, 2/12/2013, \$88,507

**Waskom, Reagan M**, Colorado Water Institute, University of Colorado, SRN: Routes to Sustainability for Natural Gas Development and Water and Air Resources in the Rocky Mountain Region, 2/4/2013, \$49,991

## April

**15-17** **NWRA Annual Conference; Washington, D.C**  
Theme: Federal Water Issues  
[www.nwra.org](http://www.nwra.org)

**16-19** **USCID 7<sup>th</sup> International Conference on Irrigation and Drainage; Phoenix, AZ**  
Using 21<sup>st</sup> Century Technology to Better Manage Irrigation Water Supplies  
[www.uscid.org/13azconf.html](http://www.uscid.org/13azconf.html)

**28-2** **2013 NGWA Summit; San Antonio, TX**  
The National and International Conference on Groundwater  
[www.groundwatersummit.org/](http://www.groundwatersummit.org/)

## June

**11-13** **2013 UCOWR/NIWR Annual Conference; Lake Tahoe, CA**  
Sustaining Water Resources and Ecological Functions in Changing Environments  
[www.ucowr.org/conferences/item/36-2013-conference](http://www.ucowr.org/conferences/item/36-2013-conference)

## August

**21-23** **Colorado Water Congress Annual Summer Conference; Steamboat Springs, CO**  
Summer Conference and Membership Meeting  
[www.cowatercongress.org](http://www.cowatercongress.org)

## September

**15-18** **28<sup>th</sup> Annual WaterReuse Symposium; Denver, CO**  
The world's premier conference devoted to sustaining supplies through water reuse and desalination  
[www.watereuse.org/symposium28](http://www.watereuse.org/symposium28)

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CSU Water Center: [www.watercenter.colostate.edu](http://www.watercenter.colostate.edu)



Jeff Baessler, a Colorado Water Conservation Board staff member, measures flows on the Huerfano River in Huerfano County.  
Photo by Bahman Hatami