COLORADO WATER

Newsletter of the Water Center of Colorado State University

Water Outreach:

October 2006

Colorado State University Reorganizes Water and Outreach Programs to Better Serve Colorado, p. 6

Collaborative Project Proposal Seeks to Protect Front Range Forest Watersheds from Catastrophic Wildfires, p. 11

The Water-Energy Equation in Irrigated Agriculture, p. 14

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TOP: Parshall takes mesasurements using his invention, the Parshall Flume, 1932, from the Ralph L. Parshall Collection, Water Resources Archive, CSU.

LEFT: Dedication of Agate Dam and Reservoir, Oregon, 1966. Photo by Bureau of Reclamation. From the Stamm Papers, Water Resources Archive, CSU.

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EDITORIAL

Moving Beyond Water Outreach

Reagan M. Waskom, Colorado Water Resources Research Institute, Interim Director

Getting your arms around water education and outreach in Colorado is at best, a daunting task. Colorado State University, the Colorado Water Conservation Board, the Colorado Water Congress, many water districts and other groups have for decades worked separately, and at times collectively, on educating Coloradans about water. More recently, the Colorado Foundation for Water Education and now the 1177 Roundtables and IBCC have joined the effort. If there is any reason to be hopeful about our collective efforts in water outreach, it is the number of dedicated people and institutions working to provide information and education about Colorado's water and what it means to our lives. On the other hand, with new folks moving here daily and the seemingly infinite amount of competing information they are bombarded with, it is unlikely that the business of water education and outreach will be finished anytime soon.

> The engaged institution must "put its resources - knowledge and expertise - to work on problems facing the communities it serves."
>
> -The Kellog Commission

Colorado State University was founded in 1870 as Colorado's land grant college as a result of the Morrill Act of 1862. The U.S. Congress soon realized that to be effective, the educational function of land-grant universities needed to be supplemented with research capabilities. Hence, the Hatch Act was passed in 1887 to provide for the establishment of research farms (Agricultural Experiment Station) where universities could conduct research into agricultural, mechanical, and related challenges faced by rural citizens. Congress later passed the Smith Lever Act in 1914, effectively establishing the Cooperative Extension Service to provide a mechanism for research-based knowledge to reach "the people." CSU has been working on irrigation and water related research and outreach in Colorado for well over one hundred years. Even with this legacy most people still want to know, "What has the University done for me lately?"

The Kellogg Foundation recently funded a commission to evaluate the role and performance of land grant universities to answer the relevancy question posed above. In its 2000 report, the Kellogg Commission noted the extensive contributions land grant universities have made to our nation, but concluded that it is time to go beyond traditional outreach and service to what the Commission defined as "engagement."

In the report, the Kellogg Commission stated, "Engagement goes well beyond extension, conventional outreach, and even most conceptions of public service. Inherited concepts emphasize a one-way process in which the university transfers its expertise to key constituents. Embedded in the engagement ideal is a commitment to sharing and reciprocity."

By engagement, the Kellogg Commission envisioned partnerships; two-way communication defined by mutual respect among the teachers and learners for what each brings to the table. The engaged institution must "put its resources - knowledge and expertise - to work on problems facing the communities it serves." To the Commission, engagement involves working in partnership with segments of society, in a two-way process. "Outreach" on the other hand, implies a one-way communication from the university to society.

In this issue of Colorado Water, readers will note that Colorado State University has recently undertaken a reorganization, that among other things, allows the university to develop a more cohesive approach to outreach and partnerships. CSU's water programs, and specifically the Colorado Water Resources Research Institute, are directly affected by this reorganization in ways that should help us operationalize the vision of the Kellogg Commission's report. As part of the changes, Cooperative Extension offices across the state will become more effective "front doors" to CSU, providing the public access to more information and services that can help them to address critical issues such as poverty, sustainable economic development, water resources and environmental issues. A new office, the Vice Provost for Outreach and Strategic Partnerships will bring together Cooperative Ex-

CONTINUED ON NEXT PAGE

tension, the Office of Economic Development, the Colorado Institute of Public Policy, Division of Continuing Education, Colorado Water Resources Research Institute, and International Programs, facilitating additional connections between university resources to enhance services to Colorado citizens and businesses.

Bringing these units together allows the university, through the existing Cooperative Extension structure that serves every Colorado county and has offices in 59 counties, to deliver more services to rural Colorado, including enhanced educational opportunities for the agricultural community. Perhaps even more importantly, Cooperative Extension's local connection provides the University with a conduit to institutionalize the two-way information process envisioned by the Kellogg Commission's definition of engagement.

Engaging the public in water education, whether coming from higher education, public agencies, foundations or the IBCC, may require us to contemplate a new model of engagement. We may need to ask ourselves if the public wants to be educated on the aspects of water that we think important. For example, does the public really want to know about federal reserve rights, augmentation credits, programmatic biological opinions, and pump back storage? Furthermore, in this age of instantaneous communication, we need to identify what our various audiences (K-12, teachers, irrigators, homeowners, politicians, etc.) want in the way of education and how they wish to receive it. There are many new Colorado residents and subsequently, just as many new ways of looking at our natural resources such as water. The 1177 Roundtables are dancing right up to the edge of allowing new and different value systems a legitimate place at the table as new faces are brought into the water dialogues being held around the state. Are we willing to provide education and information to those with different values and goals for our water resources? If we wish to effectively reach people with our water information and education programs, we may need to consider them as partners in the process, rather than simply as consumers of our products. This will require us to engage our target audiences at the onset of our programs, not after the educational materials are printed and distributed for use.

Colorado State University is intent on engaging a diverse public in our education and outreach programs and we believe there are many venues for cooperation among the groups currently working on water education. If the goal is truly to help Colorado citizens be better informed as they make decisions about our State's limited water supplies, perhaps it is time for the water education community to move beyond the traditional notion of water outreach and toward an ethic of engagement.

STAFF PROFILE

Welcome Nancy Grice

Nancy Grice has joined the Colorado Water Resources Research Institute and the Water Center at Colorado State University as the new Office Manager. She comes from the Department of Clinical Sciences, Colorado State University, where she was the Department Accountant and Research Manager for eight years. Prior to working at Clinical Sciences, she worked at Business & Financial Services, Accounts Payable, Colorado State University for five years. Nancy also has eighteen years experience in private sector accounting.

Nancy and David Grice have been married for 31 years and they have a son, Matthew, who is 25. Bobby, the Grice Family pet, is a 14-year-old tri-colored male Bassett Hound who runs the show!

Nancy's interests are traveling, gardening, cooking, reading, movies, music and making jewelry. She is an active community volunteer serving on the Laporte Area Planning Advisory Committee, Larimer County Board of Commissioners.

If you need any assistance from the Colorado Water Center or the Colorado Water Resources Research Institute, please contact Nancy at Nancy.Grice@Research.ColoState.edU or (970) 491-6308.

MEETING BRIEFS

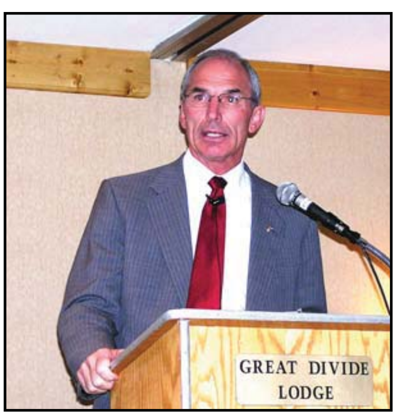
Colorado Water Congress Summer Convention

The Colorado Water Congress held its annual summer convention at the Great Divide Lodge in Breckenridge Colorado on August 24 and 25th with the theme of "Water in the Holy Land - Can we learn from water planning in the Middle East?"

Shaul Amir of the Allied Jewish Federation with Russ George.

Bob Trout and David Robbins in hallway conversation.

Highlights of the conference included presentations by DNR Director Russ George and Israeli scientist Dr. Eilon Adar of the Ben-Gurion University of the Negev. Director George reflected upon the great irrigation efforts of past civilizations and the fact that the success and very survival of these civilizations depended upon irrigation. Salinity, sedimentation, erosion, drought, and climate variability inevitably lead to the demise of the great irrigation cultures, leaving us to ponder the lessons that Colorado might learn from history and the Middle East. Dr. Adar explained Israel's approach to water as one based on the very survival of the country. Interestingly, Israel has trans-boundary water disputes on all sides and has entered into peace treaties with their neighbors that include detailed descriptions of shared water resources. Dr. Adar indicated that Israel is committed to keeping water delivery separate from any conflicts they may have with their neighbors. Rather than water being a source of conflict, is may be viewed as a catalyst for cooperation.



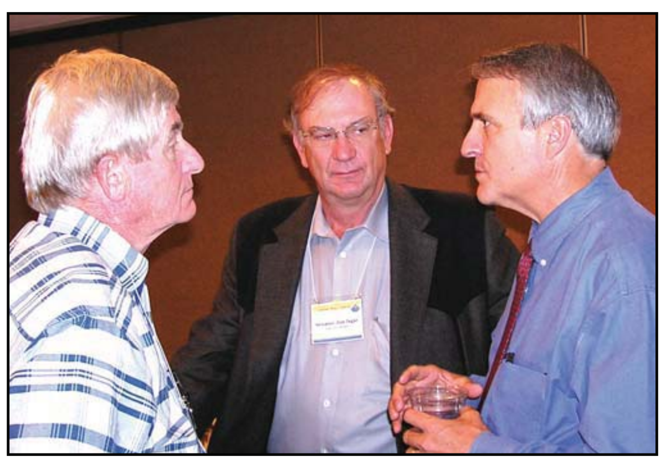
Representative Beauprez addresses the Water Congress.

Representative Harvey, Senator Fitz-Gerald and Representative Hodge discuss their trip to Israel.

The keynote speakers were followed by Colorado legislators Sen. Joan Fitz-Gerald, Rep. Mary Hodge and Rep. Ted Harvey describing their observations from a recent trip to Israel.

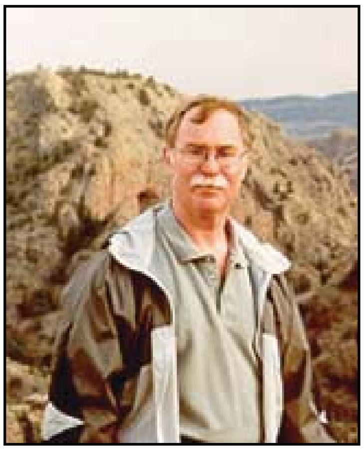
Patrick Field, of the Consensus Building Institute, provided a pre-conference workshop and a general session talk on consensus building for water resources. He noted that consensus building is not the same as unanimity and the groups of people with differing values often have a better opportunity to find consensus than groups in conflict holding the same value structure. He encouraged Roundtables and other groups to harness conflict – not avoid it.

The Water Congress summer meeting was capped by appearances from gubernatorial candidates Bob Beauprez and Bill Ritter. Both candidates discussed Colorado's water future in their vision for water and people in Colorado. The summer meeting concluded with a luncheon address by outgoing CWC President Marc Catlin's observations on the Basin Roundtable process. The CWC annual winter meeting will be held in Denver on January 25 and 26, 2007.



Senator Isgar and Gubernatorial candidate Ritter talk water.

Colorado State University Reorganizes Water and Outreach Programs to Better Serve Colorado



Colorado State University has recently reorganized to strengthen its commitment to outreach as Colorado's Land Grant University. Dr. Lou Swanson, longtime sociology professor and associate dean in the College of Liberal Arts, has been named the Vice Provost for Outreach and Strategic Partnerships - a new position created during the campus-wide reorganization last fall. Swanson, a rural sociologist, has spent the majority of his 24-year career focused on two related fields, the sociology of agriculture and rural community studies. In his new role, Swanson will oversee seven units including the Colorado Water Resources Research Institute - all of which are working to address the changing needs of agriculture, rural communities and growing urban communities in the state.

The University reorganization and filling of the Vice Provost for Outreach and Strategic Partnerships allows the University to achieve excellence in the areas of teaching and learning, retention and graduation, admissions and access, and outreach and service. Additionally, the reorganization positions the University to better assist communities with rural outreach, scientific discovery and public policy research.

Dr. Swanson's immediate goals include reinforcing the university's historic partnerships with agriculture and rural communities while simultaneously engaging new strategic partnerships in rural and urban Colorado.

Swanson began his professional career as an assistant professor at the University of Kentucky's Department of Sociology and rose to professor before leaving for Colorado State in 1997. He has served as a professor and chairman of the CSU sociology department. He was named interim associate dean in 2005 and named to the position full-time this year. Swanson was a Peace Corps Volunteer in Tunisia from 1972-1974.

The reorganization around key outreach units will allow the University to develop a more cohesive approach to outreach and partnerships that engages the entire university community. Outreach and Strategic Partnerships strategically brings together Cooperative Extension, the Office of Economic Development, the Colorado Institute of Public Policy, Division of Continuing Education, Colorado Water Resources Research Institute, International Programs and a new K-12 education outreach unit to mobilize the University to better serve the information and education needs of Colorado citizens and businesses.

A brief profile of the six outreach units is below:

Division of Continuing Education
Rick Simpson, Director

The Division of Continuing Education (DCE) extends and leverages the rich and diverse academic resources of Colorado State University, locally and globally, through timely, dynamic, and diverse courses, programs, and guided academic experiences to its communities of lifelong learners. DCE participants include individuals as well as organizations seeking improvement in quality of life, excellence at work, and the sustainability of economies, cultures, and world.

The Division of Continuing Education is excited about the recent collaborative ventures indicative of the team spirit within the new Outreach and Strategic Partnerships unit. Continuing Education is currently working with the Colorado Water Resources Research Institute and the Civil Engineering Department on a distance master's degree and also developing a noncredit Colorado Water Resources seminar to be delivered throughout the region this spring via distance technology. http://www.learn.colostate.edu/

Colorado State University Cooperative Extension
Marc Johnson, Interim Director

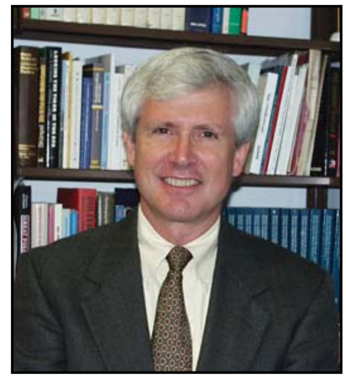
Colorado Cooperative Extension has been providing informal outreach education from the university to local residents, businesses, and governments for nearly 90 years. Examples of water-related education include participation in the Basin Water Roundtables at the request of the Executive Director of the Department of Natural Resources, coordination of the Agricultural Water Summit whereby agricultural producer organizations are exploring their common interests in future water policy at the request of the Colorado Agriculture Council (a group of agricultural interest groups), the Extension Drought Task Force which is a group of campus specialists and county agents responding with residential and farm management information related to the droughts of 2002 and 2006, and education on irrigation efficiency, irrigation with poor water quality, watershed management affected by forests and invasive weed species, effective crop selection with limited water availability, irrigation of parks and golf courses with wastewater, and financially effective methods of farming with temporary loss of irrigation water supply. Cooperative Extension provides education through a network of about 60 campus specialists and 150 county extension agents working in 59 of Colorado's 64 counties and across the state. New faculty positions are open with partial Extension appointments in Civil Engineering and Soil and Crop Sciences and Cooperative Extension has a priority to refill two regional water specialist positions in the near future. CSU Cooperative Extension can be found on the web at http://www.ext.colostate.edu/

Office of Economic Development
Hunt Lambert, Director

The Office of Economic Development at CSU has a mission to grow the economic health of the state of Colorado by systematically bringing Colorado State University and industry closer together. This is accomplished by leveraging industry partnerships to link CSU's invention capability with global innovation networks to deliver CSU's human talent, artistry and technology for the benefit of Colorado's economy.

Among the core principles of the OED are to: work with industry, capital sources and experts to allow the market to vote on the commercial value of as many technologies as possible; design and launch multidisciplinary programs that give students the chance to understand and work with the breadth of real world challenges; reward faculty for technology development and startup support; and to engage in networking on a global basis to expose our venues, talent and technologies to the providers of solutions to the great global challenges of our time.

Office of International Programs
Jim Cooney, Director



The Office of International Programs serves the needs of 1300 international students and visiting scholars at the University, sponsors Study Abroad programs and other international field experiences for 600 students annually, and facilitates international programs for faculty and students (ranging from international courses to area studies programs to the Peace Corps Masters International Program). The Office of International Programs also plays a central role in implementing CSU's international efforts as outlined in the University Strategic Plan, including an increased emphasis on international outreach. International Programs promotes international research, development and training activities to allow application of knowledge worldwide to enhance the human condition. It also brings an international perspective to the university and the state of Colorado through various strategies such as preparing students for and assisting communities in adjusting to a rapidly changing global workplace. International Programs provides technical assistance as part of its tradition of outreach excellence, promotes international research and development and provides Coloradans a link to the global marketplace. More information is available on the Web at www.international.colostate.edu

Colorado Institute of Public Policy
Lyn Kathlene, Director

The Colorado Institute of Public Policy (CIPP) at Colorado State University was founded in July 2003. The Institute was created to bring together interdisciplinary expertise across campus to help address pressing public policy issues around the connections of agriculture, environment and people in Colorado and the Intermountain West. The CIPP promotes access to credible information; creates and facilitates partnerships for building regional, state, and local community capacity; and develops and facilitates interdisciplinary research, technical assistance, and decision-making approaches.

Among the numerous activities and publications of the Institute, policy white papers, policy briefs, and "translation" research papers - short lay versions of peer-reviewed faculty research - are produced. The most recent policy white paper, "Water in 2025: Beliefs and Values as a Means for Cooperation," provides evidence of how beliefs and values of individuals and interest groups are connected to the water challenges we face today. To find opportunities for collaboration, it is necessary to identify those values held in common and respect those that differ. This paper lays the groundwork for opening up conversations that are greatly needed but largely absent.

The Institute also co-hosts a conference series, Colorado's Future, with the Center for Colorado Policy Studies at the University of Colorado - Colorado Springs. In 2004, the conference examined the role of research universities in state and regional economic development. This year's conference examines how research is used and can be more effectively used in developing sustainable water planning, management, and public policy. More information can be found at www.cipp.colostate.edu/conferences

At the heart of it, the Institute strives to create strong and lasting partnerships stakeholders and communities. Whether that is with the water community or public health stakeholders, linking practitioners with faculty expertise expands opportunities for all and more effectively addresses our most challenging public problems. For more information about the Institute, go to www.cipp.colostate.edu

Colorado Water Resources Research Institute
Reagan Waskom, Interim Director

Unlike most other university-based institutes and centers, CWRRI is legally authorized by Congress and the Colorado legislature. At the Congressional level, CWRRI is part of a national water institute program that was originally established under the Water Resources Research Act of 1964 to "assist in assuring the Nation at all times of a supply of water sufficient in quantity and quality to meet the requirements of its expanding population" by stimulating and sponsoring the "conduct of research, investigations, experiments, and the training of scientists in the fields of water and of resources which affect water".

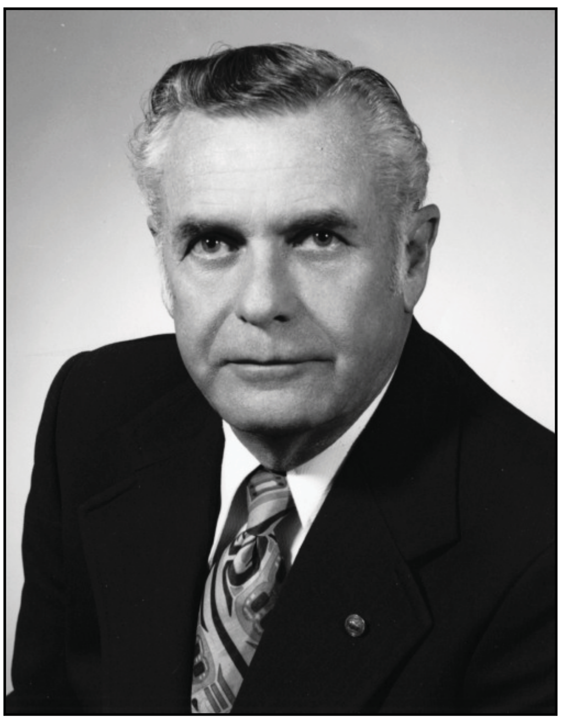
CWRRI's legal mandates require it to connect all of Colorado's higher education water expertise with the water research and education needs of Colorado's water managers and users. CWRRI is managed by Colorado State University (CSU) but works closely with all institutions of higher education in Colorado with the specific purpose of focusing the vast water expertise of higher education on the evolving water concerns and problems being faced by Colorado citizens. CWRRI develops, implements and coordinates water and water-related research programs and transfers the results to a variety of water users. More information about CWRRI is available on the Web at http://cwrri.colostate.edu

Historical Perspective: From Irrigation to Recreation

by Nicolai Kryloff, Graduate Student Assistant
Water Resources Archive, Colorado State University Libraries

It must be something in the water – every year, more than a million visitors flock to Colorado's rivers, lakes, and reservoirs to fish, kayak, raft, swim, and otherwise enjoy themselves. These activities might seem carefree and leisurely, but their presence on state waters is hardly an accident: water-based recreation has become big business. Colorado's tourism industry, worth more than $7 billion annually, is closely tied to the appeal of its natural resources, and in 2003, water recreation was the state's third most-popular outdoor activity, behind only picnicking and trail-based activities. In the same year, fishing and rafting alone had an impact of $7.5 million on the state's economy. Water recreation is booming, and with state and local funding increases for environmental tourism likely, continued growth appears certain. (Figures from Colorado State Parks, Statewide Comprehensive Outdoor Recreation Plan, 2003).

But it wasn't always this way. In fact, before World War II, recreation was barely a footnote in the use and planning of Colorado's grand water projects. Beginning in the early 1900s, the U.S. Bureau of Reclamation began constructing dams and regulating streamflows throughout the West for a single purpose – irrigation. Accordingly, the Bureau was slow to recognize recreation as a serious topic. How, then, can we account for the fleets of rubber rafts that crowd our state's waterways in the spring, or the convoys of pleasure boats that cruise our reservoirs each summer? Although historians have recently offered new insights into America's post-war romance with leisure in the context of federal lands and National Parks, relatively little attention has been paid to the rise of water recreation or the involvement of Reclamation in its evolution.



Gilbert G. Stamm, commissioner of the Bureau of Reclamation, 1973. From the Stamm Papers, CSU Water Resources Archive.

To find answers, we must rely heavily on archival materials. Institutional records and personal manuscript collections are excellent historical resources, and repositories such as the Water Resources Archive at Colorado State University are invaluable for just this sort of research. With more than 900 boxes of documents on hand, along with hundreds of maps and photographs, the Archive provides researchers with access to a wealth of information often available nowhere else.

Among the collections in the Archive that contain information about water recreation, the Papers of Gilbert G. Stamm deserve special attention. Stamm, a graduate of Colorado Agricultural College (now Colorado State University), worked for the Bureau of Reclamation from 1946 to 1977 and served at its head for five years. During his career, he witnessed the post-war explosion of water recreation. What began as a minor afterthought in most Reclamation projects eventually developed into a political and economic powerhouse, and Stamm's career coincided with the boom.

Although it is impossible to comprehend the growth of an industry through a single document, one source in particular captures the emergence of water recreation at a critical time in its growth. In 1961, Stamm delivered a 12-page speech entitled "Recreation: Its Place in Irrigation Development, Present and Future" at the Irrigation Operators Conference in Boise, Idaho. Stamm's address, delivered one year before the first federal legislation promoting the development of water recreation, confronted the growth of recreational water use and impending competition with irrigation development. While the transcript of this speech is but an isolated piece of a complex historical puzzle, it provides a glimpse of attitudes within the Bureau of Reclamation toward a growing industry on the cusp of incredible expansion. The document reveals Stamm's frank opinion of recreation's expected financial benefits, suggests his views concerning the relationship between the Bureau and public interests, and hints at the organization's impending balancing act between serving traditional water users and promoting a lucrative new industry. In short, this archival document offers a snapshot of the Bureau on the precipice of a full plunge into the recreation business.

Stamm was careful to clarify that the Bureau was, in fact, not in the business of recreation at all, yet he conceded that Reclamation facilities had huge recreational appeal. To Stamm, this appeal took shape as a public demand: although early Reclamation projects were built primarily (and often exclusively) for irrigation, "the public regards them as public bodies of water and insists upon using them." While he expressed misgivings about the lack of available funding for recreational improvements, Stamm clearly saw the financial potential: "economic benefits will go hand in hand with the increase in recreation use… By no means will all of the added business go to the boat dealer. Continuing expenditures will be made for fishing equipment, sport clothes, camping supplies, food, gasoline, car repairs, lodging, etc." Hindsight has proven this list to be even more extensive.

Dedication of Agate Dam and Reservoir, Oregon, 1966. Photo by Bureau of Reclamation. From the Stamm Papers, CSU Water Resources Archive.

But Stamm also perceived benefits of recreational development beyond tourist dollars, benefits that would accrue directly to the Bureau itself. At a time when Reclamation was increasingly concerned about its flagging public image under the weight of conservationist and preservationist environmental critiques, recreational development represented a lifeline: "We will enjoy much broader support for Reclamation development," Stamm asserted, "if we recognize these recreation benefits and accommodate them to the greatest degree possible." Recreation was thus both a financial windfall and a timely public-relations opportunity.

Speaking to a group of mostly irrigators and people with related interests, Stamm was careful not to forget his audience. His message, however, could hardly have been reassuring. While vowing to protect "the primary interests for which projects are built," Stamm conceded that demands for water to be set aside for recreation could prove "seriously detrimental to irrigation." Despite this recognition, Stamm admitted that Reclamation should be expected, increasingly, to accede to recreational demands on limited water supplies. Although he promised that the Bureau would work with irrigators to reduce friction with burgeoning recreational interests, he concluded with the message that solutions to the expenses and problems associated with increased recreational demands would ultimately fall upon the irrigators themselves: "You are the ones who should provide the push to obtain authorities, policies, and procedures to place the responsibility where it properly should be and to remove the inequities that prevail when the costs for administering recreational features of a project fall on the irrigation water users rather than the recreational beneficiaries." In short, the Bureau, while vowing to continue its service to irrigators, was determined to simultaneously promote recreational interests. Conflict, adaptation, and compromise were bound to ensue.

In the years following Stamm's speech, water-based recreation gained federal support. In 1962, the federal government established the Bureau of Outdoor Recreation to assist states in developing their recreation resources, and the 1965 Land and Water Conservation Fund Act authorized federal funding to assist this development. Planning for and implementation of recreational features quickly became an integral part of future Reclamation projects, and by 1973 the Bureau had provided 251 areas for public use – 4.2 million acres of land and 1.7 million acres of water surface area. Today, as the water recreation industry continues to grow, recent legal adaptations such as recreational in-channel diversions point toward ongoing tensions and compromises between old and new uses of Western water.

Although a complete story can rarely be deciphered through a single document, Stamm's 1961 speech nevertheless offers an early glimpse of Reclamation's initial commitment to recreational development, a process which would require other water users to share access to a vital and limited resource. Moreover, a close reading of Stamm's address suggests possibilities for additional avenues of research, pointing to other fragments of archival information which, taken together, coalesce into a richly layered historical picture. One of the great pleasures of archival research is to discover these new puzzle pieces. By reassembling them, we can begin to attain a more compelling and accurate view of the past.

For more information on the Stamm Papers and other collections in the Water Resources Archive, see the website at http://lib.colostate.edu/archives/water.

Collaborative Project Proposal Seeks to Protect Front Range Forest Watersheds from Catastrophic Wildfires

by Dave Hessel and Jeff Jahnke, Colorado State Forest Service
Don Kennedy, Denver Water
Bob Leaverton, USDA Forest Service
Dennis LeMaster, Pinchot Institute for Conservation

Forest Watersheds—At Risk from Catastrophic Fire

The same forest conditions that threaten wildland-urban interface communities on Colorado's Front Range also threaten the domestic water supply of the Denver-metro area and other communities throughout the Front Range. Such conditions—overgrown, dense forests with the same age and species composition—pose a high probability for catastrophic fires that could severely damage or destroy essential Front Range forest watersheds.

Two of the major reservoirs that provide Denver's water supply, Strontia Springs and Cheesman, were severely impacted by the 1996 Buffalo Creek and 2002 Hayman fires. The remaining reservoirs and forest watersheds critical to the region's water supply are, in many instances, characterized by forest conditions and fuel loads that are prone to comparable large-scale wildfires.

STRONTIA SPRINGS RESERVOIR AFTER THE BUFFALO CREEK FIRE: These photos show the damage that occurred after heavy rains washed debris into Strontia Springs, a major water source for the Metro Denver area. The area was burned during the Buffalo Creek Fire. Denver Water has spent millions of dollars dredging the reservoir and removing debris.

Experts generally agree that fuel loads need to be reduced in Ponderosa pine and lower mixed conifer forests by thinning vegetation and creating openings. In these forest types, fire risk mitigation parallels ecological restoration, and prescribed fire can be reintroduced as a restoration tool. Less agreement exists in the upper elevation lodgepole and spruce-fir forest types. For all vegetation types, questions exist about how best to remove excess vegetation to reduce the danger of wildfire and restore forest health. There also is some question about what to do with the biomass that results when thinning occurs. Currently, no infrastructure is available to adequately deal with biomass removal in a timely manner.

In order to address these challenges, a larger, more inclusive coalition of stakeholders must be involved in the issues surrounding fire risk and forest restoration in critical watersheds along the Front Range. To that end, the Colorado State Forest Service, USDA Forest Service and Denver Water will collaborate with the Pinchot Institute for Conservation to implement a five-step plan to protect Front Range forest watersheds from catastrophic fires.

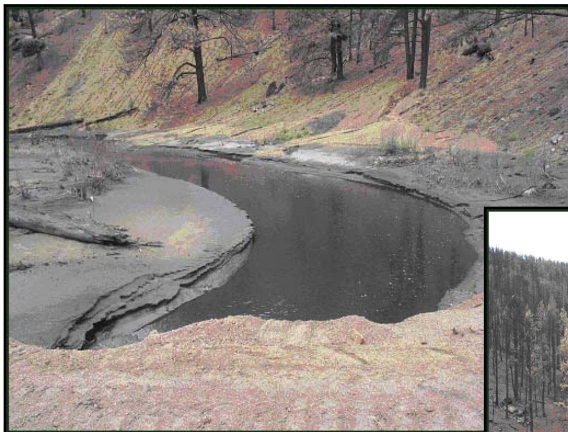
The Pinchot Institute for Conservation is a national organization established to advance conservation and sustainable natural resource management by developing innovative, practical and broadly supported solutions to conservation challenges and opportunities.

Building on the Success of Existing Programs

The project will complement and integrate two current efforts—the Front Range Fuels Treatment Partnership (FRFTP) and Front

Range Fuels Treatment Partnership Roundtable.

The Front Range Fuels Treatment Partnership is a collaborative program of the Colorado State Forest Service, USDA Forest Service and National Park Service to coordinate and implement cross-boundary fuels reduction programs on Colorado's Front Range to help protect wildland-urban interface communities from the potentially devastating effects of wildfire. (To learn more about the FRFTP, visit www.frftp.org.)



THE AFTER EFFECTS OF CATASTROPHIC WILDFIRE: The South Platte River near Cheesman Reservoir shows the erosion and sedimentation that occur from runoff following a brief rainstorm. This area was affected by the 2002 Hayman Fire, the largest wildfire on record in Colorado.

The Front Range Fuels Treatment Partnership Roundtable is a precedent-setting consortium comprised of representatives from 30 organizations including state and federal agencies, local governments, environmental and conservation organizations, academic and scientific communities, and industry and user groups. The Roundtable's mission is to "serve as a focal point for diverse stakeholder input into the FRFTP's efforts to reduce wildland fire risks through sustained fuels treatment along the Colorado Front Range."

In May 2006, the Roundtable released a report that represents the culmination of two years of work. Living with Fire: Protecting Communities and Restoring Forests, Findings and Recommendations of the Front Range Fuels Treatment Partnership Roundtable identifies 10 recommendations that, if implemented, will accelerate progress in achieving community and watershed protection, and forest restoration goals on the Front Range. (To view the Roundtable report, visit www.frftp.org and click on Roundtable then click on "Findings and Recommendations.")

The proposal to protect forest watersheds from catastrophic fire complements the Roundtable's efforts. It will help facilitate the Roundtable's work by expanding stakeholder support through inclusion of watershed information and water users. It also will foster additional political support, which will expedite implementation of the Roundtable's recommendations.

The Five-step Plan to Protect Forest Watersheds

The help protect forest watersheds, a five-step plan is being proposed. Throughout each phase of the proposed plan, Denver Water will work collaboratively with the USDA Forest Service, Colorado State Forest Service, Colorado Department of Public Health and Environment, the American Water Works Association, the Pinchot Institute, private consultants, and other key water providers and contacts.

During Phase I, partners will employ current GIS technology to develop maps of watersheds that serve Front Range communities and integrate them with other relevant data. Four maps will be produced that exhibit watersheds by water provider, watersheds by vegetation type, watersheds by ownership, and watersheds that indicate a high probability for catastrophic wildfires. Existing information, such as the ecological assessments generated by the FRFTP Roundtable, also will be used during this phase.

During Phase II, project managers will evaluate the information generated during Phase 1 to help determine the magnitude of the potential problem and identify watershed hazards along the Front Range. Based on desired future conditions established by the FRFTP Roundtable and analysis of other data, an estimate of overall treatment needs and costs, and challenges to implementation will be developed. The assessment will include a statement or definition of the problem and a strategy to achieve desired future conditions for watersheds that serve the Front Range. Desired future conditions will consider wildfire protection and forest health. A comparative analysis will be conducted to determine the cost and effectiveness of achieving desired future conditions employing the five-step program plan versus the effects of taking no action to protect forest watersheds.

During Phase III, three one-day regional meetings involving Front Range water providers and other key stakeholders on the northern, central and southern Front Range will be held to review and, if necessary, revise the assessment. During these meetings, facilitators also will gather participants' input regarding management within critical watersheds and seek their counsel about fostering broad-based support to accomplish the necessary outcomes. The primary objective of the three regional meetings is to cultivate involvement in the project by water providers and key stakeholders.

During Phase IV, feedback and decision items generated during the three regional stakeholder meetings will be considered in finalizing the assessment. Project managers will consult with key state and federal stakeholders to garner broad-based support for implementation of the assessment. A Front Range-wide meeting of water providers and other key stakeholders will be organized and conducted for the purpose of sharing the strategy that evolves from the three regional stakeholder meetings and gain the support that is essential for successful implementation.

Phase V of the project is considered optional and depends on the outcomes of the Front Range-wide meeting. This phase involves the organization of a conference pertaining to management of Front Range watersheds and vegetation to achieve wildfire protection and forest health. The conference would target water providers, land managers, landowners and other stakeholders across the Western United States. The purpose of the conference is to exchange concerns, ideas and successes regarding forest watershed management and related issues.

Project Timeline

Project partners estimate that it will take three months to create maps of Front Range watersheds and collect and integrate relevant data. This phase of the project is expected to commence in October 2006. Analyzing the data and preparing a written assessment of the situation also will take approximately three months, as will organizing the three regional meetings. Evaluating inputs and outcomes from the three regional meetings, finalizing the assessment, and organizing a larger meeting of water providers and other stakeholders will take one month. Organizing and conducting a west-wide conference on watershed and vegetation management is expected to take three months.

The Pinchot Institute, in collaboration with Denver Water, the Colorado State Forest Service and USDA Forest Service will develop a final report that includes a detailed assessment of Front Range watersheds, identifies issues and challenges affecting watershed health, and recommends strategies to successfully address those issues and challenges based on input from water users and providers.

For additional information about the Front Range forest watersheds project, contact Dave Hessel at 303.635.1597 or dhessel@lamar.colostate.edu or Katherine Timm at 970.295.6892 or kmtimm@lamar.colostate.edu.

FACULTY PROFILE

Dr. Sam Zahran, Assistant Professor Department of Sociology

Dr. Sam Zahran recently joined the Colorado State University faculty in August of 2006 as an Assistant Professor in the Department of Sociology. Dr. Zahran will teach several sociology courses including water resources and society, population, environment, and natural resources. His research appears in Society and Natural Resources, Disasters, Political Research Quarterly, Environment and Behavior, among other periodicals. Sam is from originally from Canada and he received his undergraduate training at the University of Windsor. His PhD work at the University of Tennessee analyzed the spatial distribution of treatment, storage, and disposal facilities of hazardous waste at the census tract scale. Sam comes to Colorado most recently from Texas A & M University where he finished a post-Doctoral fellowship at the George Bush School of Government. At Texas A & M University he worked on climate change and air quality policy and demographic issues funded by NOAA, the EPA, and the Texas Commission on Environmental Quality. Sam is currently a co-principal investigator on a $740,000 grant funded by NOAA to examine policy adaptations to water scarcity in Texas and New Mexico. Other current work includes prediction models of property loss, crop loss, and human casualties from flood events in Texas and Florida as a function of wetland alteration (among other variables). Dr. Zahran was recently married to Aline Beyrouti. He can be contacted at sam.zahran@colostate.edu

The Water-Energy Equation in Irrigated Agriculture

by Bill Orendorff, Senior Planner
Tri-States G&T

It takes energy to raise food, especially here in Colorado where much of the cropland is irrigated by pumped water, powered by electric motors. And it takes water to generate the electricity – a lot of water. Water can be converted to electricity directly through a hydro-electric dam or indirectly by its use in a steam-driven power plant.

Energy – Irrigation Water Relationship

Energy has always been used to produce food – only the form of energy has changed over time: from human physical labor to the use of draft animals to our current use of machinery, electricity and various fossil fuels. As we all know, irrigation here in Colorado began with water being diverted from streams through ditches and applied to crop land by gravity. The use of electricity as a power source to pump, convey and apply irrigation water began back in the 1930-40s with the invention of the turbine well pump and the formation of rural electric cooperatives as a power supplier. The amount of electricity used grew rapidly through the middle of the 20th century with the invention and expansion of center pivot irrigation. To give you an idea of the pace of this development in Colorado, by 1979 electric co-ops in the High Plains of eastern Colorado were serving 2,350 meters connected to center pivot systems. The advent of deep well irrigation pumping and center pivot application pushed electric demand higher at a significant pace throughout the 1960s, '70s, and into the '80s. That impact is shown in Table 1. In fact, irrigation was the largest single use of Tri-State member power in the 1960s and early 1970s.

Table 1. 1979 Tri-State Irrigation Data

Area	Avg. motor size	Avg. Ann. Energy
High Plains Aquifer	100+ hp	110,000 kWh
S.Platte River Basin	20-35 hp	15-30,000 kWh
Arkansas River Basin	20 hp	15,000 kWh
San Luis Valley-gravity	30 hp	20,000 kWh
-pivot	70 hp	70,000 kWh

With center pivot sprinkler systems requiring so much more electricity than other types of application methods, why did their use increase so fast and over such a large area? That answer is the same as what's been going on in all of agriculture since the early part of 20th century, namely technology. Agricultural productivity continues to be a major benefactor of technological advances in mechanization.

Since the national energy crisis of the 1970s, U.S. agriculture has improved energy use efficiency by nearly 100%: farmers and ranchers now produce twice as much crop and livestock output for the same amount of energy used – including the energy used to produce fertilizers and pesticides. Between 1978 and 1993, energy use by agriculture - excluding electricity – declined by 25%, while agricultural output increased by almost 47 percent during the same period. Efficiency gains were primarily due to agricultural producers switching from gasoline-powered to fuel-efficient diesel-powered engines, adopting energy-conserving tillage practices, shifting to larger multifunctional machines, and adopting energy-saving methods of crop drying and irrigation.[2]

That brings us to the present. What is the magnitude of water use for agricultural irrigation in Colorado and how is that related to the use of electricity? According to the Farm & Ranch Irrigation Survey from the 2002 USDA Census of Agriculture, we have over 2.5 million irrigated acres in Colorado, with approximately 85% of those acres being in cropland. The source for irrigation water is split about 60/40 between surface water and groundwater, respectively. Our irrigated acreage supports many types of crops, and pasture land. A breakdown of those crops and their average annual water applications is shown in Table 2. Using the average application rates from the table yields a total use of 3.9 million ac-ft of water for irrigation. Although most of our crop irrigation is powered by electricity, other fossils fuels are utilized to power irrigation pumping as well. The magnitude of acres irrigated and the expense incurred by each power source is shown in Table 3. More detailed data is available at www.nass.usda.gov/Census_of_Agriculture.

Irrigating that many acres takes a lot of electricity. In 2005 Tri-State supplied electricity to over 1.25 million horsepower of irrigation motors in our 4-state service territory through our 44 member electric cooperatives. Approximately half of that horsepower is located in Colorado, mostly in the eastern plains and San Luis Valley. Likewise, of the 1,172 GWh of electricity used by those motors, about half of that amount was used here in Colorado.

Over the past 20 years the average irrigation customer motor size has increased slightly, by 1½ hp, but the average annual energy usage has increased by about 10,000 kWh – a 25% increase. Additionally, the annual variation in irrigation energy

Table 2. Selected Crops & Water Applied

Crop	Irrigated Acres (rounded)	Avg. ac-ft Applied/Ac.
Corn for grain	556,000	1.7
Corn for silage	77,000	1.4
Sorghum	14,000	0.7
Wheat	157,000	1.1
Barley	83,000	1.7
Dry beans	39,000	1.5
Other small grains	10,000	1.2
Alfalfa	629,000	1.5
All other hay	473,000	1.7
Sugar beets	35,000	1.6
Potatoes	68,000	1.5
All vegetables	19,000	1.6
Orchard/Vineyard	8,000	4.3
All other crops	28,000	0.8
Pastureland	354,000	1.3

Table 3. Energy Expenses for On-Farm Irrigation Water Pumping

Power Source	Irrigated Acres Well	Irrigated Acres Surface	Expenses (1,000)	Expenses/irrigated acre Well	Expenses/irrigated acre Surface
Electricity	950,000	293,500	$52,350	$45.50	$36.40
Natural gas	68,000	22,000	$ 3,700	$53.20	$ 5.70
LP gas & propane	9,000	12,000	$ 350	$12.55	$18.45
Diesel fuel	67,000	65,000	$ 2,500	$23.65	$12.00
Gasoline	1,700	4,500	$ 15	$ 4.00	$ 1.45
Total Energy	1,095,600	397,000	$58,750	$44.40	$28.25

use has been as much as ±20% from the mean value during this same time period. On the scale of a single field, annual variations in energy use are a function of crop rotation (crop water use), as well as weather variables. However at Tri-State's scale, the individual field variables get diluted and annual variations in energy use become a function of seasonal weather variables: total precipitation and growing degree-days.

Since the beginning of this decade, annual electricity sales for irrigation motors have been 10-13% of Tri-State's total sales to its members. However, peak demand is an entirely different matter. Even with continued growth of residential customers along the Front Range and the addition of large minerals-related loads, irrigation motor use is a significant factor in our summer load, accounting for approximately one third of peak demand. While the magnitude of this seasonal demand does not vary much from year to year, the timing of the cumulative energy use between April and September can vary significantly each year due to the annual fluctuations of precipitation and growing-degree days. At the scale of the individual electric cooperative, these annual fluctuations have a significant impact on their system's revenue. In parts of the state with significant irrigated crop production, irrigation meters are the largest single category of revenue for the cooperative.

Although power consumption is directly linked to irrigation water pumping, trying to model the exact relationship is not a simple task. With funding from EPRI's Agricultural Technology Alliance, a study was begun in 1997 to develop a predictive model for irrigation power demand in northeastern Colorado. The motivation for the project was the electric cooperatives' need for a short-term forecasting tool to facilitate load control programs which were being considered. With 1992-1996 power data from Tri-State and historical local weather data, the study team of USDA-ARS and CSU Extension personnel set out to determine the correlation between peak demand and various weather variables. Even with advanced statistical analysis the only strong correlation was the inverse relationship between rainfall events and power usage. The rainfall events were a good predictor of power drops but not of future peaks. Also, an attempt was made to predict future peak demand at intervals from 1 to 7 days while ignoring precipitation, but without success.[3]

Energy is an important input for irrigated crop production in Colorado, right along with seed, fertilizer, pesticides, implements, etc. From the producer's perspective, he/she is trying to be as profitable as possible and wants to minimize production expenses. Over time, there have been significant advances in irrigation equipment and practices which have helped to increase the efficiency of water application to crops and thereby save water and reduce energy costs. Obviously, the impact of energy savings are realized first and foremost at the individual field scale, and as more and more producers in a locale make equipment and/or management changes for energy savings there is an impact to the local electric cooperative. At the Tri-State scale, however, it would take significant energy reductions from 100s of meters to make a significant impact on the system as a whole. There are many ways to increase overall irrigation efficiency which include irrigation technology, tillage technology, and water management technology.[4] All of those areas impact energy consumption but those discussions are best left to university and extension agronomists and irrigation specialists. For the purposes of this article I will discuss efficiency related to electricity usage by irrigation system pumping plants.

Pumping plant electricity use is a combination of horsepower (demand) and hours of operation (energy). Increasing the efficiency of either can lower the total cost of producing an irrigated crop. The horsepower requirement of a pumping plant is expressed by the equation:

$$HP = \frac{GPM \times TDH}{3{,}960 \times Eff.}$$

The pumping rate (GPM) relates to the volume of water needed to sustain the desired crop under given soil characteristics and known weather parameters in conjunction with the capacity of the delivery system. The total dynamic head (TDH) is the sum of the actual vertical lift of water from the well, a pressurization component and friction losses in the piping, all expressed in feet of lift. Pumps and motors are mechanical devices and, therefore, are subject to inefficiencies. Typical pumping plant inefficiencies are described in Table 4.[5] A producer can estimate pumping plant performance and potential energy savings from season-long records, using the Nebraska Pumping Plant Performance Criteria (NPC).[6]

The electric motors that power pumping plants are reliable, and easy to operate and maintain. However, they can also be a source of pumping plant inefficiency. Motor manufacturers typically market two levels of efficiency in their products. Regardless, today's motors are several percentage points more efficient that the motors manufactured even five years ago. Motor replacement is an important economic decision and can require the capital outlay of several thousand dollars. Even with dealer discounts, 3-phase motors typically cost $50-60 / hp. A calculation for energy savings is shown in Table 5.

Table 4. Causes of Excessive Energy Use

- Poor pump selection
- Pumps out of adjustment
- Worn out pumps
- Improperly sized motors
- Motors in need of maintenance or repair

Table 5. Annual Energy Savings

Savings=

$$hp \times L \times 0.746 \times hrs \times C \times \left(\frac{100}{E^{std}} - \frac{100}{E^{ee}} \right)$$

Savings	= Expected $ savings
hp	= motor horsepower
L	= load factor (percent of full load)
0.746	= conversion from horsepower to kW units
Hrs	= Annual operating hours
C	= Average energy costs ($/kWh)
E^{std}	= Standard motor efficiency rating, %
E^{ee}	= Energy efficient motor efficiency rating, %

In reality, however, formulas and calculations are not the only considerations when it comes to making efficiency improvements. The Farm & Ranch Irrigation Survey includes barriers to making improvements to reduce energy use or conserve water. For Colorado the survey respondents accounted for 7,647 farms, comprising 1,326,581 irrigated acres, receiving 2,069,622 ac-ft of water in the survey year. Respondents could choose more than one barrier to improvement and responses are ranked in descending according to acres irrigated. Those results are listed in Table 6.

Table 6. Barriers to Making Improvements to Reduce Energy Use or Conserve Water

- Improvement(s) won't save enough to cover installation costs
- Uncertainty about future availability of water
- Cannot finance improvement(s)
- Physical field conditions limit system improvement(s)
- Risk of reduced yield
- Landlord will not share cost of improvement(s)
- Improvement(s) not a priority
- Other
- Will not farm this operation long enough to justify improvement(s)

As prolonged drought conditions require more water pumping, rising energy costs are causing producers to pay closer attention to the economics of irrigated crop production. In these times, the traditional goal of maximizing yield may be giving way to the concept of maximum economic return: producing where marginal cost equals marginal return (MC=MR). If water is viewed as an economic good, a commodity, what is its value as an input to irrigated crop production? Staying at individual field scale, water could reasonably be valued as the cost to deliver it to the crop over a growing season. Another method could be to consider water's utility, or the difference between irrigated and dryland yield. However, irrigation is site-specific. Due to the differences in soils, crop rotations, pumping and application system efficiencies, energy costs and cultural practices water "value" will likely not be the same for any two given fields.

As scale increases from field to county to water basin or state, data can be collected and aggregated to give generalized values. As perspective widens, though, other quantitative and subjective factors become significant: economic activity multiplier, the intrinsic value to society of the open space created by agriculture, etc. Accordingly, water valuation on a large scale is not a simple matter and sustainable use requires input from all user classes.

Summary

In Colorado water, energy, and food production are inexorably linked in a circular fashion. Water is used to generate electricity, which is then used to pump irrigation water for food production. In the last half of the 20th century water use greatly expanded due to the availability of electricity and advancements in mechanized water application to farm land. However, the last decade has been characterized by continuing efforts toward efficiency gains to conserve both water and energy. On a micro-economic scale water is an economic input but not easily quantified. On a macro-economic level water use for food production leaves both economic and societal issues to be resolved.

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GS 592 - WATER RESOURCES SEMINAR

Fall 2006 theme:
Current Topics in Colorado Water Law

Monday, 4:10 – 5:30pm
A-206 Clark Building

Colorado State University, Fort Collins, CO

The appropriation and administration of Colorado's water resources rests upon 140 years of territorial and state law. This body of law prescribes how we put water to beneficial use in an arid land that never has enough water to satisfy all of the appropriated and environmental uses. The Doctrine of Prior Appropriation has guided the State for many years but the recent drought exposed a number of water management challenges that required new legislation and court rulings to allow water administration to continue evolving.

The purpose of the 2006 Water Resources Seminar is to examine the changing nature of Colorado water law and to ground students in basics of how our water legal system works. More specifically, the seminar will:

- Describe the theories, history and background of Colorado water law;
- Examine the role and function of the water court system and legislature;
- Discuss strengths and weaknesses of the law in surface and ground water administration;
- Examine current topics in Colorado water law, including: ground water use and augmentation, environmental and recreational flows, municipal acquisition and transfer of agricultural water, endangered species needs, interstate compacts, water quality protection and other topics.

Faculty and guests are welcome to attend and participate.

9-Oct	David Robbins, Attorney	Interstate Compacts and Federal Water Law (Case Study: Arkansas River Settlement)
16-Oct	Rep. Kathleen Curry, Colorado House Member	The Legislative Process and the Evolution of Water Rights (Case study: Recreational Flows)
23-Oct	Bill Brown, Attorney	Water Right Transfers & Adjudication: How the Water Court System works
30-Oct	Melinda Kassen, Attorney	Defending Environmental Needs and Water Quality
6-Nov	Andy Jones, Attorney & Tom Cech, Central Colorado Water Conservancy District	Current Issues in Groundwater Law and Administration (Case Study: South Platte Basin)
13-Nov	Mike Shimmin, Attorney	Colorado Groundwater Law
20-Nov	Thanksgiving Break	No Class
27-Nov	Ken Knox, Deputy State Engineer	Implementing Colorado Water Law (Case Study: San Luis Valley)
4-Dec	Mark Squillace, CU Natural Resources Law Center	Other State Approaches to Water Administration and Adjudication

The Lower Arkansas Valley Drainage System Study

by Dr. John Wilkins-Wells, CSU Sociology Water Lab

The CSU Sociology Water lab has been involved in cleaning several old tile drain lines in the lower Arkansas Valley. The lines are cleaned much in the way that sewer lines are cleaned. The study effort is designed to promote the value of restoring and upgrading these old drain lines for the purpose of improving agricultural production in the valley. A tour of these activities and a discussion of what has been learned thus far was conducted in early August. Participants visited with and listened to the testimony of participating landowners as they spoke of the benefits of improving the maintenance of the valley's old tile lines.

Jet Cleaning of Tile Lines:
Photo shows a jet nozzle working through a tile line that has been plugged for many years. The current study estimates that there are approximately 140 miles of old tile lines in the lower Arkansas Valley that need maintenance work of this nature.

On December 4-6, 2005, three landowners from the Arkansas Valley participated in a study tour to the South Columbia Basin Irrigation District, Pasco, Washington. The purpose of the study tour was to acquaint landowners with how an established drainage district operation and maintenance program is conducted. Mr. Danny Morasch, Drainage Technician with the district, guided participants through the district program. Participating in the study tour were Curtis Tempel (Prowers County), Ryan Hemphill (Bent County) and Keith Tucker (Otero County). The participants returned from the study tour and gave a presentation on their observations at our first advisory committee meeting in Lamar on March 22nd, 2006.

On June 7, 2006, we held our second advisory committee meeting in Las Animas. Mr. John Ballagh, General Manager of the Grand Junction Drainage District, was invited to discuss his drainage program. The meeting was well attended, and we learned much about organizing and managing a large drainage district.

Recent efforts to demonstrate the benefits of drainage tile line cleaning have been successful. Tile lines were cleaned on several properties. Most of the estimated 140 miles of buried tile lines in the lower Arkansas Valley appear to be salvageable. Efforts are needed to explore ways in which a routine tile line and open drain operation and maintenance program for the entire lower valley could be developed under a special district or other cooperative entity. Such an effort would assure landowner support for drainage improvements in the valley, and would be in keeping with drainage as it is practiced in other irrigated areas of the West. A portion of the next advisory committee meeting on September 13 will be devoted to looking at the formation of a valley-wide drainage authority. Mr. Walt Epley continues to map the old tile lines using global positioning (GPS) and geographic information systems (GIS) technology. He has written and submitted several reports to local drainage districts on the approximate location of tile lines within their respective boundaries. This effort is nearing completion. The next stage of the project is to begin enumerating the tile lines throughout the valley, utilizing an acceptable nomenclature practiced in Washington and California drainage districts.

Walt Epley

This involves numbering all buried tile line outlets known to exist in the valley, including any manholes associated with these lines. This numeration will provide the basis for a standardized maintenance plan to be conducted in a consistent way, much in the way a ditch company would inventory and maintain headgates, gauging stations and other canal features.

Jet Cleaning of Tile Lines:
Modern sewer maintenance technology is very well suited to maintaining buried tile lines throughout the lower valley.

For additional information on upcoming events, or to inquire how you might help the project, please contact:

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johnww@lamar.colostate.edu

http://waterlab.colostate.edu/

Water Conservation Research at the Plainsman Research Center

by Kevin Larson, Dennis Thompson, Deborah Harn, and Calvin Thompson
Colorado State University

There has been a research focus on water conservation in Southeastern Colorado even before Plainsman's official status in 1974 as an Agricultural Experiment Station Research Center. Plainsman began as an irrigation project addressing the profitability of well irrigation at Walsh. Ed Langin, the first Plainsman Superintendent/ Research Scientist, and his irrigation predecessor Don Miles, Area Extension Irrigation Specialist, conducted numerous limited irrigation studies with both reporting that a single furrow irrigation at silking or flowering produced the highest yield response (yield per applied water) for corn and grain sorghum. The current staff at Plainsman has continued and expanded the limited irrigation work of Ed and Don to include sprinkler and Subsurface Drip Irrigation (SDI) irrigation methods.

The Plainsman Research Center is located in Southeastern Colorado near the town of Walsh. There are three full time staff members at the Plainsman Research Center and all three are Colorado State University Agricultural Experiment Station employees. In additional to the three staff members, one seasonal farmer is employed at Plainsman. Support for the Plainsman Research Center comes from the Agricultural Experiment Station and the Plainsman Agri-Search Foundation. The Plainsman Agri-Search Foundation is a growers association that supports agronomic research at the Plainsman Research Center. Currently, the Plainsman Agri-Search Foundation owns 800 acres of land approximately 5 miles northwest of Walsh and leases another 80 acres south of the Plainsman Office. There are three small wells (25 gpm to 120 gpm) used for irrigating four 30-acre center pivots and two subsurface drip irrigation systems (11 acres and 35 acres) on the Plainsman farm. The bulk of Plainsman's land is dryland cropped.

Typically with a single furrow irrigation we applied between 6 to 10 inches of water per acre. With the expansion of limited irrigation from furrow to sprinkler irrigation, we formulated a working definition of limited irrigation as follows: applying less than 10 inches of water above normal precipitation. When applying similar amounts of water, we found that sprinkler irrigation increased grain yield compared to furrow

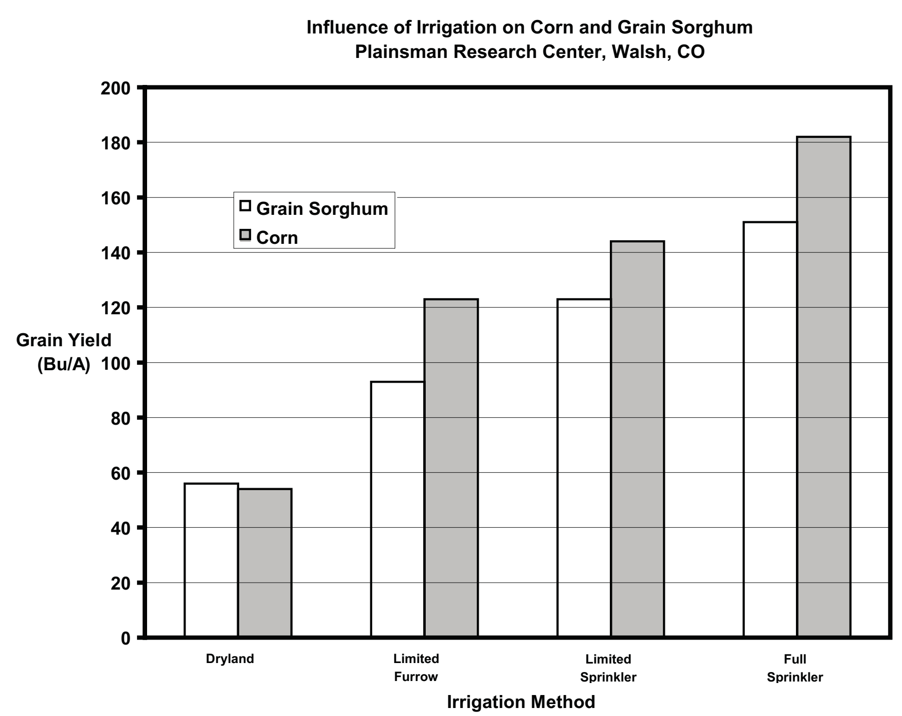


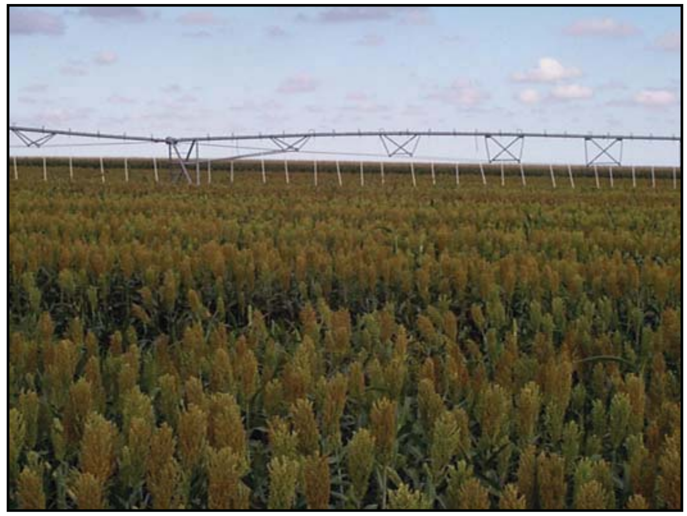
Fig. 1. Influence of irrigation on corn and grain sorghum yields. Yields are average yields at Plainsman Research Center at Walsh, Colorado. Limited furrow and sprinkler irrigation regimes averaged 9 A-in./A of irrigation. Full sprinkler irrigation averaged 17 A-in./A of irrigation.

by about 20 bu/acre for corn and 30 bu/acre for grain sorghum (Fig. 1).

Comparing limited irrigation corn and grain sorghum to full irrigation, we found that limited irrigation was more profitable when pumping costs exceeded $5/acre-in. with commodity prices at $2.29/bu for corn and grain sorghum (Fig. 2). Corn frequently has up to $0.30/bu to $0.40/bu price advantage compared to grain sorghum in the local market. Grain sorghum priced at $1.89/bu (the loan rate of grain sorghum) makes limited irrigation grain sorghum more profitable than full irrigation when pumping costs exceed $3.50/acre-in. Last year pumping costs for natural gas fueled wells in our area was around $7/A-in to $8/A-in., well above the pumping cost conversion point from full to limited irrigation.

The current high fuel cost makes pumping cost the most responsive variable driving conversion from full to limited irrigation. Other variable input costs such as fertilizer and seed, which are reduced with the lower limited irrigation yield goal, favor limited compared to full irrigation.

Subsurface Drip Irrigation (SDI) is the latest water conservation method studied at Plainsman. SDI is the most water efficient (yield per applied water) irrigation method currently in use. Many new SDI installations in Southeastern Colorado use half as much water per acre than full sprinkler irrigation (4.8 gal/min/acre for sprinkler vs. 2.4 gal/min/acre for SDI).



Some proponents of SDI have speculated that increased income may be gained with more intensive, high input SDI compared to the income derived with lower inputs. From two years of study, we found that low input SDI had higher variable net income, ranging from $7/A to $58/A, than high input SDI (Table 1).

Like limited sprinkler irrigation, pumping cost was the most responsive variable. Again as we found with limited sprinkler irrigation, when variable input costs such as fertilizer and seed increase, low input SDI income increased. Even though the low input treatment yielded significantly less than the high input treatment, the cost savings from lowering inputs of seed, fertilizer, and irrigation gave the low input treatment the income advantage. Increasing income by lowering inputs may not get you coffee shop bragging rights, but it does make economic sense.

The higher irrigation efficiency is arguably the most beneficial aspect of SDI. Two other notable benefits of SDI include greater nutrient management and more frequent and uniform water applications (Table 2). SDI is not a panacea. Drawbacks of SDI include greater management required, high expense, and more maintenance. As a grower with a new SDI installation stated, “If you don’t like the management required to run a pivot, you’re going to hate drip.”

Table 1.-Drip Irrigated Corn, High and Low Input Comparison, 2004 and 2005.

Treatment	Year	Plant Density	Silking Date	Grain Moisture	Test Weight	Grain Yield	Variable Net Income
		Plants/A (X1000)		%	Lb/Bu	Bu/A	$/A
Low Input	2004	24.3	5-Aug	14.5	59	173	237.56
High Input	2004	32.7	5-Aug	14.5	59	191	230.68
Average 2004			5-Aug	14.5	59	182	234.12
LSD 0.20 (2004)						2.6	3.34
Low Input	2005	26.2	5-Aug	14.2	59	148	126.29
High Input	2005	33.0	5-Aug	14.6	59	160	67.51
Average 2005		29.6	5-Aug	14.4	59	154	96.90
LSD 0.20 (2005)						4.6	2.89

Low Input received 26,000 (2004) or 27,000 (2005) Seeds/A and 11 in./A of water.
High Input received 34,000 Seeds/A and 16 in./A of water (2004 and 2005).
High Input received 25 Lb N/A (2004) or 60 Lb N/A (2005) more than Low Input.
2004 input cost: seed cost $1.50/1000 seeds; water cost $5/in.; N cost $0.30/lb.
2005 input cost: seed cost $1.50/1000 seeds; water cost $8/in.; N cost $0.38/lb;
Variable Net Income: grain yield x corn price ($2.15/bu) - seed cost - water cost - fertilizer cost.

Table 2 Pros and Cons of Subsurface Drip Irrigation.

Pros	Cons
* Frequent and uniform application	* Greater management required
* Nutrient micromanagement	* Crop germination difficulties
* Perform field operation while irrigating	* Animal and mechanical damage to drip tape and risers
* No soil evaporation	* More maintenance
* Less irrigation required for high crop yields	* Expensive
* Adaptive to small and odd-shaped fields	* Dedicated to field and cropping system

Net Income and Pumping Cost for Limited and Full Irrigation Corn and Grain Sorghum

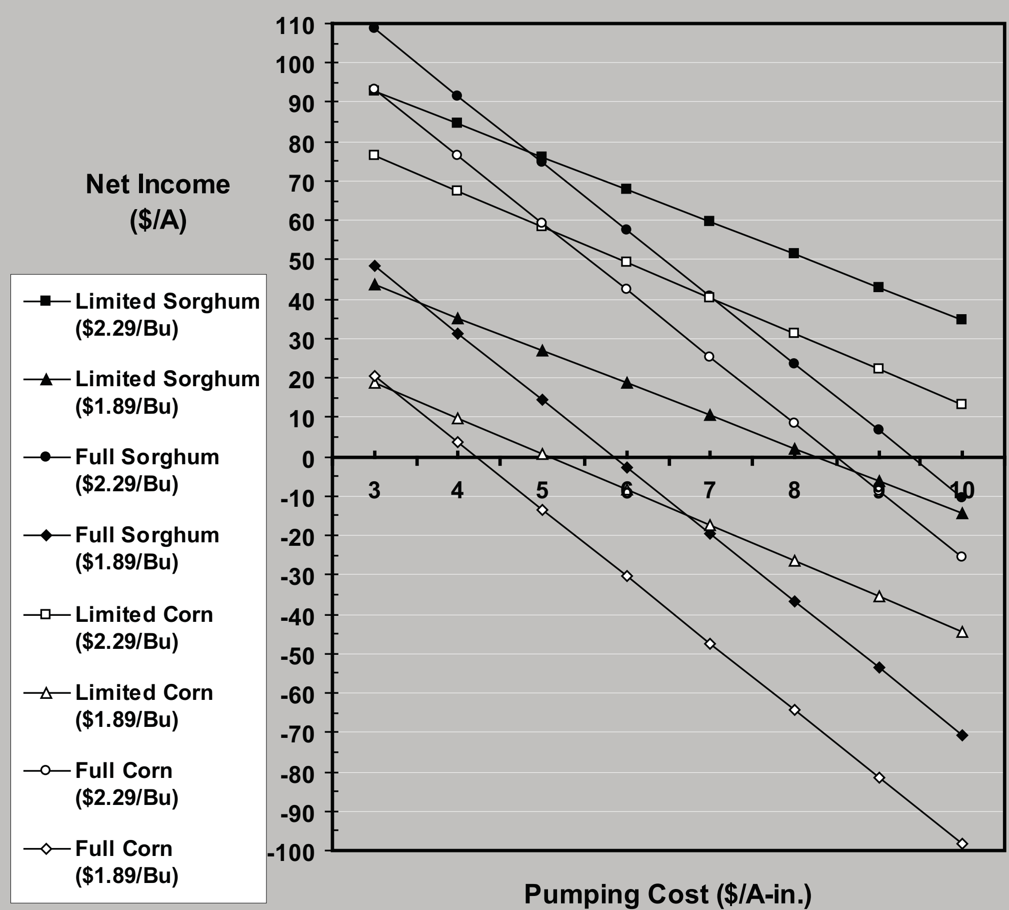


Fig. 2. Full and limited sprinkler irrigation comparison of net income for corn and grain sorghum. Assumptions: yield: 151 Bu/A for full irrigation grain sorghum, 123 Bu/A for limited irrigation grain sorghum, 182 Bu/A for full irrigation corn, and 144 Bu/A for limited irrigation corn; grain price: $1.89/Bu and $2.29/Bu; irrigation: 17 A-in./A for full irrigation corn and grain sorghum, 8.3 A-in./A for limited irrigation grain sorghum, and 9 A-in./A for limited irrigation corn; production costs: pumping cost varies from $3 to $10/A-in., all other costs remain constant.

PUBLICATION ANNOUNCEMENT
CWRRI Completion Report No. 204

URBAN LANDSCAPE IRRIGATION WITH RECYCLED WASTEWATER

ABSTRACT

by Yaling Qian
Department of Horticulture and Landscape Architecture

As the population of Colorado's Front Range continues to grow, increased use of recycled wastewater (RWW) is viewed as one approach to maximize the existing water resource and stretch Colorado's urban water supplies. Understanding the responses of urban landscape plants and soils to recycled wastewater irrigation and identifying proper management practices are critical to the long-term success of this practice. From 2003-2005, research was conducted to assess variability of chemical properties of recycled wastewater in the Front Range of Colorado and to evaluate landscape soils and plants that are currently under recycled wastewater irrigation.

Survey data indicated that, rather than cost savings, the availability and reliability of the water were the main reason for using RWW for irrigation.

Recycled wastewater samples were collected from irrigation ponds and sprinkler outlets on landscape sites. Results indicated that there were variations in water quality between wastewater treatment facilities. In all cases, the water samples met or exceeded the regulations in regard to of E. coli count as defined in the state Regulation 84, therefore the water is suitable for landscape irrigation. Nevertheless, RWW does contain varying quantities of soluble ions, with an average electrical conductivity (EC) value of 0.84 dS m1. The chemical constituents of recycled wastewater were dominated by sulfate, bicarbonate, chloride, and sodium. The average sodium and chloride concentrations of 37 water samples collected from all the sites were 99 mg/L and 95 mg/L, respectively. Adjusted sodium absorption ratio (SAR) of RWW samples ranged from 1.6 to 8.3.

To assess recycled wastewater irrigation on the long-term changes of soil, we compiled soil test data from landscape sites that were near metropolitan Denver, CO. Among these sites, six had been irrigated exclusively with domestic RWW for 4, 5, 13, 14, 19, and 33 years, respectively. The other six with similar turf species, age ranges, and soil textures had used surface water (average EC = 0.23 dS m-1) for irrigation. Our results indicated that soils (sampled to 11.4 cm) from sites where RWW was used for at least four years exhibited 0.3 units of higher pH and 200 percent, 40 percent, and 30 percent higher concentrations of extractable Na, B, and P, respectively. Compared to sites irrigated with surface water, sites irrigated with RWW exhibited 187 percent higher EC and 481 percent higher sodium adsorption ratio (SAR) of saturated paste extract. However, extractable Mg was reduced by 15 percent ($P < 0.005$). Comparison of soil chemical properties before and 4 or 5 years after RWW irrigation on two golf courses also revealed the following findings: a) 89-95 percent increase in Na content; b) 28-50 percent increase in B content; and c) 89 - 117 percent increase in P content at the surface depth.

Generally, turfgrasses had a good appearance, showing salinity damage only on a few sites with poor drainage, heavy soil structure, or shallow water table. However, chronic decline of conifer trees were often observed under RWW irrigation. Ponderosa pines grown on sites irrigated with RWW for 5-33 years exhibited 10 times higher needle burn symptoms than those grown on sites irrigated with surface water (33 percent vs. 3 percent). Tissue analysis indicated that ponderosa pine needles collected from sites receiving RWW exhibited 11 times greater Na+ concentration, two times greater Cl-, and 50 percent greater B concentrations than samples collected from the control sites. Stepwise regression analysis revealed that the level of needle burn was largely influenced by leaf tissue Na+ concentration. Tissue Ca level and K/Na ratio were negatively

associated with needle burn symptoms, suggesting that calcium amendment and K addition may help mitigate the needle burn syndrome in ponderosa pine caused by high Na+ in the tissue.

The project indicated that both problems and opportunities exist in using RWW for landscape irrigation. The use of recycled wastewater for irrigation in urban landscapes is a powerful means of water conservation and nutrient recycling, thereby reducing the demands of freshwater and mitigating pollution of surface and ground water. However, potential problems associated with recycled wastewater irrigation exist. Salts (especially the relatively high Na+ and high EC) in the treated wastewater were associated with needle burn symptoms observed in ponderosa pines subjected to RWW irrigation. The significantly higher soil SAR in RWW-irrigated sites compared to surface water irrigated sites provided reason for concern about possible long-term reductions in soil hydraulic conductivity and infiltration rate in soil with high clay content, although these levels were not high enough to result in short-term soil deterioration. This information is useful to landscape planners and managers to determine what should be monitored and what proactive steps should be taken to minimize any negative effects during planning and managing landscapes receiving recycled wastewater. Understanding the responses of urban landscape plants and soils to recycled wastewater irrigation and identifying proper management practices are critical to the long-term success of the water reuse practice.

This report may be downloaded at www.cwrri.colostate.edu

CWRRI Completion Report No. 206

SALT CHEMISTRY EFFECTS ON SALINITY ASSESSMENT IN THE ARKANSAS RIVER BASIN, COLORADO

ABSTRACT

by Curtis Allen Cooper, Grant Cardon and Jessica Davis

Electrical conductivity is an essential indicator of soil quality. Methods used to measure electrical conductivity (EC) were examined to determine the effects of laboratory analysis and extrapolations to in-situ conditions. Methods were tested using combinations of (1) surrogate irrigation waters (SI) to saturate soils over a range of chemical concentrations, (2) soils with different salinity levels, and (3) soils ground or retaining aggregates. Baseline soil EC levels were measured from soil extracts that were saturated with distilled water (ECe) and showed no significant difference between ground and aggregated treatments for the low salinity soil ECe.

When the low salinity soils were saturated with SI waters, the response ECs varied as SI concentrations increased. The sum of the baseline ECe and SI EC were not equal to the measured EC above approximately 3.5 dS m-1, suggesting that gypsum dissolution was becoming limited. Soils with high salinity (ECe >8 dS m-1) lacked structure and aggregates and could not be compared to ground soils. None of the tests with the high salinity ground soils had the sum of the baseline (distilled water) ECe and the SI EC equal to the measured EC of soils saturated with SI.

Multiple extractions from the same soil sample were processed to determine salt removal potential from calcareous/gypsiferous soil. The Ca concentrations remained relatively constant over 14 extractions while Na concentrations decreased. The ECe decreased from above 8 dS m-1 in the initial extraction to approximately 4 dS m-1 by the 9th extraction, and remained stable to the 14th extraction. This stable ECe suggests that mineral reservoirs of gypsum and calcite remain in the soils. These mineral reservoirs have implications for salinity removal, which becomes limited to the more soluble salts and minerals (e.g. Na and mirabilite).

Examination of the multiple extraction data suggests that improved leaching will not successfully lower the EC level below approximately 4 dS m-1 due to the gypsum and calcite reservoirs in the soil. Combinations of the irrigation water chemistry and precipitation and dissolution chemistry can potentially complicate or

negate expected leaching potential.

Mineralogical variations associated with salinity influence the calibration of the electromagnetic induction meter because the ions are the primary carriers of the electromagnetic resonance. Soils in the high plains of the lower Arkansas River Basin of Colorado are reservoirs of calcite and gypsum. When ions in solution precipitate, their influence on the electromagnetic resonance is decreased. Current EM-38 (Geonics, Ontario, Canada) calibration equations for the lower Arkansas River Basin rely upon electromagnetic measurements in the vertical position (EMv) and water content measurements to predict saturated paste electrical conductivities (ECe).

Calibration equations developed in this research, use either depth averaged or depth weighted salt concentrations and/or predicted pore water salt concentrations from Visual Minteq. For example, the current Downstream sub-region calibration equation relating EM readings to soil ECe has an R2 of 0.54 with an root mean square error (RMSE) of 2.16 dS m-1. The equation from this research, using depth weighted Mg concentrations and SAR with Visual Minteq has an R2 of 0.93 with a RMSE of 1.34 dS m-1, and is effective for both the Upstream and Downstream sub-regions. Validation of these equations suggests that predictability is equivalent between the initial sub-region model and the models for the entire region. The inclusion of the chemistry/mineralogy in the calibration equations serves to resolve some of the unevenness of the EMv-ECe calibration, but at the cost of more complex computing and data requirements. However, the inclusion of the chemical data offers an alternate approach not yet utilized in extrapolating the calibration of the EM-38 from a field to a regional scale.

This report may be downloaded at www.cwrri.colostate.edu

Colorado Water Workshop Moves to May

2007 Workshop will focus on Colorado River Watershed issues from the Colorado and Green river headwaters in Colorado and Wyoming to the Delta in Mexico.

It's the same workshop in the same Gunnison location and with a new date. After 32 years of annual Colorado Water Workshop conferences in late July, 2007 will see a change with a move to May 22-24 in the College Union building. Workshop director Pete Lavigne notes that the move will make it easier for Western students and faculty to participate, and will bring the workshop's economic impact to Gunnison at a slow time of year when local hotels and restaurants can easily absorb the 200 plus visitors to town. "Late July has worked well for the workshop over many years but few Western students have been around to participate then and we see some additional benefits by moving to late May. Speakers for the Water Workshop from beyond the local area are more likely to be available in May as many are on vacation in July and Gunnison hotels are emptier in May and therefore cheaper," says Lavigne. "After getting feedback from over thirty formal and informal Workshop advisors and sponsors, we went with the vast majority who liked the idea of moving the annual gathering to May." Gunnison weather in late May is usually in the high 60s with beautiful dry weather. "According to the weather records Gunnison is actually drier in May than in July and should be great for golfing, bird watching, fishing and other outdoor activities that workshop participants like to plan for," says Lavigne.

There was unanimous feedback that the 2007 theme should focus on basin wide issues in the Colorado River watershed. "1992 was the last time the Workshop specifically took a basin wide approach to the Colorado River. We'll be discussing a variety of issues from the headwaters of the Colorado and Green rivers in Colorado and Wyoming all the way to the delta in Mexico," says Lavigne. Already former Commissioner of the Bureau of Reclamation Dan Beard has committed to keynote the Workshop and other potential speakers are also volunteering. Lavigne adds, "George Sibley did a fantastic job of widening the Workshop's reach over the past five years and his great work is making it easy to attract top notch speakers for the plenary sessions and workshops. As the advisors work with us on specific panels and topics over the next few months I'll be announcing those results as we go along. In the meantime we hope many folks from the region will write in the new dates and plan to attend."

RESEARCH AWARDS

Colorado State University, Fort Collins, Colorado
Awards for August 2006 to September 2006*
(in alphabetical order)

Bauder, Troy A--1170--USDA-NRCS-Natural Resources Consvtn Srv--Validation and Demonstration of the Colorado Agricultural Meterological Network-CoAgMet for Improved Irrigation --**$53,420**

Berrada, Abdelfettah--3040--USDA-NRCS-Natural Resources Consvtn Srv--Conserving Water and Minimizing Leaching of Salts and Nitrate-Nitrogen in the Arkansas Valley Through Enhanced ...--**$75,000**

Bestgen, Kevin R--1474--DOI-Bureau of Reclamation--Annual YOY Colorado Pikeminnow Fall Monitoring (Project No. 138)--**$15,000**

Clements, William H--1474--DOI-USGS-Geological Survey--Effects of heavy metals in Rocky Mountain strems --**$40,526**

Cooper, David Jonathan--1472--DOI-NPS-National Park Service--Data Collection and Detailed Restoration Design Rodeo Beach Wetland Complex--**$19,855**

Culver, Denise R--1474--Colorado Division of Wildlife--Survey of Critical Biological Wetland Resources in Hinsdale County, Colorado Task Order for Colorado Division of Wildl...--**$5,000**

Denning, A Scott--1371--MTU - Michigan Technological University--Land-Atmosphere Exchanges of Carbon, Water, and Energy Across the Midcontinental Region of North America: Processes...--**$103,560**

Garcia, Luis--1372--USDA-ARS-Agricultural Research Service--Apply & Enhance the Object Modeling System for Building New Models for Field, Farm, & Watershed Scales--**$145,000**

Gates, Timothy K--1372--DOI-Bureau of Reclamation--Identification, Public Awareness, & Solution of Waterlogging & Salinity in the Arkansas River Valley--**$10,000**

Hanan, Niall P--1499--Northern Arizona University--Carbon, Water, and Land Use in Conservation Reserve Program Lands of the Shortgrass Prairie--**$112,683**

Hansen, Neil--1170--USDA-ARS-Agricultural Research Service--Irrigation, Tillage, and Weed Management to Maintain Agricultural Profitability with Limited Water--**$40,000**

Hawkins, John A--1474--DOI-Bureau of Reclamation--Yampa River Nonnative Fish Control: Translocation of Northern Pike from the Yampa River--**$5,000**

Labadie, John W--1372--DOI-Bureau of Reclamation--Modsim Model Code and GUI Enhancements --**$27,000**

Loftis, Jim C--1372--DOI-NPS-National Park Service--Continuation of Inventorying & Monitoring Natural Resources Status & Trends in the National Park System--**$510,847**

Loftis, Jim C--1372--DOI-NPS-National Park Service--Design Expertise & Tech Support to the NRPC of the NPS, Web Technology--**$14,867**

Norton, Andrew P--1177--University of California at Davis--Support for the 2006 Tamarisk Research Conference --**$4,958**

Ojima, Dennis--1499--DOI-NPS-National Park Service--Assessing Ecological and Biogeochemical Responses to Changing Atmospheric Nitrogen and Sulfur Deposition at Local to ...--**$65,000**

Theobald, David M--1499--DOI-NPS-National Park Service--Assessment of Natural Resources and Watershed Conditions for Rocky Mountain National Park and Florrisant Fossil B...--**$40,000**

Thornton, Christopher I--1372--DOI-Bureau of Reclamation--Investigation of Alphabet Wiers. --**$55,001**

Waskom, Reagan M--1372--USDA-CSREES-Coop State Rsrch Edu & Ext--Coordinated Agricultural Water Quality Programming for the Northern Plains and Mountains Region--**$586,080**

Westfall,Dwayne G--1170--USDA-ARS-Agricultural Research Service--NLEAP Computer Modeling --**$25,000**

RESEARCH AWARDS

Wohl, Ellen E--1482--NSF - National Science Foundation--Field Characterization of the Hydraulics of Steep Channels--**$137,499**

Wohl, Ellen E--1482--USDA-USFS-Forest Research--Aquatic-Riparian and Wetland Assessment of the White River National Forest--**$20,000**

Yang, Chih Ted--1372--DOI-Bureau of Reclamation--Taiwan River Restoration and Sedimentation Studies --**$45,000**

Due to technical difficulties, some grants received in August 2006 and September 2006 may not appear on this list.

Research awards from institutions of higher education in Colorado other than Colorado State University are provided by self-report of the Principal Investigator. If you have water related research awards to report, send them to cwrri@colostate.edu

CALENDAR

Oct. 25-28	**Ground Water and Surface Water Under Stress: Competition, Interaction, Solutions**. Boise, Idaho. For more information go to www.uscid.org/
Oct. 25-26	**From Gold Rush to Urban Crush. The past, present and future of South Platte River Basin.** Longmont, CO. For more information visit http://www.southplatteforum.org/
Oct. 26-27	**NCES 8237: Advanced Topics in Floodplain Management**. For more information and/or to register visit www.cudenver.edu/engineer/cont and select "Course information"
Oct. 26-27	**Joining Forces & Partnering for Success Workshop.** Denver, CO. For more information please contact Loretta Pineda at (303)866-3819 or loretta.pineda@state.co.us or Julie Annear at (303)866-3685 or julie.annear@state.co.us
Nov. 1	**Deadline for paper submissions to Fourth International Conference on Irrigation and Drainage: Role of Irrigation and Drainage in a Sustainable Future**. Sacramento, CA. for more information go to http://www.uscid.org/
Nov. 5-9	**Water Quality Technology Conference & Exposition**. Vail, CO. For more information or to register visit http://www.awwa.org/conferences/wqtc/?CFID=13593176&CFTOKEN=71866516
Nov. 6-8	**Colorado Rural Water Association's Fall Conference & Exhibition**. Grand Junction, CO. For more information visit http://www.crwa.net/
Nov. 6-9	**American Water Resources Association 2006 Annual Conference.** Baltimore, MD. For more information go to www.awra.org/meetings/Baltimore2006/.
Dec. 13-15	**Colorado River Water Users Association 61st Annual Conference**. Las Vegas, NV. For more information visit http://www.crwua.com/
2007	**2007**
Jan. 22-23	**American Water Resources Association Third National Water Resources Policy Dialogue.** Arlington, VA. For more information, go to http://www.awra.org/meetings/DC2007/index.html.
Jan. 25-26	**Colorado Water Congress 49th Annual Convention.** Denver, CO. For more information go to: www.cowatercongress.org, or phone 303/837-0812, or email macravey@cowatercongress.org .
May 22-24	**Colorado Water Workshop. Gunnison**, CO. For more information please contact Peter Lavigne (Director Colorado Water Workshop) at plavigne@western.edu or pete@igc.org. Contact by phone: 970-641-2579
Jun. 25-27	**SWRA Summer Specialty Conference: Emerging Contaminants of Concern in the Environment: Issues, Investigations, and Solutions**, Vail, CO. For more information go to http://www.awra.org/meetings/Vail2007/index.html
July 24-26	**2007 UCOWR/NIWR Conference: Hazards in Water Resources.** Boise, ID. For more information visit http://www.ucowr.siu.edu.
Sep. 30 to Oct. 5	**Fourth International Conference on Irrigation and Drainage: Role of Irrigation and Drainage in a Sustainable Future**. Sacramento, CA. for more information go to http://www.uscid.org/

WATER TABLES

an Evening with the Experts

Dinner & conversation with today's men & women making history in Colorado's waters

January 27, 2007
5 p.m. Reception & Archive Open House
7 p.m. Dinner & Conversation

A benefit for the Water Resources Archive, Water Tables offers a rare and unique firsthand experience of Colorado's water resources past and present in an intimate dinner setting. This is your opportunity to meet and engage with the foremost water experts specializing in the environment, engineering, water law, history, and more while exploring the Water Resources Archive.

Beginning at 5:00 p.m. with a reception and tours of the Water Resources Archive, guests will view photographs, documents, maps, and other artifacts that reveal Colorado's water past while mingling with an array of water experts. Following the tours and reception, guests will be escorted across the plaza to the ballrooms of Lory Student Center where water experts, serving as table hosts, will facilitate engaging topic conversations while dinner is served.

Tickets are $125 per person. We will begin taking reservations in November and reservations will be accepted through January 10.

For reservations and information, please call 970.491.1833
http://lib.colostate.edu/develop/events/watertables07/

Colorado Rural Water Association's Fall Conference & Exhibition

November 6 - 8, 2006
Grand Junction, Colorado
Double Tree Hotel

For more information, contact:
719-545-6748
or
http://crwa.net/

COLRADO WATER CONGRESS
49th ANNUAL CONVENTION

January 25 - 26, 2007
Denver International Airport Hotel and
John Q. Hammonds Convention Center
15500 East 40th Avenue
Denver, Colorado

For more information, go to:
http://www.sccwebdata.com/cwc2/default.asp
or
303-837-0812
or
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