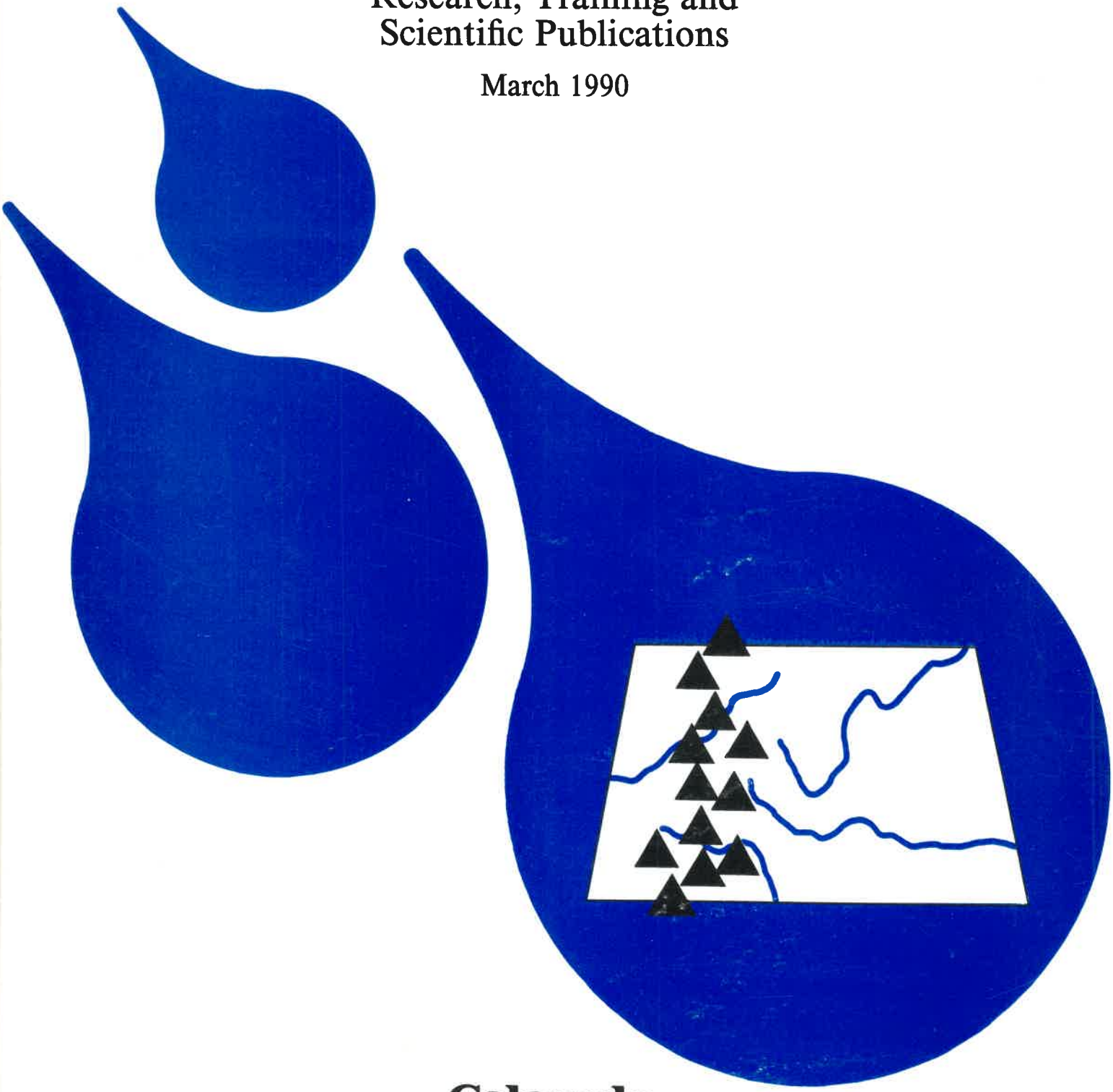
The Colorado Water Resources Research Institute

25 Years of Research, Training and Scientific Publications

March 1990



Colorado State University

COLORADO WATER RESOURCES RESEARCH INSTITUTE

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DIRECTOR'S MESSAGE

Dr. Neil Grigg has been the Director of the Colorado Water Resources Research Institute since July, 1988.

Coloradoans sense a natural relationship with their water resources. Miraculously, the winter snowpack slowly releases its stored moisture for beneficial use in homes, businesses and on farms. Mountain canyons provide natural storage sites to make possible even more storage and water management. The snowpack provides a skier's wonderland in winter and spring and a fishing and boating paradise during summer and fall. The rushing waters grind rocks which deposit over a millennia and become alluvial aquifers that enable additional water management possibilities. This water management is an important key to Colorado's three largest economic sectors: industry, agriculture and recreation.

To manage this gift is our challenge. The Institute's part is to provide the funds and research organization needed by creative scientists and teams as they seek to bring insight and new facts to aid in water management.

CWRRI was born out of the Water Resources Research Act of 1964; in 1990 it finished its first 25 years of service. This publication describes some of the achievements of that quarter-century and the challenges that lie ahead.

CWRRI's most important contribution is its research program directed at Colorado's water problems. Behind the scenes is the work that goes into research coordination and scientific publication which impacts the work of local, state and federal organizations, as well as private businesses and citizens. Activities that aid in coordination include: CWRRI's annual state water conference; focused workshops; presentations before agencies, commissions and interest groups; the Water Issues Forum program; CWRRI's newsletter; its reports and publications; and the activities of its committees.

These are the basic elements of CWRRI's program, and they will continue. However, future water challenges in Colorado demand a more intense focus on the key problems that the State faces. Such as:

* How to develop improved approaches to water management within the constraints of the Appropriation Doctrine;
* How to reconcile value conflicts between Colorado's water organizations, interest groups and regions;
* How to improve the state's water use efficiency while utilizing interstate compact entitlements;
* How to solve diverse problems of water quality in the state;
* How to manage the state's groundwater resources;
* How to improve instream flows to enhance Colorado's environment;
* How to meet the water supply needs of Colorado's urbanizing regions;
* How to develop state-local-federal relationships in water management;
* How to create the data, modeling and decisions support systems needed for water management in the 21st century.

CWRRI's Research Planning Advisory Committee has identified a number of technical problems needing research in the State. They include: Conjunctive management of surface and groundwater; Economic value of nonconsumptive water uses; Economics of alternative strategies for fishery enhancement; Fate of metals in Colorado streams; Technology for new uses of the satellite stream monitoring system; Improvement in drought forecasts; Improvement in runoff forecasts - flood, late season; Preservation of wetlands - economic costs and benefits; Improvement in urban storm runoff control measures; Biological effects of metals on aquatic organisms; Streamflow criteria for flow-based discharge permits; Reclamation of polluted groundwater; Evaluation of impacts of water exports on basin-of-origin; and Technology for efficient groundwater recharge.

In the upcoming years, CWRRI will expand its research horizons to seek solutions to these and other water resource problems that face Colorado. The Institute will also work with the network of 17 western state institutes to advocate improved water management through cooperative projects.

WHY CWRRI WAS CREATED AND HOW IT OPERATES

In 1959, as a result of a water crisis, the Senate Select Committee on Water Resources set out to study the management of the Nation's water resources. Two years later it recommended water planning changes and more effective coordination of the Nation's water research programs. In 1962, under the direction of New Mexico's Senator Clinton Anderson, legislation was drafted to create a national Water Resources Research Program. The bill was patterned after the Hatch Act of 1887 which established the State Agricultural Experiment Station system.

The proposed water research program received widespread support from Congress and the university community. William E. Morgan -- president of Colorado State University and chairman of the Water Resources Committee of the National Association of State Universities and Land Grant Colleges at the time -- played a key leadership role. Congress passed the bill and on July 17, 1964 President Lyndon B. Johnson signed into law the Water Resources Research Act of 1964. At the signing, Johnson said,

> "The Water Resources Research Act of 1964, which I have approved today, fills a vital need...it will create local centers of water research. It will enlist the intellectual power of universities and research institutes in a nationwide effort to conserve and utilize our water resources for the common benefit."

The Act authorized the establishment of Water Resources Research Institutes in each of the 50 states and Puerto Rico. Later, Institutes would be formed in Washington, D.C., Guam and the Virgin Islands.

Originally the water resources research programs were managed by an office in the Department of the Interior (the Office of Water Resources Research), but 20 years later the Water Resources Research Act of 1984 incorporated the programs under the U.S. Geological Survey. Between September 1985 and June 1987 an independent review team -- as mandated by the Water Resources Research Act of 1984 -- conducted on-site evaluations of all Water Resources Research Institutes. The review team reported that all of the Institutes were fulfilling their objectives and operating in a cost-effective manner.

Although it remains accountable to the Federal Government through the USGS, the Colorado Water Resources Research Institute received statutory authority from the Colorado General Assembly in 1981 to operate as a unit of Colorado State University. The Institute operates under the supervision of Colorado State's Vice President for Research and a Policy Advisory Council. A Research Planning Advisory Committee that includes representatives from state and federal agencies and the private sector, identifies Colorado's high-priority water problems. A Technical Advisory Committee, consisting of faculty from the State's research universities, evaluates proposals and offers advice on technical approaches.

The Colorado Statute requires these functions of the Institute:

(1) consult with state and local government agencies, water-user associations, the General Assembly, and other potential users of research in identifying and prioritizing water problems for research;
(2) plan and manage research projects in any qualified university of the State for conduct of specific research projects responsive to the identified high-priority water problems;
(3) disseminate new information and transfer new technology to water managers as it is developed and ready to use;
(4) provide for liaison between Colorado and Federal research funding agencies as an advocate for Colorado water research needs; and
(5) facilitate and stimulate research that;
   (a) deals with policy issues facing the General Assembly,
   (b) supports State water agencies' missions with research on problems encountered and expected, and
   (c) provides water planning and management organizations with technological tools to increase efficiency and effectiveness of water planning and management.

"The Water Resources Research Act... will enlist the intellectual power of universities and research institutes... to conserve and utilize our water resources for the common benefit."

Lyndon B. Johnson, 1964

COLORADO'S WATER ISSUES AND CWRRI'S RESEARCH ACHIEVEMENTS

PLANNING AND MANAGEMENT

Managing the South Platte River Basin

The South Platte Basin contains nearly 70 percent of Colorado's population and the State's heaviest concentration of irrigated acreage. The river basin provides a supply of 2.2 million acre-feet of water that is used and reused in such a way that total annual water withdrawals exceed 4.6 million acre-feet. But in spite of efficient reuse, farms in the basin receive only 80 percent of their minimum irrigation needs, and there is heavy pressure for management changes in the basin.

A number of Institute projects sought to improve water management in the South Platte River Basin. In an interdisciplinary project, a nine-member team including engineers, computer specialists, an economist and a political scientist identified options for improved management of the basin's water supply. The team identified a voluntary, integrated basinwide management strategy as the preferred option, and Institute research continues on that option.

In a 10-year sequence of CWRRI research, Dr. Hubert Morel-Seytoux of Colorado State and Dr. Jorge Restrepo produced SAMSON (Stream-Aquifer Management by Simulation and Optimization), a computer-based hydrologic model of the South Platte River Basin. The model simulates the basin's response to proposed water projects or facilities, and to different water management strategies.

Three field tests were used to verify and refine SAMSON. The first test evaluated potential measures to lessen the impact of a multi-year drought. The second, conducted for the Groundwater Appropriators of the South Platte, Inc. (GASP), evaluated the organization's river augmentation plan. The third test, conducted in cooperation with the State Engineer's Office, evaluated the effect of specific artificial aquifer recharge proposals on the timing and location of return flows to the river.

A computer-based hydrologic model of the South Platte river basin (shown here north of Denver), simulates the basin's response to proposed water projects.

Salinity Management in the Colorado River Basin

Stunted crops and damaged plumbing can be the result of a salty water supply. As rivers such as the Colorado and its tributaries flow through arid regions, water withdrawals, evaporation and minerals leached from surrounding soils combine to increase the river's salt content. In some cases the problem can be treated by changing upstream water and land uses, but an economic tradeoff exists between the cost of corrective efforts and downstream benefits.

CWRRI contributed to a regional study that analyzed and applied dollar figures to this tradeoff. Researchers from Arizona, California, Colorado and Utah aimed their work at two main objectives. First, they estimated the direct and indirect economic damages of various salt concentrations to agricultural and municipal users of Colorado River Basin water. Second, they analyzed the costs of salinity control measures by upstream water users. Results of this economic evaluation of salinity management options are being used by the U.S. Bureau of Reclamation for its salt-load control program on the upper Colorado River Basin.

The Bureau of Reclamation also is using results of other salinity studies supported by the Institute. Colorado State researchers have investigated the amount, sources and mechanics of salt loading in the Colorado River. They have found that erosion of tributary channels, gulley walls and banks unloads high concentrations of dissolved salts into the river. Salts are also added to the river via watershed runoff.

Water Transfers

As streams and rivers have become overappropriated, potential water users are turning to already-existing water rights. By way of transfer, an abundant supply of water can be realized as a substitute to constructing new projects. Difficulties remain, however, in the actual legal transfer of the rights. In fact, the exchange process in many western states is inefficient to the point that it is not economically feasible to consider as an option.

This predicament was the incentive for the latest regional proposal submitted to the USGS by CWRRI on behalf of the Colorado River Consortium of Water Institutes and Centers (CWIC).

The resulting project had active cooperation by Arizona, California, New Mexico, Utah, Wyoming and Colorado. Project administration was provided by the director of the CWRRI and the principal investigator was Dr. Lawrence J. MacDonnell, Director of the Natural Resources Law Center, University of Colorado at Boulder. The investigators studied the legal and institutional factors that influence efficiency and equity of water transfers as well as the related transaction costs. In the final phase, the project team compared the findings from the six states. They identified specific measures for expediting the transfer and exchange process consistent with protection of other water rights and public interest. Throughout the study, there existed a project advisory group to help compile data as well as lend guidance. Two representatives from each of the six states comprised the advisory group which included members from the offices of the State Engineer and the State Attorney General, State Representatives, the Environmental Defense Fund and others.

In north Denver, the effect of rapid growth on available water for agricultural purposes was the topic of another Institute-sponsored study. Due to the immense increase of water demand, two suburbs initiated condemnation suits against irrigation companies in an effort to obtain their water rights. However, this water supplied 400 farms that supported 561 jobs and $8 million production yearly. The researchers documented the need for further development of municipal water supplies. They concluded that through careful management and planning, joint use of existing supplies and development of unused supplies could alleviate some of the economic impact on the farming community.

In the past, water transfers in many western states have not been economically feasible due to inefficiencies.

Aerial photography of remote Colorado locations could determine water supplies for the coming summer.

Decision Support Systems

Planning the efficient use of water in the western states requires accurate and timely information on available supplies in far-flung locations. The Institute has sponsored several studies to document the applicability of remote sensing (aerial photography or imagery) to water research.

Watershed simulation models can be aided by remote sensing. Data is gathered on actual surface characteristics which are relevant to hydrologic effects, and input into the model. This theory has been successfully tested in the Williams Fork Watershed in central Colorado.

In Colorado, most of our water originates from melting snowpack, so snowmelt runoff forecasts become very important. Because many of the high mountain areas are inaccessible, remote sensing of snowpack from planes or satellites can be utilized. One study documented this procedure (the difference in ground elevation between pre-snow and mid-winter photographs was the depth of the snowpack).

Dr. William Striffler and Diana Fitz compiled a review of the past research done as well as potential uses for high-tech data management. One of their ideas was that surface water inventories could be kept by taking repeated photographs of the same area. Another idea was that damage from a flood could be compiled with remote sensing. The researchers also looked into the use of remote microwave systems to document snowpack. The microwaves can penetrate into the snowpack, and the amplitude of scattered radiation correlates to the density and moisture content of the snow. This system is not available yet, but the investigators encouraged more research.

MODSIM - A Hydrologic Simulation Model

MODSIM, a sophisticated computer model developed by Dr. John Labadie of Colorado State University helps city staff find optimum water management strategies. It accounts for reservoir storage and releases, transport and distribution systems, return flow, evapotranspiration, water right priorities and exchange agreements.

MODSIM was used to develop a complex plan for delivering treated effluent from the city's waste treatment system to serve as cooling water for the Rawhide Power Plant. Also, Fort Collins' staff used the model to simulate severe drought conditions in order to project water demands, assess the reliability of the city's current water supply, and develop emergency plans.

The City of Fort Collins used the MODSIM model to simulate severe drought conditions such as this one in 1977.

MODSIM also has been used by the Northern Colorado Water Conservancy District, Denver Water Department, Western Area Power Administration, Bureau of Reclamation, Corps of Engineers and private engineering firms.

Economic Analysis of Water Use in Colorado

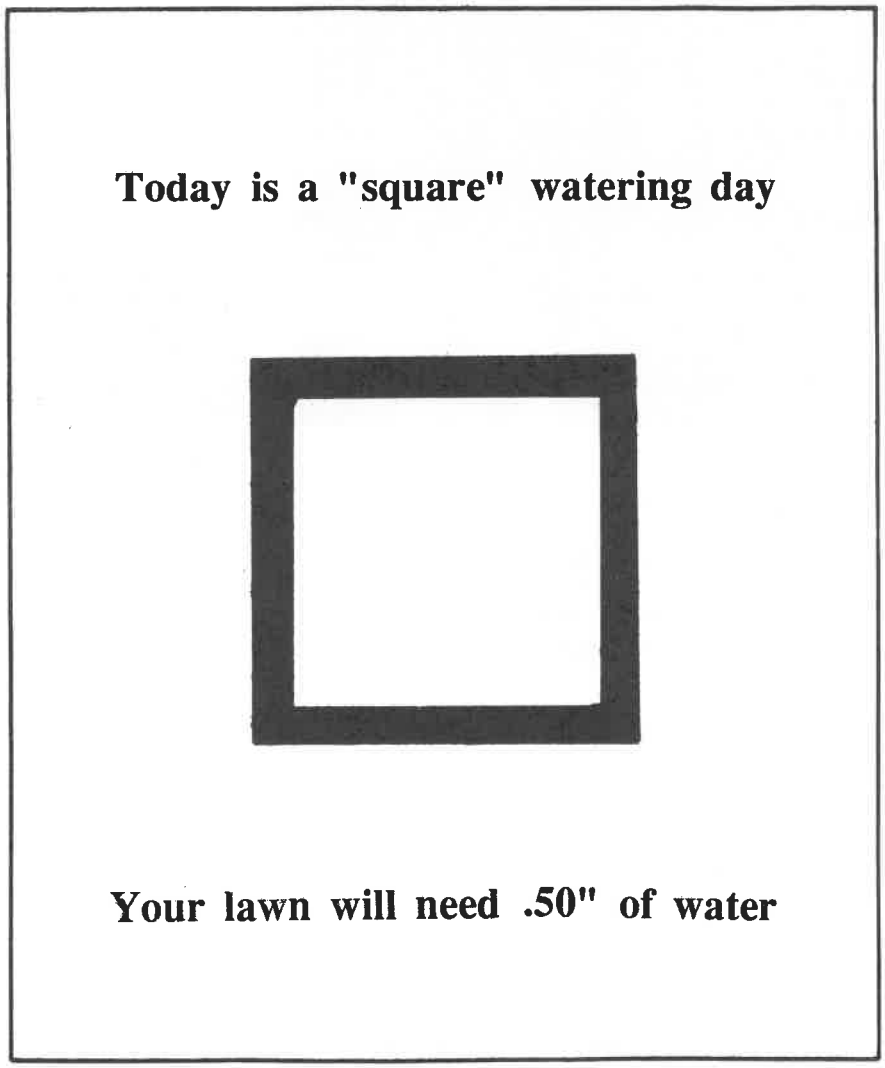
To what extent would a new diversion tunnel from the Colorado River to the Front Range affect the West Slope's agricultural economy? Or, if a new meat processing plant began operations in eastern Colorado, would it contribute enough to state employment and income to justify its high demand for water from the region's supply?

Colorado State economists, through Institute-sponsored research, have created an economic input/output model to help answer questions like these. Drs. Lee Gray and John McKean analyzed the water requirements and the employment and income contributions of each of Colorado's economic sectors. With this information, they created a computer-based, decision-making tool that calculates the economic consequences of any number of water resources development scenarios. Additionally, the computer model calculates the consequences of proposed economic activity on Colorado's water supply. This tool serves as a valuable analytical aid for business and government.

CONSERVATION AND WATER USE EFFICIENCY

Rapidly increasing population and industrial growth in Colorado have sharply increased demands for water. Yet the water supply has been relatively fixed. In an overall study, Institute researchers developed various options for increasing supply and making more efficient use of present supplies.

Ideas for increasing supply included re-evaluation of Colorado's commitment to downstream states, storage construction, increasing state support for watershed management, and increasing groundwater withdrawals. Options for increasing efficiency included integrating various management goals (i.e. land and water planning, water quality and water quantity, or ground and surface water), and encouraging conservation methods.



The Evapotranspiration program is one method of urban water conservation. It designates which households should water their lawns, and how much water is needed.

Urban Water Conservation

"Achieving Urban Water Conservation," is a handbook for municipal managers that estimates the cost-effectiveness of various water-saving measures. The handbook helps managers develop reliable and acceptable water conservation programs for their municipalities. The handbook was compiled by Dr. J. Ernest Flack of the University of Colorado and Dr. Duane Hill of Colorado State University. It assessed several practices, including use of water-saving devices and recycling systems, metering, leakage reduction and horticultural changes. These conservation measures were studied alone and in various combinations for their engineering and economic feasibility. The researchers also studied the social and political acceptability of possible conservation programs.

"Today is a 'square' watering day and your lawn will need .25" of water." These are familiar words to the many Coloradoans who participate in the "ET" (evapotranspiration) program. This program, developed by Institute researcher Dr. Robert Danielson and adapted by the Denver Water Department, features daily television and newspaper announcements that explain how to maintain healthy lawns with minimal amounts of water. In its first year, the "ET" program reduced urban water demand by 200 million gallons and saved nearly $1.2 million in water treatment costs.

Scientifically developed stress-resistant corn is reducing losses due to salty water.

Agricultural Water Conservation

Agriculture uses approximately 80 percent of Colorado's water, and some say the water use is not efficient enough. However, the picture is much more complex than that. CWRRI's research shows that irrigation water which some consider to be wasted serves as aquifer recharge water that reappears in streams or is pumped for later use. CWRRI has evaluated several aspects of this problem using teams assembled from engineering, economics and agronomy. More research is needed.

Salt-Tolerant Crops

One solution to water quality problems is to find ways to use salty water. As irrigation water evaporates from fields in arid and semiarid regions, some salt stays behind. Over time, enough salt can accumulate in the soil to seriously decrease crop production.

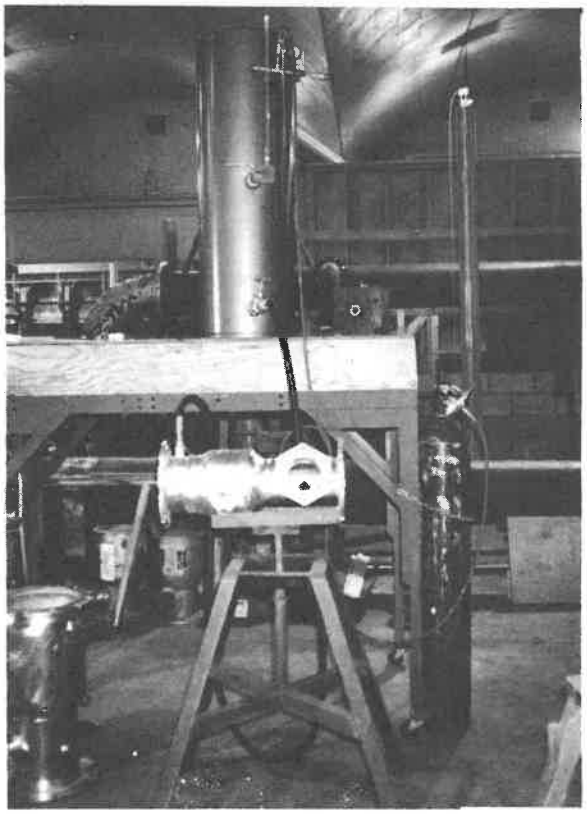
However, with a few years of start-up support from the Institute, a Colorado State botanist developed laboratory techniques for selecting and cloning salt-tolerant crops. Early in his research, Dr. Murray Nabors produced oats with twice the normal tolerance for salty soil. Today, through the Tissue Culture for Crops Project (TCCP), Nabors and his staff work to develop stress-resistant corn, rice, wheat and other food crops. Stresses other than salty water and soil include drought, dissolved aluminum and low nitrogen. The TCCP, with facilities on the Colorado State campus, is supported by the U.S. Agency for International Development and attracts visiting researchers and students from around the world.

PROTECTING WATER QUALITY

Municipal Wastewater Treatment

Some claim that municipal wastewater is America's forgotten resource. This idea is adeptly explained in an award-winning film produced by the Institute under contract with the U.S. Environmental Protection Agency.

The film, which explained land treatment of municipal sewage, its feasibility, costs and benefits, and limitations, won second place in the "informative and prestigious" category of an international AGRO film competition. By describing successful treatment sites from around the U.S., the documentary film shows that land treatment of municipal wastewater from small communities has several advantages. When sewage sludge and effluent are applied to land, they serve as a source of irrigation water and nutrients for plants. The film, an explanatory brochure, and a short slide-tape presentation of two case studies were sent to officials from all 50 states.



The Colorado Chemigation Act requires all chemigation valves to be tested and certified by the Institute. This valve is being tested for leakage.

On-Site Wastewater Treatment

Research support and workshop sponsorships are evidence of the Institute's commitment to solving the problems of on-site wastewater treatment. Projects supported by the Institute have included studies of on-site systems and alternatives to septic tank systems. For several years the Institute, together with the Colorado Environmental Health Association and Cooperative Extension, has sponsored the biennial workshops for On-Site Wastewater Treatment in Colorado. Workshop participants review new technology and management developments, and discuss evolving regulations regarding the treatment of sewage from homes in areas without sewer systems.

Pesticide Transport

In a recent study, two computer simulation programs were evaluated that aid Colorado farmers in the management of pesticide applications. Originally, the two simulation programs, OPUS and PRZM, were designed for evaluation in heavy rainfall areas. The results from this research (done by Dr. Jim Warner of Colorado State University) modelled a sprinkler-irrigated Colorado farm and provided valuable information on soil moisture and chemical concentrations in the soil.

The Institute is also involved with the Colorado Chemigation Act. Chemigation is the process of applying chemicals (pesticides and fertilizers) to land or crops with water through a closed irrigation system. The Act requires manufacturers of chemigation valves to obtain certification through a testing procedure administered by the Institute. The tests take place at Colorado State University's Hydraulics Laboratory, and the Institute issues the certification. This leads to a permit from the Colorado Department of Agriculture.

Water Quality and Water Rights

A recent Institute publication addresses the issue of water quality and its relation to use. Completion Report No. 151 - "Water Quality and Water Rights in Colorado" by Dr. L. J. MacDonnell of the University of Colorado's Natural Resources Law Center, gives an excellent view of early Colorado water quality law and its evolution to our present-day system outlined under the Colorado Water Quality Control Act. The report states: "Water quality is becoming an important consideration in certain kinds of water rights decisions in Colorado. Colorado law encourages maximum utilization of its limited water resources by allowing new, out-of-priority use to occur so long as there is no injury to existing rights. It explicitly requires that any exchanges or substituted supplies be of a quality that will meet the requirements of the senior user. Determination of the adequacy of the quality is to be made by the water court. The basis for determining the adequacy of the quality is not yet clear."

Mine Waste

Abandoned mines scattered throughout the Colorado Mineral Belt leak pollution and threaten the State's waters. CWRRI's Handbook for Metal Mining Operations helps operators to understand how the various substances originate in mine water and what can be done to eliminate or control them. Colorado School of Mines professor Dr. Tom Wildeman was the principle investigator.

WATER LAW

Water to Colorado is like oil to Saudi Arabia; the state's economy relies heavily upon the benefits resulting from the various uses of water throughout the state. Early settlers in the state selected the doctrine of prior appropriation to direct the use of this resource, an action that has determined the destiny of water law to the present time.

Rapid growth, affluence, technological innovations and increased energy consumption have created an urgent need to evaluate the effect of water law upon environmental quality. Professors George Radosevich, a water law specialist, and Gustav Swanson, a wildlife biologist studied the water laws that affect man-made alterations of natural water areas. The purpose was to identify needed modifications of older laws with both water needs and environmental considerations in mind.

Another Institute study traced the evolution of water law and determined: that Colorado will depend on its water supply for future prosperity; that the state should shift from a 'use orientation' to a 'management orientation' treatment of its waters; and that the greatest constraints to changing Colorado water law lie with the people themselves.

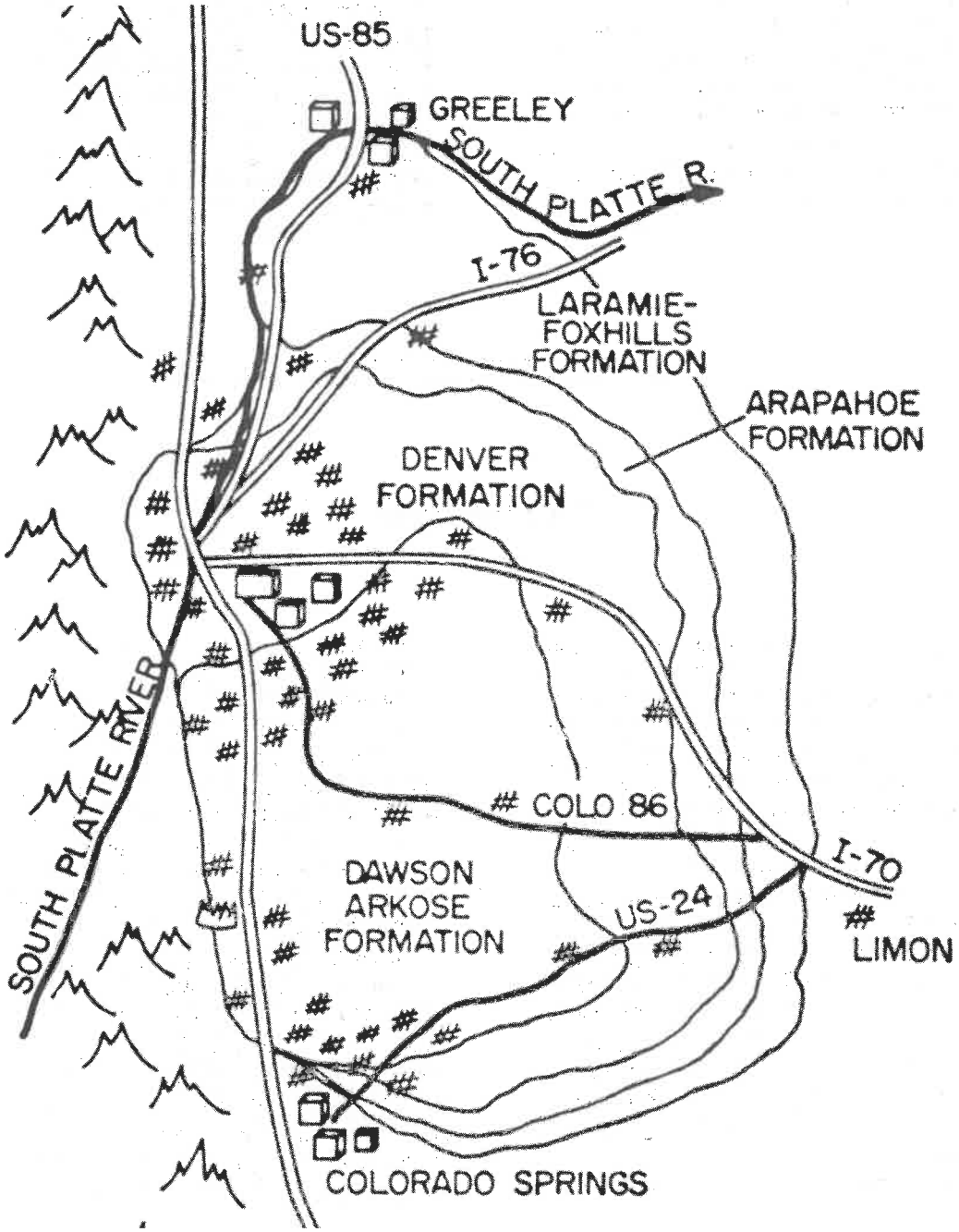
In an Institute project of the 1970's, "A Guide to Colorado Water Law" was developed as a primer for high school students and other interested individuals. Funded by the US Office of Education, the guide offers an easy-to-understand, general introduction to Colorado Water Law. Since the original printing it has been updated and is still in use today.

A Colorado water right is a private property right to divert water for beneficial use. The first one to put water to beneficial use shall have the preferred right.

MANAGING COLORADO'S GROUNDWATER

Denver Basin Aquifer

The Denver Basin Aquifer is a valuable water resource for the Front Range area. Legislators, policy makers, and water resource planners needed to understand the workings of the aquifer, as well as the associated problems and issues. CWRRI published "The Denver Basin: Its Bedrock Aquifer"; this small booklet contains an explanation of how the aquifer was formed, where it is located, how much water is usable, and answers to several other questions.



The Denver Basin Aquifer lies along the Front Range from Colorado Springs to Greeley. Researchers have studied techniques to determine the volume of water that is recoverable.

Management of the Denver Aquifer requires estimation of the volume of water recoverable from the formation (specific yield). Through the Water Institute, Dr. David McWhorter of CSU's Department of Agricultural and Chemical Engineering studied the potential of borehole geophysical measurements as a method to determine specific yield. In the past, borehole measurements (or well logging) have come from the petroleum industry; it used the method to determine porosity, permeability and fluid distribution of a soil. Dr. McWhorter theorized that these parameters could also relate to specific yield of an aquifer. By comparing geophysical logs to actual specific yield measurements from a lab, he determined the accuracy of the technique. Several types of geophysical techniques were tested, and the nuclear magnetic log emerged as the most promising. The concept of using well-logging to determine specific yield in confined aquifers could have far-reaching potential for better management of the Denver Aquifer.

Ogallala Aquifer

The Ogallala Aquifer extends from the grasslands of South Dakota to the plains of eastern New Mexico and by 1980 provided water for 15-20 percent of the Nation's irrigated acreage and nearly 40 percent of the Nation's livestock. But this may not be true in the future if users of Ogallala water maintain their present withdrawal rates.

Institute-supported research by Dr. Robert Young, a Colorado State agricultural economist, contributed valuable information to a regional study of the Ogallala Aquifer. Young projected a significant depletion of the aquifer by the year 2020. He also determined that the projected depletion and subsequent decrease in agricultural production could result in a loss of over $3 billion of regional economic output per year.

Findings of the High Plains-Ogallala Aquifer study resulted in the 1986 passage of Public Law 99-662, which authorizes a program of research and demonstration projects for improved management of the aquifer.

Groundwater Quality Monitoring

An Institute project is leading the way in developing criteria to monitor one of this decade's most serious environmental problems -- groundwater pollution. Although legislation enacted in 1976 and 1982 deals with prevention, detection and cleanup of groundwater contamination, few criteria exist for designing regulatory programs to monitor groundwater quality.

A small team of investigators, led by Colorado State engineer Dr. Jim C. Loftis, first reviewed and defined existing groundwater quality data. They then developed a "menu" of statistical procedures for characterizing groundwater quality and detecting changes. Such monitoring criteria can be incorporated into the decision-making process of governmental regulatory agencies.

Groundwater Quality Indicators

One of the Institute's most recent projects, "Groundwater Faunas as Indicators of Groundwater Quality: The South Platte River System," "examined the distribution, structure, and composition of groundwater animals to assess their potential value as indicators of groundwater quality." Aquatic organisms have long been used as indicators of surface water quality, yet this study into groundwater animals, conducted by Dr. James Ward of CSU is one of the first of its kind in North America.

Groundwater in the Prior Appropriation System

Groundwater has long served as a supply source for different uses in Colorado. The nature of Colorado's prior appropriation system for surface water naturally led to confrontation between holders of surface rights and well owners due to the hydraulic connection between the two sources. In another CWRRI study conducted by Dr. Larry MacDonnell of CU, three organizations of well owners in the South Platte Valley, including GASP, were examined on their integration of groundwater use into the existing priority system.

In 1980, the Ogallala Aquifer provided water for 15 - 20 percent of the nation's irrigated acreage and nearly 40 percent of the nation's livestock.

STORMWATER AND FLOOD CONTROL

Urban Drainage

During 1970-75, an excessive number of lawsuits over urban property assessments for surface drainage benefits nearly stopped construction of municipal drainage systems. But, an Institute-organized team of Colorado State engineers, an attorney and personnel of the Metropolitan Drainage and Flood Control District helped solve this problem. They developed techniques to evaluate direct benefits from urban drainage projects so cost assessments to property can be made equitable. A manual of drainage assessment procedures prepared by the research group is in wide use in Colorado. Also, the project received the Consulting Engineers Council Award for Engineering Excellence.

Watershed Prototype

Studying erosion, localized flooding and runoff-induced transfer of pollutants has been made easier by an outdoor facility designed, constructed and initially tested under an Institute-sponsored project.

The facility, adjacent to Colorado State's Engineering Research Center and the Bureau of Reclamation's Horsetooth Reservoir, is a one-acre, outdoor, watershed prototype with a sprinkler system to simulate rainfall. The unique outdoor laboratory allows researchers to run controlled and repeatable experiments, and accurately predict the responses of small watersheds to various intensities and durations of rainfall and other hydrologic inputs.

This unique outdoor laboratory allows researchers to study the response of a watershed to rain in a controlled manner.

Floodproofing Manual

Reducing structural damages from floods is the goal of "The Colorado Floodproofing Manual" published by the Institute and the Colorado Water Conservation Board. Produced for floodplain administrators, and government or business professionals, the manual's text and graphics outline procedures and design techniques to protect buildings constructed on floodplains. Flood-prone areas have been identified in 266 Colorado cities and towns.

Urban Flood-prone areas can benefit from the Institute's "Colorado Floodproofing Manual".

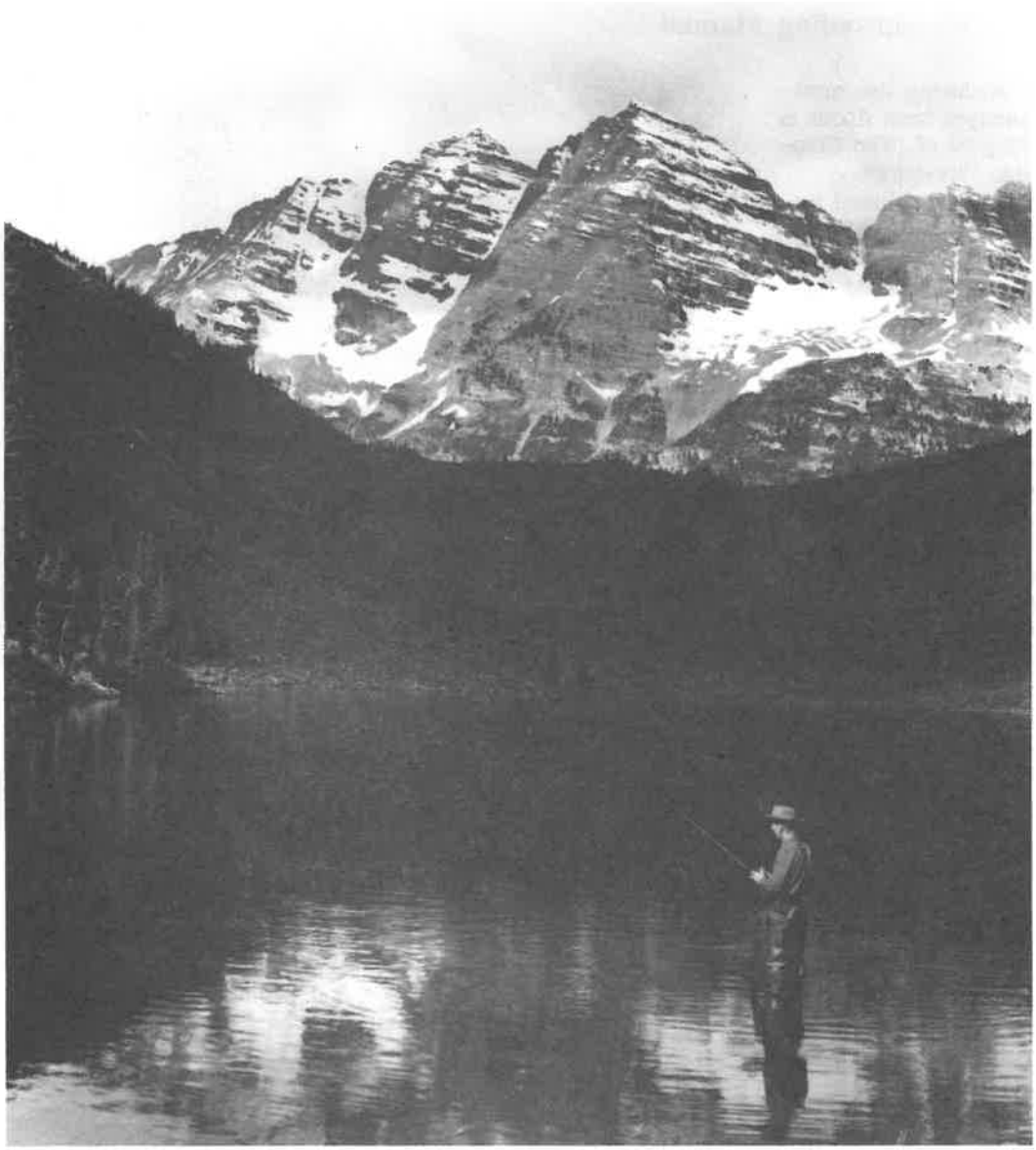
RECREATION

Colorado is one of the most beautiful regions in the United States. In the high country is a series of glacial and man-made lakes surrounded by dense forests and majestic snow-capped peaks. Recreationists from Colorado and throughout the country and world are aware of this recreational opportunity, and make the most of it. This growing tourism industry has resulted in overcrowding and overuse of the existing water sites open to the public. With this overuse, the public is destroying the very physical environment that it seeks. The only apparent solution is to restrict the number of recreationists.

However, a series of studies done by Drs. Richard Walsh and Robert Aukerman have increased the knowledge of physical, legal, political, and social potentials with regard to water recreation in an effort to find acceptable solutions. Studies have focused on the number of recreationists, the economic and employment value of recreation, and the resources themselves. Many studies found recreationists frustrated with the present overcrowded conditions, and willing to pay more for higher quality recreation in better environments. The results of these studies should aid decision makers in their jobs.

Multiple Use of Reservoirs

Institute researchers have identified the possibility of alleviating the overuse of existing areas by distributing the recreational load. Many high country water storage reservoirs (40 percent of the total surface area of all Colorado reservoirs), are specifically earmarked for agri-industrial or municipal use. Yet these reservoirs, through enlightened management procedures such as providing access, facilities, and timed water delivery, could satisfy the recreational needs with little or no conflict with the primary user rights. A CWRRI study surveyed the behavior and preferences of recreationists and found a legitimate demand on smaller (less than 300 surface acres) high country reservoirs.



High Country recreation may become more expensive as the demand for water increases.

Managing Reservoirs

Once a reservoir has been pinpointed for multiple use, the managers, planners, and owners of the water need to make informed decisions on the development of the resource for recreational use. The Water Institute sponsored a study that addressed feasible storage levels, fishery requirements and liability concerns, as well as other legal aspects of reservoir management.

The Institute also published an inventory of Front Range high-mountain reservoirs. This single core of information proved useful to local, state, and federal governments.

River Management

Streams and rivers are not only a means for transporting water, but also provide valuable recreational benefits for fishermen and white-water enthusiasts. Managing streamflow to satisfy downstream needs as well as providing optimum recreational opportunities is not easy. A Water Institute-sponsored study analyzed the public benefits of river recreation using a marginal analysis. This enabled those making water decisions to make a financial comparison between downstream benefits and recreational benefits.

REACHING OUT - SERVING AND NETWORKING WITH COLORADO'S WATER INDUSTRY

The number and diversity of organizations working in Colorado's water industry are amazing! CWRRI's coordination activity seeks to network with and serve them. A list of these organizations is included at the end of this publication.

Research

CWRRI works hard to determine research needs, obtain funding, plan and organize projects, and finally apply the results. Research needs are identified by practitioners, and results are disseminated through completion Reports, Technical Reports, and the Institute's Information Series. More than 20,000 of these publications have been distributed since 1980.

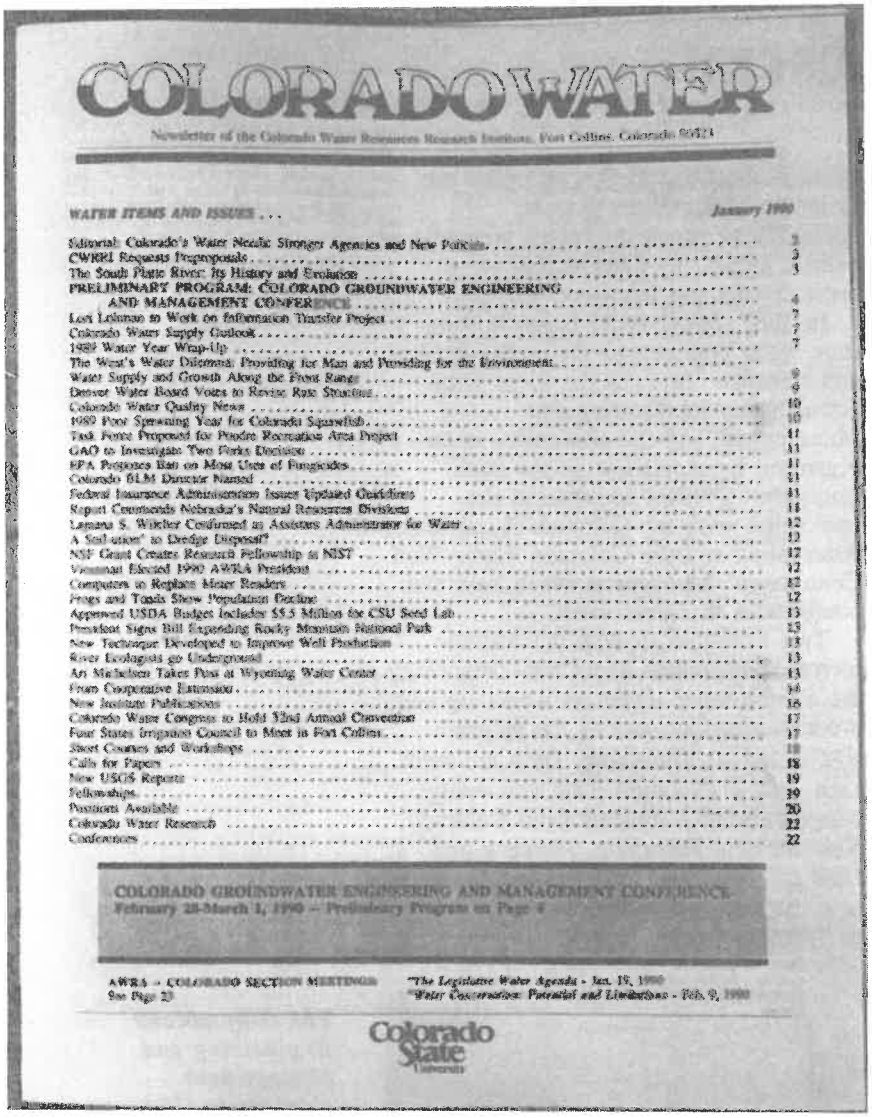
Conferences, Meetings and Workshops

The Institute and the Cooperative Extension Service co-sponsor a monthly luncheon in Denver called the Colorado Water Issues Forum. Authoritative speakers present programs of current interest to water managers, professionals and interested citizens.

In 1987, the CWRRI began hosting state water conferences for professionals and students. In 1990 the focus is on Groundwater Engineering and Management, and the conference is co-organized by the Office of the State Engineer. CWRRI coordinated the conference with the Colorado Rural Water Association and the Colorado Water Well Contractors' Association which held their conferences the same week.

Two examples of how the Institute increases awareness about new technology are a wastewater treatment workshop and a conference for users of the software HEC-2. Also, Hydrology Days are held each year at Colorado State University where university students from Colorado, New Mexico, Wyoming, Montana and Utah gather to hear professional papers on new research and development advances in hydrology.

The Groundwater Engineering and Management Conference (Denver, February 1990), is just one example of the Institute's commitment to the Colorado Water Industry.



COLORADO WATER

Newsletter of the Colorado Water Resources Research Institute, Fort Collins, Colorado 80523

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Colorado State University

The Colorado Water newsletter has informed readers on state and federal water issues since 1983.

Publications

The Institute's Completion Reports, Technical Reports and Information Series have been very effective in making water users and managers aware of new developments and technology.

Another Institute publication is its bi-monthly newsletter that reaches more than 1,300 readers. "Colorado Water" is distributed widely throughout the state and to: Water Institutes; faculty members at Colorado universities; selected federal agency personnel out of state; and others upon request. The newsletter has been expanded to include more items on state and federal water issues and information about water research at Colorado State University, University of Colorado and Colorado School of Mines.

Cooperative Agreements

The Colorado Water Resources Research Institute and Cooperative Extension have signed an agreement to cooperate in the field of water quality and quantity. These CSU-based programs have related missions to provide information, training and technology transfer services to Colorado water agencies and practitioners. Cooperative Extension, a much broader-based program, is entering the water quality field because of the need to serve agriculture with information about better management practices.

Another important cooperator is the Colorado Water Congress. Representing all water users, it is the forum for policy issues and calls upon the Institute for assistance.

NAWID, CWIC

In July of 1974 the National Association of Water Institute Directors (NAWID) was formed to unite the regional associations and better coordinate the Institute program internally and externally. Eight regional associations are represented in NAWID by the directors from each of the 54 institutes. Colorado is a member of region seven and is grouped with Arizona, California, Nevada and Utah.

Coordination on regional water problems is obtained through participation in the Colorado River-Great Basin Consortium of Water Institutes and Centers (CWIC). Other coordinating associations are the Colorado River Basin water research centers (Colorado, Arizona, California, Nevada, Utah, New Mexico and Wyoming) and the associations for the Missouri River and the Arkansas-Rio Grande River Basins.

Students

Approximately 600 graduate-level students at Colorado universities have participated in research projects since the implementation of the Water Resources Research Act in 1964. The students' work has not only aided the Institute, but has also prepared them for water-related careers.

COLORADO WATER INTEREST GROUPS

Agricultural Organizations

Colorado Cattlemen's Association
Agricultural Experiment Station
Cooperative Extension
State Board of Agriculture
Farm Bureau
Irrigators Association
Ditch Companies
Association of Soil Conservation Districts
Grain and Feed Association
Cattle Feeder's Association

Associations

American Water Works Association
League of Women Voters
Colorado Bar Association
Colorado Forum
Colorado Mining Association
Colorado Public Interest Research Group
Colorado Water Congress
American Water Resources Association
American Society of Civil Engineers
Water Pollution Control Federation
Professional Engineers of Colorado
Consulting Engineers Council
Colorado Rural Water Association
Colorado Water Well Contractor's Association
Native American Rights Fund
Colorado Association of Realtors
Water User's Associations
Colorado Groundwater Association
Metro Water Conservation Inc.

Economic Development Organizations

Club 20
Western Colorado Congress
Economic Development Council of Colorado
Denver Chamber of Commerce
Colorado Tourism Board
Colorado Association of Ski Towns
Chambers of Commerce
Environmental Organizations
Nature Conservancy
Environmental Caucus
Environmental Organizations

Federal Government

Environmental Protection Agency
Bureau of Reclamation
Fish and Wildlife Service
Forest Service
Corps of Engineers
Geological Survey
Soil Conservation Service
National Oceanic and Atmospheric Administration
Western Area Power Administration
Elected Office Holders
National Park Service
Bureau of Land Management
Agricultural Research Service

Industries and Business Groups

Attorneys
Consulting Engineers
Rocky Mountain Oil and Gas Association
Colorado Association of Commerce and Industry
Colorado Ski Country
Homebuilders Association
Industries
Public Service Company

Colorado Legislature

Interim Water Committee
Legislative Committees
Legislative Council

Local Government

Elected Office Holders
Metro Water Providers
Denver Water Board/Department
Denver Regional COG
Northwest Colorado COG
City and County of Denver
Special District Association
Colorado R. Water Conservation District
SE Colorado Water Conservancy District
Northern Colorado Water Conservancy District
Colorado Municipal League
Colorado Counties
City Water Departments
Private Water Companies
Wastewater Utilities
City Departments of Public Works
Water Boards
Conservation Districts
Conservancy Districts
Irrigation Districts
Groundwater Management Districts
Water Authorities
Water and Sanitation Districts

State Government

Governor's Office
Elected Office Holders
Department of Natural Resources
Division of Water Resources
Water Conservation Board
Water and Power Resources Development Authority
Groundwater Commission
Water Quality Control Commission
Attorney General
Colorado Department of Health
Land Use Commission
Colorado Water Courts
Colorado Department of Agriculture
Colorado State Forest Service
Colorado Geological Survey
Colorado Division of Mines
Division of Parks and Outdoor Recreation
Soil Conservation Board
Division of Wildlife

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Colorado Water Resources Research Institute
Natural Resources Law Center
State Climatologist
Academic Departments

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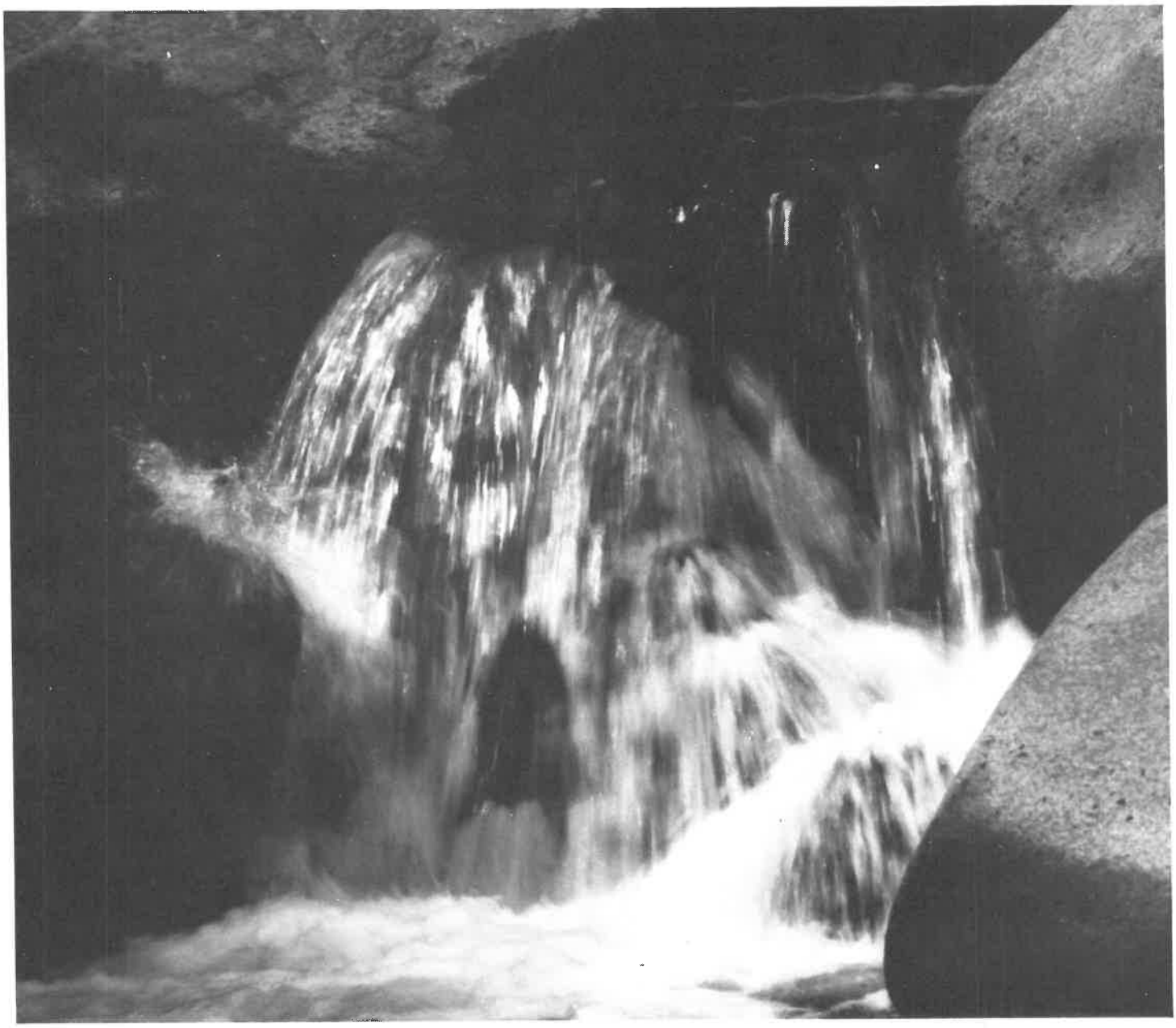

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