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WATER ITEMS AND ISSUES . . . *June 1996*

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. . . . . *Inside*:

SEVERE, SUSTAINED DROUGHT IN THE COLORADO RIVER BASIN
See page 4

Upcoming: The Colorado Section of AWRA will sponsor a half-day symposium on Colorado River Issues in Colorado on Friday, July 26, 1996 in Glenwood Springs. For more information call Bill Green at the Colorado Water Conservation Board, 303/866-3441.

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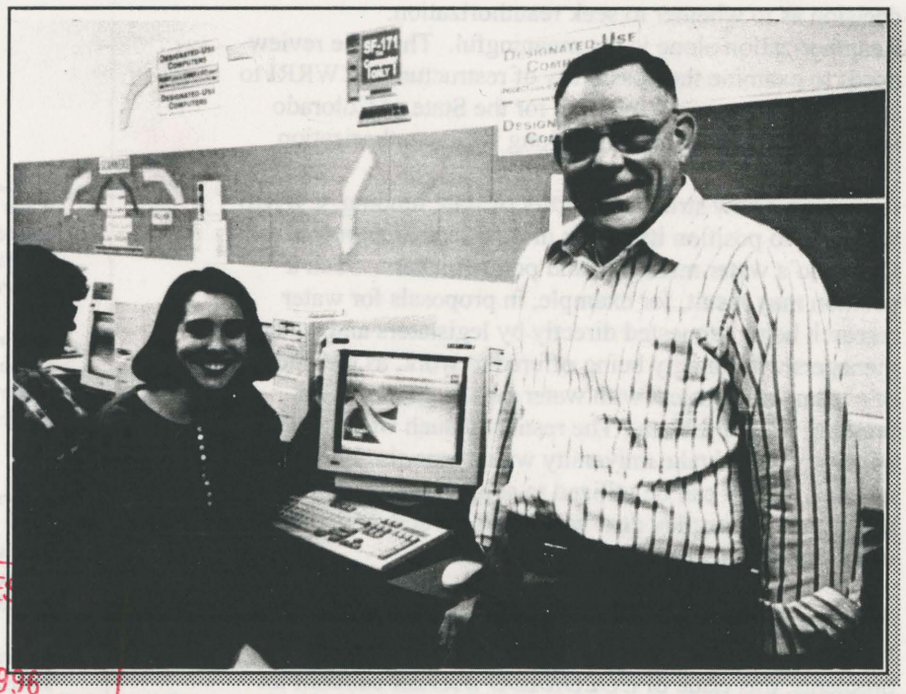

Ana Perea and Freeman Smith demonstrate the new Colorado Water Knowledge WWW Home Page at Hydrology Days -- see page 23

Colorado State University

Colorado State University

BEING ACCOUNTABLE

Editorial by Robert C. Ward

CWRRI, being accountable to both the Federal Government and Colorado State University for its funding, undergoes periodic evaluations. The Federal Government performed an evaluation of the National Water Institute Program in 1994. CWRRI, as part of this national network of water institutes, was evaluated at that time. As a result of the evaluation, several changes were made in CWRRI's Research Planning Advisory Committee (RPAC) membership. This committee guides CWRRI's water research program and a broader membership base was recommended as part of the federal review.

Colorado State University (CSU) requires all its units to undergo regular reviews. CWRRI will undergo such a review this Fall. As part of this review, a document describing CWRRI activities and accomplishments over the past five years has been prepared and distributed to RPAC membership. If any *COLORADO WATER* reader would like a copy, please contact us at 970/491-6308 and a copy will be provided. Input from Colorado water users and managers is a critical part of the review process.

Since CWRRI's authorization by the Colorado Legislature expires July 1, 1997, one outcome of the review will be a decision as to whether to seek reauthorization. Reauthorization alone is not meaningful. Thus, the review needs to examine the possibility of restructuring CWRRI to serve a water research function for the State of Colorado worthy of state funding to go along with reauthorization.

In seeking a new structure worthy of state funding, CWRRI will have to position itself in a more direct support role for Colorado's water managers and policy makers. Such a position may result, for example, in proposals for water research being requested directly by legislators and water managers with faculty being offered to work, as members of a team, on a project with water managers to solve a pressing water problem. The results of such work hopefully would take university water expertise into places where it readily can be utilized to support water managers and legislators as they deal with complex and difficult water management problems.

To illustrate the type of water research that can help legislators and water managers deal with future water problems, this issue of *COLORADO WATER* contains an assessment of how existing institutional arrangements might cope with a severe, sustained drought in the Colorado River Basin. This study consists of a number of scientific investigations which, when integrated, produce fascinating insight into what could happen in the Colorado River Basin under severe drought conditions. The study also resulted in thought-provoking recommendations based on the findings. It is the production of such insight that ultimately proves the value of water research.

To further elaborate on the severe, sustained drought project, it was initiated under the regional research program of the National Water Institute Program. A number of water organizations contributed funding, and faculty from a number of universities in the Colorado River Basin worked on the project over a number of years. Such a complex research effort, involving a number of disciplines

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Robert C. Ward, Director

producing interlocking findings, required the best of university faculty and the backing of the water institutes of the Colorado River Basin to be brought to a successful completion. The findings, while controversial, do point out the value of water research in identifying future water conflicts, potential consequences, and options for coping with such hydrologic extremes with minimum disruption to the lives of people dependent upon Colorado River water.

The Colorado Severe, Sustained Drought study is one of over 300 water research projects in which CWRRI has been involved over the past 30 years. Thus, in performing a review of CWRRI over the next few months, I invite comments on the type of water research performed by CWRRI(as regularly reported in *COLORADO WATER*, evaluations of CWRRI research with which you are familiar (good and bad), reviews of CWRRI's operations and publications, and suggestions as to how CWRRI should best position itself for the future. Colorado's higher education system has considerable water expertise in which citizens have invested, and CWRRI is committed to seeing that Colorado citizens obtain a hefty return on this investment. The ongoing review is designed to ensure that this return is maximized.

LEGISLATIVE UPDATE!

On May 24 President Clinton signed legislation reauthorizing the Water Resources Research Act and the State Water Institute Program (SWIP). The legislation authorizes $7 million in Fiscal years 1997 and 1998, and $9 million in Fiscal Years 1999 and 2000. It also authorizes $3 million for each of the fiscal years 1996 through 2000 for research on regional water problems.

RESEARCH OPPORTUNITIES

HYDROSPHERE OFFERS DATA GRANTS TO ENVIRONMENTAL RESEARCHERS

Hydrosphere Data Products Inc. has announced that it will award $20,000 in data grants during 1996 to support environmental research worldwide. Researchers may immediately contact the company for grant applications. Applications for 1996 grant awards should be submitted to Hydrosphere before October 31, 1996. Applications will be evaluated on a first-in, first-out basis.

Grant recipients will receive free use of titles from Hydrosphere's commercial library of ready-to-use environmental databases on CD-ROM. Its Hydrodata and Climatedata CD-ROMS feature USGS hydrologic, NOAA climatologic, EPA water quality, and other environmental databases. A complete listing of topics is available from the company.

The criteria for trant awards will be the potential of proposed or ongoing research to yield theoretical advances or technological innovations that encourage the establishment of sustainable development public policies or professional

Applicants must also demonstrate the inability to obtain necessary data with existing research resources. The company's discs and its custom environmental database software will allow researchers to more rapidly locate, examine and export data relevant to their work. The $20,000 grant allowance is approximately equivalent to the use of 80 separate titles for one year.

Sample research areas previously supported by Hydrosphere include the fate and transport of contaminants, endangered species protection, watershed ecosystems, hydrologic decision support systems, distributed hydrologic models, riparian habitat rehabilitation, and wetlands restoration. This data grant program expands and formalizes the company's commitment to support environmental research worldwide.

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WATER RESEARCH

SEVERE SUSTAINED DROUGHT
Managing the Colorado River System in Times of Water Shortage

by the Severe, Sustained Drought Study Team

This article summarizes a multidisciplinary study conducted by the Powell Consortium, an alliance of seven Water Resources Research Institutes and Centers from the states of Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming. The consortium was formed to work on water resources problems of the Colorado River/Great Basin region. The complete report presents papers collected and published in a special issue (Oct. 1995) of the American Water Resources Association's WATER RESOURCES BULLETIN. Robert A. Young, Professor of Agricultural and Resource Economics, Colorado State University, authored the publication's Introduction and Overview. William Lord was senior author of the Evaluation of Institutional Options discussed in this article. A complete list of study participants, in alphabetical order, can be found at the end of the article.

The Colorado River is one of the most highly controlled river systems in the world. In most years, the flow of the river is so intensively utilized that there is no final discharge into the Gulf of California, its outlet to the sea. Today, the river provides part of the municipal water supply for 20 million people in seven states, for two million acres of farmland, generates 12 million kW of electricity a year, and provides habitats for fish, birds and wildlife, including a number of endangered species. Six national parks and recreation areas support a multimillion-dollar recreation industry of boating, hiking, fishing and whitewater rafting.

Dividing up the Colorado River waters involved compromises, tradeoffs, interstate compacts, a U.S. Supreme Court decree, a treaty with Mexico and federal legislation. An interstate compact was proposed in 1920, and a federal-state compact commission began negotiations in 1922. The commission divided the watershed into two basins -- the Upper Colorado Basin (Colorado, New Mexico, Utah and Wyoming) and the Lower Colorado Basin (Arizona, California and Nevada). Of the river's then estimated 16.9 million acre-feet, the commission apportioned 7.5 million acre-feet of consumptive uses to the upper basin and 7.5 million acre-feet of uses to the lower basin, with an additional 1 million acre-feet going to the lower basin states, if available. By 1944 treaty, Mexico receives 1.5 million acre-feet, about one-tenth of the estimated average virgin flow. The existing complex of Colorado River water allocation and management rules is referred to as the "Law of the River."

Additionally, Native Americans living along the Colorado River have, in many instances, claims on water that date back to the mid-1800s. They are often the senior owners of river rights, according to U.S. Supreme Court rulings.

Systematic river flow measurements in the Colorado River Basin, which began only a little over a century ago, show considerable fluctuation in annual water supplies and include some intervals of persistent low flows. Instead of the 16.9 million acre-feet estimated to be there for the dividing in the '20s, the river has been flowing at an observed mean rate of 15.2 million acre-feet and during periods of drought has dropped as low as 9 million acre-feet a year.

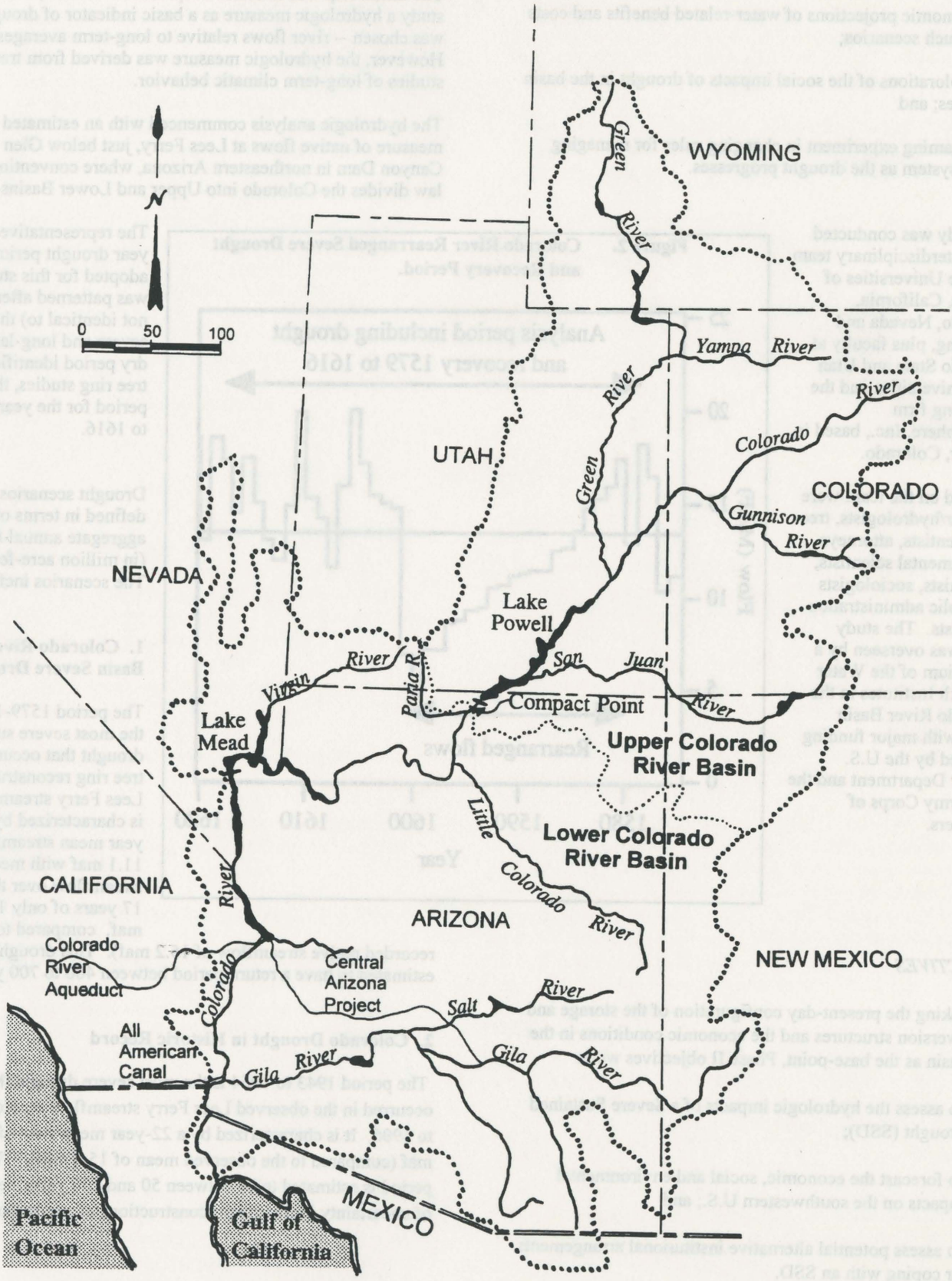
The U.S. Bureau of Reclamation has constructed water storage facilities with a capacity of roughly four times the annual flows, which renders the issues of drought impact unimportant during normal climatic fluctuations. However, under extreme climatic conditions, drought management could become significant.

Investigators from several Colorado River Basin states have been engaged for about a decade in a major program of research designed to evaluate the capability of the region's water management structures and institutions to cope with a severe sustained drought (SSD). Phase I of this research program included the following:

- Tree ring reconstructions of historic rainfall conditions;
- Hydrologic analyses of the probability distribution of river flows;
- Engineering simulations of the functioning of the water management facilities and institutions under various runoff scenarios;
- Legal and other institutional analyses of current interstate water allocation rules, and possible changes in them;

Figure 1. Colorado River Basin

Harding, Sangoyomi, and Payton

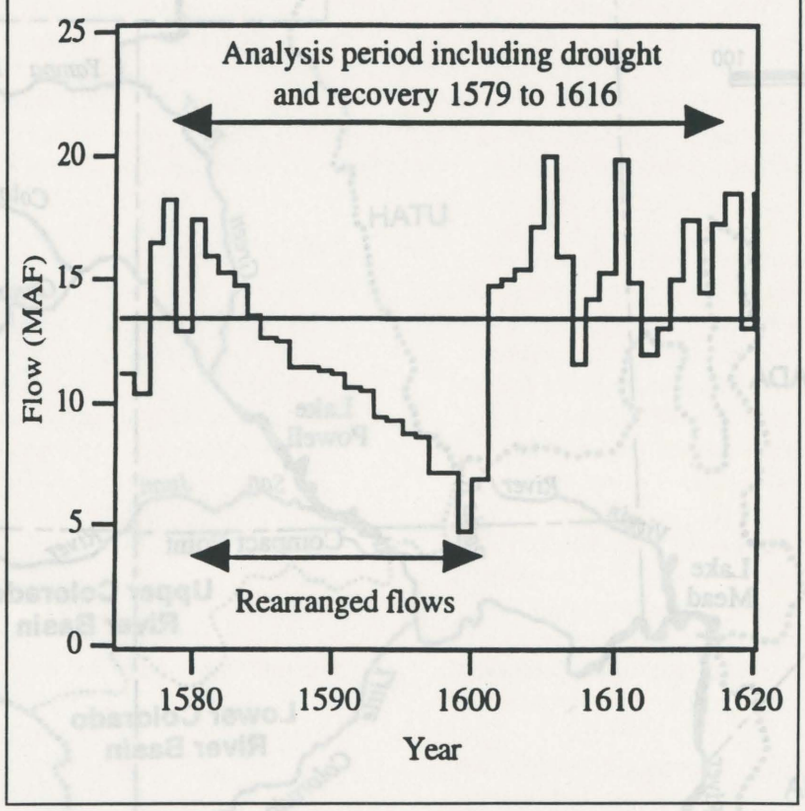


- Studies of potential environmental impacts of different hydrologic scenarios;
- Economic projections of water-related benefits and costs of such scenarios;
- Explorations of the social impacts of drought in the basin states; and
- A gaming experiment in changing rules for managing thesystem as the drought progresses.

The study was conducted by an interdisciplinary team from the Universities of Arizona, California, Colorado, Nevada and Wyoming, plus faculty at Colorado State and Utah State Universities and the consulting firm Hydrosphere, Inc., based in Boulder, Colorado.

Included on the team were engineer/hydrologists, tree ring scientists, attorneys, environmental scientists, economists, sociologists and public administration specialists. The study group was overseen by a consortium of the Water Research Institutes in the Colorado River Basin states, with major funding provided by the U.S. Interior Department and the U.S. Army Corps of Engineers.

Figure 2. Colorado River Rearranged Severe Drought and Recovery Period.



OBJECTIVES

- Taking the present-day configuration of the storage and diversion structures and the economic conditions in the Basin as the base-point, Phase II objectives were:
- To assess the hydrologic impacts of a Severe Sustained Drought (SSD);
- To forecast the economic, social and environmental impacts on the southwestern U.S.; and
- To assess potential alternative institutional arrangements for coping with an SSD.

DROUGHT SCENARIOS

The initial step was to select a representative SSD, and for this study a hydrologic measure as a basic indicator of drought was chosen -- river flows relative to long-term averages. However, the hydrologic measure was derived from tree ring studies of long-term climatic behavior.

The hydrologic analysis commenced with an estimated measure of native flows at Lees Ferry, just below Glen Canyon Dam in northeastern Arizona, where convention and law divides the Colorado into Upper and Lower Basins.

The representative 38-year drought period adopted for this study was patterned after (but not identical to) the most severe and long-lasting dry period identified by tree ring studies, the period for the years 1579 to 1616.

Drought scenarios were defined in terms of aggregate annual flows (in million acre-feet). The scenarios included:

1. Colorado River Basin Severe Drought

The period 1579-1600 is the most severe sustained drought that occurred in tree ring reconstruction of Lees Ferry streamflow. It is characterized by a 22-year mean streamflow of 11.1 maf with mean streamflow over the first 17 years of only 10.5 maf. compared to mean recorded native streamflow of 15.2 maf). This drought is estimated to have a return period between 400 to 700 years.

2. Colorado Drought in Historic Record

The period 1943 to 1964 is the most severe drought that occurred in the observed Lees Ferry streamflow record dating to 1906. It is characterized by a 22-year mean flow of 13.4 maf (compared to the observed mean of 15.2 maf). The return period is estimated to be between 50 and 100 years, regardless of uncertainty in tree ring reconstructions of streamflow.

3. Colorado Rearranged Severe Drought

An artificial scenario is formed by taking the flows in Scenario 1 and assuming they occur in decreasing order so that the lowest flows come at the end. It is characterized by a 16-year mean flow of 9.6 maf and has a return period from 2,000 to 10,000 years or more. This scenario is designed to discover how the system would respond to a truly catastrophic drought. This scenario was the "representative drought" that served as the basis for the study.

APPROACH

The first component of the study was, for each year of the representative drought, to predict overall native flows and then to break these down into water availabilities as key locations in the Basin. Concurrently, socio-economic conditions in the region for future decades were projected. The analysis assumes a drought would begin at the time of the study's commencement -- 1990. These hydrologic and socio-economic projections provide the basis for the study's impact assessment and the institutional analyses.

The second component was a legal and institutional assessment, designed to identify and investigate alternative legal and organizational arrangements that could be used to increase capacity for preparing for and coping with SSD. The third component was to estimate damages or impacts from droughts on economic sectors (including both instream and offstream beneficiaries), on social considerations, and on the environment.

These three components were then incorporated into two complementary types of interdisciplinary modeling assessment studies:

- A computer optimization that evaluates economic impacts on instream and offstream water users of alternative policy instruments; and
- A dynamic "gaming" phase, an interactive computer program designed to represent impacts of policies chosen in real time by players representing various basin interests.

IMPACTS OF A SEVERE, SUSTAINED DROUGHT

Findings, conclusions and recommendations derive largely from computer simulations of the behavior of the physical-institutional water management system when subjected to the stress of a 38-year severe drought, a drought resembling one which occurred late in the 16th century. The findings, conclusions and recommendations fall into three groups:

- Those which pertain to the existing operating rules (the Law of the River);
- Those which pertain to potential changes in the existing rules; and
- Those which pertain to the feasibility of making such changes (through negotiation, legislation, or litigation).

DROUGHT PERFORMANCE OF THE LAW OF THE RIVER

The SSD hydrologic models predict that, under present institutional arrangements (the Law of the River), Lake Powell and other major Upper Basin reservoirs would be emptied, and Lake Mead nearly so, after two decades of severely reduced runoff. Water deliveries for consumptive uses in the Upper Basin would fall to about half of normal levels, *albeit* for only a few years. Consumptive uses in the Lower Basin would be largely unaffected, save for those served by the Central Arizona Project

Until recently, California was able to use about a million acre-feet of Colorado River water annually beyond its regular compact entitlements. After the completion of the Central Arizona Project canal, such "surplus" usage is unlikely to recur reliably, and chronic inability to divert this surplus as a drought-caused shortage is not included. In all, basinwide shortages would be less than 25 percent of normal demands, even at the depth of the drought. California, in its recent droughts, has coped with more severe shortages.

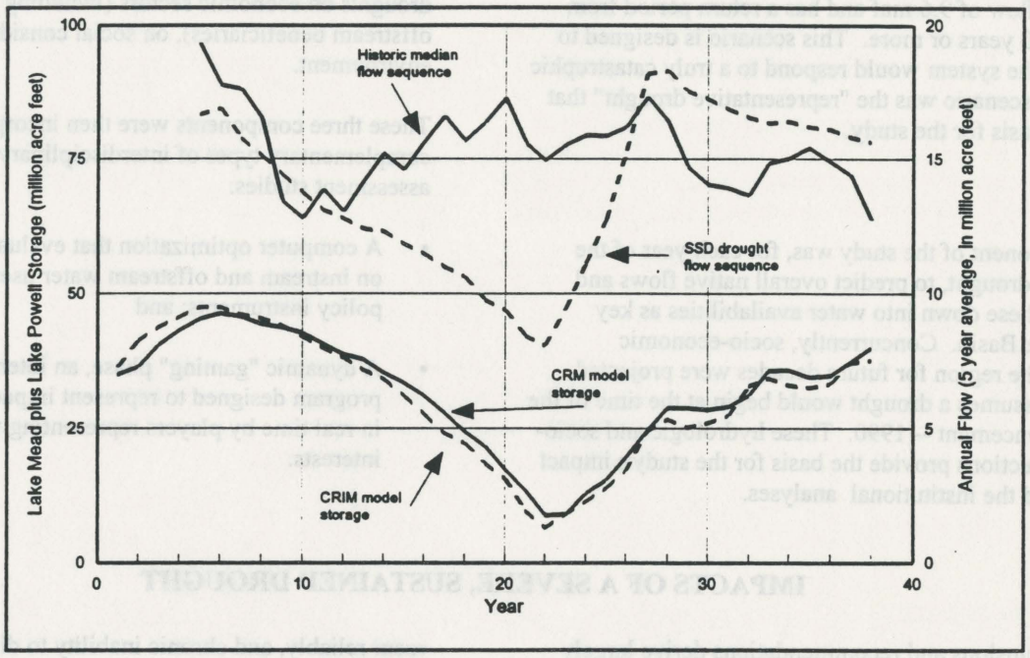
So-called instream, or nonconsumptive, water uses by the lower basin (hydroelectric power generation, water-based recreation, environmental protection and salinity control) would fare less well. Predicted power generation declined during the low-flow years and would cease altogether at the depth of the drought.

Water-based recreation at Lakes Mead and Powell and at five other system reservoirs would decline with decreasing water levels in those reservoirs (see Fig. 3, next page). Instream flows would be inadequate at times for the survival of some endangered species at some locations. Riparian wetlands would be seriously affected. Salinity levels in drinking and irrigation water would rise to levels higher than experienced since the completion of Hoover Dam.

The single largest predicted economic impact of the drought was the loss of electricity, with an average value of $600 million annually. Reductions in water deliveries to municipal, industrial and agricultural users would also be substantial, and benefits to those users would be significantly reduced due to salinity increases.

Recreational benefits would fall by lesser but still appreciable amounts. Lower Basin states would experience minimal losses to consumptive water uses but would suffer major losses to nonconsumptive uses.

Figure 3. Severe and Sustained Drought Flow Sequence (top, right scale) and the Resulting Combined Lake Powell and Lake Mead Contents from CRIM and CRM (Harding et al, 1995).



Just the opposite was true of the Upper Basin states. The estimated present value of discounted economic damages, excluding salinity, for the entire drought was $5 billion, 45 percent of which was to consumptive uses. To say that nonconsumptive uses would sustain 55 percent of drought damages is an understatement, because it ignores both salinity and nonmonetary damages, such as extirpation of endangered species.

Both local extirpations of endangered species and loss of wetlands occurred as a result of the drought and may have been aggravated by management measures taken to protect consumptive uses. Most instances of environmental deterioration are to some degree reversible. In the case of threatened and endangered species, however, losses are not so easily reversible. Localized extirpations were predicted in Flaming Gorge, Navajo and Lake Powell reservoirs, and in the Green River below Flaming Gorge. All of the reservoir extirpations were eventually reversed, but that in the Green River was not.

DROUGHT PERFORMANCE OF ALTERNATIVE OPERATING RULES

Several potential revisions to the Law of the River were formulated and evaluated, both by SSD institutional researchers and by those who participated in the gaming experiment. Among these changes were:

- Adopting a reverse equalization rule, which would tend to maintain similar water levels in Lakes Mead and Powell (the existing equalization rule protects Mead at the expense of Powell);
- temporarily ignoring the Upper Basin's delivery obligation to the Lower Basin to avoid Upper Basin shortages at times when no shortages were imposed upon the Lower Basin (in effect sharing system-wide shortages proportionally among the basin states);
- Revising reservoir operating rules to store water in headwaters reservoirs as long as possible (thus minimizing evaporative losses); and

- Permitting water banking and marketing between states, so long as no other states were harmed thereby.

Changes in intrastate water allocation and management were more effective in mitigating drought damages than were those changes in the Law of the River which were analyzed. In particular, transferring water from low-valued agricultural uses to higher-valued municipal and industrial uses shows considerable promise. Such reallocations did occur in the recent California drought and have been long observed in Colorado. Reducing agricultural water use during drought could also partially sustain nonconsumptive uses.

Studies showed that the gains from managing system reservoirs to maintain hydropower production would outweigh concomitant consumptive water use damages if those damages were suffered only by agriculture.

Shorting consumptive uses is most effective if concentrated in the Upper Basin because more downstream nonconsumptive uses can benefit. Measures that redistribute shortages away from the Upper Basin for reasons of increased equity would increase the system-wide damages from the drought.

Despite the mostly temporary extirpations, there was a net improvement in conditions for the four threatened and endangered species whenever the operating rules were interpreted to include invoking the Endangered Species Act to modify reservoir release rules and protect these species whenever it appeared to be necessary. To do so, of course, caused some reduction in water deliveries for offstream consumptive uses to the Upper Basin.

INSTITUTIONS FOR CHANGING OPERATING RULES

The kinds of changes in the Law of the River which were explored can be accomplished in several different ways, as is shown by the history of the Law's evolution.

- **Interstate Negotiation**--This is how the two interstate compacts (Upper and Lower Basins) were formulated.
- **Federal Legislation**—This is how the major reservoirs were constructed and how the 1922 Upper Basin-Lower Basin apportionment was originally put into effect.
- **Judicial Decision**--Represented by the far-reaching 1968 decree in Arizona v. California.
- **Administrative Rule-making**--Represented by the promulgation of the Interior Secretary's operating criteria for Hoover and Glen Canyon dams.

The gaming experiment placed players (who were research team members) acting as representatives of the seven basin states and the federal government in three collective choice situations where they were required to agree upon changes in the Law of the River in order to mitigate drought impacts. Each of these situations was governed by rules which were variants of the interstate negotiation model. The participants achieved only minor rule changes, and even less substantial mitigation results, perhaps due to perceived restrictions in the scope of their responsibilities and to information deficiencies. They were most successful when permitted to engage in bilateral water banking and water marketing transactions. Their greatest achievements in reducing drought damages resulted from the intrastate water management changes which they were able to make independently.

IMPLICATIONS

NONCONSUMPTIVE WATER USES ARE HIGHLY VULNERABLE TO DROUGHT

Nonconsumptive uses are far more vulnerable to drought than are consumptive water uses, at least when the system is managed pursuant to current rules or pursuant to the variants on those rules. Existing operating rules and those changes which were examined favor consumptive water uses over such nonconsumptive uses as hydroelectric power generation, environmental protection, salinity control and recreation. Both absolute and relative declines in the monetary values of nonconsumptive water uses are far greater than is true for consumptive uses, taken as a whole.

CONSUMPTIVE WATER USES ARE WELL-PROTECTED FROM DROUGHT

The severe sustained drought does produce damages or losses to consumptive water users (farmers, industries and municipalities), even if only in the Upper Basin, and there only for a few years. A substantial drop in water deliveries to consumptive uses occurred when the drought was at its worst. However, when states managed their intrastate waters efficiently, the drop in monetary benefits was much smaller, in relative terms, than was the shortage which produced that drop.

DROUGHT RISK IS GREATEST IN THE UPPER BASIN, BUT IN NORMAL YEARS SUPPLIES ARE ABUNDANT

The 1922 Colorado River Compact essentially gives the Lower Basin states seniority in claiming the first 7.5 maf of Colorado River flows, although it is often held that half of the delivery obligation to Mexico must come out of that allotment. This Lower Basin priority effectively transfers all of the drought risk to the Upper Basin. Current Upper Basin depletions amount to over four million acre-feet annually (including present perfected rights). Therefore, at the present

level of development, the Upper Basin uses far less than its entitlement as long as runoff is near normal.

THE LOWER BASIN SUFFERS CHRONIC WATER SHORTAGES BUT BEARS LITTLE DROUGHT RISK

By the 1922 compact agreement, the Lower Basin gained the assurance of a stable water supply at the expense of limiting its long-term mean withdrawals to less than the amount needed to meet its potential demands. Conversely, the Upper Basin states gained a long-term limitation on the Lower Basin's share of the system yield, at the cost of assuming almost the entire drought risk of the entire basin.

OPPORTUNITIES EXIST FOR WIN-WIN RULE CHANGES

It would be relatively inexpensive for the Upper Basin and Arizona to reduce their long-term claims upon Colorado River water to enable California to meet already-existing demands. It would be similarly inexpensive if California agreed to share the burden of future drought shortages more equally, thus relieving what could be traumatic shortages in Upper Basin states, particularly Colorado.

ONLY MINOR CHANGES CAN BE MADE UNDER EXISTING RULES

The three SSD gaming experiments were conducted within the limited context of those changes in interstate water allocation believed to be attainable without changes in statutes or judicial interpretations. The most striking aspect of the outcomes of three drought gaming exercises was their similarity. The players simply were unable to change those outcomes very much through negotiating changes in the operating rules, even though a great deal of communication occurred in both the second and third games, and many water transfer deals were successfully struck in the third game.

The players seemed to attempt, almost single-mindedly, to maximize Colorado River water deliveries to their respective states within and up to the limits of their compact entitlements. It seems that, with the exception of the equalization rule, the existing operating rules are hard to improve upon, from the limited perspective of coming as close as is possible to fulfilling compact entitlements.

RECOMMENDATIONS

Study participants recommend that the basin states and the federal government explore the possibility of replacing the 1922 compact with a federal interstate compact that:

- Establishes an interstate compact commission, perhaps modeled after that now in place in the Delaware River Basin;
- Provides that this commission be served by a technical staff, either within the present Bureau of Reclamation or apart from it, whose mission should be to conduct technical studies for the commission aimed at discovering common interest solutions to drought and other water management problems;
- Establishes an advisory committee to the commission composed of representatives of all major water user groups, including agricultural, industrial, and municipal water consumers, hydroelectric power interests, environmental organizations, recreational users, and Indian tribes;
- Mandates consideration of meeting nonconsumptive water demands and uses on a no less urgent and important basis than that of serving consumptive uses;
- Establishes long-term allocations of Colorado River water in proportion to current demands, rather than to 1922 allocations;
- Provides for proportional sharing of short-term (drought) shortages, much as does the current upper basin compact;
- Is empowered to encourage and facilitate interstate water banking and marketing; and
- Is authorized to conduct joint explorations with Mexican entities of possibilities for restoring and maintaining the estuarine ecosystem of the Gulf of California (Sea of Cortez). Equitable cost sharing provisions should be an important part of such an innovation.

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Professor L. Douglas James, then Director of the Utah State University Water Research Laboratory, spearheaded the planning, conceptualization and proposal preparation that culminated in the Phase II effort described in this article and served as Principal Investigator and Technical Coordinator for the first two years of the project. Professor Henry Vaux, then Director of the University of California Water Resources Research Institute and an active participant and contributor in the Phase I study, aided greatly in early planning and fund-raising efforts. In 1992 Davis S. Bowles became Director of the Utah Water Research Laboratory and took over the administrative management for the remainder of Phase II. At that time, William B. Lord assumed the role of Technical Coordinator, and was succeeded in February 1993 by R. A. Young. J. P. Matusak of the Metropolitan Water District of Southern California and William Werick, Institute of Water Resources, Corps of Engineers, provided counsel and facilitated contacts with modeling experts.

Views and statements are solely those of the authors and do not represent official views or policies of the Powell Consortium, U.S. Geological Survey, U.S. Army Corps of Engineers, Metropolitan Waster District of Southern California, Upper Colorado River Basin Commission, Water Resources Research Centers of the Colorado River Basin, U.S. Department of State, or the American Water Resources Association.

Editor's Note: James F. Booker's Ph.D dissertation, "Economic Allocation of Colorado River Water: Integrating Quantity, Quality, and Instream Use Values," received an award for Outstanding Water Resources Dissertation from the Universities Council on Water Resources. Awards are given annually, after national competition, in the categories of Engineering and Physical Sciences, Environmental and Biological Sciences, and Social and Behavioral Science. Booker worked under Professor Robert A. Young on a USGS-funded project that examined impacts of using water markets to allocate Colorado River water resources.

Editor's Note: While the preceding article provided scenarios of the effects of drought in the Colorado River Basin, the following articles describe current efforts by the State of Colorado, the Bureau of Reclamation and the U.S. Geological Survey to have available more comprehensive information on the Colorado River system.

COLORADO RIVER DECISION SUPPORT SYSTEM APPROACHING MILESTONE

The Colorado River Decision Support System (CRDSS) is a collection of computerized water resource databases, models and tools. This multi-year, multimillion dollar project is sponsored by the Colorado Water Conservation Board (CWCB) and the Colorado Division of Water Resources (DWR) to provide a strong foundation for the State and others to make decisions on Colorado River issues and to provide a tool for water resource planning, management and administration within Colorado.

The first development phase, which began in January 1994, is nearing completion and will result in an integrated system containing tabular databases, map databases, consumptive use models, water resource planning models, and "Big River" MODELS. The second phase will continue in the next several years with emphasis on developing tools for real-time water administration, refreshing the databases, and improving the models and means of access.

CRDSS PRIMARY PURPOSES

In 1991, as a result of endangered species recovery efforts and discussions concerning Colorado River operations among the seven Colorado River Basin states, Colorado determined that it needed to be able to better evaluate and analyze water resources data and issues. A subsequent feasibility study in 1993 identified 90 major types of water resource information used by state, federal and local water user agencies. Though the state will be the primary user of the system, it will also be available to local water users and federal agencies. Identified needs were grouped into general need categories and prioritized. The highest ranked need categories are indicated below.

- Interstate Compact Analysis:
  - Annual Reservoir Operations Planning
  - Compact Policy Evaluation
- State Water Resource Planning
  - Basinwide Water Resource Planning
  - Project Yield/Development Analysis
  - Appropriation and Management of Instream Flow Rights for Endangered Species
- State Water Rights Administration:
  - Real-time Administration
  - Water Rights Operation/Yield Analysis
  - Compact Administration Within Colorado

CURRENT CRDSS ELEMENTS

A major goal of CRDSS was to develop accurate and more useable databases to support water resource decisionmaking associated with the Colorado River resources. These databases can be considered as the center of the system. The two types of databases in CRDSS are relational (tabular) and spatial (map).

The CRDSS relational dataset contains the following:

- Daily diversions for the period of 1975 through the early 1990s for West Slope diversion systems as obtained from the Colorado Division of Water Resources.
- West Slope reservoir end-of-month content records for the period of 1975 through the early 1990s as collected from the Colorado Division of Water Resources.
- Records of daily streamflows for the West Slope streamgages for their period-of-record as obtained from the U.S. Geological Survey.
- Historic records of daily climate data (primarily temperature and precipitation) for the National Oceanic and Atmospheric Administration (NOAA) and other climate stations on the West Slope.
- Water right information that makes up the state tabulation of water rights.
- An inventory of irrigated acreage on the West Slope as defined in 1993.

The spatial dataset for the West Slope includes:

- Irrigated acreage existing in 1993 with acreage tied to structure providing the water supply to the acreage.
- Hydrology
- Elevations
- Lake Evaporation
- Solar Radiation
- Land Use
- Soils
- Boundaries (counties, Public Land Survey System, water districts and divisions)
- Sites (cities, diversion headgates, reservoirs, streamgates, climate stations

Current models include:

The Consumptive Use Model -- A simulation model and relevant data to estimate the West Slope consumptive use of water from irrigation, municipal and industrial uses, reservoir evaporation, and other uses. Irrigation consumptive uses are typically calculated using the Blaney-Criddle method and the 1993 irrigated land inventory mentioned above. Interaction between the consumptive use model and the water resource planning model described below provides a better understanding of Colorado's water supplies and uses.

Water Resource Planning -- A simulation model and the relevant data used to simulate instate river operations and evaluate water resource development options on a monthly time step for a historic trace, integrating both physical hydrology and water rights administration for the Yampa, White, Upper Colorado, Gunnison, San Juan and Dolores River Basins.

Big River Models -- The "Big River" models can be used to investigate water operations in the Colorado River Basin under the "Law of the River." The "Big River" models that initially have been incorporated into CRDSS are the U.S. Bureau of Reclamation's (USBR) Colorado River Simulation System and the USBR Annual Operating Plan Model.

Training for the current system will be offered for both state and non-state representatives in the latter part of July.

DEVELOPMENT TEAM

A development team headed by Riverside Technology, Inc. of Fort Collins was selected for the first two and one-half years of CRDSS development. Other members of that development team include Colorado State University and W. W. Wheeler and Associates. Boyle Engineering Corporation and Enartech, Inc. have been added to the CRDSS Development Team for the 3rd CRDSS development year. The Boyle/Enartech Group brings a fresh set of eyes as well as expertise in water resources and water rights. To manage the Development of the CRDSS, a State Project Management Team was established consisting of senior staff members of the CWCB and DWR and a contract Project Manager. To provide additional guidance during CRDSS development, a 20-person technical advisory committee (TAC) has been formed which includes major Colorado River water users and federal and state representatives.

Questions on the CRDSS Project should be directed to Ross Bethel, CRDSS Project Manager, c/o the Colorado Water Conservation Board, 1313 Sherman Street, Room 721, Denver, Colorado 80203. Phone 303/866-3441 Ext 308; FAX 303/866-4474.

USBR/USGS COOPERATE ON WATERSHED AND RIVER SYSTEMS MANAGEMENT PROGRAM

The demands placed on water resource systems have increased greatly over the past few decades. Meeting consumptive use demands, while still vitally important, is no longer the only objective to be considered in operational and planning decision making. Key issues in the management of the Colorado River watershed include:

- Flood control
- Increased consumptive use demands
- Water quality (especially salinity)
- Recreational uses on reservoirs and rivers
- Endangered species and other environmental concerns
- Water rights (particularly for Native American Nations)

To address these issues, the U.S. Bureau of Reclamation and the U.S. Geological Survey, in a joint effort, will research and develop a data-centered decision support system (DSS) that utilizes relational database and advanced modeling technologies to integrate water, power, and weather data, both historical and forecasted. The system is presently being applied to the Colorado River Basin and ultimately could be applied to many other large basins throughout the Western United States.

The program will focus on seven major efforts:

- Research and develop a data-centered decision support methodology which will focus on the use of relational database technology and ensure compatibility between the main modeling tools being used -- initially MMS and PRSYM -- and other modeling and analysis tools yet to be developed.

- Test that system on the selected study areas including the San Juan Basin, the Lower Colorado Basin, the entire Colorado Basin for long-term policy and planning, and the Pecos River Basin.

- Select additional basins in other regions for future system development and implementation. As the technology is utilized in regional, area and field offices, it will be fin-tuned, expanded and enhanced in order to deal with key issues in these basins and regions as necessary. If additional needs are identified, the framework will be broadened to allow the use of additional quantitative modeling and analysis approaches.

- Research and develop extensions to the PRSYM modeling framework, to include the modeling of other key water quality constituents (i.e., dissolved oxyten, sediment), the ability to account for water ownership, new approaches to applying linear programming to reservoir system management, and a stochastic control methodology for short-term operations use.
- Research and develop extensions to the MMS modeling framework. This work will be done by the USGS.
- Research and develop other modeling components as needed. These may include biotic modeling components developed by other agencies and included in the DSS.
- Share information on new and improved modeling capabilities.

Note:

MMS -- The Modular Modeling System -- is a model building framework to simulate a wide range of interdisciplinary environmental and water resource physical processes. Basin models may be run using meteorological historic data or input from weather and climate models. Resulting simulated streamflow is used directly by river basin managers or to subsequently simulate alternative operating scenarios.

PRSYM -- The Power and Reservoir Systems Model -- is a general-purpose, interactive model building tool used to develop water distribution models for short-term operations and scheduling, mid-term operations and planning, and long-term policy and planning.

The design and implementation of the **Hydrologic Database (HDB)** was completed in 1995. The HDB includes streamflow, reservoir operations, SNOTEL and other snowpack data and weather data. Data is continually updated automatically from telemetry, SCADA, and other real-time systems. Further work including extension of the HDB to handle water accounting/water rights will be completed by the end of 1996.

HDB has been installed at the Upper Colorado Regional Office and the Hoover Dam Facilities Office. Additional applications will be developed as needed (including query and reporting applications specific to each office).

A daily model for water scheduling has been implemented at Hoover using PRSYM. This model has been successfully tested by running it side-by-side with the existing water scheduling mode, CRSSl. Replacement of CRSS is scheduled for the spring of 1996.

Interfacing of the PRSYM and MMS models with the relational database is underway using the San Juan Basin as a test case and should be completed by mid-1996.

Development of accounting and water rights capabilities on the San Juan Basin is underway as well and should be completed in 1996.

Modeling capabilities in PRSYM will continue to be expanded during 1996. In addition to water accounting/water rights, the development of a scenario management module, the design of a quantitative trade-off analysis module, and the design of a stochastic, risk analysis module will be done. Modelinig capabilities of MMS will continue to be enhanced by the USGS team.

The Watershed and River Systems Management Program (WARSMP) is a cooperative effort of the U.S. Bureau of Reclamation and the U.S. Geological Survey. Additional cooperation and support comes from the Tennessee Valley Authority (TVA), the Electric Power Research Institute (EPRI), the University of Colorado's Center for Advanced Decision Support for Water and Environmental Systems (CADSWES), the Western Area Power Administration (WAPA), the National Weather Service (NWS), and the NOAA-Environmental Research Labs (ERL).

An ad-hoc User Group reviews the models and other products developed with this program. Any interested party is invited to join the User Group.

Contacts for additional information are:

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George Leavesley — Phone: 303/236-5026
E-Mail: george@snow.cr.usgs.gov

The World Wide Web URL IS:

http://donews.do.usbr.gov/Denver/tsc/D8510

WATER RESEARCH AWARDS

A summary of water research awards and projects is given below for those who would like to contact investigators. Direct inquires to investigator c/o indicated department and university.

Colorado State University, Fort Collins, CO 80523

Analysis of Fish Samples from the Yampa River, Yampa Canyon, Colorado, John A Hawkins, Fishery & Wildlife Biology. Sponsor: National Park Service.

Water & Sediment Flow Routing on the Green River, Marshall Flug, Civil Engineering. Sponsor: National Park Service.

Computer Modeling of Two Crossings on the Mississippi River, Daniel Gessler, Civil Engineering. Sponsor: Corps of Engineers.

***Responses of Hydrologic & system Processes to Potential Climate Change...**, Jill S. Baron, Natural Resource Ecology Lab. Sponsor: National Park Service.

Impacts of Trails on Bird Lowland Riparian Areas, John A. Wiens, Biology. Sponsor: Colorado State Parks.

Measuring the Value of Threatened & Endangered Species, John B. Loomis, Agricultural & Resource Economics. Sponsor: Bureau of Reclamation.

***Abiotic & Biotic Controls on Upper & Lower Timberline & Intermediate Ecotones**, Daniel F. Binkley, Forest Sciences. Sponsor: National Park Service.

Landscape Gap Analysis, Thomas J. Stohlgren, Natural Resource Ecology Lab. Sponsor: National Park Service.

Ecological Management & Restoration on Eglin Air Force Base, Florida, Robert B. Shaw, Forest Sciences.

CSU GIS Habitat, Denis J. Dean, Forest Sciences. Sponsor: Colorado Division of Wildlife.

***Support for Global Change Research Program**, Thomas J. Stohlgren, Natural Resource Ecology Lab. Sponsor: National Park Service.

DEC Design Guidance, Chester C. Watson, Civil Engineering. Sponsor: DOD-ARMY-Corps of Engineers.

WetScape: Test, Refinement & Documentation, Luis Garcia, Chemical & Bioresource Engineering. Sponsor: Bureau of Reclamation.

***Global Analysis of the Earth Energy Budget & Water Cycle Using Satellite Observations...**, Thomas H. Vonderhaar, Atmospheric Science. Sponsor: National Aeronautics & Space Admin.

***Effects of Woody Vegetation on Channel Roughness**, Steven R. Abt, Civil Engineering. Sponsor: Corps of Engineers.

***Systems Analysis Methods for Water & Natural Resources Decision Making**, Marshall Flug, Civil Engineering. Sponsor: National Biological Survey.

Water Blend Basin Model, Steven R. Abt, Civil Engineering. Sponsor: Denver Water Department.

Larimer County Inventory - Natural Heritage Resources, Christopher A. Pague, Fishery & Wildlife Biology. Sponsor: Larimer County.

Cadmium & Arsenic QA/QC - ENSR/Globeville, John Domenic Tessari, Environmental Health. Sponsor: ENSR Consulting & Engineering.

***Training & Education for Agricultural Chemicals & Groundwater**, Reagan Waskom, Soil & Crop Sciences. Sponsor: Colorado Department of Agriculture.

Ecological Modeling in Support of County Decision Making(GIS), N. Thompson Hobbs, Natural Resource Ecology Lab. Colorado Division of Wildlife.

Breeding Bird Communities in Cottonwood Forests Along the Yampa River, Colorado, Richard L. Knight, Fishery & Wildlife Biology. Sponsor: Colorado State Parks/CO Natural Areas Prog.

Snow Deposition Studies in Two National Parks of the Rocky Mountain Cordillera, Kevin J. Elder, Earth Resources. Sponsor: National Park Service.

Establishment of Baseline Water Quality Conditions in the National Park Service, John Stednick, Earth Resources. Sponsor: National Park Service.

Fundamental Design of Branched Fluid Particle Separators Based on Inertial Migration..., David Dandy, Chemical & Bioresource Engineering. Sponsor: National Science Foundation.

Projecting the Effect of Global Change on Vegetation in Park Landscapes..., Dennis Ojima, Natural Resource Ecology Lab. Sponsor: National Park Service.

Effects of Outdoor Recreation on Wildlife, Richard L. Knight, Fishery & Wildlife Biology. Sponsor: Boulder County Parks & Open Spaces.

Mercury Deposition Network: A Subnetwork of the National Atmospheric Deposition Program, Richard B. Flagler, Natural Resources Ecology Lab. Sponsor: Various "Non-Profit" Sponsors.

Bedload Transport Processes in Gravel-Bed Rivers, Steven R. Abt, Civil Engineering. Sponsor: USDA-USFS-Rocky Mtn. Experiment Station.

The University of Colorado, Boulder, CO 80309

***Hydrology, Hydrochemical Modeling and Remote Sensing of Seasonally Snowcovered Areas**, Mark Williams, Institute of Arctic and Alpine Research. Sponsor: University of California at Santa Barbara.

***Biodiversity of Open Space Grasslands at a Suburban/Agricultural Interface**, Jane Bock, Environmental, Population and Organismic Biology. Sponsor: City of Boulder.

REU Supplement to Effects of Climate Change in the Colorado Alpine, Timothy Seastedt, Institute of Arctic and Alpine Research. Sponsor: National Science Foundation.

Meltwater Flow Through Snow from Plot to Basin Scales, mark Williams, Institute of Arctic and Alpine Research. Sponsor: National Science Foundation.

***Dynamics of Subglacier Water Routing and Characterization of the Basal Hydraulic System**, Mark Meier, Institute of Arctic and Alpine Research. Sponsor: National Science Foundation.

Impact of Tropical Ocean Surface Fluxes on the Atmosphere and Upper Ocean: Extension from TOGA COARE, Judith Curry, Program in Atmospheric and Oceanic Sciences. Sponsor: National Science Foundation.

***The Effects of Climate Variation on Disturbance Regimes and the Dynamics of Montane Forests in the Colorado Front Range**, Thomas Veblen, Geography. Sponsor: National Park Service.

***Nitrogen Dynamics: Interactions Between Snowmelt and Runoff**, Mark Williams, Institute of Arctic and Alpine Research. Sponsor: National Park Service.

***Hydrology and Water Resources Research**, David Kassoy, Center for Advanced Decision Support for Water and Environmental Systems (CADSWES). Sponsor: U.S. Geological Survey.

Unified Quantitative Methodology for Integration of Nondestructive Bridge Evaluation and Bridge Management Systems: Development and Demonstration, George Hearn, Civil, Environmental and Architectural Engineering. Sponsor: Department of Transportation.

***Rotating Hydraulic Channel Flow with Friction**, Daniel Ohlsen, Program in Atmospheric and Oceanic Sciences. Sponsor: Department of the Navy.

Meltwater Flowthrough Snow from Plot to Basin Scales, Mark Williams, Institute of Arctic and Alpine Research. Sponsor: Department of the Army.

Using Spectral Mixture Analysis to Assess and Validate a Global Snowcover Mapping Algorithm (Snowmap), Anne Nolin, Cooperative Institute for Research in Environmental Sciences. Sponsor: National Aeronautics and Space Administration.

Using a New Canopy Model to Study Heat, Moisture, and Ozone Fluxes, Jielum Sun, Program in Atmospheric and Oceanic Sciences. Sponsor: Department of Agriculture.

Aerological Estimates Over the Major Arctic Watersheds, Mark Serreze, Cooperative Institute for Research in the Environmental Sciences. Sponsor: Marine Biological Laboratory.

TVA PRYSM Maintenance, Edith Zagona, CADSWES. Sponsor: Tennessee Valley Authority.

***Laurentide Ice Sheet Instability: Heinrich Events in Labrador Sea**, and Rapid Climate Change, John Andrews, Cooperative Institute for Research in Environmental Sciences. Sponsor: National Science Foundation.

***Biosphere/Atmosphere Interactions: Biochemical Causes to Global Implications**, Russell Monson, Environmental, Population and Organismic Biology. Sponsor: National Science Foundation.

***Predicting Sediment Delivery and Stratigraphy on Marginal Slopes and Shelf Basins**, James Syvitski, Institute of Arctic and Alpine Research. Sponsor: Department of the Navy.

*Supplement to existing award.

UNIVERSITY WATER NEWS

WATER CENTER CREATED AT COLORADO STATE UNIVERSITY

Colorado State University has a national and international reputation for its knowledge and applied research in water resources. Now, the University's multiple water programs will come together across several departments and colleges to form The Water Center at Colorado State University. Colorado State's water-related courses, research and service involve more than 30 programs that involve close to 200 faculty. The Water Center will provide "an arena where faculty can come together on an interdisciplinary basis to write proposals and engage in joint scholarly activity in the water field," says Neil S. Grigg, Chairman of Colorado State's Civil Engineering Department. He is optimistic that fragmentation can be organized into a collaborative effort. CWRRI's Director Robert Ward believes The Water Center "enhances the ability of higher education to be more responsive to the evolutionary changes taking place in the water and environment management community."

The long-range vision, says Grigg, includes eventually creating a facility for The Water Center that will incorporate classrooms and laboratories; a water museum to promote public education about water; and a media center that will include the University's wealth of historical documents, archives, and special collections related to water. The contributions of Colorado State University's water faculty, including department archives and special donated collections

including photos, inventions, measurement instruments and documents related to water, would be housed in The Water Center's Museum.

This summer the first phase of The Water Center will begin -- a plaza just south of the Engineering Building will be landscaped with an elaborate water feature showing the flow of water from melting snow on mountaintops, down through rivers and streams, into reservoirs and ditches, flowing through agricultural fields, and draining, finally, into the wetlands that support our water life populations. It will, says CWRRI Director Robert Ward, "show the commitment of this campus to honor its strong water heritage and the role this University has played in its development."

A five-member board of directors composed of the deans from the Colleges of Agricultural Sciences, Engineering, and Natural Resources, and the directors of Cooperative Extension and the Experiment Station has appointed Grigg the Center's director to get the center organized. Decisions regarding the Center's operations are made by a management committee that includes Grigg, heads of five other departments, and Robert Ward, the director of the Colorado Water Resources Research Institute (CWRRI).

Engineering Newsletter, Spring 1996

AGRICULTURAL EXPERIMENT STATION DIRECTOR ACCEPTS POSITION IN HAWAII

Charles Laughlin has accepted a position as Dean of the College of Tropical Agriculture and Human Resources at the University of Hawaii effective July 1, 1996. The announcement was made on May 3 by Kirvin L. Knox, Associate Provost for Agriculture and Public Service, and Dean of the College of Agricultural Sciences. Laughlin served as Director of the Agricultural Experiment Station for almost four years. Knox said Laughlin's leadership, enthusiasm and energy were enormous assets to Colorado State University, particularly in focusing the AES agenda and addressing critical issues facing the outstate research centers. Knox will name an interim director for the Agricultural Experiment Station and initiate a search for a permanent director.

WATER SUPPLY

The Surface Water Supply Index (SWSI) developed by the State Engineer's Office and the USDA/SCS is used as an indicator of mountain-based water supply conditions in the major river basins of the state. It is based on stream flow, reservoir storage, and precipitation for the summer period (May-October). During the summer period stream flow is the primary component in all basins except the South Platte, where reservoir storage is given the most weight. The following SWSI values were computed for each of the seven basins on July 1, 1995 and reflect conditions during the month of August.

Basin	May 1, 1996 SWSI Value	Change From Previous Mo.	Change From Previous Yr.
South Platte	+3.3	-0.3	+2.5
Arkansas	+1.9	-0.3	-1.3
Rio Grande	-2.2	-1.0	-5.6
Gunnison	+1.7	-1.1	-1.9
Colorado	+1.1	-1.1	-1.5
Yampa/White	+1.8	-0.6	+2.2
San Juan/Dolores	-2.0	-0.1	-4.2

SCALE

-4	-3	-2	-1	0	+1	+2	+3	+4
Severe Drought		Moderate Drought		Near Normal Supply		Above Normal Supply		Abundant Supply

WATER PUBLICATIONS, DATABASES

USGS REPORTS

Contact the U.S. Geological Survey, Earth Science Information Center, Open-File Reports Section, Box 25286, Mail Stop 517, Denver Federal Center, Denver, CO 80225 or call 303/236-7476.

Surface-Water Quantity and Quality Data, Rocky Flats Environmental Technology Site near Denver, Colorado, Water Years 1994-95, by Mark E. Smith, John W. Unruh, and Clayton H. Thompson. Open File Report 96-314 (Interim Report).

Trend Analysis of Selected Water-Quality Data Associated with Salinity-Control Projects in the Grand Valley, in the Lower Gunnison River Basin, and at Meeker Dome, Western Colorado, by David L. Butler. Prepared in cooperation with the Bureau of Reclamation. Water-Resources Investigations Report 95-4274.

Methane-Concentration and Methane-Isotope Data for Ground Water and Soil Gas in the Animas River Valley, Colorado and New Mexico, 1990-91. Prepared in cooperation with the Colorado Oil and Gas Conservation Commission, La Plata County, and the Southern Ute Tribal Council. Water-Resources Investigations Report 93-4007.

Environmental Setting and Implications on Water Quality, Upper Colorado River Basin, Colorado and Utah, by Lori E. Apodaca, Nancy E. Driver, Verlin C. Stephens and Norman E. Spahr, National Water-Quality Assessment Program. Water-Resources Investigations Report 95-4263.

Hydrogeology of the Alluvial Aquifers at the Pueblo Depot Activity Near Pueblo, Colorado, by Daniel T. Chafin. Prepared in cooperation with the U.S. Army Corps of Engineers and the U.S. Army Pueblo Depot Activity. Water-Resources Investigations Report 95-4137.

Initial Effects of Stagecoach Reservoir on Discharge, Water-Quality Characteristics, and Suspended Sediment Loads in the Yampa River, Northwestern Colorado, by Robert L. Tobin. Prepared in cooperation with the Upper Yampa Water Conservancy District. Water-Resources Investigations Report 95-401.

PUBLICATIONS FROM OTHER SOURCES

Restoring the West's Waters: Opportunities for the Bureau of Reclamation -- a 2-volume report from the Natural Resources Law Center, University of Colorado. Ninety years after the Bureau of Reclamation helped transform western rivers into economically productive assets, the agency faces a new challenge: helping to restore a functional level of ecological integrity to the rivers its facilities transformed. The Center's report describes 15 examples where minor changes in BOR project operations resulted in addressing environmental concerns without decreasing traditional economic benefits.

Volume I explores opportunities to change the manner in which demands for water resources are satisfied in order to address environmental concerns. The Center examined in detail six Western river systems in which operations play a significant role: the Truckee-Carson, Upper Snake, Yakima, North Platte, Rio Grande and Upper Colorado. For each basin Volume II discusses general hydrological and physical information, environmental concerns, and a summary of efforts to change historical water management practices, including those of Reclamation facilities. The report documents modest changes to the traditional manner in which Western water demands have been satisfied and examines the legal issues associated with making what in some cases are complex changes.

The report represents the work of several current and former staff members of the Center, including former Director Lawrence J. MacDonnell, former Associate Directors Sarah Bates (now Sarah Van de Wetering) and Judith Jacobsen, and Senior Staff Attorney Teresa Rice. The report was developed under a joint grant from the U.S. Environmental Protection Agency and the Bureau of Reclamation with additional support from the Ford Foundation.

Contact: Natural Resources Law Center, University of Colorado School of Law, Campus Box 401, Boulder, CO 80309-0401. Phone 303/492-1288; FAX 303/492-1297.

The Watershed Source Book: Watershed-based Solutions to Natural Resource Problems - 1996. Contains detailed descriptions of 76 watershed-related efforts westwide divided according to major river basins. Also included are maps of the regional basins. Contact the Natural Resources Law Center, University of Colorado, Campus Box 401, Boulder, CO 80309-0401. Call 303/492-1286 or FAX your request to 303/492-1297. $25 per copy, plus $3 shipping.

Hydrology and Water Resources in Arizona and the Southwest, Proceedings of the 1995 meeting of the Arizona Section, American Water Resource Association and the Hydrology Section, Arizona-Nevada Academy of Science. Contact: R. Sayers, School of Forestry, Box 15018, Northern Arizona University, Flagstaff, AZ.. 86011. For information FAX 520/1080.

Watershed Protection: A Statewide Approach, published by EPA's Office of Wetlands, Oceans, and Watersheds. Contact EPA at 202/260-7166 and ask for Doc. No. EPA 841-R-95-004, August 1995. A companion document, **Watershed Protection: A Project Focus**, deals with developing watershed projects.

WET SPOTS ON THE WEB

FIND WATER DATA QUICKLY AND EASILY -- SEE WHAT'S ON-LINE!

NCWCD Joins the Web

The Northern Colorado Water Conservancy District has joined the growing ranks of water providers with wet spots on the Web. The NCWCD Home Page will appear soon on the Web at the address: Users will find information on weather, snowpack, upcoming Board of Directors meeting agendas, or previous meeting minutes. They can also take a tour of the Colorado-Big Thompson Project in pictures and words. Also to soon become available on the Web is NCWCD's crop and weather information -- today's or yesterday's weather, growing-degree day data, and lawn or agricultural crop evapotranspiration (ET) figures. (Currently users can call 970/593-1605 and punch in a three-or four-digit code to get this information.)

http://www.ncwcd.org.ncwc

National Watershed Network -- Contains information on watershed groups accessible by state and key word search.

http://www.ctic.purdue.edu/watershed/watershedoptions.html

IWRN Directories of Water Resources Organizations and Training Opportunities for North America

The Center for Environmental Studies (CES) at Florida Atlantic University and the Universities Water Information Network (UWIN) are collaborating to create these *Directories* for the Inter-American Water Resources Network (IWRN). The IWRN is a network of people and information dedicated to improving water management in the Western Hemisphere. Its Technical Secretariat is headquartered at the Organization of American States in Washington, D.C. The *Directories* will be publicly available on the World Wide Web and will be fully searchable with hotlinked e-mail addresses and URLs. Include your organization's information in these *Directories* by filling out the on-line form at the URL below or request that the forms be mailed to you. Contact: Faye Anderson, UWIN, e-mail: faye@uwin.siu.edu; FAX 618/453-2671.

http://www.uwin.siu.edu/FORMS/

Water Environment Federation Launches WWW Home Page

Sites accessible from the WEF Home Page include: What's New, WEF Technical Resources, Technical Discussion Groups, Member Networking, regulations and Legislation, WEF Member Programs, Member Association Exchange, Public Information, and Water Environment Research Foundation.

http://www.wef.org

Bureau of Reclamation WWW Sites -- Regional Office and Main Home Pages:

http://www.gp.usbr.gov	Great Plains Regional Office
http://www/lc.usbr.gov	Lower Colorado Regional Office
http://www.mp.usbr.gov	Mid Pacific Regional Office
http://www.pn.usbr.gov	Pacific NW Regional Office
http://www.uc.usbr.gov	Upper Colorado Regional Office
http://www.usbr.gov	Reclamation's main home page

River Systems and Meteorology:

http://donews.do.usbr.gov/Denver/tsc/D8510

Watershed and River System Management Program:

http://donews.do.usbr.gov/Denver/tsc/D8510/warsmp

WATER NEWS DIGEST

THE COLORADO RIVER

Babbitt Says Water Release Successful

Interior Secretary Bruce Babbitt says preliminary results show that release of water from Glen Canyon dam has worked so well that the government may try it elsewhere on the Colorado River. Babbitt said the artificial flood increased the sand beaches in the canyon by as much as 30 percent. The release was designed to stir up enough sediment to add another 3 feet of sand to some canyon beaches. The dam now traps about 90 percent of the sand that would rebuild beaches, according to a Bureau of Reclamation scientist. The flood also created new habitat for rare fish and plants found in the canyon. But questions remain over the cost and whether such actions in the future will reduce water supplies to Colorado and the other states in the upper basin of the Colorado River -- Wyoming, Utah and New Mexico. Colorado water users also worry that releases will drain off stored water that upper basin states may need in the event of a drought.

Optimistic about the results, Babbitt has suggested that the experiment could serve as a model for ecosystem restoration that may be used in the Florida Everglades, California's Central Valley, the Pacific Northwest, the Midwest's Platte River, and the Mississippi River Delta.

Denver Post Washington Bureau, 4/12/96, *Western States Water*, May 3, 1996

Rising Colorado River waters caught some rafters by surprise, arriving sooner than they expected and chasing them off their sandbar perch in Havasu Canyon. A commercial river guide who floated through the canyon a few days later said the river dropped too quickly, to the detriment of beach rebuilding. The guide said as they floated through, his groups rated the beaches either as net gains or net losses. He noted that scientists may determine that they dropped the water too quickly, leaving many of the new beaches too saturated and much more susceptible to erosion. But science aside, he described the ride "like winning the lottery."

Grand Junction Daily Sentinel, 4/25/96

THE ARKANSAS RIVER

Judge Upholds Pumping Restrictions

On May 1 a state water judge upheld pumping restrictions on farm wells in the Arkansas River Basin issued by State Engineer Hal Simpson to help pay back Kansas for water that Colorado illegally diverted for 40 years. In a 25-page decree, Division 3 Water Court Judge John Anderson ruled that the restrictions are necessary to fix long-running depletions in the river basin's groundwater system. About 2,800 Colorado wells are subject to the new rules.

Denver Post, 5/1/96

Westcliffe Family Gets Three-Year Reprieve

During the last day of the trial presided over by Judge Anderson, a Westcliffe family and state attorneys signed an agreement that would exempt the family's well from replacement requirements for three years, giving the family time to find replacement water. The family argued they haven't found any water to buy to replace what their well might take from downstream irrigation ditches. The agreement calls for the State Engineer's office to help find a place to build a small pond so the family can exchange water, store it and then release it when their well is taking water from the Texas Creek system. State Engineer Hal Simpson said he made the sole agreement because the Proctors went through the court process.

Pueblo Chieftain, 4/19/96

THE RIO GRANDE RIVER

Colorado/Texas Have Differing Views on Unused Water

Colorado water engineers claim a water district in booming El Paso has allowed about 3.58 billion gallons of irrigation water to run unused through the Rio Grande Project, a fertile farm belt that straddles the river from southern New Mexico through El Paso and down part of the Texas-Mexico border. The engineers suggested that the water may have been deliberately allowed to run unused so the project's Elephant Butte Reservoir in New Mexico wouldn't spill. There is dispute about whether a legal spill would have occurred, since 25,000 acre-feet of the reservoir's waters are flood-control storage, not irrigation storage.

The Rio Grande Project is a system of reservoirs, canals, ditches and flumes that waters about 150,000 acres of cropland in New Mexico and Texas. While it was built for agriculture, an increasing share of its water has shifted to domestic use as metropolitan El Paso has grown. The concern in Colorado is that Elephant Butte might never spill again. The theory is that urban requirements for steady, year-round flows downstream could flatten the seasonal highs and lows that allow the reservoir to fill and spill in years of abundant snowmelt from southern Colorado mountains.

Southern Colorado's snowpack is only 60 percent of normal this year, according to the division water engineer in Alamosa. That could mean severe shortages if Colorado were still required to send water downriver when an Elephant Butte spill would have canceled that obligation. When Elephant Butte is full, said the engineer, Texas has about a four-year guaranteed water supply.

A resolution by Hal Simpson, Colorado State Engineer, would declare an official spill as of Feb. 19 because "substantial" quantities of Elephant Butte water were sent "unused" downstream. A second proposal would study changing water use on the Rio Grande. That would protect farm water rights while allowing domestic use, given the rising demand in El Paso, Albuquerque and Las Cruces.

The controversy came on the eve of the 57th annual meeting of the Rio Grande Compact Commission, which allocates the river's waters among Colorado, New Mexico and Texas according to the 1938 compact. At the meeting, Texas' member of the three-state commission voted against Colorado's bid to declare that Elephant Butte Reservoir had officially "spilled," and the vote failed. USBR representatives told the commission it was still studying Colorado's complaint and hadn't concluded whether a spill would have occurred.

Denver Post, 4/14/96 and 4/18/96

♦ ♦ ♦

THE SOUTH PLATTE RIVER

South Platte Flow Through Denver Increased

Denver officials have negotiated a deal that would keep 150 cubic feet of water per second flowing through the metro area along more than 20 miles of the South Platte River from May to September. The deal involves the Farmers Reservoir and Irrigation Company, which brings water to farmers northeast of Denver as well as some suburbs. FRICO would let Denver keep the water the company now claims from the Platte in winter months. Denver will store that water at its own reservoirs to replace the summer releases. The deal basically involves exchanging water, not paying money. It is the first of many new water exchanges metro area water managers are considering. Ken Salazar, former head of the Colorado Department of Natural Resources, has worked with Denver on this project.

The guaranteed flow of 150 cfs also is expected to attract wildlife. A report to Mayor Wellington Web from Chips Barry, Head of Denver's Water Department, says that 17 species of fish-eating birds, song birds and deer could live along the river. The report was the product of a task force that has worked on the issue since late 1994.

Denver Post, 5/2/96

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FEDERAL WATER RIGHTS

Allard Proposes Greeley/Forest Service Land Swap

U.S. Rep. Wayne Allard has introduced a bill in Congress that calls for the Forest Service to trade eight mountain reservoirs for Greeley-owned land near two designated wilderness areas west of Fort Collins. The legislation would end a year-long battle that began when the Forest Service required the cities of Greeley and Fort Collins to release more water from their reservoirs before it would reauthorize the cities' easements. Greeley's Mayor called the proposed land exchange "an extraordinary opportunity; however, a Forest Service concern is that Greeley would not be required to meet Endangered Species Act requirements concerning the amount of water it must release downstream. An Allard spokesman said the bill would assure increased flows to help wildlife.

Fort Collins Coloradoan, 5/29/96

Overland Ditch Sues Forest Service

Overland Ditch and Reservoir Co. has filed suit against the U.S. Forest Service. The lawsuit is not a direct challenge to the Forest Service demand that Overland bypass 2 cubic feet per second from its ditch into Cow Creek, which adds up to one-quarter of Overland's reservoir storage right. Instead, the case tackles the issue of whether a 1985 easement the Forest Service issued to Overland nullified two previous Forest Service easements for the water project issued in 1905 and 1920. Those easements made no mention of bypass flows. The 1985 easement, negotiated when Overland needed to repair and enlarge its reservoir, required Overland to make the bypass to revive the fishery in Cow Creek.

Grand Junction Daily Sentinel, 4/18/96

♦ ♦ ♦

RECREATION

Whirling Disease Found at Bellvue Hatchery

Up to 800,000 young trout will not be stocked in some popular high mountain lakes west of Fort Collins and on the Western Slope because the hatchery where the fish were grown has tested positive for the parasite that causes whirling disease. Bellvue Hatchery was certified as clean by the Division of Wildlife in April. However, it is believed the parasite was spread to the hatchery's settling ponds by herons and other birds that fed on infected fish. The stocking restriction will affect the following: East Delaney Lake, South Delaney Lake, North Michigan Reservoir, Big Creek Lakes, North Platte River and all high mountain lakes. Unaffected are: Poudre River, Dowdy Lake, Bellaire Lake, West Lake, Lake John and Cowdrey Lake. Bellvue is the ninth of 16 DOW hatcheries to test positive for whirling disease.

Fort Collins Coloradoan, 6/5/96

♦ ♦ ♦

WILDLIFE/ENDANGERED SPECIES

In 1995 Congress enacted a moratorium on new endangered species listings and refused to lift the ban when it passed the appropriation bill in April 1996. A number of so-called environmental "riders" were the focus of intense controversy during negotiation between the White House and Congress. When Congress finally did pass the bill,, however, it gave President Clinton authority to lift the ban, which he exercised quickly. This enabled the Fish and Wildlife Service to proceed with work on listing new endangered species. The Interior Department now has 425 species under consideration for protection under the Act. Of the 243 closest to a final decision, according to the FWS, 162 face imminent or high magnitude of threat. Most decisions are not expected until after the summer, except in emergency cases. Meanwhile, the new FWS approach includes greater consultation with states and stakeholders to develop protection programs.

Western States Water, 5/17/96

AMERICAN RIVERS NAMES MOST ENDANGERED/THREATENED RIVERS

Two Colorado Rivers on American Rivers List

American Rivers released its 1996 List of Most Endangered Rivers in mid-April, and two Colorado Rivers made the list -- The Animas River, among the ten most endangered, and La Poudre Pass Creek in Rocky Mountain National Park, a "threatened" river. AR says the Animas River could be "dewatered" by the massive Animas-la Plata water project, and the diversion of water from La Poudre Pass Creek, mainly for irrigation, "completely obliterates" the aquatic habitat in several sectors of the river bed. Atop the group's list was once again the Yellowstone River, where developers hope to build a giant gold mine. Other rivers named in the top ten included the Missouri River, New York's Upper Hudson, Maine's Penobscot, the Northwest's Columbia, and the Upper Chattahoochee and Etowah Rivers in Georgia.

Fort Collins Coloradoan, 4/18/96

WATER QUALITY

NPS Guidance Document Released

The U.S. Environmental Protection Agency has released final national guidance on nonpoint source (NPS) pollution management programs. The new guidance significantly reduces federally-imposed administrative requirements. It reduces state reporting responsibilities and speeds up grant schedules. It drops targets for groundwater, watershed resource restoration projects and national monitoring projects established under prior NPS guidance. States will have maximum flexibility to apply Section 310 funds for these purposes. States can also devote a portion of their Section 319 grants to carry out specific NPS-related assessments and to revise and strengthen NPS management programs. An allocation formula will replace the competitive approach used to allocate Section 319 funds.

Beginning in late FY1996 and continuing in FY1997, states will be encouraged to review their NPS programs and revise them as needed to achieve nine key program elements:

- explicit goals and strategies to protect surface and groundwater;
- strong partnerships among governments and private entities;
- a balance between statewide NPS programs and targeted programs for impaired and threatened watersheds;
- a program to abate known NPS impairment and prevent significant NPS threats;
- identification of waters and watersheds impaired or threatened by NPS pollution and programs to progressively address them;
- state review, upgrade and implementation of all Section 319 program components and establishment of flexible, targeted, iterative approaches to achieve and maintain beneficial uses of water as expeditiously as practicable;
- identification of federal lands and objectives inconsistently managed with state program objectives;
- efficient and effective management and implementation of state NPS programs, including financial management needed; and
- feedback loops for states to review, evaluate and revise the NPS assessment and management program at least every 5 years.

For more information contact GeoffreyGrubbs, EPA (4503-F), Washington, D.C. 20460, FAX 202/260-7024.

Western States Water, 5/24/96

Satellites Used to Inventory Wetlands

New technology once available only to the nation's intelligence community is helping Alaska and California biologists inventory wetlands and target vulnerable areas for protection. Alaska holds more than 60 percent of the nation's wetlands. Unlike California, which has lost an estimated 96 percent of its historic wetlands, Alaska has lost perhaps one percent of its 170 million acres. Studies had been limited to ground surveys and photos from Aircraft and some lower-resolution civilian satellites. The new satellite images paint a vivid picture of where wetlands have disappeared, where they remain but are threatened, and where they have been restored. Seventeen pilot projects have used the new high-resolution images in Alaska in the past year.

Fort Collins Coloradoan, 4/3/96

WATER DEVELOPMENT AND GROWTH

Agreement Negotiated on Lowry Water

The state has renegotiated an agreement concerning rights to billions of gallons of water beneath the former Lowry Bombing Range. The agreement revises a lease under which the state land board had given two entities -- the Rangeview Metropolitan District and Pure Cycle Corp. -- rights to sell the water. Two years ago, when questions were raised about the validity of the lease, Rangeview and Pure Cycle filed a lawsuit in Denver District Court asking the court to validate the lease. Money received from the sale of water will go to a trust fund for elementary and secondary schools.

Denver Post, 4/11/96

Pipeline for Douglas County?

A consultant for the county's major water districts is recommending the districts join together to construct a water pipeline system to bring South Platte River water to the county, ending dependence on underground aquifers. The county has a population of 100,000 and a 12 percent growth rate. Water would be reserved in two reservoirs -- one in the southern portion of Highlands Ranch and the other in Parker. The next step will be a comprehensive study on how to finance the project.

Denver Post, 5/15/96

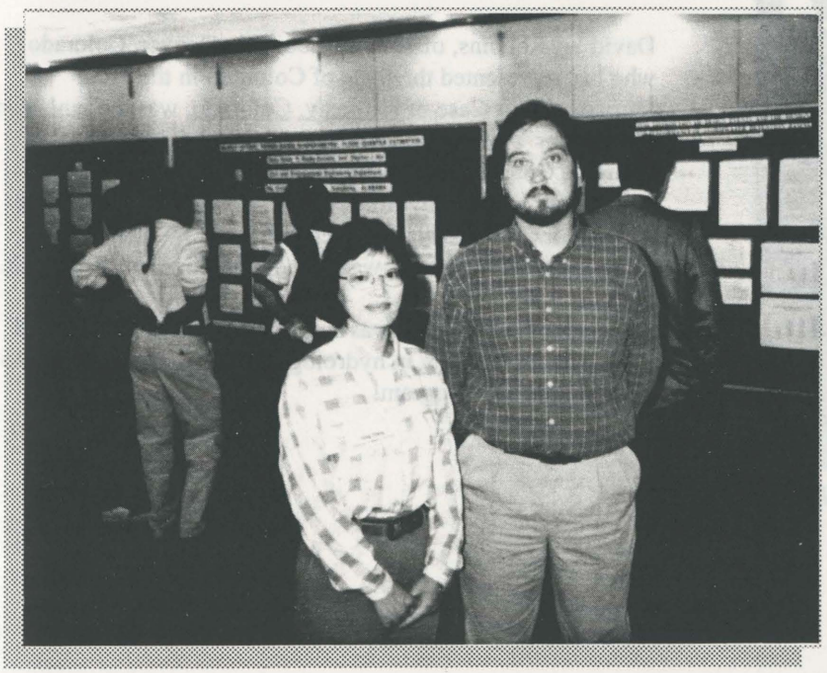
16TH ANNUAL HYDROLOGY DAYS

by Cindy Brady

Once again the American Geophysical Union held its annual hydrology Days at Colorado State University, on April 15-18, 1996. This year's Hydrology Days was dedicated to Dr. Everett Richardson for his contributions to fluvial hydraulics and sediment transport; to Dr. Hsieh Wen Shen for his contributions to erosion, sedimentation and waterway management, including ecological restoration of wetlands; and to Dr. Daryl B. Simons for his contributions to river mechanics, sediment transport and hydraulic modeling. Drs. Richardson, Shen, and Simons are professors emeritus in the Civil Engineering Department at Colorado Sate University.

From left: H. W. Shen, H.J. Morel-Seytoux, Daryl Simons, Everett Richardson

Hydrology Days gives professionals, students, and academics in the field of hydrology an opportunity to share ideas and findings. The conference consists of both student and professional papers and posters.



Award winners Hong Zang, University of Western Australia, and Dennis H. Cumbie, University of Tennessee

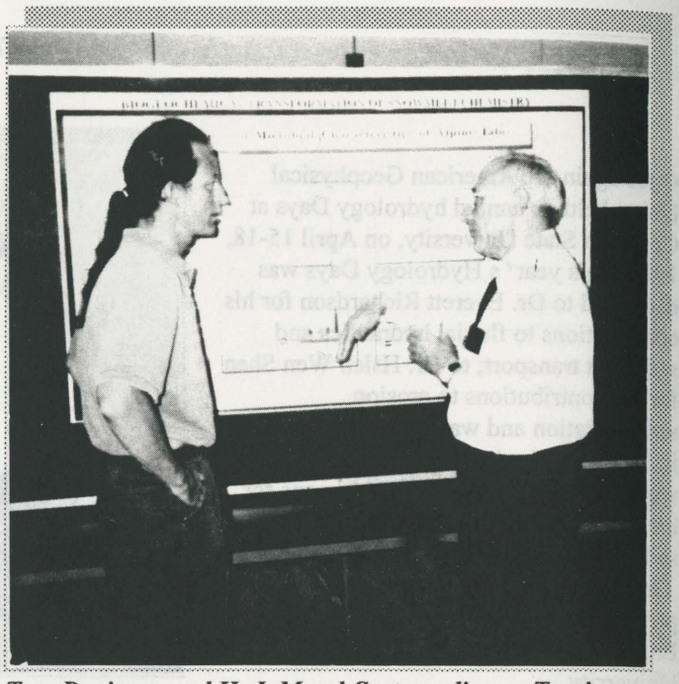
Students in both M.S. and Ph. D. programs presented their papers on the first day. Topics included modeling, transport, evapotranspiration, channel morphology and well pumping. Awards were presented to the best presentation in each category. Dennis H. Cumbie, of the University of Tennessee, received the award for best M.S. paper,. His paper was titled "Laboratory Scale Investigations of Colloidal Transport in Fractured Shale Saprolite using Fluorescent Latex Microspheres as Tracers." For best Ph. D. presentation, Hong Zang, University of Western Australia, Nedlands, Perk, won with her paper titled "A Fluid Response in the Vicinity of a Recovery Well Pumped at a High Flow Rate."

The professional and academic presentations started the next morning. Topics covered in this session included research opportunities, flooding, Colorado water in 1995, and climate fluctuations. The luncheon speaker was Kevin Bestgen, Ph.D candidate and Research Associate, Larval Fish Laboratory, at Colorado State University. His presentation dealt with the relationship between streamflow and the behavior of endangered species, mainly in the upper Colorado River Basin.

Student and professional posters were on display after the luncheon, with topics that included afforestation, stormwater, flooding, erosion, transmountain diversions, water quality, modeling, infiltration, groundwater quality, water supply, water storage, and sedimentation.

Two student awards were given for the best student posters. In the M.S. category, Andrew Wilcox, of the University of California at Berkeley, won with his poster, "A Hydrologic and Geomorphic Impacts of Transmountain Water Diversions with Reference to the Proposed Union Park project, Gunnison County, Colorado."

Because twice as many posters were presented in the Ph. D. category, two awards were given: one for surface hydrology and the other for subsurface hydrology. Changi Sun of Utah State won for best surface hydrology poster, "The Potential of Using Artificial Neural Network in Estimation of Snow Water Equivalent from SSMI/I Data." The award in the subsurface hydrology category went to CSU student Judy Billica for her poster, "Investigation of Two-Phase Flow in Porous Media Using a Total Velocity-Based Numerical Model."



Tom Davinroy and H. J. Morel-Seytoux discuss Tom's poster paper

Glen Stout and Steven Johnson discuss Steve's poster paper

Wednesday and Thursday professional and academic presentations continued. The topics included hydraulics and ecology, hydrologic measurement and modeling on heterogeneous watersheds, subsurface hydrology, and general hydrology.

David W. Robbins, of Hill & Robbins in Denver, Colorado who has represented the State of Colorado in the U.S. Supreme Court Case of Kansas v. Colorado, was the luncheon speaker for Wednesday. His talk, "What did the U.S. Supreme Court Decide in the Kansas v. Colorado Case," showed the role that hydrology plays in the legal battle over water. Mr. Robbins also pointed out that how water users affect stream flow makes watershed modeling more difficult.

A wealth of information was shared by students, faculty and professionals working in hydrology. Don't miss next year's Hydrology Days Program!

MEETINGS

BRINGING THE RIVER BACK ... TO THE FUTURE: URBAN AND RURAL WATERSHED MANAGEMENT

The 7th Annual South Platte Forum

October 29-30, 1996 -- Denver, Colorado

People view rivers with different visions. A fisherman visualizes a vicious strike while the tourist sees a shady picnic or a cool swim. The hydrologist sees hydraulic control where the boater pictures riding the perfect wave. A farmer envisions the blood of a healthy and productive field, while an engineer considers stormwater quality, flood hazard and pier scour. Being many things to many people has not come easy for our nation's rivers, and a toll has been taken as natural processes occurring in and around rivers have been altered to accommodate human use. Recently, people have taken notice, and resources have been brought to bear to restore what we've damaged, and to preserve what's left. But physical, social, economic, and political constraints make restoration to pristine, pre-settlement conditions impractical or impossible. So where do we go? How do we get there?

The **7th Annual South Platte Forum** will examine the existing and proposed management of waterways within our basin. We will answer the practical questions about planning and development of improvement projects, such as:

- What initiated the project?
- How was it funded?
- Have public goals been met?
- Does integrated resource management really work?

Your participation in this year's Forum will help focus the collective vision defining the future for the South Platte Basin. Specific topics to be presented at the one and one-half day conference include:

- Restoration, preservation and enhancement project planning, development, and funding, including the role of Great Outdoors Colorado (GOCO);
- Integrating multiple objectives: specifically, the compatibility of wildlife habitat, recreation, aesthetics, source and non-point source pollution prevention, and flood control;
- Criteria for success;
- Monitoring and adaptive management;
- Defining "the future" for South Platte Basin rivers and water bodies.

There will be an informal social hour following the first day of presentations. A field trip to Denver's South Platte urban corridor the following afternoon will allow participants the opportunity to see project implementation while it happens.

Confirmed speakers include:

Denver Mayor Wellington Webb and
Mr. Ken Salazar; Parcel, Mauro, Hultin & Spaanstra, P.C.

For information about the conference or exhibit space, call or write:
David Graf, Coordinator
Colorado Water Resources Research Institute
410 University Services Building, CSU
Fort Collins, CO 80523
Phone 970/491/6308 FAX 970/491.2293

INSTREAM FLOWS: MINIMUM DOCTRINE/MAXIMUM CONTROVERSY
21ST ANNUAL COLORADO WATER WORKSHOP
August 7-9, 1996
Western State College, Gunnison Colorado

Ever wonder how developers, environmentalists, recreationists, politicians, ranchers, farmers, endangered species, aquatic plant life and hydroelectric power plants all get the water they need from a river? Who governs, enforces and creates new policies for those interests? How do other states with similar resources answer those questions? Your chance to stop wondering comes on August 7-9, 1996 at the **21st annual Colorado Water Workshop** at Western State College in Gunnison. **Instream Flows: Minimum Doctrine/Maximum Controversy** is the title for the provocative program, where almost 300 water constituents from all walks of water life gather to debate, discuss and deliberate water issues. Highlights of the program include:

- History of prior appropriation as it relates to instream flows from recently appointed Supreme Court Justice Greg Hobbs;
- Legislative updates and discussions of what they mean to the general public, including an update on Senator hank Brown's bypass flow amendment to the Farm Bill from former Colorado Attorney General Duane Woodard;
- Presentations from instream flow coordinators from Idaho, Montana, Nebraska, Oregon and New Mexico and the coordinator of a recent national instream flow conference series: Christopher Estes from Alaska;
- Discussions of recent agreements and proposed plans for the Arkansas, Colorado, Yampa and South Platte Rivers;
- A chance to voice your opinion in professionally moderated breakout groups to identify and provide solutions to the most pressing instream flow questions.

Not only will the program provide a wonderful opportunity to learn more about one of this year's most contentious topics, it is a chance to visit gorgeous Gunnison County in the summer (the Mecca of thousands of recreational fun seekers). A limited number of scholarships are available to assist with the $220 registration fee. Application can be made by writing a short biography and the reasons for requesting the scholarship addressed to: Colorado Water Workshop, c/o Pam Ayers, Quigley hall 101F, Western State College, Gunnison, CO 81230.

For further details about the conference, call 970/943-7156 or e-mail payers@western.edu.

UCOWR '96
INTEGRATED MANAGEMENT OF SURFACE AND GROUND WATER
July 30-August 2, 1996, San Antonio, Texas

The conference theme will cover many topics related to:

- Legal and institutional impediments to integrated use and management
- Incorporation of groundwater into watershed management plans
- Risk assessment for surface and groundwater systems
- Water marketing
- Preservation of biological diversity
- Artificial recharge
- Water quality impacts of integrated use
- Conflict resolution in an integrated use setting.

Additional events will include a Risk Management Workshop conducted by Dr. Yacov Y. Haimes, the Lawrence R. Quarles Professor of Systems Engineering and Civil Engineering, School of Engineering and Applied Science, and Director, Center for Risk Management of Engineering Systems, University of Virginia, Charlottesville, VA; and a technical tour of the Edwards Aquifer region. For further information contact: **Camille Hedden, UCOWR Director's Office, Faner Hall, Room 4543, Southern Illinois University, Carbondale, IL 62901-4526, Phone 618/536-7571, FAX 618/415-2671, or E-mail hedden@uwin.siu.edu.**

CALLS FOR PAPERS

ROCKY MOUNTAIN HYDROLOGIC RESEARCH CENTER
51ST ANNUAL MEETING
THEME: ECOLOGICAL ISSUES IN MOUNTAIN WATERSHEDS

The meeting will encourage interdisciplinary communication among a variety of professionals representing hydrology, engineering, environmental science, and other related issues in the Rocky Mountain Region. There will also be a tour of the research facility, the Rocky Mountain Hydraulic Lab along the North St. Vrain Creek. Topics for the meeting:

- Watershed and River Basin Management
- Rainfall and Snowmelt Runoff in Mountain Watersheds
- Hydraulics, Sediment Transport and Geomorphology of Mountain Streams
- Climate, Climate Change and Weather Modification in the Western United States
- Hydrologic and Engineering Field Methods at Remote and Mountain Sites
- Paleohydrology and Paleoclimatology
- Ecologic Measurements and Methods
- Water Rights and Water Supply
- Watersheds and Wetlands
- Water Resources and Environmental Policy
- Other Topics of Hydrologic, Engineering, Ecological or Environmental Interest

Submit abstracts of no more than one page in length by June 30, 1996 to: **Donald K. Frevert, Mail Code D-8510, Technical Service Center, Bureau of Reclamation, PO Box 2007, Denver, CO 80225.** Presentations will generally be scheduled at 20 to 25-minute intervals with open discussion. A volume of abstracts will be provided to all persons registered for the meeting. Registration is expected to be no more than $25.

For information contact Donald K. Frevert, Phone 303/236-0123, extension 225, FAX 303/236-0199 or E-mail dfrevert@do.usbr.gov.; or Marshall Flug, Phone 970/226-9391, FAX 970/226-9230, or E-mail Marshall_Flug@NBS.GOV.

COMPETING INTERESTS IN WATER RESOURCES -- SEARCHING FOR CONSENSUS
December 5-7, 1996, Las Vegas, NV

The conference will include sessions on four major topics: **Environmental Needs; Demand Management; Water Marketing and Water Transfers, and Social and Economic Impacts**. Papers should address one or more of the four major topics, reflecting the current views of water interests representing urban, rural, agricultural, environmental, social, legal, political, tribal, national or international perspectives. The conference will include a poster session where additional papers will be presented. To obtain an abstract form contact U.S. Committee on Irrigation and Drainage(USCID), 1616 Seventeenth St., Suite 483, Denver, CO 80202; Phone 303/628-5430, FAX 303/628-5431, or E-mail stephens@uscid.org.
Deadline: July 12, 1996.

The USCID web address is: **http://www.uscid.org**

ASCE WATERPOWER'97
August 5-8, 1997, Atlanta, GA

The conference, Hydropower: New Challenges, Opportunities and Partnerships, it will feature plenary and concurrent session presentations and also graphic presentations. To obtain abstract form contact Patricia Dalton, American Society of Civil Engineers (ASCE), Phone 800/548-ASCE or 212/705-7283, FAX 212/705-7975. Deadline: August 5, 1996.

WEFTEC'97
Oct. 18-22, 1997, Chicago, IL

Join water quality and wastewater treatment professionals to learn about the latest developments and to see cutting-edge technology. For abstract format instructions contact: Water Environment Federation, Attn: WEFTEC '97 Program, 601 Wythe Street, Alexandria, VA 22314-1994, Phone 800/666-0206, FAX 703/684-2471, or E-mail confinfo@wef.org.
Deadline: December 16, 1996.

CALENDAR

July 10-13 WHAT WE HAVE LEARNED FROM THE BIG THOMPSON FLOOD -- 20 YEARS LATER, Fort Collins, CO. Contact Eve Gruntfest, University of Colorado-Colorado Springs, P.O. Box 7150, Colorado Springs, CO 80933-7150; (719) 593-3531; fax (719) 593-3019; e-mail: ecg@spring.uccs.edu. Sponsors: Federal Emergency Management Agency and others.

July 14-17 WATERSHED RESTORATION AND MANAGEMENT, Annual AWRA Symposium, Syracuse, NY. Contact: American Water Resources Association, Phone 703/904-1225; FAX 703/904-1228; E-Mail: awrahq@aol.com.

July 21-24 INDUSTRIAL WASTEWATER TREATMENT: MUNICIPAL AND INDUSTRIAL PERSPECTIVES, Indianapolis, IN. Water Environment Federation. Call 1-800/666-0206, Select Option #4 to put your name on mailing list.

July 25-26 HIGH ALTITUDE REVEGETATION SUMMER FIELD TOUR. Contact: Camille Farrell, 970/728-5487; or Gary Thor, 970/491-7296.

Aug. 3-7 PROMOTING WATERSHED STEWARDSHIP, THE FIFTH NATIONAL VOLUNTEER MONITORING CONFERENCE, Madison, WI. Contact: Celeste Moen, Wisconsin DNR, WR2, P.O. Box 7921, Madison, WI 53707; FAX 608/267-2800, e-mail: moenc@dnr.state.wi.us.

Aug. 8-9 3RD ANNUAL ENDANGERED SPECIES ACT CONFERENCE, Denver, CO. Contact: CLE International, 1541 Race St., Suite 100, Denver, CO 80206. Phone 800/873-7130, e-mail cleintl@nilenet.com.

Aug. 17-22 10TH ANNUAL RESIDUALS MANAGEMENT BIOSOLIDS SPECIALTY CONFERENCE, Denver, CO. Water Environment Federation. Call 1-800/666-0206, Select Option #4 to put your name on mailing list.

Sept. 8-11 1996 ANNUAL CONFERENCE, ASSOCIATION OF STATE DAM SAFETY OFFICIALS, Seattle, WA. Contact: ASDSO, 450 Old East Vine St., 2nd Floor, Lexington, KY 40507. Phone 606/247-5140, FAX 606/323-1958.

Sept. 11-14 APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) TO THE SUSTAINABILITY OF RENEWABLE NATURAL RESOURCES, Jackson, WY. Contact: Renewable Natural Resources Foundation, 5430 Grosvenor Lane, Bethesda, MD 20814-2193. Phone 301/493-9101, FAX 301/493-6148, Internet RNRF@AOL.COM.

Sept. 20-21 ECOLOGICAL ISSUES IN MOUNTAIN WATERSHEDS, ROCKY MOUNTAIN HYDROLOGIC RESEARCH CENTER 51ST ANNUAL MEETING, Estes Park, CO. Contact: Marshall Flug, National Biological Service, Phone 970/226-9391, FAX 970/226-9230, Internet Marshall_Flug@NBS.gov OR 970/491-6016 at CSU campus and FAX. Internet: skiflug@lamar.colostate.edu.

Sept. 22-25 RIVERTECH '96, 1st International Conference on New/Emerging Concepts for Rivers, Chicago, IL. Contact: Rivertech '96, IWRA, University of Illinois, FAX 217/333-9561, E-mail: nbarrett@uiuc.edu.

Sept. 22-26 32ND ANNUAL AWRA CONFERENCE AND SYMPOSIUM, Fort Lauderdale, FL. Contact: American Water Resources Association, Phone 703/904-1225, FAX 703/904-1228, E-Mail: awrahq@aol.com.

Octo.29-Nov. 1 THE CLEAN WATER COMPLIANCE INSTITUTE, Breckenridge, CO. Contact: Government Institutes, 4 Research Place, Rockville, 1MD. Phone 301/921-2345, FAX 301/921-0373, E-mail giinfo@aol.com.

Oct. 31-Nov. 2 HYDROGEOLOGY OF THE SAN LUIS VALLEY AND ENVIRONMENTAL ISSUES DOWNSTREAM FROM THE SUMMITVILLE MINE, a field trip in conjunction with the 1996 Geological Society of America Annual Meeting, Denver, CO. For information call Isobel McGowan (303/477-5338), Doug Cain (719/544-7155 X130), Kathleen Smith (303/236-5788) or Alan Davey (719/657-3304).

Nov. 18-20 109TH ANNUAL MEETING, NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND GRANT COLLEGES, San Diego, CA. Contact: NASULGC, One Dupont Circle, NW, Suite 710, Washington, DC 20036-1191. Phone 202/778-0818, FAX 202/296-6456.

Colorado Water Resources Research Institute
410N University Services Center
Colorado State University
Fort Collins, CO 80523

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