ARROYO

Vol. 1 No. 2 Summer 1987

Water quality, a complex issue

"Pure and simple" is an expression that does not fit when water quality is the topic. To assure the delivery of good quality, pure water is not a simple matter at all, as water quality managers well know.

Water quality managers confront a complex array of issues that defy simple solutions—rapidly changing conditions of water use, water chemistry, water standards, and social calculations of risks and benefits. And these issues are further complicated when a new source of water arrives. For example, water quality managers and decision makers in southern Arizona must decide how to manage Colorado River water flowing to their towns and cities through the canals of the Central Arizona Project. The new source must be integrated into the on going management process so that consumers continue to receive water of acceptable quality at reasonable cost.

Presently a variety of options exists for maintaining or enhancing the quality of water supplies. A water manager may decide on conventional and advanced, in-plant water treatment; artificial recharge; mixing or blending various water supplies; matching water supplies of various qualities to appropriate uses; and others. The water quality manager must evaluate this array of options and select the technique (or to make matters more complicated, combination of techniques) most fitting for his or her situation.

And there is more. The water quality manager has numerous criteria to consider when assessing the suitability of water quality management approaches. First, the selected approach must be effective; that is, it must be capable of producing finished water of adequate quality for its intended uses. Second, the method must be reliable and yield water of adequate quality on a consistent basis. Third, the selected method must be economically efficient. Fourth, any water quality management alternative must be compatible with environmental, institutional, legal and political constraints. Finally, the approach must be flexible enough to accommodate changing conditions.

The last criterion mentioned above—a flexible approach to accommodate change—is a key consideration for water managers. Water quality decisions are made in an environment of changing and expanding information. For example, the quality of water is constantly changing. Some changes are small and transient; others represent long-term trends affecting the quality of a particular supply. Short-term fluctuations in well-known water constituents usually can be handled through competent monitoring and temporary adjustments in the management process. Some water quality changes, however, represent new or quite different issues for managers. The identification of novel contaminants, or rapid increases in water pollution levels, might require the selection of quite different management approaches than those employed in the past. Water quality managers must be prepared for both types of changes in water quality.

In addition, new information about the effects (human health, environmental, or economic) of even familiar water constituents may pose new challenges to water decision makers. Also, societal interpretations of water quality information may change. For example, public opinion may become less tolerant of a certain type of water-related risk that was previously accepted. Frequently such new information (or new interpretations) is translated into new standards and regulations for water quality, and management approaches must be able to adapt to such changing conditions.

One last point for the water manager to consider is that the mix of intended water uses is also subject to change over time. A good example is the intended use

of CAP water. Originally conceived as a project to preserve irrigated agriculture in portions of Arizona, CAP is now primarily intended to provide water for municipal and industrial purposes. Clearly the water quality requirements for municipal (including drinking water) uses are substantially different than those for irrigated agriculture. Again, flexibility is a key to a successful management program.

Confronted by options and criteria, the water manager cannot even count on secure, definitive information to guide his or her choices. Complete information is rarely available. The selection of management alternatives, therefore, inevitably will occur with substantial uncertainty. Some types of uncertainty can be clarified by additional research. Managers, however, will often be confronted by decisions for which additional research will be unable to provide guidance. In these cases the policy process must be relied upon to make the necessary trade-offs.

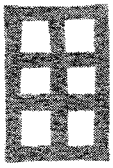
This issue of *Arroyo* examines several facets of water quality management, particularly in the context of the arrival of CAP water. The wide variety of concerns provides a glimpse of the complexity of this vital water management activity. ▼

INVITED COMMENT

EPA Proposes Water-Quality Standards

Charles Gerba, professor of microbiology and immunology, and nutrition and food science at the University of Arizona, provided the Invited Comment *for this issue.*

The Safe Drinking Water Act, which was passed last year by Congress, requires that the Environmental Protection Agency issue permanent standards for 83 drinking-water contaminants. In response to this legislation, EPA recently issued a ruling about surface water treatment for the control of *Giardia* and viruses.



Sign for water in early chemistry

I am a member of the EPA science advisory board which meets every two months to review EPA research programs and pending regulations affecting drinking water. Recently we reviewed the surface-water-treatment ruling which will be published in the Federal Register in September. At that time comments will be invited.

EPA's draft ruling requires that utilities filter and disinfect when treating surface waters. Disinfection is interpreted to assure 99.9 percent inactivation of *Giardia lamblia* cysts and 99.99 percent inactivation of enteric viruses. Both filtration and disinfection are required because filtration best controls *Giardia* and disinfection best controls viruses.

This ruling will affect utilities in various ways:

- Since half the water suppliers in the country do not now filter and disinfect, compliance will result in added costs. New construction costs for utilities are estimated to be between $2 and $6 billion.

- The new requirements will encourage utilities to increase the amount of chlorine used in the disinfection process. This, in turn, may increase trihalomethanes in drinking water. If more chlorine is not added, the size of the contact chamber will have to be increased. This would be difficult and expensive since many utilities may not have the necessary land to increase the contact chamber.

- The reluctance to rely on traditional disinfection methods that use chlorine will encourage some water suppliers to try alternative disinfectants such as ozone.

- If utility companies use any innovative technology or any technology other than the standard treatment train of filtration and disinfection, they would have to demonstrate to EPA through pilot plant studies, literature or documentation that the required removal was achieved.

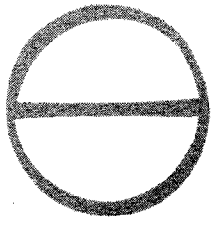
- Water suppliers may have to perform better and more frequent monitoring of their turbidity, coliforms and total bacterial numbers.

These rulings will undoubtedly influence decisions on how CAP water is to be treated because the new requirements will have to be considered as CAP treatment methods and facilities are planned.

Other pending water quality regulations will also affect CAP water treatment. Groundwater regulations are being developed but will not be finalized until 1991. Arizona water quality planners have to start thinking about what this ruling will involve because these groundwater regulations will affect recharged CAP water treatment. The regulations will probably require mandatory disinfection but with variances allowed. This would indicate that even if CAP water is recharged, it would still have to be disinfected upon recovery.

If a variance were allowed, disinfection may not be required. Variances, however, would depend on such factors as 1) the availability of a pristine source of water; 2) the absence of septic tanks in the area; and 3) the absence of any waterborne outbreaks in the system.

Many water utilities are beginning to plan now to assure they will meet the evolving water treatment regulations. ▼



Medieval sign for water, one of the four elements

Water Resources Research Conference Set for Oct. 23

The theme of the Water Resources Research Center's second annual conference is *University Water Research in Arizona: What Have We Learned? Where Are We Going?* The conference is to be conducted at the Francisco Grande Resort in Casa Grande on Friday, October 23 from 8 a.m. to 4 p.m.

Morning panels will discuss equity and efficiency in water allocation; CAP and water quality; and effluent reuse. Each panel will consist of a speaker who will review research from a topical area, followed by two research users who will comment on the research. The afternoon panel will discuss the university research process. The need for basic and applied research, the proper role of the universities vis-a-vis other water research organizations; and the improvement of the research process to meet the needs of water managers and planners are among the topics to be discussed.

A poster session is also planned for researchers to present the results of their work.

The registration fee is $25 before Oct. 6 and $30 after Oct. 6, with a special student registration fee of $15. The registration fee covers lunch.

For additional information contact: Mary G. Wallace, Water Resources Research Center, University of Arizona, Geology 318, Tucson, AZ 85721 (602) 621-1648.

LEGISLATIVE NEWS

Water quality is not easily managed. For example, water managers with plans to develop a water quality strategy for Central Arizona Project water must contend with economic, engineering and environmental factors as well as a thicket of institutional and legal issues.

The legal concerns have to do with laws at various levels. Two federal laws have special authority in the matter of water quality: the Safe Drinking Water Act, amended in 1986, and the 1977 Clean Water Act. Water managers must also check on state legal requirements. For example, Arizona's Environmental Quality Act, whose passage coincided with the arrival of CAP water in Arizona, covers a broad area of water quality considerations.

In addition to the laws and regulations which affect water quality directly, various legal constraints influence the selection, design, construction and operation of any facility or activity to manage water quality, whether a treatment plant or recharge facility. These constraints are the result of legislation at federal, state and local levels. Policy makers working to identify CAP water qualitiy management options must be aware of the requirements of each of the following:

Federal Legislation

National Environmental Policy Act; Clean Water Act; Safe Drinking Water Act; Resource Conservation and Recovery Act; Toxic Substance Control Act; Insecticide, Fungicide, Rodenticide Act; Clean Air Act; National Historic Preservation Act; Wild and Scenic Rivers Act; Fish and Wildlife Coordination Act; Endangered Species Act; Executive Order 11988 (floodplain management considerations); Executive Order 11990 (wetlands protection)

Arizona Legislation

Environmental Quality Act; Groundwater Management Act; Recharge and Underground Storage and Recovery Act; Arizona Native Plant Law; Dry Well Regulations (HB2229)

Local Ordinances and Requirements

Floodplain use permits; zoning ordinances; county pretreatment ordinance (for disposal of hazardous ingredients in used water); Pima County ordinance on secondary standards.

Many of the above laws and regulations outline specific permit processes and requirements that must be consulted to manage CAP water quality. Therefore, they determine the nature and type of activities that may take place. Activities must be reviewed on a case-by-case basis to determine which laws, regulations, and permit processes apply.

Obvious questions arise: What problems may result from the existence of a multitude of rules and regulations? How will they affect the development of a water quality management plan?

A major concern is that as various agencies or bodies issue regulations, rules coming from one source may conflict with rules from another. For example, if a city were to apply for permits under the Recharge and Underground Storage and Recovery Act and the Environmental Quality Act to operate a recharge project involving effluent, applications would have to be submitted to the Department of Water Resources and the Department of Environmental Quality. DWR, concerned with conservation, might want a percentage of the water left in the aquifer to contribute to its replenishment. DEQ, on the other hand, is concerned about the quality of the treated effluent in the aquifer and might want over 100 percent of the recharged water pumped out to assure that all possible impurities were removed.

Conflicts may also develop between agencies at different levels of government. Pima County's Board of Supervisors recently enacted secondary drinking water standards for sulfate levels that are more stringent than state or federal standards. This action, which is being contested, may severely limit CAP water use in Pima County since the water would not meet the newly established local standards.

The CAP project involves water managers with new situations to work out. Solutions—some untested and untried—will have to be attempted within the context of various laws and regulations. Undoubtedly some details will have to be settled. ▼

RESEARCH NEWS

Each issue of Arroyo *presents brief descriptions of water research projects relevant to Arizona. This issue provides a summary of Tucson Water's* Recharge Feasibility Assessment *study. A unique and comprehensive effort, the* Recharge Feasibility Assessment *program thoroughly evaluates the feasibility of conducting groundwater recharge activities within the Tucson Active Management Area.*

The project staff gathered and organized a vast quantity of information that is available to researchers, government agencies, consultants, etc.

The study will be implemented in three phases. Phase A consists of a technical and institutional evaluation. Phase B will include the design, construction, and operation of demonstration recharge projects to evaluate variables that would affect Tucson's recharge program. Phase C will involve assessment of alternative plans and develop a comprehensive master plan to recharge water supplies from identified feasible sources.

Phase A, which is in draft-report form, is summarized here and was prepared by CH2M Hill, Inc. in association with Errol L. Montgomery & Associates, Inc. and L.G. Wilson, recharge specialist. Phase A is divided into various tasks.

Recharge Methods Evaluation

The initial task or phase of the study consists of three subtasks: 1) literature review and survey; 2) area survey evaluation; and 3) recharge site visits.

During the literature review and survey, available material on artificial recharge activities was compiled and reviewed to determine relevance to the Tucson area and Tucson Water's goals. After 640 references were examined, a screening process reduced the number of relevant references to 493. To help organize the literature, the material was abstracted and divided into seven categories: 1) case studies; 2) natural resource studies 3) feasibility studies; 4) reviews; 5) technical research studies; 6) health effects studies; and 7) economic studies. Each abstract includes a statement on the relevance of the abstract to Tucson area conditions and to other project tasks. A computerized index was developed for efficient access to author, date of publication, relevance and recharge method.

The purpose of the second subtask was to evaluate the suitability for Tucson conditions of the recharge methods identified during the literature review. The methods identified were: water spreading in shallow basins; water spreading in ditches and canals; spreading in deep basins; and spreading and induced recharge in natural channels, recharge wells, injection wells, and recharge shafts. Each method was examined for specific constraints in the Tucson area, including effects of the available water sources on the operation of spreading areas. The literature review of recharge methods and constraints concluded that known recharge methods could operate with some degree of success in the Tucson area.

The third subtask was to visit operating recharge facilities to provide project staff with a complete background in the implementation of well recharge and spreading methods. Eleven major water agencies were visited during the fall of 1986.

Research of Water Quality Requirements for Recharge

Water quality significantly affects artificial groundwater recharge, regardless of the recharge method. Therefore, a review of the operational experiences of various projects involved with the impacts of water quality on recharge is an important task. The information gathered will help lay the groundwork to plan, design, implement and monitor groundwater recharge projects conducted by the City of Tucson.

Two water-quality concerns that affect the operation of a recharge program are 1) potential reduction in the ability of the soil and rock strata to transfer recharge water to the aquifer and 2) potential degradation of existing groundwater quality.

Artificial recharge, if properly managed, may improve the quality of the recharge water. The water quality requirements prior to recharge, the long-term treatment capabilities of the soil-aquifer system, and ultimately, the acceptability of adding recharged water to a community potable water supply are major health-related issues.

The potential sources for recharge water for the City of Tucson are runoff water, reclaimed water and CAP water. Each is associated with a major water-quality concern. With runoff it is the high suspended solids content of runoff water in surface-water drainages. Reclaimed water in recharge projects raises public health issues, and the recharging of CAP water that has a total dissolved solids content higher than the in situ groundwater will be a major concern if Pima County continues to require that federal secondary drinking water standards be met.

The recharge methods are grouped into two categories: spreading methods and recharge wells. The two most important water quality factors affecting recharge performance using spreading methods have to do with the soil-aquifer matrix and the recharge water. The ongoing performance of recharge wells also depends on the quality of the recharge water.

The report discusses the suitability of each of the potential recharge water sources with respect to water quality standards, degradation of existing groundwater quality, interactions between source waters and the matrix materials of the vadose zone, and the constraints associated with various recharge methods.

Evaluation of Existing Water System and Wells for Recharge of Treated CAP Water

The potential to utilize the existing (and near future) city potable water distribution system and wells for recharge of treated CAP water was evaluated. This task consisted of three principal areas of investigation.

First, the suitability of utilizing existing wells for recharge together with an estimation of probable rates and volumes of recharge was determined. Basic

information on the wells such as location, construction details, annual pumpage, groundwater levels, aquifer test data, and system operational data was obtained from Tucson's computer-based well data system and well files.

Next, the ability of the distribution system to move water toward proposed points of recharge was analyzed with the use of the city's hydraulic model. The model provided an analysis of the 1995 distribution system, and three separate conditions were evaluated—peak, average, and minimum annual demand for the distribution system.

Finally, a review of available literature and project experiences abstracted from a previous task was used to evaluate the retrofitting of existing wells for use as recharge facilities.

A preliminary analysis indicates that, given certain assumptions, the capability exists to recharge available CAP supplies over and above the amounts of water to be served directly. However, many aspects of long-term recharge rates, costs, and efficiencies of recharge wells must be more thoroughly documented to refine the estimates contained in this section of the Recharge Assessment report.

Hydrogeological Evaluation for Recharge Sites

A hydrogeologic investigation of the study area was conducted. The initial work involved an intensive data search and compilation. Tucson Water's files provided substantial relevant information which was supplemented with data from the U.S. Geological Survey, Arizona Department of Water Resources and the Pima Association of Governments. Numerous investigations and reports were also reviewed relating to the geology, groundwater hydrology, water chemistry, surface water hydrology, and infiltration characteristics of stream channels of the area.

This task also included the following activities: evaluation of hydrogeologic characteristics which impact recharge within the study area; assessment of groundwater quality characteristics; development of criteria for recharge potential; estimation of recharge rates and quantities; mapping of aquifer parameters and flow patterns; evaluation of stream channel recharge characteristics; and providing Tucson Water with a ranking of potential recharge sites based on these work products. In addition, recommendations were provided which identified requirements for subsequent investigations.

The principal hydrogeologic units of relevance to this study for recharge potential are the recent alluvium associated with modern streams and washes, the Fort Lowell Formation and the upper Tinaja beds. Transmissivity and permeability computations were made based on selected data. The direction of groundwater movement and altitude of groundwater levels above mean sea level were also developed for the study area.

The entire study area was evaluated for potential recharge through injection wells. Areas were identified where the percent fines in the aquifer to be recharged are small. The areas were also rated for the following: thickness of the unsaturated zone; potentially large aquifer transmissivity; and favorable chemical quality of groundwater.

Evaluation of the chemical quality of the indigenous groundwater involved the construction of approximately 2,700 Stiff diagrams. These were analyzed and used to classify principal water types and basic water quality characteristics.

Based on the hydrogeologic data evaluated, a number of areas have been identifed as potential recharge for long-term storage and recovery of water.

Water Source Evaluations for Recharge Sites

The objective of this task was to evaluate the issue of using various recharge water sources—runoff water, reclaimed water and CAP water—at recharge sites identified in previous Phase A tasks. The location, availability, and quality of recharge water sources are defined. The potential water quality impacts of recharging these water sources are also discussed.

Using available information, the potential for geochemical reactions with the study area was assessed. Equilibrium calculations for mineral saturation levels indicate no anticipated precipitation of mineral species involving dissolved ions in either CAP, recharge water or groundwater. For CAP water, the chemistry will change slightly when recharged and mixed with in-situ groundwater. The only potential problem associated with CAP water would be in areas where Laveen soils exist such as in Avra Valley. In these areas recharge by injection methods should be considered.

The different facilities needed to deliver recharge source water to desired recharge sites are described. The facilities needed for each type of recharge source water are identified. Volume of stored recharge water was incorporated into the analyses together with amount of recoverable groundwater. Relative cost estimates were developed for each site with appropriate source waters which include both capital and operational costs.

A ranking of potential recharge sites that takes into account all technical factors is provided.

Institutional and Regulatory Requirements for Recharge

This task identified regulatory and permitting requirements for recharge projects in the Tucson Active Management Area. Also, institutional impediments to recharge projects were identified and modifications and planning approaches recommended. Institutional constraints are discussed in terms of the federal, state, county, and city legislation affecting the construction, operation, maintenance, and monitoring of an artificial recharge operation.

The study indicates that institutional impediments may be the greatest obstacle to overcome when implementing recharge projects. Concerns such as the following, which can be formidable obstacles to various recharge methods and source waters, must be considered: the balance between chemical water quality of existing groundwater and source waters; the right to recover the recharged waters; the right to collect and divert appropriable surface waters; the possible impact stream channel recharge will have on flooding; and complex permitting and reporting requirements. These constraints on recharge projects must be evaluated and resolved as the City of Tucson moves toward implementing its recharge programs. ▼

RESOURCES AND INFORMATION

Arroyo *features in each issue a resource or source of information of interest to people concerned with water issues. The intent is to inform readers of the varied water-related resources and information sources available to both professionals involved with water projects and to the general public.*

This issue features the publication, Central Arizona Project Water Quality: An Examination of Management Options. *An issue paper published by the Water Resources Research Center, the publication discusses various topics of importance to people involved with managing CAP water quality and will be a helpful resource to them. (See* Publications *section of this newsletter for the publication information on the issue paper.)*

As Central Arizona Project water flows into Arizona, water managers confront an important question: How is CAP water to be managed to assure that it meets the water quality standards applicable to its intended uses? The question is complex since CAP is intended to be used for various municipal, agricultural and industrial purposes.

Central Arizona Project Water Quality: An Examination of Management Options is a valuable resource to assist water managers to wisely choose a suitable water-quality strategy for various CAP water uses. To do this, a water manager must be knowledgeable about the various water-quality management options available. This publication discusses available choices, evaluating the relative advantages and disadvantages, strengths and weaknesses, and costs and benefits of various water-quality management methods.

The report has six objectives: 1) to identify questions to be addressed when evaluating alternative management strategies for Arizona's use of Colorado River water; 2) to answer questions for which previous research and experience provides appropriate guidance; 3) to interpret those answers for policy making and provide an assessment of the necessary trade-offs; 4) to identify areas of remaining uncertainty; 5) to identify areas needing further scientific research to remove uncertainty; and 6) to identify areas where further research will not be productive, and that will require, instead, policy judgments to guide choices.

The following topical areas are addressed: water quality management conditions; water quality constituents; health effects of water constituents; non-health effects of water constituents; water treatment considerations; economic, engineering, and environmental factors; and instituional and legal issues.

The publication reports no new research. Instead, the authors evaluate existing information and evidence, intending to encourage the kind of research that will provide the information needed to understand more fully various policy choices. At the same time, information relevant to water quality management options is identified and reviewed.

The report draws upon a variety of information sources. It looks at the experiences of other Colorado River basin states, particularly California. Published literature was reviewed, and people knowledgeable about relevant issues were consulted. The preparation of the report involved two review panels: one panel made up of university faculty members and other water scientists and the other composed of federal, state and local government representatives, and members of various interest groups.

It is not the intention of the report to provide definitive solutions to particular cases because there is no single, simple answer. The selection of a water quality approach must be based on a careful assessment of a wide variety of factors. Also, the selection of a management alternative is inherently a political rather than an analytic function. As such the selection process belongs in the policy-making arena.

The proper function of a report of this type is to provide on a timely basis the most accurate and complete information possible, and to provide it in a format that is accessible to policy makers.

PUBLICATIONS

Central Arizona Project Water Quality: An Examination of Management Options

by K. James DeCook and Marvin Waterstone

This publication evaluates the relative advantages and disadvantages, strengths and weaknesses, and costs and benefits of various CAP water-quality management methods available to water managers. It is of special use to water managers as they develop a water-quality management approach to prepare CAP water for various uses—municipal, agricultural and industrial.

To purchase this publication write to: Librarian, Water Resources Research Center, Geology 318, University of Arizona, Tucson AZ 85721; (602) 621-1648.

Water and Poverty in the Southwest

by F. Lee Brown and Helen Ingram

This study of the political economy of water use and allocation in the Southwest draws on case studies involving Hispanics of northern New Mexico and Tohono O'odham Indians of southern Arizona to show how the rural poor have been systematically deprived of water rights to the advantage of Anglo-owned ranches, mines and urban centers. The University of Arizona Press, 1615 East Speedway, Tucson, AZ 85719. $19.95 cloth; $12.95 paper.

Proceedings

Hydrology and Water Resources in Arizona and the Southwest

Volume 17 of *Hydrology and Water Resources in Arizona and the Southwest*

includes papers presented at the April 1987 meeting of the Arizona Section—American Water Resources Association and the Hydrology Section—Arizona-Neveda Academy of Science and the Arizona Hydrological Society.

To order this volume and other AWRA publications contact: Ms. Dale Wright, Office of Arid Lands Studies, College of Agriculture, University of Arizona, 845 N. Park Ave., Tucson, AZ 85719. (602) 621-1955. $14.

Government Publications

Hydrogeology of the eastern part of the Salt River Valley area, Maricopa and Pinal Counties

by R. L. Laney and Mary Ellen Hahn
Water-Resources Investigations Report 86-4147

This study, carried out in cooperation with the Arizona Department of Water Resources, determined the location, depth, thickness, and hydrologic properties of the water-bearing units in the eastern part of the Salt River Valley.

Copies are available for inspection at U.S. Geology Survey offices in Flagstaff, Phoenix, Tucson and Yuma.

Water Resources Data for Arizona, Water Year 1984

by Natalie D. White and W.B. Garrett
U.S. Geological Survey
Water-Data Report AZ-84-1

This recently-published report was prepared by the U.S. Geological Survey in cooperation with the state of Arizona and other agencies. It provides a compilation of surface-water, chemical-quality, and groundwater data.

The report is free from the U.S. Department of the Interior, Geological Survey, Water Resources Division, 300 W. Congress St., FB-44, Tucson, AZ 85701-1393 while supplies last. Copies are available for inspection at the U.S. Geological Survey offices listed in the previous entry.

CONFERENCES AND SEMINARS

Call for Papers

Critical Water Issues and Computer Applications

June 1-3, 1988
Norfolk, Virginia

Abstracts of papers to be considered must be submitted by November 1, 1987. For additional information contact: Mike Strech, Technical Program Chairman, Dannenbaum Engineering Corporation, 3100 West Alabama, Houston, Texas 77098; (713) 527-6489.

Symposium on Water-Use Data For Water Resources Management

August 28-31, 1988
Tucson, Arizona

Papers are invited on various topics; papers are also solicited for a poster session. The deadline for submission of abstracts is January 1, 1988.

For additional information about conference topics and the submitting of abstracts contact: Dr. Marvin Waterstone, University of Arizona, Water Resources Research Center, Geology Building, Room 318, Tucson, AZ 85721; (602) 621-7607.

American Water Resources Association and Symposium

November 6-11, 1988
Milwaukee, Wisconsin

The theme for AWRA's 24th Annual Conference and Symposium is *Water for the Years Ahead—Quality and Quantity: 1990 and Beyond.* The deadline for submitting abstracts is Jan. 15, 1988. For additional information contact: Max Anderson, University of Wisconsin-Platteville, College of Engineering, Platteville, Wisconsin 53818

Meetings

Rocky Mountain Ground Water Conference

October 20-21
Cheyenne, Wyoming

The conference is designed to serve as an outlet for state-of-the-art developments in groundwater hydrology. Conference participation is encouraged from industry, consulting firms, local, state and federal agencies, and academic institutions. The interdisciplinary nature of hydrology is recognized; many varied disciplines are commonly represented on conference agendas.

For additional information contact: Richard Stockdale or Dale van Dam, Wyoming State Engineer's Office, Ground Water Section, Herschler Building, 4th East, Cheyenne, Wy 82002; (307) 777-7354.

Water Resources Research Conference

Oct. 23, 1987
Case Grande, Arizona

See page 3 for conference write up.

American Water Resources Association Conference and Symposium

Oct 31-November 6
Salt Lake City, Utah

The theme of AWRA's 23rd annual conference is *Averting Water Crises. Water Resources Related to Mining and Energy—Preparing for the Future* will be the topic of discussion at the symposium.

For information about the conference contact: A. Bruce Bishop, Dean, College of Engineering, Utah State University, Logan, UT 84322-4100 (801) 750-2775.

For information about the symposium contact: Richard Dworsky, Chief of Planning & Evaluation, U.S. Bureau of Land Management, 701 "C" Street, Box 13, Anchorage, AK 99513 (907) 271-3349.

Toxic Substances in Agricultural Water Supply and Drainage: Searching for Solutions

December 3-5, 1987
Las Vegas, Nevada

Sponsored by the U.S. Committee on Irrigation and Drainage, this national meeting follows a series of four regional meetings held in 1986 which examined the problems associated with toxics in agricultural water. The purpose of the national meeting is to provide a forum for those with divergent interests to identify and constructively examine possible solutions to the toxics problem.

For additional information contact: U.S. Committee on Irrigation and Drainage, Post Office Box 15326, Denver, CO. 80215 or call Larry D. Stephens, USCID Executive Vice President, (303) 235-6960.

The Fifth National Drainage Symposium

December 14-15, 1987
Chicago, Illinois

Sponsored by the American Society of Agricultural Engineers, the drainage symposium covers a broad range of technology for design, installation, control and operation of water management systems.

For additional information contact: William R. Johnston, Bureau of Reclamation, Engineering & Research Center, Building 67, Box 25007, Denver, CO 80225; (303) 234-2041.

On-Site Treatment— Fifth National Symposium on Individual and Small Community Sewage Systems

December 14-15, 1987
Chicago, Illinois

Sponsored by the American Society of Agricultural Engineers, the conference covers a full range of technology for comprehensive, cost efficient design and analysis of on-site waste disposal systems for small communities.

For additional information contact: Karen Mancl, 590 Woody Hayes Drive, Ohio State University, Columbus, OH 43210; (614) 292-6007.

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