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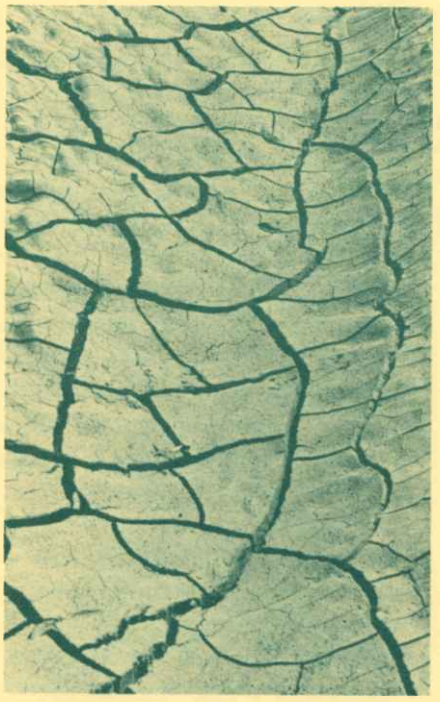
Drought Planning — Preparing for Dry Spells, Even in the Desert

Drought in Arizona might seem less a special water management concern than a natural and permanent condition. That an area is generally desert, however, with a warm, arid-semiarid climate does not mean it is afflicted with drought. Usually enough precipitation falls in the state to support a thriving desert ecosystem, with its varied flora and fauna, all adapted to dry conditions.

Although a land of little rain, the desert at times receives still less precipitation. Against the backdrop of Arizona's generally arid climate, various periods of exceptional dryness stand out. A 100-year study of Arizona's climate beginning in 1865 identified 12 significant dry periods lasting from six to 76 months. The most prolonged drought extended from September 1896 to August 1904. The study demonstrates that periods of dryness and drought are recurring phenomenon, a normal part of climate in Arizona, and not an extreme and random occurrence.



Drought forms jigsaw pattern on land. Photo: *Allan Fertig*

If scrutiny of past events urges concern about drought in Arizona, present developments might well add to that concern. One such development is climatic change, an issue that is provoking much debate and controversy. Will a greenhouse effect, caused by an increase in carbon dioxide emissions, influence global and regional climate, and how will this potential change be manifested? Might Arizona experience more frequent and intense droughts as a result? James Hansen of NASA's Goddard Institute was recently quoted in *U.S. Water News* as attributing the current western drought to global warming.

Also, Arizona might be more vulnerable to the effects of drought and prolonged dry periods because of its expanding population, a phenomenon more readily characterized than climatic change. The continuing growth of the state's population has resulted in an increased demand on its natural resources, especially water. Dry periods that at one time might have had negligible effects might now have more serious consequences on the state's population, wildlife and native vegetation.

Whether Arizona is currently experiencing drought is a debatable issue. Drought is an elusive concept, difficult to define and apply, and even more so in an environment such as Arizona's. Some officials believe that the state is in fact experiencing drought, disagreeing mainly about when it began, four or five years ago. Others are reluctant to say drought is presently a fact in Arizona, only that the state is in its third year of below average surface water supplies.

A current research project is examining the effects of a severe, sustained drought in the Southwest. Directed by Frank Gregg from the

University of Arizona, Phase 1 of the project involved researchers from various southwest universities, with funding provided by a grant from the Man and Biosphere Program of the U.S. Department of State. This recently completed phase of the project reviewed various hydrological, legal, and institutional issues relating to southwest drought and discussed strategies to cope with such an event. Phase 2 of the project is directed by Douglas James of Utah State University and is funded mostly by the U.S. Geological Survey.

What is Drought?

Because it is not easy to pin down with a ready and precise definition, drought is variously described. Most definitions, however, refer to a scarcity of precipitation, with various factors used for climatological and hydrological characterization. Among such factors are precipitation, soil moisture, snowpack, runoff, recharge, evaptranspiration, and average temperature. Other drought definitions do not rely on various hydrologic parameters, but emphasize socioeconomic factors, such as the availability of desired quantities of water at desired costs.

Various technical formulas to define and measure drought have been devised, such as the Palmer Drought Severity Index. Best suited for conditions in the Midwest, the Palmer index was found wanting by some officials in states with drier conditions. Seeking a more appropriate index, Colorado officials came up with a Surface Water Supply Index. SWSI has since been adapted to situations in other states, including Oregon and Montana. Some state officials believe that Arizona should work to adopt an index suitable to its conditions.

The Phoenix drought management plan includes a useful, working definition of drought, one suitable for general, nontechnical discussions. It states that drought is "generally interpreted as a set of complex physical and social influences on a large geographical area. It is not a distinct event, such as a hurricane or a flood, but a combination of many coincidental factors working together over a long time. In simple terms, a drought is when water supplies cannot meet established demands for a period of time that cannot be defined."

The Effects of Drought

Unlike other climatic phenomenon, such as floods, drought causes problems that are often difficult to define. Floods create environmental and property damage that is usually immediately visible and readily associated with the forceful flow of water. Drought, on the other hand, builds up and evolves, with conditions worsening over time as consequences eventually become apparent. The conditions that form the cracked, parched land, an image often used to represent drought, probably took years to develop.

Yet certain consequences can be expected. For example, drought in Arizona will likely cause economic and social disruptions. Economic hardships result from unemployment in industries relying on water resources, from crop and timber production to recreational enterprises. Tax revenues decrease, while expenditures for new water resources increase. Society feels the detrimental effects of unemployment, as well as having its health and safety undermined by increased fire hazards, water pollution, and fewer recreational opportunities.

Another consideration is the effect of drought on lifestyle and quality of life, abstract terms that imply a certain level of satisfaction and comfort. Difficult terms to define, they are even more difficult to measure. How does drought affect an Arizona lifestyle and quality of life? Will severely limiting or even prohibiting outdoor water use undermine a valued lifestyle? How is the quality of life affected when recreational opportunities are lessened because of drought? Answers to such questions would help define the consequences of drought.

Natural systems are also threatened by drought. Although their worth is usually associated with economic and recreational benefits, fish, wildlife, forests, and wetlands have an intrinsic value. They are part of a complex ecosystem that includes all forms of life, including human life. The serious harm that drought can inflict on natural systems should therefore be carefully considered.

Is Drought Likely in Arizona?

Basically, drought, wherever it occurs, is a problem of supply and demand. If inadequate water resources are available for certain needs, such as social, economic, and/or environmental, an area will experience drought. In other words, the degree to which Arizona is vulnerable to the effects of drought depends upon the extent and reliability of its water sources. And, as is readily known, evaluating and determining the state's water supplies is a difficult and controversial task.

It is relatively easy to identify drought when a town is totally dependent upon surface water or a very shallow aquifer. Pine, a town northwest of Flagstaff, is such a place. When its limited supplies were recently depleted, the town experienced drought. The Arizona Department of Water Resources and the state's Division of Emergency Services worked to relieve the drought situation in Pine.

Of course, the situation becomes more complex when the entire state and its varied water sources are the focus of concern. Broad, complex questions arise. Are groundwater resources available to make up for shortages in surface water flow during drought? How dependable is the flow

of the Colorado River? What effects will drought have on the Salt River Project (SRP) and its delivery of water?

A document prepared by the Western States Water Council stated, "Drought is not a major problem in Arizona, due to the State's primary dependence on ground water reserves." This statement reflects the premise that groundwater resources are relatively unthreatened by drought. In a state where many citizens now feel protective about groundwater, however, any plan that considers the resource as plentiful and readily available will certainly be questioned.

The recent infusion of Central Arizona Project (CAP) water into the state provides an alternate water source to groundwater. If, because of drought, CAP water supplies are reduced, increased amounts of groundwater can again be expected to be used. Not only that, but a diminished CAP water supply could no longer be a source for recharge, further adding to the net loss of groundwater in the state.

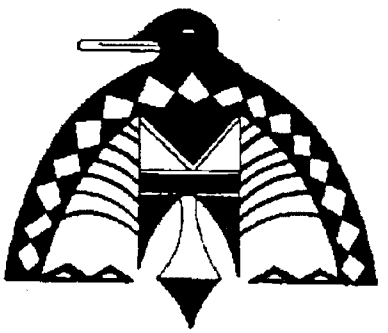
Although the extent of groundwater reserves is debated, some hydrologists believe them to be vast and extensive and able to withstand the effects of the most prolonged drought. Additional expenses would be entailed, however, as new and deeper wells would be needed. Also, further incidents of land subsidence could be expected.

Other officials believe that a reliance on groundwater resources will at best delay or temporarily shelter an area from drought damage. They argue that the state's groundwater resources are limited, with its use increasingly regulated in major population centers by the Arizona Groundwater Management Act (GMA). The availability of groundwater to meet emergency needs caused by drought is therefore uncertain, especially drought that is prolonged and sustained. This will be increasingly true as the GMA's conservation requirements become progressively more stringent.

Drought and Arizona Surface Water Supplies

The demand for groundwater then is determined by surface water flows, and the Colorado River, the source of CAP water supplies, is a major provider of Arizona surface water. The state holds rights to 2.8 million acre-feet (MAF) of Colorado River water. When completed, the CAP is to deliver a major portion of this water supply, initially 1.5 MAF, with most flowing to the Phoenix and Tucson AMAs. Will the Colorado River be able to supply regular and consistent deliveries during times of regional drought?

With its flow effectively controlled, stored, and directed, the Colorado River is managed as a water works or, as it is frequently referred to, a plumbing system. Its elaborate workings contribute to a drought mitigation strategy, with water stored in reservoirs during wet years for release during dry periods. As long as reservoir levels are maintained, the CAP is assured of sufficient water supplies.



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Reservoir storage levels, however, are determined by various factors – hydrologic, legal, political, and climatic, all helping to fix the amount and allocation of stored Colorado River supplies. Basic to this complex situation is the extent of runoff into the Colorado River, its virgin flow. Reservoirs would be seriously depleted, if periods of extremely low flows extended over many years.

Colorado River flow during relatively recent times has been generally ample, with no threatening extended sequence of dry years occurring. This situation, however, is not typical of the long range, as reconstructed by tree-ring research. Prior to the river's development, its average flow was less, with more extensive and extreme dry years occurring. How effective the Colorado River and its reservoirs will serve Arizona during such periods has not been tested.

Since the Colorado River is a much managed river, more than natural flow affects the fullness of its reservoirs. There are also legal matters. Law apportions the river in favor of the lower Colorado basin states, Arizona, California and Nevada. They are guaranteed that the upper basin states will deliver an annual average of 7.5 MAF.

Another legal matter is less favorable to Arizona. According to the Colorado River Basin Project Act, if the upper basin states are unable to provide full apportionment to lower basin states, Arizona's CAP is to absorb the shortage, with California entitled to its full appropriation. Before this occurs, however, storage would need to be depleted, with virgin Colorado River flows severely reduced.

Such severe shortages have not yet occurred. In fact, the upper basin states have never been able to use their full allocation of Colorado River water. Unused allocations therefore have flowed downriver to be stored in reservoirs and eventually to serve Southern California. If upper basin states experience expanded growth and development, however, their al-

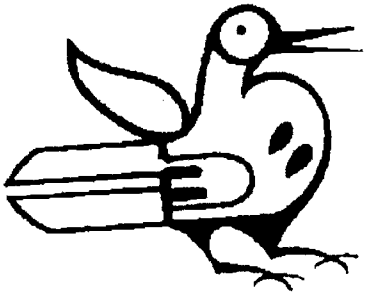
locations would be more fully used, with less available for storage and eventual use by lower basin states, including Arizona.

Reservoirs and other water management facilities usually have designated purposes, such as hydropower generation, flood protection, and water supply. Such purposes determine when stored water will be released. If power generation is to be maximized, the timing of water storage and release is quite different than if water is to be stored for use when needed for municipal, industrial or agricultural consumption. This is a controversial issue since many argue that the "law of the river" assigns a higher priority to water supply than to the generation of hydropower.

When evaluating the Colorado River as a reliable Arizona surface water source, the dependability of the CAP system to deliver water must also be evaluated. CAP system failures could seriously disrupt its service, even during times when ample Colorado River water can be diverted to the canal. Malfunction, not to mention other mishaps and hazards such as earthquakes and subsidence are always possible in such a vast and complex project. (Water is being diverted 330 miles from its source and pumped 2,000 feet uphill through 14 pumping plants before arriving at its most distant delivery point in Tucson.) Short-term disruptions can be expected.

Although just briefly described here, the above situations demonstrate the complexities involved when attempting to establish the availability and use of Colorado River water, whether during drought or normal periods. Whatever benefits the river might provide during drought must be interpreted in light of such variables, a very complex, difficult task. John A. Dracup, Don R. Kendall, Douglas S. Kenney and David M. Getches discuss and analyze many of these situations in their contributions to the previously mentioned study of severe and sustained drought in the Southwest.

Some measure of the reliability of Colorado River supplies to Arizona was worked out by Kenney, a graduate associate in research at the UA School of Renewable Natural Resources. He investigated how reduced Colorado River flows would affect the CAP; more specifically, he looked at the effects of 20 years of 11 MAF and ten years of 9.7 MAF. (Long-range average flows are about 13.5 MAF annually.) Such diminished



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flows occurred during 1579-1598 and 1584-1593, respectively, information worked out by UA tree-ring researchers Charles W. Stockton, David M. Meko, and William Boggess, all of whom are also involved in the drought research project. This period represents the most severe known drought in the area.

Kenney found that after 20 years of 11 MAF Colorado River flow, CAP supplies would probably be secure, but only if CAP water uses were given preference over power generation. He also considered what would happen to CAP deliveries if flows were reduced to 9.7 MAF for ten years, the situation that existed during 1584-1593. Kenney found that, if such a drought recurred, CAP supplies could be maintained if 13 MAF of storage were available to draw on. This is not an unreasonable expectation since 13 MAF is about a fifth of the system's storage capacity. Kenney therefore believes that municipal and industrial supplies would probably be maintained during such a drought. Agricultural supplies are much more vulnerable, largely due to constraints imposed by power generation objectives.

The above projection reflects a rather short period of time and does not attempt to account for the effects of a prolonged and severe drought. Although not evident in present historical records, such a drought could indeed deplete storage and severely affect existing uses.

Other critical Arizona surface water resources are supplied by the Salt River Project (SRP). Along with providing water for agricultural uses, the SRP supplies surface and groundwater to major municipal areas, including Phoenix, Scottsdale, and Mesa. SRP supplies about 1.05 MAF per year to the area.

Along with interpreting Colorado River reserves, Kenney also studied SRP's capacity to continue service during prolonged drought. He indicated that SRP, which includes a total of seven dams on the Salt and Verde Rivers, has a total storage capacity of 2 MAF. Historically, however, SRP storage is typically only about half of capacity. SRP's maximum groundwater pumping capacity is about 360,000 acre-feet.

Usually about 1.2 MAF flow into SRP reservoirs each year. Kenney determined if that amount decreased to 690,000 acre-feet, storage resources could be depleted. He estimates, however, that drought-lowered surface water flows would still contribute about 516,000 acre-feet per year to supply SRP customers. That amount, along with SRP's maximum groundwater pumping capacity of about 360,000 acre-feet per year, would make up an annual delivery of about 800,000 acre-feet per year during a severe, sustained drought, not an un-

manageable reduction from its target delivery of 1.05 MAF per year. Kenney determines, therefore, that, although SRP customers would receive reduced deliveries, the shortages would unlikely be calamitous.

Regarding such projections as provided above, both for the Colorado River and the SRP, it should be emphasized that they are based on various assumptions, such as upper Colorado basin water usage or the stability of Phoenix area population levels. The possibility exists that such assumptions may or may not be accurate and/or relevant when an actual drought occurs. In a document prepared for the research project, Kenney provides lengthy discussion of such assumptions and qualifies his findings in reference to them.

Drought Management Planning

Crisis events, such as drought, tend to attract most attention while hardships are being endured. Often, as the sense of crisis passes, so does the commitment to fix underlying problems. It is to avoid this no-pain/no-plan syndrome that drought management plans are advocated in advance of the actual occurrence of drought.

An underlying premise of most drought management plans is that stress and loss from drought can be as much the result of management practices as climatic and hydrologic conditions. With such plans, drought can be identified early, and actions designated to mitigate adverse effects. Drought planning is conducted at various levels and by different agencies: federal, state and local governments as well by major water utility companies.

That states have become increasingly concerned about drought is demonstrated by the number of states recently adopting drought management plans. Such plans are part of comprehensive state water management strategies. Surveys conducted by the International Drought Information Center indicate that in 1982 only three states reported having drought management plans. Its 1990 survey, however, indicated that 21 states had such plans, with one state at work developing a plan. Arizona is without a formal state drought management plan.

Various conditions in Arizona complicate any effort to develop a state drought management plan. For example, the state can be divided into three water provinces – the plateau uplands, the basin and range lowlands, and the central highlands – each with its distinct geographic, geologic and climatic conditions. Precipitation varies from mountainous, forested areas to low lying desert.

Although Arizona lacks an overall drought management plan, varied state government activities are taking place that contribute to the state's ability to cope with drought. The Arizona Department of Water Resources (DWR), for example, is in the process of producing an Arizona State Water Resources Plan. Consisting of two phases, the plan will gather and analyze varied information, including current and projected water supply and demand data. The plan will also critically review institutional arrangements and identify statewide issues and concerns. It is expected that these activities will greatly contribute to identifying drought prone areas in the state, as well as the resources needed to assist such areas.

Further, DWR, as part of its water resources plan, intends to publish annual reports of water supply conditions, as well as annual projections of expected supplies. Drought educational materials will be provided with the statewide resource plan.

A logical next step is to further quantify water supplies and demands in the state and develop a drought contingency plan. Such a plan would result from the cooperative efforts of state and local government agencies and the local communities, with statewide and community needs carefully considered and balanced.

Once drought does occur, Arizona's Division of Emergency Services (DOES) stands by to provide drought assistance. The division takes action after the governor formally declares an emergency. DOES is then charged with organizing and coordinating various state and federal relief activities to protect life and property. In the past, this after-the-fact relief constituted the main focus of most drought planning.

Drought Strategies in Arizona

Drought plans are afoot within the state, with various types of agencies and organizations working out drought management strategies. Following are brief descriptions of drought planning activities undertaken by a water user, water provider, and water deliverer.

With its water supply increasingly coming from surface sources, the city of Phoenix feels vulnerable to water shortages resulting from drought. About 90 percent of its water supply is now surface water, and plans call for eliminating groundwater use when adequate surface water resources are available. As a result, the city is much more active in planning for drought than cities, such as Tucson, that rely mainly on groundwater supplies.

Recently approved by its city council, the Phoenix plan recognizes four drought stages, and specifies certain responses or actions to be taken when each stage is reached. The stages are determined by the availability of water from the city's suppliers, CAP and SRP. With water resources becoming less available, drought intensifies, and the drought plan advances from stage one to four.

The first stage is a water alert.

Fifth Symposium on Artificial Recharge of Groundwater in Arizona

The theme of the 1991 symposium is *Challenges of the 1990s.* Sponsored by the Salt River Project, U.S. Water Conservation Laboratory ARS-USDA, and the UA Water Resources Research Center, the symposium will be held May 29-31, 1991 in Tucson Arizona. For additional information contact Susanna Eden, Water Resources Research Center, University of Arizona, 350 North Campbell Avenue, Tucson, AZ, (602) 792-9591.

Considered cautionary, this stage puts the city on notice that future water shortages are possible. Because of SRP's decision to reduce allocations this year, Phoenix has declared stage one of its drought plan. If a supplier actually cutbacks its deliveries, the director is authorized to declare stage two, a water warning. Voluntary reductions are encouraged, and groundwater and other emergency water supplies are tapped. A drought surcharge of up to 15 percent is imposed, its amount set to maintain adequate revenues during a time of decreased water use, pay for emergency supplies, as well as cover education and programming cost for achieving required conservation.

Stage three is a water emergency. Mandatory conservation measures are now implemented since adequate water supplies are lacking. Water rates include up to a 30 percent drought surcharge to cover increased regulatory and enforcement expenses and for revenue replacement. If stage three emergency supply and conservation programs are insufficient to meet water demand, stage four is declared. Called a water crisis, stage four includes a rationing scheme based on financial incentives. Water price rationing and the drought surcharge are adjusted to reduce demand to match available supplies.

The Salt River Project, a water provider, is also devising plans to cope with drought. Its plan is to ensure water resources during a seven-year drought. Seven years is the duration of the longest drought on record for the Salt and Verde Rivers.

In the event of drought and declining reservoir levels, deficiencies will be met by pumping additional groundwater. As drought conditions continue, therefore, SRP water supplies will include increasing percentages of groundwater. The strategy is to conserve surface water supplies as long as possible. During normal, non-drought times, SRP's supplies include about 10-15 percent groundwater, but during severe droughts as much as 35 percent may be groundwater.

If drought continues further and groundwater pumping has been maximized and reservoirs are dangerously low, water allocations would be reduced by applying a formula. Necessary reductions would be prorated among all users and would depend upon the amount of land served. For example, this year deliveries are to be reduced to 2.5 feet per acre from the usual 3 feet per acre, a measure not taken since 1951. Thus, all users are to be treated alike, municipal, industrial, and agricultural.

SRP is presently confronting a shortage of surface water supplies. Because of low inflows during the last three years, the SRP storage level has significantly dropped. Despite a recent, favorable increase in precipitation, SRP storage levels are now at 49 percent capacity. SRP has increased its groundwater pumping to compensate for surface water shortages, as well as having reduced water allocations.

As a water supplier, SRP lacks the statutory power to enforce conservation rules. The cities, the water users, are in a better position to enforce such conservation measures as alternate watering days and the use of low-flow plumbing. SRP's power to reduce allocations, however, does have the effect of strongly encouraging conservation practices.

The Central Arizona's Water Conservation District (CAWCD) is a water deliverer concerned with transporting Colorado River water to areas in central Arizona. The district perceives drought as occurring when it is unable to deliver water, an event more likely to result from outage or systems failure than with climatological developments. An accident, mechanical breakdown or other unforeseen event could completely cut off a supply for several weeks, with only a few hours notice. The agency has issued a report that identifies possible causes of outage and alerts users to be prepared for such situations on short notice.

CAWCD's concern with drought due to a lack of precipitation is less detailed. With the extensive Colorado River storage capacity, climatological variations are able to be evened out somewhat, and water allocations more reliably scheduled. Drought is therefore less unpredictable. As a result, CAP water shortages can be usually anticipated about five years in advance. This allows enough lead time for district customers to locate alternate water sources to mitigate drought effects.

Federal Role in Drought Planning

The federal government's drought planning role is debated. Some state water officials have criticized the federal government for not providing more emphatic drought management leadership. More specifically, they complain that the federal government

has not provided incentives for states to develop drought plans. For example, the Federal Emergency Management Agency encourages states to prepare for certain natural hazards, such as landslides, by funding the preparation of various planning documents. Seed money is then provided to states to adapt the plans to their situations. This same type of support is lacking in the area of drought planning.

Although traditionally concerned mainly with navigation and flood control, the Corps of Engineers has recently been active in researching drought at the national level. In 1988 the Corps initiated its National Study of Water Management During Drought. The three-year study is reviewing the drought response methods currently in use nationwide. Another objective of the study is to recommend a national strategy for managing the country's water resources during drought.

The Corps also plans to initiate drought preparedness studies in various regions of the country. Intended as demonstration projects, the studies will test and apply various aspects of drought response strategies adopted by certain states. The studies are to determine if such strategies are applicable to the regions in which the demonstration projects are being conducted. No drought preparedness studies are currently planned for the Southwest.

As operator of water storage and delivery facilities, the Bureau of Reclamation is involved in drought management. Storage facilities are maintained to ensure a consistent flow of water during dry periods. Further, water transportation facilities, like the CAP canal, are available to exchange water within areas of the state, an important service during times of short-term emergencies and shortages.

The Bureau is seeking to be more actively involved in drought management. In a recent report to the President and Congress the Bureau identified administrative and legislative initiatives that would support the agency's timely intervention during drought. In fact, legislation recently introduced in Congress would give the Bureau permanent authority to respond to drought, subject to the provisions of state law.

Further, the Bureau seeks to better acquaint states with its drought management capabilities. To do this the Bureau looks to working with each of the 17 states it serves to develop long-term drought contingency plans. Such planning would involve the Bureau working with all concerned state agencies and irrigation districts. Bureau project operations would be described, as well its resources and services available during drought.

Institutional Concerns

Beyond a commitment to conservation, drought planning also involves more complicated issues, some requiring institutional or legal responses. One such issue involves setting priorities among water users during drought. For example, in the event of drought, can the SRP decide to cut off or reduce water deliveries to agricultural users to better serve municipal or industrial users? Would some kind of state intervention be needed to allow such priorities? Can it be done by an executive order? Would legislative action be needed? Would compensation be required and, if so, what compensation?

If water cannot be legally taken without compensation from one user group to allocate to another, other courses of action might be considered. For example, an urban center, such as Phoenix, might lease a drought insurance water supply from various farmers. The farmers would receive regular advance payments until the city experiences certain drought conditions. Having been compensated, the farmers would then supply water resources to the city during drought. Questions arise about whether this arrangement would face any legal or institutional restraints in Arizona.

Already a well established movement, water transfer would gain in importance as a component of a drought mitigation strategy. If this is to occur, certain procedures may need to be reviewed to facilitate water transfers during drought periods. For example, if water is to be transferred, whether during drought or more normal times, the same hearing and noticing requirements must now take place. Would special considerations be justified for reviewing transfers during drought conditions?

That the GMA does not include any special provisions for times of drought is also of concern. The purpose of the GMA is to conserve the state's dwindling groundwater resources. Conflict with the law is therefore possible if its provisions disallow extensive groundwater pumping, at a time when such pumping is sought to alleviate drought. Legislative changes or modifications to the act may be needed to adjust GMA water duties in the event of drought.

Conclusion

Only relatively recently have water officials perceived a need to devise strategies for anticipating and responding to drought. This awareness was prompted by the occurrence of drought in various parts of the country and the subsequent discovery that preparedness was often woefully lacking. Drought planning is also encouraged in part by the acknowledgement that new water projects are unlikely to be built and, as a result, more comprehensive water management strategies are in order. Even the Corps of Engineers and the Bureau of Reclamation are seeking to define more clearly their roles in drought management.

Arizona, unlike parts of Califor-

nia, has not suffered from a devastating drought. As a result, some water officials believe the state has lacked a strong incentive to work out a drought strategy. It is readily recognized, however, that the state does have various elements of a strategy in place. For example, Arizona's GMA is seen by some as contributing to drought planning. The act intends to conserve groundwater resources, and such resources may provide valuable reserves during drought. Arizona's concern with its groundwater resources have also contributed to its commitment to better water management and supply augmentation, two basic strategies in drought planning.

The editor thanks the following people for contributing information to this newsletter: Bob Brumbaugh, *U.S. Army Corps of Engineers*; Larry Dozier, *Central Arizona Water Conservation District*; Ron Jones, *Soil Conservation District;* John Keane, *Salt River Project*; Bill Mee, *City of Phoenix;* Tom Phillips, *Bureau of Reclamation;* Doug Toy, *Arizona Department of Water Resources*; Donald Wilhite, *University of Nebraska.*

The ideas and opinions expressed in the newsletter do not necessarily reflect the views of any of the above people.

Arroyo is published quarterly by:

Arizona Department of Environmental Quality
2005 North Central
Phoenix, AZ 85004
(602) 257-2306

Arizona Department of Water Resources
15 South 15th Avenue
Phoenix, AZ 85007
(602) 255-1554

Arizona State Land Department
1616 West Adams
Phoenix, AZ 85007
(602) 542-3500

Office of Arid Land Studies
College of Agriculture
University of Arizona
845 North Park
Tucson, AZ 85719
(602) 621-1955

Water Resources Research Center
College of Engineering and Mines
University of Arizona
Tucson, AZ 85721
(602) 621-7607

Address comments to:
Joe Gelt, Editor/Writer
Water Resources Research Center
350 N. Campbell Avenue
University of Arizona
Tucson, AZ 85721

THE UNIVERSITY OF ARIZONA
TUCSON ARIZONA

ARROYO

T HE UNIVERSITY OF ARIZONA
Water Resources Research Center
Tucson, Arizona 85721

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