ARIZONA
WATER RESOURCE

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Whatever else the photo at right might suggest it would not likely be a water treatment plant. Yet, water treatment plant it is, the winged, taunt, angular sculptures adding an artistic flair to the facility. With the graceful structures along with other design elements, Scottsdale's Chaparral Water Treatment Plant stands out as an attractive public feature in its residential neighborhood setting, adjacent to Chaparral Park.

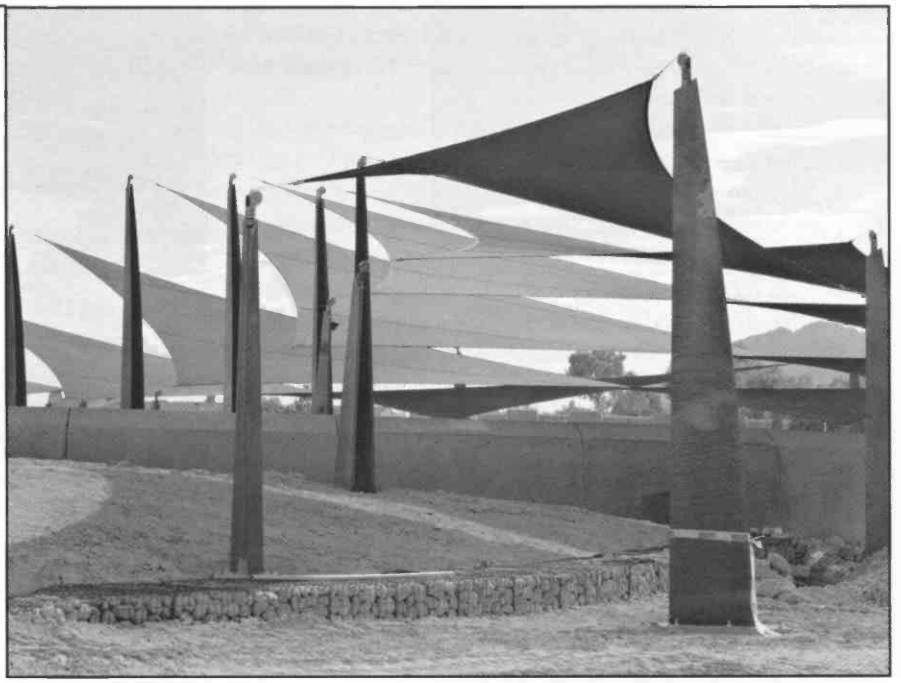
Aesthetics along with function was a prime consideration when designing the plant. A mega-box concrete block building surrounded with razor wire would not do in a suburban residential area.

Other artistic touches include the basket weave pattern of the exterior brickwork and curved and gabion walls. The wire-and-rock gabion walls have a symbolic significance, to represent the filtering process occurring within the plant. Plans also call for a six-acre terraced desert garden that relies on collected rainwater.

Neighborhood recreational interests will be served by an off-leash dog park and two ball fields.

To further accommodate its suburban setting, the treatment plant includes a wall to conceal deliveries, soundproofing to muffle pump noise and a system for filtering and deodorizing air used in the treatment process.

Swaback Partners was the architectural design consultant to Black & Veatch, the engineering firm that built the plant.



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Urban Heat Island — Higher Temperatures and Increased Water Use

Another issue for water planners to ponder

by Joe Gelt

The urban heat island might be viewed as an unintended consequence of urban growth and development: UHI resulted when cityscapes were built-up and built-over. Unintended consequences then spawn their own set of consequences. A consequence of the UHI that is getting increased attention is its effect on the water resources of an area.

The workings of the UHI are generally understood. Urban areas are increasingly becoming "hot spots," their impervious paved surfaces and reduced vegetation resulting in less of the sun's incoming radiant energy reflected back into the atmosphere.

The unreflected heat is stored by asphalt, brick, concrete and other materials that make up much of the urban environment. These have greater thermal storage capacity than natural surfaces. Energy stored during the day and released after sunset results in higher nighttime temperatures; in other words, the UHI effect.

UHI effects are most pronounced at nighttime. In 1948, Phoenix's average nighttime low temperature was 75 degrees; in 2003 it had increased to 86.7 degrees. Some researchers say that at some time in the future 100-degree nights will be the norm.

Compared to Phoenix the UHI is less of a problem in the Tucson area. One study showed that while Phoenix's daytime temperature averaged 4.5 degrees higher than Tucson's, its nighttime temperature averaged 10 degrees warmer. Partly accounting for the difference is Tucson's smaller size; also the city contains less heat-absorbing materials.

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Not as well understood as its causes are the UHI's likely effects on the water resources of an area. Will higher UHI temperatures result in an increased consumption of water? What UHI-related factors could cause increased water use? This is an issue with public policy implications, of importance when reckoning water availability and consumption and devising efforts to achieve sustainability. Water lost due to the UHI is water unavailable for other uses.

Arizona State University researchers are attempting to answer such questions with studies of the Phoenix area.

Water Needed for Energy

One study is investigating the effects UHI has on energy and water sustainability in the Phoenix area. As is becoming increasingly recognized, energy and water are interrelated issues, with water needed to produce energy and energy needed to treat and distribute water. Researchers Jay Golden and Anthony Brazel, both with the ASU Global Institute of Sustainability, are examining the significance of the water/energy interrelationship in regards to the UHI.

Thermoelectric power generation accounts for more water withdrawal than any other water usage, including agricultural irrigation or municipal water consumption. The ASU researchers are considering the increased amounts of water needed to generate energy to power air conditioners. In response to the UHI, air conditioners will become necessary appliances, with more purchased, adding to the large number already in use.

In effect, greater amounts of water will be needed to generate needed power to run more air conditioners for longer periods of time to cope with the discomforts of higher UHI temperatures.

Examining historic climatic records enabled the researchers to determine that Phoenix is experiencing an increased number of cooling degree days and a reduced number of heating degree days. Cooling degree days and heating degree days, variances in the daily average temperature above or below 65 F respectively, are used to estimate the amount of energy needed to cool or heat buildings. Both are affected by urbanization.

During the 1950s the region averaged 42,264 heating degree hours per year while during the 1990s the region annually averaged 29,800 heating degree hours. Reversing the trend, cooling degree hours in the 1950s averaged 95,597 per year increasing to 112,551 cooling degree hours per year in the 1990s.

That calculation enabled the researchers to figure the net impact over time of overall increased energy consumption based on increased cooling degree hours and decreased heating degree hours of a single-family residence. It went from 7,888 kilowatt-hours in the 1950s to 8,706 kWh during the 1980s to currently 8,873 kWh from 1994 to 2004. The figures represent the electricity consumption requirements resulting from the thermal modification of urban environments.

These figures along with an analysis of power generation operations enabled the researchers to determine actual water consumption for residential electricity generation within the Phoenix region.

Increasing Evaporation

Sophisticated scientific enquiry is not needed to realize that additional UHI-related water consumption will result from increased evaporation. Higher UHI temperatures will cause larger volumes of water to evaporate from swimming pools, urban ponds and wetlands and surface-irrigated areas.

At the same time, however, evaporation cools, mitigating UHI effects. Some gain would seem to result from water lost. The problem suggests a solution that, if pursued, would worsen part of the problem.

Patricia Gober, co-director of ASU's Decision Center for a Desert City, says research is needed to determine the amount of surface area covered with water in the Phoenix region, including urban lakes and pools. Knowing this would enable researchers to determine the amount of water evaporated. She says, "A pool replaces its volume of water every year through evaporation. People don't know it; it is a silent thing." She considers pools more UHI water-consumptive than landscaping in the Phoenix area.

UHI Effect on Vegetation

The UHI effect on vegetation is a complicated, unsettled matter. Some say since plants will be coping with higher nighttime temperatures they will become stressed, requiring more frequent watering to survive. Others are not so sure; they say photosynthesis occurs during daylight hours when temperatures are less affected by the UHI effect.

What is generally agreed upon, however, is that vegetation helps reduce the UHI effect. If impervious paved surfaces and reduced vegetation contribute to UHI, increased vegetation will counteract the effect. More vegetation — and increased watering — will help combat the UHI effect.

Urging increased vegetation might undercut a central message of most outdoor water conservation programs, that xeriscape principles be applied. Xeriscape means planting low-water use vegetation in a water-scarce environment. A reader's response to a recent *Arizona Republic* editorial demonstrates that some people, depending upon how they perceive the message, believe they are being advised to discard xeriscape in favor of more water-consuming vegetation to relieve UHI discomforts.

The July 23 editorial noted a study supported by ASU's Decision Center for a Desert City that the growth and the intensity of the UHI is exceeding researchers' expectations. It warned that it

Continued on page 4

Combat Global Warming: Use Less Water

Interest in the urban heat island's effect on water resources demonstrates a growing awareness of the interrelationship of water and energy. Simply stated: the supply and use of one depends upon the supply and use of the other. The fuller implications of this interrelationship is evident in the suggestion in an article in the *Mercury News* that residents should use less water to help combat global warming. The article explained that pumping water, transporting and treating it requires a great deal of energy. Generating this energy produces carbon dioxide, a greenhouse gas. By using less water, less energy would be needed, with less carbon dioxide released into the atmosphere to contribute to global warming.

Water Vapors

Creativity Helps When Info is Needed

So much water information, so little time, so few resources. Such is the dilemma confronting those needing data and information for research, planning and decision making. Useful and much needed facts, figures and information, although there for the taking, often remain out of reach for the lack of means for gathering or collecting it. Creative efforts are called for.

Bird Scientists

One such creative effort involves using pigeons to collect air quality information. In a project at the University of California, Irvine, pigeons will be outfitted with miniature backpacks stocked with a global positioning system monitor, pollution sensors, and cell phone transmitting equipment. Data will be sent directly to a blog where it will be overlaid on Google maps. Anyone interested can roll over the maps to learn about air pollution in an area.

The birds' airborne overland flights will cover areas beyond the scope of the stationary monitors researchers now rely on. Air pollution information will be available from a much greater range.

Further the researchers hope the data-gathering pigeons will pique public interest in air quality issues and debates. The data and information gathered by the birds will be transmitted in real time and available to the public.

Wanted: Citizen Scientists

The above concept, without the birds, is behind an effort at the University of Arizona to recruit citizen scientists to collect simple rainfall observations in their backyards. The gathered data will provide high temporal and spatial resolution information needed for drought monitoring and hydrologic modeling across the Southwest.

Citizen scientists have an important role to play. Additional observations are critical in tracking highly variable precipitation across the southwestern United States. Highly localized summer thunderstorms can produce rainfall amounts in excess of one inch within an hour. These rainfall events often occur between official National Weather Service meteorological stations and go unobserved. Citizen scientists are helping to close these observational gaps through Rainlog.Org.

Recruitment is underway. If you are a resident of the Southwest and have a backyard rain gauge, you can become a citizen scientist by participating in Rainlog.org. Web site registration includes a Google map utility to pinpoint the latitude and longitude of gauge locations, plus guidance on selecting and installing rain gauges. Also included is information on collecting high quality observations.

Uploading data after rain events is a simple, straight-forward process using web forms. Those who have had rain gauges for years are invited to upload historic data in their own personalized "My Data" section of the site. Now numbering over 400, the ranks of citizen volunteers is growing.

Rainlog.org is a partnership between the National Science Foundation's Sustainability of semi-Arid Hydrology and Riparian Areas Center and the University of Arizona's Cooperative Extension.

Fewer Citizen Scientists?

The results of a study for The Nature Conservancy has likely implications to such efforts as recruiting citizen scientists. The study found that Americans' interest in visiting natural areas like national forests and parks is waning due to increased time committed to television viewing, video games and the Internet.

According to the study per-capita visits to national parks have been on a downward trend for years. Examining data starting from 1930, the report found a visitation highpoint in 1987, with 1.2 visits per person per year. It had declined by 25 percent by 2003, with 0.9 visits per person per year.

To determine the cause of the decreased visits the researchers looked at over two dozen possible explanations, narrowing them down to video games, movie rentals, going to movies, Internet use and higher fuel prices. The researchers found that these account for 98 percent of the decrease in national park excursions.

According to the study its results do not bode well for environmental stewardship when delight and interest in the natural environment is trumped by the ubiquitous draw of the electronic media.

The role of a citizen scientist recording rainfall, even if the Internet is involved, might likely seem dull and stodgy to those valuing the glitz and glitter of the electronic media.

U.S. Geological Survey Sponsors Supplement

This edition of the "AWR" contains a 4-page supplement sponsored by the U.S. Geological Survey with information about research along the San Pedro River. By sponsoring the supplement the agency is supporting the publication of this newsletter. We appreciate the opportunity to work with U.S.G.S. and the agency's generous support.

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Arizona Water Resource Staff
Editor: Joe Gelt
jgelt@ag.arizona.edu
Editorial Assistant: Gabriel Leake

WRRC web site:
http://cals.arizona.edu/azwater/

WRRC Director: Dr. Sharon Megdal

Arizona Water Resource
Water Resources Research Center
College of Agriculture and Life Sciences
The University of Arizona
350 North Campbell Avenue
Tucson, Arizona 85719

520-792-9591 FAX 520-792-8518
email: wrrc@cals.arizona.edu

News Briefs

Research Looks at Effects of Yuma Desalting Operations

Research to monitor water quality in the Cienega de Santa Clara, located in the Colorado Delta in Mexico, has both environmental and political significance. The research is to evaluate how the operation of the Yuma Desalting Plant will likely affect the cienega. What will be the environmental consequences to this wetland that provides habitat to at least 95 different species of resident and migratory birds including the endangered Yuma Clapper Rail?

Its political significance is that the research is being conduced after various groups involved in a controversy about the YDS operations were able to work out their differences to identify a set of management alternatives agreeable to all. It was considered an extraordinary collaborative effort.

The principal concern was that operating the plant would result in the Cienega getting less water, with the water much saltier, causing harm to plants and animals. Many, however, believed that the plant's operation was needed to help cope with ongoing drought conditions.

Researchers will begin collecting baseline data in August. Plans call for the YDP to conduct at 3-month trial run at 10 percent of its full capacity during the spring 2007, with scientists gathering water quality data during and after the trial run.

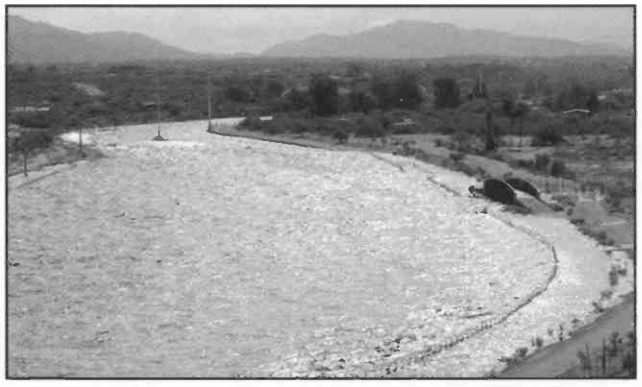
Water sampling will be conducted every month for the next year from 17 locations within the cienega. The water will be tested for salinity, dissolved oxygen, nutrients, selenium concentration and other characteristics to determine if the trial run of the YDP has affected water quality and to what extent.

"Monitoring during the next year will provide long-needed baseline information and increase our understanding of how hydrologic variation affects environmental quality in this critical wetland," said Flessa, the project's principal investigator and University of Arizona geoscience professor.

The report issued by the working group called for water quality monitoring of the cienega. The Central Arizona Project has contributed $80,000 to the effort.

Neither BuRec nor Bureau but Restoration

By referring to the agency as "Restoration," rather than "BuRec" or the "Bureau,"



The above picture taken July 31 shows the record-breaking flow in the usually dry Rillito River. Many Tucsonans find it a goading sight to see an abundance of free-flowing water heading downriver, out of reach. An idea that often surfaces with rising waters is the construction of an inflatable dam to capture water for local use. This flood was no exception, with the idea again making the rounds that a dam be built, or rather inflated, near the confluence of the Rillito and the Santa Cruz River. Tempe's Town Lake is cited as an example. In an editorial the Arizona Daily Star *rhapsodized about the possibilities: "With some visionary thinking, we might someday look from the bridges near Downtown and see people in non-motorized boats and in restaurants along the banks of an attractive waterway." Photo: Arturo Baez*

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won't be long before overnight lows will likely reach 100.

To counteract the UHI effect the editorial exhorts citizens to "Plant more vegetation. Shade from trees and bushes reduces the heat absorbed by walls and pavement. Leaves, meanwhile act as nature's air-conditioners, cooling the surrounding air when water evaporates through their pores."

A reader's take on the message is evident in her July 25 response: "For 30-some years Phoenicians have been exhorted to save water by covering their lawns with sand and gravel and a few desert plants. Now, according to Sunday's paper, we're told we need more grass and shade trees to fight the heat island we've created.

"Forty years ago we had a desert lawn in the front yard, but only for two years until we measured the temperature and found a 15-degree difference between the front yard and the grassy backyard. We quickly shoveled up the sand and planted grass out front, cooling the whole house down."

And at the same time greatly increasing their water use.

Some call it a trade-off, determining the amount of water that can be used to grow vegetation to deter the UHI before its use becomes excessive, threatening valuable supplies needed for other applications and for achieving sustainability. In other words, how much water can we spare or trade-off in efforts to cope with the UHI.

Others don't see so much a trade-off as a bind, that in the rush to grow and develop urban areas we have created various problems; that to resolve the UHI problem we consider exacerbating another human-engendered problem: water scarcity. One problem is worsened to mitigate the effects of another.

There is another aspect to the UHI-vegetation issue to ponder. The significantly higher temperatures extending longer into the evening will modify the ecosystem. With winter freezes in Phoenix likely becoming events of the past, citrus and other high water-use vegetation will have a better survival rate and be more

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Two Views Offered on Ways to Increase Water Supplies and Restore Rivers

Two recent Arizona Republic *opinion pieces addressed the topic of water, each offering a suggestion the writer believed would improve water management in the state. The pieces are summarized below.*

International Consortium Would Provide New Arizona Water Supplies

In an August 19 piece Karl Kohloff argued that establishing an international consortium could help Arizona to its "next bucket of water." He envisions such a consortium as being made up of Mexico, California, Nevada and Arizona, with the U.S. Bureau of Reclamation also participating.

The consortium would play a pivotal role in constructing a large desalting plant along the Gulf of California and a companion power generator plant in Mexico. He envisions the operation providing possibly more than 3 million acre-feet of water, to be pumped into the lower Colorado River Basin.

The desalted water then could be exchanged with agricultural districts so that water they presently use would remain in Lake Mead to augment California, Nevada and Arizona water supplies.

Significant expense would be involved to desalinate and pump the water. To cover the cost Kohloff advocates establishing a new Arizona Water Authority with taxing and bonding powers. He views it as similar to the Arizona Power Authority, emphasizing that it would have to be transparent. Appropriate governance and costs would be equitably shared by those benefitting from the taxing and bonding.

He envisions Arizona's transmission system as a second CAP, financed by the state with projects for both northern and southern Arizona.

Ecosystem Fee Would Help Restore Rivers

Karl Flessa, a University of Arizona geoscience professor, is concerned about the condition of the state's rivers and riparian areas. Groundwater pumping and diversions have greatly reduced the flows of many Arizona rivers, with attendant recreational, economic and environmental costs. Flessa offers a plan to help restore flows to the rivers.

In an August 21 piece he suggests that an ecosystem fee of $1 be charged for every 100,000 gallons of water used. He figures this would not be a particularly onerous fee, coming only to about $1.34 for the average Phoenix household.

Flessa figures if every household and farm in the Southwest using Colorado River water paid the ecosystem fee it would come to about $45 million per year. This amount would be further increased by fees paid for use of other surface water and groundwater.

The monies could be put to various uses. A prime use would to help restore and protect the ecosystem services depending on water. Also it could be used to improve irrigation practices, with water that is saved used for restoration. Ecosystem funds could support research on ways to use reclaimed water to restore riparian habitats. It could also pay farmers to fallow fields for a year, with their water then used to support natural or restored habitats.

He believes a regional and international approach is justified since natural ecosystems aren't confined by political boundaries.

Bureau of Reclamation officials are hoping that whatever inconveniences are caused by the extra syllables will be more than made up for by the new name more clearly stating the agency's mission.

What a "BuRec" is could be anybody's guess. Confusion results if the agency is called the "Bureau," especially in the West where the Bureau of Land Management is active. Mention "Bureau" and people wonder, "dirt or water?"

As a result, officials of the water and power agency are requesting that their employees, stakeholders and the press refer to the operation simply as "Reclamation."

The few extra syllables of "Restoration" are nothing compared to the nomenclature adjustment the agency attempted in 1979 when its name was changed to Water and Power Resources Service.

The recent name change is part of a two-year visual identity program that is attempting to ensure consistency throughout the agency. The program includes new letterhead, a refined logo and a new tagline: "Managing Water in the West."

The U.S Geological Survey and the Park Service had undertaken similar efforts in recent years.

Earth Fissure Info to be More Available

Recent legislation will enable prospective homebuyers to check on a concern they oft overlook: earth fissures. Fissures are caused by excessive groundwater pumping in an area.

The bill addresses two of the main reasons fissures are overlooked: homebuyers, many of whom are from out of state, don't think of them, and information about fissures has not been readily available. A person may become aware of fissures only after having purchased real estate.

The bill will raise homebuyers' awareness about fissures and make information about them more generally available.

The law requires that the Arizona Department of Real Estate post online maps of earth fissures, or subsidence cracks, with the maps updated every five years. This may be done as early as January.

The law organizes a team effort, with the State Land Department, the Arizona Geological Survey and the Arizona Department of Real Estate coordinating the required data collecting. The AGS will receive funding for geologists to do field work and map the cracks. Estimates for compiling a set of maps is about four years; priority areas for mapping will be areas slated for development.

A recurring problem in the state, earth fissures have been attracting increased attention as development moves into previously agricultural areas.

Development and real estate interests supported the bill.

Guest View

Geology Deserves Greater Role in Groundwater Assessment

This Guest View was contributed by M. Lee Allison, state geologist and director, Arizona Geological Survey. Mr. Allison joined the agency in June.

Geology is playing an increasingly important role in understanding our water resources. Let me share some examples of what is happening now, and what more needs to be done.

The demands on our water resources and especially groundwater are increasing at an alarming rate. For much of the past 150 years, it was relatively easy to drill a hole in the valley floor and you could usually find water. Today you may have to go much deeper than your grandparents did. As we tap more of the water-bearing sediments in the basins and expand exploitation of our bedrock aquifers, it will be increasingly important to characterize the geologic framework in order to balance maximizing resource recovery with aquifer sustainability.

The petroleum industry has relied on reservoir characterization for the past 30+ years to drain every last drop from declining fields. Prior to that, it was typical to drill wells on a regular spacing and treat the oil reservoir like a giant sponge. Today, geologists and engineers recognize the geologic heterogeneities that control porosity, permeability, and the ultimate recovery of oil from a field.

We are only starting to apply reservoir characterization techniques to groundwater resources. Too often, our aquifer models are idealized and simplified. This raises the question of whether our estimates of water resources may be unrealistically high or low, or perhaps both high and low, at different locations. It's going to take significantly more effort to realistically map the aquifer geology in order to accurately assess our groundwater resources.

One of the things we can do right now is start using more realistic basin models for Arizona. Open virtually any geology or hydrology publication for the state, including those of my own agency, and you will find a cartoon-like cross section of a "typical" Arizona sediment-filled basin. There are matching high-angle normal faults bounding the basins against the bedrock mountain fronts, descriptions of coarse grained sediments near the mountain fronts, with finer grained sediments in the valley center, perhaps along with playa or axial stream deposits. All of the sediments are symmetrically arrayed across the basins.

A second thing we can do is to get geologists, hydrologists, and engineers talking together so our hydrologic models are consistent with the best geologic reservoir characterization we have.

The reality for Arizona is much more complex. Many basins are strongly asymmetric, with low-angle normal ("detachment") faults dominating their shapes. Sediment distribution can be equally asymmetric with coarser grained materials on one side and finer grained on the other. Plus there are deposits of salts reaching thicknesses of thousands of feet in some areas. Piecing together an accurate subsurface picture is essential for understanding water volumes, storage capacity, producibility, and recharge rates.

A second thing we can do is to get geologists, hydrologists, and engineers talking together so our hydrologic models are consistent with the best geologic reservoir characterization we have.

Arizonans rely heavily on bedrock aquifers for water in some parts of the state, although there seems to be little public recognition of this. Good sized cities such as Payson rely entirely on bedrock aquifers. Identifying water resources in bedrock has its own challenges. Many of the geologic units are severely deformed after hundreds of millions of years of tectonic activity. Some of these rock units are twisted, broken, and offset along faults. In many cases, the water is concentrated in fractures and faults cutting through otherwise "tight" formations. Finding and assessing the water resource in these cases demands detailed geologic mapping.

On a different tack, there is a growing demand for detailed geologic maps of surficial deposits, delineating Holocene-aged sediments (10,000 years old and younger) from older Quaternary (up to 1.6 million year old) sediments. Water law in Arizona assumes that water from Holocene sediments is not drawn from underlying aquifers but is subflow from nearby or adjacent rivers and streams. This has significance to anyone who wants to drill for water in a riverine environment, and it means there is need for more detailed mapping to delineate the extent and depth of Holocene sediments.

Lastly, the rapid depletion of groundwater from some of our basins produced substantial subsidence in recent decades, reaching over 18 feet in some locations. A consequence of this is the development of the essentially human-induced geologic hazard of earth fissures, cracks that may reach hundreds of feet down from the surface and extend across the countryside for hundreds of feet to miles. Geologists are still learning how fissures form, propagate, and evolve. In response to publicly prominent fissures that opened overnight following monsoon rains in 2005 in the Phoenix region, the Arizona legislature recently approved a bill for the Arizona Geological Survey to undertake a comprehensive mapping effort to precisely map all the earth fissures in the state. Users will be able to create their own customized maps through an interactive GIS website run by the State Land Department, and also distributed by the Arizona Department of Real Estate. Beyond mapping of the fissures themselves, subsidence mapping by the Department of Water Resources is critical to developing predictive capabilities for new fissures as groundwater depletion continues.

Taken together, these examples show the necessity for geology to be more integral to our assessment of potential groundwater resources and to respond to the consequences of our current practices in using this incredible resource.

USGS
science for a changing world

Prepared in cooperation with the
BUREAU OF LAND MANAGEMENT

Hydrologic Requirements of and Evapotranspiration by Riparian Vegetation along the San Pedro River, Arizona

This report summarizes analyses of riparian system hydrologic requirements and ground-water use detailed in U.S. Geological Survey Scientific Investigations Report 2005–5163, "Hydrologic requirements of and consumptive ground-water use by riparian vegetation along the San Pedro River, Arizona," compiled by J.M. Leenhouts, J.C. Stromberg, and R.L. Scott.

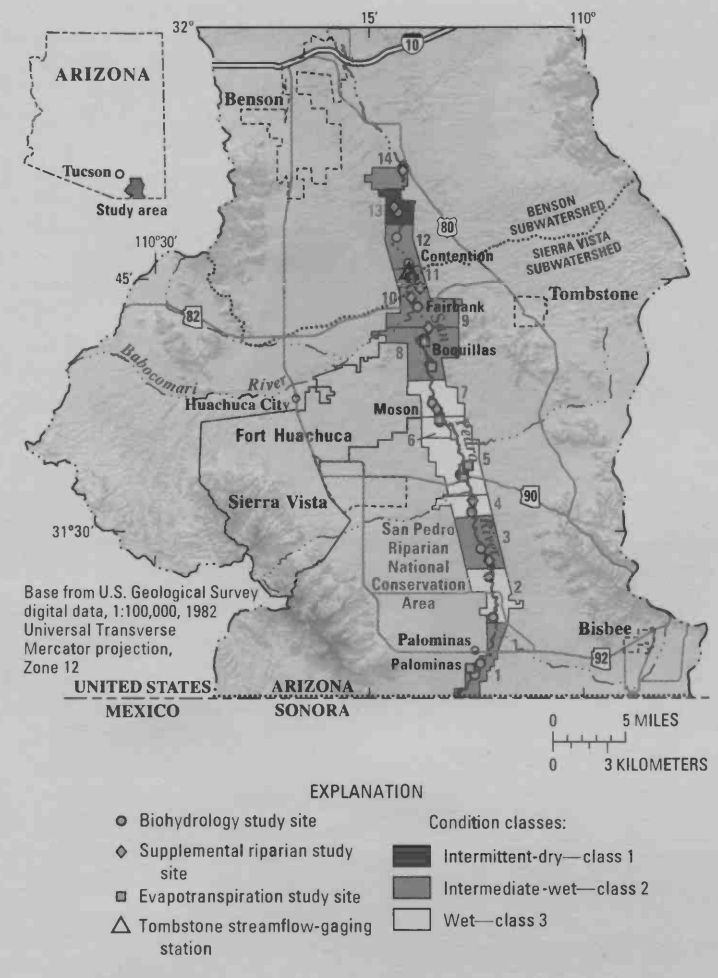

Figure 1. Boundaries of the Sierra Vista Subwatershed and locations of study sites and 14 reaches of the San Pedro River in the San Pedro Riparian National Conservation Area, Upper San Pedro Basin, Arizona.

In 1988, Congress designated portions of the San Pedro River in the Upper San Pedro Basin of Cochise County, Arizona, as the San Pedro Riparian National Conservation Area (SPRNCA; fig. 1). This conservation area is home to an ecologically diverse and important riparian system. The basin also hosts growing populations of residents in areas hydraulically upgradient from sensitive reaches of the riparian system. The largest communities are Sierra Vista, Bisbee, Tombstone, Huachuca City, and the U.S. Army's Fort Huachuca. The total population of these communities and surrounding rural developments is about 75,625 (Arizona Department of Economic Security, 2003). Residents of several local communities have responded to the need for water planning by forming the Upper San Pedro Partnership (USPP), a consortium of 21 agencies and organizations with a primary goal of ensuring long-term water needs are met, both for the area residents and for the riparian vegetation and wildlife along the river within the SPRNCA. As part of the overall planning strategy, the USPP assembled a multidisciplinary team of researchers and began a study to characterize the water needs of the SPRNCA's riparian system.

The characterization of riparian water needs was done by determining the (1) annual water-use rates for riparian species and open-water evaporation, (2) areal distribution of riparian species and, (3) relation between hydrologic factors, water-use rates, and the distribution of riparian species. These characterizations not only helped define the current water needs for the SPRNCA's riparian system, but also provided information about how the ecological structure of the system and its water needs could change under different hydrologic conditions. The study was a collaborative effort by the U.S. Geological Survey, Arizona State University, and the U.S. Department of Agriculture-Agricultural Research Service with assistance from the U.S. Army Corps of Engineers, the University of Wyoming, and the University of Arizona.

The San Pedro River within the SPRNCA was delineated into 14 reaches that were internally homogenous in terms of streamflow hydrology (spatial intermittence of streamflow) and geomorphology (channel sinuosity and flood-plain width). A total of 26 sites (fig. 1) within the SPRNCA were selected for collection of vegetation data from three primary streamflow regimes: perennial, intermittent-wet, and intermittent-dry (fig. 2). These regimes were defined by observed ranges of ground-water and streamflow conditions (table 1). Hydrologic data were collected at 16 of these sites (called biohydrology sites); water-use and water-source data were collected at a subset of 5 sites. Vegetation data were also collected at sites in the Lower San Pedro Basin. Data were collected from 2000 to 2003.

The term "riparian" refers to transitional areas between terrestrial and aquatic ecosystems that depend on the existence of surface or subsurface water flows. The riparian corridor in the SPRNCA is a band along the river that encompasses low-flow channel sandbars, streambanks, and post-entrenchment flood plains, as well as pre-

Table 1. Observed hydrologic conditions of the three riparian condition classes

Condition class	Streamflow regime class	Streamflow permanence (percent)	Average flood-plain ground-water depth in dry season, in meters	Annual ground-water fluctuation, in meters
3	Perennial	100	Less than 2.5	Less than 0.5
2	Intermittent-wet	Between 100 and 60	Between 2.5 and 3.5	Between 0.5 and 1.0
1	Intermittent-dry	Less than 60	Greater than 3.5	Greater than 1.0

Figure 2. Active channel of the San Pedro River in summer. *A*, Perennial Moson site; *B*, Intermittent-wet Contention site.

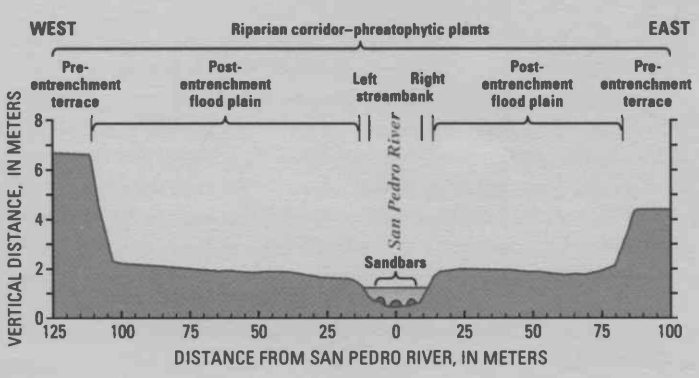

Figure 3. Cross section of stream-channel morphology, San Pedro Basin, Arizona.

entrenchment terraces at a higher altitude than the current flood plain (fig. 3) that are vegetated, in part, by phreatophytic plants that use ground water from the stream alluvium.

The hydrologic factors measured included ground-water depth and streamflow. Riparian vegetation measurements included biomass structure, abundance of common riparian plant species, and abundance of plants classified into functional groups. Riparian evapotranspiration (ET) and free-water evaporation were measured by using a combination of sap-flow, eddy-covariance, and meteorological techniques.

Distribution Patterns, Effects of Hydrologic Conditions, and Water Use by Riparian Vegetation

Fremont Cottonwood (*Populus fremontii*)-Goodding Willow (*Salix gooddingii*) Forest

Cottonwood-willow forests are present mainly in the active flood plain; a few old cottonwood trees are present on the pre-entrenchment terraces. The forests were dense and multi-aged where maximum ground-water depths averaged less than about 3 meters, streamflow permanence was greater than about 60 percent, and intra-annual ground-water fluctuation was less than about 1 meter (Lite and Stromberg, 2005), but declined in abundance and age-class diversity where water availability was less (fig. 4). Cottonwood-willow forests gave way to tamarisk stands as site-average ground-water depths across the flood plain exceeded 3 meters. Conditions were too dry at intermittent-dry streamflow regime sites to allow for establishment of cottonwood and willow seedlings.

Cottonwood sap flow was measured during most of the 2003 growing season to estimate transpiration along a perennial and an intermittent-wet reach (table 2). Cottonwood transpiration at the perennial reach was about 20 percent greater on a per canopy area basis than previous estimates (Goodrich and others, 2000). Cottonwood transpired considerably less at the intermittent-wet reach than at the perennial reach, and had greatly reduced rates of transpiration as ground-water levels declined in the premonsoon season. Reduced transpiration likely was a result of physiological stress. Roughly 40 percent of the cottonwood forests in the SPRNCA were classified as being on intermittent reaches. Work by Snyder and Williams (2000) suggests that cottonwood transpiration was fully derived from ground water at perennial reaches and about 85 percent derived from ground water at intermittent reaches.

Table 2. Total growing-season evapotranspiration of specific vegetation types and annual evaporation from open-water surfaces per unit land area

[---, indicates no data; ET, evapotranspiration; ET is reported per unit land area occupied by each vegetation type; ET is the total water use by the vegetation, including ground- and surface-water sources]

Vegetation type	Water use, in millimeters		
	2001	2002	2003
Mesquite woodland	694	638	670
Mesquite shrubland	---	---	565
Cottonwood – perennial reach	---	---	966
Cottonwood – intermittent-wet reach	---	---	484
Sacaton	---	---	554
Open-water evaporation	---	---	1,156
Seepwillow	---	---	819

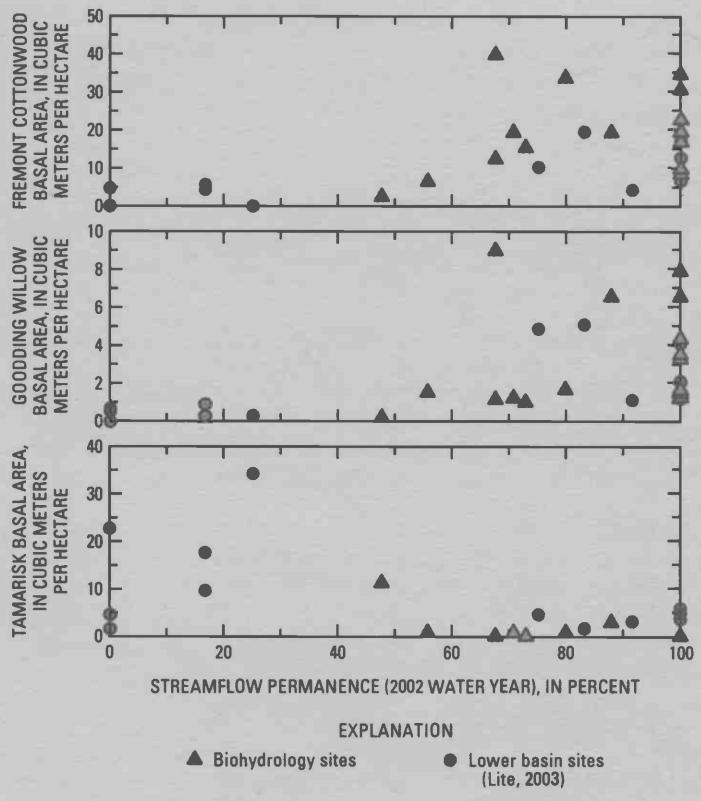

Figure 4. Basal area of Fremont cottonwood, Goodding willow, and tamarisk in relation to streamflow permanence of San Pedro River sites, Arizona. Each data point represents a site. Data shown for the 16 biohydrology study sites in the San Pedro Riparian National Conservation Area, and for 12 sites in the Lower San Pedro Basin, Arizona (Lite, 2003).

Mesquite (Prosopis velutina) Woodland and Shrubland

Velvet mesquite is deep-rooted and can survive in areas where it does not access ground water, but forms denser stands when in riparian settings. It was widely distributed in the SPRNCA, being abundant at dry and wet sites and on flood plains and terraces. Growth form and abundance of velvet mesquite was related to site elevation (with trees larger and more abundant at downstream sites) and to average flood intensity but not to site water-availability factors.

Mesquite is the most abundant vegetation type within the SPRNCA. Multiyear ET observations from a mature mesquite woodland and a mesquite shrubland indicate that (1) both used substantially more water than previously estimated, and (2) their water use was nearly equal on a per unit canopy area basis (table 2). Stable-isotope measurements ($\delta^{18}O$) revealed considerable seasonal variation in the proportion of mesquite transpiration derived from ground water between sites. Mesquite used a combination of surface (recent precipitation), ground-water, and deep (1 to 10 meters) vadose-zone sources depending on the availability of each source through the season. There was a tendency toward proportionally less ground-water use in mesquite stands that had comparatively less access to ground water (deeper water table). Nevertheless, mesquite at all isotope sample sites used substantial quantities of ground water.

Sacaton (Sporobolus wrightii) and Other Herbaceous Vegetation

The perennial grass sacaton occupies more area on the Upper San Pedro River flood plain than any other herbaceous plant species and is also abundant on terraces. Bermuda grass and johnson grass also have high cover on flood plains. These common flood-plain plants show some seasonal variance in cover and likely use a variety of water sources, including ground water, precipitation, and flood water, depending in part on seasonal availability. Some plant groups, including wetland annuals, upland annuals, and xerophytic perennials, increased sharply in abundance following the summer monsoonal rains and floods; this relation likely indicates primary reliance on monsoon water sources.

The ET of sacaton in this study (table 2) was substantial and was partially derived from ground water; this result differs from a previous study that reported that sacaton did not use ground water (Scott and others, 2000). The likely reason for this discrepancy was shallower ground water depths (less than 3 meters) at sacaton sites in the current study. High-resolution topographic measurements suggest that about 30 percent of the total sacaton within the SPRNCA likely grows where depth to ground water is less than 3 meters.

Tamarisk (Tamarix ramosissima)

Currently, there is a relatively small amount of tamarisk in the SPRNCA, mainly restricted to areas north of Fairbank. In contrast to the patterns of cottonwood and willow, tamarisk abundance increased at dry sites, likely due, in part, to reduced competitive interactions with cottonwood and willow trees (Sher and Marshall, 2003). This study also found that the relative abundance of tamarisk to that of cottonwood-willow along the San Pedro River has been stable at many sites but has increased over time at other sites, including those in the Palominas and Boquillas-Fairbank areas and north of Fairbank. Recent increases in tamarisk abundance may be indicative of decreasing site water availability.

For the water-use estimates, ET rates and ground-water use patterns of tamarisk were assumed to be similar to those of mesquite, in part, because mesquite and tamarisk have a similar stand structure and are able to acquire ground water at deeper depths than cottonwoods.

Seepwillow (Baccharis salicifolia) Shrublands

Seepwillow is an evergreen shrub that forms thickets on low-lying flood plains adjacent to the stream channel. Seepwillow was most abundant on surfaces where the annual maximum (2002 data) ground-water depth was less than about 2 meters. Seepwillow had very sparse cover at the intermittent-dry sites.

Seepwillow transpiration was measured using sap-flow methods as a preliminary step toward quantification. Because available cover data indicate that total seepwillow area is small in the SPRNCA, ground-water use by seepwillow was likely small and was omitted from the water-use budgets.

Streamside Wetland Vegetation and Open Channels

Among all herbaceous plant groups analyzed, the wetland perennials showed the strongest correlation with surface-water availability. Rushes, bulrush, and other wetland perennial herbs depend on shallow, inflowing ground water and had high abundance only at sites with perennial or near-perennial streamflow; abundance declined sharply as flows became intermittent. The channel-bar vegetation became sparser and less diverse, and species composition shifted towards more mesic species such as bermuda grass (Cynodon dactylon) as sites became increasingly intermittent (along spatial gradients and through time). Wetland herbaceous plants (perennials and annuals) varied in abundance between years; they were particularly abundant in 2001 in response to a large flood in October that increased streamflow in the SPRNCA for several months.

Wetland vegetation ET was not quantified owing to the relatively small area that the vegetation occupies. The evaporation from the river surface (table 2) was determined using potential evaporation and a reduction factor to account for the effect of shading and entrenchment that would reduce this rate relative to the rate for unsheltered open water.

Riparian Condition Class

A riparian condition index was developed, on the basis of field-measured vegetation traits, to diagnose and monitor riparian vegetation condition change as related to changes in streamflow and ground-water conditions. Site index scores allow for categorization into condition classes 1 through 3, each associated with particular ranges for site hydrology, vegetation structure, and ecosystem functional capacity. Condition class 3 indicates ecological conditions reflecting the highest water availability, class 2 indicates intermediate availability, and class 1 indicates the lowest water availability presently occurring within the SPRNCA (table 1). Overall, 39 percent of the SPRNCA riparian corridor fell within class 3, 55 percent in class 2, and 6 percent in class 1 (fig. 1).

At class 3 sites (and reaches), flood-plain vegetation is characterized by tall, dense, multi-aged cottonwood-willow forests and woodlands with intermixed areas of other vegetation types. Drought-tolerant, deep-rooted pioneer species such as tamarisk are subdominant in the forests. The stream channel is lined by dense and diverse herbaceous cover. At class 2 sites, cottonwood and willow are the dominant pioneer trees in the flood plain, but tamarisk presence is increased, and cottonwoods and willow trees undergo dry-season declines in water use and productivity. Major changes in the herbaceous vegetation occur between classes 2 and 3. Streamside cover of wetland plants is reduced, owing to loss of perennial streamflow. Many of the wetland perennial herbs have been replaced by perennials that are more drought tolerant, such as bermuda grass.

In the transition from class 2 to class 1, major changes occur in woody vegetation composition and structure in the flood plain. Hydrologic thresholds for cottonwood and willow survivorship have largely been exceeded and only a few age classes of these species persist in favorable locations. Deep-rooted phreatophytes, typically tamarisk, have replaced shallower-rooted species. Structurally, the flood plain is dominated by shrublands with little upper canopy cover. Streamside herbaceous cover is sparse in the summer dry season.

The vegetation characteristics of the three condition classes provide some measure of the changes in vegetation structure and composition that might occur in response to future changes in base flow and ground-water availability. For example, if streamflow became more intermittent and depth to the alluvial ground-water table increased, herbaceous species such as bulrush and rushes would decline in abundance, and streamside-zone species composition would shift towards species such as bermuda grass. Across the flood plain, cottonwood-willow recruitment rates would decrease and mortality rates would increase; cottonwood-willow forests could give way to tamarisk shrublands. A reverse scenario would occur if streamflows became more permanent and ground water in the alluvium became shallower and more stable.

In all three condition classes, periodic floods of varying size and timing increase diversity by providing the physical disturbance that allows for establishment of a wide range of disturbance-adopted and pioneer plant species.

Scaling-up Water Use Estimates to the System Scale

Vegetation cover maps were used to scale species-specific ET measurements to the system scale. Mesquite ground-water use was the dominant component of the riparian water use, owing to high abundance, followed by cottonwood-willow, open water, sacaton, and tamarisk. Riparian ground-water use in 2003 along the San Pedro River from the international boundary to the USGS streamflow-gaging station near Tombstone, 09471550, (within the Sierra Vista Subwatershed) was calculated to be 9,065,000 to 11,112,000 cubic meters per year (7,350 to 9,010 acre-feet per year), 12 to 37 percent higher than the total that Goodrich and others (2000) estimated for 1997. Combining totals for the Babocomari River and the San Pedro River, 11,840,000 to 14,867,000 cubic meters per year (9,600 to 12,050 acre-feet per year) of ground water was consumptively used within the riparian corridors of the Sierra Vista Subwatershed for 2003. This is 25 to 57 percent greater than the 9,498,000 cubic meters per year (7,700 acre-feet per year) estimate of Corell and others (1996) owing in part to a large disparity between the two studies' estimates for the Babocomari River. It is important to recognize that interannual climatic variability will result in different water-use values year to year (as much as 30 percent for mesquite).

—James M. Leenhouts (U.S. Geological Survey), Julie C. Stromberg (School of Life Sciences, Arizona State University), and Russell L. Scott (Southwest Watershed Research Center, Agricultural Research Service, U.S. Department of Agriculture)

References

Arizona Department of Economic Security, 2003, July 1, 2003, population estimates for Arizona's counties, incorporated places and balance of county areas, accessed November 17, 2005, at http://www.workforce.az.gov/admin/uploadedPublications/1003_EEC-03.pdf

Corell, S.W., Corkhill, F., Lovvik, D., and Putnam, F., 1996, A groundwater flow model of the Sierra Vista Subwatershed of the Upper San Pedro Basin, southeastern Arizona, in Modeling Report No. 10: Phoenix, Arizona Department of Water Resources, Hydrology Division, 107 p.

Goodrich, D.C., Scott, R.L., and 17 others, 2000, Seasonal estimates of riparian evapotranspiration using remote and in-situ measurements: Agricultural and Forest Meteorology, v. 105, p. 281–309.

Leenhouts, J.M, Stromberg, J.C., and Scott, R.L., 2006, Hydrologic requirements of and consumptive ground-water use by riparian vegetation along the San Pedro River, Arizona: U.S. Geological Survey Scientific Investigations Report, 2005–5163, 154 p.

Lite, S.J., 2003, San Pedro River riparian vegetation across water availability and flood disturbance gradients: Tempe, Arizona State University, Ph.D. dissertation, 166 p.

Lite, S.J., and Stromberg, J.C., 2005, Surface water and ground-water thresholds for maintaining Populus - Salix forests, San Pedro River, Arizona: Biological Conservation, v. 125, no. 2, p, 153–167.

Scott, R.L., Shuttleworth, W.J., Goodrich, D.C., and Maddock, T., 2000, The water use of two dominant vegetation communities in a semiarid riparian ecosystem: Agricultural and Forest Meteorology, v. 105, no. 1–3, p. 241–256.

Sher, A.A., and Marshall, D.L., 2003, Seedling competition between native Populus deltoides (Salicaceae) and exotic Tamarix ramosissima (Tamaricaceae) across water regimes and substrate types: American Journal of Botany, v. 90, no. 3, p. 413–422.

Snyder, K.A., and Williams, D.G., 2000, Water sources used by riparian trees varies among stream types on the San Pedro River: Journal of Agricultural and Forest Meteorology, v. 105, no. 1–3, p. 227–240.

For further information, contact:
James M. Leenhouts
U.S. Geological Survey
Arizona Water Science Center
520 North Park Avenue, Suite 221
Tucson, Arizona, 85719-5035
Email: leenhout@usgs.gov or
visit http://az.water.usgs.gov

Legislation and Law

Challenge to AZ's NPDES Primacy May Go to High Court

A question at issue in Arizona might end up before the U.S. Supreme Court; defendants are considering a high court appeal to decide whether state regulators need to consider endangered species when issuing stormwater discharge permits. It is a landmark case with national implications.

In 2002 the Arizona Department of Environmental Quality submitted a request to the regional EPA office to allow the state agency to issue permits and manage compliance with the National Pollutant Elimination System Permitting Program.

A NPDES permit is required to discharge wastewater into a navigable stream. Stormwater discharge permitting is of special interest to developers who are required to have such permits if rain water flows through pipes, culverts ditches or other channels and enters waterways.

The Arizona Legislature provided legal groundwork for ADEQ's request when it passed a bill establishing the Arizona Pollutant Discharge Elimination System. Passed during the 2001 regular session, the bill required ADEQ to seek regulatory authority to replace NPDES with AZPDES. Arizona was within a small minority of six states without this authority when the bill was passed.

Environmentalists expressed concern when EPA approved Arizona's request to manage its own storm water discharge program, fearing the program would not enforce endangered species regulations as thoroughly as federal statutes. The Defenders of Wildlife and the Center for Biological Diversity filed suit in 9th U.S. Circuit Court of Appeals arguing the state administration of the NPDES program would be to the disadvantage of endangered species.

The main issue before the court was: does the Endangered Species Act authorize, even require the EPA, when considering transferring water pollution authority to a state, to take into account the impact its decision will have on endangered and threatened species and their habitat? Referring to a Fish and Wildlife Service's biological opinion, EPA argued that it lacked the authority to consider such impacts.

Plaintiffs in the case challenged EPA's transfer decision, particularly its adherence to the proposition that its authority is limited.

The court sided with the environmental interests and denied Arizona authority to issue water discharge permits. The court held, "that the EPA did have the authority to consider jeopardy to listed species in making the transfer decision, and erred in determining otherwise. For that reason among others, the EPA's decision was arbitrary and capricious." For the text of decision see: http://caselaw.lp.findlaw.com/data2/circs/9th/0371439p.pdf

In June the Ninth Circuit Court denied a petition for rehearing on the AZPDES primacy case. The original ruling therefore stands, that the program returns to EPA. In response, a motion was filed to stay issuance of the mandate to allow for an appeal to the Supreme Court. This was granted; ADEQ therefore maintains permitting authority pending the filing of a request that the Supreme Court hear the case. Opinions vary about the chances that the Supreme Court will take the case.

A Supreme Court refusal to hear the case will raise questions about ADEQ-issued permits; it would then have to be determined which remain valid and for how long. Also the status of pending applications would have to be decided.

The National Association of Home Builders is heading an effort to organize support among state officials and other interested parties to petition the Court.

Report: TCE Cancer Threat Greater Than Thought

A recent National Academy of Sciences report stating that increased evidence is available that TCE can cause cancer in humans is prompting a call that current TCE limits in drinking water be reconsidered. The Environmental Protection Agency's current standard limits TCE to no more than 5 parts per billion.

The results of the NAS 379-page report vindicates a 2001 EPA draft document warning that TCE or trichloroethylene posed a much greater cancer risks than previously thought. The draft report was not received well by the Defense Department, the Energy Department and NASA, agencies maintaining TCE-tainted sites. For example, the Pentagon has 1,400 contaminated facilities. Critics argued that TCE was not dangerous at low levels of exposure

In response to allegations that the EPA inflated the TCE risk, the Bush administration directed the NAS to review the issue. The report stated that additional information available since the draft report supports its premise.

The report states, "The committee found that the evidence on carcinogenic risk and other health hazards from exposure to trichloroethylene has strengthened since 2001. Hundreds of waste sites are contaminated with trichloroethylene, and it is well documented that individuals in many communities are exposed to the chemical, with associated health risks."

The report is providing grounds for EPA to undertake another TSE risk assessment, this time with information from the report, to determine if drinking water standards should be revised. Some are calling for the standard to be dropped to 1 ppb for drinking water.

The NAS report states that TCE is a pollutant at about 60 percent of the nations's worst contaminated sites in the Superfund program. If EPA adopts stricter TCE water quality standards, more thorough and more costly cleanup operations would likely be required at various military and other polluted facilities, at a costs of billions of dollars.

Meanwhile the Arizona Department of Environmental quality has published new standards pertaining to TCE in the soil. Now set at 27, standards for residential property were lowered to 17, school property dropped from 27 to 3 and commercial property lowered from 70 to 65.

Publications & On-Line Resources

"Layperson's Guide to Arizona Water," a WRRC Work in Progress

As part of its commitment to serve the water education needs of Arizona citizens, the Water Resources Research Center has teamed up with the Water Education Foundation to produce a "Layperson's Guide to Arizona Water." Publication date is set for February, 2007.

The publication will meet a longstanding need: it will offer in a single, reader-friendly source information Arizona citizens need to know to be well informed about state water issues.

Water professionals know that water information flows from various sources, from government reports to web sites. What has not been readily available is a single, focused and succinct source that the nonprofessional can dip into.

Few would doubt the need for a citizens' guide or primer describing the ins and outs of Arizona water. Arizona is a rapidly growing state attracting people from many different areas who need to be educated about water in semi-arid Arizona. Also many current Arizona citizens would benefit from an overview of state water issues to better participate in addressing water problems. Or the guide could serve just to satisfy the curiosity of those who are interested in the fascinating topic of Arizona water.

Various organizations have generously contributed to the project. These include Central Arizona Project, Salt River Project, U.S. Bureau of Reclamation - Phoenix Area, Arizona Municipal Water Users Association and the Southern Arizona Water Users Association.

An advisory committee made up of Arizona water professionals will provide guidance and advice in the writing of the guide.

The "Layperson's Guide to Arizona Water" will be available in a printed version from the Water Education Foundation as well as on-line at the WRRC web site.

ADWR's Arizona Water Atlas, Vols. 1 and 2, Available

The Arizona Department of Water Resources has issued draft versions of the first two volumes of the Arizona Water Atlas; the completed project will consist of nine volumes. The Atlas is described in a press release as "a compilation of currently available water-related information for the State of Arizona." Much water information is contained therein, to serve several primary purposes: provide an overview of state water supply and demand conditions; to be a source of water resource information for planning and resource development purposes; and to assist in identifying the water-related needs of communities throughout Arizona, particularly those outside the Active Management Areas.

Non-AMA, primarily rural areas receive special attention since such locations are in particular need of water information for planning and management purposes. The Atlas staff seeks to identify issues requiring further study, note water resource concerns facing rural Arizona communities and help find solutions. The Atlas is part of a renewed and more systematic ADWR effort to maintain a rural Arizona database.

That water is managed differently within the AMAs than outside AMAs influences the organization and to some extent the content of the Atlas. The introductory Volume 1 is followed by individual planning area volumes (Volumes 2-7) for each of the six planning areas outside of AMAs. Treated as a separate planning area, the AMAs are described in Volume 8; Volume 9 is a summary volume covering the entire state.

Draft versions of Volumes 1 and 2 are available on the ADWR website: www.azwater.gov Public and professional comment is invited; the atlas will be revised based on received comments. An electronic comment form is available on the website. ADWR plans to finalize the Atlas in early 2007, with printed copies and CD-ROMs available. For additional information, contact: Linda Stitzer, Atlas co-manager: 520-770-3815 or lsstitzer@azwater.gov

Discourse on Water

The summer issue of the quarterly journal Reconstruction: Studies in Contemporary Culture is dedicated to water; its theme is "Water: Resources & Discourses." The academically orientated journal takes a philosophical or cultural look at the topic. A question asked in its introduction is: "Is there a field of knowledge, a sector of the economy, a practice of everyday life that is not quickened by water and its multifarious uses and significations?" The issue intends to attract the attention of water professionals who will find a nontraditional approach to their interests. The issue is available on-line at http://reconstruction.eserver.org/063/contents.shtml

Research Publications and Presentations on the Binational Upper San Pedro River Basin, Arizona/Sonora 1997-2006

The University of Arizona's Udall Center for Studies in Public Policy

The above bibliography provides a chronology and synopsis of research on the Upper San Pedro River basin published by Udall Center researchers and their collaborators over the past decade. The documents explore the roots of conflict and cooperation in the basin, focusing on water resources management as identified and examined during the Center's engagement in the region. Much of the research was prompted by an interest in maximizing opportunities for cross-border cooperation and stakeholder involvement. Researchers interested in these topics, either in the San Pedro River basin or other watersheds, will find the bibliography a useful introductory guide. The document is available at the Udall web site: http://udallcenter.arizona.edu/

Special Projects

WRRC-Funded Research Projects Produce Results

The University of Arizona Water Resources Research Center administers Section 104B of the Water Resources Research Act, funded by the U.S. Geological Survey. Funds support small research projects that focus on state and regional water issues, reflecting the WRRC mission of promoting understanding of critical state and regional water management and policy issues. Only faculty at Arizona state universities are eligible for 104B funding. Following are research results of recent 104B projects:

Preliminary Evaluation of Perchlorate Contamination of Ground Water In The Lower Colorado River Region; Charles Sanchez, University of Arizona, Yuma Agricultural Center.

There is a concern that years of irrigation with perchlorate-contaminated Colorado River water may have contaminated the Yuma aquifer with perchlorate, and that communities around the greater Yuma region using groundwater as their source of potable water may be exposed to perchlorate by drinking perchlorate-contaminated groundwater. The results of a conducted survey showed that well waters being used by PWS and rural households are well within regulatory limits of perchlorate. Detectable perchlorate concentrations are mostly limited to wells less than 20 ft in depth, and the concentration ranges seen reflect concentrations seen in the Colorado River water, which is within the calculated EPA DWEL of 24.5 µg/L.

An Outdoor Multi-stage, Continuous-flow Photobioreactor for Bioremediation of Nitrate-contaminated Groundwater; Qiang Hu, Dept. of Applied Biological Sciences, Arizona State University East, Milton Sommerfeld, School of Life Sciences, ASU.

Groundwater makes up more than 40 percent of Arizona's drinking water supply. Widespread and persistent nitrate contamination in the groundwater poses a concern to health and the state's and region's economic prosperity. Several conventional chemical and physical technologies have been proposed or tested for groundwater nitrate removal. The projected high capital and operational costs, however, have prohibited commercial applications of these approaches. In this study, a pilot-scale Multiple-stage, Continuous-Flow Photobioreactor has been successfully designed, fabricated, and operated under outdoor conditions for groundwater nitrate removal. Preliminary results indicate that MCP can be a cost-effective, sustainable nitrate removal system for use as a centralized facility for large cities such as Phoenix and Tucson; a scaled-down model would be suitable for small communities in remote areas. Furthermore, algal biomass produced as a by-product from the photobioreactor can be used as an organic fertilizer or animal feed, providing additional value to this advanced environmental clean-up green biotechnology.

An outdoor multi-stage, continuous-flow photobioreactor (MCP) for groundwater nitrate removal.

Big Chino 3-D Digital Hydrogeologic Framework Model, Abe Springer, Dept. of Geology, Northern Arizona University.

The objectives of the study were to further define the subsurface geology of Big Chino Basin and to create an interactive three-dimensional digital hydrogeologic framework model using EarthVision. Well logs re-interpreted for lithology, in combination with geophysics data and a geologic map prepared by the U.S. Geological Survey were used as the basis for the hydrogeologic framework. A hydrogeologic framework is similar to a geologic framework except that unit designations are based on hydrogeologic properties rather than stratigraphy. The completed model will be presented to relevant stakeholders this summer.

Opportunities for Passive Restoration of the Salt River Riparian Corridor, Juliet C. Stromberg, School of Life Science, Arizona State University.

Portions of the urbanized Salt River have been dewatered and are now targeted for ecosystem restoration by measures such as tree planting. Little attention has been paid to the potential for natural redevelopment of plant communities along this river reach. We investigated the vegetation and soil seed banks of three reaches of the Salt River in and near Phoenix to determine 1) how the riparian plant community has been altered by diversion of stream flow and 2) how the pockets of riparian vegetation that developed naturally at rewatered urban reaches compare to those in the upstream perennial reach.

Results indicate that long-term diversion of the Salt River has converted a species-rich hydromesic riparian forest/shrub community to a species-poor xeric shrub community. Yet, riparian species, such as cattail (Typha domingensis) and umbrella sedge (Cyperus odoratus) are present in the seed bank of these xeric shrublands. Species richness and functional group composition of the riparian patches in the rewatered urban reach (near urban storm drains) were very similar to values in the upstream rural perennial reach.

These findings have implications for the way riparian restoration is approached. These small riparian storm drain communities provide anecdotal evidence for the resilience of this system, given adequate restoration of stream flows and sediments. The species composition of these sites provides an example of a plant community that can establish and maintain itself with limited intervention under these altered conditions. Also, these communities, if left intact during the planned restoration interventions, could function as source of propagules for the establishment of riparian species in adjacent reaches.

Announcements

Research Funding, Special Event Are Opportunities For AZ Universities

WRRC Invites Research Proposals

The University of Arizona's Water Resources Research Center will soon issue a request for proposals for research grants under the Water Resources Research Act, Section 104B. Funded by the U.S. Geological Survey, Section 104B provides support for small research projects on water-related issues of importance to the state and region. Faculty members at the three Arizona state universities may submit proposals. The WRRC typically funds three to five small grants of about $10,000 to $12,000. Projects are funded for 12 months and will start March 1, 2007. To receive a notice of the RFP announcement, contact Terry Sprouse at tsprouse@ag.arizona.edu or 520-792-9591 ext. 13.

Arizona Water Institute Issues RFP

The Arizona Water Institute is issuing a RFP for a new grants program with proposals due Sept. 22. Information is available at http://www.azwaterinstitute.org/rfps.html. Faculty and staff from Arizona's state universities must be the primary applicants; grants are for applied projects with direct benefits to water quality and water quantity management stakeholders. Projects also must be collaborations between the universities and/or directly partnered with stakeholders. Please note that there are "theme leaders" associated with a series of research topics. If you have any questions about a potential project idea please contact either the campus coordinators for the three campuses (http://www.azwaterinstitute.org/campus-coordinators.html) or the theme leaders (http://www.azwaterinstitute.org/themeleaders.html).

Questions about the RFP can either be addressed to the coordinators or to Kathy Jacobs at kjacobs@azwaterinstitute.org

UA Water Forum Scheduled

The Water Sustainability Program (WSP) is sponsoring the second annual University of Arizona Water Forum, Nov. 2 at the UA Student Union, South Ballroom from 2:00 to 5:00 pm. This year's event will feature UA faculty and staff talking about "Tools and Technology for the Water Trade," supported through TRIF (Technology and Research Initiative Fund) funding. Posters on campus water related research, outreach and education activities are invited. Student entries will be eligible to enter a poster competition that will offer cash prizes. Please see the WSP web site for details as plans are finalized: http://uawater.arizona.edu/cgi-bin/uawater/news.pl?ID=50

Agricultural Water Reuse Conference

The WateReuse Association, the U.S. Department of Agriculture and Washington State University will present a specialty conference on Opportunities and Challenges in Agricultural Water Reuse October 29-31 in Santa Rosa, CA. The conference will cover success stories in agricultural reuse, the USDA's role in water management, regulations and health aspects of the use of recycled water on edible and nonedible crops, economics, technology, and public perception. For more information check http://www.watereuse.org/USDA_conf.html

Call For Proposals AZ - NM History Convention

Persons involved in the history of water take note: the program committee invites proposals for papers on any aspect of Arizona history or New Mexico history for presentation at the Arizona-New Mexico Joint History Convention at Pinetop-Lakeside, AZ. Proposals must be submitted by Oct. 1 to Bruce Dinges, c/o Arizona Historical Society, 949 E. Second Street, Tucson, AZ 85719. For more information, contact Bruce Dinges, 949 E. Second Street, Tucson, AZ 85719, (520) 628-5774, or check: www.arizonahistory.org.

Research Conference on the Pesky Tamarisk

The "Tamarisk Research Conference: Current Status and Future Directions" will be conducted Oct. 3 - 4 in Fort Collins, Colorado. In efforts to better manage the non-native tamarisk (Tamarix spp.), scientists across the West have been conducting research on the habitats it occupies, its effects on ecosystems, control methodologies and restoration approaches. The purpose of this conference is to bring tamarisk researchers together at a single venue to share their results with other scientists and western land managers so that future management efforts can be guided by the state-of-the-science. Additionally, this conference will promote dialogue between researchers and managers to identify future research needs for the development of effective policy and management decisions. To register and for more information check: http://www.tamarisk.colostate.edu

Public Policy Review

by Sharon Megdal

Visit Shows Israel Faces Similar Water Management Issues as Arizona

I traveled to Israel this summer to present a paper at a conference and to meet with researchers and other water professionals to learn about Israeli water management and policy. My perception was that, while quite a bit of Arizona-Israeli collaboration on technical water issues seemed to have occurred, less had taken place in the social science and policy arenas. I hoped to build upon recent collaboration with an Israeli resource economist. My trip was extremely productive. Fortunately my travels were unaffected by the violence in Gaza; the trouble to the North did not erupt until after I returned to the United States.

I met with officials from the Israel Water Commission and Mekorot (the national water supplier); I also met with researchers from several disciplines and university campuses. I heard conference presentations on issues relating to water for the environment and water levels in the Sea of Galilee.

Although Israel and Arizona have much different systems for managing water resources, the water management issues are very similar: drought, salinity, seawater desalination, effluent re-use, institutions, water pricing, and allocation across water using sectors (including the environment). I will discuss a few of these issues.

The institutional setting for water policy in Israel is changing. The Ministry of Infrastructure's Water Commission had set water allocations and oversaw much water policy. Different ministries handled other water matters, such as water quality and determining allocation of water for the environment. I was told, however, that a new Water Authority, recently established by the legislature, will bring together various ministries to promote better coordinated water management. The head of the Water Authority, to be housed in the Ministry of Infrastructure, will have a five-year appointment and will work with a board of representatives from the various ministries (Agriculture, Treasury, Infrastructure, Environment, Interior Affairs) plus two appointees from the public. Time will tell if the Water Authority, which is just being implemented, will work as envisioned.

Israel has a very centralized approach to allocating water. The country faces the same issues as Arizona does in times of drought: how much water to take out of storage and the extent of water cuts. Israeli agriculture is viewed as a sector more able than the municipal sector to cut back water use during drought. Agricultural water allocations are largely at the discretion of the central government; cutbacks do not depend on voluntary arrangements for water transfers, as contemplated in the western United States. The papers I read in preparation for my trip noted that the agricultural sector represents a strong lobby in Israel; it emphasizes the importance of its operations for providing home-grown food supplies and preserving open space and green areas.

Israel has the advantage of a seacoast. I visited what is said to be the world's largest operating seawater RO (reverse osmosis) desalination plant and surprised Israelis with my interest in seawater desalination. I explained that desalination along coastal California has the potential to enable landlocked Arizona to gain more Colorado River water. Israel, like the United States, has long considered seawater desalination. Repeated droughts there have prompted a program to construct several plants over a five-year period to eventually deliver 315 million cubic meters of freshwater. With construction having begun in 2003, the plant in Ashkelon was built through a public-private partnership as a build-operate-transfer (BOT) facility. Fully operational in 2005, the plant produces 100 million cubic meters (approximately 81,100 af) of desalted water per year. It is a 20-minute process to produce fresh water. Also Israel shares Arizona's interest in removing salts from brackish groundwater, with projects underway in the southern part of the country.

Using detailed hydrologic information, the Water Commission and Mekorot, which supplies about two-thirds of the water used in Israel, have developed a management system to limit the amount of high-salinity water entering the water system from the Sea of Galilee. The Galilee's lowering water levels, however, are a concern, reflective of recent drought conditions and decisions regarding how much water to draw out of storage.

An important global concern is environmental water needs, an issue the Israeli Ministry of the Environment must consider in response to recent legislation. As we in Arizona know, restoring lost riparian areas, necessary for flora and fauna and valued by people, is difficult. Yet Arizona has not developed a strategy for recognizing the environment as a water-using sector. Observing Israeli efforts as well as those of other locales, including Victoria, Australia (the subject of two presentations at the conference), could be of value to Arizona and other semi-arid or arid regions.

Water re-use is an important issue. The Israelis hope to increase agriculture's approximately sixty percent use of the country's effluent to 80 to 85 percent. Arizona's effluent picture is much different, with reclaimed water mostly used for golf courses, turf irrigation and as cooling water for the Palo Verde Nuclear Power Station. Various factors limit Arizona's agricultural use of effluent, including a lack of proximity to sources of effluent, as well as cost and other considerations.

My limited introduction to Israeli water pricing indicated that, as is true elsewhere, water pricing involves economic as well as political/policy considerations. Compared to Arizona, water pricing is a much more centralized function. Prices are set in ways, however, that do not necessarily cover costs of service. Tiered pricing has been introduced in the agricultural sector, and an extraction levy has been assessed to reflect the scarcity value of the water resource, a policy economists advocate but rarely see considered, let alone adopted, by policy makers.

Water resource management concerns across the globe are frequently very similar, although countries often approach them differently. That we can learn from each other's experiences is clear. I hope my visit leads to future collaborations and additional learning opportunities for myself and others.

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often grown. This will increase water use.

Residential Water Use

What effect might the UHI have on residential water use? Some believe its effect is already evident, if not recognized in water use records. For example, Gober says, "Residential water use in Phoenix has declined over time on a per capita basis. But I think it would have declined faster than it did due to conservation practices if the UHI had not been around."

Subhro Guhathakurta of ASU's School of Planning and the Global Institute of Sustainability and colleagues are studying the effect the UHI has on Phoenix residential water use. They want to determine if a higher UHI temperatures will result in increased residential water use.

Despite UHI's overall impact and its general increase in temperature over a broad area, a spatial variation is evident, with different nighttime temperatures occurring in localized areas. By focusing on the spatial variations in summer nighttime temperatures Guhathakurta wanted to determine what effect varied nighttime temperatures have on household water use.

He looked at average water demand for single-family residential units by census track and correlated it with certain water demand variables, including size of house and lot, size of pool and amount of vegetation. Demographic variables also were included in the analysis, along with nighttime temperature variables.

Guhathakurta says, "We discovered that the nighttime temperatures were a fairly significant predictor of water demand." A cross-sectional analysis of a detailed dataset of water use in June 1998 showed that water demand for single-family residences increases two percent for each percent rise in nighttime temperatures.

He described the work as an exploratory study to determine whether the UHI significantly affects residential water use. He plans follow-up studies to better understand the cause-and-effect relationships that account for the increased residential water use.

An Anomaly

With UHI raising concerns about increased water use, one study stands out by suggesting that the UHI might actually cause an increase in precipitation in a certain situation. J. Marshall Shepherd, a climatologist at the University of Georgia, relied on a 108-year-old data record as well as data from NASA's Tropical Rainfall Measuring Mission satellite to study rainfall patterns in Phoenix. His records showed a 12 to 14 percent increase in monsoon rainfall in the northeast suburbs of Phoenix from the pre-urban (1895-1949) to the post urban (1950-2003) periods. Other areas in the region did not share this rainfall increase.

Shepherd said, "There was something strange and interesting about that lower Verde River basin area to the northeast of downtown Phoenix." He wanted to account for the anomaly.

He hypothesizes that UHI conditions are a likely factor to account for the increased rainfall. He says, "During the monsoon season thunderstorms form in the mountains east of Phoenix. Many of those storms produce outflow boundaries that move west toward the city of Phoenix. We hypothesize that the outflow from those mountain storms are interacting somehow with the urban heat island circulation in the northeastern part of the metro area; that is why it is a preferred area for enhanced rainfall."

He says, "The results showed us just how sensitive the water cycle can be to human-induced changes, even under arid or drought conditions."

Reducing the UHI effect would be good news, although its reduction also might result in more water being used. A major concern about UHI is that its higher temperatures will discourage growth and development. Reducing the UHI then might ensure continued growth which in turn might mean more people using more water.

When it comes to conserving water, reducing the UHI effect could be a win-some, lose-some situation.

Arizona Water Resource

Water Resources Research Center
College of Agriculture and Life Sciences
The University of Arizona
350 N. Campbell Ave
Tucson, AZ 85721

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