Southwest HYDROLOGY
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Riparian Restoration

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Southwest HYDROLOGY
The Complete Hydrologic Resource

A bimonthly trade magazine for hydrologists, water managers, and other professionals working with water issues.

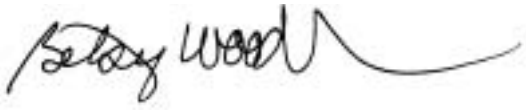
From the Editor

*This issue marks the completion of the first year of **Southwest Hydrology**. The response to the magazine has been extremely positive, and has confirmed that there is indeed an audience for this type of publication. We are excited about the features and articles we have planned for our second year, and want to thank the many readers who have helped us shape its content.*

*Our second year of publication will bring one big change: a switch to paid subscriptions. Our year of free subscriptions allowed us to develop our product and distribute **Southwest Hydrology** widely; however, we can not operate over the long term that way. The nominal $35/year subscription rate will allow us to continue to provide you with high-quality content at a good value. In order to avoid missing the next issue, featuring desalination issues in the Southwest, we will need to receive your subscription payment by April 11.*

Our current feature takes us to surface water and the issue of riparian restoration. This topic has gained considerable attention recently, and we wondered if there is any consistency in how restoration actually occurs. As you will read, a variety of methods can be applied, and not surprisingly, no single formula works in all settings. The issue of trying to eradicate non-native (alien) species is addressed in a thought-provoking manner, and we also learn about a local restoration operation on the U.S./Mexico border. We are grateful to all the features authors for their contributions, including photographs, to this issue.

We thank all of our contributors listed on the opposite page, and as always, encourage your comments and news. And — don't forget to send in your subscription!



Betsy Woodhouse
Editor

Cover photos: 1 and 2 – San Pedro River, southern Arizona, near Charleston Bridge. Photo 1 – July 1990; Photo 2 – July 1992 after two years of voluntary (by landowner) rest from grazing. (Photos: BLM San Pedro National Riparian Conservation Area). Photo3 – Incised channel created by erosion following the Cerro Grande fire near Los Alamos, NM, 2000. (Photo: John A. Moody, U.S. Geological Survey) Photo 4 – Volunteers planting rooted cottonwood cuttings, S. fork of Kern River, CA. (photo: Ron Riller). Photo 5 – Overbank flooding along the Bill Williams River, Arizona during a high flood release from Alamo Dam. (Photo: Patrick Shafroth)

Inside This Issue

Departments

When Riparian Systems Decline:

An array of natural and human-generated processes can degrade the proper functioning of Southwestern riparian areas. A range of disturbances can affect these desert oases from the sub-alpine headwaters to flowing desert bosques. To manage, protect, or repair riparian systems that are in decline, we need to fully understand the causes and effects of the changes we have made throughout the entire watershed. Several experts share their thoughts on what has gone wrong, and what might be done to reverse the decline of riparian areas.

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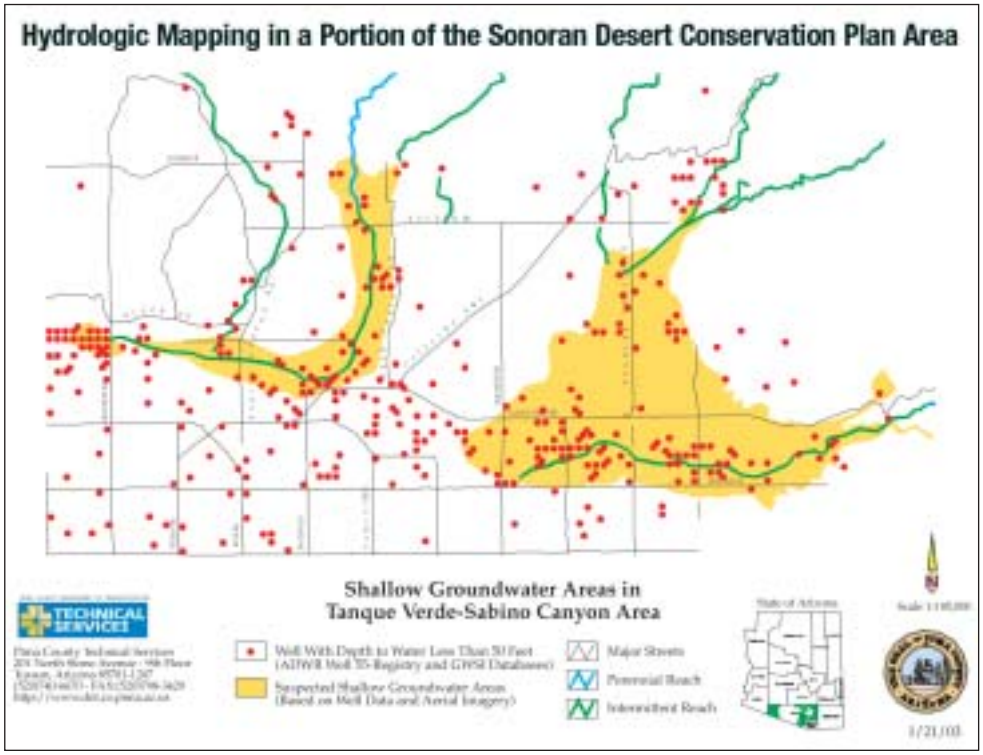
Science, Water, and the Sonoran Desert Conservation Plan

Barbara Tellman *– consultant on water and environmental history topics*

Pima County in southern Arizona has, for the past three years, been developing the nation's most comprehensive attempt to protect threatened and endangered species, while also accommodating a whole range of human land uses in this area. The resulting Sonoran Desert Conservation Plan (SDCP), still a work in progress, designates areas for environmental and historic preservation as well as areas suitable for human use. Covering more than 9,100 square miles, Pima County is one of the largest counties in the nation and the plan's environmental resource studies encompass the entire area except tribal lands. A full description of the plan is outside the scope of this article, but more information is available on the SDCP web site. CDs containing the major studies are available from the county.

In many similar planning efforts, studies such as this one have been given lower priority than political considerations. One important aspect of the SDCP is the value that political decision-makers have placed on good science.A team of the leading local biological scientists, including representatives of government agencies and the University of Arizona, was assembled to develop the plan and identify the role of water-related studies. The team met regularly to discuss which species should be included, how their habitat needs should be defined, and to recommend the most effective land uses to protect those species and habitats. The team and county staff oversaw the consultants who conducted detailed studies. More than 75 reports resulted from this collaboration.



In addition to the Science Team, a Cultural Resources Team performed a similar role for historical and archaeological resources, also a significant part of the plan. A Ranching Team and a Parks and Recreation Team also provided valuable input. SDCP has been developed under the general oversight of a 75-member Steering Committee that includes ranchers, developers, environmentalists, and others. All team and committee members served as unpaid volunteers.

In this arid region, the importance of water is paramount. The Pima Association of Governments (PAG) conducted one of the earliest water studies, mapping perennial and intermittent streams in the county. PAG also mapped shallow groundwater areas and areas of groundwater pumping to determine the locations most in jeopardy from groundwater pumping. Pima County staff identified previously unmapped springs, and a consulting firm mapped and classified riparian vegetation communities.

University of Arizona researchers studied water resources and water-related legal issues, water conservation, and, with an engineering firm, mapped the distributary flow floodplains. Another study looked at environmental justice issues, including studies of water supply and quality as related to low income and minority populations.

The final land use plan will include riparian areas in special need of protection, along with natural park expansion and wildlife conservation areas. These will be acquired through a combination of outright purchase, conservation easements,

See SDCP, page 32

International Center for Water Technology Created in San Joaquin Valley

***David Zoldoske** – International Center for Water Technology*

California State University, Fresno (Fresno State) and the San Joaquin Valley Water Technology industry have recently joined together to form a public-private partnership dedicated to the development and promotion of new technologies that maximize the effectiveness of water use for agricultural, commercial, environmental, and municipal applications. The new entity is the International Center for Water Technology (ICWT), a collaborative venture between industry, academia, and public agencies across the country.

The ICWT was formed from the premise that access to useable water is developing into the greatest challenge of this century. The world's ability to find, use, clean, recycle, transport, distribute, sell, tax, and conserve water will determine in large measure whether the world will progress or digress in the next 100 years. ICWT believes that the technology to properly use and manage water is the critical tool to providing sufficient water supplies for the world's major needs.

In addition to providing a technology demonstration facility, the ICWT plans to advance water and fluid science technologies in four primary areas:

- ***Research and Development:*** The R&D Division of the ICWT will incorporate

See ICWT, page 33

Passive Diffusion Bag Samplers: A Cost-Effective Sampling Method for VOCs

Dee O'Neill *– Columbia Analytical Services and* ***Hugh J. Rieck*** *– Arizona Department of Environmental Quality*

The use of passive polyethylene diffusion bag (PDB) sampler technology in long-term groundwater monitoring projects for volatile organic compounds (VOCs) provides a cost-saving alternative to conventional sampling methodologies, eliminating well purging and decreasing field labor and waste disposal costs. In typical applications, they provide depth-specific, time-weighted samples of dissolved phase VOCs. Like all sampling methods, PDBs have their own characteristic strengths and limitations that determine their applicability given the data quality objectives and contaminant hydrology of the wells being monitored.

Developed and patented by Don Vroblesky of the USGS and Thomas Hyde of General Electric, PDBs are made of low-density polyethylene, acting as a semi-permeable membrane. The membrane is fashioned into a long sealed tube, typically 24 inches long and 1-1/4 inches in diameter, filled with approximately 230 mL of certified, laboratory-grade, deionized water. Different sizes are available to meet sampling requirements. The PDB is lowered into a groundwater well and suspended at a specific depth in the saturated portion of the open (screened) interval of the well. They rely on natural advective movement of groundwater across the open interval and, in the absence of vertical flow through the well, reflect dissolved phase VOC concentrations in the aquifer immediately adjacent to the well screen. Most VOCs, excluding certain ketones, ethers and alcohols, diffuse though the membrane. Diffusion occurs until equilibrium is established between VOC concentrations in the groundwater and those in the PDB. The PDB is then raised to the surface and the contents transferred into vials, which are sent to laboratories for analysis.

Compounds showing good correlations with other methods			
Benzene	Dibromochloromethane	trans-Dichloroethene	1,1,2-Trichloroethane
Bromodichloromethane	Dibromomethane	1,2-Dichloropropane	Trichloroethene
Bromoform	1,2-Dichlorobenzene	cis-1,2-Dichloropropene	Trichlorofluoromethane
Chlorobenzene	1,3-Dichlorobenzene	1,2-Dibromoethane (EDB)	1,2,3-Trichloropropane
Carbon tetrachloride	1,4-Dichlorobenzene	trans-1,3-Dichloropropene	1,1,2,2Tetrachloroethane (PCA)
Chloroethane	Dichlorodifluoromethane	Ethyl benzene	Tetrachloroethene
Chloroform	1,2-Dichloroethane	Naphthalene	Vinyl chloride
Chloromethane	1,1-Dichloroethene (1,1-DCE)	Toluene	Xylenes
2-Chlorovinyl ether	cis-1,2-Dichloroethene	1,1,1-Trichloroethane	
Compounds showing poor correlations with other methods			
Acetone	Methyl-tert-butyl ether (MTBE)	Styrene	Methyl-iso-butyl ketone2 (MIBK)

VOC diffusion correlation with samples taken by other methods. (From Vroblesky and Campbell, 2001 and Sivavec and Bagel, 2000.)

In laboratory studies, the VOCs in the table above were shown to exhibit good diffusion and good correlation with samples taken by other methods.

Hydrologic and field data suggest that PDBs be left in place at least two weeks to allow ample time for equilibration of contaminant distribution and restabilization of the well and flow-dynamics to occur after PDB deployment (possibly longer for poorly permeable formations). In quarterly monitoring situations, PDBs are routinely left in wells for the full quarter, allowing sample collection and deployment of next quarter's PDBs to occur during a single field event.

Ions, large or strongly polar molecules, and hydrophilic compounds do not diffuse well across polyethylene. Therefore, some contaminants of interest, like semivolatile organics, oxygenates, metals and other inorganic parameters are not candidates for sampling by PDB technology. However, the diffusion characteristics of PDBs can solve problems that plague samplers of alkaline or turbid wells. Because sediment, including colloidal clay particles, cannot diffuse into PDBs, turbidity and associated matrix interference will cease to be a

See PDB Samplers, page 34

EPA's Online Tool Allows Access to Environmental Compliance Records

On Nov. 20, the U.S. Environmental Protection Agency (EPA) announced the release of the Enforcement and Compliance History Online (ECHO) tool, giving the public direct access to the current environmental compliance record of more than 800,000 regulated facilities nationwide. A 60-day public comment period began Nov. 20 to provide users and interested parties, particularly those responsible for facilities included within the database, an opportunity to review and comment on ECHO's content, design, and accuracy.

The Web tool integrates EPA and state compliance information for facilities regulated under the Clean Air Act, Clean Water Act, and Resource Conservation and Recovery Act (RCRA). Data reports are updated monthly and cover a two-year period. The system retrieves information from federal and state data entered into EPA databases: the Air Facility System, which provides information on compliance with air permits for various stationary sources of air pollution; the Permit Compliance System, which provides information on companies issued permits to discharge waste water into rivers; and the RCRA Information System, a national program management and inventory system about hazardous waste handlers. ECHO includes links to additional state enforcement and compliance information.

ECHO also provides an online error reporting process that allows users to alert EPA and the states to possible errors, and to ensure continued public participation in data quality.

Visit ECHO at www.epa.gov/echo

Administration Acts on Wetlands Protection

On Jan. 10, the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (Corps) announced a pair of actions that they say will help Americans comply with the Clean Water Act's requirements for protection of the nation's wetlands. These actions, which reaffirm federal authority over the vast majority of America's wetlands, are in response to the Supreme Court's 2001 decision in Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers (SWANCC), which limited federal authority under the Clean Water Act (CWA) to regulate certain isolated wetlands.

The two agencies jointly issued clarifying guidance for the federal government's rules to protect wetlands, which are regulated under the CWA. Simultaneously, the Bush Administration announced its intention to publish an Advance Notice of Proposed Rule Making (ANPRM) to solicit data and information from the public to clarify the extent of Clean Water Act coverage in light of SWANCC. These two steps complement the actions announced Dec. 26, 2002, when the Corps and EPA issued a regulatory guidance letter "to improve wetland protections through compensatory mitigation," and the administration unveiled a National Wetlands Mitigation Action Plan listing 17 action items intended to "improve the effectiveness of wetlands restoration." Through those actions, the agencies assert their commitment to achieving the goal of no net loss of wetlands, and to increase the overall function and value of the nation's wetlands through public and private, regulatory and non-regulatory initiatives and partnerships.

Congress included protections for wetlands in the 1972 Clean Water Act. However, in the SWANCC, a divided Supreme Court held that the Corps had exceeded its regulatory authority under the law when it tried to block construction of a landfill site that would destroy seasonal ponds that provide habitat for hundreds of migratory birds. The court held that habitat protection for the birds was not enough to warrant government jurisdiction over the ponds and raised the question whether the Clean Water Act protects "non-navigable, isolated, intrastate" waters. According to the NRDC, the SWANCC ruling has created confusion by leaving open to interpretation the question of which wetlands are in fact "isolated." Some have read the decision to mean that isolated wetlands -- possibly comprising as much as 30 percent of America's wetlands -- are, in fact, excluded from protection under the Clean Water Act.

Critics of the recent administration rulings claim the administration is weakening the

CWA and threatening existing wetlands. The Natural Resources Defense Council (NRDC) states that the Corps' new "general" permits weaken environmental protection by lifting a 300-foot limit on the destruction of streams, revoking standards that require an acre-for-acre replacement of destroyed wetlands, and loosing restrictions on filling wetlands in floodplains.

The National Wildlife Federation (NWF) and the NRDC say the SWANCC decision and the new administration rulings are inviting the destruction of millions of acres of so-called isolated wetlands, eliminating their important role in providing flood control, natural water purification and essential wildlife habitat. According to Mark van Putten, president of the NWF , the Bush administration would "muddy the waters of the CWA by giving developers unlimited ability to fill, pollute, and destroy many of America's waterways and wetlands. At the same time, the administration is also making it harder for the public and state governments to use the CWA as a tool to protect our country's water resources."

The Federal Register document and additional information are available from EPA's Office of Water: www.epa.gov/owow/wetlands/swanccnav.html

NRDC and NWF statements are available at www.nrdc.org/media/pressReleases/020723.asp, and www.nwf.org/news/wetlands01102003.ht

CA Water Sharing Deal Far From Settled

For years, California has overdrawn its share of water from the Colorado River, which it shares with six other states. In an effort to curb California's consumption, the federal government ordered four Southern California water boards to reach an agreement, called the Quantification Settlement Agreement (QSA), by Dec 31, 2002. This pact would enable California to reduce its annual use of the Colorado River from 5.2 million acre-feet to 4.4 million acre-feet over the next 15 years. A key condition of the QSA is the Imperial Irrigation District's (IID) sale of 200,000 acre-feet per year of Colorado River water to the San Diego County Water Authority (SDCWA). The Coachella Valley Water District (CVWD) and the Metropolitan Water District (MWD) are also a part of the agreement.

Both Coachella Valle and Metropolitan water districts and SDCWA approved the agreement, but the IID voted against approval, according to a Dec. 31 CVWD press release. IID and SDCWA then reduced the terms of the agreement by 30 years and added monetary requirements regarding management of the Salton Sea. MWD and CVWD did not agree with the revisions and the deal fell through.

On Jan. 7, California senators talked of introducing legislation that would cut IID's water supply by 10 percent, according to the *Sacramento Bee*. IID reacted by filing a lawsuit to stop the water cut.

Despite involvement from lawyers and legislators, the parties neared settling on an agreement. In January, water officials met in Sacramento, approaching an agreement on the IID water sale, which was contingent upon the boards' agreement to share river water. The state committed $200 million to pay for Salton Sea environmental programs and $150 million in loan guarantees for Imperial County farmers to install conservation measures, the *San Diego Union Tribune* reported.

Lawmakers are under pressure to renew legislation that would weaken environmental protections for some rare fish and wildlife along the river corridor – a necessary step for progress, according to the *Tribune*.

"We have completed and signed agreements necessary to implement a water transfer with SDCWA," IID General Counsel John Carter said in a Jan. 21 IID news release. IID and SDCWA have also agreed that after 45 years the water sale would end a change from the former 75-year pact, which favors CVWD.

As of press time, Southern California water boards were still in disagreement, and the situation appeared destined for the courts to settle.

Perchlorate Regulation in CA to be Delayed

On Nov. 22, the Associated Press (AP) reported that California's bid to become the first state to set drinking water standards for perchlorate has been delayed. Los Angeles County Superior Court Judge Dzintra Janavs ordered state officials to submit a draft public health goal for perchlorate to a second round of review by scientists, AP said, delaying establishment of the health goal by at least several months.

According to AP, a draft perchlorate goal of 6 parts per billion (ppb) in drinking water for California was announced in March. Kerr-McGee Corp. and Lockheed Martin Corp., which owned sites where perchlorate was either manufactured or tested, then sued the state, seeking a second round of peer review, reported AP. The U.S. Environmental Protection Agency is considering federal perchlorate regulations, and has recommended a more stringent goal of 1 ppb, AP said.

Under state law passed in September, a public health goal for perchlorate concentration in drinking water was to be adopted by Jan. 1 2003, and a primary drinking water standard for perchlorate in public water systems was to be adopted on or before Jan 1, 2004.

According to AP, adoption of the primary drinking water standard in California, which takes into consideration the cost and feasibility of meeting the standard, will likely be delayed by the additional review as well.

(See related article, page 28.)

Critical Management Area Declared in South-Central NM

From the New Mexico Office of the State Engineer

On Dec. 4, 2002, New Mexico State Engineer Thomas C. Turney declared the La Luz/Fresnal and Laborcita Canyon watersheds in south-central New Mexico as Critical Management Areas (CMA). The CMA designation declares that the State Engineer will no longer allow new groundwater appropriations for non-domestic purposes from within the watershed area, and will limit diversions from new domestic wells to 0.30 acre-feet per year. In addition, all permits for domestic wells issued subsequent to this order will require metering.

The order affects the headwaters of the

drainage areas of La Luz-Fresnal-Laborcita Watersheds except for the Mescalero Indian Reservation and ends approximately at the east side of the basin fill. Mr. Turney based this decision on the severe drought that has resulted in greatly diminished surface and subsurface flows.

Visit www.seo.state.nm.us.

New Arizona Governor Identifies Leaders of Natural Resource Agencies

From the office of [then] Governor-elect Napolitano, Dec. 11, 2002

Arizona's new governor, Janet Napolitano, announced in December her choices to lead the state's natural resources agencies. She nominated Mark Winkleman to lead the Arizona Land Department, state Sen. Herb Guenther to head the Arizona Department of Water Resources, and Steve Owens to direct the Arizona Department of Environmental Quality. In addition, Napolitano announced that Lori Faeth will serve as her policy advisor for natural resources and the environment.

Guenther, a Democratic state senator from Yuma at the time of his nomination, was formerly a senior biologist with the U.S. Bureau of Reclamation and a biological assistant with the Arizona Game and Fish Department. He was a member of the Arizona House of Representatives from 1986 to 1993.

The founder and managing partner of MGS Partners, LLC, a commercial real estate business, Winkelman has been a close advisor to Governor Napolitano on land and land use issues.

Owens, an environmental lawyer, comes to the Napolitano administration with a wealth of public service experience. As a Congressional aide, Owens was active in the passage, reauthorization and oversight of several major federal environmental statutes, including the Resource Conservation and Recovery Act (RCRA).

Faeth was most recently the director of governmental relations for the Nature Conservancy of Arizona.

Texas to Designate Groundwater Management Areas

From the Texas Water Development Board

In November, the Texas Water Development Board (TWDB) adopted the preamble and rules for the designation of groundwater management areas (GMAs) in the state. The purpose of GMA designation is to identify the most suitable area for the management of groundwater resources. GMAs are important in both groundwater district creation, and in coordination of planning for groundwater resources. Cooperative water planning is a key element of Texas' 2002 State Water Plan.

In August 2002, the TWDB authorized the publication of a proposed rule to designate GMA boundaries. The boundaries were designated in a manner that coincided most closely with the boundaries of aquifers, consistent with the direction set forth in the Texas Water Code. TWDB staff used aquifers and other hydrologic boundaries to guide the delineation of the GMAs. The boundaries primarily honored the boundaries of the major aquifers of Texas as identified in various TWDB publications, including the 2002 State Water Plan. In areas with multiple major aquifers, TWDB staff generally placed a preference on the overlying aquifer. Several of the major aquifers were divided into multiple GMAs. These divisions are based on hydrogeology and current water-use patterns and coincide with natural features where possible.

For its initial designation of the GMAs, the TWDB looked primarily at aquifer boundaries. Following the public comment period, however, they revised the proposed rules and boundaries such that the adopted GMA boundaries are consistent with political subdivisions (primarily county lines) when such changes create no significant compromise to regional management of the resource. In addition, the TWDB assigned counties to the GMA in which the most significant use of groundwater occurs. In some instances, a county remained split if the use in two aquifers/GMAs was significant in both.

The adopted preamble, rules, and GMA boundary designations are available on the TWDB's Web site www.twdb.state.tx.us.

Costa, Hertzberg, and Kelley Receive ACWA Awards

At their annual fall conference in Anaheim, the Association of California Water Agencies (ACWA) presented several awards to California legislators. Then-Senator Jim Costa (D-Fresno) was awarded a Lifetime Achievement Award for his accomplishments in his 24 years in the Legislature and his dedication to water issues. During his tenure as chair of the Senate Agriculture and Water Resources Committee, he is credited with forging landmark agreements that led to Proposition 204 of 1996 and Proposition 13 of 2000. The two bond measures provided nearly $3 billion in funding for water supply reliability projects, water quality improvements, and other critical programs. Costa authored legislation requiring local agencies to give greater consideration to water availability before approving major new development. In addition, he crafted important legislation on groundwater management, water transfers, and governance of the CALFED Bay-Delta Program. Costa retired from the Senate at the end of his term.

Assembly Speaker Emeritus Robert Hertzberg (D-Van Nuys) was awarded ACWA's 2002 Legislative Leadership Award for his efforts to broker a landmark agreement on a proposed water transfer between Imperial Irrigation District and San Diego County Water Authority. Hertzberg has been an active player on water issues since his election to the Assembly in 1996. He chairs a select committee on the CALFED Bay-Delta Program, and was the chief architect of the Legislature's response to the energy crisis.

Assemblyman Dave Kelley (R-80) was awarded a special President's Recognition Award by ACWA for his many years of distinguished service in the Legislature, particularly his efforts to address key water issues and his effective representation of his constituents. First elected to the Assembly in 1978, Kelley served eight years in the Senate before returning to the Assembly. He left the Legislature at the end of 2002 having authored key measures on water conservation, local government organization, water rights, and agricultural land preservation. He also has been active in efforts to resolve Colorado River issues.

Visit www.acwanet.com

Pender New President of NGWA

Ernest Pender, President of Pender Water Wells in Texarkana, Texas, became the new President of the National Ground Water Association at the 2002 Ground Water Expo, which was held in Las Vegas in December.

Pender is an NGWA-certified Master Ground Water Contractor and has been an active member of NGWA for many years. He has held many positions with NGWA, including Secretary of the Board of Directors, Chairman for the Finance Committee, Chairman of the Rural Water Subcommittee, and member of the Government Affairs Committee. He also has served four terms as President of the Arkansas Water Well Association.

Visit www.ngwa.org

Birman and Todd Receive Life Membership Awards from NGWA

At the 2002 Ground Water Expo of the National Ground Water Association (NGWA), Life Membership Awards were presented to six active members of NGWA who have retired or are of retirement age and have contributed special service in the furtherance of the ground water industry or to NGWA. Joseph H. Birman, Ph.D., CEG, of South Pasadena, California and David Keith Todd, president of Todd Engineers in Emeryville, California, were among the recipients from the Southwest.

Birman was a professor at Occidental College from 1950 to 1984. He pioneered the design and application of instrumentation to evaluate shallow groundwater temperatures for groundwater assessment, water resources exploration, and development. Founder and president of Geothermal Surveys, Inc., Birman has performed groundwater exploration and development throughout most of the western United States, Mexico, South America, and the Middle East.

Todd has devoted his career to advancing groundwater technology and educating others about groundwater. His classic text, *Groundwater Hydrology*, has been used by more than 50 U.S. universities and has been translated into six languages. In addition, Todd has made basic hydrologic information more accessible through six other books and more than 120 publications. He is currently a Professor Emeritus at the University of California at Berkeley. Todd's practice continues to address the occurrence, movement, development, and quality of groundwater, primarily in alluvial and some consolidated aquifer systems. His work has been centered in California, but he has consulted in all parts of the world, including Africa, Central and South America, and the Far East.

Life Membership Awards were also presented to Fletcher G. Driscoll, author of the second edition of *Groundwater and Wells*; John Dufford, President of Dufford Drilling Company; Carl Mason of Baroid Industrial Drilling Products; and Joseph Proch, retired owner of Book and Proch Well Drilling.

Visit www.ngwa.org.

Coconino Plateau Hydrologic Database, Web Site Available Through USGS

The U.S. Geological Survey (USGS) recently completed a compilation of geologic, water resources, climate, land use, land-surface elevation and vegetation data of the Coconino Plateau in northern Arizona. The data were incorporated into a database for ongoing and planned water-resource studies of the area. Data from the study are also published in a report (cited below). In addition, the investigation is described on a Web site, which is currently being expanded for users to retrieve the data through interactive maps, displays, and graphs. The study was performed in cooperation with the City of Williams, who received grant funding from the Arizona Water Protection Fund Commission, and with USGS cooperative funds.

Groundwater from deep regional aquifers has become increasingly important for household, municipal, and in-stream uses on the Coconino Plateau. Increasing growth, development, and recent drought conditions have increased public interest in the availability and sustainability of water resources in this mostly rural part of Arizona. The roughly 5,000-square-mile Coconino Plateau is bounded by Grand Canyon, the Little Colorado River, Flagstaff, and Seligman and is larger than the state of Connecticut. The study area is roughly 10,300 square miles in size — approximately one-tenth the land area of Arizona. The hydrologic data collected include information on wells, springs, stream flow rates, water chemistry, and water use. According to Donald Bills, lead author of the report and a hydrologist with the USGS in Flagstaff, Arizona, the occurrence and movement of groundwater are poorly understood because the aquifer systems are deeply buried, which limits exploratory drilling and testing, and because the geologic structure, which partly controls the occurrence and movement of ground water, is complex.

"Data compiled in this report represent the

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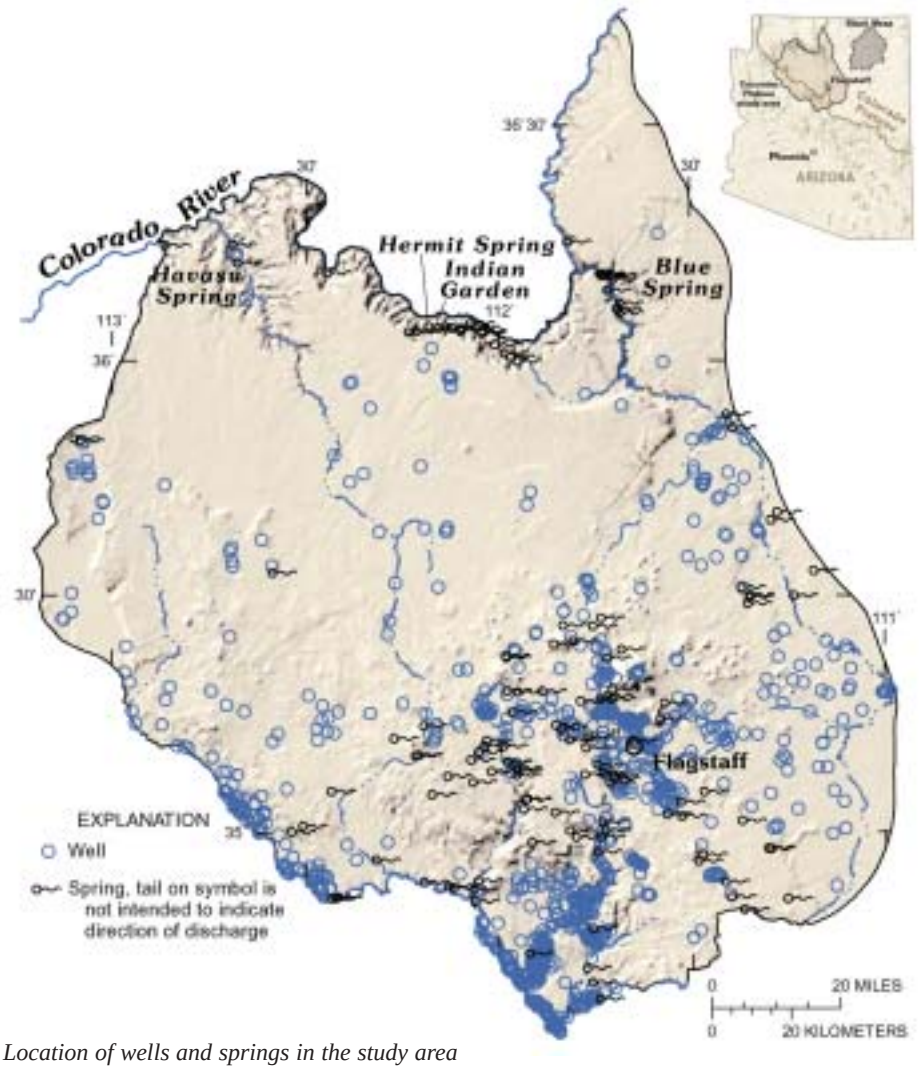


Location of wells and springs in the study area

Ccontinued from previous page

initial phase of a comprehensive cooperative study to assess the water resources of the Coconino Plateau as part of the State's Rural Watershed Initiative," said Bills. "Regional studies like this one provide water resources managers with important tools needed to develop and manage water resources. We are particularly excited about our project Web site that will make it possible to access, view, and print interactive maps for the study that contain hydrologic data and satellite imagery for the study area. This will make it easier for water managers and the public to monitor changing water conditions in their area of interest over the next few years."

The report "Hydrologic Data for the Coconino Plateau and Adjacent Areas, Coconino and Yavapai Counties, Arizona" by Donald J. Bills and Marilyn E. Flynn is published as USGS Open-File Report 02-265 and can be accessed online at az.water.usgs.gov/pubs/02-265intro.html. A USGS Fact Sheet on the study is available at az.water.usgs.gov/factsheets/FS-113-02.pdf.

Irvine Ranch Using Recycled Water in Office Buildings

Irvine Ranch Water District

Irvine Ranch Water District (IRWD) has successfully converted a new 14-story Irvine office building to recycled water use in two air conditioning cooling towers. This is the first such use for recycled water in Orange County, and brings to 11 the total number of facilities converted to interior recycled water use by IRWD. Cooling towers use water to exchange heat in air conditioning systems, and use of recycled water in these towers can help cut water costs by as much as 40 percent.

The building, located at 2040 Main Street in Irvine, also uses recycled water for toilet flushing, which accounts for approximately 25 percent of the recycled water used in the building. The cooling towers use the remaining 75 percent. After conversion, recycled water use will account for about 90 to 95 percent of the total building water use and will save an estimated 3.3 million gallons of potable water per year.

IRWD has been a leader in promoting recycled water use for landscaping and agricultural needs for more than 30 years. Wastewater is collected and treated using tertiary treatment, producing high quality water that earned the district the first unrestricted use permit in California in 1991. This permit allows the recycled water to be used for everything but drinking. Recycled water is delivered through a completely separate pipeline system throughout the community. Recycled water now makes up more than 20 percent of IRWD's total water supply, reducing the need to import expensive water and helping to keep rates low.

IRWD serves a population of 266,000 in the city of Irvine and portions of Tustin, Newport Beach, Costa Mesa, Lake Forest, and Orange.

Visit www.irwd.com

Tests Show Many Water Vending Machines Fail State Health Standards

Environmental Law Foundation

Glacier Water Services, the largest seller in California and the United States of filtered water from vending machines, claims its machines dispense chemical-free drinking water. But in California, the first statewide tests of vended water for chemical contaminants found that one-third of Glacier machines sell water that fails state health standards.

In a report released Dec. 10, Environmental Working Group (EWG) and the Environmental Law Foundation (ELF) say that buying water from a vending machine in California is like playing a slot machine: you can't be sure what will come out. "Considering the steep premium that vended water customers are paying for supposedly 'chemical-free' water, this is an outrageous fraud," said EWG analyst Renee Sharp, principal author of the report.

ELF filed a suit in San Francisco Superior Court charging Glacier with unfair or fraudulent business practices under Section 17200 of the state Unfair Competition Law, which allows private citizens and groups to sue companies for consumer fraud.

Glacier, based in San Diego County, operates more than 7,000 machines statewide, and more than 14,000 vended water machines nationwide. California is one of the few states where vended water – almost always ordinary tap water filtered as it passes through the machine – must be cleaner than tap water.

California state law targets trihalomethanes (THMs), chlorination byproducts linked to increased risk of multiple types of cancer, miscarriages, and birth defects. THMs in vended water must not exceed 10 parts per billion (ppb), the level at which studies show an association with low birth weight of babies whose mothers drank contaminated water during pregnancy.

EWG and ELF tested samples from 274 Glacier machines in nine urban counties, and more than one-third had THM levels above 10 ppb. About one in six had THM levels twice as high as the state standard. More than two-thirds couldn't live up to Glacier's claim that its filters "typically remove 97 percent of all contaminants from the source water."

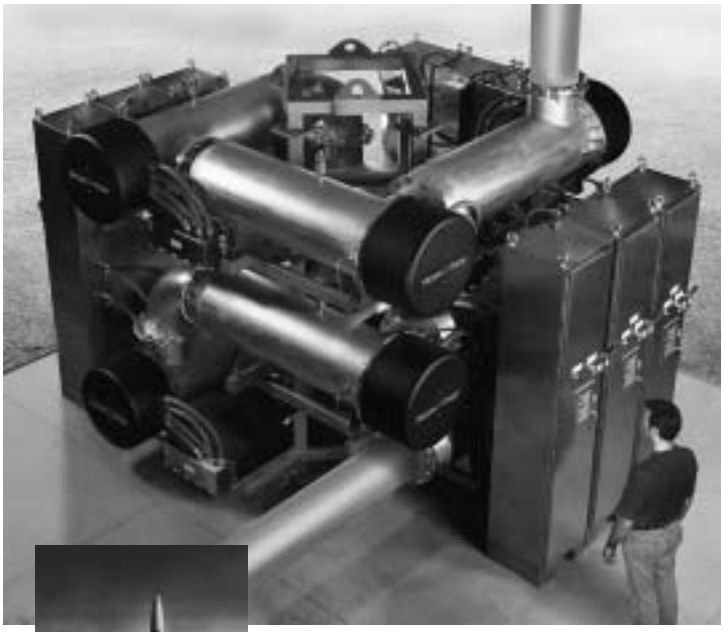
Brian McInerney, President and CEO of Glacier Water Services, Inc. claims on the company Web site that the report and lawsuit are part of an "absolutely fabricated controversy." McInerney states that "these so-called state standards have nothing to do with what is safe for the people," and "as the EWG report notes, 100% of the Glacier water machines sampled met federal EPA standards for safe drinking water."

The report is available at www.ewg.org. The Environmental Law Foundation's complaint is at www.envirolaw.org/cases/vendbrief.htm. Visit www.glacierwater.com

Update on Emerging Contaminants: NDMA

Excerpted from the NDMA Fact Sheet by Trojan Technologies, Inc.

N-nitrosodimethylamine (NDMA) has recently attracted significant attention from the water treatment community as a potent and potentially wide-ranging water contaminant. In its pure form, NDMA is a semi-volatile, yellow, oily liquid with very little odor. During the 1950s, NDMA was a key intermediate in the production of 1,1-dimethylhydrazine, a component of liquid rocket fuel. It has also been used in battery, rubber, and polymer manufacturing, and can be found in some lubricants. NDMA was produced



NDMA is an intermediate in the production of liquid rocket fuel, such as that used to propel the German V2 rocket

Commercial UV reactors such as the Trojan UVPhoxTM can be used to treat NDMA on a large scale (hundreds of million gallons per day).

commercially until the mid-1970s, but today it is produced only in limited quantities for research purposes.

In many cases, NDMA is not directly released into the environment. If it is released in quantities greater than 10 pounds, and such incidences are rare, the United States Environmental Protection Agency (USEPA) requires that it be reported to the Toxic Release Inventory (TRI). However, even in the absence of direct releases, NDMA is being detected in drinking water supplies and wastewater streams, as the compound can form in the environment under suitable conditions and in the presence of precursor compounds. While there appear to be a number of possible pathways, NDMA can be formed by the combination of dimethylamine and nitrite, particularly in slightly acidic waters. Another important formation pathway occurs during the disinfection of drinking water and wastewater with the widely-used disinfectants chlorine and chloramines. Either disinfectant, when combined with dimethylamine, has been shown to form NDMA. Dimethylamine is a common component of animal and human waste and can remain in water even after secondary wastewater treatment. Due to this formation pathway, NDMA can be classified as a disinfection by-product. Studies are ongoing to determine the conditions and precursors that favor NDMA formation.

NDMA has a high chronic and acute toxicity. The USEPA, the Agency for Toxic Substances and Disease Registry, and the Department of Human Services, among others, have determined that NDMA may reasonably be considered a human carcinogen that is hazardous at very low concentrations. The EPA's Integrated Risk Information System lists the one in one million lifetime cancer risk for NDMA in drinking water as 0.7 parts per trillion (ppt) consumed by a 70-kg person drinking 2 liters of water per day. California's Office of Environmental Health Hazard Assessment reports a one in one million cancer lifetime cancer risk of 2 ppt in drinking water.

Reflecting this health risk, many regulatory bodies have moved to regulate NDMA. While historically not considered a common drinking water contaminant, NDMA is listed on the 2001 CERCLA Priority List of Hazardous Substances. In 2002, the California Department of Health Services set an action level for NDMA of 10 ppt. At the national level, EPA has issued recommendations that NDMA levels in lakes and streams be limited to 0.69 ppt. Playing a role in the lowering of regulatory standards is the improvement of analytical methods for detecting NDMA. A handful of laboratories, currently using high-resolution gas-chromatograph/mass spectroscopy techniques, can detect NDMA at 0.1 ppt and report at concentrations of 0.4 ppt.

NDMA is not easily removed from water because it is highly soluble, resists adsorption, and has low volatility. Thus, traditional methods such as carbon adsorption and air stripping fail to remove NDMA. However, it does degrade relatively quickly when exposed to ultraviolet radiation. This action is cost-effectively performed in optimized UV reactors containing lamps with the special characteristics needed to destroy NDMA. Trojan Technologies is one company with the technology to cost-effectively remove NDMA from water.

For more information about NDMA, including treatment alternatives, contact Adam Festger at Trojan Technologies at afestger@trojanuv.com

Overview of Riparian Restoration in the Southwest

David R. Dreesen, Ph.D. *– USDA-NRCS New Mexico Plant Materials Center*

Wildlife biologists and plant scientists have long recognized the value of riparian vegetation for the diversity of plant and animal life present in desert oases of the Southwest. However, the protection and proper management of these highly prized resources has become a primary mission for public and private land managers only in the last several decades. Multi-disciplinary studies of riparian ecosystems in the Southwest (such as Prichard and others, 1998) have shown that properly functioning riparian zones can provide many benefits to watersheds, including:

- Reducing erosion of sediments and improving water quality by lessening the impact of flood events.
- Aiding in the development of floodplains by filtering and capturing sediments.
- Assisting the retention of floodwaters, reducing maximum flows and recharging shallow alluvial aquifers.
- Resisting the cutting force of flowing water by root masses of riparian vegetation stabilizing stream banks.
- Providing rare and diverse terrestrial and aquatic wildlife habitats that result from the formation of assorted channels and ponds.

An array of natural and human-generated processes can degrade the proper functioning condition of Southwest riparian areas. These disturbances affect riparian systems from the subalpine headwaters to the forested floodplain riparian areas ("bosques") along rivers flowing through desert regions.

A Range of Disturbances

At lower elevations, agricultural irrigation and flood control have imposed structures and water management regimes that have disrupted the natural regeneration of cottonwood bosques. River flow management has created man-made hydrographs and prevented or limited natural flood events that have altered sediment deposition and hydrologic conditions required for the regeneration and maintenance of cottonwood bosques. Flood control levees have constrained the extent of the floodplain and restricted the natural meanders of these river systems. Riverbeds have been channelized to reduce flooding and increase water transport efficiency, in effect forming man-made water conveyance systems. Drainage of agricultural lands has altered shallow alluvial aquifers that had previously supported riparian-wetland plant communities.

The loss of natural regeneration of cottonwoods and willows and the increased salinity of floodplain soils have aided the invasion of exotic woody species including saltcedar and Russian olive. The elimination of flooding which severely reduces the decomposition of woody debris, together with the fuel loads produced by noxious woody invaders, has created degraded riparian areas very susceptible to catastrophic wildfire.

At higher elevations in forest environments, catastrophic wildfires can result in massive erosion and sediment deposition in riparian areas, destroying fish and wildlife habitat, recreational facilities, and municipal water supplies. Poor management of domestic and wild herbivores can result in decimated vegetation that perturbs proper function of riparian systems. Watersheds suffering from long-term overgrazing are more susceptible to extreme flood events resulting in accelerated rates of channel lowering. Poorly designed and utilized logging roads and skid trails as well as inadequate buffer zones bordering streams have contributed to the degradation of montane riparian plant communities. Roads and recreational facilities in forested areas are typically situated in canyon bottoms with the resulting degradation of stream courses and surrounding riparian areas.

Restoring Compromised Riparian Zones

Some restoration approaches rely on landscape-scale management. For instance, overgrazing by elk and cattle can be addressed by fenced exclosures of degraded riparian areas or by reducing wild animal numbers through hunting and predation, management of cattle herd size, and timing of utilization. The devastation of catastrophic wildfires can be reduced by allowing natural or prescribed burns to reduce fuel loads and tree density, introducing fuel breaks, and restoring heterogeneous plant communities to forested landscapes.

In natural stream systems, manipulating channels to re-establish the appropriate sinuosity, width/depth ratios, and gradients have restored proper function or counteracted processes degrading riparian zones (Rosgen, 1996). Bioengineering approaches have restored critical areas experiencing severe erosion, provided that these methods have been applied in accord with the hydrology and morphology of the particular stream reach. Such applications include brush matting or brush mattresses, brush layering,

fascines or wattles, and root wads (Bentrup and Hoag, 1998).

Some natural regeneration of riparian areas is conceptually feasible for human-altered river systems. By storing snowmelt in reservoirs during times of higher than normal precipitation, such as El Niño periods, water releases can be timed to simulate natural spring floods for several successive years. Assuming that invasive exotics have been removed from the floodplain, the resulting floodwaters should help to:

1. Regenerate the dominant riparian trees if seed sources are still present.
2. Decompose accumulated woody debris, reducing fuel loads and aiding nutrient cycling.
3. Create new side channels and wetland habitats as restricted by existing levees.

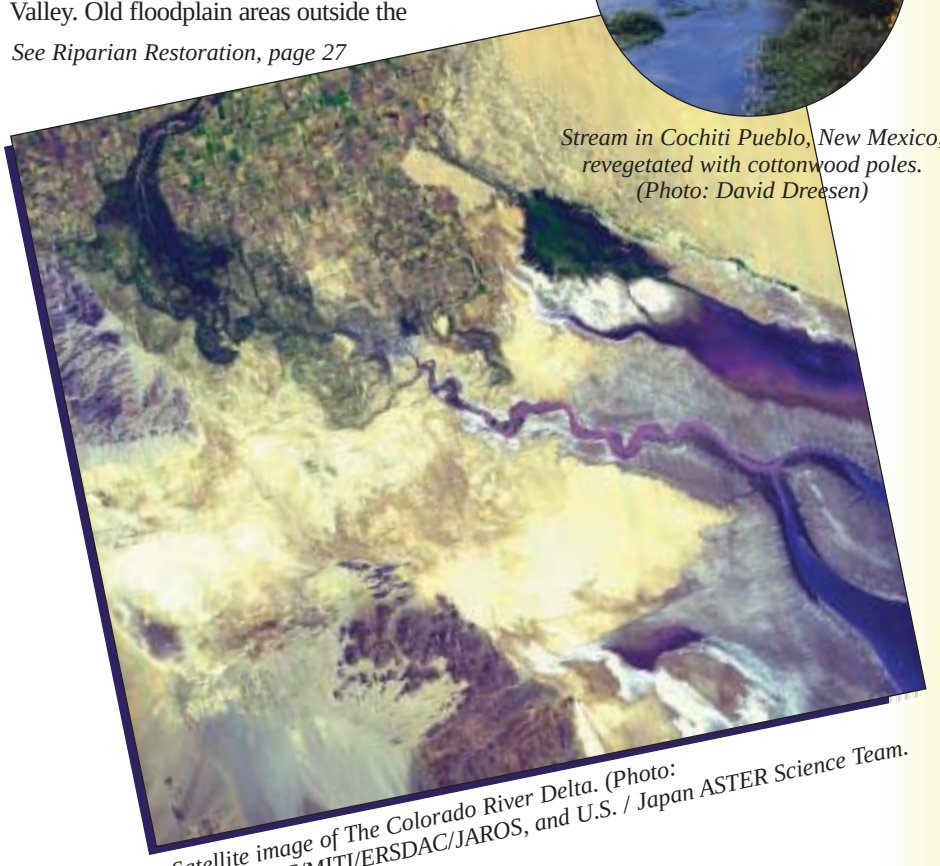
Such an approach requires storage of sufficient water to simulate a natural spring flood hydrograph as well as the ability to release water at times most advantageous for riparian forest regeneration, which may not coincide with the needs of other users of river water. A successful example of manipulated flooding has been implemented at the Bosque del Apache National Wildlife Refuge in the Middle Rio Grande Valley. Old floodplain areas outside the

See Riparian Restoration, page 27

Channelized stream without riparian vegetation. (Photo: Apache-Sitgreaves National Forests)

Revegetated stream in Sonoran Desert. (Photo: Apache-Sitgreaves National Forests)

Stream in Cochiti Pueblo, New Mexico, revegetated with cottonwood poles. (Photo: David Dreesen)



Satellite image of The Colorado River Delta. (Photo: NASA/GSFC/MITI/ERSDAC/JAROS, and U.S. / Japan ASTER Science Team.

What Is A Riparian System?

In common speech, riparian typically refers to a vegetation zone adjacent to streams, rivers, lakes or ponds. Often the term riparian-wetland is used to describe these zones because it supports a progression in vegetation types from wetland plants – sedges, rushes and bulrushes – that occupy saturated sediments, to riparian forests that typically experience seasonal flooding but inhabit relatively thick unsaturated alluvium above the water table.

The attributes of a properly functioning riparian system include:

- *A floodplain that is inundated relatively frequently.*
- *A recovering riparian system that exhibits a widening zone of riparian-wetland vegetation.*
- *A channel system with sufficient sinuosity, width/depth ratio, and gradient to dissipate stream energy associated with bankfull flows.*
- *Upland watershed condition sufficient to prevent degradation of the riparian area.*
- *Floodplain and channel characteristics capable of dissipating the energy of high flow events.*
- *A channel system which does not exhibit excessive erosion or deposition.*
- *Channel lowering that occurs at a natural rate.*
- *Lateral movement of the stream channel is associated with natural sinuosity.*

The characteristics of the vegetation in a properly functioning riparian plant community include:

- *An age class distribution indicating the recruitment of young individuals and the maintenance of older individuals.*
- *A diverse species composition comprised of robust and healthy individuals.*
- *Vegetation consistent with the existing soil moisture and water table conditions.*
- *Species with root systems and vegetative cover capable of protecting stream banks from high flow events.*
- *Large woody debris produced that can modify the hydrology of the channel and floodplain in certain types of riparian systems.*

Developing Recovery Plans for Riparian Ecosystems

Mark Briggs *– Restoration Ecologist and* ***W. R. Osterkamp, Ph.D.*** *– U.S. Geological Survey Hydrologist*

Riparian ecosystems are declining or have disappeared throughout the arid southwestern United States and northern Mexico. To address the ecological decline of these important areas, numerous natural resource agencies and organizations have implemented a variety of riparian recovery strategies with varying degrees of success. Experiences from implementing and evaluating riparian recovery in Arizona and Mexico indicate that several key factors are crucial in determining the effectiveness of improving habitat and stemming ecological decline.

To be effective, recovery efforts need to:

- Be based on a clear understanding of current and past ecological conditions and the reasons for site ecological decline.
- Incorporate an implementation approach that both addresses the reasons for site decline and promotes natural regeneration.
- Approach both evaluation and implementation from a watershed perspective.
- Have strong public involvement and coordination.

Identifying Reasons for Ecological Deterioration

A key lesson learned from past experience with riparian recovery is the importance of understanding current habitat conditions, the extent of their decline, and the reasons for ecological deterioration (Van Haveren and Jackson 1986; Briggs et al. 1994) prior to formulating a recovery plan. Often we too quickly jump to conclusions about the causes of ecological decline, how to fix them, and what the end result should be. Through a thorough evaluation of site conditions, it becomes feasible to understand the causes of ecological decline and to assess approaches that may be effective in addressing them.

Watershed Perspective

A watershed perspective that considers ecological conditions is critical for developing effective recovery strategies for bottomland ecosystems. To understand past and current ecological conditions adequately, it is necessary to evaluate conditions of the uplands, channel reaches above and below the degraded riparian area, and tributaries that enter the degraded area. Project managers should avoid myopic scorecard or classification approaches that focus on particular reaches of the drainage system. The key to a rational recovery design is a thorough knowledge of flow rates in the drainage basin and the fluvial processes that determine landforms.

Recovery efforts should begin with upland considerations. A watershed approach is typically inclusive, a foundation for combining conservation and restoration efforts that are taking place throughout the watershed – both uplands and bottomlands. This approach may yield benefits that ultimately allow project managers to expand efforts beyond original objectives.

Understanding Current and Past Ecological Conditions

An evaluation program that identifies ecological conditions and why changes have occurred forms the technical foundation of a riparian-recovery effort. In particular, the evaluation process needs to document past and current conditions of stream flow, groundwater, channel morphology, soil properties, and riparian vegetation.

Stream flow and alluvial groundwater data describe water availability, flow dynamics, and patterns (statistics) of flow. Channel morphology and its change over time portray channel stability. Physical and chemical soil data are essential for understanding which plant associations can be reestablished in an area. An inventory of vegetation allows project managers to gauge the challenges that invasive plants present to recovery efforts.

Almost always, perturbations imposed on channels in the southwestern United States and northern Mexico have prompted unanticipated and often undesirable fluvial adjustments. Therefore, evaluation efforts should be weighted toward understanding fluvial processes and developing measures consistent with stable channels and adjacent bottomlands. Especially important is the characterization of fluxes and flux changes of water, sediment, and organic matter for the entire drainage basin.

Promote Processes of Natural Regeneration

Natural regeneration can be one of the ecosystem manager's strongest allies. All riparian recovery efforts should promote natural regeneration by addressing the causes of degradation (no matter how far removed they are from the degraded bottomland environment) and allowing periodic flood disturbances to occur. Where a flood plain exists, a flood is any flow, natural or altered, that inundates the flood plain. If the re-establishment of natural lowland conditions and the protection of physical and biological

systems are objectives of a rehabilitation effort, the restoration of flood flows as a normal component of the hydrologic system must be an objective, and riverine engineering should not be designed to eliminate or reduce them.

Strong Community Involvement

Gaining strong community involvement in riparian recovery efforts is one of the most critical aspects toward realizing the project's long-term objectives and is probably the most challenging to achieve. A lack of local community involvement has kept many past riparian recovery efforts from realizing their potential (Briggs and Cornelius 1999; Briggs 1996). In some cases, projects that are implemented successfully from a technical standpoint do not succeed when follow-up monitoring and maintenance do not take place because the local community was not invested in the project.

When placed on a watershed scale, strong community participation and political backing can also allow project managers not only to expand restoration efforts to other parts of the watershed, but also to directly address root causes of ecological decline. This is even true for public land managers, who may be jurisdictionally limited to working only on public lands, but who could expand restoration efforts to include non-public lands by working with neighbors, local community groups, private conservation organizations, and friends groups.

In summary, a variety of factors must be considered when developing recovery plans for riparian ecosystems. Current and past ecologic, hydrologic, and geomorphic conditions in the reach of interest and in the surrounding watershed must be understood. Promoting natural regeneration by allowing flood flows to occur is also a critical component to restoration efforts. Finally, in addition to scientific studies, community participation plays an important role in riparian recovery efforts, particularly in ensuring their long-term success.

See related article, page 26.

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Volunteers planting rooted cottonwood cuttings on the South Fork of California's Kern River. (Photo: Ron Tiller)

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Background Photo: Newly-planted coyote willow whips along the bank at Cochiti Pueblo, New Mexico. (Photo: David Dreesen)

Natural Flooding and Dams

Affects on Riparian Systems

Patrick Shafroth *– U.S. Geological Survey, Fort Collins Science Center*

The composition, structure and dynamics of riparian vegetation are determined largely by past and present hydrologic regimes and geomorphologic conditions. To continue to thrive, riparian vegetation depends on alluvial sediments as a growth substrate, abundant moisture from surface flow, and relatively shallow alluvial water tables.

Hydrologists, geomorphologists, and ecologists have teamed to identify aspects of the physical environment that exert strong influence on riparian ecosystems. Evaluating current and natural dynamics of channel pattern, channel cross-section, and the size and distribution of bottomland landforms can help to identify which components of the system are in greatest need of restoration attention (See Briggs and Osterkamp, p. 18). Further, a growing database clarifies alluvial groundwater dynamics and the responses of stream and floodplain biota to various aspects of surface flow – such as timing, magnitude, frequency, duration, and rate of change.

Floods Influence Landforms and Biota

In riparian areas, flooding is a particularly important natural process, strongly influencing the physical environment of river bottomlands by eroding and depositing sediments, destroying and creating fluvial landforms, moistening sediments, flushing salts that have concentrated in sediments, and transporting plant propagules. These flood-driven processes largely determine the distribution, size, shape, and sediment characteristics of surfaces within a river bottomland upon which vegetation grows.

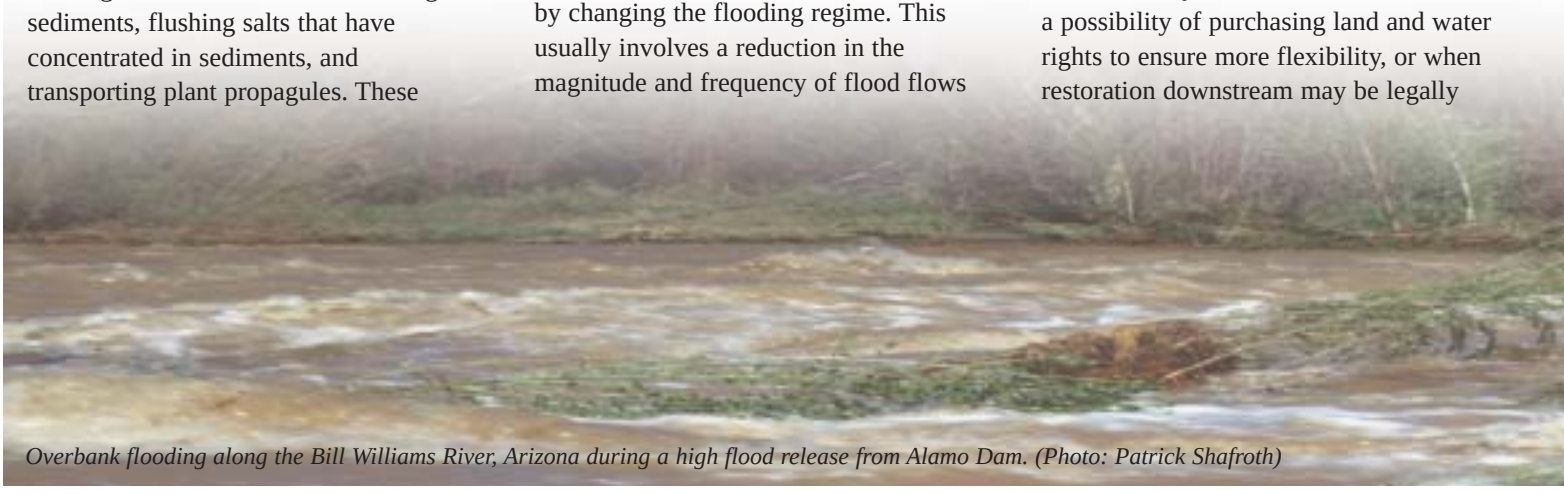
The life cycle of many riparian plants is intimately related to these site conditions and, hence, to flooding. In the Southwest, riparian restoration efforts often endeavor to promote the regeneration of native cottonwood and willow forests. The natural reproduction of these tree species is highly dependent on flood-driven processes. To germinate, the seeds require bare, moist substrates during a limited period of time in spring and summer. Floods naturally create these substrates. As flows recede following a flood, soils must remain moist enough for the drought-sensitive seedlings not to desiccate. Seedlings are also vulnerable to removal by subsequent floods. Given these rather specific requirements, successful seedling establishment of cottonwood and willow trees may only occur once every five to ten years, despite the fact that thousands of germinants can be found almost every year.

Surface Flows Affected by Dams

Today, most rivers in the Southwest have been dammed. While dams may be operated in a number of ways depending on the primary purposes, they nearly always affect surface flows downstream by changing the flooding regime. This usually involves a reduction in the magnitude and frequency of flood flows and a change in the timing and duration of flooding, all of which alter the physical conditions influencing riparian vegetation. These changes can adversely affect native species that are dependent on natural flooding regimes. Conversely, non-native species may be better suited to the new flow regimes (see Stromberg et al., p. 22).

Low flows are also important because they influence dry season alluvial water table depths, which can constrain the abundance and composition of riparian vegetation, particularly in arid regions. Downstream from dams, low flows are commonly altered in different ways as well, depending on dam operation priorities. In some cases, where flows are diverted from a reservoir, for example, low flows downstream may be reduced, leading to drier conditions than can be tolerated by many riparian plants. In other cases, where water is delivered for summer irrigation downstream, low flows may be increased, allowing for greater survival and growth of riparian plants than might have occurred with natural flows.

Given the importance of surface flow to riparian vegetation, an increasingly common restoration approach has been to manage streamflow downstream of dams. Changing dam operations may be feasible along rivers where patterns of downstream water delivery are flexible, when there is a possibility of purchasing land and water rights to ensure more flexibility, or when restoration downstream may be legally



Overbank flooding along the Bill Williams River, Arizona during a high flood release from Alamo Dam. (Photo: Patrick Shafroth)

required and dam reoperation is found to be less expensive and more sustainable than active restoration. In the Southwest, this approach has often involved modifying the parts of the regulated hydrograph that are hindering cottonwood recruitment or survival.

Along rivers in Alberta, Canada, low flows have been increased to maintain the vigor of existing cottonwood forests, and the rate of flow recession following flood peaks has been controlled to promote seedling establishment. Along the Truckee River in Nevada and the Bill Williams River in Arizona, managed floods have been used in combination with controlled flow recessions to promote cottonwood recruitment. In these cases, the restoration objectives were achieved over many river miles, without costly, intensive, on-the-ground actions. It is important to recognize, however, that naturalized flow regimes alone may not supply all of the conditions required for successful restoration, particularly if sediment and geomorphic dynamics are still altered.

Dam Removal Considerations

Another means of mitigating the downstream effects of dams is to remove the dam altogether. Dam removal is on the increase throughout North America, primarily because many dams have become unsafe over time or are no longer serving the purposes for which they were originally constructed. Environmental restoration is seldom the primary or sole reason for removing dams, but restoration benefits may accrue. If there are no other dams upstream, dam removal may restore natural flow and sediment regimes and the associated natural processes that favor native riparian vegetation. However, large volumes of sediment trapped in the

See Flooding, page 27

Alien Plants and Riparian Ecosystem Restoration:

The Tamarix Case

J. C. Stromberg, Ph.D., S. J. Lite, and M. K. Chew *– Arizona State University*

What differentiates an "alien" species from a native one? Ecosystems, by definition, are open to flows of energy and matter, and biological communities do not have fixed, unchanging rosters. Therefore, eliminating alien species from riparian (or any) ecosystems is theoretically a non-issue. Nevertheless there is strong sentiment against aliens, and a great deal of effort is expended in attempts to suppress or eliminate them. Much of the concern stems from the role of these newcomers as indicators of loss – fearing their presence indicates a disappearance of familiar, native plant species, lower habitat values, reduced native biodiversity, reduced stream flow, and other changes that many people deplore and would like to reverse through restoration.

Upper photo: cottonwood trees. Lower photo: salt cedar trees. (Photos: J.C. Stromberg)

One of the most widespread newcomers in riparian corridors of the southwestern United States is salt cedar (Tamarix ramosissima, T. chinensis, or the endemic American hybrid, T. ramosissima x chinensis). Salt cedars were introduced to the United States in the late 1800's from Europe and Asia as ornamentals, and for windbreaks and erosion control. They subsequently spread along water courses throughout the country, and they now cover nearly 1.5 million acres of floodplain area in 23 states (Di Tomaso 1998, Zavaleta 2000), infiltrating or replacing large expanses of cottonwood-willow (Populus-Salix sp.) forests.

As pioneer species, cottonwood, willow, and salt cedar display short generation times, grow rapidly, and produce large numbers of small seeds. All three species colonize bare stream edges, and their establishment is closely adapted to hydrologic regimes. Cottonwoods and willows have evolved to exploit dependable regional spring flooding by producing seeds only during a short annual period. A flood coinciding with seed dispersal scours away existing vegetation and creates a germination site. The flood must then recede slowly enough that a seedling's growing roots can maintain contact with the water table, without rising to inundate them again.

Salt Cedar's Competitive Advantages

Salt cedars are adapted to less predictable disturbance regimes, and sometimes produce seeds nearly year-round. They also root deeply when required and tolerate extended drought and inundation. Salt cedar's "pre-adaptations" give it competitive advantages over native riparian trees along rivers with culturally modified hydrologic regimes. Human influences have helped give salt cedars a competitive advantage as well. Dams, surface water diversions, and groundwater pumping have revised the hydrology of most western riparian ecosystems. Flood peaks are reduced and delayed as spring runoff is captured in reservoirs and released for summer irrigation. This timing suppresses recruitment of cottonwoods and willows, but salt cedar can continue to germinate around reservoirs as storage diminishes and along rivers as irrigation deliveries dwindle. Deeper rooting than the natives, salt cedar can also thrive on rivers where pumpage from groundwater wells reduces the elevation of the alluvial aquifer. Excreting salts, it survives where dissolved solids are concentrated by irrigation runoff and reservoir evaporation. Salt cedar also has an advantage along rivers with culturally modified grazing regimes, given its low palatability to cattle.

The more we change the abiotic components of an ecosystem, the more we stress the native biotic community and create niches for new species. As we drastically manipulate waters, we have to expect consequent changes in riparian flora and dependent fauna. Simplifying that equation, suppressing floods also suppresses riparian biodiversity. Salt cedar often gets the blame for loss of ecosystem

function when the underlying reason for the loss is the alteration of river processes, leading to the absence of cottonwoods and willows or to the loss of habitat diversity (Stromberg and Chew 2002).

Because many bird species evolved with and prefer tall cottonwood-willow forests, salt cedar stands often support lower avian species densities and diversities (Ellis 1995). But there are also cases where salt cedar provides valuable ecosystem functions. Along the middle Pecos River, for example, salt cedar serves as an important habitat for birds (Hunter et al. 1988). Stromberg (1998a) found salt cedar forests along the San Pedro River to be functionally equivalent for six out of 13 defined "ecosystem functioning" traits, such as maintenance of plant species diversity and floodplain sedimentation. These findings suggest that salt cedar not only invades, but participates in ecosystems where native species are failing. Removal itself may be increasingly harmful as salt cedar is assimilated into American ecosystems. As a case in point, salt cedar has become an important nesting site for southwestern willow flycatcher, an endangered bird species.

Salt Cedar Restoration: Worth the Effort?

"Restoring" riparian areas by eliminating salt cedar is a popular exercise. Large amounts of time, money, and labor are expended in burning, hacking, applying herbicides, and deploying biological controls, but at best these offer no more than a cosmetic fix. Removal of exotics, with or without replanting native trees, often fails because it does not address the underlying causes of species replacement. Cottonwoods and willows are traditionally described as poor competitors in relation to salt cedar, but in a laboratory experiment, cottonwood seedlings out competed salt cedar seedlings under conditions simulating natural seasonal hydrology (Sher et al. 2000). Along perennial, free-flooding portions of Arizona's San Pedro River where livestock were excluded, young cottonwood and willow trees now outnumber salt cedar (Stromberg 1998b). Such studies suggest that riparian biota can recover without further human intervention after historical stream flow rates and patterns and grazing regimes have been restored through appropriate management actions. Because cottonwood seedlings are larger and grow faster than salt cedars, cottonwoods can physically dominate by shading out salt cedars under normal conditions.

Since the success of the native trees is strongly coupled to particular hydrologic and grazing regimes, and when favored, the natives outcompete the exotics, it follows that the most ecologically viable long-term anti-salt cedar strategy is to restore the physical conditions that favor the natives. Our lost native riparian woodlands can be found again, by finding the will to give them what they need. Lacking that will, salt cedar is the present and future keystone of riparian forests. Salt cedar is now effectively the "more native" plant, not by simplistic standards of geographical origin, but by demonstrated fitness and continued survival and reproduction under prevailing conditions. Punishing it for succeeding while simultaneously providing it with ideal conditions is an absurd and futile exercise.

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Fire and Riparian Ecosystems

J. C. Stromberg and M. K. Chew

Is fire on the increase in riparian ecosystems of the American Southwest? Along flow-regulated desert rivers including the lower Colorado, floods no longer scour vegetation and organic debris, and riparian fire is increasingly common. Recreational and other human uses have increased ignitions along many rivers, including the upper San Pedro, where nearly a third of the woodland burned between 1990 and 2000. However, we know little about historic riparian fire frequency.

Lightning fires probably were more common in riparian areas surrounded by desert grassland and woodland than by desert scrub, although generalities on fire frequency are complicated by pre-Columbian setting of riparian fires. Ecologically, fire can locally reduce abundance of Fremont cottonwoods and convert riparian forests into savannas, but Goodding willow, Arizona sycamore, saltcedar, and many other riparian tree and shrub species will resprout from live roots. Many riparian grasses and forbs germinate or resprout after fire and can be favored by canopy light gaps, although post-burn hydrophobic soils can retard revegetation. Extreme fires that burn entire watersheds with high intensity likely produce different effects from smaller, more localized burns, but more studies are needed to increase our understanding of the complexities of riparian fire ecology.

Background photo: Incised channel created by erosion following the Cerro Grande fire near Los Alamos, NM in 2000. (Photo: John A. Moody, U.S. Geological Survey.)
Visit wwwbrr.cr.usgs.gov/projects/Burned_Watersheds/index.html.

Small-Scale Restoration in the Colorado River Delta:

The Power of Restoration at the Community Level

Miriam Lara Flores *– Biologist, Pronatura Sonora and* ***Mark Briggs*** *– Restoration Ecologist*

At the end of the summer of 2002, Javier Mosqueda eagerly considered the results of a recently planted 25-acre parcel of family agricultural land that borders the Rio Hardy – a former branch of the Colorado River that drains much of the Mexicali agricultural valley in the Colorado River Delta, Baja California, Mexico. Prior to that summer, the land had been abandoned for more than eight years, offering little ecologic, economic, or aesthetic value to the Mosqueda family or the tourists that came to stay in the cabins the Mosqueda family operates to supplement incomes from traditional agriculture and aquaculture activities. What sparked Javier's emotion wasn't the sight of the newly-planted cotton and alfalfa but the small-scale restoration effort that reestablished hundreds of native mesquite trees (Prosopis glutinosa and P. pubescence). Smiling with enthusiasm, Javier noted "Este es solamente el inicio" (this is only the beginning).

The Colorado River Delta once encompassed several hundred thousand hectares of wetland, riparian, and intertidal habitat that supported an incredible diversity of flora and fauna. In his book "A Sand County Almanac," Aldo Leopold wrote about his trip to the Colorado River Delta in 1922:

> *On the map the Delta was bisected by the river, but in fact the river was nowhere and everywhere, for he could not decide which of a hundred green lagoons offered the most pleasant and least speedy path to the Gulf.*

Javier Mosqueda, Miriam Lara Flores, and Mark Briggs at Campo Mosqueda. (Photo: Elissa Ostergaard)

The green lagoons of Aldo Leopold's day are now a thing of the past. Dam construction and water diversion along the lower Colorado River and increasing pressures from agriculture and urbanization, as well as water regulations that neglect environmental considerations, have significantly altered and fragmented the once-lush Delta. Today, much of the Delta has been reduced to remnant systems of brackish mud flats and streamside locations dominated by non-native species such as salt cedar (Tamarix ramosissima).

Restoring the Delta

The decline of the Colorado River Delta has made it a conservation priority for many federal and state agencies, universities, and non-governmental organizations on both sides of the international border. During the past five years, a bi-national, collaborative effort has coalesced in the Delta, bringing together a diversity of personnel, not only from Mexican and United States agencies and universities, but also from non-governmental groups such as Pronatura, the Sonoran Institute, and the newly formed community-organization, Asociacion Ecologistas y Usuarios del Rio Hardy y Rio Colorado (AEURHYC). The overall goal of this bi-national, collaborative effort is to change the management of the Colorado River in a manner that will improve the Delta environment for both its people and its natural communities.

To achieve this goal, six major steps will be particularly important:

- Ecological investigations of the Delta must take place to set restoration goals and strategies that are grounded on a strong understanding of the region's current ecological condition and why it has changed.
- Work with residents of Delta communities should raise awareness of the changes that have occurred, an understanding of how those changes have affected the residents, and a path toward effective community participation in water policy decisions being made in Mexico and the United States.
- A bi-national, broadly supported restoration goal should be put forward to describe the restoration objective for each of the main Delta ecosystem types: wetland, riparian, and intertidal.
- The story of the Delta has to be better understood by the media, policy-makers, and the general public on both sides of the border.
- Policy analysis and reform need to be advanced so that the law of the river recognizes the Delta ecosystem as a legitimate user of Colorado River water.
- Site-specific restoration efforts need to be implemented to demonstrate the potential for restoration as well as to enhance the participation of Delta residents in local and regional conservation plans.

Background photo: New irrigation pipes provide water for riparian restoration on the Campo Mosqueda property. (Photo: Mark Briggs)

Campo Mosqueda Sets Restoration Example

From a broad perspective that considers the restoration of thousands of hectares and the combined efforts of governments, agencies, private organizations, and residents from both sides of the border, Mosqueda's restoration project appears relatively insignificant. However, the design and implementation of his project, sponsored by the North American Wetland Conservation Act, has required deep commitments of time, funds, and energy, involving more than 30 local residents, three community-based organizations, two universities, and assistance from federal agencies on both sides of the border.

The amount of work, time, and energy required for this effort convincingly demonstrates that the Delta cannot be restored by such small-scale efforts alone. Nevertheless, the successful completion of Mosqueda's initial restoration effort has created a positive force that goes well beyond the immediate footprint of the project. For example, during the two-year course of implementing the project, Mosqueda has become interested in additional restoration projects and, as President of the local community-based organization AEURHYC – whose mission unites residents in efforts to improve the ecological condition of the Colorado River Delta – Mosqueda has encouraged AEURHYC members to become actively involved in additional restoration efforts. As a result, and with additional funding secured from North American Wetland Conservation Act, AEURHYC is now involved in efforts to establish a chain of restored sites downstream of the Campo Mosqueda site. In addition, Mosqueda is participating in political meetings concerning the management of the Colorado River and has become one of the leading community voices in Mexico regarding the Delta's conservation and restoration.

Community Involvement Provides Momentum

The Campo Mosqueda effort provides scientists, conservationists, restoration practitioners, and agency personnel tangible evidence of the Delta's restoration potential. If restoration of abandoned Delta agricultural land – typically characterized by high soil salinity and low water availability – is possible, the restoration of riparian environments along the Colorado River mainstem, wetland areas, and inter-tidal zones is even more promising. The momentum from this effort has also helped to strengthen the involvement of numerous agencies and funders from both sides of the border.

Even more important is the awareness and involvement of the people who live and work in the Delta itself. Strong participation of Delta residents is absolutely essential to the effectiveness and long-term success of restoring the Delta to its natural habitat. This key ingredient for success cannot be overlooked, as these small-scale restoration efforts encourage the involvement of Delta residents in larger conservation issues.

See Small-Scale Restoration, page 27

Important Concepts for Riparian Recovery

***Mark Briggs** – Restoration Ecologist and **W. R. Osterkamp, Ph.D.** – U.S. Geological Survey Hydrologist*

Formulating a practical recovery plan for riparian systems requires understanding of hydrologic and geomorphic terms and an application of the concepts of fluvial dynamics.

Stage is the water-surface elevation of a stream above an established datum plane.

Bankfull discharge is the flow rate that occurs when the stage of a stream coincides with the uppermost bank level.

Bankfull stage is the water level at channel capacity, when bankflow discharge occurs. It is a geomorphic term requiring an interpretation of site-specific landforms.

Flood plain is a unique, identifiable geomorphic surface associated with alluvial stream channels.

Although bankfull stage can refer to various channel-bank levels, it generally applies to alluvial stream channels that are (1) adjusted to prevailing discharges, (2) principal conduits for streamflows through a length of alluvial bottomland, and (3) bounded by flood plains receiving water and sediment when discharge exceeds that of bankfull. In perennial streams, bankfull discharge is correlated to the mean annual flood (Wolman and Leopold, 1957). In dry regions with intermittent to ephemeral streams, bankfull discharge may correspond to floods with return periods of 100 years or more (Osterkamp, 2003).

Knowing the rate of bankfull discharge is of great importance to bottomland recovery efforts, as significant physical changes occur when flow surpasses bankfull discharge and transitions from in-channel to overbank conditions. The change in hydraulics as flow depth increases controls the geomorphic processes related to flood-plain formation, regardless of any return period associated with the bankfull discharge (Petts and Foster, 1985). Channel designs for a recovery program must be compatible with this hydraulic change to maintain a stable reconstructed channel.

Bankfull stage, from which bankfull discharge is calculated, is recognized easily along channels with point-bar deposits, especially if recent overbank deposits overlie point-bar sediment. For channels lacking point bars, interpretation of bankfull stage necessitates observations of channel morphology and gradient, channel sediment, vegetation, root exposure, and indications of flood processes.

Channel Characteristics

Channel characteristics of stream reach are a function of the fluxes of water and sediment (including discharge variability and the range and proportions of sediment sizes) conveyed to the reach from higher in the drainage basin. Vegetation is also a determinant of channel and near-channel characteristics, but it too is dependent on fluxes of water and sediment.

A wide range of flux conditions can produce similar channel conditions at a site. In addition, site conditions are variable in time, reflecting recent floods or flood sequences. Therefore, multiple evaluations of channel conditions should be conducted over time, as sediment released by one flood may not be representative of long-term, mean fluxes of water and sediment.The slope of the channel, or its gradient, is an integration of water and sediment inputs to a reach over time, and thus should be regarded as a diagnostic of long-term conditions of the reach. The re-establishment of bottomland characteristics and habitat similar to those that persisted prior to modification depends on an approximate replication of the previous channel gradient.

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Photos: Apache-Sitgreaves National Forests, Arizona

Riparian Restoraton, continued from page 17

levees were cleared of saltcedar and designed to impound water to create soil moisture conditions similar to a natural flood event. This approach successfully re-established cottonwoods and willows on extensive impounded areas (Taylor and McDaniel, 1998).

Other methods of reintroducing trees and shrubs have proved successful on degraded riparian areas that presently do not experience flooding. Planting long-dormant stem cuttings, known as poles, from cottonwood, willow, and other riparian species into augered holes that extend to the water table has allowed the re-establishment of riparian trees on hundreds of acres in the Middle Rio Grande Valley (Dreesen and others, 2002). Containerized plants with very deep root systems have helped establish additional species not suited to pole planting in areas with a fairly shallow water table. These methods are stopgap because the plants will not regenerate unless flooding is eventually reintroduced into the riparian system.

The conflicts between the extraordinary natural resource value of riparian areas and the limited surface water resources in the Southwest will result in future struggles over the allocation of water for the restoration of disturbed riparian areas and for the preservation of pristine riparian areas.

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Flooding, continued from page 21

reservoir during the life of the dam may be transported and deposited downstream, creating rather unnatural conditions. Thus, following dam removal, the dam-altered system may not be immediately restored, as it will need to adjust to this influx of sediment, as well as to a return to natural flows. The timing and nature of these system responses will vary from river to river and are not yet well-understood by scientists.

Opportunities to remove dams or to change dam operations are limited, and dam reoperations may not always provide all of the missing processes. In cases where only partial restoration of key processes is possible, more active restoration measures may be targeted to mimic what is still missing. For example, restoring naturally high magnitude floods and the associated physical disturbance, which is essential to the reproduction of desirable, native pioneer trees and shrubs, may not be possible. In these cases, active measures can be used to mimic the physical disturbance, such as bulldozing existing, undesirable vegetation, and following that activity with stream flows that moisten the surface. In cases where stream flows are too regulated to provide the moistening function, controlled irrigation may be necessary. Even when several active restoration measures are required, they are more likely to succeed if they tend to mimic key functions of natural processes.

Restoring natural flow regimes and fluvial processes can have numerous benefits. Restoration efforts that require many active measures and much future maintenance are generally less sustainable, more expensive, and confined to relatively small areas. In contrast, when natural processes are restored, restoration projects tend to be more sustainable, less expensive, and more extensive. Although in some cases, factors unrelated to a river's hydrology or geomorphology may be a central source of degradation, the success of riparian restoration efforts will be enhanced when the important roles of natural processes are considered and incorporated.

Contact Shafroth at Pat_Shafroth@usgs.gov

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Small Scale Restoration, continued from page 25

To attain the long-term involvement of community residents, small-scale restoration efforts should benefit both the environment and the people who live and work nearby. As part of the Campo Mosqueda effort, a picnic area was established to provide tourists with a place to visit and enjoy themselves. In addition, the site's aesthetic location and restoration history will provide a worthwhile stopping point for ecotourism groups that regularly pass through the Delta on their way to such coastal attractions as San Felipe and El Gulfo. Downstream restoration efforts will focus on improving fisheries habitat – an important consideration for local fisherman.

The stronger the link between the restoration efforts and the local communities, the more successful the project will be. With each small success comes greater community interest and involvement. And greater community involvement ensures the Delta restoration will benefit both the region's ecosystems and its people. Such a result would be the highest conservation triumph.

Contact Miriam Lara Flores at mjlara@lycos.com or Mark Briggs at mkbriggs@msn.com

Arco Settles Lawsuit Over Drinking Water Contamination

Article originally appeared on WaterTechOnline, Dec. 18, 2002

A lawsuit alleging 143 Arco gas stations caused soil and groundwater pollution that threatened drinking supplies in Orange County has been settled for a total of $8 million, the county district attorney's office announced. The lawsuit, originally filed in 1999, claimed underground gasoline storage tanks at the stations leaked the fuel additive methyl tertiary butyl ether (MTBE) into the soil and groundwater.

According to the Associated Press (AP), the settlement calls for Arco to pay $3 million into a fund that will pay for an independent consultant to monitor the cleanup of all the identified gas stations in Orange County. The oil company also will pay $5 million to reimburse legal costs incurred by the district attorney's office, which hired two outside firms to help with the complex civil case, AP reported.

Arco, which merged with London-based BP Amoco in 2000, also agreed to pay for all cleanup and to bring all of its gas stations into compliance.

Orange County District Attorney Tony Rackauckas said he sued after health officials expressed concerns that the MTBE could migrate from shallow groundwater into Orange County's deeper drinking-water system, the Orange County Register reported. The newspaper said nearly 50 percent of local drinking water comes from deep-water wells.

According to the Register, Arco spokesman Paul Langland said the oil company has been negotiating the tank cleanup for four years, spending more than $100 million statewide and $16 million in Orange County, but added that Arco will not raise gas prices as a result of the settlement.

Visit www.watertechonline.com

Rocketdyne Denies Responsibility for Perchlorate Contamination

Article originally appeared on WaterTechOnline, Dec. 17, 2003

Defense contractor Rocketdyne is denying it is responsible for perchlorate contamination of water in the Simi Valley region.

The *Los Angeles Times* said the company found itself on the defensive after investigators discovered perchlorate in Simi Valley and at Ahmanson Ranch, but Rocketdyne officials say it did not come from their test site in the Santa Susana Mountains.

During a media briefing at the Santa Susana Field Laboratory, Rocketdyne scientists said years of research into the soil, water, and geology of the hilltop site between Simi Valley and Chatsworth show that the perchlorate could not have traveled to the valley floor, the *Times* reported.

Their statement came in response to the discovery by state investigators of the chemical in 18 shallow wells scattered across Simi Valley, the newspaper said. Perchlorate, a component of rocket fuel, can cause thyroid dysfunction in humans.

The highest concentration found in Simi Valley was 20 parts per billion (ppb). Any level above 4 ppb is considered dangerous, the newspaper reported.

The recent discovery by state investigators coincides with a finding of trace amounts

of perchlorate in a well at nearby Ahmanson Ranch, said the *Times*.

Although there are several "hot spots" of perchlorate contamination in the soil and water at the field lab, data do not support the critics' theory that perchlorate passed from the site to the valley via streams and springs, Rocketdyne officials said, according to the newspaper.

However, Ali Tabidian, a professor of hydrogeology at Cal State Northridge who has studied the area for more than a decade, theorizes that the substance was carried down the mountain from Rocketdyne by water trickling through natural drainage systems, according to the article.

He presented his theory at the meeting Wednesday night, ending his remarks by saying, "Based on the data, there is no reason to believe the source is anywhere but the Santa Susana Field Laboratory," the *Times* reported.

Rocketdyne officials suggest a former plant nursery on Ahmanson Ranch may have been the source of the perchlorate there, the article said.

See related article, page 10.
Visit www.watertechonline.com

USFilter Supplies Phoenix with Arsenic Removal System

US Filter reported that Phoenix is the first U.S. city to install a full-scale arsenic removal system utilizing GFH™ media. USFilter will supply 60,000 lbs of GFH media for the city's 1.5 million-gallon-per-day (MGD) arsenic removal system, which is expected to be operational in April.

In addition to removing arsenic, GFH media also removes chromium, lead, selenium, antimony, uranium, and other heavy metals from groundwater. The media is operated as a fixed bed adsorber, and is typically installed in pressure vessels to allow a single pumping stage for the treatment system.

To select an appropriate adsorption media option, the city's consulting engineer, Narasimhan Consulting Services, Inc. of Phoenix, Ariz., conducted a 3-month benchscale and pilot study, comparing the GFH media's ease-of-use, reduced waste generation, minimal chemical handling requirements and overall performance to three other adsorption media options. In addition, the GFH media treated more than five times the bed volumes of its counterparts before being exhausted.

Visit www.usfilter.com

New Faces at Hydro Geo Chem

Hydro Geo Chem, Inc. (HGC), an environmental consulting firm based in Tucson, recently announced several personnel changes.

Dr. Gary Walter, who has been with HGC since 1980 and President since 1999, has left the firm to pursue scientific research. He is now Principal Scientist at Southwest Research Institute in San Antonio, Texas.

A newly created Management Team headed by Chief Operations Officer Cheri Hoff Minckler has assumed Dr. Walter's management responsibilities. Ms. Minckler was hired in 2002 to re-organize HGC. She has 15 years experience in management and business development in the chemical, petroleum, and electric utility industries, and is interested in developing landfill gas to energy projects.

Todd W. Schrauf recently joined the professional staff in the Tucson office. Mr. Schrauf comes to Hydro Geo Chem from an environmental firm in Lima, Peru, where he served as Operations Manager supporting mining projects. He adds expertise to HGC in the areas of hydrologic modeling, water supply development, and remediation technology.

With great sadness, HGC reported that Doug McCaulou passed away in December 2002. A registered geologist and engineer, McCaulou was a respected colleague and friend of many.

For information, contact Cheri Hoff Minckler at cherim@hgcinc.com.

CDM Wins NGWA Ground Water Remediation Award

CDM was awarded Outstanding Project in Ground Water Remediation by the National Ground Water Association. The award recognizes outstanding engineering and do-it-yourself innovation in the area of groundwater remediation, and recognized CDM for its teamwork on the Glendale, California water treatment system project.

CDM has been working for several years to provide comprehensive site remediation services for the Glendale Operable Unit site in Southern California. CDM's role included a detailed analysis of three alternative treatment systems and a final design of the treatment facility. The Glendale treatment plant, where CDM is now providing full-time operations and maintenance, has provided an efficient and cost-effective solution to remediate and reuse ground water in the San Fernando Basin. CDM's efforts demonstrate how a large-scale plant can be used to reclaim water that would have otherwise been unusable.

Visit www.cdm.com

Ground Water Awareness Week March 16-22

The National Ground Water Association's annual Ground Water Awareness Week is March 16-22. Ground Water Awareness Week is cosponsored by the Groundwater Foundation, a nonprofit organization dedicated to educating and motivating people to care for and about groundwater.

Ground Water Awareness Week celebrates groundwater as a valuable and renewable natural resource. This year's theme is "Schedule Your Water Well Checkup," promoting routine annual maintenance checks for private water wells. State organizations, groundwater businesses, and individual groundwater professionals are encouraged to help secure the future of the groundwater resource and industry by informing their communities about groundwater and groundwater-related professions during Awareness Week or any other time of year. The sponsors suggest that making presentations to civic groups, local schools, youth groups, or any community organization can be a very effective means of helping consumers understand the role of groundwater in their everyday lives.

For more information on planned activities, and ideas on how you can become involved, visit www.ngwa.org/education/aware.html.

International Conference on Groundwater Use Nets Declaration

***W. Peter Balleau** – Balleau Groundwater, Inc.*

The Symposium on Intensive Use of Groundwater (SINEX) drew 150 hydrologists from around the world to Valencia Spain, Dec. 10-14, 2002. The symposium was organized to discuss the net effect of using aquifers intensively as a water source and to answer misconceptions about the sustainable use of the groundwater resource.

The symposium produced a declaration for distribution to water-policy makers worldwide. The declaration states that the health and well being of hundreds of millions of people depends on groundwater, including people in demographic transition in developing countries. Aquifer storage serves to mitigate drought and supports the explosive productivity of the green revolution. It is the low-cost source of water in much of the world and can be self-supplied in most areas without government subsidy. Economic development for the foreseeable future requires the continued and expanded use of the groundwater resource.

However, intensive use of aquifers can cause problems with resource depletion, including external effects such as baseflow and wetland impact involving other users and the ecosystem, and can cause land subsidence.

The symposium declaration advises that the deleterious effects of intensive groundwater use must be anticipated and managed without improvidently abandoning the essential benefits of the resource.

The historical evolution of intensive wellfield use for municipal purposes, as presented by Ken Howard of the University of Toronto, invariably has led to a final stage of aquifer recovery of water levels and interrelated surface flows. Thus the depletion and ecosystem problems tend to be an intermediate phase in a longer cycle of eventual water excess from importation and effluent returns.

But where can water come from for growth while the third world catches up economically to the first world? According to conference presenters, the answer involves two sources: more groundwater and substitution of lower-valued uses for higher ones. The symposium learned that 97 percent of the economic product around the world relies on 5 percent of the water. Population and economics can grow a great deal by acquiring another 5 percent from the lower-valued water uses such as irrigated pastures.

The SINEX conference was co-organized by the International Association of Hydrogeologists (IAH), UNESCO, International Water Resources Association (IWRA), Food and Agriculture Organization, International Atomic Energy Agency, and the National Ground Water Association of USA in collaboration with the Spanish Chapter of IAH and IWRA.

Papers from the conference will be published by the International Association of Hydrologists in their Selected Papers series. The volume "Intensive Use of Groundwater – Challenges and Opportunities," by M.R. Llamas and E. Custodio, was released for discussion at the December meeting in Valencia. It was published by A.A. Balkema Publishers (balkema.ima.nl).

Upcoming Artificial Recharge Symposia

Organizations in both California and Arizona have scheduled spring meetings on artificial recharge. The Groundwater Resources Association of California, together with the U.S. Geological Survey, the California Department of Water Resources, and the International Association of Hydrogeologists, will hold a workshop on the technical and policy challenges of artificial recharge in California April 30 - May 1 in the South San Francisco Bay area, with an optional field trip on May 2. The workshop will provide presentations on the status of artificial recharge in California, including the intricacies and challenges faced to implement and manage artificial recharge projects, case histories, and the political and policy issues.

The 11th Biennial Symposium on Artificial Recharge of Groundwater, sponsored by the Arizona Hydrological Society, Salt River Project, U.S. Water Conservation Laboratory, and the Arizona Department of Water Resources, will be held June 5-6 in Tempe, AZ (the Phoenix area), with a field trip on June 7. Conference topics include conjunctive use, environmental benefits, legal and regulatory aspects, case studies, monitoring methods, natural recharge, public involvement, recharge methods, research and development, and water reuse.

Visit www.grac.org for more information on the California meeting. Contact Jenny Bush at Clear Creek Associates, (602) 294-9600 for more information on the Arizona meeting.

Cal State Sacramento to Hold American River Conference

California State University in Sacramento announced a Lower American River Science Conference to be held June 5-6.

The Lower American River is a unique resource of the Sacramento region, making important contributions to the economic, environmental and recreational quality of the region. It is the most heavily used recreational river in California, and many public and private agencies are concerned with its welfare.

Factors affecting the health of the river include increased flood control requirements, population growth, rising pressure on water use, changing recreation patterns, new understanding of aquatic ecosystems, fish issues, flow management, and restoration projects.

The three concurrent sessions of the meeting will cover the following themes:

- Fish, including in-stream flow, fish biology and genetics, effects of dams, and surface water quality.
- Groundwater, including stream/aquifer interaction, contaminant plumes, ground water versus surface water basins, and conjunctive use.
- Weather, including forecasting extreme precipitation in the Sierra Nevada and implications for the American River Watershed.

Visit www.cce.csus.edu/conferences for more information.

NGWA 2002 Expo Shined in Las Vegas

The National Ground Water Association's (NGWA) Ground Water Expo, held in Las Vegas in December, set attendance and exhibitor records and featured a wide variety of events.

A record 5,561 people attended the expo, including 2,454 contractors and 278 exhibitors, 51 of whom were first-time exhibitors.

The expo included the Annual Conference and Meeting for the Association of Ground Water Scientists and Engineers (AGWSE). The theme of this year's meeting was "Linking Surface and Subsurface Hydrology—from Science to Technology." Excellent keynote presentations were given by Scott Bair, Cliff Dahm, David Pyne, Bridget Scanlon, Edward Sudicky, Garth Van Der Kamp, Ingrid Verstraeten, and William Woessner. David Hyndman delivered the 2002 Darcy Lecture. In addition, numerous "Technical Interactive Presentations," or enhanced poster presentations, and "Action Demonstration Sessions" were made during the course of the event.

Also at the meeting, the AGWSE Board established three new committees: an association-wide Emerging Issues Committee to identify and examine issues on the horizon that may affect NGWA members and groundwater; a Transboundary Aquifers Interest Group; and an Interdivisional Cooperation Committee that will focus on improved community among the divisions of NGWA.

An auction held to raise money for the National Ground Water Educational Foundation garnered nearly $50,000 for the scholarship fund.

Visit www.ngwa.org.

SDCP, continued from page 6

agreements with landowners and agencies, and conservation banking. The final studies analyze the cost alternatives under different scenarios. In addition to land use decisions, SDCP includes policy changes such as new water conservation requirements. Once the plan is complete and is approved by the Pima County Board of Supervisors, it goes through a final public participation process supervised by the U.S. Fish and Wildlife Service who must approve the plan some time in 2003. It then becomes a formal agreement with the Service. County elected officials have unanimously supported the plan concepts and policies and have respected the recommendations of experts.

For more information and any of the more than 250 reports, visit www.co.pima.az.us/cmo/sdcp/.

Business Directory

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SENIOR HYDROLOGIST, FORT DEFIANCE, AZ

The Navajo Nation Department of Water Resource's Water Management Branch anticipated a Senior Hydrologist position to open Feb. 19. Annual salary is $47,340 and candidates must have at minimum a Bachelor's degree in hydrology or related science and four years of experience. For more information, visit the Navajo Nation Job Vacancy web page at www.nndpm.navajo.org, or contact John Leeper or Hope Wilson at the Water Management Branch office at (928) 729-4004.

Southwest Hydrology offers one column-inch of ad space without charge for Job Openings.

CALIFORNIA BRANCH OFFICE MANAGER (Job # 247)

Daniel B. Stephens & Associates, Inc. (DBS&A) is seeking a gifted manager and business developer, with proven client development capabilities in California, to lead their growth in the California marketplace. This position requires a BS degree, MS degree preferred, in geology, hydrology, or closely related area. Desirable areas of experience include vadose zone and groundwater hydrology, multi-phase contaminant transport, water resources analysis, including artificial recharge and groundwater resource management. Visit www.dbstephens.com for more information, or contact HR Director at (505) 822-9400.

ICWT, continued from page 7

current research activities of Fresno State's Center for Irrigation Technology, as well as expand its focus to include research and development of urban and environmental water needs. These activities will focus on water/energy efficiency, effective water reuse, conservation, and promoting private and/or public innovation.

- ***Industry Testing and Certification Services:*** The Testing and Certification Division plans to provide the water and fluid science industry with state-of-the-art testing and certification facilities and to conduct testing and certification on water technology equipment and applications. The division will then communicate the results of conducted tests to water users, policy makers, manufacturers, contract customers, and other interested parties.

- ***Public Policy and Education:*** The Public Policy and Education Division will communicate to the public and policy makers the technical aspects of water issues and resulting consequences; educate governments, end users, designers, lending institutions and others in the proper design of water application systems in irrigation, municipal and industrial water applications; and provide a center for continuing education for water industry personnel.

- ***Cooperative Marketing to the Water Technology Industry:*** ICWT will conduct cooperative marketing activities that benefit the water technology industry by increasing water and flow technology use worldwide. Strategies will include development and operation of the Water Technology Exposition Center and trade shows; development and implementation of an international awareness campaign targeting major user groups; and export marketing assistance.

Plans for a $60 million water research and development facility were unveiled in October. Construction on the first phase of the new facility should begin in 2003. When fully constructed, the International Center for Water Technology will house "the best-equipped and most comprehensive testing and certification laboratories in the United States", according to J. Michael Ortiz, Provost and Vice President for Academic Affairs at Fresno State, who added, "It will also be home to an exhibit hall in which water technology companies from around the world will permanently display working demonstrations of their products."

ICWT's public-private partnership is actively seeking funding to establish programs and build a state-of-the-art facility. So far, approximately $1.4 million in grants and contracts has been secured, with an additional $10 million pending. Land for the new facility will be provided on the Fresno State campus. Significant support for the project has been expressed from water and fluid technology companies, public agencies, water districts, and civic organizations.

Visit www.ICWT.net for more information.

PDB samplers, continued from page 8

problem. Similarly, the foaming and loss of VOCs that can occur when sampling alkaline groundwater into pre-preserved VOA vials is avoided because alkaline constituents diffuse very poorly, if at all, into PDBs.

Disproportionate contribution from individual aquifer zones lying within or adjacent to the zone of interest is avoided through use of PDBs. Pumping, even by low-flow methods, produces a flow-weighted sample biased toward water from any zone of higher hydraulic conductivity. These effects can cause sample dilution or contamination. Assuming horizontal flow through the open interval of the well, PDB sampling avoids aquifer pumping stress and associated sample agitation, so samples taken through the use of PDB technology are likely to be more representative of aqueous phase VOCs in the aquifer directly adjacent to target interval than samples taken by other methods.

The PDB's ability to reflect dissolved VOC concentrations in the adjacent aquifer allows determination of stratification and vertical concentration gradients of VOC contaminants. Generally, each two foot-long PDB represents not more than five feet of the well screen interval. VOC concentrations may be measured at specific well screen depths by hanging PDBs in tandem. In addition to gaining information about the well's hydrogeological attributes, correct positioning of a future single PDB may be determined.

Cost Savings Can Be Considerable

In a cost evaluation study at McClellan AFB, the costs associated with use of PDBs, passive Diffusion Multi Layer Samplers (DMLS™), low-flow purge (MicroPurge®), and conventional purge sampling methods were compared. The PDB cost $65 per sample, compared to from $308 to $555 per sample for the other methods (Parsons Engineering, Inc. 1999)

In a subsequent study at McClellan AFB, a cost comparison of PDBs, Micropurge, and conventional purge methods was made (McCellan AFB, 2000). The comparison assumed one VOC sample tested per monitoring well per year (exclusive of quality control samples) for 500 wells, tested at a frequency of 125 wells per quarter and 5% field duplicates. Capital costs were $9,000 for the PDB compared to $11,800 to $12,525 for the other methods. One-time costs were $32,500 for both the PDB and conventional purge, and zero for the MicroPurge. Most notably, however, annual recurring costs were $98,000 for the PDB compared to $412,000 for the MicroPurge and $377,000 for the conventional purge (the latter two costs include disposal of purge water).

Additional Efforts

Through the Interstate Technology Regulatory Cooperation's (ITRC) Diffusion Sampler Work Group (DSWG), a wealth of data on deployments and side-by-side comparisons of the use of PDB technology and conventional sampling technologies (purge and bail, moderate- and low-flow-rate pumping, and MicroPurge technologies) has been gathered. It is available on the ITRC's website at www.itrcweb.org under the Diffusion

Sampler Information Center, and includes the USGS's User Guide for Deployment of the PDBs (Vroblesky, 2001), and the ITRC DSWG's Recommendations for the Use of PDBS for Long-Term Monitoring of Volatile Organic Compounds in Groundwater (2002). The DSWG consists of representatives from the USAF, US Navy, US EPA, USGS, ACOE, private industry and six different state agencies. It is through this group's unbiased efforts that great strides have been made in the regulatory communities' acceptance of the use of PDB technology.

The PDBs are available commercially through two authorized suppliers: Columbia Analytical Services, Inc. at 800-695-7222 x 11 (www.caslab.com), and Eon Products, Inc. at 800-474-2490 (www.eonpro.com). Contact Dee O'Neill at doneill@corp.caslab.com and Hugh Rieck at Rieck.Hugh@ev.state.az.us The views expressed in this article are those of the authors and do not necessarily constitute official endorsement by the Arizona Department of Environmental Quality.

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McClellan AFB/EM, 2000. Technology Application Analysis Report, National Environmental Technology Test Sites (NETTS) for Passive Diffusion Membrane Samplers, Final, August 2000.

Parsons Engineering Science, Inc., 1999. Final Technical Report for the Evaluation of Groundwater Diffusion Samplers, December 1999, Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division

Sivavec, T.M. and S.S. Baghel, 2000, General Electric, written communication.

Vroblesky, D.A.,2001 "User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells-Part 1: Deployment, Recover, Data Interpretation, and Quality Control and Assurance", USGS, Water-Resources Investigations Report 01-4060, 2001.

Vroblesky, D.A. and T.R. Campbell, 2001, Equilibrium Times, Stability, and Compound Selectivity of Diffusion Samplers for Collection of Groundwater VOC Concentrations, Adv. Env. Res., 5(1); pp.1-12.

Irrigating India: My Five Years as a USAID Advisor

by Sol Resnick as told to Elaine Minow Resnick, published by P.B.Publishing, a division of Printstar Books, $12.95

*Reviewed by **Lorne Graham Wilson, Ph.D.** – Hydrologist Emeritus, University of Arizona*

Following World War II, teams of professionals, under the auspices of the U.S. Agency for International Development, dedicated themselves to improving the lives of villagers in third world countries. Sol Resnick, one of the finest representatives of this group, worked alongside native villagers in drought stricken regions of India to construct small-scale irrigation projects. Working under difficult and often dangerous conditions, he demonstrated the effectiveness of a large number of village-scale projects as opposed to fewer large-scale schemes. Following his experience in India, he had an acclaimed academic career at the University of Arizona.

Resnick's hydrological expertise was sought in countries throughout the world. In looking back over a life of accomplishments, he feels the best five years of his life were those spent in India. I worked with Dr. Resnick for more than 20 years and was always delighted when he reminisced about his experiences in India. This memoir allows his recollections to be shared with a wider audience. Told in his usual modest style with his fine sense of humor, I strongly recommend this memoir to both technical and lay audiences. It should be required reading for those contemplating assignments in the Peace Corps.

Printstar Books are available through most bookstores.

STANMOD Software Review

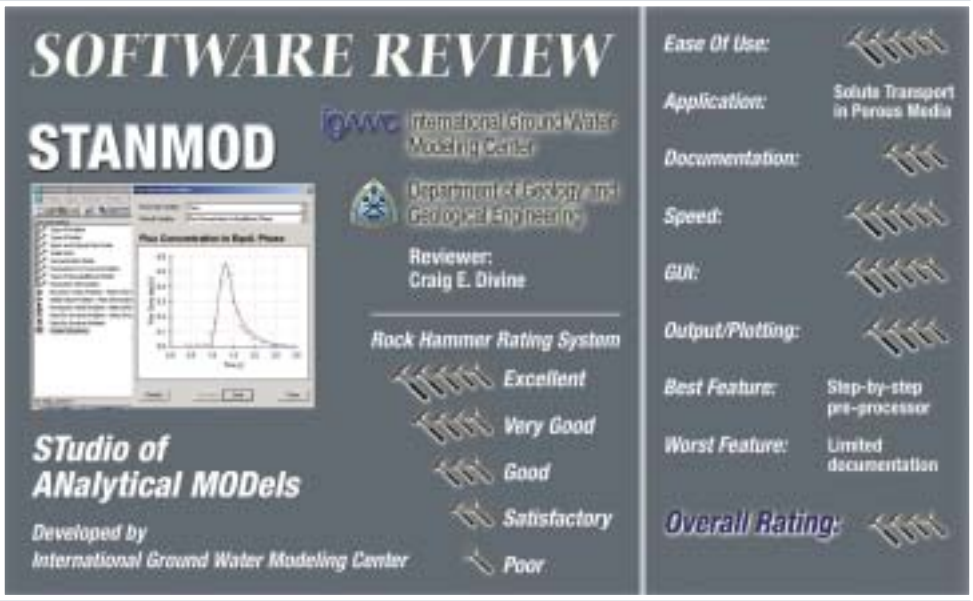
Craig E. Divine *– International Ground Water Modeling Center*

STANMOD (STudio of ANalytical MODels) is a suite of porous media solute transport models created by the U.S. Salinity Laboratory incorporating some of their more popular, previously-developed models in a common, user-friendly pre- and post-processor. Specifically, STANMOD 2.0 includes CHAIN, CFITM, CFITIM, CXTFIT, 3DADE and N3DADE.

These models are based on analytical solutions of the convection-dispersion equation and consider a variety of complex solute transport processes, including sequential first-order decay and chemical/physical non-equilibrium (rate-limited) processes. Field-scale solute transport can be evaluated using simplified stochastic methods. Several of the codes include inverse algorithms for estimation of optimal transport parameter values by fitting models to observed data. Because they are based on analytical solutions, STANMOD codes assume homogeneous medium properties and steady boundary conditions. Consequently, accuracy of the models is related to the degree to which actual conditions deviate from these and other model assumptions.

While there are no modifications of the previously-released versions of the underlying transport models, STANMOD greatly increases utility of these models by providing a straightforward pre-processor and useful post-processor/plotting options. The technical documentation (which includes online help) for the STANMOD interface is brief; however, the Windows-based interface is intuitive and numerous example problems are provided. Electronic copies of the original documentation for the transport models are included and the developers at the U.S. Salinity Laboratory can be contacted for technical assistance.

A demo version of STANMOD and its individual underlying transport models is available free of charge at www.ussl.arc.usda.gov. The most recent version of STANMOD (version 2.0) can be purchased for $500 through the International Ground Water Modeling Center (www.mines.edu/igwmc/).



MARCH 2003

1 **ABSTRACTS DUE!** Colorado State University and other sponsors. **10th Annual Conference on Tailings and Mine Waste**. October 12-15, Fort Collins, CO. *www.engr.colostate.edu/hsrc/*

3-7 National Ground Water Association. **Ground Water Geochemistry: Fundamentals** (March 3-4) and **Applications** (March 5-7). Scottsdale, AZ. *www.ngwa.org/education*

4-5 National Ground Water Association. **Application of Health Risk Assessment for Environmental Decision Making**. Scottsdale, AZ. *www.ngwa.org/education*

10-14 Government Institutes/ABS Consulting. **Chemistry for Non-Chemists Bootcamp**. Las Vegas, NV. *www.govinst.com*

17-18 Government Institutes/ABS Consulting. **Toxicology for Non-Toxicologists**. Scottsdale, AZ. *www.govinst.com*

17-21 Government Institutes/ABS Consulting. **U.S. Environmental Laws and Regulations: Introduction** (March 17-19) and **Advanced** (March 20-21). Scottsdale, AZ. *www.govinst.com*

17-21 Princeton Goundwater, Inc. **The Remediation Course**. Denver, CO. *www.princeton-groundwater.com*

19-21 National Ground Water Association. **3rd International Conference on Pharmaceuticals and Endocrine Disrupting Chemicals in Water**. Minneapolis, MN. *www.ngwa.org/education*

27-28 CLE International. **California Wetlands: 10th Annual Conference**. Los Angeles, CA. *www.cle.com*

29-April 2 American Planning Association. **2003 National Planning Conference**. Denver, CO. *www.planning.org*

31 **ABSTRACTS DUE!** Arizona Hydrological Society. **16th Annual Symposium**. Sept. 17-20, Mesa, AZ. *www.azhydrosoc.org*

31-April 4 Government Institutes/ABS Consulting. **The RCRA Compliance Institute**. Scottsdale, AZ. *www.govinst.com*

APRIL 2003

1-4 UNESCO and HydroSciences Montpellier Maison des Sciences de l'Eau. **Hydrology of the Mediterranean and Semi-Arid Regions**. Montpellier, France. *www.unesco.org/water/water_events/Detailed/127.shtml*

6-10 Environmental and Engineering Geophysical Society. **Annual Meeting/Symposium on the Application of Geophysics to Environmental and Engineering Problems**. San Antonio, TX. *www.eegs.org/sageep/index.html*

7-11 Government Institutes/ABS Consulting. **Federal Facility Environmental Compliance Bootcamp**. Las Vegas, NV. *www.govinst.com*

7-11 The Nielsen Environmental Field School. **Fundamentals of Ground-Water and Contaminant Movement** (April 7); **The Complete Ground-Water Monitoring Field Course** (April 8-11); **Ground-Water Monitoring Well Design, Construction and Development** (April 8-9); **The Ground-Water Sampling Field Course** (April 10-11); **Micropurge Low-Flow Purging and Ground-Water Sampling** (April 11). San Diego, CA. *www.envirofieldschool.com*

10-11 CLE International. **California Water Law**. San Francisco, CA. *www.cle.com*

20 **ABSTRACTS DUE!** International Ground Water Modeling Center. **MODFLOW and More 2003: Understanding through Modeling.** September 17-19, Golden, CO. *www.mines.edu/research/igwmc/events/modflow2003/*

27-May 1 Montana Tech. **Mine Design, Operations and Closure Conference 2003**. Polson, MT. *multimedia.mtech.edu/mineop*

29-May 1 Groundwater Resources Association of California. **Model Calibration and Uncertainty Analysis Using PEST**. San Francisco, CA. *www.grac.org*

30-May 2 Groundwater Resources Association of California and others. **Artificial Recharge in California: Technical and Policy Challenges**. San Francisco area, CA. *www.grac.org*

30-May 2 New Mexico State University. **Aquatic Resources in Arid Lands**. Las Cruces, NM. *leopold.nmsu.edu/dcowley/ARIAL_Conference.htm*

MAY 2003

1-2 University of Arizona Water Resources Research Center. **Local Approaches to Resolving Water Resource Issues: What's Working, What Hasn't Worked, and Building on Existing Efforts**. Prescott, AZ. *ag.arizona.edu/AZWATER*

8-9 CLE International. **Law of the Colorado River**. Phoenix, AZ. *www.cle.com*

12-15 U.S. Committee on Irrigation and Drainage. **Water for a Sustainable World—Limited Supplies and Expanding Demand**. Phoenix, AZ. *www.uscid.org*.

12-16 Government Institutes/ABS Consulting. **The Environmental Compliance Bootcamp**. Phoenix, AZ. *www.govinst.com*

15-16 CLE International. **Endangered Species Act**. San Diego, CA. *www.cle.com*

20-22 Government Institutes/ABS Consulting. **Chemistry for Non-Chemists**. Phoenix, AZ. *www.govinst.com*

JUNE 2003

5-7 Arizona Hydrological Society and others. **11th Biennial Symposium on Groundwater Recharge**. Tempe, AZ. Contact Jenny Bush at (602) 294-9600 or email dbartlett@clearcreekassociates.com

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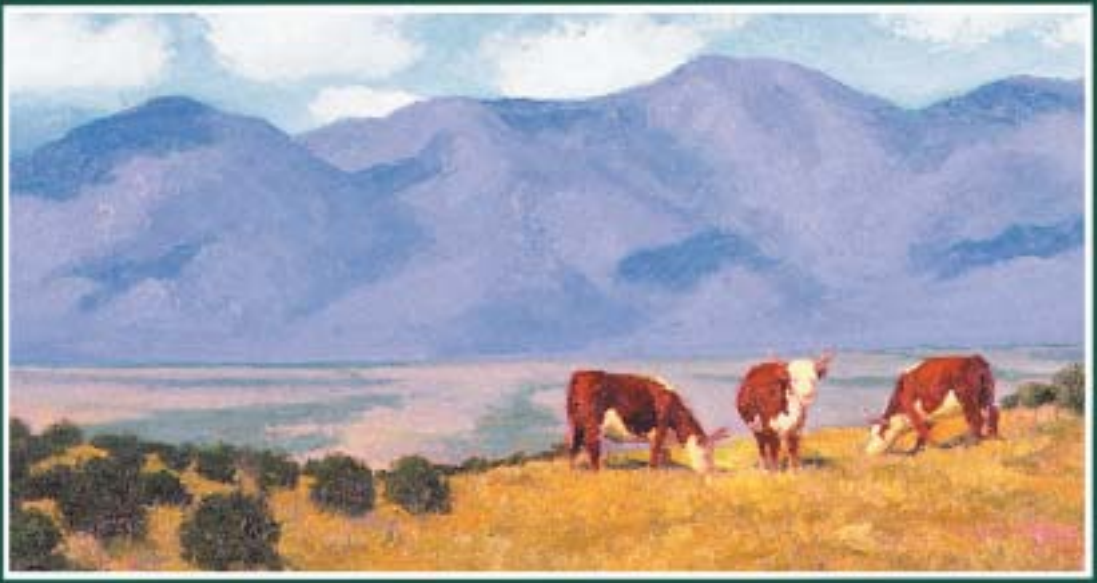

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