

THE ARIZONA HYDROLOGICAL SOCIETY

NEWSLETTER



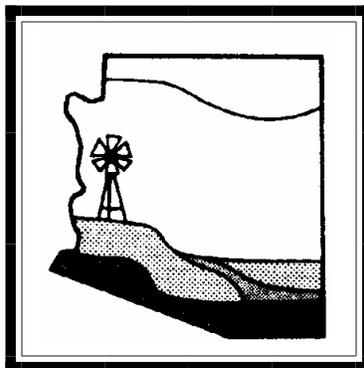
CONFESSIONS OF A WATER BUFFALO

-by Grady Gammage, Jr.
Gammage & Burnham

This article was published in the January 2, 2005, edition of the Arizona Republic under the title, "Water: Waste not, want not, but overreact not." It is presented here with the author's original title and his permission. LKB

The headquarters of the Central Arizona Project sits in obscurity at the far north end of the City. Since 9/11, the security fencing, entry procedures and out-of-the-way approach make it feel like the fortress of some James Bond villain who feeds failed henchmen to his pet piranha. Inside, a map of the canal system covers an entire wall, like a connect-the-dots painting, where LED's glow red or green to display the status of the pumps which move Arizona's water from the Colorado River, through Phoenix and on to Tucson.

I am driving back down into the City, having just left my last meeting after twelve years as a member of the Central Arizona Water Conservation District ("CAWCD") Board of Directors. I got lost the first time I tried to get there and then walked into a room of strangers. The boardroom itself is a simple, unpretentious chamber with a large U-shaped table and an audience of 60-70 people. That first board meeting, I recognized almost no one. Today it feels like I am leaving a lot of old friends: the community of water buffaloes.



I do not know who started calling the few dozen people who make (and hopefully understand) Arizona's water policy "water buffaloes." Originally, the name probably referred to the fact that the group was mostly middle aged, male, and somewhat overweight engineers, lawyers and farmers who spoke in acronyms. That is not true any more — there are a number of women, younger faces, even people of color. But the name sticks, maybe because water buffalo are slow moving, stub-

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CALL FOR SPONSORS/EXHIBITORS AT 2005 RECHARGE SYMPOSIUM

-by Mike Block
Metro Water District, Recharge Symposium Fund-raising Chair

Yes, it is that time again to think about your sponsorship and/or exhibit at the 2005 AHS 12th Biennial Symposium on Groundwater Recharge. The conference will be held from Wednesday, June 8, through Saturday, June 11, 2005, at The Inn Suites which is conveniently located off Interstate 10 in downtown Tucson. The Symposium will feature recent advances in recharge science, planning, design, and management.

We would like to thank and acknowledge the Arizona Department of Water Resources, the

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**RECHARGE SYMPOSIUM
CONTINUED FROM PAGE 1**

Central Arizona Project, the City of Tucson Water Department, the Metropolitan Domestic Water Improvement District, and the Salt River Project for their generous in-kind and volunteer support in producing this Symposium.

The Symposium has some new sponsorship categories in addition to the usual ones, and includes Corporate, Icebreaker, Lunch, Break and Field Trip Sponsor, and Exhibitors.

On Wednesday evening June 8, a social Icebreaker is available for sponsorship. The Icebreaker is scheduled immediately after Dr. Herman Bouwer's afternoon recharge workshop.

On Thursday and Friday, June 9 and 10, sponsors and exhibitors will be featured within the main meeting room. The meeting room has prime space for sponsors and exhibitors to directly interact with the Symposium participants during session breaks and lunches as well as during the event.

The Thursday and Friday lunch presentations will feature notable speakers. David Modeer, Tucson Water Director, has agreed to join us. Final preparations for our other lunch speaker are nearing completion and the individual will be announced in next newsletter.

Lastly, a Field Trip is open for sponsorship on Saturday, June 11. The Symposium Field Trip will include tours of the City of Tucson surface-spreading recharge facilities and the extensive well injection system at Raytheon Missile Systems.

The deadline to have your organization included in the Symposium registration brochure is February 28, 2005.

If you are interested in being a sponsor/exhibitor at the Symposium and you have not received a personal invitation, you can find more information (and a sponsorship form) at the AHS website (www.azhydrosoc.org/symposium_recharge.html) or you can contact Mike Block, Fundraising Chair, at (520) 575-8100 or 



**BLM SEEKS HELP FOR
GROUNDWATER
LEVEL MONITORING
PROGRAM IN
CIENEGA CREEK
BASIN**

-by Mike Block
Metro Water District

Some attendees of the 2004 AHS Symposium may remember the scenic and "spirited" field trip entitled "The Hydrology, Rangeland Ecology, and Wine of Upper Cienega Creek Basin." Hopefully, the sober ones do!

The first field trip stop was at the Bureau of Land Management's Las Cienegas National Conservation Area (NCA). One of the things learned during at this stop was that the rural areas adjacent to the 42,000-acre NCA could be urbanized and negatively affect the NCA's perennial streamflows and riparian areas.

The BLM is seeking technical assistance from interested AHS members to help them plan, design, and implement a long-range basin wide groundwater level monitoring network. If there is sufficient member inter-

est to volunteer on the project, then the Bureau of Land Management could use that volunteer service as a fund match to get matching dollars to purchase monitoring equipment.

If this type of volunteer effort appeals to you, please contact me at (520) 575-8100 or mblock@metrowatr.com.

Please note in your response if you want to be on the planning, design, or implementation phase of the monitoring project. 



**WATER BUFFALO
CONTINUED FROM PAGE 1**

born, and like wallowing in mud. I like to think of myself as a water buffalo, and consider it an earned honor.

Twelve years is a long time. Besides being able to sling acronyms with the best of them, what did I learn?

Of Drought, Crisis, Indians and Las Vegas.

Shortly after I was elected, the Secretary of the Interior declared the CAP canal "complete." That declaration tripped a requirement that the price of water increase in order to recover the multi-billion dollar cost of construction. As a result, demand plummeted and we were awash in extra water we could not sell. For a time, it looked like Arizona would not use its full Colorado River allotment for decades. But as a result of lowering the price to encourage farming use, and inventing creative mechanisms to pump water 300 miles and then let it seep slowly underground, we managed in the last few years to use our full share.

My thanks to those of you who sent your renewals in Christmas cards — they really brightened my days. LKB

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**WATER BUFFALO
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We moved very quickly from a period where we seemed to have too much water to a time when we fret about not having enough. Such is the nature of life in the desert. Today, we are in the ninth year of what may become the record historic drought. But that does not mean we are in crisis. Our routine condition would be considered a catastrophic drought anywhere else in the country. We have built and maintain a sophisticated, elaborate water supply based on multiple sources precisely because we live in such a dry place. More than any other arid city in America (maybe in the world), metropolitan Phoenix has done a capable job of dealing with persistent aridity and the cycle of wet/dry years. This reality does not mean we have the luxury to waste water, but it *does* mean that we should not overreact and behave as though there is a desperate crisis when there is not. We should not turn off the decorative fountains at Phoenix City Hall and elsewhere. We should not be telling people to turn off the water when brushing their teeth. The justification for these kinds of measures is that it is useful to create a psychological reminder of drought conditions, even though the actual "savings" are essentially meaningless. But what we communicate by such messages is that we are in a severe crisis. The public then does not understand how we can continue to approve new subdivisions. Token gestures, shallow slogans and manipulative public messages do not well serve the cause of understanding water issues. We need to thoroughly explain to the public the sources and qual-

ity of our water supply and speak in detail how we are dealing with drought in a way that keeps it from becoming a crisis.

Within the last month, Arizona has struck two extraordinary, complex and important deals: one with the Gila River Indian Community (GRIC) and the second with Las Vegas. Both represent creative water management at its best, and are the latest pieces of a long line of important actions by Arizona dealing with the big picture of Western Water. But it is hard for the public to grasp why we would be "giving" our water to keep the fountains on at Bellagio when we stopped running the ones in downtown Phoenix. Or why a relatively tiny population of Native American Arizonans should control nearly half of our Colorado River water.

The GRIC settlement, now signed into law by the President, resolves decades of litigation over the rights of the tribe to the waters of the Gila River. Under federal law, when the U.S. government created the reservations, it "reserved" enough water to the tribes to farm the irrigable land. The claim against the Gila (which we dried up to create the Salt River Project) was arguably huge — it hung as an unquantified threat over all water management in Central Arizona. Theoretically, if finally adjudicated and demanded for delivery, that claim would have required taking back water from metropolitan Phoenix cities. By using CAP water to settle the claim, we ended the uncertainty, reduced our repayment to the federal government and resolved the litigation. Until the GRIC can actually take delivery of the water, the CAP will resell it for recharge to our depleted

aquifers. In the future, the GRIC will either use it to farm (which is a good thing) or lease it back to Arizona cities that need additional supply.

The Las Vegas deal involves a fraction of the amount of water in the GRIC settlement, but it is enough water to tide that city over until a time when their in-state resources are developed. Because Las Vegas has no agricultural heritage, they are decades behind Arizona in water development. The 40,000 acre feet per year we have guaranteed to Las Vegas is a commitment we can satisfy without jeopardy to our needs. In exchange, we receive serious money, but more importantly we gain an ally in the great game of western water. We may call upon that allegiance in revisiting our low priority in times of shortage.

Water is a Special Commodity.

When I first got on the CAWCD Board, like many private-sector, free-market capitalists, I saw no reason why water should be different from other commodities. It seemed clear that with a few exceptions, markets should be allowed to operate, prices should be uncontrolled, and the highest bidder should be able to obtain the most water. Bob Robb recently articulated a similar view in his thoughtful column of December 19.

After twelve years of observing the unusual little bastion of American socialism that is water policy, I have come to the realization that water is unique. Like air, water is absolutely necessary to sustain life. But water is also a resource that can be contained, hoarded, and trans-

CHAPTER NEWS



FLAGSTAFF

-by Nancy Riccio
Plateau TechComm / Plateau
MediaWorks

FEBRUARY MEETING

**Wednesday, February 16,
2005**

Time: 4:00 PM

**Location: Geology Building at
NAU, Room 103**

**Topic: "The Occurrence,
Transport and Fate of Viruses
and Pharmaceuticals in
Groundwater Impacted by
Septic System Effluent: The
Hydrogeologists and Human
Health" presented by Dr. Wil-
liam Woessner, University of
Montana**

On February 16, at 4:00 PM in Room 103 of NAU's Geology Building, Dr. William Woessner of the University of Montana will be presenting the 2005 Birdsall-Dreiss Lecture of the Hydrogeology Division of the Geological Society of America. His talk is entitled "The Occurrence, Transport and Fate of Viruses and Pharmaceuticals in Groundwater Impacted by Septic System Effluent: The Hydrogeologists and Human Health." A reception will likely follow his presentation at a location to be determined. Contact Abe Springer at (928) 523-7198 or abe.springer@nau.edu for information. To learn more about the lecture, check <http://gsahydrodiv.unl.edu/general/birdsalldreiss.htm>. An abstract of Bill's presentation follows.

"Over the last 20+ years, I have studied how the disposal of sewage from households and larger multiple-user facilities in unsewered areas has impacted the underlying groundwater. When the densities of dwellings using septic systems increase, concern is often raised by adjacent homeowners and/or local and state governments that potable groundwater will be impacted. Though individual household wells are usually not regularly tested, groundwater serving multiple households, communities, or the public must be free of fecal coliform bacteria and must contain nitrate-nitrogen below 10 mg/L. Recently, however, federal regulators have suggested groundwater supplies should be tested for viruses. In addition, the discovery of trace quantities of pharmaceuticals in surface water impacted by sewage and sewage treatment plant waste has raised concerns that groundwater degraded by septic system effluent may also contain low levels of pharmaceuticals.

This presentation will focus on the occurrence of a select group of viruses and pharmaceuticals in septic systems and the processes controlling the transport and fate of these constituents in the underlying shallow aquifers. I will present the results of sampling sewage impacted groundwater associated with a high school drain field and virus tracer experiments used to assess transport processes in shallow sand and gravel dominated aquifers. The results of a survey-level study that chronicled the occurrence of 20 pharmaceutical compounds in a

large number of individual septic tanks and the prevalence and fate of these compounds in the associated groundwater will also be discussed. Both prescription and nonprescription drugs were detected. The presentation will conclude with a discussion of how hydrogeological data may be used to examine related risks to human health."

Next Symposium Planning Meeting

We're getting together at roughly monthly intervals these days to plan for the 2005 Symposium. Check the Flagstaff Chapter page of the AHS Web site (<http://www.azhydrosoc.org/flagstaff.html>) for information about our next meeting. Details are also announced via email. ☐



PHOENIX

-by Lee-Anna Walker
Archaeological Consulting Services, Ltd.

JANUARY MEETING SUMMARY

The Phoenix Chapter held its annual kick off meeting on January 14 at Keith Scoular's house. Chapter members discussed goals and issues for 2005.

FEBRUARY MEETING

Tuesday, February 8, 2005

Time:
5:30 PM Social Hour
6:30 PM Dinner
7:15 PM Meeting

Location:
Macayo's Depot Cantina
300 S. Ash, Tempe

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CHAPTER NEWS



PHOENIX NEWS
CONTINUED FROM PAGE 4

Cost: \$12 members, \$17 non-members, \$5 students

Please RSVP by Friday, February 4th to Beth Proffitt by phone at (602) 437-0330 or by email at: eproffitt@transgeo.com.

Topic: "Sovereign Boundary Determination on the Colorado River" presented by Pat Quinn, P.E. and Mike Kellogg, GIT, JE Fuller / Hydrology & Geomorphology, Inc.

Abstract: The Arizona State Land Department (ASLD) is legislatively mandated to manage sovereign lands. Sovereign lands are those lands lying in the beds of navigable waterways. They are held in trust by the sovereign in order to provide public access to those waterways for the purposes of fishing, commerce, and navigation.

The determination of sovereign boundaries is a complex undertaking that involves principles of both law and science. Findings are based upon the collection, analysis, synthesis, and interpretation of the temporal and spatial interrelationship of facts within the context of guiding legal principles. The extent and depth of the data collection and analysis effort for the sovereign boundary determination depend largely on the intended end-use of the resultant boundary information, the complexity of the physical system in the study area, and the availability of the various base data and factual information.

Generally, channel change may be categorized as accretive or avulsive. Legal doctrines provide guidance as to the resultant impact to sovereign land boundary location. Accretive channel change results from gradual and imperceptible movement of the channel banks with time through the normal processes of erosion and deposition. According to the Doctrine of Accretion, the sovereign land boundaries change position in conjunction with the changes in position of the channel banks. Avulsive channel change is the result of a sudden and dramatic shift in channel location such that the new channel completely abandons its former location.

The ASLD has completed two investigative studies of sovereign boundary determination on the Colorado River; a 26 mile reach near Yuma, Arizona, and a 29 mile reach near Bullhead City, Arizona. The ASLD has also completed a field survey of the ordinary high water mark (OHWM) in a portion of the Bullhead City reach, and has submitted a series of plat maps with the Mohave County Recorder's Office describing the surveyed OHWM angle points. These plat maps are for use by the public as a reference to determine the extent of the State's sovereign claim within river-front parcels. An individual parcel owner who desires to either make improvement on their property or to un-cloud title can access the plat maps and obtain the necessary information to incorporate the OHWM data into a parcel boundary survey.

LOOKING AHEAD...

In March, Dr. Phil Christensen of ASU will talk about Mars.

Patrick Dent with the CAP will give a presentation on CAP Canal hydraulic operations at the April meeting.

NEW BABY NEWS



The Phoenix Chapter would like to extend our congratulations to AHS member Kevin Murdock (CH2MHill) and his wife Jiravann on the birth of their daughter Kiri. Kiri was born late New Year's Eve night, weighing 6 lbs 7 oz. ☑



TUCSON

DECEMBER MEETING SUMMARY

- by Marla Odom
Errol L. Montgomery & Associates, Inc.

On December 14, 2004, Dr. Thomas Maddock, from the Department of Hydrology and Water Resources at the University of Arizona, presented a talk titled, "Current Water Issues and Policy in the San Pedro Watershed". The meeting was primarily attended by hydrologists, consultants, lawyers, and interested parties in the San Pedro Watershed.

Dr. Maddock began by defining capture, and stating that in a safe-yield system, you can only pump what you can capture. Anything else is aquifer depletion, or removal from storage. He described recharge and discharge components to an aquifer, highlighting gaining and los-

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**TUCSON NEWS
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ing streams. Dr. Maddock argues that both gaining and losing stream systems have subflow pumped by nearby wells. Others argue for varying appropriations for these scenarios, which is the argument at the center of current adjudication issues.

Capture is calculated with models and has no "real" values to compare to. Because models are used to calculate capture, Dr. Maddock places high importance on the incorporation of seasonalization to models. Seasonalization is the conversion of boundary conditions or source-sink terms of a groundwater flow model with multi-year or annual stress periods, to within-year seasonal stress periods. He argues that annual or multi-year stress periods mask ecological effects on stream systems and evapotranspiration. Also, climatological change in seasonal distribution of precipitation or recharge and discharge can have ecological effects. Annual data can make it appear as though streams do not go dry when they do.

Reliable models have several necessary ingredients. Surface and groundwater components, base case (steady-state, steady oscillatory models) and historical (transient) modeling, control variables, state variables, and parameters are all required to make a model useful. Subtraction by stress period of historical streamflow from base streamflow provides an estimate of surface water capture by groundwater pumping. Drastic differences are often noted between seasonal oscillation models' calculation of capture and annualized model capture.

So, with all this in mind, what needs to happen on the San Pedro River? Dr. Maddock says that if you see long-term change, the problem has already happened. In order to determine and/or alter change, you need:

- a monitoring network far enough away from the river to detect gradient changes
- limited pumping near the stream corridor
- conservation on development
- artificial maintenance of the system (artificial recharge)

Dr. Maddock says, "The San Pedro Basin is the most measured basin in the country, but that may not help the demise of the river, just document it."

The current San Pedro model is not predictive of long-term climatology. Maddock stresses that you never want to predict beyond the length of historical data. If you have 60 years of data, don't predict farther than 60 years into the future, although predicting only 10 years into the future is far more realistic.

Maddock also talked about the current debate over subflow, or groundwater associated with a stream. A first attempt to define subflow occurred with the Gila River adjudication. This set up the "50/90" rule, where 50% of water pumped within 90 days is appropriable. However, the debate lingers over how wide the subflow regions should be defined. Maddock claims this is basically a "mines versus environmentalists" debate. Judge Goodfarb (Gila River adjudication) ruled that subflow is defined by the Holocene alluvium. This decision was upheld and made law. The Arizona Depart-

ment of Water Resources did not fight the definition at the time.

Tom ended his talk by saying that we also need to manage riparian areas. Even if we are able to maintain or supplement streamflow, more water means more riparian growth, which translates to more water taken in to evapotranspiration. We need to not only keep people growth within the San Pedro basin in check, but riparian growth as well.

We thank Dr. Maddock for an interesting presentation.

**JANUARY MEETING
SUMMARY**

-by Ken Carroll
Water Management Consultants

Jon Spencer from Arizona Geological Society was the speaker for our January meeting. Jon presented his talk "First water from the Colorado River: An analysis of the hydrologic and geochemical evolution of an early Pliocene chain of lakes in the lower Colorado River valley." Jon used strontium isotopic ratios to determine that the rocks deposited in the Colorado River Basin were formed by lake sedimentation instead of marine deposition. However, the fossil record indicates the presence of marine life. Jon suggested the possibility of lake evaporation causing saline conditions in a series of five lakes that allowed for marine life to thrive. Then he used a volume budget model accounting for evaporative increases in salinity to simulate conditions in the five lakes that was similar to sea water.

The Tucson Chapter would like to thank Jon for his time and an interesting presentation.



**TUCSON NEWS CONTINUED
FROM PAGE 6**

FEBRUARY MEETING

Tuesday, February 8, 2005

Time:

7:00 PM Social Half Hour

7:30 PM Presentation

Location:

**Errol L. Montgomery &
Associates
1550 E. Prince Rd.**

Topic: "Tucson Water Resource Plan" presented by Ralph Marra, Tucson Water

LOOKING AHEAD...

We have tentatively rescheduled, Dr. Frank D'Agnese, a Consultant and Senior Partner at Earth Knowledge, LLC, for our March 8 meeting. Dr. D'Agnese's presentation will discuss Earth Knowledge's current efforts to build stronger and more-informed multi-stakeholder involvement in water sustainability projects in the southwestern US.

Watch for more details in next month's issue. 



**WATER BUFFALO
CONTINUED FROM PAGE 3**

ported. Its use evolves over decades. Its price cannot be subject to extreme volatility. The infrastructure costs to develop water in this kind of climate are huge, and not easily subject to a hard nosed investment analysis. Water is the ultimate communal commodity. It must be shared among a large enough group to pay for the infrastructure to manage it. That group becomes our tribe—"us"—those outside who want our water become "them."

Water also is not just the single fluid substance you hold in a plastic bottle. An essential component of water is not just what you have, but your right to get more in the future. Water that has high delivery reliability is worth a lot more than water that can be cut off. Water that is used for drinking, cooking, bathing, showering, needs to be cheap enough for any family to afford. Water that is used for aesthetic and decorative purposes should be priced higher. Water that is wasted should be priced in a way that discourages waste. Water that can be taken away from a user (like a farmer) in times of severe need should be priced more cheaply. This kind of complex pricing function is not easily accommodated by purely private markets. There is a stronger role for pricing in water management. Water is too cheap in metropolitan Phoenix. There is a role for private water markets, but there is an inherent community role in managing the price and delivery of this unique commodity.

Government is Not All Bad.

Arizonans deeply believe in the American perspective that the less government, the better. We sometimes interpret that to mean that no government would be best of all. There are some things that only government can accomplish. Government can spread societal costs more broadly than any private enterprise. It can think longer term than any profit-motivated actor. Sometimes only government can manage negative externalities like environmental impact, structuring ways to avoid the "tragedy of the commons," where individual rational action leads to collective damage. Water management is one of

these primarily governmental activities.

Water management is rooted in social evolution. Every society treats the handling of water as part of the function of some kind of governmental unit. Indeed, a case can be made that government may have been first created in the arid regions of the Middle East precisely because of the need to manage water distribution systems and resolve water disputes.

Just before Christmas, the Colorado River Water Users Association met in Las Vegas to talk about how the Colorado River is shared, managed and allocated. Some private interests were at the table, but by and large the conversation is between seven individual states, the United States, and a series of local governments including cities and special districts. Even within a single state like Arizona, the handling of our share of "The River" is a discussion among dozens of different governmental entities.

It looks like a confusing, overlapping, redundant example of government inefficiency. That's why it works. Decisions unfold slowly after being vetted in the crucible of chaotic democracy. Change happens in small increments, but then mistakes happen in small increments, too. Water management is our State's greatest governmental success story. It is a success because we have been able to cooperate about water management for more than a hundred years. It has been—and must continue to be—recognized as a legitimate function of government where we should raise and spend the collective revenues necessary to do a good job.

"I never give them hell. I just tell the truth and they think it's hell." - Harry Truman

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**WATER BUFFALO
CONTINUED FROM PAGE 7**

The federal government repeatedly helped us make it a success: the “Feds” are not always the bad guys. Most of all, it is a success because generations of Arizonans have regarded it as a matter of common public interest. Policy has prevailed over politics. That continues to be true to this day.

Water buffaloes are ponderous, slow moving, stubborn, jealously guard their turf and usually move as a herd. Our public policy has benefited from those qualities. Long may they wallow in the mud. ☐



**TSUNAMI LEAVES
BEHIND HUMAN
DEVASTATION AND
ENVIRONMENTAL
DAMAGE THAT MAY
TAKE DECADES TO
RECOVER**

The following is a press release from the Nature Conservancy. For more information, visit <http://nature.org/pressroom/press/press1726.html>. LKB

**SCIENTISTS BEGIN TO ASSESS
DAMAGED MARINE AND COASTAL
RESOURCES THAT WILL IMPACT
LOCAL ECONOMY AND LIVELI-
HOODS FOR YEARS TO COME**

As aid arrives to countries hit by the tsunami to provide much-needed food, shelter and medicine for the survivors, scientists are beginning to focus on the longer-term environmental damage that will affect the livelihoods of fishermen and coastal communities for years to come. While the extent has yet to be quantified, coral reefs, mangroves, seagrass beds, beaches and coastal wetlands have been severely damaged

by the tsunami, depleting natural resources that communities rely upon for survival.

In addition to the direct destruction caused by the storm, contamination from runoff, pollution and sedimentation continues and will result in even further damage to the surrounding areas. Coastal erosion will likely continue for many years.

“The environmental impact is massive and will likely be felt for many years by the survivors of this tragedy,” said Lynne Hale, director of The Nature Conservancy’s Global Marine Initiative who worked in Thailand’s Phuket Island and Sri Lanka – both severely hit by the tsunami – for many years. “As countries begin to rebuild from the damage, the conservation community needs to work with government officials to restore and protect the natural habitats that support local communities.”

Hale added: “Food security is directly tied to marine resources. In order to make sure fisherman can rebuild their economy and people can eat, reefs, wetlands and marine protected areas must be restored. Conservationists should also work with local officials to rebuild the lost scientific and management capacity needed to bring damaged ecosystems back to health.”

Many of South Asia’s coral reef systems – which were already threatened by overfishing – are now smashed to rubble or buried by mounds of sediments. These reefs provided vital habitat for a variety of fish and rare species. Fish depletions

will severely affect countries hit by the tsunami, such as Indonesia whose people rely on fish for 53 percent of their protein.

The damage will affect the region’s fishing as well as tourist industries.

“While tsunamis are a natural process in coastal ecosystems in Southeast Asia, the impact of this tsunami on marine and coastal biodiversity is extraordinary and may well cause the extinction of entire species,” said Dr. Ian Dutton, Director of Conservation Measures at The Nature Conservancy and who led the Conservancy’s Indonesian program for many years. “Studies of corals affected by submarine earthquakes and tsunamis have shown that recovery will take many decades and the resulting coral community may be much different than the previous one.”

Dutton said the coastal and marine damage caused by the tsunami may have been exacerbated by poor environmental planning, such as over-development in low-lying areas with little natural protection and human-caused destruction of mangroves, coral reefs and other natural barriers that protect against coastal erosion. Damage to some communities that had healthy mangrove and reef systems was less severe because the natural barriers shielded against large waves and flooding.

“We must protect these areas, so they can protect us,” Dutton said. “Along with restoring and protecting the marine and coastal resources of the areas hardest hit by the tsunami, we

ARIZONA HYDROLOGICAL SOCIETY
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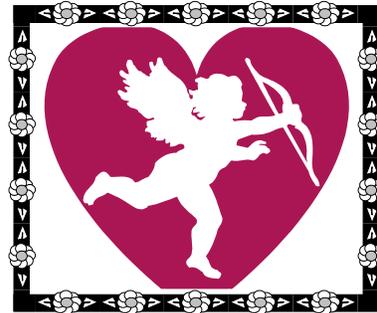
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AHS NEWSLETTER SUBMITTALS

Submittals and comments should be addressed and faxed to Leilani Bew at Errol L. Montgomery & Associates, Inc. by the 15th of each month. If you learn of something timely after the deadline has passed, call me, and we can discuss it.

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Thanks are extended to Errol L. Montgomery & Associates, Inc. for their donation of phones, fax, computers, and staff to support publication of this newsletter.



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