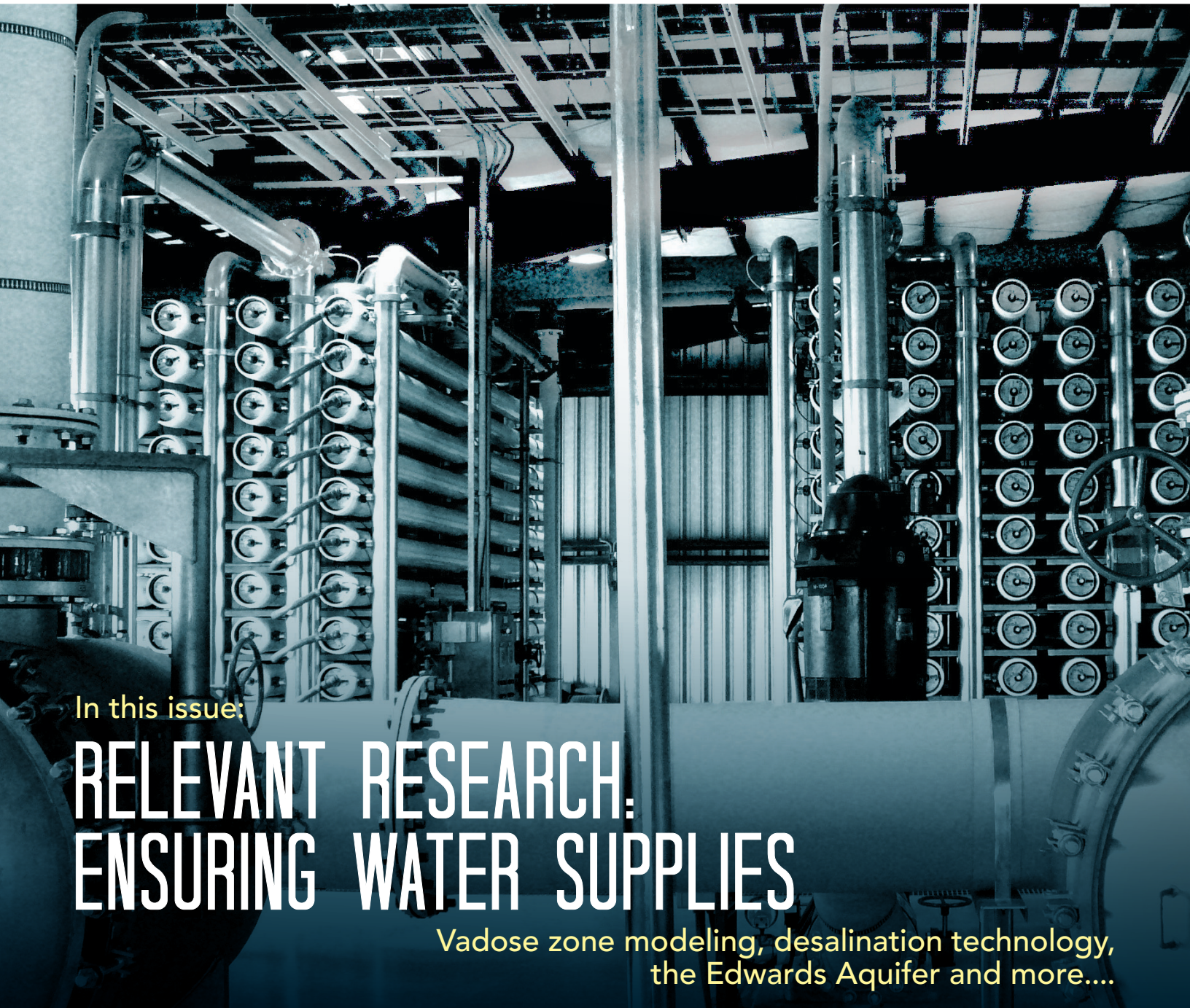


# tx : H<sub>2</sub>O

A Publication of the Texas Water Resources Institute

Fall 2012



In this issue:

## RELEVANT RESEARCH: ENSURING WATER SUPPLIES

Vadose zone modeling, desalination technology,  
the Edwards Aquifer and more...



*Working to make  
every drop count*

The 2011 drought in Texas highlighted the scarcity of water in the state to just about everyone. Because we know the next drought is potentially “just around the corner,” and that some parts of the state never got out of drought, this issue of *txH<sub>2</sub>O* focuses largely on projects dealing with water quantity, and each project is in a different stage of the research process: research and development, testing and evaluation or technology transfer.

Dr. Calvin Finch, director of the new Water Conservation and Technology Center, located in San Antonio, outlines the center’s mission in a question and answer interview. Finch, who has written water conservation and horticulture columns for more than 20 years, has his first *txH<sub>2</sub>O* column in this issue.

Dr. Binayak Mohanty and his interdisciplinary research team’s vadose zone work, an example of applied research and development, covers all aspects of soil moisture, which is critical to understanding how to predict and respond to future droughts.

This issue also covers a great example of the realities of testing and evaluating a new, research-based technology. In South Texas, scientists tested an innovative technology for desalinating brackish water, learning much about what worked and what didn’t.

Technology transfer—that critical last step of getting science out to the public—is highlighted in a story on the Edwards Aquifer Recovery Implementation Program. Using information based on research and water management knowledge, a diverse group of agencies and water users reached a land-mark consensus resolution to the regional conflict between species protection and Edwards Aquifer pumping.

The institute continues to press on in leading and communicating water resources research and issues, and the remaining articles spotlight a few projects in which the institute is involved.

Finally, the last few weeks have been exciting with a focused conversation on evaluating the possible opportunities for an expanded institute through a formal partnership with the Dwight Look College of Engineering. An institute taskforce composed of Agriculture and Engineering faculty has been preparing a concept paper for the colleges’ vice chancellors to review and consider. Stay tuned for more details.

As always, let’s continue to make every drop count.

Roel Lopez  
Interim Director

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On the Cover:  
Inside the Southmost Regional Water Authority Regional Desalination Plant near Brownsville. Photo by Danielle Kalisek.

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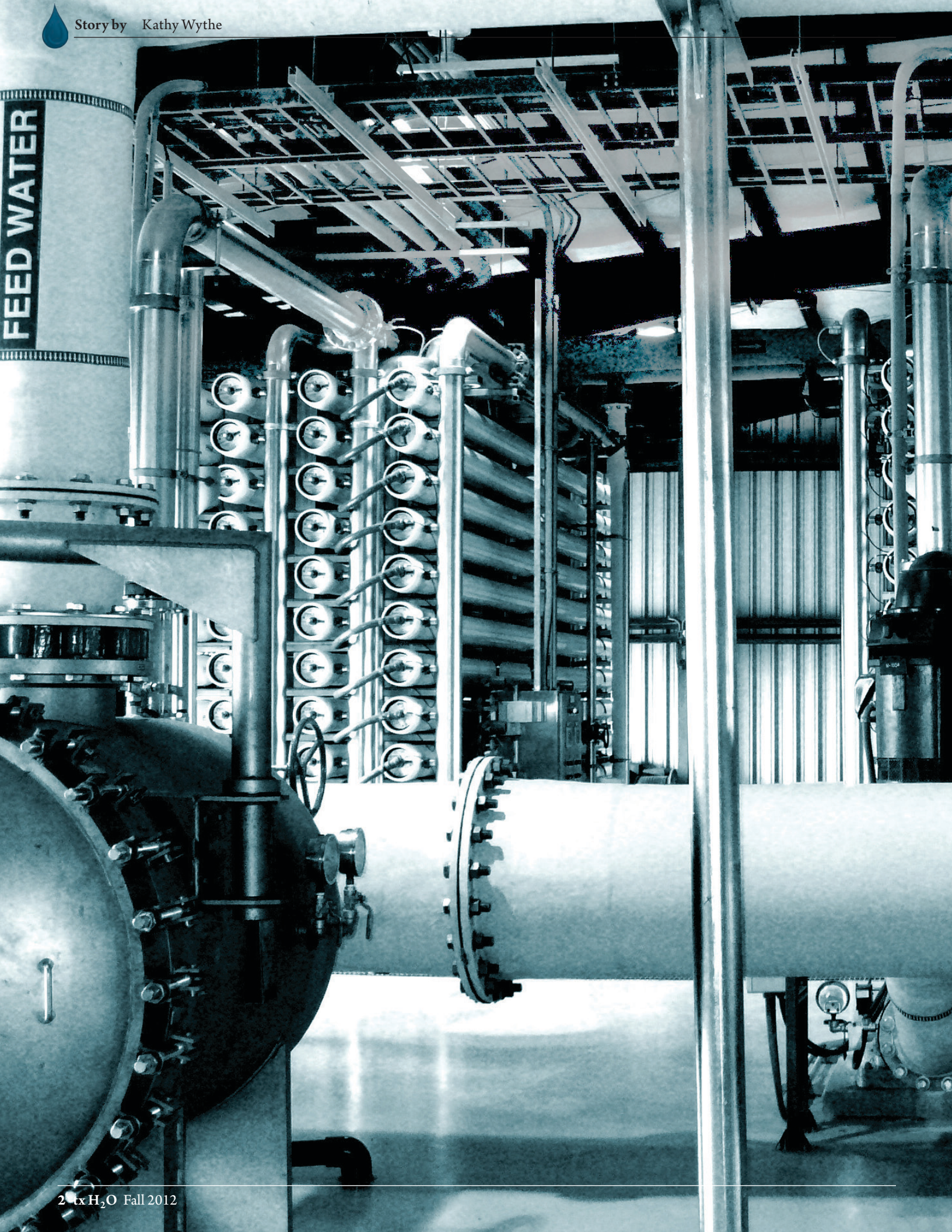
Inside the Southmost  
Regional Water Authority  
Regional Desalination Plant  
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Danielle Kalisek.

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FEED WATER



# ON THE CUTTING EDGE

Director shares vision for center's role in addressing Texas water problems

The Texas A&M University System's Water Conservation and Technology Center was created to be on the cutting edge of helping Texas solve its water problems—problems that have gained attention because of the drought, increasing energy demands and Texas' economy.

The center is a collaboration with Texas A&M AgriLife Research, Texas A&M AgriLife Extension Service, Texas A&M Engineering Experiment Station and Texas A&M University–San Antonio. It is administered by the Texas Water Resources Institute (TWRI) and Texas Center for Applied Technology (TCAT).

*txH<sub>2</sub>O* talked with Dr. Calvin Finch, the center's director, to find out more about the center.

**Q: What is the Water Conservation and Technology Center, and why is it needed?**

A: The center is the A&M System's effort to focus on water conservation and those important topics that are necessary to make the recommended water resources and conservation measures to successfully implement the state water plan. And, of course, unless we successfully implement the state water plan, we will have problems in continuing the economic growth and the quality of life that we all enjoy in Texas.

We have many resources at A&M that will be important to the future of meeting our water needs and the Water Conservation and Technology Center is the system's focal point. Our job at the center is to make sure we know what resources are available at Texas A&M University and the system's agencies. We need to mobilize these when needed and coordinate efforts to turn out products that will be required and useful to all the water purveyors, agencies and private sector firms that are important in successfully implementing the state water plan.

I am excited about being part of the Texas A&M effort to step forward to say, "We realize that as the premier university we have to do our part; we have to be there to provide answers and to interpret the research necessary to get the job done."

**Q: Does the recent drought make the center more important?**

A: Water issues now, after several years of drought, are more important. Because of its water challenges, San Antonio has been involved in water issues for a long time. But everybody is involved now in water issues and everybody is realizing that any community can be faced with water supply problems. It doesn't matter how much rain falls; it doesn't matter how full your reservoirs are at one point. Water can be used up and may not be refilled. So, you have to deal with these issues.

**Q: What do you see as the vision for the center?**

A: My vision for the center is that there will be lots of action. We will be contributing small parts to some issues and big contributions to other issues. We will be willing to get into the middle of any issues that come up that have to do with water.

We have identified four focus areas: 1) outdoor water conservation, 2) water reuse, 3) groundwater desalination and 4) energy development and water use. Those are our target areas. But we are going to be flexible; we are going to step forward to say that we are ready and willing to do what is necessary, with the result that we are going to help water purveyors, communities and private sector firms to do what they need to do to provide water.

**Q: As director, what are your first priorities and goals to accomplish and when do you hope they will be accomplished?**

A: My number one priority is I have to make sure I have a good grasp of the resources at Texas A&M. Also I need an advisory group. Decisions will need to be made on priorities and how to use our available resources from time to time, so having an advisory group will be necessary.

I have only been on the job for a short time, and I have found that there are opportunities out there that we have already been trying to address. ➔

Desalinating brackish groundwater is one area of water resources the Water Conservation and Technology Center is targeting. A desalination facility already in operation is the Southmost Regional Water Authority Regional Desalination Plant near Brownsville. Photo by Danielle Kalisek.



It is obvious that Texas A&M, TWRI, TCAAT and the Water Conservation and Technology Center are going to play an important role in addressing water issues because already we have folks who are looking to us to help with issues they have.

**Q: Will the center collaborate only with Texas A&M or with others?**

A: The center's involvement will be statewide, and we are making that clear. We have a huge reservoir of experts at Texas A&M, and that is an advantage of the Water Conservation and Technology Center. We can use A&M's experts and researchers, people who have experience with every part of water issues. The inventory of those resources is going to be important, but we are not going to hesitate to collaborate.

If we are going to get this job done and keep the economic growth that we have enjoyed and keep moving in that direction, then we are going to have to do what is necessary to answer all of the questions about water resources. A&M expertise is a big part of that, but collaboration is necessary. We have to organize the experts needed to answer every question that comes up in terms of water resources.

**Q: The startup plan talks about the operating model of 1) applied research and development, 2) testing and validation or proof of concept and 3) technology transfer through training and extension education. Can you explain what that model is and why it is important?**

A: Quite often translating basic research into action at the end is the most difficult part of addressing an issue. That is what the Water Conservation and Technology Center is about. We have access to the personnel who can identify the research that exists and can look at it to see how the research might relate to the problem or issue we are attempting to address. They can translate that research, test the ideas to make sure they work and turn the ideas into solutions that are specific to the task we are looking at. As is important with anything we do at A&M, the center will help educate people on using the technologies that we come up with.

Water resources industry people can identify gaps in water resources issues; our job becomes addressing those gaps. Finding the research that is important to address those gaps, and manipulating and fine-tuning and passing on that technology to the people trying to make the state water plan a reality is needed.

**Q: As you said earlier, the center is focusing on four areas: 1) groundwater desalination, 2) water reuse, 3) energy development and water use and 4) outdoor water conservation. Is there one area that is more important than the others?**

A: I don't think any of them are more important. An important tenet of the Water Conservation and Technology Center is to be responsive to whatever opportunities and challenges are out there. For example, if those turn out to be more in the development of brackish groundwater as a good resource for providing communities the water they need, then we will concentrate our efforts there.

As we have seen in San Antonio and the surrounding region, water conservation can get a good response and can be applied across the board. It is one of those areas of potential increased water supplies that everyone—wherever they are—can take part in and contribute to solving the issue.

**Q: Does the center have any projects currently?**

A: We are working with the San Antonio Water System, looking at the energy used in its water distribution and production systems. We can make its water production more efficient if we can figure out ways to reduce the amount of energy required per unit of water produced.

We are also going to make an effort to get information and discussions on various water conservation topics distributed to communities and newspapers across the state.

We are discussing new projects with agencies, so we hope we will have a series of projects in place soon.

**Q: What are the long-term plans for the center?**

A: One of the things we will do is be flexible. We know what our goals are; we know what can be accomplished if we are to be successful. We know what the expectations from the state and the citizens of Texas are, so we are going to stay responsive. We are not going to create a structure where the structure becomes more important than the project. We are going to be light on our feet.

The way we are organized is a testimony to that. We are going to make use of all those experts and the support capability of Texas A&M and partnerships with private sector firms and other universities. Funding will come from agencies, water purveyors and communities where the issues are, as well as private sector firms.





# CONSERVATION AND DROUGHT MANAGEMENT

Water conservation and drought management are related, but they are not the same.

Water conservation is a long-term effort to reduce the amount of water it takes to manufacture goods, manage households and care for landscapes.

Drought management is water-use rules initiated to deal with reduced water supply or increased demand in an emergency. Often the “emergency” is regularly expected as in an area where rainfall is erratic.

Both water conservation and drought management are reasonable ways to manage water resources. Effective use of water conservation and drought management meets water needs at a reduced cost to ratepayers.

Through technology and behavior changes, communities can get the same jobs done without using as much water. In the home, some obvious water conservation technologies are high efficiency toilets, showerheads, washing machines and water heaters. Behavioral changes include turning the water off except when rinsing while shaving and brushing teeth and putting full loads in dishwashers and washing machines. Using efficient irrigation systems and fixing leaks are also behavioral habits that can save water.

The use of low water-demand landscape plants probably qualifies as a technological change. However, a lush, colorful landscape using less water comes only if people caring for the landscape choose to use the right amount of water at the right time to take advantage of the plants’ capabilities.

Water purveyors can conserve water with good maintenance and leak repair of distribution systems.

New leak detection techniques fit in the technological conservation area, but getting the repairs done is a behavioral issue.

Effective conservation can significantly increase water supplies. As a result of water conservation efforts, the city of San Antonio is able to provide water to 50 percent more people than it did in 1982, without using more water. Even more remarkable, BBC Research and Consulting did a cost benefit analysis of the program in 2003 and determined that every dollar invested in water conservation by San Antonio saved the community \$4-\$7 by reducing the need for more water resources and more wastewater treatment.


San Antonio spends about \$300 per acre-foot of water yield from conservation on education, incentives and enforcement. New water resources generally cost the community at least \$1,000 per acre-foot.

Drought management is typically used when reservoir supplies are diminished and water demand is high. Drought management tools include water restrictions and increasing water costs for users.

Landscape irrigation in the summer often accounts for 50 percent or more of the water used in a community, so reducing landscape watering can save a lot of water. Ideal use of drought management techniques involves temporarily reducing water use without slowing economic activity or causing permanent damage to landscapes.

San Antonio achieves this goal by restricting landscape watering when the Edwards Aquifer level falls because of drought.

This option is attractive because water use on landscapes can be reduced significantly without permanent landscape damage. In San Antonio, Stage 3 water restrictions limit lawn watering to once every two weeks, which local studies show is enough water to keep grass alive.

Tolerating a dry-looking lawn for a few months is a small price to pay to preserve available water for manufacturing and in-home use. Reducing demand also means that special water supplies do not need to be paid for every year for the less frequent occasions when demand would be high enough to use it. 





# UNLOCKING SECRETS OF THE VADOSE ZONE

*Researchers say this layer of soil holds keys to tracking water's every move*





*Editor's note: The stories in this issue of txH2O are examples of each stage of the research process, beginning with applied research, which is the application of science to solve practical problems. This story examines Dr. Binayak Mohanty and his team's investigation into the vadose zone to help solve issues related to global water management, agriculture, flood forecasting, climate prediction, weather, energy balance and contaminant transport.*

**W**hen drought strikes, water planners, scientists and farmers alike look to surface water and ground-water supplies for answers. But what if the answer to drought prediction and mitigation isn't there? What if it's in a place few people have ever heard of?

That place is called the vadose zone—the layer of earth that lies between topsoil and groundwater—and it has some secrets to tell. Fortunately, a team of Texas A&M University scientists led by Dr. Binayak Mohanty is listening.

Mohanty, a professor in Texas A&M's Department of Biological and Agricultural Engineering, a Texas A&M AgriLife Research Faculty Fellow and a Texas A&M Engineering Experiment Station Faculty Fellow, has studied the vadose zone for years. He has enlisted postdoctoral and graduate student researchers from a variety of disciplines to work beside him. Their common objective is to examine, model, scale and understand what happens in this layer of soil, helping scientists all over the world better understand and predict not only drought, but a wide range of natural processes that impact both water quality and quantity.

### **What is the vadose zone?**

Also known as the critical or unsaturated zone, the vadose zone is the section of soil located above the water table.

"This zone is right under our feet, so whatever we do, it impacts the vadose zone," Mohanty said. "In layman's terms, it's soil."

The vadose zone could hold keys to everything from drought mitigation to how water contaminants move, to food production and flood prediction, but unfortunately it's not a simple place to understand, Mohanty said. Always changing and shifting, the zone is intrinsically dynamic because it's unsaturated.

"The critical aspect of the vadose zone is that it is not saturated," he said. "It is always in a dynamic mode, fluctuating between saturated and dry conditions. During times of heavy rainfall, it fully saturates, and during drought times, it becomes drier due to evaporation."

"The challenges are even more complex because you need to understand how those dynamics evolve under different variables—different locations, different hydro-climatic conditions, different types of crop cover, different types of soil and different types of landscape features."

### **Tracking water to mitigate drought**

The water cycle is a basic concept often taught to young children—in Texas' state curriculum it's covered in second grade—but a clear understanding of precisely how and where water moves is not nearly so elementary.

Employing physics, hydrology, remote sensing, geographical information systems (GIS) and a host of other techniques, the research team maps out its understanding of this dynamic and complicated part of the earth. Mohanty's ultimate goal is to use the collected data to quantify the processes happening in the vadose zone.

"We're trying to unravel the complexity of the vadose zone and how the water migrates through it," Mohanty said. "The vadose zone is also very important to weather feedback: Basically, the land and atmosphere interact to create local weather conditions, and much of the water in the vadose zone goes back to the atmosphere. The water in the vadose zone controls these dynamics by acting as a switch that determines how much water from rainfall flows into streams and how much penetrates the earth and reaches the groundwater. So, the amount of the water that's in the vadose zone is important to weather and climate forecast models." ⇨

Sayena Farid-Marandi collects ground-based soil moisture data for calibration/validation of remote sensing platforms in Oklahoma.



Above: The research group uses soil moisture and land atmosphere interaction monitoring networks to collect data.

That water’s movement depends on the variables in the environment, so Mohanty’s team studies areas with various soil types, conditions, landscape attributes and features—including complex topographies, catchments and watersheds.

“How does rainfall migrate on the ground and send water into the vadose zone?” he asked. “We look into that process, describe the differential flow, try to innovatively model it and then develop more sophisticated, process-based models for near-surface water that other scientists can use.

Because the water that resides in the vadose zone dictates how much water is available for plants, understanding the zone is critical to mitigating drought. Mohanty said that the different kinds of drought—hydrological, agricultural and climatological—are all tied to the vadose zone. “When we have conditions of little precipitation and high amounts of evaporation from the vadose zone, this results in permanent wilting of plants, or agricultural drought,” he said.

Hydrological drought entails a reduction in streamflow, Mohanty said, and climatological drought is reduced precipitation. Vadose zone hydrologists focus mainly on hydrological and agricultural drought. His team aims to provide the information needed to optimize water resources and at least reduce the impact of drought by minimizing runoff and maximizing crop productivity.

“Drought is such a natural calamity—it damages not only local conditions and the livelihoods of so many farmers, but it also affects the global economy,” Mohanty said. “Unfortunately, drought is going to be happening more and more, and the basic reason is because the water cycle and available water resources are changing.”

Climate change, misuse or over-use of available water resources, agricultural practices and urbanization are some of the reasons for those changes, Mohanty said.



Left: The vadose zone research group, including (front row, left to right) Dr. Binayak Mohanty, Bhavna Arora, Champa Joshi, and Nandita Gaur; (middle row, left to right) Yongchul Shin, Dipankar Dwivedi, and Jun Wang; (top row, left to right) Raghavendra Jana, Zhenlei Yang, Sayena Farid-Marandi, and Jonggun Kim; is a multidisciplinary team.

Right: Mohanty's team uses soil core extractions for soil water retention and hydraulic conductivity measurements.



“One of the biggest scientific challenges facing Texas right now is that we don’t have a widespread, concerted effort to observe and develop a scientific understanding of the critical zone. We’re trying to bring this to Texas.”

### Understanding contaminant transport

This fundamental understanding of soil and the vadose zone is not only key to managing water, reducing the risk of drought and flood, and improving agricultural lands and ecosystems—it can also enable scientists to better track environmental pollutants that are harmful to ecosystems and groundwater supplies. Examining mechanics of contaminant transport is a part of the team’s research.

“The vadose zone contributes to (understanding) contaminant transport,” Mohanty said. “If you apply pesticides or fertilizers on the land surface or store any municipal or industrial contaminants,

for example, in some containers below the ground, those chemicals cannot move until the water in the vadose zone carries them. The transport of these chemicals in the vadose zone eventually moves them into aquifers or into groundwater supplies.”

Mohanty said that the team looks at how different chemicals interact and create different oxides or combinations in the soil and eventually either migrate to the groundwater system or become stabilized in the vadose zone. How contaminants move depends on soil type and hydrology and whether the contaminants were preexisting or caused by humans.

“Understanding how they’re transported is very important for the contaminant removal processes,” he said.

High nitrate levels in groundwater are one such contaminant that Mohanty’s team studies. Nitrates existing in groundwater can cause health ➔



problems in certain groups, such as pregnant women, Mohanty said. The team is examining how water becomes contaminated by nitrates and how contaminant levels can be reduced in Texas' water supplies.

Another project that the team is currently working on involves developing multiple conceptual models of how contaminants are transported in the vadose zone, and this knowledge is important to the military as well as the energy industry and regulators, he said. The team has also analyzed landfill sites and worked to understand contaminant transport in such sites.

"Whatever chemicals are left in the ground, they eventually leak into the groundwater," Mohanty said. "So, if we can at least understand how the contaminants move over time, then we can develop alternative strategies to minimize those negative impacts."

Because the vadose zone is critical to so many global applications, the team conducts research that can be developed on the global scale and then applied locally.

### Studying soil from space

State-of-the-art remote-sensing techniques have been developed over the last several decades, with new satellites launching every year, Mohanty said. This wealth of new technology opens doors to expanding research in ways that were previously limited. The team has used data from many different satellite programs, including data from NASA, such as the Advanced Microwave Scanning Radiometer (AMSR-E).

"Instead of digging a hole in everyone's backyard, now we can efficiently collect remotely sensed data from satellites," Mohanty said. The team acquires soil moisture data from programs, such as NASA's upcoming SMAP (Soil Moisture Active-

Passive) satellite, and then analyzes it and develops techniques to incorporate the remotely sensed data into predictive hydrology and climate models.

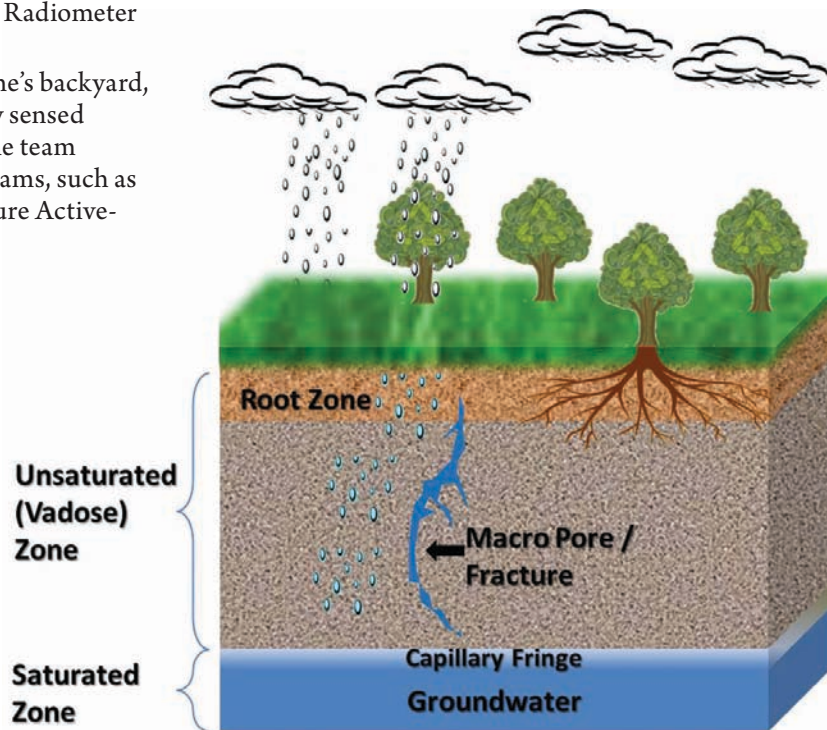
"Traditionally, people identified soil properties using local, ground-collected soil information, but with these new technologies and satellites, we can generate and populate findings on a global scale," he said. "This enables us to get soil hydraulic parameter data that is timeless and useful in many applications."

### Scaling data makes it globally relevant

Mohanty said the group is continually working to specifically understand the zone's underlying processes and then model the dynamics of soil moisture at multiple scales, using various ground, air and space techniques.

"To address all of the complexity of the vadose zone, we look into very fundamental processes and then scale them," Mohanty said. "From the scale of pores, where the water lies, we scale the data all the way to larger fields where crops grow, farther up in the hierarchy to the watershed scale, where the water creates surface runoff, and then eventually all the way to the regional, continental and even global scale.

"We cannot do this using only one technique, so we assimilate data from various platforms, such as ground-level measurements at the finest scale and remote sensing measurements up to the watershed,



Left photo: Illustration of NASA's upcoming SMAP (Soil Moisture Active Passive) satellite, used by the team to acquire soil moisture data.

Right photo: Vadose zone research group students collect samples during soil moisture field campaigns for calibrating and validating satellite based remote sensors.

regional and continental scales. So in addition to ground techniques, we also use airborne sensors and space-borne sensors to understand and unravel the processes of soil moisture in the vadose zone.

“We have discovered how to scale up and scale down these data sets that come from different sensors at different scales. For example, if you have data collected at the local scale, can you scale it up to the watershed scale or visa-versa? Now we can.”

Because upscaling and downscaling are some of the research group’s major focuses, they have learned how to scale remote sensing data down to local fields so that farmers can apply techniques for water management or drought prediction. Conversely, their ground-sensing data can be scaled up to the regional scale for hydroclimatic applications, Mohanty said. They use simple data to describe complex processes.

“Our findings are not just site-specific; more general findings can be transferred and adapted to any place in the world,” Mohanty said.

### The right team and the right technology

Mohanty’s team combines these diverse technologies with people from diverse fields of expertise to convert data into new, innovative models for forecasting drought, managing water better and minimizing water loss. The group includes researchers in engineering, biological sciences, chemistry, geology, mathematics and physics, together analyzing the full range of soil parameters, which are nonlinear and not easy to model, Mohanty said.

“Our job is to provide these fundamental understandings of soil moisture to state officials, farmers or Extension professionals and give them tools such as models and data sets to use for various applications,” Mohanty said. “We also develop a lot of new statistical techniques that enable us to better analyze these kinds of data sets.”


Thanks to funding from the National Science Foundation, NASA, U.S. Geological Survey, U.S. Department of Energy, National Institute of Environmental Health and other state and federal agencies, Mohanty’s group has continually produced new findings about the vadose zone.

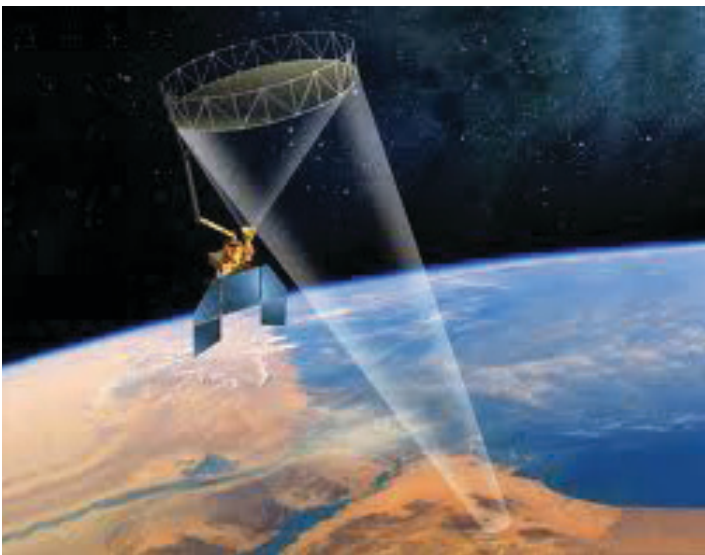
“With that funding, we’ve completed over 25 projects in the last 10 years,” he said. “We are continually striving to improve our predictive skills of the water cycle in the vadose zone under different types of conditions.”

### How can the vadose zone help us right now?

In hydrology, soil moisture is known as the “gate keeper,” Mohanty said. And that’s why his team works so hard to link together so many different disciplines and processes—because understanding soil moisture in the vadose zone has important, global implications for natural resources.

“The vadose zone is important to all extreme events that happen in hydrology. And from all angles—everything from agriculture to weather to hydrology and energy balance, the vadose zone affects it all. From food security to water security, it has large implications that we cannot ignore.”

For more information, see Mohanty’s research group website: [vadosezone.tamu.edu](http://vadosezone.tamu.edu). 





*Editor's note: During the testing and validation or proof of concept state of a research effort, a technology is tested and evaluated in preparation for application. At this point, researchers begin to see if it is feasible for the product to be used on a large scale. AdVE technology is an example of proof of concept work.*

A revolutionary desalination technology, invented by a Texas A&M University professor, could give Texas water suppliers a new way to purify water.

Though not yet ready for widescale production, Advanced Vapor-Compression Evaporation, or AdVE, may desalinate brackish and salty water more efficiently and more economically while using less energy than conventional evaporation technology, according to the experts involved in the technology.

This new technology was tested in a pilot project in Laredo. The pilot AdVE project, which opened in August 2010, was funded by the city of Laredo and Terrabon, Inc., a bioenergy technology transfer company.

Because the population of Laredo is rapidly increasing, the city needs to find sustainable ways to provide water to residents. Underground brackish and saline water is available in the area, so the city chose to invest in the AdVE method of creating potable water.

Laredo and Terrabon installed the new technology at the city's Santa Isabel Water Plant. This plant currently uses a reverse osmosis (RO) unit to desalinate water. RO, which uses membranes to filter out the salt, is the most established desalination technology.


### How it works

The basic concept behind AdVE is not new.

Dr. Mark Holtzapple, professor in Texas A&M University's Artie McFerrin Department of Chemical Engineering and inventor of the AdVE technology, said its history goes back "at least 60 years, if not longer" and was used during World War II. In fact, according to Dr. Dean Schneider, a Texas A&M Engineering Experiment Station project manager, conventional vapor-compression evaporation is still used on ships today.

The technology uses multiple chambers of water and steam held at increasing temperatures. Each chamber, known as a heat exchanger, separates the liquid salt water from high-pressure steam. AdVE →





Workers watch as the AdVE system is installed at Laredo's Santa Isabel Water Plant. Photo courtesy of the Texas Center for Applied Technology.

# PROVIDING PROOF

*Desalination technology tested for efficiency, economics*



desalination increases efficiency because it adds heat to salty water by compressing steam instead of burning fuel, said Schneider, who is also assistant director of the Texas Center for Applied Technology's Energy and Environmental Sustainability Division.

When the water becomes hot, the steam it produces no longer contains any salt, Holtzapple said. "What you do is take the steam above the salt and put it into a compressor, which raises its pressure and also raises the temperature at which it will condense."

From there, Holtzapple explained that heat flows from a higher temperature to a lower temperature, that is, from the steam to the salt water. The steam then condenses, causing more water to evaporate from the salt water.

Water is removed from each chamber as it becomes distilled. The brine water moves to adjacent heat exchangers, which further concentrates the brine, before it is finally moved out of the system to be disposed.

AdVE is set apart from previous, conventional versions of the technology primarily by two features: a novel heat exchanger and the StarRotor compressor.

### Heat exchanger

The heat exchanger used by AdVE is a Terrabon technology, according to Gary Luce, chief executive officer and director of Terrabon.

When developing the technology, Holtzapple said he asked: "What is the required temperature difference to drive the heat across the heat exchanger wall from high-pressure steam to boiling water?" The greater the temperature difference, the more pressure is required by the compressor and the more energy is consumed.

Economically, the answer to this question is vital because energy is the dominant cost in water desalination. Therefore, the goal is to have a low temperature difference, which requires less pressure from the compressor, thereby reducing energy use.

A cost-effective coating on the heat exchanger promotes liquid droplets, Holtzapple said, and this allows the exchanger to push heat across the barrier between the steam and water with a 0.2 degree Celsius temperature difference.

Holtzapple explained how this coating works by comparing it to a waxed car. Normally, rain makes a film of liquid on a car; however, if a car has been waxed, the rain forms beads of liquid on the car. In a normal heat exchanger, the condensing liquid forms a film and acts as an insulator that reduces heat transfer. Holtzapple said an AdVE heat exchanger

uses a coating that causes the liquid to bead, which keeps the heat exchanger bare and increases the transfer by a factor of about 20.

"Point 2 degrees Celsius is very small," he said. "That's a very, very small number. The consequence of that is that a very small amount of power is required to do the desalination."

### StarRotor compressor

The StarRotor compressor, developed by Holtzapple, is more efficient than conventional compressors and is better suited for compressing steam.

"The compressor has to be efficient from an energy standpoint but also from a capital standpoint," Holtzapple said. "There are a number of technologies that could be used, but we have found that the so-called StarRotor compressor works the best. Although there are many types of compressors in the world, very few of them are suitable for compressing steam, and the StarRotor compressor has shown to be particularly efficient and effective in that job."

One of the "tricks" of the compressor is that water can be sprayed into it while it is operating, he said. Spraying liquid water into the compressor keeps it cool and reduces energy consumption.

### Putting it into practice: the Laredo test

AdVE successfully desalinated water at the Laredo plant, but it did not produce the amount of fresh water expected. Schneider said the AdVE-equipped plant was originally expected to produce 50,000 gallons of water per day, but produced only 10,000 gallons per day.

Although this difference was caused by engineering issues, Schneider said, "We did validate that the efficiency of the process still seems to be theoretically possible."

Problems with the seals in the heat exchangers lessened efficiency. "Basically, the endplate gasket was allowing the hot side of the heat exchanger to leak over to the cool side of the heat exchanger," Luce said. "So it was the endplate gaskets that we didn't get good seals on, which was causing problems in understanding what the real heat transfer rate was."

When the gaskets don't seal and liquid water accumulates on the steam side of the heat exchanger, the heated surface area isn't enough for the heat to transfer efficiently, Holtzapple said. "Essentially, the steam side was flooded. This problem should be easily overcome by using a better control system."

"Controlling the bubble point temperature, or the saturation temperature, at the first and last exchanger is another issue we ran into," Luce said.



At the Laredo plant, five heat exchangers were used. For the process to be most effective, thermal efficiency must come from all five heat exchangers. While the middle three heat exchangers produced thermal efficiency, the heat exchangers on both ends were not thermally efficient, the experts said.

One of the favorable findings from Laredo, the experts said, is that the AdVE technology can save money through reducing the amount of waste left from the process by removing more water from the incoming salty water. With any water desalination technology, waste contributes a significant amount of cost to the process.

An added economic benefit of the technology is that very little scaling—which is when salts adhere to the heat exchanger and reduce heat transfer efficiency—occurred on the heat exchangers, the experts said. This is an important observation because scaling is costly to fix, Holtzapple said.

### Interpreting the outcomes

The pilot results showed that AdVE is not as cost-effective as an alternative to RO but is useful as a secondary desalination technique to RO, according to Schneider. He said using AdVE secondary to RO would increase water recovery from about 70 percent to at least 95 percent.

Luce explained that as the salt concentration increases, the cost of RO increases also. The cost of AdVE also goes up as salt concentration increases, but not as steeply. Because of this, at a certain point those two numbers intersect and AdVE becomes cheaper. This means that a lot of water can be taken off on the front half by RO and then AdVE can complete the task with the remaining brine water.

By going through this process, more water is recovered and the overall cost decreases.

“Where AdVE is cost effective by itself is in the treatment of high-salinity water,” Schneider said. ➔

The AdVE system was tested to determine if it would desalinate brackish and salty water more efficiently and more economically than conventional evaporation technology. Photo courtesy of the Texas Center for Applied Technology.





This high-salinity water, also known as high-severity service, can contain 50,000 parts per million of salt.

Luce put that number into perspective by comparing it to seawater, which contains about 35,000 parts per million of salt.

Using AdVE on its own for high-severity services, Luce said, has been tested economically but not fully in practice, and therefore its long-term effect on the heat exchangers is unknown.

This ability to desalinate high-severity services differentiates it from RO, which is susceptible to developing problems because its filters cannot handle the high salt concentrations.

### Promising future?

“We see a lot of upside associated with the technology, but we need to find a good partner that we can work with,” Luce said. “So we’re looking for somebody, really in the oilfield services side of the business or a producer that’s dealing with frac water, and things of that sort, that we could partner with to really move the technology to the next stage.”

Because the experts know how to fix the problems that were encountered, they said AdVE could produce more water at a lower cost if the demonstration is run again with certain modifications.

“I do believe the technology has great promise,” Holtzapple said. “I believe that it has significant advantages over current technology. It’s not just creating another way to do the same thing. It’s better, in my opinion, than what we’re doing now.”



The evaporator of the AdVE system. Photo courtesy of the Texas Center for Applied Technology.





# DEVELOPING CONSERVATION PLAN FOR THE EDWARDS AQUIFER

*Stakeholders reach consensus resolution to balance protection of endangered species and water use*

What does it take to get a group of environmental activists, city water planners and farmers all to agree on a complicated plan to balance the needs of endangered species and water users? Persistence.

In December 2011, a stakeholder group in the Edwards Aquifer region of Texas achieved a milestone in a struggle that has lasted nearly six decades.

Working together, participants in the Edwards Aquifer Recovery Implementation Program (EARIP) developed a habitat conservation plan that will protect endangered species and still provide water for human use.

The Edwards Aquifer is a major groundwater system in south central Texas serving about 2 million people. It is also the source of the two largest springs remaining in Texas: the Comal and San Marcos springs. These springs are the only known habitats for eight federally listed threatened or endangered species.

“These springs are not only vital to several endangered species, but they also feed tributaries to the Guadalupe River that, in turn, provide fresh water inflows to bays and estuaries on the Gulf Coast,” said Dr. Robert Gulley, the former program coordinator for EARIP.

The primary threat to these species is the intermittent loss of habitat from reduced spring flows due to fluctuating rainfall patterns, regional intermittent pumping and drawing down of the aquifer.

In 1991, the Sierra Club, a grassroots environmental organization, sued the U.S. Fish and Wildlife Service (FWS) for allegedly failing to protect the federally listed species in the aquifer.

“Judge Lucius Bunton ruled in favor of the Sierra Club and directed the Texas Legislature to act immediately to protect the species,” said Dr. Todd Votteler, an employee for Judge Bunton at the time. Currently Votteler is executive manager of science, intergovernmental relations and policy for the Guadalupe-Blanco River Authority. He also served as a member of EARIP.

In response to the judgment, in 1993 the Texas Legislature passed Senate Bill 1477, which created the Edwards Aquifer Authority (EAA). The aquifer authority manages withdrawals from the aquifer and implements measures to protect the different species.

“Senate Bill 1477 required EAA to implement and enforce water management practices, procedures and methods to ensure that, by Dec. 31, 2012, the →

Comal and San Marcos springs are the only known habitats for eight federally listed threatened or endangered species. Photo courtesy of the Edwards Aquifer Authority.



continuous minimum spring flows of the Comal Springs and the San Marcos Springs are maintained to protect the endangered and threatened species to the extent required by federal law,” Gulley said.

Beginning in 1999, the aquifer authority worked for five years to develop a habitat conservation plan. However, that plan did not satisfy minimum flow and withdrawal cap requirements as required by the senate bill.

In 2006, FWS formed the recovery implementation program. Recovery implementation programs are voluntary, multi-stakeholder initiatives that seek to balance water use and development with the recovery of federally listed species.

In 2007, the Texas Legislature, through Senate Bill 3, mandated that EAA and four state agencies participate in the EARIP. Participating agencies included the Texas Department of Agriculture, Texas Water Development Board, Texas Parks and Wildlife Department and Texas Commission on Environmental Quality. The Legislature also created a 21-person steering committee, which ensured the participation of river authorities.

Stakeholders in the collaborative, consensus-based EARIP included not only state and federal agencies, but also water utilities, cities, groundwater conservation districts, agricultural users, industrial users, environmental organizations, individuals,

river authorities, and downstream and coastal communities.

Gulley’s role was to provide stakeholders with needed information about the issues and ensure they remained focused on the important issues. Gulley said that because of the chemistry among the group, everything fell into place.

“Dr. Gulley managed the process quite capably, and the EARIP and other participants in the room responded as a group to his management,” said Con Mims, executive director of the Nueces River Authority and steering committee chair.

After four years of once- or twice-monthly meetings, each with more than 50 attendees, members drafted, developed and molded a habitat conservation plan that was approved by the EAA Board of Directors. In addition, a funding and management agreement to implement the plan was approved at the board’s Dec. 28, 2011, meeting.

“The plan marks the first time that area stakeholders have reached a consensus resolution to the regional conflicts between species protection and Edwards Aquifer pumping that have existed for decades,” Gulley said. “As a result, the region will now have certainty about its use of the aquifer, control of the aquifer and the aquifer will be managed at a regional level rather than by the federal government.”

The U.S. Fish and Wildlife Service listed eight species that depend directly on water in, or discharged from, the Edwards Aquifer system as threatened or endangered:

- Fountain darter
- San Marcos salamander
- San Marcos gambusia
- Texas blind salamander
- Peck’s cave amphipod
- Comal Springs dryopid beetle
- Comal Springs riffle beetle
- Texas wild rice



Texas blind salamander



Fountain darter

Photos courtesy of Edwards Aquifer Authority.

The implementation of the habitat conservation plan is divided into two phases that will take place over 15 years. The first phase includes implementation of habitat protection measures to increase the viability of the species at Comal and San Marcos springs, Gulley said. The second phase will implement any additional needed measures, including the continuation of phase one.

The two major projects in the plan are paying farmers who sign up for a voluntary irrigation suspension program and placing additional water in the San Antonio Water System Aquifer Storage and Recovery facility in the Carrizo Aquifer. Many other measures are included in the plan, such as habitat improvements in the Comal and San Marcos springs, municipal conservation programs and a Stage 5 pumping cutback as a last resort.

Further study over the next seven years will determine whether these measures are sufficient to protect the listed species, Gulley said. If they are not effective, additional methods will be studied.

The conservation plan and supporting documents were submitted to FWS for its approval. Gulley said that FWS requires 10 to 12 months to review documents and anticipates a decision regarding the plan will be made by January 2013.

“The approval of the habitat conservation plan will help protect the region from litigation under

the Endangered Species Act and will bring unprecedented certainty to Edwards’ groundwater rights for as long as the plan is in effect,” he said.

He added that implementing the plan will cost an estimated \$18.6 million a year and, as a result, increase aquifer management fees.

“The municipal and industrial users of the aquifer will bear almost all the cost of implementing the habitat conservation plan with the increase of aquifer management fees collected by EAA,” Gulley said.

“An implementation committee held their first meeting Jan. 30, 2012 to review and discuss responsibilities in implementing the conservation plan,” Mims said. “The EARIP, for all practical purposes, has completed its work and the implementation committee takes over from here.”

After many years as an environmental litigator, Gulley said he has come to believe that litigation does not necessarily solve anything and considers this achievement the high point of his career.

“Members of this stakeholder group recognized that this was the last real chance, the last opportunity they had to act without the federal government becoming further involved and mandating certain results,” he said.

For more information or to view the plan, visit [eahcp.org](http://eahcp.org). 



Comal Springs dryopid beetle



Peck's cave amphipod



Comal Springs riffle beetle



# BEHIND THE SCENES OF TRINITY WATERS PROJECT

*Partnerships and technology deliver cooperative conservation in the Trinity River Basin*

The shores of Lake Livingston in the Trinity River watershed. Photo by Blake Alldredge.

A rapidly increasing population and growing water demands have troubled the Trinity River Basin, but a partnership between conservation-minded organizations and agencies is educating local stakeholders in an effort to maintain and restore the essential functions of the basin.

The *Building Partnerships for Cooperative Conservation in the Trinity River Basin* project (Cooperative Conservation) delivers educational materials and information about conservation to the public. In this way, the partnership hopes to protect the much-needed water resources of the Trinity River and build capacity for Trinity Waters, a nonprofit organization of Trinity River Basin landowners.

With more than 8 million residents, the Trinity is the most populated river basin in Texas. From its headwaters north of the Dallas–Fort Worth Metroplex, past Houston to its outlet into Galveston Bay, the 512-mile river and its 1,983 miles of tributaries drain an area of more than 18,000 square miles and support primary water needs for more than 40 percent of the state.

The river is directly affected by human activities, including urbanization, commercial and industrial development, and agricultural and timber production. Therefore, the project promotes responsible land stewardship and education to safeguard and improve the water and wildlife habitat resources of the Trinity River Basin for present and future generations.

The focus of the Cooperative Conservation project is to educate middle Trinity River Basin stakeholders between Dallas and Lake Livingston by promoting awareness of water quality issues and providing educational programs. Education and increased awareness are provided not only through traditional means but also through social media. These new tools provide rapid and effective ways to inform stakeholders on water quality issues and

conservation practices, thus guiding stakeholders to implement practices to improve the water and wildlife resources of the Trinity River Basin.

This project supports the *Trinity River Basin Environmental Restoration Initiative* initiated in September 2006 by Gov. Rick Perry. This initiative focused on building the capacity of organizations, such as Trinity Waters, committed to conserving the natural resources of the basin. Trinity Waters' mission is to “improve the quality of life, economic sustainability and ecological integrity of areas associated with the Trinity River Basin through a coalition of local communities, nongovernmental organizations and stewards of private and public lands.”

### History of Trinity Waters

In 2005, several landowners along the middle Trinity River formed the Trinity Basin Conservation Foundation. Recognizing the challenges associated with restoring the Trinity River, these landowners joined together to promote conservation through a broad-based coalition of local communities and municipalities, nongovernmental organizations and stewards of private and public lands, particularly local wildlife management cooperatives and associations (see sidebar on page 22).

In 2011, the foundation was renamed Trinity Waters, and Ken Klaveness of Dallas was hired as executive director. The Texas A&M AgriLife Extension Service's Department of Wildlife and Fisheries Sciences helped build Trinity Waters' capacity. Blake Alldredge, Extension associate, serves as the education and outreach coordinator and Dr. Jim Cathey, Extension wildlife specialist and associate department head, has worked with Trinity Waters since the early stages, and now serves as a board member. ⇨

*Editor's note: txH2O asked Blake Alldredge and Danielle Kalisek, who help support the Trinity project, to give readers an inside look at how this grass-roots, wide-reaching effort could impact the water resources of more than a third of the state.*



### Social media and technology

In addition to building partnerships in person, Trinity Waters also uses online tools to spread the conservation message in the basin. Launched in July 2011, The Trinity Waters website ([trinitywaters.org](http://trinitywaters.org)) is a resource for landowners and a clearinghouse of reliable information. It includes more than 400 publications and links related to water conservation, habitat restoration, wildlife and livestock management, and educational and economic resources. The website has contact information for water and land management experts, tips on becoming involved, information on ongoing conservation projects, financial incentives for implementing approved restoration and conservation practices, news updates and recreational opportunities in the basin.

Trinity Waters also reaches stakeholders through a Facebook page, Twitter account and Scoop.it! online newspaper. These social media outlets, as well as the Wild Wonderings blog ([wild-wonderings.blogspot.com](http://wild-wonderings.blogspot.com)), provide connections to other agencies and resources outside of the Trinity River Basin.

The Cooperative Conservation project includes the updated Trinity River Information Management System (TRIMS) online mapping tool developed

by the Texas A&M Institute of Renewable Natural Resources. TRIMS gives stakeholders access to the latest aerial photographs of the basin and information such as elevation, soil types, hydrology and land use. Featured TRIMS tools help stakeholders measure acreage and lengths, such as property lines or points for building a fence. Wildlife and livestock managers can use these tools when developing management plans and determining implementation costs. These datasets and tools provide baseline support for projects addressing wildlife habitat management and water quality, particularly native grassland and wetland restoration, and bottomland hardwood establishment. Traditional agricultural operations also benefit from using TRIMS.

Trinity Waters is involved in multiple conservation projects:

### Water As A Crop™

Developed by the Sand County Foundation in Wisconsin, the Water As A Crop™ project seeks to empower landowners to enhance their water resources by implementing conservation practices. Trinity Waters works as the local implementing and operating partner for Texas' Water As A

**For more information about these projects and other Trinity-based projects, visit the Trinity Waters website at [trinitywaters.org](http://trinitywaters.org) and visit the following links:**

- Facebook.com/TrinityWaters
- Twitter.com/TrinityWaters
- Scoop.it/trinity-river-basin

**Other members of the Trinity Waters coalition are:**

- Texas Wildlife Association
- Texas A&M AgriLife Extension Service
- Texas Parks and Wildlife Department
- Texas A&M Institute of Renewable Natural Resources
- Texas Water Resources Institute
- Texas State Soil and Water Conservation Board
- USDA Natural Resources Conservation Service
- U.S. Army Corps of Engineers
- Tarrant Regional Water District
- Trinity River Authority
- Ducks Unlimited
- U.S. Fish and Wildlife Service
- Delta Waterfowl
- Holistic Resource Management of Texas
- Houston Wilderness
- Taking Care of Texas



Crop™ pilot project based in the Mill Creek watershed in Navarro County. Mill Creek is an important tributary of the Trinity River as it joins with Chambers Creek and eventually flows into Richland-Chambers Reservoir, a major source of water for urban residents of northeastern Texas.

Trinity Waters targets about 3,000 acres and numerous landowners along the creek to implement conservation practices, such as riparian buffers and fences for rotational grazing. Major financial contributors, including MillerCoors, Dixon Water Foundation, the Meadows Foundation and the Knobloch Foundation, provide landowners with financial incentives to implement conservation management practices.

### Western Navarro Bobwhite Recovery Initiative

The discovery of remnant quail populations in Navarro County led to the development of the Western Navarro Bobwhite Recovery Initiative (WNBRI) to revive the quail populations in the western third of the county. Trinity Waters has been involved with WNBRI since its inception in 2006. Currently, 34 landowners are enrolled in WNBRI, creating a cumulative land base of 30,000 acres. Coordinated by Jay Whiteside, technical guidance biologist with Texas Parks and Wildlife Department, WNBRI was established to restore and maintain contiguous habitat of native bunchgrasses and forbs that quail need for food and shelter. Drought has challenged this restoration process, but as of 2011, 1,500 acres have been restored to native grassland.

### Trinity Learning Across New Dimensions in Science

The Learning Across New Dimensions in Science (LANDS) program was developed by the Texas Wildlife Association, and together with Trinity Waters, it provides a natural resources conservation message to classrooms across the Trinity River Basin. Currently, four schools participate in this program, which introduces students to the basics of water quality and proper land management. Students then travel to two locations in the basin for hands-on learning opportunities about water quality sampling and land management practices.


### National Water Quality Initiative

In May 2012, the Chambers Creek watershed of Ellis and Navarro counties was selected to participate in the National Water Quality Initiative to improve Texas waterways. The Natural Resources Conservation Service is providing \$5.4 million in financial assistance to farmers, ranchers and others who implement voluntary conservation practices that will benefit water quality and yield. Such practices include cover crops, riparian buffers, cross fencing for rotational grazing, filter strips and terraces. Trinity Waters was selected as a partner because of its work with landowners in the Water As A Crop™ project in the Chambers Creek watershed.

### Looking ahead

The Cooperative Conservation project has produced several publications, with more coming soon. *Native Grassland Restoration in the Middle Trinity River Basin* was published early in August 2012 for landowners in the Blackland Prairie and Post Oak Savannah ecoregions. Publications currently available in the Texas A&M AgriLife Extension Bookstore include *Linking Water Conservation and Natural Resource Stewardship in the Trinity River Basin*, *Techniques for Wetlands Construction and Management*, and *Habitat Restoration in the Middle Trinity River Basin*.

Currently, project partners are conducting educational workshops to bring middle-basin stakeholders together to discuss and promote the motto: “All Things Trinity, All Things Conservation.” These workshops focus on topics such as water quality basics, effects of land management activities on water quality and quantity, and options for protecting water resources. The ultimate goal of these workshops is to equip stakeholders with the information needed to determine the best direction for managing basin watersheds. A capstone summit is planned for spring 2013 after the workshops have concluded.

*The Building Partnerships for Cooperative Conservation in the Trinity River Basin* project is funded by the Texas State Soil and Water Conservation Board through Clean Water Act funds from the U.S. Environmental Protection Agency. It is a partnership between the Texas Water Resources Institute, Texas A&M Institute of Renewable Natural Resources, Trinity Waters and AgriLife Extension. 



# GROUNDWATER NITRATES IN THE SEYMOUR AQUIFER: PROBLEM OR RESOURCE?

In the Rolling Plains of Texas, the Seymour Aquifer is the major source of water for Haskell, Jones and Knox counties. The water from the Seymour Aquifer, however, contains nitrate levels that often exceed the federal safe drinking water standard of 10 milligrams per liter of nitrate-nitrogen. Scientists at the Texas A&M AgriLife Research and Extension Center at Vernon and the University of Texas Bureau of Economic Geology are working on ways to manage the nitrate levels in this aquifer.

## Tracking the source

Nitrates in groundwater can come from runoff, fertilizer use, leaks from septic tanks, sewage and erosion of natural deposits, according to the U.S. Environmental Protection Agency (EPA).

Nitrates can also come from plants—legumes such as mesquite, alfalfa or bluebonnets—that contain nitrogen-fixing bacteria in their roots. Plants use only the exact amount of nitrates needed, and no more. What remains in the soil eventually ends up in the groundwater.

Dr. Bridget Scanlon, senior researcher at the Bureau of Economic Geology, is working with AgriLife Research scientists on the *Groundwater Nitrogen Source Identification and Remediation in the*

*Texas High Plains and Rolling Plain project*. The aim of this project is to understand how nitrates move through the soil and how they can be managed to improve water quality in underlying aquifers.

“I am looking at the fate of nitrates in the High Plains as an analog for the Seymour Aquifer,” Scanlon said. “Previous studies by the Bureau of Economic Geology suggest that 75 percent of the nitrogen found in the soil is associated with initial cultivation.

“In the Texas High Plains, some of the nitrates come from organic nitrogen that was in the soil before the land was cultivated,” she said.

Clearing native vegetation and tilling the land for cultivation changes the structure of the soil and aerates it, she said. This increases the soil wetness and oxygenation, which turns organic nitrogen into nitrate. After cultivation, under both dryland and irrigated conditions, increased water movement through the soil causes the highly soluble nitrates to enter the aquifer below.

To track the source of nitrates in the Seymour Aquifer, Scanlon applied a bromide tracer on the land’s surface and will drill boreholes this winter to see how deep the bromide has traveled. “This will give us an idea of how rapidly water moves through



the soil and how long it takes for the aquifer to recharge,” she said.

According to the U.S. Geological Survey, the Texas High Plains south of Lubbock and the Rolling Plains are particularly vulnerable to groundwater contamination because of their well-drained, sandy soils, higher percentage of croplands than grasslands, and high nitrogen inputs from agriculture. Agricultural regions have the highest levels of groundwater nitrate pollution. “Nitrate is the most widespread contaminant in groundwater in Texas and in the United States,” Scanlon said.

And in the Rolling Plains, nitrate concentrations in the groundwater are rising.

### Rising concern

The Seymour Aquifer has always had high groundwater nitrate levels. Records show that the water from the aquifer already exceeded recommended nitrate concentrations in 1936, before the use of nitrogen fertilizers became widespread. The reason why the aquifer has such high concentrations of nitrates is still unknown.

According to Dr. Srinivasulu Ale, AgriLife Research geospatial hydrologist at the Vernon center, and his postdoctoral research associate, Dr. Sriroop Chaudhuri, the high nitrate levels can be attributed in part to the Rolling Plains region’s soil characteristics.

“Basically whatever you throw on the ground will soak in pretty fast,” Chaudhuri said.

This region is a recent geological formation composed mostly of sand and gravel, and the high porosity and water conductivity of these soils favor groundwater movement.

Ale and his team studied the long-term trends of nitrate groundwater contamination across Texas and recently published their results in the *Journal of Environmental Quality*. The team analyzed 213 wells from the Seymour Aquifer and found that “over the past 50 years, the concentration of groundwater nitrates has been increasing in the Rolling Plains region,” he said.

According to Chaudhuri, the rising nitrate levels in the Seymour Aquifer can be attributed to several factors, including the soil’s characteristics, the nitrates naturally present in the soil and in the irrigation water, and nitrates used in agriculture. “We found that irrigation with high-nitrate groundwater coupled with nitrate fertilization is one of the major pathways through which nitrates enter the aquifer.”

Regardless of the source, the nitrate levels in the Seymour Aquifer are still increasing. “All I can say is, any contaminant rising eternally is quite aggravating to our environment,” Chaudhuri said.

But, according to Ale, a possible solution exists.

“The implementation of best management practices on a large-scale could reduce the amount of nitrates leaching to the groundwater and thus improve groundwater quality,” Ale said, “but it is a slow process and it may take several years before we see improvement.”

### Putting nitrates to work

AgriLife Research environmental soil scientist Dr. Paul DeLaune is exploring one of these best management practices.

Last July, Ale and DeLaune welcomed members of the Rolling Plains community to the Chillicothe Research Station to discuss a technique that allows producers to take advantage of the nitrates already available in the Seymour Aquifer. They call this method nitrogen crediting.

“With nitrogen crediting, producers take the nitrate in irrigation water into account (when fertilizing their crops),” DeLaune said. “By using the nitrogen that is naturally available, a producer can reduce the use of commercial fertilizer.”


At the field day, DeLaune showed the results of his demonstration. When taking into account the nitrogen in the groundwater, fertilizer applications were reduced by 73 percent in furrow irrigation and 42 percent in pivot and subsurface drip irrigation, without affecting crop yields. In some cases, nitrates in the well water provided more than enough of the crops’ nitrogen needs.

Applying less nitrogen fertilizer to the crops could mean significant monetary savings to the producers, DeLaune said.

“The average nitrate concentration in the Seymour Aquifer is 13.5 milligrams per liter,” he said. “If a producer applies 12 inches of this water, he is applying 37 pounds of nitrogen per acre. If nitrogen costs \$0.79 per pound, then the producer will save \$29 per acre.”

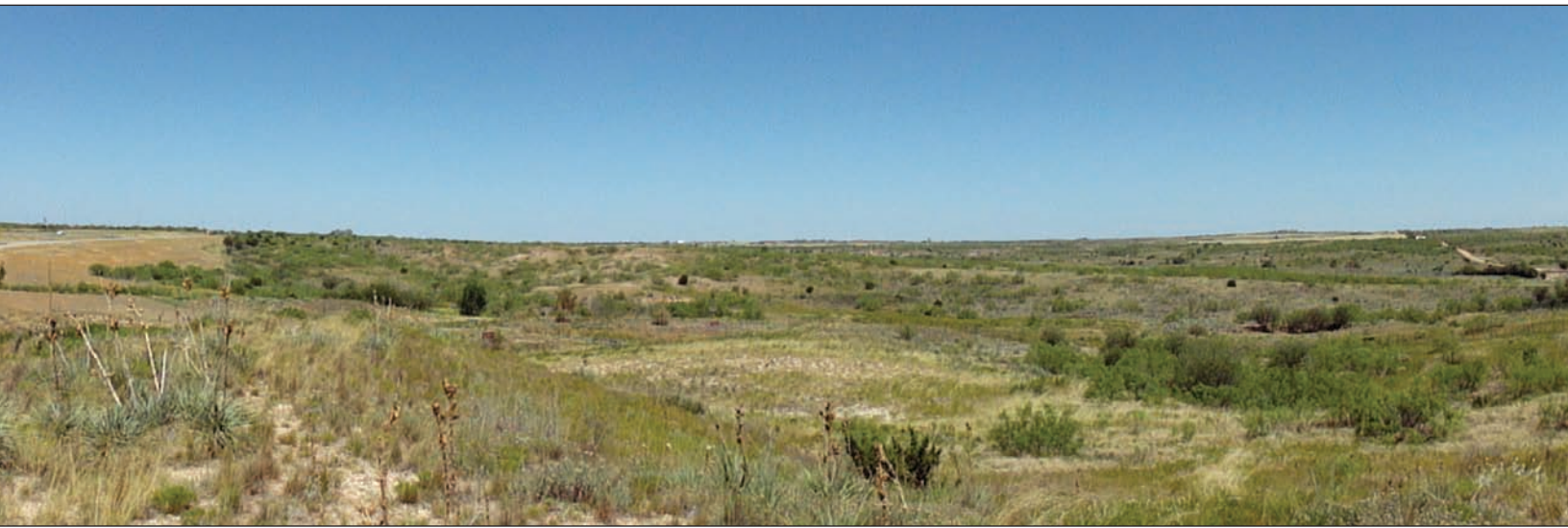
In addition to the economic incentives, nitrogen crediting also offers an important ecological benefit.

“Accounting for this available nitrogen in irrigation water has the potential to reduce nitrate levels in local groundwater resources,” DeLaune said. “Properly managing what we can control, with nutrient management and nitrate crediting, will only aid in protecting our water resources.”

The *Groundwater Nitrogen Source Identification and Remediation* project is managed by the Texas Water Resources Institute and funded by the Texas State Soil and Water Conservation Board through a Clean Water Act grant from the EPA. To learn more about the project, visit [groundwatern.tamu.edu](http://groundwatern.tamu.edu). 

Some information from news releases.

Through nitrogen crediting, producers can take the nitrate in irrigation water into account when fertilizing their crops, including cotton. Photo by Lucas Gregory



# LANDOWNERS LEAD SUCCESSFUL BUCK CREEK RESTORATION

Landowners in the Buck Creek watershed in the Texas Panhandle were the driving force behind the successful restoration of the watershed and its removal from the Texas Commission on Environmental Quality's list of impaired water bodies, according to Texas A&M AgriLife Research and Texas A&M AgriLife Extension Service staff involved in the restoration efforts.

The U.S. Environmental Protection Agency (EPA) recently highlighted the Buck Creek watershed as Texas' fifth water quality restoration success story.

"The removal of Buck Creek from the impaired list is a direct result of the efforts of local landowners," said Phyllis Dyer, research associate at the Texas A&M AgriLife Research and Extension Center at Vernon and the Buck Creek watershed coordinator.

"As a result of voluntary implementation of conservation practices by landowners that were based on data collection, analysis, education and outreach delivered in the watershed, *E. coli* levels in Buck Creek have dropped below impairment levels," she said.

"This success story for Buck Creek and the state of Texas attests to the power of dedication and cooperation of all involved," said Dr. John Sweeten,

resident director and professor at the Vernon center. "It was a coordinated effort by local landowners, soil and water conservation districts (SWCDs), AgriLife Research scientists, AgriLife Extension associates and county Extension agents."

Located in the Texas Panhandle counties of Donley, Collingsworth and Childress, Buck Creek was originally listed as being impaired for elevated bacteria levels in 2000.

Lucas Gregory, the Texas Water Resources Institute's (TWRI) project manager for Buck Creek, said that in 2002, landowners took the initiative to secure the scientific information needed to better evaluate both water quality in the creek as well as potential sources of bacteria across the watershed. Using funding secured from the Texas State Soil and Water Conservation Board's Clean Water Act provided by the EPA, the Buck Creek restoration effort began.

Initially, AgriLife staff collected water quality data and conducted a source survey of the watershed, according to Dr. John Sij, retired agronomist and former project leader at the Vernon center.

"This effort verified that bacteria levels periodically reach problematic levels," he said.



Dr. Paul DeLaune, an environmental soil scientist at the Vernon center, continued water-quality monitoring efforts. He partnered with others to bring scientific information to the landowners, as well.

Water samples were processed using bacterial source tracking (BST) under the direction of Dr. George D. DiGiovanni, who, at the time, was professor of environmental microbiology at the Texas A&M AgriLife Research Center at El Paso.

“Using BST, we determined what the general sources of bacteria were in the creek,” Di Giovanni said.

Dr. R. Karthikeyan, professor in Texas A&M’s Biological and Agricultural Engineering Department, developed a watershed model for Buck Creek that estimates the potential pollutant contributions for catchments within the watershed.

“This tool provided useful information for planning and implementation of management practices so that we could achieve the most pollutant reduction for the dollar spent,” Karthikeyan said.

“Combined, these efforts provided information to the landowners that they needed to make informed management decisions,” DeLaune said.

As research progressed, information was delivered to watershed stakeholders through an

extensive series of public meetings and workshops, Gregory said.


“Landowners were led by TWRI and AgriLife Research personnel from the Vernon center in developing a watershed protection plan designed to restore Buck Creek,” he said.

Even before the plan was completed, landowners began implementing conservation practices across the watershed, DeLaune said.

“Landowners used information provided to them through workshops and field days hosted by AgriLife Research and Extension and supported by the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS), local SWCDs and TPWD personnel,” he said.

Gregory said that some landowners used their own money while others used assistance programs such as those offered by NRCS, local SWCDs, TPWD or USDA Wildlife Services.

Burl Brim, a local landowner, said landowners learned some important things through this process. “Getting involved with local water issues is an opportunity to learn,” he said. “It’s important to find out what other folks are doing to protect the environment and how you can help.”

For more information on the efforts to restore water quality in Buck Creek and to read the complete water quality success story from EPA, visit [buckcreek.tamu.edu](http://buckcreek.tamu.edu). 

Buck Creek watershed in the Texas Panhandle has been delisted from the Texas Commission on Environmental Quality’s impaired water list after efforts of landowners. Photo by Phyllis Dyer.



# WEEVILS SUCCESSFULLY DESTROY ACRES OF LAKE-INVADING PLANT

Through a statewide giant salvinia management program, a weevil that feeds exclusively on giant salvinia successfully destroyed about 150 acres of the invasive plant on B.A. Steinhagen Lake near Woodville in East Texas this summer. Now a similar effort aims to recreate these successful results at Caddo Lake in northeast Texas.

Researchers from U.S. Army Corps of Engineers, Texas Parks and Wildlife Department (TPWD), Texas A&M AgriLife Extension Service and Texas

A&M AgriLife Research are working in Texas to control giant salvinia, a free-floating aquatic fern native to South America. The plant has invaded 17 Texas lakes and other water bodies in the southeastern United States, according to Dr. Allen Knutson, AgriLife Extension entomologist at the Texas A&M AgriLife Research and Extension Center at Dallas.

Knutson said the rapidly growing plant forms dense mats, which interfere with water recreation,

displace native vegetation and reduce oxygen content of the water, often harming fish and other aquatic life.

Since late 2010, TPWD's Aquatic Habitat Enhancement Program staff has released more than 112,000 adult weevils, grown at its Jasper rearing facility, onto B.A. Steinhagen Lake.

Knutson, Dr. Abhishek Mukherjee and Dr. Kevin Heinz of Texas A&M University's Department of Entomology, along with Chris Moret of TPWD, have studied the population dynamics of the weevil at the lake throughout 2011 and 2012. Knutson said they have documented the weevils' impact on giant salvinia and identified ways to improve the effectiveness of the weevil as a biocontrol agent.

"Our research has shown that following the mild winter of 2011-2012, the number of overwintering weevils at B.A. Steinhagen Lake was about 20 to 30 weevils per kilogram of salvinia, which is a high survival rate," Knutson said. "This large spring population allowed weevils to quickly increase to numbers necessary to control salvinia. By mid-summer, their feeding resulted in widespread reduction in salvinia infestations at our research site on the lake."

"Weevil densities have now exceeded 60 weevils per kilogram of salvinia, which is an excellent population," Mukherjee said. "Populations of this size cause more damage to the plant than it can overcome and are able to effectively control giant salvinia."

"Photos taken before and after weevil releases illustrate the tremendous job the weevils have done in controlling giant salvinia this year," said Floyd Boyett of the U.S. Army Corps of Engineers. "We purposefully refrained from spraying this area to see what the weevils could do this year."

"Now, there is abundant open water, and what giant salvinia remains is contained within floating mats of grass or lotus along the shore," he said. "Weevils are in areas east and south of where they were released, indicating that the floating material must have carried the weevils a good distance and allowed them to establish."

Knutson said the team is hoping to recreate these results at Caddo Lake at a weevil-rearing facility at the U.S. Fish and Wildlife Service's Caddo Lake National Wildlife Refuge. The facility is operated by the Center for Invasive Species Eradication, a center of the Texas Water Resources Institute (TWRI), AgriLife Research and AgriLife Extension and in

collaboration with TPWD, U.S. Fish and Wildlife Service's Caddo Lake National Wildlife Refuge and the Caddo Lake Institute.

Lucas Gregory, TWRI's manager for the project, said giant salvinia is extremely abundant at Caddo Lake this year.

"The flood and freezes in the winters of 2010 and 2011 greatly reduced the amount of giant salvinia present in Caddo Lake, but it has come back with a vengeance this year," he said. "Some areas of the upper lake are almost impassable due to thick mats of salvinia."

So far in 2012, the center's weevil-rearing facility has produced about 50,000 adult weevils, which were then released at a research site on the lake, Knutson said.


"Efforts to establish a self-sustaining population of weevils on Caddo that will disperse widely and reduce the salvinia infestation are under way," he said.

"However, the effectiveness of the salvinia weevil, a tropical insect, is limited by cold winters, especially at Caddo Lake," he said. "Our research has demonstrated that populations of salvinia weevils vary in their ability to survive freezing weather. We are now searching for cold-tolerant strains of the salvinia weevil that could better survive cold winters in Texas and therefore have a greater impact on salvinia infestations the following summer."

Knutson and Mukherjee plan to acquire some weevils from Argentina later this year and evaluate their cold-hardiness in laboratory tests at Texas A&M.

"By collecting weevils in higher, and therefore colder, elevations in Argentina, we expect to find weevils more cold tolerant than those currently in the United States, which were originally collected from Brazil," Knutson said. "Finding more cold-tolerant weevil populations would be especially helpful when colder winters return to East Texas."

"We are confident that an integrated pest management approach including biological control combined with other control methods, such as herbicide spraying, will be successful," Knutson said.

The Caddo Lake giant salvinia project is funded by Congressional support through the USDA's Natural Resources Conservation Service. For more information, visit [txH2O](http://txH2O.twri.tamu.edu/publications/txh2o) online at [twri.tamu.edu/publications/txh2o](http://twri.tamu.edu/publications/txh2o). 

Giant salvinia thrived over the winter of 2012 in B.A. Steinhagen Lake. By August, weevils had cleared this part of the lake of most giant salvinia. Photo courtesy Floyd Boyett, U.S. Army Corps of Engineers.

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