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A Publication of the Texas Water Resources Institute

Fall 2007

In This Issue:

MANAGING BACTERIA POLLUTION IN TEXAS WATERS

MIMICKING NATURE

CELEBRATING 50 YEARS

AND MUCH MORE...

Texas Water Resources Institute | Texas Agricultural Experiment Station | Texas Cooperative Extension

Dr. B.L. Harris

Message from the Associate Director

Working Together for Texas Water

During the 80th Session of the Texas Legislature, significant legislation regarding Texas water issues was passed and signed into law by Gov. Rick Perry. These laws contain numerous changes in water policy that will impact Texas and its people—today and in the future—and provide numerous opportunities for Texas university scientists and educators.

The most substantial bills were Senate Bill 3 and House Bills 3 and 4. These bills include provisions for protecting environmental flows, establishing a Water Conservation Advisory Council, and designating as "unique reservoir sites" all sites that were recommended for such designation in the 2007 State Water Plan. Also included are important changes for the Edwards Aquifer Authority, increasing the pumping limit and establishing a process for the development of a critical period management plan.

Both the environmental flows provision, which creates a stakeholder-driven, science-based process, and the 23-member advisory council will include opportunities for university scientists and educators from throughout the state to become involved.

Through other bills, the Legislature created seven new groundwater districts, addressed flooding and desalination, dealt with rainwater harvesting and irrigation and provided significant appropriations to implement various water projects and programs, including more than $750 million in water infrastructure projects identified in the state water plan.

For more information on these bills, visit the Texas Water Development Board's Wrap-Up at **/www.twdb.state.tx.us** or the Texas Commission on Environmental Quality Summaries at **www.tceq.state.tx.us/comm_exec/igr/80_legsum.html**.

Although some issues and concerns were not dealt with, overall, more than 100 bills that in some way addressed protecting and preserving Texas waters were signed into law. Texas Water Resources Institute strongly encourages university scientists and educators to become involved where opportunities exist.

B.L. Harris

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On the cover:

Low-temperature electron micrograph of a cluster of E. coli bacteria. Each individual bacterium is oblong shaped.
Photo by Eric Erbe, digital colorization by Christopher Pooley. USDA Agricultural Research Service

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Texas Water Resources Institute
make every drop count

volume 3 number 2, fall 2007

2 | Managing Bacteria Pollution in Texas Waters

7 | Showcasing a Project
Groups work to solve stream's impairment

10 | Agencies Approve Bacteria TMDL Task Force Recommendations

12 | TSSWCB Bacteria-Related Projects

12 | Bacteria TMDL Projects

13 | Surface Water Quality Standards

14 | Mimicking Nature
Computer model helps manage nation's, world's waters

18 | SWAT Goes International

19 | Managing Solutions
Institute's managers coordinate water quality, quantity projects

22 | Savings Along the Rio Grande
2006–2007 RGBI accomplishment report published

24 | Celebrating 50 Years
Texas Water Development Board makes impact on clean, adequate water

26 | TWDB History

28 | TWRI Briefs

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Story by Kathy Wythe

MANAGING BACTERIA

POLLUTION
IN TEXAS WATERS

With 310 water bodies in Texas failing to meet water quality standards because of bacteria, managing bacteria pollution is commanding the attention of water agencies, researchers and stakeholders across Texas.

These water bodies are listed in the *2006 Texas Water Quality Inventory and 303(d) List* for failing to meet the standards designed to protect for contact recreation use and/or oyster water use. Updated every two years by the Texas Commission on Environmental Quality (TCEQ), the number of bacteria-impaired waters increased from 197 in 2004 to 310 on the 2006 list.

"Bacteria pollution is the No. 1 cause of impairment in Texas," said Kevin Wagner, a Texas Water Resources Institute (TWRI) project manager involved in projects addressing bacteria impairment.

Although other pollutants such as metals and nutrients cause problems, bacteria pollution currently accounts for about 57 percent of the polluted waters in Texas.

"Controlling bacteria is necessary to support the recreational use of surface water and protect humans' health from illnesses caused from waterborne pathogens," said Thomas Weber, water programs section manager of TCEQ's Chief Engineer's Office.

The first step in managing this pollution is identifying the waters that are contaminated. TCEQ, along with other federal, state, regional and local agencies, continually monitors and evaluates the state's water.

To determine bacteria impairment, water managers measure *E. coli* for freshwater and *Entercocci* for salt water as indicators of the possible presence of pathogens that may cause illnesses. Bacteria in the water may come from waste from humans, livestock, pets and/or wildlife and can find their way into the water through stormwater runoff from the surrounding land, inadequate wastewater treatment and failing septic systems.

Once a water body or water segment is designated as impaired, the federal Clean Water Act requires the state to either 1) develop a total maximum daily load or TMDL, 2) conduct a use attainability analysis to change the water quality standard, or 3) collect additional monitoring data to verify the impairment. A TMDL determines the amount of a pollutant a specific water body can receive and still meet the water quality standard; it also provides numeric estimates of how much the pollutants must be reduced. Once a TMDL is completed and approved, its implementation plan or I-Plan, outlines specific measures to reduce the pollution.

TCEQ and Texas State Soil and Water Conservation Board (TSSWCB) collaborate with other state agencies, universities, companies and stakeholders in the watershed to develop these TMDLs and I-Plans.

TCEQ currently has 17 TMDL projects addressing 114 impairments to recreational and oyster water uses.

As the first bacteria TMDLs were completed in Texas, Wagner said a number of stakeholders expressed concerns over the appropriateness of the bacteria water quality standards, inadequate communication about ongoing TMDLs, and the need for better and more consistent methodologies, tools and science to develop bacteria TMDLs.

To help find answers to these issues, TCEQ and TSSWCB established a joint task force in September 2006 to identify the best and most cost-effective and time-efficient tools for developing bacteria TMDLs and TMDL I-Plans. The seven-member task force, chaired by Dr. Allan Jones, TWRI's director, was charged with making recommendations on effective methodologies and including a science road map to reduce uncertainty in what is known about how bacteria behave under different water conditions in Texas.

The task force report examined bacterial source tracking (BST), an emerging assessment tool that uses DNA fingerprinting and antibiotic resistance typing methods to differentiate between wildlife, pets, livestock or human sources of fecal bacteria, such as *E. coli.*

"BST provides valuable information that will help develop management strategies to address bacterial

contributions from specific human and animal sources of fecal pollution in each watershed," said Dr. George Di Giovanni, an environmental microbiologist at The Texas A&M University System Agricultural Research and Extension Center at El Paso and a task force member. Di Giovanni is one of the researchers at the forefront of developing BST and part of the research team that won the 2007 Texas Environmental Excellence Award in Agriculture for its BST work.

In one of the first studies completed in Texas, Di Giovanni and his postdoctoral student, Dr. Elizabeth Casarez, along with Dr. Suresh D. Pillai of Texas A&M University and Dr. Joanna Mott of Texas A&M–Corpus Christi used BST to investigate bacteria contamination in Lake Waco and Lake Belton and portions of major tributaries to those lakes. They developed libraries for thousands of *E. coli* bacteria and used these libraries to identify the sources of fecal pollution contaminating the water.

Their research in the Lake Waco/Belton project, coordinated by the Texas Farm Bureau and funded by TSSWCB through a Clean Water Act grant, showed that 40 percent to 49 percent of the *E. coli* bacteria came from wildlife sources in these particular waters, followed by cattle and then humans.

As this was one of the first studies of its kind in Texas, a secondary objective was to evaluate several analytical methods to identify the optimal method or combination of methods for future BST application.

The combination of two DNA fingerprinting techniques or a DNA fingerprinting and an antibiotic resistance typing method appeared to be the most suitable, accurate and economical for future library-based BST studies, Di Giovanni said. In addition, a new technique, which provides presence/absence detection of ruminant, human, horse and pig fecal pollution, will be used in future studies to corroborate the library-dependent *E. coli* results.

Another scientific method used in managing bacteria pollution and developing TMDLs is predictive

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Portions of Gilleland Creek in northeastern Travis County do not meet water quality standards for contact recreation use because of elevated bacteria. The Lower Colorado River Authority worked with TCEQ to coordinate public involvement, collect additional data and determine the sources of the impairment. TCEQ recently approved the TMDL. *(Photo courtesy of TCEQ)*

computer models. Researchers and water managers use these fate and transport models to identify pollution hot spots and to estimate the reductions needed to meet water quality standards. Models range from simple mathematical models to more complex hydrologic water quality models.

Dr. Hanadi Rifai, professor in University of Houston's Department of Civil and Environmental Engineering and a task force member, said models are important for a number of reasons.

"They improve our understanding of the system," she said. "They are used to answer 'what if' type questions and are tools to help managers, decision makers and stakeholders make informed decisions. They are also used to examine possible scenarios and their predicted outcomes.

"Selecting a model or models is critical in the TMDL and I-Plan process," Rifai said. "But selecting the appropriate model or models is a challenge since numerous ones are available. The different goals of TMDL and I-Plan development may require the use of different bacteria models with different levels of complexity."

Since one of the issues raised with developing TMDLs was the uncertainty associated with the modeling results, much work is being done to improve them. The models should continually evolve as the knowledge base used in developing them changes, Rifai said.

Other issues that are not well represented in the models and need to be addressed are in-stream sediment settling and resuspension processes, and bacteria regrowth and decay.

Harris County is beginning to work with TWRI and Texas A&M scientists and other university faculty to determine if *E. coli* can proliferate and grow in the waters downstream of its Houston wastewater treatment plants.

"Through this research, the group will be testing the ability of *E. coli* to survive and regrow once it enters water bodies," Jones said.

Identifying the source and amount of the bacteria is crucial, but more important is cleaning up the waters once the pollution source is known.

As part of its Statewide Bacterial Water Quality Impairment Reduction Initiative, TSSWCB, which maintains a lead role in TMDL development when agricultural nonpoint sources are involved, is currently funding about 15 bacteria-related education, assessment, demonstration and implementation projects, including four managed by TWRI. These projects account for about a fourth of its funded nonpoint source projects, said Aaron Wendt, TSSWCB's state watershed coordinator.

All agree that early and active stakeholder input and participation is essential to the success of cleaning up Texas waters from bacterial pollution.

"Stakeholder input is important throughout the entire process of TMDL and I-Plan development," Weber said. "Entities within the watershed have a vested interest in controlling pollution and protecting human health from waterborne disease."

More importantly, Weber said, stakeholders are the ones responsible for applying the measures to reduce inputs from the controllable bacteria sources. The success of a particular I-Plan will rely on these efforts.

Wendt, who said TSSWCB works closely with agricultural producers and cattlemen as well as commodity groups, agreed.

"We need to provide stakeholders the information they need to make informed decisions about managing the water resources in their watershed," he said. "Whether stakeholders are wastewater treatment plant staff or cattlemen, they are the ones who are going to be affected."

To comment on this article, visit its electronic version at **twri.tamu.edu/news/2007**.

Story by Kari Miller

SHOWCASING A PROJECT

Groups work to solve stream's impairment

Buck Creek, a small fresh water stream in the Red River Basin that has excessive bacteria, is within a predominantly rural and agricultural landscape in the panhandle region of Texas. A group of cooperators is evaluating approaches to restore the stream and is developing a watershed protection plan.

With one phase and three years of monitoring completed, a group of cooperators are beginning the next step in bringing Buck Creek, a small stream in the Red River Basin, to acceptable water quality.

The creek, which runs through three counties in the southeast corner of the Texas Panhandle, is on the state's 303(d) List for not meeting water quality standards for contact recreation because of bacterial contamination.

Now, the Texas Agricultural Experiment Station, Texas Cooperative Extension and Texas Water Resources Institute (TWRI), along with the Texas State Soil and Water Conservation Board (TSSWCB), local soil and water conservation districts (SWCDs) and the Red River Authority are beginning the project's second phase to fix the problem.

In this phase, the cooperators will begin identifying specific bacteria sources, evaluating approaches for restoring the stream and developing a watershed protection plan through a stakeholder-driven process.

"This may be one of the first efforts on small streams such as this to get scientific involvement from step 1, the impairment, through the entire process of identifying the sources of nonpoint pollution and looking for solutions through a watershed management plan," said Dr. John Sij, an agronomist at The Texas A&M University System Agricultural Research and Extension Center at Vernon.

For five years, beginning in 1996, the Red River Authority conducted quarterly sampling at one site on the creek as part of the Texas Commission on Environmental Quality's Clean Rivers Program. Its data showed bacteria levels were periodically elevated at that site.

To verify these findings, the cooperating groups instituted the three-year Bacterial Monitoring for the Buck Creek Watershed project to monitor bacteria levels at 13 sites along the creek. The project was funded with 319(h) grant monies allocated to Texas through the U.S. Environmental Protection Agency (EPA) and administered by TSSWCB.

EPA guidelines state that a single water sample containing *E. coli* should not exceed 394 colonies per 100 milliliters of water. To meet the water quality standard, this level must not be exceeded more than 25 percent of the time, and the geometric mean of all samples should not exceed 126 colonies per 100 milliliters.

Phyllis Dyer, the project's watershed coordinator and research technician at the Vernon center, said the results from this monitoring confirmed indications from preliminary data—the creek exceeded the 25 percent bacteria limit at several of the sites.

Based on those results, TSSWCB funded the second phase of the project, Watershed Protection Plan Development for Buck Creek.

Lucas Gregory, TWRI Buck Creek project manager, said this phase's most important objective is the formation of a stakeholder committee to develop the watershed protection plan.

"Having a stakeholder group to guide the development of this plan will be crucial to the success of this project and the success of future implementation efforts," Gregory said.

The plan will include nine elements that outline water quality issues and management measures needed to improve the watershed's quality.

"Once completed, this plan will be a tool for area stakeholders to find information about appropriate management measures that can be implemented in the Buck Creek watershed, which, in turn, will enhance overall stream health and water quality," he said.

"This plan is 100 percent voluntary and will address the concerns of watershed stakeholders. It can only be successful if stakeholders voluntarily implement the management strategies suggested in the plan," Gregory said.

So far, there seems to be a lot of support from stakeholders, said Sij, project leader for the Buck Creek studies. "We recently had a meeting with 42 people present and most of them were landowners in that watershed," he said. "That was one of the

best-attended meetings of landowners we've probably had in the state."

The team is bringing in Dr. George Di Giovanni, an environmental microbiologist at The Texas A&M University System Agricultural Research and Extension Center at El Paso, to conduct bacterial source tracking (BST). He will use DNA analyses to identify the sources of the creek's bacteria, determining whether the contamination is from human, livestock and/or wildlife waste.

Di Giovanni will use two DNA fingerprinting techniques to identify the sources of *E. coli* in Buck Creek. In addition, a new BST technique that provides presence or absence detection of ruminant, human, horse and pig fecal pollution will be used in future studies to confirm the *E. coli* results.

"BST will be used to help rank the different sources of fecal pollution in the watershed," Di Giovanni said. "BST results combined with water quality monitoring, land use patterns and watershed sanitary surveys will be used to help develop effective management strategies."

Once the bacteria sources are determined, alternative land management measures or best management practices can be developed to reduce the impacts on bacteria levels in the creek from those sources.

"If BST determines that cattle are a significant source of fecal bacteria in the watershed, the project team will develop integrated watering, grazing, shade development, feeding and prescribed burning strategies to decrease the frequency and time cattle spend near Buck Creek, " Gregory said. "Likewise, if wildlife or other sources of bacteria are identified as significant contributors, management measures to reduce the bacteria will be evaluated and recommended accordingly."

Sij said the project's second phase is expected to take three years. After bacteria sources are determined and a watershed protection plan is implemented, a third phase would begin to monitor effects of the plan and to make adjustments accordingly.

"The project could go on for five or six more years," Sij said.

Because the project is so thorough, it is something of a showcase study, he said.

"We've incorporated a scientific approach to this whole project—identifying the problem, determining what's causing the problem and developing a watershed protection plan with the stakeholders," Sij said. "We will provide the data and the stakeholders will develop it (the plan). There are repeated analyses over multiple sites from multiple years and not all sites have that. It's a start-to-finish project."
(Agricultural Communications contributed to this story.)

To comment on this article, visit its electronic version at **twri.tamu.edu/news/2007**.

Photo Caption:
Dr. George Di Giovanni and his research team—Dr. Elizabeth Casarez of El Paso, Dr. Suresh Pillai of Texas A&M-College Station and Dr. Joanna Mott of Texas A&M-Corpus Christi—received a 2007 Texas Environmental Excellence Award in Agriculture for their research in bacterial source tracking. The award was presented by the Texas Commission on Environmental Quality at its May banquet in Austin and is the state's highest environmental achievement. From left to right: Texas Senator Kip Averitt, Casarez, TCEQ Commissioner H.S. Buddy Garcia, TCEQ Commissioner Larry R. Soward and Di Giovanni.

Story by Kathy Wythe

AGENCIES APPROVE BACTERIA TMDL TASK FORCE RECOMMENDATIONS

In June 2007 the Texas Commission on Environmental Quality (TCEQ) and the Texas State Soil and Water Conservation Board (TSSWCB) approved the recommendations of the Bacteria Total Maximum Daily Load (TMDL) Task Force and asked their agencies to update their TMDL guidance documents to reflect these recommendations. They also authorized establishing a multi-agency bacteria TMDL work group to examine the research and development needs identified in the task force report.

Both TCEQ and TSSWCB members complimented the task force on the report. Larry Soward, TCEQ commissioner, called the task force report "significant, very important and well done," adding that he was impressed with "how open and inclusive it [the process] was."

"I think it's a good report," said Jerry Nichols, TSSWCB chairman, thanking the task force for their time and effort.

Dr. Allan Jones, Texas Water Resources Institute director and chairman of the seven-member task force, gave an overview of the report and its recommendations at the joint meeting. Other members of the task force were Drs. George Di Giovanni, The Texas A&M University System Agricultural Research and Extension Center at El Paso; Larry Hauck, Texas Institute for Applied Environmental Research at Tarleton State University; Joanna Mott, Texas A&M University–Corpus Christi; Hanadi Rifai, University of Houston; Raghavan Srinivasan, Texas A&M University; and George Ward, The University of Texas at Austin. An expert advisory group of approximately 50 stakeholders and agency staff assisted the task force in developing the report.

Jones said the task force members had a few guiding principles when preparing the report, with the first one being the importance of stakeholder involvement. "This is a process that is not well understood by the public," Jones said. "We recommend in the report that agencies work very hard through existing organizations to get local input."

The task force report describes characteristics, strengths and weaknesses of several computer models

(both existing or under development) that assist bacteria TMDL and implementation plan (I-Plan) analysis as well as bacterial source tracking methods.

The report also recommends a three-tier approach that incorporates adaptive management, phased TMDLs and phased implementation to the extent allowable by the U.S. Environmental Protection Agency, Jones said in an interview.

"The objectives of Tiers 1 and 2 are to ensure that each TMDL is developed using a scientifically credible, cost-effective process with strong stakeholder involvement," he said.

Tier 3 is designed to develop a feasible I-Plan, and, for some complex TMDLs, expands the information available for TMDL development, he said. *(See information below for a summary of the three-tiered approach.)*

The task force concluded its report by summarizing a number of research activities needed to strengthen the scientific tools available for TMDL and I-Plan development.

The report and related documents are available at **twri.tamu.edu/bacteriatmdl/**.

Recommended Three-Tier Approach for Bacteria TMDL Development

Tier 1 Analysis (T1) (one-year)
Required for all bacteria TMDLs.
- Form TMDL stakeholder advisory group.
- Develop comprehensive GIS inventory for watershed.
- Implement source survey for watershed.
- Calculate load duration curves (LDCs).

Analyze Tier 1 data with stakeholder advisory group.

Decision 1 (D1)	Are data and analysis adequate?
Yes	Go to D2.
No	Go to T2.
Decision 2 (D2)	Are needed load reductions socially and economically attainable?
Yes	Complete and submit draft TMDL for agency approval.
No	Complete and submit a draft TMDL that includes a recommended change in designated use (i.e. Use Attainability Analysis).

Tier 2 Analysis (T2) (one-to-two years)
Implemented for most bacteria TMDLs.
May be adequate for I-Plan development for non-controversial TMDLs.
- Implement targeted monitoring to fill data gaps.
- Perform library-independent BST and limited library-dependent BST analysis.
- Develop simple LDC, GIS and/or Mass Balance Models.

Analyze Tier 2 data with stakeholder advisory group.

Decision 3 (D3)	Are data and analysis adequate?
Yes	Go to D4.
No	Initiate a "phased TMDL" and go to T3.
Decision 4 (D4)	Are needed load reductions socially and economically attainable?
Yes	Complete and submit draft TMDL (or I-Plan) for agency approval.
No	Complete and submit a draft TMDL that includes a recommended change in designated use (i.e. Use Attainability Analysis).

Tier 3 Analysis (T3) (two-to-three years)
Normally used for I-Plan development.
May be required for development of complex "phased TMDLs."
- Assure extensive stakeholder involvement.
- Implement extensive targeted monitoring.
- Perform extensive library-dependent BST analysis.
- Complete mechanistic modeling.

Analyze Tier 3 data with stakeholder advisory group.

Decision 5 (D5)	Are needed load reductions socially and economically attainable?
Yes	Complete and submit draft I-Plan (or revise "phased TMDL") for agency approval.
No	Complete and submit a draft TMDL that includes a recommended change in designated use (i.e. Use Attainability Analysis).

TSSWCB BACTERIA-RELATED PROJECTS

The Texas State Soil and Water Conservation Board is directing numerous education, assessment, demonstration and implementation projects as part of its Statewide Bacterial Water Quality Impairment Reduction Initiative. A few of the projects are listed below.

- **Peach Creek Water Quality Improvement Project**
- **Monitoring and Educational Programs Focused on Bacteria and Nutrient Runoff on Dairy Operations in the Leon Watershed**
- **Development of the Plum Creek WPP**
- **Impact of Proper Organic Fertilizer Management in Production of Agriculture**
- **PLAN for Tomorrow: Poultry Litter Application on New Sites**
- **Watershed Protection Plan Development for Buck Creek ***
- **Education Program for Improved Water Quality in Copano Bay ***
- **Lone Star Healthy Streams ***
- **Environmental Management of Grazing Lands ***

TWRI-managed projects

More information on the initiative is available at **www.tsswcb.state.tx.us/managementprogram/initiatives/bacteria**.

BACTERIA TMDL PROJECTS

Texas' Total Maximum Daily Load (TMDL) Program works to improve water quality in impaired or threatened water bodies in the state. TCEQ works with TSSWCB and other entities to develop TMDLs. The following is a list of TMDL projects for water bodies where swimming or wading may be unsafe or harvesting of oysters is limited or prohibited due to high concentrations of bacteria.

- **Atascosa River: A TMDL Project for Bacteria**
- **Buffalo and White Oak Bayous: A TMDL Project for Bacteria**
- **Clear Creek: A TMDL Project for Bacteria**
- **Dickinson Bayou: A TMDL Project for Bacteria**
- **Elm and Sandies Creeks: A TMDL Project for Bacteria and Dissolved Oxygen**
- **Gilleland Creek: A TMDL Project for Bacteria**
- **Guadalupe River above Canyon Lake: A TMDL Project for Bacteria**
- **Houston Metropolitan Area: A TMDL Project for Bacteria**
- **Leon River below Proctor Lake**
- **Northwest Houston Area Bacteria TMDL Project**
- **Oso Bay and Oso Creek: A TMDL Project for Bacteria**
- **Peach Creek: A TMDL Project for Bacteria**
- **Lower San Antonio River: A TMDL Project for Bacteria**
- **Upper San Antonio River: A TMDL Project for Bacteria**
- **Trinity River: A TMDL Project for Bacteria**
- **Upper Oyster Creek: A TMDL Project for Bacteria and Dissolved Oxygen**
- **Copano Bay: A TMDL Project for Bacteria in Oyster-Harvesting Waters**

For more information on the bacteria TMDL projects, visit TCEQ's Web site at **www.tceq.state.tx.us/implementation/water/tmdl/nav/tmdlprogramprojects.html**.

Story by Kathy Wythe

SURFACE WATER QUALITY STANDARDS

As part of the ongoing program to manage Texas water quality, the Texas Commission on Environmental Quality (TCEQ) is currently reviewing the Texas Surface Water Quality Standards, including the standards for contact recreation use.

Preliminary public comment plus input from the Surface Water Quality Standards Advisory Work Group have provided guidance on options available for revising the standards, said Jim Davenport, leader of the TCEQ Water Quality Standards Team. This advisory group, with representation from water associations, the agricultural industry, engineering firms, environmental organizations, consumer groups and government entities, is working with TCEQ staff to review and possibly revise the standards.

For contact recreation use, Davenport said TCEQ is reviewing the range of applicable recreational categories, the way in which these uses are assigned, and the numerical criteria that are appropriate to effectively protect recreational uses.

"The Commission will seek substantial additional public comment on any proposed changes to the standards before adopting them into the state administrative code," Davenport said. "Because of the complexity and regulatory importance of the water quality standards, the overall process is expected to continue into 2009."

For some, Texas' standards for contact recreation are not appropriate for many water bodies on the impaired list.

Aaron Wendt, Texas State Soil and Water Conservation Board's state watershed coordinator, said the standards for contact recreation, with only a few exceptions, are uniformly applied regardless of water body type or the actual level of recreation use.

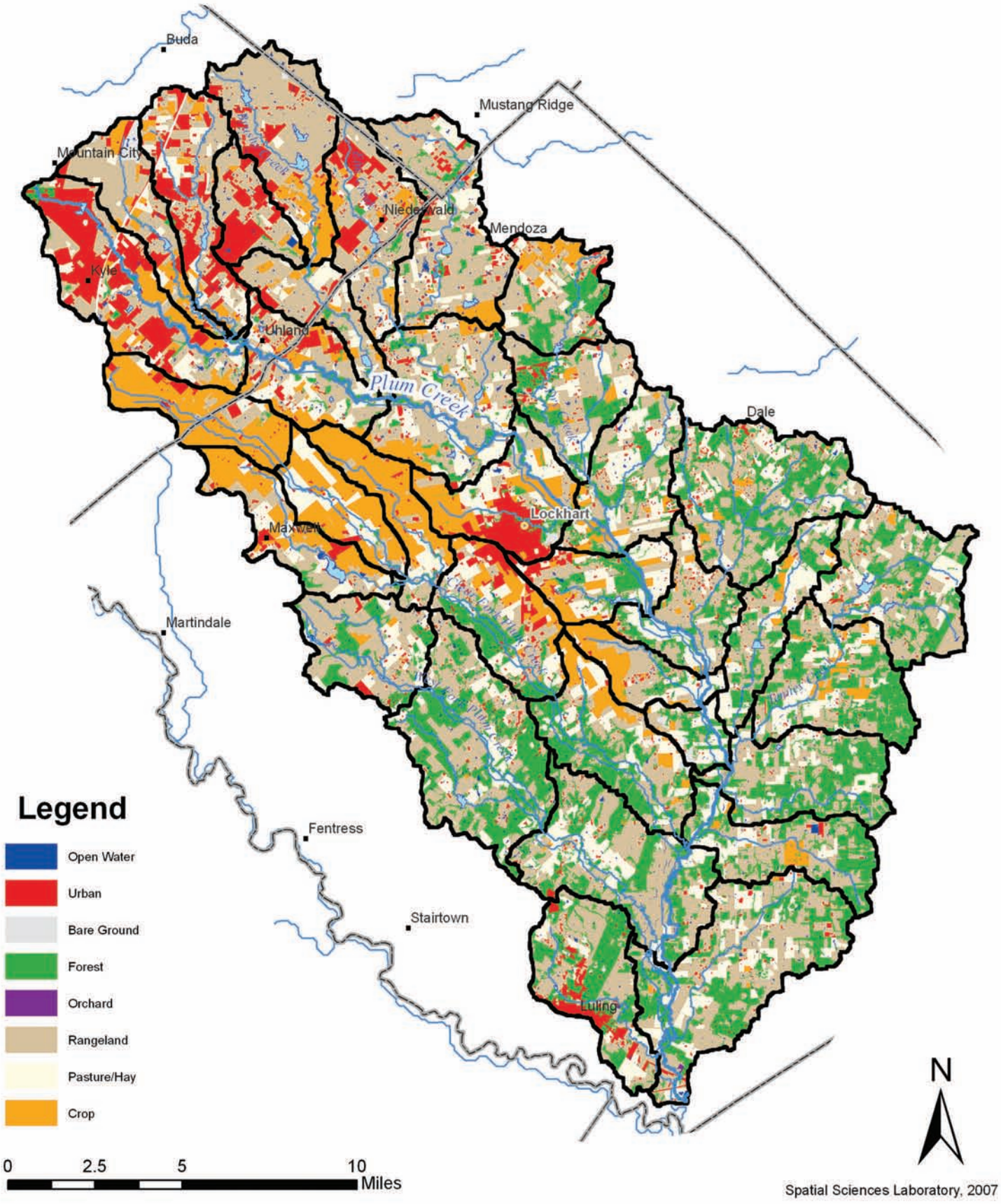
"Because a minimum of 10 water samples over a five-year period is considered an adequate dataset, it's pretty easy to get listed for bacteria impairment," Wendt said.

Kevin Wagner, a project manager for Texas Water Resources Institute (TWRI), agreed, asking the question, "Should almost *all* water bodies in the state be protected for contact recreation as they are now?"

Wagner said some people believe that making rural creeks with almost no contact recreation meet the same standard as Hill Country rivers that have people swimming and tubing all year long is unnecessary and too costly for the state and local stakeholders.

Dr. Allan Jones, TWRI's director, said the standards issue needs to be resolved. "If not, we may be shooting at targets almost impossible to meet."

For more information, visit TCEQ's Web site at **www.tceq.state.tx.us/nav/eq/eq_swqs.html**.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Spatial Sciences Laboratory, 2007

MIMICKING NATURE

Computer model helps manage nation's, world's waters

In the 1980s, a group of scientists in a small research building in Temple, Texas, began a journey to mimic how watersheds work. Today, a major product of their efforts—SWAT—is used throughout Texas, the nation and the world.

SWAT, the Soil and Water Assessment Tool, is a sophisticated computer model that predicts the impacts of weather, soils, land use and land management on water supplies as well as nonpoint and point source pollution in small to large watersheds. Information such as rainfall amount, soil type, and the amount of nutrients and pesticides applied to the land over the years are fed into the model. Geographical Information Systems (GIS) are also integrated into the computer program that has 400 to 500 mathematical equations with more than 50,000 lines of computer code.

The model predicts how much water, sediment, nitrogen, phosphorus, pesticides, bacteria and other pollutants are running off the land and getting into lakes and rivers, and the impact different water management decisions could have.

"We're trying to mimic nature," said Dr. Jeff Arnold, research leader and agricultural engineer for the Grassland Soil and Water Research Laboratory in Temple, part of the U.S. Department of Agriculture's Agricultural Research Service (ARS). "We give our best estimate of what's going to happen.

"And SWAT's estimation gives decision makers a tool to solve water quality problems, Arnold said.

Dr. Raghavan Srinivasan, director of Texas A&M University's Spatial Sciences Laboratory and professor in the Departments of Ecosystem Science and Management, and Biological and Agricultural Engineering, agreed.

"For policy makers, models such as SWAT can serve as virtual laboratories for testing the effectiveness of alternative environmental policies and pollution control programs," he said.

SWAT is a continuation of models developed over 30 years at the ARS laboratory in Temple. Srinivasan, who was at Blackland Research and Extension Center at the time, and Arnold worked together with other Experiment Station, USDA Natural Resources Conservation Service (NRCS) and university scientists to develop SWAT and its national spatial databases and GIS interfaces.

"Srinivasan took these large-scale databases—the soils data and land use and topography—and really pulled all those together in a form we could use in the models," Arnold said. He explained that GIS takes the maps and associated data and spatially pulls everything together, automatically develops all the SWAT inputs and then displays the information on maps. "Without that application, the model's use would be very limited."

One of the big drivers for developing the model was determining environmental impacts of different conservation practices, Arnold said. Congress, through the Resources Conservation Act, requires NRCS to report to Congress every 10 years on the status of the nation's soil and water resources and evaluate conservation practices.

So, in the early 1990s, the researchers sold NRCS on the idea of using EPIC (Erosion Productivity Impact Calculator), SWAT and GIS to model the

48 contiguous states, simulating the effects management activities have on water quantity and quality in watersheds, Srinivasan said. The result was the Hydrologic Modeling of the United States or HUMUS project, a $1 million five-year project. Before HUMUS, NRCS relied on field observations and statistical approaches to estimate the impacts of conservation programs.

"This was the very first time we were able to model the continent using EPIC and SWAT models," Srinivasan said. "There were no models at that time for such a large area."

The latest national assessment for NRCS, Conservation Effects Assessment Project, or CEAP, is currently being developed. In this assessment, the scientists are using SWAT to incorporate outputs from APEX (EPIC's successor), which simulates cultivated lands. SWAT routes pollutants such as sediment, nutrients and pesticides through streams, rivers and lakes to the sea, Arnold said.

"The USDA Farm Program has spent billions of dollars supporting conservation practices with the farmers, and they want to know the environmental impacts of these practices," Arnold said.

Because of the success of the HUMUS project, the SWAT research team started working with the U.S. Environmental Protection Agency (EPA) and state environmental agencies in the late 1990s to evaluate the environmental impacts of pollutants at the local watershed level in support of the federal Clean Water Act. EPA's Office of Science and Technology developed a tool kit—Better Assessment Science Integration point and Non-point Sources or BASINS—to help states analyze their impaired water bodies, estimate Total Maximum Daily Loads (TMDLs) and evaluate various best management practices suggested for each pollutant. SWAT, GIS and the databases are part of that tool kit.

Today, many states across the country use SWAT in their TMDL programs.

Dr. Jeff Arnold, research leader and agricultural engineer for the ARS's Grassland Soil and Water Research Laboratory in Temple, examines one of the SWAT's watershed maps. SWAT is a river basin-scale model developed to quantify the impact of land management practices in large, complex watersheds.

Dr. Raghavan Srinivasan, director, and Jennifer Jacobs, senior research associate, Spatial Sciences Laboratory, work on generating land use maps for one of the SWAT projects.

In Texas, the Texas Commission on Environmental Quality and Texas State Soil and Water Conservation Board use SWAT to develop TMDLs for bacteria impairments. The SWAT model characterizes the watershed, identifying the source of the impairment, grouping the water segments based on the source of the impairment, and developing TMDLs in a most cost- and time-efficient manner, Srinivasan said.

In 2007, Arnold and Srinivasan began working on the Hydrologic and Water Quality System, or HAWQS, project, an extension of HUMUS. HAWQS, which will incorporate SWAT and another water quality modeling tool—U.S. Geological Survey's Spatially Referenced Regressions on Watershed Attributes (SPARROW)—will model seven categories of pollutants, including bacteria and heavy metals. It will provide information that estimates human health risk, drinking water treatment costs and criteria exceedence frequencies for these pollutants.

This three-year project, funded by the EPA, will use state-of-the-art GIS and more detailed databases to provide much more information about the watersheds, Srinivasan said. In the HUMUS project, the research team divided the country into 2,100 watersheds for analysis; the HAWQS project research team is dividing it into 2.7 million watersheds.

"Having more detailed information helps water managers and policy makers to pinpoint the hot spot areas of pollution, so they can evaluate the areas, make changes and bring those areas within water quality standards," Srinivasan said.

Another important and growing use of SWAT is determining the impacts of climate change in the United States and abroad, Arnold said. Global circulation models help predict what is going to happen to temperature and precipitation. Information from those models is fed into SWAT to see what changes will occur to the water supply, reservoir levels and aquifer recharge based on the predicted global climate changes.

Srinivasan and other SWAT developers and users travel around the country and the world, conducting workshops and teaching SWAT and related tools. To date, Srinivasan has conducted 30 international workshops and 50 U.S. workshops.

"We really wanted to deliver a tool that is usable and useful and applied to solve real-world assessments rather than a pure research tool that sits on a shelf," Srinivasan said. "We made the decision to take the technology to the users.

"SWAT is really starting to take off in a much more significant way to solve water quality and water quantity issues around the world," Srinivasan said, adding that 300 peer-reviewed publications have been written based on SWAT.

For this, they are glad. "We really want to make an impact," he said.

To comment on this article, visit its electronic version at **twri.tamu.edu/news/2007**.

Story by Kathy Wythe

SWAT Goes International

The Mekong River Commission used SWAT to help in the assessment of the Mekong River Basin, in southeast Asia.

International researchers and program managers in 90 countries around the world use the Soil and Water Assessment Tool (SWAT) model. Germany, the first country interested in SWAT, uses it to model its large watersheds, said Dr. Raghavan Srinivasan, director of the Spatial Sciences Laboratory and professor in the Departments of Ecosystem Science and Management, and Biological and Agricultural Engineering. Once the European Union formed, it started looking at water issues and used SWAT to help assess watersheds and transboundary water issues of the 15-country union, increasing the use of the modeling tool throughout Europe.

The U.S. Agency for International Development funded a research project for the Kenyan government in which researchers applied the SWAT model to a portion of the Tana River below Mt. Kenya to determine the effects of reforestation policies on a reservoir.

Researchers used SWAT to assess a four-country area in the Mekong River Basin in Southeast Asia, which at 675,000 square kilometers is the largest river basin outside of the United States modeled. Other international projects using SWAT include assessing irrigation management in a Pakistani river basin and developing a conservation assessment for a 25-country area in Europe much like USDA's Natural Resources Conservation Service's Conservation Effects Assessment Project or CEAP.

A research group in Zurich, Switzerland, is developing a global CEAP-like assessment focusing on water supplies and water issues. "They are currently running SWAT across the African continent with plans of gearing up to global," said Dr. Jeff Arnold, research leader and agricultural engineer for the Grassland Soil and Water Research Laboratory.

To answer this expanding interest worldwide, the research team organized the first international SWAT conference in 2001 in Germany with 35 participants from 16 countries and five continents presenting 20 papers.

"This conference gave us a platform to launch SWAT to a large audience," Srinivasan said.

In 2003, the conference in Italy attracted 65 scientists from 23 countries, presenting 40 papers, and in 2005, the Switzerland conference had 105 participants with about 70 papers presented from 32 countries. The 2007 conference in the Netherlands attracted more than 140 participants and about 90 papers. The 2009 international conference is planned in England. Beginning in 2008, regional conferences are planned with the first one in China, in January 2009 in Chang Mai, Thailand, and the 2010 conference in New Delhi, India.

Srinivasan said researchers from every continent except Antarctica attend the international meetings. "They have been a huge success," he said. "Every conference we have about doubled the number of papers and participants."

Story by Emily Baker

MANAGING SOLUTIONS

Institute's managers coordinate water quality, quantity projects

Texas Water Resources Institute (TWRI) project managers work together with scientists and educators as well as government funding agencies to address water quality and quantity issues in Texas.

Each of TWRI's five project managers administers several projects, coordinating meetings, administering budgets, monitoring research and ensuring that deadlines are met.

One of the project managers' primary functions is to align interested research scientists from the Texas Agricultural Experiment Station and other universities and Texas Cooperative Extension specialists and agents with funding agencies, a process that most commonly occurs in one of three ways.

"Project managers will monitor funding agencies to keep track of who has funding and for what projects," said Lucas Gregory. "Once we've determined who has funding, a project manager will call a researcher or specialist and see if his or her research or education ideas fit with the agency's funding. Or, a researcher or specialist will contact TWRI, and we'll start talking to different agencies to see if the person and the agency can collaborate based on his or her interests. Finally, some agencies come to TWRI with funding, and we develop a project to use the funds."

Gregory began his role at TWRI in 2006 upon completion of a master's degree in water management and hydrological science at Texas A&M University. A former Mills Scholar, Gregory was familiar with TWRI. He saw that the institute complemented his educational interests, and he now manages several 319(h)-funded projects that work to resolve nonpoint source pollution issues in collaboration with the U.S. Environmental Protection Agency (EPA) and Texas

TWRI manages four water quality projects on the Arroyo Colorado.

State Soil and Water Conservation Board (TSSWCB). These projects include Buck Creek Water Quality, which consists of two projects; Pecos River Watershed Protection and New Technologies for Animal Waste Pollution Control.

He also manages two federal initiative projects—Water Quality Program for Lake Granbury, Texas, funded by the U.S. Department of Energy (DOE) and the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), and Environmental Infrastructures for the North Bosque River, funded by U.S. Army Corps of Engineers and DOE; a NRCS-funded Conservation Innovation Grant—Assembly and Testing of an On-Farm Manure to Energy Conversion BMP for Animal Waste Pollution Control; and a Caddo Lake project.

Gregory said that it is vital for researchers, Extension specialists and funding agencies to develop a working rapport with each other in order to best form a symbiotic partnership.

"Establishing relationships with people is the key," he said. "The more people you know, the more you can connect researchers and funding agencies. Meeting people and communicating what we do is the biggest piece of the pie."

Project Manager Cecilia Wagner agreed.

"New projects, new funding and new issues come up all the time—knowing different researchers and specialists and knowing their expertise is our job," Wagner said, who began her second stint at TWRI in 2006.

Wagner said project managers produce a number of deliverables depending on the project. These items may include newsletters, budgetary items or reports.

"The researchers conduct the work, and we serve as liaisons between them and funding agencies," she said. "We let the scientists or specialists do their job without letting the red tape get in the way. Grant funding is a competitive world; we want to get funds in, and just as quickly hand them out. We don't care whose name is on the reports and projects, rather we want to solve water-related problems."

She manages four Arroyo Colorado projects funded by EPA through TSSWCB and Texas Commission on Environmental Quality, and Texas Water

Project Managers Cecilia Wagner, Kevin Wagner, Danielle Supercinski, Dr. Bill Fox and Lucas Gregory work to link university researchers and Extension specialists to appropriate funding agencies to provide research-derived, science-based information to help answer diverse water questions addressing Texas' water quality and water quantity issues.

Development Board-funded projects—Irrigation Training Program and Precision Irrigators Network.

Kevin Wagner, who joined TWRI in 2005 from TSSWCB, has spent several years working with environmental issues. He is currently pursuing his doctorate evaluating best management practices for reducing bacterial runoff from cattle wastes entering streams. Wagner manages four bacteria-related TWRI projects: Environmental Management of Grazing Lands and a Conservation Innovation Grant Bacteria Runoff BMPs for Intensive Beef Cattle Operations, both funded by NRCS; and TSSWCB-funded projects—Lone Star Healthy Streams and Education Program for Improved Water Quality in Copano Bay.

Wagner recommends that researchers and specialists contact project managers with their research ideas so that collaboration is possible.

"We tell researchers and specialists who are not familiar with TWRI to come visit with us about a project idea and we'll work out a scope of work and look for places to submit the idea, and we'll refine it depending on the grant we're looking to get," Wagner said. "The most important thing is to get something on paper before we take that first step."

As project manager for the Rio Grande Basin Initiative (RGBI), Danielle Supercinski has been successful in documenting the project's outcomes. She works with researchers and Extension specialists and agents, helping pull together reports, publications, news articles, an annual accomplishment report and other project-related materials and reporting.

"I put together an annual progress and accomplishments report for the project that is almost 100 pages of project outcomes—water savings, money savings and collaborative efforts," Supercinski said. "The report is given to project participants as well as officials in Washington to show that we are saving water, producing results and doing what we are getting funded to do."

Dr. B.L. Harris, RGBI project director and TWRI associate director, said, "Documenting results and outcomes is important to any project and RGBI serves as a model program of outcomes, focused on water conservation accountability."

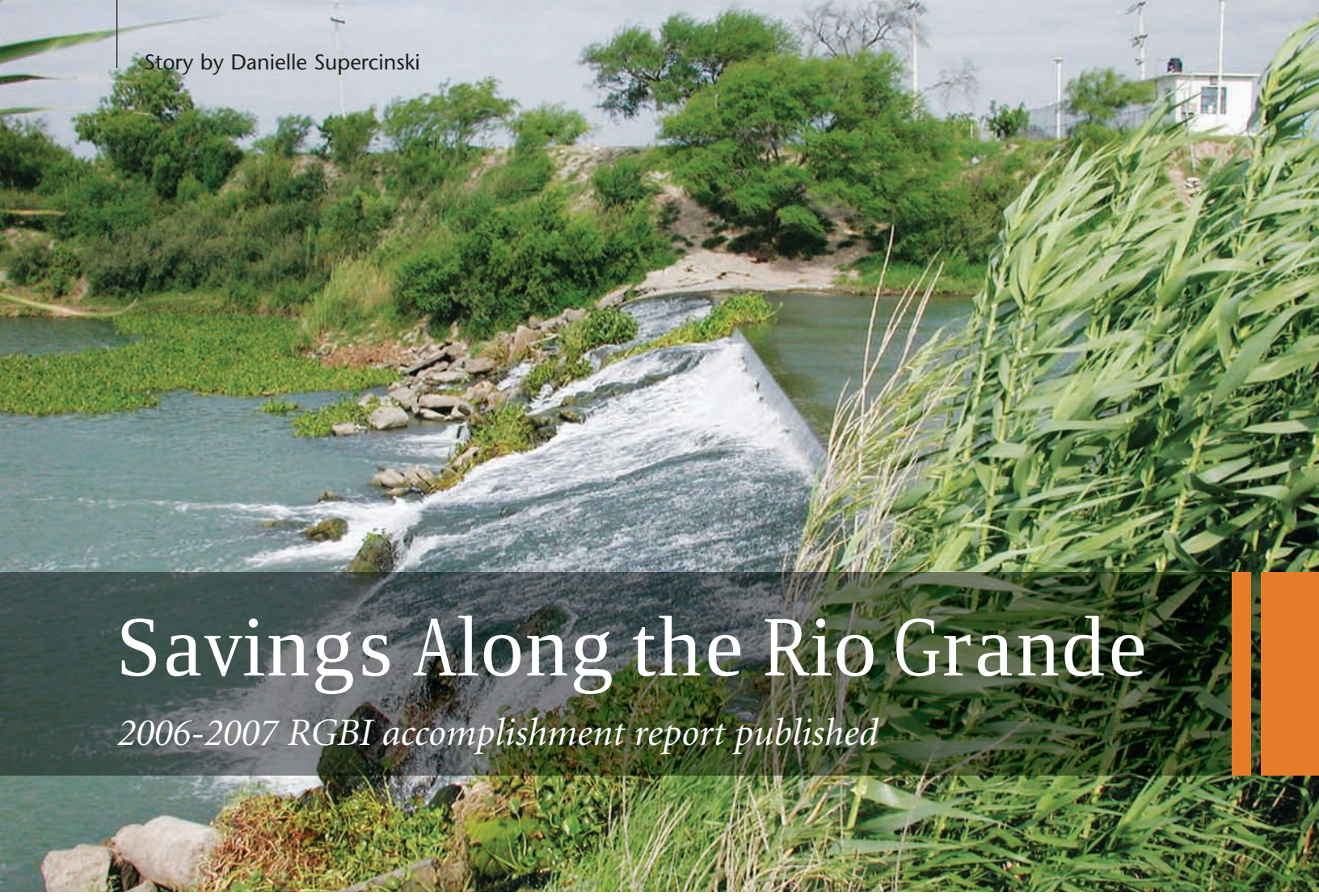
RGBI is a joint project between Texas and New Mexico Agricultural Experiment Stations and Cooperative Extension, and is funded by the U.S. Department of Agriculture's Cooperative State Research, Education and Extension Service. This partnership, along with numerous other agency, organization and university collaborations, minimizes duplication of efforts and produces greater outcomes because of everyone working together.

"Collaboration has produced numerous accomplishments because these researchers and Extension specialists and agents are working toward the common goal of conserving water," Supercinski said. "Since the inception of the project in 2001, more than 2.8 million acre-feet of water have been saved. Through continued project efforts, even more water savings can be accomplished through RGBI and other water conservation projects, providing water supplies to meet current and future water demands."

Another example of the importance of project partnership is the Fort Hood Range Revegetation Pilot project. Dr. Bill Fox, senior research scientist and manager for this project, has served as the liaison among the project's partners: the U.S. Department of Defense, the U.S. Department of Army, NRCS and the Experiment Station, including Blackland Agricultural Research and Extension Center and TWRI in the NRCS-funded four-year project. The success of this project has led to an increase in Fort Hood's military construction budgets for a more widespread application of best management practices to control erosion, he said. Fox is also involved in project and federal initiative development.

"This project is working to restore the training lands of the military installation by developing and implementing best management practices and decision support tools," Fox said, who conducts research for the project. "Everyone agrees that improving training conditions for U.S. Army soldiers is the number one accomplishment of the project. I am glad TWRI can be a part of it."

Story by Danielle Supercinski



Savings Along the Rio Grande

2006-2007 RGBI accomplishment report published

Conserving water is vital for the Rio Grande Basin, one of the most productive agricultural areas in the United States. Irrigated agriculture claims 85 percent of its water, and urban water use is expected to double in the next 50 years.

Texas and New Mexico Agricultural Experiment Station researchers and Cooperative Extension specialists and agents have tackled these issues and their achievements were reported in the Rio Grande Basin Initiative (RGBI) *2006–2007 Progress and Accomplishments Report*, published in May 2007.

Results range from development of new models, more efficient irrigation technology, new Web site components, rehabilitation of irrigation district infrastructure and activities to promote in-home water conservation. The report showed that cost and water savings as well as new, more efficient technologies impact the basin the most.

One example of these new technologies is the DESAL ECONOMICS© model, an Excel® spreadsheet, developed by the RGBI Extension economics team. This model calculates life-cycle costs of desalination per acre-foot and per thousand gallons. The team designed this model for economic and financial analyses of desalination facilities and the model is broadly applicable across many types of facilities.

VIDRA©, Valley Irrigation District Rate Analyzer, another spreadsheet model, helps irrigation districts understand scenarios of likely financial outcomes in changing water delivery rates to agricultural, municipal and industrial users. Seven irrigation districts are currently using VIDRA, with one district collaborating to develop a customized version.

Extension engineers, working with RGBI, assist irrigation districts in completing project applications by analyzing the conditions, water losses and potential

water savings in irrigation canals. Irrigation districts have saved from 290 to 6,500 acre-feet of water per year from canal replacement, lining and/or seepage-loss testing. In addition, technical support from Extension engineers have saved districts more than $180,000 on engineering services.

On-farm studies resulted in an average 25 percent to 40 percent water savings with drip irrigation systems while maintaining similar yields using furrow irrigation. Watermark sensors can help farmers estimate water requirements for more precise irrigation and improved yields with the potential to conserve between 7,500 and 10,300 acre-feet of water per year valley-wide on cucurbits.

To promote in-home water conservation, Extension specialists and agents conducted an in-home water conservation study of 24 households in eight counties in the basin. Each household received one of three types of conservation training and, as a result, reduced water use from 4 percent to 21 percent, saving 400 to 3,000 gallons of water. RGBI also promotes rainwater harvesting and efficient landscape irrigation as other methods of conserving water.

Other RGBI efforts continue to yield even more accomplishments. Researchers analyze water samples for animal and human viruses and indicator organisms, study giant cane control agents, identify weed management programs for noxious weeds and analyze sap-flux and water-use estimates for saltcedar trees. Publications developed from this research address irrigating urban landscapes with moderately saline water. Researchers have also acquired a user-friendly framework for Rio Grande Basin Web sites, adding real-time data, query functions and other data to the water resources database. They are also developing an interactive statewide county mapping system to provide a resource geographic information systems (GIS) database.

In addition to accomplishments, collaboration is key to this project. Collaborators and the efforts they contribute to the project were highlighted in a new section of the report this year. More than 100 collaborators are listed.

Water and cost savings continue to be the main focus of RGBI as the basin's population, costs and water demands increase. Therefore, RGBI researchers, specialists and agents continue their efforts to produce even greater outcomes and results.

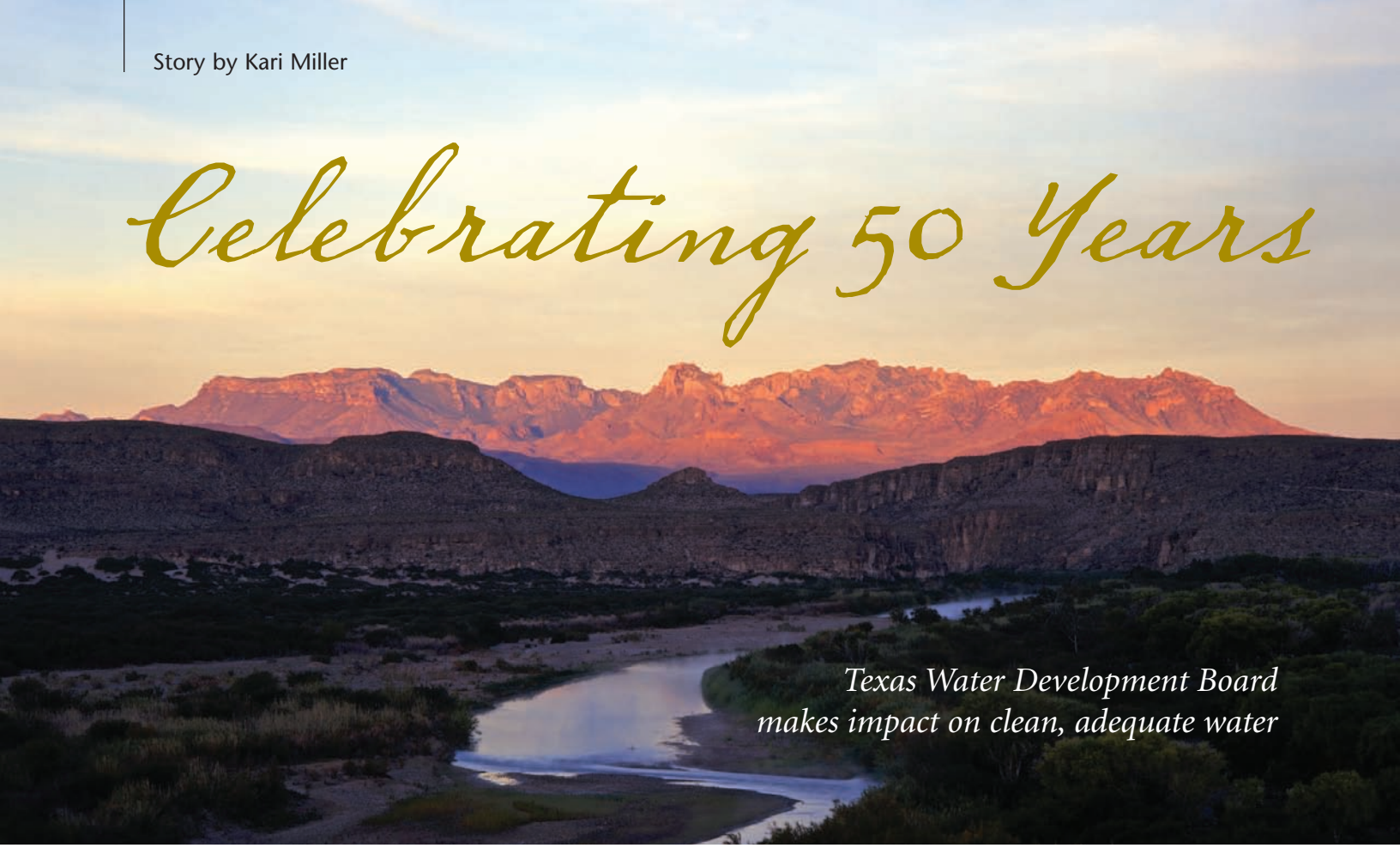
To download the accomplishment report or for more information on the 2007 conference, visit **riogrande-conference.tamu.edu/wrapup/2007/**.

To comment on this article, visit its electronic version at **twri.tamu.edu/news/2007**.

Watch Dog watermark sensors are installed in this onion field to monitor the amount of irrigation. Watermark sensors can help farmers estimate water requirements and become more precise in irrigating and improving yields. *Photo from Juan Enciso*

Story by Kari Miller

Celebrating 50 Years



Texas Water Development Board makes impact on clean, adequate water

In December 2007, the Texas Water Development Board (TWDB) will celebrate its 50th anniversary. As the state's water planning and water project financing agency, TWDB has made significant impacts during the last five decades on ensuring clean and adequate water for Texans.

TWDB was established by the citizens of Texas after a major drought from 1950 to 1957 to make certain that future droughts would not have the same devastating effects. Since 1957, TWDB has been charged with addressing the state's water needs to ensure the availability of sufficient water at a reasonable cost while protecting the state's agricultural and natural resources.

TWDB's mission is to provide leadership, planning, financial assistance, information and education for the conservation and responsible development of water for Texas. According to its Web site, TWDB's main responsibilities are threefold: collecting and disseminating water-related data; assisting with regional water planning and preparing the state water plan to develop the state's water resources; and administering cost-effective financial programs for constructing water supply, wastewater treatment, flood control and agricultural water conservation projects.

In November 2006, the board adopted the 2007 State Water Plan and in January 2007, presented it to the Governor, Lieutenant Governor, Speaker of the House of Representatives and members of the Legislature. *Water for Texas—2007* is the eighth state water plan since 1957.

This plan suggests many water management strategies to ensure enough water for Texas during drought, including municipal and agricultural conservation, and water reuse and building reservoirs, wells, and desalination plants.

"As the state continues to experience rapid growth and declining water supplies, implementation of this state water plan is crucial to ensure public health, safety and welfare, and economic development in the state," said E.G. Rod Pittman, TWDB's chairman of the board.

In addition to developing state water plans, TWDB provides funding for water supply projects and water-related research in Texas through grants and loans. Each year TWDB provides hundreds of millions of dollars in financial assistance to water and wastewater service providers, including cities, water districts and other municipal utility districts. These programs are funded through state-backed bonds, a combination of state bond proceeds and federal grant funds, or limited appropriated funds.

George Farland, general manager of the Harris County Municipal Utility District No. 50, is a recent TWDB customer.

"The TWDB has provided very valuable services and assistance to us," Farland said. "I had a great deal of personal assistance from their staff. They helped us through all the hurdles and provided this much-needed financial and technical assistance to help our community."

Jim Conkwright, general manager of High Plains Underground Water Conservation District, said TWDB has provided funding for the district's agricultural water conservation equipment loan program from 1985 to 2001 as well as the current Texas Alliance for Water Conservation Demonstration Project in Floyd and Hale counties.

"We have a great relationship with TWDB officials and staff. They have assisted us as we work to conserve the groundwater resources within the district's 15-county service area," Conkwright said.

Looking to develop "new" water sources, in April 2006, TWDB awarded $1.3 million to the Brownsville Public Utilities Board to conduct a 12-month seawater desalination pilot plant. After completing this study in late 2007, the utilities board is expected to make a decision to construct a full-scale plant, which would be the first large-scale seawater desalination plant in Texas. All planning-level activities will be completed with the current pilot study. TWDB and Brownsville Public Utilities Board are presently exploring all funding options that will enable the utilities board to proceed with the design and construction of the plant. If constructed, the plant will become operational by 2010.

Over the years, TWDB has provided various research grants to support the development of desalination, including desalination of brackish groundwater.

Through its involvement in rainwater harvesting, TWDB has published several documents with information and recommendations about how to implement the practice.

TWDB also maintains the Texas Natural Resources Information System (TNRIS), a database of information on the state's natural resources. According to the Texas Water Code, this database is to provide a "centralized information system incorporating all Texas natural resource data, socioeconomic data related to natural resources, and indexes related to that data that are collected by state agencies or other entities."

The governor appoints board members, who meet monthly in Austin to consider loan applications, award grants and other business such as approving regional water plans and adopting the state water plan. Current members are Dario Vidal Guerra, Jr., Thomas Weir Labatt, III, James E. Herring and William W. Meadows. The chairman is E. G. Rod Pittman and vice chairman is Jack Hunt.

2007 Water Summit

The Texas Water Development Board is hosting Reflections, Water Summit 2007 on December 2–4, 2007 at the Henry B. Gonzalez Convention Center in San Antonio to coincide with the board's 50th anniversary.

The summit will feature speakers on many water-related topics such as desalination, rainwater harvesting, innovative technology, landscape irrigation, agricultural irrigation in Texas and municipal water conservation.

For more information, visit www.twdb.state.tx.us.

TWDB History

TWDB's history reaches back into the early part of the twentieth century and tracks the climate and culture of the state. Here are a few significant events in the evolution of the agency.

1904 — A constitutional amendment was adopted authorizing the first public development of water resources.

1913 — The 33rd Texas Legislature created the Board of Water Engineers to regulate water appropriations.

1926 — The Board of Water Engineers points out the potential advantages of a statewide water plan.

1977 — The three water agencies existing at the time, TWDB, the Texas Water Rights Commission and the Water Quality Board, were combined by the Texas Legislature, creating the Texas Department of Water Resources (TDWR). This new single agency was responsible for developing Texas' water resources, maintaining the quality of water and assuring equitable distribution of water rights.

1985 — Sunset Legislation reorganized the Texas Department of Water Resources, splitting the agency into two separate agencies, the Texas Water Commission and TWDB (current agency). TWDB was made responsible for long-range planning and water project financing. In addition, legislation established the first comprehensive programs for water conservation and studies of environment flow needs for Texas bays and estuaries.

1989 — The 71st Texas Legislature and voters of the state passed comprehensive legislation and constitutional amendments establishing the Economically Distressed Areas Program (EDAP) to be administered by TWDB.

1954-1956

Texas suffered the most severe drought in the state's history.

1957

TWDB was created by legislative act and constitutional amendment. The constitutional amendment, approved by Texas voters, authorized the TWDB to issue $200 million in State of Texas General Obligation Water Development Bonds for the conservation and development of Texas' water resources through loans to political subdivisions.

1962

The Board of Water Engineers was reorganized, renamed the Texas Water Commission and given specific responsibilities for water planning (57th Texas Legislature).

1965

The Texas Legislature restructured the state water agencies, transferred water resource planning functions to TWDB and renamed the Texas Water Commission to the Texas Water Resource Commission (TWRC).

1968

The 1968 Texas Water Plan included a comprehensive water resource development plan including importing water from the Mississippi River. However, voters did not approve a constitutional amendment providing for necessary state funding of the plan.

1972

The Texas Natural Resources Information System (TNRIS) was created, succeeding the Texas Water-Oriented Data Bank, incorporating a centralized repository and clearinghouse of maps, census information and water-related information.

1997

The 1997 State Water Plan was adopted as a consensus effort by TWDB, the Texas Parks and Wildlife Department and the Texas Natural Resource Conservation Commission.

1997

The Texas Legislature passed Senate Bill 1 which established the Regional Water Planning program, a "grass roots" approach to statewide water planning.

2001

The Texas Legislature passed Senate Bill 2 which created significant groundwater legislation and included the creation of many groundwater conservation districts.

2001-2002

In 2001, the sixteen Regional Water Planning Groups completed their first regional water plans. In 2002, TWDB combined the regional plans and adopted the 2002 State Water Plan.

2006-2007

In 2006, the Regional Water Planning Groups completed the second round of regional plans which included more comprehensive water conservation strategies. In 2007, TWDB completed and adopted the 2007 State Water Plan.

2007

As it celebrates its 50th Anniversary, TWDB has received extensive additional responsibilities from the passage of Senate Bill 3 and increased funding by the 80th Texas Legislature.

Baylor outdoor facility bridges gap between field and indoor lab studies

By Kari Miller

In September 2006, Baylor University's Center for Reservoir and Aquatic Systems Research opened the Baylor Experimental Aquatic Research facility (BEAR), an outdoor lab to study how pollution affects aquatic life in streams in Texas. This project, funded by Altria Group Inc., Baylor and the City of Waco, consists of 12 miniature streams and 24 model wetlands that draw their water from the outflow of Lake Waco Wetlands. Here, the North Bosque River is pumped for the natural purification the wetland affords, so the water used in the facility is very clean.

Each stream is approximately 2 feet wide and 60 feet long and is designed to imitate the habitat of central Texas streams by including riffle, glide and pool sections. A riffle is a fast-flowing, shallow section of a stream that usually has cobble or gravel. Glides are also shallow but with a slower current, and pools are deep, slow areas. Each of these sections usually support different species of wildlife adapted to that particular habitat, so the facility's streams have been populated with living organisms such as algae, bacteria, aquatic plants and insects from nearby streams.

Baylor scientists Dr. Ryan King, assistant professor of biology, and Dr. Bryan Brooks, associate professor of environmental studies, are the principal investigators of the BEAR streams. Dr. Robert Doyle, associate professor and chair of biology, is the lead developer of the model wetlands.

"The intention of the BEAR facility is to bridge the gap between field observations, which represent the habitat of interest but may be influenced by many interacting chemicals or other aquatic stressors simultaneously, and laboratory or small field experiments, which allow for control of environmental variables, yet are too small and unrepresentative of natural conditions to be realistic," King said. "Because of its size (more than 30,000 square feet), outdoor location and close proximity to natural aquatic habitats, the BEAR facility is a unique, state-of-the-art resource for conducting controlled yet realistic water research studies."

Attendees at the opening of Baylor's BEAR facility in September 2006 in Waco view the 12 miniature "real life" streams, which can be manipulated to look and act like streams found across central Texas and in other regions.

New Faculty

Dr. Jacqueline Aitkenhead-Peterson

Soil & Crop Sciences

Dr. Jacqueline Aitkenhead-Peterson joined the Department of Soil and Crop Sciences as an assistant professor of urban nutrient and water management.

Aitkenhead-Peterson received her doctorate in natural resources from the University of New Hampshire in 2000.

Her research focuses on the mechanisms that influence carbon, nitrogen and phosphorous cycling and loss to surface water under different land uses within watersheds including links between *E. coli* and nutrients in urban storm and irrigation runoff. She believes that good water quality is essential for sustainable population growth.

Dr. Bryan Boulanger

Civil Engineering

Dr. Bryan Boulanger joined the Zachry Department of Civil Engineering's Environmental and Water Resources Division as an assistant professor.

Boulanger received his doctorate in environmental engineering from the University of Iowa in 2004.

His research employs a multi-disciplinary, cross-scales research approach to explore the fate and transport of materials in natural and engineered systems. His group has a particular interest in the fate of emerging contaminants in water and wastewater, use of reclaimed water and biosolids in agriculture and risk management from environmental exposures.

Dr. Emily Zechman

Civil Engineering

Dr. Emily Zechman joined the Zachry Department of Civil Engineering's Environmental and Water Resources Engineering Division in August as an assistant professor.

Zechman received her doctorate in civil engineering from North Carolina State University in 2005 where she held a position as a research assistant professor.

Her research focuses on the use and development of computational and analytical tools for water resources and environmental problems, including threat management of water distribution systems, groundwater pollutant source identification, and sustainable design of transportation infrastructures.

TWRI Adds Staff

Laura De La Garza joined Texas Water Resources Institute in June 2007 as program coordinator for the Institute's Arroyo Colorado Watershed Protection Plan Implementation project, transferring from the Texas Sea Grant College Program at Texas A&M University.

She coordinates the Arroyo Colorado Watershed Steering Committee in addition to facilitating and tracking implementation measures described in the completed watershed protection plan for the Arroyo Colorado. As program coordinator, she will publicize and build awareness of these watershed improvement efforts and provide extensive outreach and education activities.

De La Garza received her bachelor's degree in geology and completed her course work for master studies in community and regional planning from the University of Texas.

Dr. Ralph Wurbs, professor in Texas A&M University Zachry Civil Engineering Department, has joined Texas Water Resources Institute as a part-time associate director with the responsibility of representing the engineering aspects of water research, extension and education. Wurbs will assist Dr. Allan Jones, director, and Dr. B.L. Harris, associate director, in working with funding agencies, research beneficiaries, researchers and administrators.

Wurbs joined the Zachry Department of Civil Engineering faculty in 1980 and has served as division head for the department's Environmental and Water Resources Engineering Division since 1999. He will continue to devote two-thirds of his time to his engineering faculty duties.

Jones said the institute sought out Wurbs for this position because he understands water resources and the water management community of Texas and has been involved with TWRI activities for 25 years. Jones said the goal of this partnership is to integrate the efforts of the diverse university research community to more effectively contribute to solving the water resources problems faced by Texas, the nation and the world.

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ZEROS Energy & Water Alliance

ZEROS Energy & Water Alliance signed a $2 million endowment agreement with the Texas A&M Foundation to support the enhancement and development of the teaching, research and Extension activities of the Texas Water Resources Institute. Present at the signing were (left to right) Dr. B. L. Harris, TWRI associate director; Dr. Mark Hussey, Texas Agricultural Experiment Station director; Dr. Elsa Murano, vice chancellor and dean of agriculture and life sciences for The Texas A&M University System; Steve Clark, Alliance trustee and developer of ZEROS; John Stropp, interim president of the Texas A&M Foundation; and Dr. Allan Jones, TWRI director.