New Waves
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TNRCC Chooses Computer Models Developed at TAMU, UT, to Analyze the Availability of Water Rights

When Texas' lead environmental management agency recently needed help in updating their water availability model, a Texas A&M University (TAMU) researcher provided a neatly "WRAPped" solution.

Throughout the 1990s, Ralph Wurbs, a researcher in the Environmental and Water Resources Division of the TAMU Civil Engineering Department, has worked to develop and refine the Water Rights Analysis Package (WRAP). This summer, the Texas Natural Resource Conservation Commission (TNRCC) selected WRAP as the model it will use to support statewide water planning activities.

TWRI also provided assistance to David Maidment, a researcher in the Civil Engineering Department at the University of Texas (UT) at Austin, to develop a graphical user interface which works with WRAP and similar models. This interface allows users to view maps, tables, and charts that provide supplemental information about water rights issues.

Water in rivers and lakes is held by Texas in trust for the benefit of its citizens. Rights to use surface waters are granted through a permit system which is administered by the TNRCC. When each permit is considered, individual applications must be analyzed by the agency to confirm that enough water is available to meet these diversions, without jeopardizing the rights of downstream users. Water availability models are used to analyze if enough water exists so that water rights permits can be issued.

The TNRCC and its predecessors developed water availability models for eight river basins during the 1970s. However, these basin-specific computer programs have become obsolete and are no longer being used. On the other hand, WRAP is a generalized river and reservoir system simulation model which can be applied to any watershed. Input files for WRAP are now being developed for each of Texas' 22 major river basins and this process, Wurbs says, and should be completed during the next three years.

"The 75th Texas Legislature wanted a modern tool to support a new State water planning activity," says Wayne Jordan, the Director of the Texas Water Resources Institute (TWRI), which funded the research over a period of 10 years. The Legislature directed

the TNRCC to develop or acquire a new generation water availability model which would replace those which had been used previously.

Wurbs says support from TWRI was critically important in helping his research team develop the model. "Seed money provided by TWRI provided us the consistent support we needed to develop a modeling system which is now able to perform the simulations the State needs."

Getting TNRCC to select WRAP as the model of choice wasn't an easy or simple task. To determine which model should be utilized, the TNRCC organized a multidisciplinary team from state agencies, water managers, and engineering firms to evaluate which of 21 models the State should use. This summer, the group chose WRAP as the best tool to analyze water rights over simulation programs developed by the Danish Hydrologic Institute, Colorado State University, the State of Colorado, and other groups.

"Although 26 criteria were used to rate these models, the fact that WRAP is available to the public free of charge and was developed for Texas appeared to tip the balance in our favor," Wurbs says. "We're now working under a contract with the TNRCC to improve and expand WRAP's flexibility so it can be used immediately in regional water planning studies required by Senate Bill 1, which was passed in the last session of the Texas Legislature."

Jordan says that the State's selection of WRAP is a real research success story. "We feel the use of WRAP will have a huge, positive, impact on how well we manage water in Texas for many years to come," Jordan says. "The bottom line is that every State agency and river authority, as well as many of the larger cities and engineering firms dealing with water supplies will now be using this model to analyze if water is available to support economic growth. Citizens will benefit because WRAP is available free. It puts all potential users on a level playing field because everyone involved in the process has access to the same suite of decision making tools."

The evolution of WRAP illustrates how university research progresses from the initial stages of concept development to implementation. "This modeling tool was conceived and refined over a 10-year period to accomplish a number of research objectives," Jordan says. "I'm very pleased that TWRI was able to play a part in maintaining continuity in this research project over time so that Wurbs could refine it to the point where it's a very effective tool for everyday water management."

NOTE: TWRI has published many articles and technical reports about Wurbs' WRAP work. For more information on this research, contact TWRI at (409) 845-1851 or twri@tamu.edu or visit the Institute's World Wide Web site at http://twri.tamu.edu. Wurbs can be contacted at (409) 845-3079 or r-wurbs@tamu.edu.

TWRI Conference Provides Discussion, Debate, Education, About SB 1 Issues

A standing room only crowd of 370 participants gathered in Austin December 1-2 for the Texas Water Resources Institute's (TWRI) "Water for Texas Conference." The meeting provided attendees with a rich source of information about the new regional water planning process generated by Senate Bill 1 (SB 1) as well as current, critical, water resources concerns.

TWRI Director Wayne Jordan moderates the WRAP panel at the 1998 Water for Texas Conference.

According to TWRI Director Wayne Jordan, the level of interest, attendance, and enthusiasm for this event was a record high for a number of reasons. "I think this meeting went over so well because SB 1 is involving more people in the regional water planning process than ever before," Jordan says. "It's placing a lot of responsibility on individual citizens at the 'grass-roots' level. Many of these people may not have been involved in water resources planning previously, and they came to our meeting to get the information and tools they need to make essential decisions about water resources management."

The meeting was co-sponsored by the Texas Agricultural Experiment Station, the Texas Agricultural Extension Service, and the Texas Water Conservation Association. It featured many prominent speakers, including State Senator James "Buster" Brown and State Representative Ron Lewis, both of whom played key roles in crafting SB1. Administrators of State water resources agencies, including Craig Pedersen of the Texas Water Development Board, Ken Petersen of the Texas Natural Resource Conservation Commission, Larry McKinney of the Texas Parks and Wildlife Department, and Bill Harris of the Texas Agricultural Extension Service, presented overviews of their agencies work in SB 1-related activities.

Many sessions at the meeting discussed strategies and techniques that may help manage water resources more effectively. For example, a number of talks described how site-specific brush management methods may increase the amount of water flowing off rangelands, while others explained how efficient pricing can encourage water conservation. Other themes presented at the conference include the marketing of water rights, and the use of alternative supplies generated by cloud seeding and water reuse. Additional sessions focused on drought planning, the dependability of water supplies, water policies, agricultural irrigation, groundwater, and environmental needs.

University research was prominently featured. A panel discussion featuring Ralph Wurbs of Texas A&M University and David Maidment of the University of Texas at Austin explained work to develop water availability models. Twelve researchers associated with Texas universities also made presentations.

Effects of the 1996 Drought on Lake Tawakoni

Author: Robert W. Pitt and Haydn Fox, Biological and Earth Sciences Department, Texas A&M University-Commerce, Commerce, TX.

Problem Statement: The Lake Tawakoni reservoir, located in northeast Texas, suffered an excessive decline in water levels due to the 1996 drought. The Sabine River Authority (SRA) maintains nine water quality testing sites on Lake Tawakoni. The data had not previously been examined to determine the effects of the drought on water quality. Knowledge of the impacts of drought on water quality would aid in drought contingency planning for preventative treatment of water obtained from reservoirs during future droughts.

Objectives: Water quality data collected from 1990 through 1996 were obtained from SRA and analyzed to: 1) establish baselines for temperature, dissolved oxygen, pH, phosphorous, fecal coliform, chlorophyll-A, and turbidity; 2) determine the relationships between the water quality parameters versus rainfall and lake levels; and 3) determine the impacts of the drought.

Methods: Water quality data were analyzed according to the EPA publication, "Statistical Methods for the Analysis of Lake Water Quality Trends." To determine whether drought year data were significantly different from "normal" years, it was necessary to determine the robustness of the non-drought years. Regression analysis was used to establish a theoretical normal value for each month and a residual value. The number of outlying data points were compared for drought and non-drought years. Correlations were developed to compare water quality data to rainfall amounts and volumes. Rainfall data were obtained from the National Climatological Commission, and lake volumes were obtained from the USGS web page.

Results and Analysis: Residual comparisons showed that the turbidity levels for the Kitsee Inlet and the Cowleech Fork sites, as well as values for fecal coliform at Cowleech Fork were significantly different during the drought year. Excluding turbidity values at Kitsee Inlet, all significant values were from robust data sets. In each of these data sets there were outliers as part of a natural cycle. The Chi Square test indicated that fecal coliform values at Cowleech Fork and the Near Dam site; phosphorus levels at Cowleech Fork, and turbidity for all sites were substantially above the normal limits for the study period. Remaining Chi Square values were within normal limits. Since turbidity at Cowleech Fork and Kitsee Inlet was not robust, had a considerable amount of deviation during the drought year, and deviated from the theoretical model, these water quality parameters indicated that there was a significant impact between the drought and turbidity at these sites. Turbidity at Cowleech Fork and Kitsee Inlet showed significant impacts. Correlation tests showed that neither of these sites exhibited a linear or inverse

relationship between turbidity and rainfall or lake volumes. This may have been due to the water depth at the two sites. The water level of the site near the dam was not significantly impacted by the drought and the water depth near the dam is always deeper than at the Cowleech Fork and Kitsee Inlet sites. The researchers speculate that the drought may have acted as a "flow-through" system which did not result in significant impacts on the remaining water quality parameters of the Lake Tawakoni reservoir, but this hypothesis requires more research. Lake Tawakoni was reduced to 61% of the original volume by the drought, but drought impacts may be more visible in lakes which suffered greater drought losses.

Reference: Pitt, R., Master's Thesis, Effects of the 1996 Drought on Lake Tawakoni, TAMU-Commerce, 1998.

Combined Effects of Fish, Nutrients, on Phytoplankton

Researchers: Ray Drenner, Kirsten Gallo, Robert Baca, and J. Durward Smith, Biology Department, Texas Christian University, Fort Worth, TX.

Problem: The water quality of lakes is determined in part by the density and biomass of phytoplankton. In lake ecosystems, the production of phytoplankton and biomass are regulated both by fish as well as such nutrients as phosphorus and nitrogen. Typically, ecological studies have focused on the independent, not combined, impacts of fish or nutrients on phytoplankton populations. However, studies of the combined effects are needed to better simulate "real world" conditions and to understand how fish and nutrients work together to regulate phytoplankton biomass.

Objectives: The overall goal was to examine how nutrient loading interacts with omnivorous fish to regulate the biomass of phytoplankton in small mesocosms and larger pond ecosystems.

Methods: The experimental designs of the mesocosm and pond experiments included four treatments: 1) no fish or nutrient addition, 2) fish and no nutrient addition, 3) no fish with nutrient addition, and 4) fish and a nutrient addition. Mesocosms, which are fiberglass tanks, were filled and stocked with blue tilapia and carp in September 1998. The mesocosms are located on the TCU campus. Phosphorus was combined with nitrogen and was added as a source of nutrients. The mesocosms were drained and fish were recovered in October 1998. Water column samples were analyzed for total phosphorus (TP), total nitrogen (TN), chlorophyll-a, and turbidity. Gross phytoplankton productivity was determined by measuring oxygen levels. The larger scale experiments were carried out in 23 earthen ponds at the Eagle Mountain Fish Hatchery near Fort Worth. In October 1991 and 1992, all ponds were stocked with fingerling largemouth bass and bluegill, and half of the ponds were stocked with carp. This combination of fish was meant to better reflect the diversity of fish species found in many Texas lakes. Liquid agricultural fertilizer was added to simulate nutrient loadings. Ponds were sampled monthly from March 1992 to August 1993 to assess TP, TN, chlorophyll-a, and turbidity. From July to August 1993, ponds were sampled to measure macrophyte biomass. To

assess fish populations, ponds were electrofished in November 1993. Data sets were examined using analysis of variance techniques.

Results and Discussion: In the mesocosm studies, nutrient loading significantly increased TP, TN, primary productivity and chlorophyll. Introducing omnivorous fish significantly increased TP, TN, primary productivity, chlorophyll-a, and turbidity. The presence of clay decreased TP and increased turbidity. In the pond studies, nutrient loading had significant effects on chlorophyll-a and turbidity, but a significant interaction between nutrient loading and carp was not detected. The original hypothesis of this study was that nutrient loading and omnivorous fish may operate synergistically to enhance phytoplankton biomass. However, these studies suggests that nutrient loading and omnivorous fish may operate independently. Carp did reduce the biomass of many aquatic plants, including bushy pondweed, filamentous algae, and the number of macrophyte species per pond. Eurasian milfoil may have affected water quality in the ponds by helping decrease turbidity. Results of the mesocosm studies suggest that there is a synergistic effect between nutrients, fish, primary productivity, and chlorophyll. Findings from the pond studies indicate that the suppression of herbivorous zooplankton by omnivorous fish did not result in a synergistic effect between nutrients and fish. Drenner says this study sheds light on the comparative value of small-scale mesocosm studies, and larger-scale pond experiments. Although mesocosm experiments are effective ways, both in terms of time and cost, to explore ecological interactions, these results should be confirmed by larger, more complex investigations in ponds, lakes, and rivers.

Reference: Drenner, R., K. Gallo, R. Baca, and J. Smith, "Synergistic Effects of Nutrient Loading and Omnivorous Fish on Phytoplankton Biomass," Canadian Journal of Fisheries and Aquatic Science, 1998, pp. 1-10.

Assessing Water Quality Trends in the Lower Rio Grande Valley by Examining Historical Environmental Trends

Author: John Tiefenbacher, Geography and Planning Department, Southwest Texas State University, San Marcos, TX.

Problem Statement: Currently, the Lower Rio Grande Valley is challenged by a number of potential water resources problems, including contamination from industrial, urban, and agricultural sources. At the same time, the rapidly increasing population is intensifying water demands and creating other potential sources of water quality degradation. A better understanding of today's resource issues can be obtained if one examines historical events which may have introduced practices into the Valley which may now contribute to contamination.

Objectives: To establish a framework by which the environmental health of the Lower Rio Grande Valley can be understood, and to suggest a framework which may be useful for assessing water quality in other situations.

Methods: The history of settlement of the Lower Rio Grande Valley was divided into seven periods, and events and trends which may influence water quality were identified within each time span. These events and trends were then analyzed to determine how they influenced the current environmental state of the region. The seven periods developed and named by the author include the Rio Bravo Wilderness (before 1895), Wetting the Seeds for Development (1895-1904), Pioneering the Valley (1905-26), Modernity and Oil (1927-39), the Americanization of the Valley (1940-63), Facing South (1964-87), and Hard Realities (1988 to now).

Results and Analysis: Prior to 1895, Tiefenbacher notes the region was sparsely settled and cattle ranching was the dominant economic activity. Between 1895 and 1904, the first irrigation network in the region, which branched off the Rio Grande to water a sugar cane plantation in Hidalgo County, was developed. Other irrigation projects were developed in this period. From 1905 to 1926, the region developed rapidly due to the activities of the St. Louis, Brownsville, and Mexico Railroad. The railroad led to the development of many towns and promulgated numerous land and water companies. At this time, fertilizers were not widely used in the Valley and pest control used natural ingredients to treat blights and infestations. The time from 1927 to 1939 was characterized by new developments in fertilizers and pesticides which have both a positive and negative impact. In 1930, DDT was first widely used as a pesticide. Liquid formulations made the application of pesticides and herbicides more efficient, more effective, and possibly more harmful. From 1940 to 1963, some water quality problems first began to appear. For example, it was during this period that citrus peels and fruit liquors, which previously were discharged into public sewers and had an adverse effect on water quality, were first converted into cattle feed. Irrigated farmland in the region mushroomed from 260,000 acres in 1941 to 536,000 acres in 1946. Fertilizer use increased, in general, and synthetic pesticides first began to be commonly used. From 1964 to 1987, two non-agricultural trends appeared that influenced water quality. The first was the introduction of "maquiladora" industrial plants; the other was the widespread development of colonias (substandard housing without adequate drinking water or wastewater) for many new immigrants. On the positive side, the amount of farmland was reduced by 25% and pesticide and fertilizer use also declined. Since 1988, more symptoms of environmental pollution seem to be occurring, including the troubling finding of birth defects and the occurrence of toxic chemicals throughout much of the region. Tiefenbacher suggests this type of study can be used to reflect water quality or environmental trends and can shed light into public health and environmental policies.

Reference: Tiefenbacher, J., "It's In the Water: Rio Grande 'Brew' and Water Quality in the Lower Rio Grande Valley," Presented at the "Water Crises in Texas & the Southwest" Conference, Trinity University, San Antonio, TX, 1998.

NOTE: Tiefenbacher can be contacted at (512) 245-8327 or jt04@swt.edu.

Effects of Best Management Practices on Agricultural Nonpoint Source Pollution in the Arroyo Colorado Watershed

Researchers: Joan Flowers, Nancy Easterling and Larry Hauck, Texas Institute for Applied Environmental Research (TIAER), Tarleton State University

Problem: The Arroyo Colorado watershed, located in the coastal border region of southern Texas, has experienced numerous water quality problems in recent years. Evidence points to agriculture, a primary industry in the area, as one possible source of the pollution.

Background: This section 319 (h) project was designed to promote the use of best management practices (BMPs) to abate non-point source pollution from agricultural sources in the Arroyo Colorado study area. The project was funded by the U.S. Environmental Protection Agency through the Texas Natural Resource Conservation Commission and the Texas State Soil and Water Conservation Board, with matching funds for mathematical modeling efforts provided by the Texas Water Development Board. Participants include the Texas Agricultural Extension Service, the U.S. Department of Agriculture Natural Resources Conservation Service, the Southmost Soil and Water Conservation District, and the Texas Institute for Applied Environmental Research at Tarleton State University.

Objectives: 1) To demonstrate BMPs to lessen nonpoint source pollution from agricultural sources in the Arroyo Colorado watershed, 2) to promote their adoption among area producers, and 3) to estimate the effects of BMP implementation on local water quality.

Methods: Primary tasks of the project included the establishment of coordinating committees, the installation of BMPs and monitoring of demonstration sites, mathematical modeling of the study area, and education and technology transfer. TIAER's involvement included performing laboratory analyses on water samples collected at the demonstration sites, as well as modeling pollutant fate and transport. Two fields were selected for implementation and demonstration of BMPs suitable to the project area. One demonstration field employed dryland cropping practices while the other was irrigated. Each field was divided into a control section, which was managed according to conventional practices, and a treatment section utilizing improved management practices. Samples of surface runoff and subsurface drainage were collected from the control and treatment sections of the fields for chemical analyses. The Environmental Policy Integrated Climate (EPIC) model was applied to estimate the effects of BMP implementation throughout the project area. A multi-layer geographic information system (GIS) database was created for the study area as part of the modeling efforts. Data layers included soil types, land use and vegetative cover, topographical information, monitoring wells, and geographic and cartographic features. The agricultural land uses in the study area were separated into categories based on soil type, crop, and farming practices (dryland or irrigated). Simulations were performed to estimate changes in edge-of-field pollutant loadings for scenarios with and without BMPs. Average annual loads of nutrients, pesticides and sediment were estimated for the study area based on the

modeling results for the following BMPs: 1) improved nutrient management, 2) improved residue management, 3) improved irrigation water management, 4) improved irrigation technology, 5) irrigation land leveling and precision land forming, and 6) integrated pest management (IPM). A seventh scenario represented the implementation of combinations of these BMPs for each category. Companion reports address the demonstration and educational activities associated with this project.

Results and Discussion: Mathematical modeling results indicated that substantial reductions in nutrient and pesticide loadings would be achieved from BMP implementation within the study area. It was estimated that total nitrogen loads could be reduced by more than 30% through improved nutrient management, better irrigation water management, and advances in irrigation technology. Improved nutrient management had the greatest impact on total phosphorus loads, with an estimated 15% reduction attributed to this BMP. With respect to pesticide and sediment losses from croplands, the two BMPs dealing with irrigation practices (improved irrigation water management and improved irrigation technology) showed the greatest potential for reducing pollutant loads from the study area. Reductions estimated for total nitrogen, pesticide and sediment losses exceeded 60% for all BMPs combined. Much of the environmental benefits associated with some BMPs has been realized (especially regarding IPM and laser leveling of croplands) since these efforts are already widely implemented. Educational and planning efforts of many groups to promote integrated pest management and land leveling practices have successfully encouraged agricultural producers to adopt these practices.

Reference: Flowers, J., N. Easterling, and L. Hauck, Prediction of Effects of Best Management Practices on Agricultural Nonpoint Source Pollution in the Arroyo Colorado Watershed, Report PR97-06, Tarleton State University, Texas Institute for Applied Environmental Research, Stephenville, TX, 1998.

NOTE: The report is available in pdf format from TIAER's web page,http://brahma.tarleton.edu/web/pub.html. Joan Flowers can be contacted at (254) 968-9554 or flowers@tiaer.tarleton.edu.

Designing a Reverse Osmosis Drinking Water Treatment Unit for an El Paso Colonia

Researchers: Charles Turner, Jesus Moncada, and John Walton, Civil Engineering Department, University of Texas-El Paso (UTEP), El Paso, TX.

Problem: In 1993, UTEP researchers performed a preliminary study of the water supply and water quality problems of the colonias in El Paso County. Generally, water supplies were saline and were not sufficient to meet the drinking water needs of people living in colonias, which are subdivisions without proper water and wastewater services. Membrane desalinization has been identified as a economically and technically viable method to improve the quality of saline waters and provide safe drinking water to these people.

Objectives: To document the process to develop designs for a pilot desalination plant which, in turn, may serve as a model for a full-sized plant to desalt waters in the El Paso region.

Project History: Through a coordinated effort, the UTEP project team was able to obtain commitments to develop a pilot reverse osmosis treatment plant. The Homestead Municipal Utility District (MUD) provided the land, electricity, and water supply to operate a low-pressure reverse osmosis pilot desalinization plant. Other cooperators include the El Paso Water Utility and Fluid Process Systems, Inc. The pilot plant was designed to produce 50,000 gallons per day (gpd) of potable water, which could then be blended with untreated groundwater before it would be distributed to individual consumers. After obtaining commitments to develop the pilot plant, UTEP worked with the U.S. Bureau of Reclamation to design, construct, and operate a brackish groundwater desalinization plant and brine reject facility. The goals for this full-sized plant are to produce a high quality water supply for Homestead MUD, to analyze the performance of the pilot plant, to assess the feasibility of using brines in solar ponds as an energy source, and to utilize a self-sealing membrane in evaporative cells to eliminate the need for expensive, "geo-membrane" liners.

Project Design: To minimize the amount of brine reject which is produced, a two-stage, nanofiltration membrane system was utilized. The first stage operates at 100 pounds per square inch (psi) and the second stage runs at 200 psi. The two-stage process reduces brine volumes to 10% of the feed flow rate of 67 gallons per minute (gpm). The groundwater which is fed into this system contains high levels of sodium and calcium cations and sulfate and chloride anions. After just one pass through the system, the levels of calcium and magnesium are high enough to begin fouling the membranes. The ion exchange unit, sited between the first and second stages, is intended to prevent fouling. In arid areas like El Paso, where land is inexpensive, evaporation ponds are often a preferred way to dispose of brines. However, the cost to line these ponds can still be expensive. In this project, the UTEP researchers investigated whether the salts generated in this process could work to "self-seal" the bottom of the ponds. A U.S. Geological Survey computer program is being utilized to evaluate whether the water quality from these ponds could be managed to promote self-sealing. The semi-arid climate of El Paso County is ideal for evaporation ponds. Although climate conditions favor evaporation, the evaporation rate is still not high enough to treat all the brine reject water created by this system and additional amounts of land may still be needed to evaporate reject brine water. As a result, the researchers are investigating other ways to dispose of brine and increase evaporation, such as the use of fine mist sprayers and netting, as well as the construction of a berm to increase the pond's volume.

Discussion: Because of this project, the residents of Homestead MUD are benefiting from much better water quality than existed at the beginning of this effort. Preliminary research results suggest that brine waters can be managed so that "natural" liners would be acceptable. The performance of the full-scale plant is still being evaluated.

Reference: Turner, C., J. Moncada, and J. Walton, *Designing for Brine Reject Utilization*, UTEP Civil Engineering Department Internal Report, 1998.

TWDB Awards Grant to UT Austin to Examine Hydrogeology of Carrizo-Wilcox Aquifer

In August 1998, the Texas Water Development Board (TWDB) awarded grants for five water resources research projects.

Robert Mace and Alan Dutton of the Bureau of Economic Geology at the University of Texas at Austin will compile, evaluate and synthesize hydrogeologic characterization data for the Carrizo-Wilcox Aquifer in Texas. At the completion of this study, the researchers will provide TWDB an interactive, user-friendly, and easily updated database about the permeability of the aquifer. The project involves geographically referencing the transmissivity and hydrologic conductivity of the system.

Other projects funded by TWDB include a study of compensation for interbasin water transfers, which will be performed by Milton Holloway of Resource Economics, Inc. of Austin, and water marketing research, which will be conducted by Michael Booth of the Booth, Ahrens, & Werkenthin law firm of Austin. TWDB also funded studies to assess current membrane desalinization technology and the cost to treat brackish and saline water in Texas, which will be studied by James Dodson of the Nueces River Authority, as well as market strategies for improved service by water utilities which will be investigated by David Yanke of Reed-Stowe & Company, Inc. of Austin.

For details about any of these projects, contact Danna Stecher of TWDB (512) 936-0854 or dstecher@twdb.state.tx.us.

Impact of Heat Stress on Wheat Yields, Quality, is Goal Joint Research by Texas Tech, TAES, Israeli Center

Henry Nguyen of TTU is investigating how heat stress affects wheat yields.

Ask any Texan about what you experience in a typical summer and you'll probably hear endless stories of how day after day was unbearably hot and miserable. Researchers at Texas Tech University (TTU) and the Volcani Institute in Israel are now investigating what the "dog days" of Texas summers do to wheat crops. The research grew out of concerns that heat stress, which is often accompanied by a plant's increased need for moisture and water, may be adversely impacting wheat yields and quality.

The research is led by Henry Nguyen of the TTU Plant and Soil Sciences Department and the Texas Agricultural Experiment

Station (TAES) in Lubbock and A. Blum of the Volcani Institute in Israel. It was funded by the Texas Department of Agriculture's Texas Israeli Exchange. The goal of this on-going project is to investigate how heat stress, which occurs when wheat grains fill, affects the build-up of heat shock proteins in the wheat endosperm. They are also researching how heat stress lessens the quality of dough produced from wheat that has been exposed to extreme heat. In this project, Nguyen and Blum conducted heat stress tests on 20 wheat varieties. Some plants underwent a three-day heat stress treatment, in which they were exposed to temperatures of 104 degrees F for six hours a day and then returned to 68 degrees F for the rest of the day. After being subjected to this heat stress, the plants were returned to a "normal" environment in which temperatures were 77 degrees F during the day and 59 degrees F at night.

The results suggest that heat stress cut the mass of grain kernels by roughly 25% at harvest, although those losses were somewhat offset by an increase in protein content. Ultimately, the goal is to learn enough about the genetic structure of wheat plants so that genetic engineering could be used to develop wheat plants which can resist high temperature stress.

For details, contact Nguyen at (806) 742-1622 or bwhtn@ttacs.ttu.edu.

UT, TAES, Israeli Scientists Test Possible Adverse Effects of Wastewater, Sludge, Irrigation on Groundwater, Soil, Quality

When sewage sludge and wastewater effluents treated to secondary levels are used for irrigation, what are the risks to the environment? This is the question currently being investigated by researchers at the University of Texas at Austin (UT), the Texas Agricultural Experiment Station (TAES), and the Israeli Agricultural Research Organization. The project leaders are Joseph Malina of the UT Civil Engineering Department, Lloyd Fenn of TAES-El Paso, and Pinchas Fine of the Israel Ministry of Agriculture. The study was funded through the Texas Israeli Exchange, which is supported by the Texas Department of Agriculture.

The overall goal of the project is to determine how the land application of sewage sludge and treated effluents may threaten soils and groundwater supplies. Specifically, the researchers want to learn how heavy metals bind to soils, how the rate and type of organic carbon compounds in soils affect the transport of heavy metals in soils, and to determine if various forms of nitrogen may enhance microbial activity in soils, thereby lessening pollution risks.

So far, the research team has simulated an aquifer in a laboratory setting to monitor the movement of virus particles. They also examined whether "natural" methods can be used to inactivate viruses and to promote the adsorption of viruses to soil particles. Ultimately, the researchers hope to develop flexible management strategies that may allow effluents and sludge to be applied to arid lands while minimizing environmental risks.

For details, contact Fenn at l-fenn@tamu.edu or (915) 859-9111 or Malina at (512) 471-4614 or jmalina@mail.utexas.edu.

TTI Researchers Develop Improved Method to Estimate Risk Scour Poses to Bridges

Although most bridges look safe and secure, in part because they are built with seemingly sturdy concrete and steel, a researcher at the Texas Transportation Institute (TTI) says the stability of many bridges is being threatened by bridge scour. "One out of every 35 bridges you cross could collapse," says Jean-Louis Briaud of TTI.

The United States has about 600,000 bridges, and as many as 17,000 are considered "scour critical." Scour is the erosion of the streambed as well as soil and geological features which are washed away around bridge piers or abutments. Scouring slowly digs away soil around the structures that secure the bridge, with potentially dangerous consequences.

TTI researchers have developed a better method to predict scour that may lessen damaaes at bridaes like this site in East Texas.

"Scour is serious business," says Briaud. "It is important to make proper measurements so construction or repairs can be made." Briaud notes that most research into bridge scour has focused on scouring in sandy soils. He notes that using data from bridges which are affected by sand scouring to repair bridges built on clay soils may result in unnecessary construction or repair costs.

Briaud and H. C. Chen of the Texas A&M University Civil Engineering Department have developed a new method to determine scour rates in cohesive soils like clay. The scour rate in cohesive soils (SRICOS) method is a site-specific test that involves removing soil samples and testing them in a special, TTI-developed device called an erosion function apparatus. From these measurements and formulas, the method generates the potential depth of scour development at that pier. Chen says SRICOS will make it easier for district engineers to determine scour depths and scour potential for bridges in their district. For cases that require a more detailed analysis, Chen has developed a real-time flow simulation called CHIMERA-RANS.

For details, contact Briaud at (409) 845-3795 or briaud@tamu.edu, or Chen at (409) 847-9468.

UTEP Develops Sustainable Development Strategy for El Paso, Las Cruces, Juarez Region

Researchers at the University of Texas at El Paso (UTEP) have developed an economic development strategy for the Paso del Norte region which is based on the sustainable use of the region's water resources. The project was conducted by researchers in the UTEP Center for Environmental Resources Management and was led by Ed Hamlyn and Nancy Lowery.

The Paso del Norte region consists of the five western-most counties in Texas, two counties in southern New Mexico that lie along the Rio Grande, and four "municipios" (similar to counties) in the Mexican state of Chihuahua that border the Rio Grande down to its confluence with the Rio Conchos. The region falls within the arid Chihuahuan desert. While most of the region is sparsely populated, the Rio Grande floodplain is intensively irrigated, and the area encompassing the El Paso, Juarez, and Las Cruces area is becoming a major urban center. Coordinated resource management planning is made difficult by differences in the laws of the three states and two nations.

Historically, the urban areas have exploited high quality groundwater while the region's farmers have relied on the surface waters of the Rio Grande. Over time, overpumping has lowered the water tables of the region's aquifers, yet overall municipal and industrial water consumption and population growth are increasing. Currently, cities in the region are considering shifting from groundwater to surface water, which could lessen the availability of surface water for agricultural uses.

CERM has prepared a series of technical studies describing such issues as existing water use, the relationship of water use to the regional economy, the types of water treatment technologies that may be necessary as the region becomes reliant on lower-quality water resources, the potential benefits and negative impacts which may result from a market-driven reallocation of surface water, and legal and institutional issues. These reports were then used by a task force which examined such regional issues as water resources, the environment, agricultural water needs, the quality of life, and economic development.

The highest priority actions identified by the task force included the need to inventory the extent of regional aquifers, greater promotion of the use of treated effluent, resolving disputes about water rights, mandatory water conservation, greater use of xeriscaping, and drought management planning. Other issues which need to be explored, the study says, include the ability of cities to "borrow" irrigation water, the sale of agricultural waters, regional binational planning efforts, how to extend water and wastewater utilities to unserved areas, and coordinating the efforts of water and wastewater service providers.

The water management strategy and many of the technical reports are available at http://www.utep.edu/rio. For more details about this project, contact Hamlyn at (915) 747-5667 or edhamlyn@utep.edu.

Book from TAMU Press Describes Early Exploration of the Texas Red River Country

The Texas A&M University Press recently published a book detailing the first official surveys of the headwaters of the Red River. The book, "The Texas Red River Country," was edited by T. Lindsay Baker of the Texas Heritage Museum at Hill Junior College in Hillsboro.

The book describes the efforts of a party of army engineers, teamsters, and a civilian draftsman who departed from Fort Elliott in the Texas Panhandle to explore the headwaters of the Red River in 1876. Previously, their reports had been available only to a limited audience. This version focuses on the reports as environmental history and includes the survey party's ornithological report as well as a new introduction.

To order, contact the TAMU Press at (800) 826-8911 or visit their WWW site at http://www.tamu.edu/upress.

UT Publishes New Translation of La Salle Expedition to Texas

The Center for Studies in Texas History at The University of Texas at Austin has released a new English translation of The La Salle Expedition to Texas. The center is part of the Texas State Historical Association (TSHA), which is located at UT.

Edited and introduced by William Foster and translated by Johanna Warren, the journal recounts the story of Henri Joutel, one of the few survivors of La Salle's last expedition. Joutel served as post commander for La Salle and, as a lay historian, he described in accurate and colorful detail the daily experiences of the expedition group. These adventurers encountered Native American cultures and enormous herds of bison and unknown plants and animals. Joutel's journal details the precise route La Salle's party followed in 1687 from the Texas coast to the Mississippi River. Foster has used Joutel's descriptions to establish where La Salle was murdered by his men, and to correct many erroneous geographic interpretations made by scholars during the past century.

To order, contact the Center (512) 471-1525 or visit their WWW site at http://www.tsha.utexas.edu.

PIRG Report Documents Toxic Chemicals in U.S. Waters

A new report from the U.S. Public Interest Research Group (PIRG) characterizes industrial discharges of pollutants into United States' waters from 1992 to 1996. The report, "Troubled Waters," states that roughly 1 billion pounds of toxic chemicals were discharged into America's waterways during the study period.

According to the report, significant amounts of pollutants are being released into many Texas waters. For example, the Brazos River ranked third in terms of waters receiving the greatest amount of toxic pollution (33 million pounds) followed by the Houston Ship Channel (6th). The report also finds that Texas ranks as the second most polluted state (only behind Louisiana) in terms of the volume of pollutants discharged both directly and

through sewers (79 million pounds). The study also reports that Texas is ranked 8th in terms of states with waters receiving the most carcinogens (563,000 pounds), although the Brazos River ranked 13th among specific rivers and streams, followed by the Neches River (21st). Additional details in the report discuss waters receiving the most persistent toxic metals (Texas was 5th with 984,000 pounds) and individual facilities which release the most toxic pollutants into waters.

Much of the data in this report can be found at the PIRG World Wide Web site at http://www.pirg.org/. You can purchase a copy of the report by e-mailing pirg@pirg.org.

SWT Historian Examines Perceptions, Early Development of South Texas, Rio Grande Valley

When visitors travel throughout the Lower Rio Grande Valley today, the image they will likely leave with is a region flourishing with green crops and orchards as well as rapidly growing towns and cities. However, a researcher at Southwest Texas State University (SWTSU) says that an analysis of historical accounts from the 1600s and 1700s presents an opposite view. Namely, the region was thought by Spanish colonists and officials to be nearly uninhabitable.

Jesus de la Teja is an associate professor in the SWTSU History Department. In 1988, he presented a paper summarizing the development of the region, and its implications for land and water use, at a conference titled "Water Crises in Texas & the Southwest" at Trinity University.

De la Teja notes that the region south of the Nueces River and extending to the current Mexican state of Tamulipas was largely unsettled and unexplored until the late 17th Century.

In 1747, captain Joaquin de Orovio Basterra reported that "there was no place suitable for settlement from the area of the Nueces River to the Rio Grande, essentially because of the great absence of fresh water." A decade later, military engineer Agustin Lopez de la Camara Alta reached a similar conclusion, noting the lands north of the Rio Grande were desolate, sterile, and wanting in water supplies. He argued that human settlement should only be undertaken along the Rio Grande, with the rest of the region "worthless except for raising livestock."

De la Teja also explored how the availability and apportionment of water supplies influenced how lands were settled and used. He notes that landowners were granted varying amounts of water, depending on whether they were irrigated or dryland farmers or ranchers. He also suggests that special rules applied if springs were sited on a property. Water scarcity also produced a bias in favor of livestock grazing that fostered the development of a ranching culture that lasted through the late 19th Century, when technological and economic change created other possibilities.

For details, contact de la Teja at (512) 245-2149 or jd10@swt.edu.

Texas Tech Studies How Deregulation of Electric Utilities May Affect How Much Farmers Pay to Power Irrigation

While utility deregulation for the state of Texas may seem to be a good idea, researchers at Texas Tech University (TTU) wanted to take a closer look. A recent project at TTU investigated what could happen to farmers who rely on irrigation, if deregulation increased the price people pay for power. Phillip Johnson of the TTU Agricultural and Applied Economics Department studied the possible economic effects of utility deregulation throughout the Texas High Plains region.

Phillip Johnson of TTU (above) examined what may happen to irrigators if electric deregulation may raise power prices.

The Texas High Plains is a high-volume consumer of electricity for irrigation during the summer, when crops need the most water and when electric consumption hits a peak throughout the region. Unfortunately, summer is also the time when it costs the most to generate electricity. Roughly 55% of the irrigated acreage in the region relies on electricity to power irrigation wells and sprinklers. Deregulation will mainly impact those who rely on electricity, not gas, to run their pumps and sprinklers, Johnson suggests.

In this project, Johnson studied the electrical power needed to irrigate cotton, corn, grain sorghum, and wheat throughout the region. In addition, more focused, farm-level, studies were carried out in Hale County.

Results of the research suggest that the biggest economic impact of deregulation may fall on farmers who irrigate cotton, because they may likely switch to lower-yielding dryland cotton if it costs too much to irrigate. The results also show that, in general, electrical rates under utility deregulation may have a significant negative impact on the economy of the region, with possibly severe impacts for individual farmers. "I think it's incorrect to assume that everybody is going to benefit from utility deregulation," Johnson said.

Johnson says farmers who are dependent on electricity for irrigation may need to make structural changes in their operations. He suggests farmers affected by utility deregulation may want to use a generator that runs off of natural gas to provide power for their farms, or several farmers may want to share the cost of electricity by purchasing it as a group. "They need to look at their farm and alternative methods to power their irrigation systems."

TTU recently published a technical report that summarizes this project. For more information, contact Johnson at (806) 742-2821 or uypnj@ttacs.ttu.edu.

TAMU Scientists Examine Carbon Dioxide Fluxes, Freshwater Needs, in Coastal Marshes

Texas A&M University (TAMU) researchers are now testing the amount of carbon dioxide taken up and released by marsh plants in an effort to determine where and when injections of freshwater may be the most beneficial. This research is being conducted in marshes near the Oso River in the Corpus Christi area, and is led by James Heilman and Kevin McInnes of the TAMU Soil and Crop Sciences Department. In this study, Heilman and McInnes are measuring the volume of carbon dioxide taken up and released by marsh plants, through the use of tower-based conditional sampling. This system captures air samples and analyzes the amount of carbon dioxide taken in and released by marsh plants. The data is sent to Heilman's laboratory at TAMU.

TAMU Research Associate Doug Cobos obtains a sample from this coastal marsh.

This is one of the first cases in which tower-based conditional sampling has been used in wetlands, though it has been used previously in dryland settings. Heilman believes this system is an improved method to monitor marshes. In the past, researchers would typically visit marshes on a regular basis (once a month, for example) to take samples of water and plants. Tower-based conditional sampling, on the other hand, provides a way to continually monitor marsh ecosystems and provides clues about why and when carbon dioxide fluxes occur.

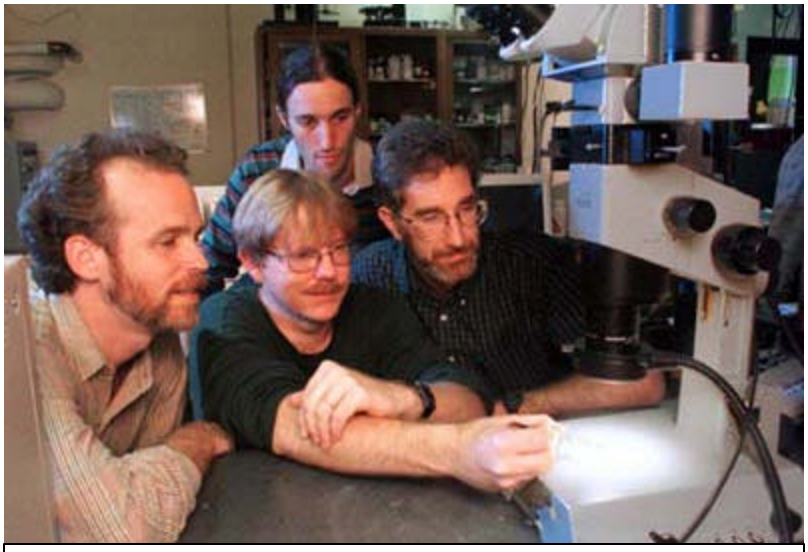
Heilman and McInnes have found that positive net carbon exchange occurs during the daytime - the same time photosynthesis primarily takes place. A major problem is that these marshes only receive freshwater through rainfall and flooding of the Oso River.

The problem is that photosynthesis also requires freshwater and this is sometimes a problem for the marshes near the Oso River. "The Oso River has been channelized and dammed, and that prevents the river from flowing into the delta and the marshes," says Heilman. "Freshwater helps the marshes by providing nutrients and causing salinity to decrease."

Heilman and McInnes are trying to find a way to inject freshwater into these marshes when they most need it. "The problem is when you need freshwater it isn't available. The summer months are when the marshes have the greatest need for freshwater," says Heilman. "We know when the marshes need water, we just don't know where to get it from." The problem may become worse as water becomes more limited in the Corpus Christi area. Currently, marshes in the Corpus Christi area receive less freshwater than similar ecosystems elsewhere along the Gulf Coast.

UT Develops "Electronic Tongue" To Measure Tastes of Food and Beverages; Composition of Waters

Using chemical sensors, University of Texas at Austin (UT) researchers have designed an electronic tongue that mimics the real thing. Like its natural counterpart, the electronic tongue has the potential to distinguish between a dazzling array of subtle flavors using a combination of the four elements of taste: sweet, sour, salt and bitter. In some ways, the electronic tongue has outdone "Mother Nature" - it has the capacity to analyze the chemical composition of a substance as well. Although much of anticipated use for this man-made tongue will be in testing food and beverage products, it can also be used to diagnose the different toxic chemicals which occur in water supplies or the amount of wastewater which is present.



UT Researchers (left to right) Eric Anslyn, John McDevitt, Jason Shear, and Dean Neikirk developed the electronic tongue.

The research is a collaborative effort of Dean Neikirk of the Electrical and Computer Engineering Department, and John McDevitt, Eric Anslyn, and Jason Shear of the Chemistry and Biochemistry Department.

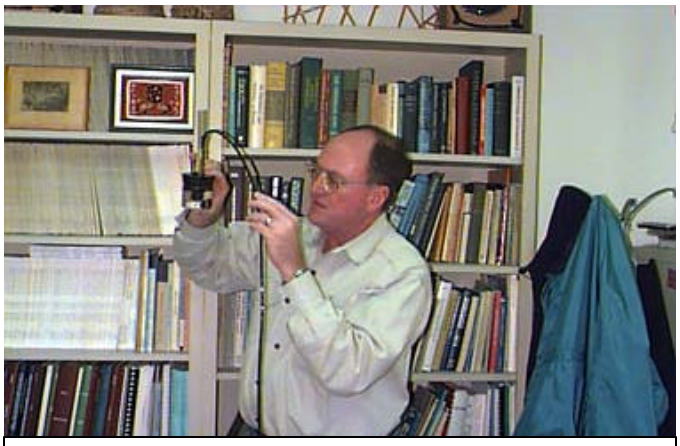
The electronic tongue uses several different chemical sensors which are attached to minute beads and placed on micro-machined wells in a silicon wafer. The wells mimic the tongue's many cavities that hold chemical receptors known as taste buds. Each bead, like a tongue's receptor, has a sensor that responds to a specific chemical by changing color. One sensor may turn yellow in response to high acidity, but may display purple under base conditions. The researchers read the sensor's results through an attached camera-on-a-chip connected to a computer. The sensors respond to different combinations of the four artificial taste elements with unique combinations of red, green and blue, enabling the device to analyze several different chemical components simultaneously.

From the silicon tongue, the team hopes to create a process to make artificial tongues more cheaply and quickly. For example, you could place them on a roll of tape which could be used once and thrown away. The researchers hope this technology can be applied to environmental uses, especially providing feedback and quantitative data about the precise chemical makeup of site specific water and air resources.

For details, contact Neikirk at (512) 471-8549 or neikirk@mail.utexas.edu, McDevitt at (512) 471-0046 or mcdevitt@huckel.cm.utexas.edu.

TAMU Project to Develop Method for Public to Manage, Protect, Water Quality in San Antonio Streams

An interdisciplinary team of Texas A&M University (TAMU) researchers has received a $899,892 grant from the U.S. Environmental Protection Agency (EPA) to develop a method to rehabilitate an urban watershed in San Antonio using stakeholder feedback. The research team, working in collaboration with and under the auspices of the Center for Public Leadership Studies (CPLS) in the Bush School of Government and Public Service, will use ecological monitoring and modeling with stakeholders to actively guide the investigation and develop a restoration plan for the Salado and Leon Creek watersheds.



Bill Neill will use this respirometer to measure how fish adjust to poor water quality.

The project, "Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning," integrates expertise from ecological and social scientists. The principal investigators are Marty Matlock of the Agricultural Engineering Department and Charles Samuelson of the Psychology Department and CPLS. Co-principal investigators are William Neill of the Wildlife and Fisheries Sciences Departments, Ann Kenimer of the Agricultural Engineering Department, Tarla Rai Peterson of the Speech Communication Department, and Guy Whitten of the Political Science Department. Other researchers are senior research scientists Arnold Vedlitz of the Political Science Department and CPLS, sociologist Letitia Alston of CPLS, and research associate Susan Gilbertz from the Geography Department.

Matlock explains that the TAMU Watershed Working Group, which is supported by the Texas Water Resources Institute (TWRI), was an essential element in making this project a reality. "The Working Group gives the TAMU academic community a chance to come together and discuss emerging water resources issues and provides an environment for development of collaborative work," Matlock says. "The Working Group provided a framework for discussion which evolved into a partnership with CPLS which ultimately resulted in the award of this comprehensive project." CPLS staff and faculty conduct basic and applied research and actively seek to identify and put together interdisciplinary research teams from the TAMU System and academic departments, helping conceptualize and design research projects, build research teams, obtain funding, and manage and implement projects. "It is clear that the funding agencies see that today's complex problems require a interdisciplinary approach for their solutions and want more cross-disciplinary team research - that's what our Center does," CPLS Director Vedlitz says.

The three-year project begins this spring. Ecological scientists Matlock, Neill, and Kenimer will evaluate the ecological integrity of Salado and Leon Creeks, which flow through San Antonio, by examining algae growth and how poor water quality may affect the respiratory functions of sunfish. "From a water quality standpoint," Matlock says, "we want to see how the types and levels of pollutants change as rivers flow from upstream, undisturbed sites, through an urbanized area and continue downstream. We hope to learn how the urban environment influences changes in water quality by examining upstream and downstream sites of the same rivers."

Salado Creek does not meet water quality criteria. According to the Texas Natural Resource Conservation Commission's (TNRCC) statewide basin management schedule and the EPA Total Maximum Daily Load (TMDL) watershed strategy, water quality in the creek must be improved by 2003. A TMDL has been implemented for Salado Creek. The TAMU team will work with the TNRCC, the San Antonio River Authority, the San Antonio Water System, and the Alamo Area Council of Governments. "Stakeholders will be major participants in the project's work to develop a plan to improve the water quality of Salado and Leon Creeks. They will help guide the work of the ecological sciences team," Matlock says. We will provide a clear representation of what we do and don't know about these systems, including risk-based assessments of restoration options. The stakeholders will discuss and evaluate this information and suggest directions for more investigations and assessments."

Social scientists Samuelson, Peterson, and Whitten will work with ecological scientists and stakeholder groups. "We will provide stakeholders with scientific, technical, and legal information concerning this project and they will help guide the policy development process regarding water quality restoration," says Samuelson. "Scientists often have a tendency to tell stakeholders what they need to do, and the reactions can be negative. Our goal is to create a collaborative atmosphere that encourages group participants, including researchers, to learn from each other, and to generate and debate options to improve water quality." Stakeholders will have opportunities to ask questions of scientists, and researchers will be able to ask questions of stakeholders. This direct communication will allow stakeholders to suggest new directions that the research could take that would be useful to the stakeholder groups' policy planning activities. "This approach does not emphasize finding a permanent solution, but rather improving the current situation and allowing stakeholders the opportunity to openly discuss possible improvements," he says.

Peterson says the research is designed to test how well communication strategies and feedback loops work in managing complex environmental problems like this. "A challenge is that this project will generate a good deal of technical data which may be difficult for the public to understand. Effective policy cannot be developed unless scientists and local residents work together. Our team hopes to provide a process that will increase the ability of stakeholders to understand and use complex scientific information, think in terms of ecosystem management, and grasp difficult concepts, such as the trade-offs between available resources and the level of certainty desired for how actions will affect the environment."

TPWD Site Provides Details on Texas Waters, Lakes

The Texas Parks and Wildlife Department (TPWD) has recently grouped much of their water resources information on one part of their World Wide Web (WWW) site.

The site is titled, "Texas Water Information - Senate Bill 1," and is located at http://www.tpwd.state.tx.us/conserve/sb1/index.htm. Currently, it can accessed from the main TPWD home page.

This site brings together a variety of water resources information on such diverse topics as target flows of water needed for environmental purposes, endangered and threatened species, river and stream segments, wetlands, recreation and economics data, fish and wildlife management issues, terrestrial habitat, and other related links. These resources also contain TPWD agency perspectives on Senate Bill 1 as well as links to the Texas Water Development Board and other agencies participating in regional water planning efforts.

Another feature on the TPWD WWW site may also be worth checking out. "Texas Freshwater Lakes," located at http://www.tpwd.state.tx.us/fish/infish/regions/instate.htm, contains detailed information about many of the larger lakes in Texas, including when each lake was built, its capacity, access points, and detailed maps, as well as generous amounts of fishing information.

A&M-Corpus Christi WWW Site Describes Coastal Projects

The Center for Coastal Studies at Texas A&M University - Corpus Christi has recently developed a WWW site, which discusses bay and estuary research and education programs at the university.

The site features detailed descriptions of many Center efforts, including the Economic Development Administration's Fisheries Program, which is intended to help develop management strategies to keep the fisheries industry economically viable. The WWW site also discusses the Center's joint efforts with the U.S. Geological Survey to examine marine toxicology issues. At this site, you can also learn about such educational programs as "Adopt-A-Wetlands" and the "Marine Mammal Stranding Network."

The site also leads users to Center reports and discusses the expertise of faculty who work with them. The WWW site address is http://www.sci.tamucc.edu/ccs/welcome.htm. For details about the Center, contact its Director, J. Wes Tunnell, at jtunnell@falcon.tamucc.edu or (512) 994-2736.

Remote Sensing Data is Focus of PVAMU WWW Site

The use of remote sensing to gather environmental information about the Gulf of Mexico region is the heart of a new WWW site at Prairie View A&M University (PVAMU).

The site was created by the PVAMU Texas Gulf Coast Environmental Data Center (TEXGED), which is funded by the National Aeronautics and Space Administration

(NASA). The Center, which is led by Safwat Shakir, utilizes remotely-sensed images to analyze environmental and water resources issues. Some of the Center's recent projects include a spatial analysis that uses satellite imagery to measure the impacts of water stress on alfalfa and other crops, and an image analysis of surface temperatures of Gulf Coast waters. In the future, the Center hopes to create a searchable database of environmental issues in the region.

The WWW site address is http://texged.ips4.pvamu.edu.