New Waves
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Texas A&M University Scientists Assess if Cracks in Clay Soils Increase Risk of Groundwater Pollution

Sometimes research can be a mundane task. Researchers sit at a computer in their office and spend hours poring over data and computer programs. At other times, however, science requires one to get down, dirty, and wet. That was what soil scientists went through recently to complete a research project funded by the Texas Water Resources Institute (TWRI).

The project was carried out by researchers Kevin McInnes, Tom Hallmark, and Larry Wilding and graduate student Willem Heuvelman of the Texas A&M University Soil and Crop Sciences Department. The goal of the study was to determine if some clay soils might -- contrary to popular opinion -- increase the risk of groundwater pollution. Specifically, they wanted to determine if large fissures or cracks called "macropores" that are formed when clay soils shrink and swell provide a path that contaminants can follow to rapidly reach and pollute groundwater supplies. Other goals of the study were to measure and accurately estimate the time it takes for pollutants to travel through the soils.

Field research was conducted near the Brazos River at sites with clay and sandy loam soils. At the site, the researchers used a "flow interceptor" they had developed and built. In laymen's terms, the device looks like an ice cube tray with 98 1 inch square individual cells arrayed in a 7 x 14 grid. Individual cells in the flow interceptor were hooked up to collection bottles and a vacuum system.

Installing the flow interceptor was the hardest part of the study. Samples were collected at depths of 1, 2, and 3 feet for the clay soil and 1, 3, and 4 feet for the sandy loam. To install the flow interceptor, a six-foot long tunnel was dug. The flow interceptor was then installed at the deepest of the three test depths so that the composition of higher soil layers would not be disturbed. Once the device was in place, water was applied to Bermuda grass growing on the surface of the site. Flows through the soil were collected for detailed statistical analysis. The process was later repeated at the two higher depths. Because of the nature of the field work, things didn't always go smoothly. A tunnel collapsed while tests of the sandy soil were underway. Heavy rains in the Spring of 1993 flooded out the site, making it temporarily unusable.

After all the effort, what did the scientists learn? McInnes said that the study suggests that areas with clay soils and macropores may transfer pollutants from the surface to

groundwaters much more rapidly than was previously expected. However, McInnes cautioned that the amount of pollutants that are transferred is still in question and may be quite small. The study yielded valuable insights into subsurface flow patterns in clay soils. In particular, the flow interceptor accurately portrayed the variability of flow rates within a given soil. Although the attempts to measure and simulate travel times through the soils were successful, they may be more accurate when a greater number of samples are taken.

Results of this project were recently published by TWRI as technical report 161, *Water and Solute Flow in a Highly Structured Soil*. Free copies of the report are available by contacting TWRI at (409) 845-8571. McInnes can be reached at (409) 845-5986.

Graduate student Willem Heuvelman of the Texas A&M University Soil and Crop Sciences Department [shown here] worked with researcher Kevin McInnes to conduct field tests to determine if cracks in clay soils provide rapid pathways for the transport of pollutants. In this photo, he prepares samples of water and a tracer that will be used to track pollutant flows. Below, he installs a flow interceptor that will measure how much water flows through specific soil types.

Baylor Geology Department Produces McLennan County Environmental Atlas

Joe Yelderman of the Baylor Geology Department created the Atlas.

A series of color maps with detailed information on water and environmental issues in McLennan County has been published by the Geology Department of Baylor University. The report, *Environmental Atlas of McLennan County,* was produced by Joe Yelderman of the Baylor Geology Department and Robert Cervenka, an urban planner with the City of Waco. The maps provide detailed information on climate, elevations, floodplains, geology, soils, and vegetation. They also graphically display areas likely to be inundated by floods; the location and elevation of lakes and rivers; groundwater systems; and sites where septic tanks and on-site wastewater systems may be appropriate. Each map is accompanied by easy to read instructions on how best to utilize and access the information. For details, call the Baylor Geology Department at (817) 755-2361.

Using GIS for Wellhead Protection

Researchers: Karl Kilborn, Hanadi Rifai, and Philip Bedient, Environmental Science and Engineering Dept., Rice University, Houston, TX.

Problem: The U.S. Environmental Protection Agency (EPA) has developed a Wellhead Protection (WHPA) model to define areas near drinking water wells that should be managed and monitored to prevent pollution. Output from the WHPA model consists of maps and graphs showing areas that need to be protected. Linking the model with geographic information systems (GIS) can provide many benefits including improved analytical capabilities and not having to reenter data in many different programs.

Objective: To demonstrate how a GIS can be used to manage a wellhead protection program; to extend the capabilities and usefulness of the WHPA model; and to develop an interface between the WHPA model and the GIS that processes and converts data and produces needed graphics automatically.

Methodology: A vector-based GIS was used that allows standard query language searches and the creation of temporary and permanent entries in the database. The WHPA model includes four computational programs that define capture zones for pumping wells, and map the extent of contamination originating from injection wells. Capture zones are areas surrounding a well that supply groundwater recharge. Much of the input needed for the simulation models is similar. Common variables include the well location and information on aquifer characteristics and pumping rates. A problem is that the

WHPA program originally developed for personal computers does not synthesize the data from the four models. As a result, a universal data structure was constructed for a linked WHPA-GIS that all the models can use to input and output data. A preprocessor was designed for the WHPA program to prompt users for data that is common to all four models. A GIS was constructed to supply the types of input data required by the WHPA model. The GIS includes detailed data on individual wells (an identification number, the depth to groundwater, pumping rates, and aquifer thickness and transmissivity). Information for the GIS was obtained from digital line graphs supplied by the U.S. Geological Survey and from data provided by the City of Houston. An interface was developed that queries the GIS for the information needed by the WHPA model. The program first prompts the user for the wells in the database that are to be included. Then, it asks the user to draw a polygon that includes the wells to be studied. A chart is then created which includes information for the wells that are selected. The model can transfer WHPA output plots to the GIS.

Results: A linked GIS-WHPA model was developed that includes information on more than 200 drinking water wells in the City of Houston. Tests of the GIS-WHPA interface showed that it can be used to create accurate wellhead protection maps. A major advantage is that this system reduces the need to enter redundant data in many different models. The system allows individual wellhead protection areas to be easily updated, which is very beneficial for major urban areas with many water wells. The GIS can also be used to compile tabular information on the location of potential sources of contamination, which can then be further analyzed.

Reference: Kilborn, Karl, Hanadi Rifai, and Philip Bedient, "Connecting Groundwater Models and GIS," *GeoInfo Systems*, February 1992.

Rotifer Populations in Northeast Texas Reservoirs

Researchers: Robert Wilson, E. Fred Klaus, Robert Williams, Sally Davis, and John Shoemaker, Biology Department, East Texas State University, Commerce, TX.

Problem: Biological species can be a key indicator of water quality in Texas lakes and rivers. Rotifers, small multicelled microorganisms, are a major indicator of water quality because they are sensitive to subtle environmental changes and because of their short life cycle. However, few records are available on rotifer populations in Texas rivers and lakes.

Objectives: To examine rotifer populations in selected northeast Texas reservoirs and to assess how water quality may be affecting the number and health of these species.

Methodology: Rotifer populations were sampled weekly at Lake Fork from 1982 to 1985. Samples were collected monthly at Lake O' The Pines and Lake Pat Mayse from 1985 to 1987; from Lake Wright Patman and Lake Lavon from 1985 to 1986; and from Lake Tawakoni and Lake Cypress Springs from 1986 to 1987. Most of the rotifers that were collected were from the genus *Branchionus*. Eleven species of *Branchionus* were identified.

Results: All the rotifer species that were collected are indicators that eutrophication is occurring. One species (*B. Angularis*) was found in each of the reservoirs during each month of the year. Another species (*B. Bidentata*) occurred in seven reservoirs and was found in all months except December and January. *B. Havanensis* was found in all the reservoirs sampled and was most common in the Summer and early Fall. Some of the species (*B. Budapestensis, B. calyciflorus*) were more common in cooler months, while others (*B. quadridentatus*) were found more often in warm months. Population levels changed rapidly in periods as short as only a few days. Data suggest that population levels are probably not dependent on pH (six species were found at pH levels ranging from 6.9 to 8.5), although seasonal factors likely play a key role.

Reference: Wilson, Robert, E. Fred Klaus, Robert Williams, Sally Davis, and John Shoemaker, "The Occurrence of the Genus *Brachionus* Dallas in Northeastern Texas Reservoirs," *Texas Journal of Science*, January 1994.

Development of a Simplified, Easy to Use Computer Simulation Model for the Edwards Aquifer

Researcher: Nisai Wanakule and Robert Anaya, Edwards Aquifer Research and Data Center, Southwest Texas State University, San Marcos, TX.

Problem: Computer models are an effective method to evaluate options that are available to manage groundwater resources like the Edwards Aquifer. For example, simulation models allow managers to explore the impact of various plans without actually implementing a strategy that may reduce flows or harm spring-fed species. However, most of the existing models are too complicated and difficult to use in everyday decision-making and aquifer management.

Objective: To develop and test a simple and easy to use lumped parameter model to accurately simulate monthly water levels and springflows of the Edwards Aquifer.

Methodology: This computer model was formulated using a discrete, nonlinear, non-stationary system based on control theory. The Edwards Aquifer is represented as a series of connected rock-filled tanks that represent eight major drainage basins of the aquifer and springflows at Comal and San Marcos Springs. Individual drainage basins include the Nueces River, the Frio River, the Sabinal River, Upper and Lower Seco and Hondo Creek (these represent flows on both sides of Knippa Gap), the Medina River, Helotes and Salado Creek, Cibolo Creek, and the Blanco River. Data from the Guadalupe River basin were not available and thus were not included. The model estimates monthly recharge, water levels, and pumping in each basin. It also allows for the interaction of ground and surface water between sub-basins. Sensitivity analyses were performed. Monthly stream gauge and aquifer level data from 1975 to 1990 were used to calibrate the model, while data from 1962 to 1974 were analyzed to verify its performance. A Kalman filter was used to improve the simulation results.

Results: Most importantly, the simulation exercises showed that the model is accurate and very easy to use because much less data is needed. When a Macintosh computer with

a 68040 microprocessor was used, the lumped parameter model efficiently simulated 189 monthly iterations of water levels for nine drainage basins in less than four minutes. Recharge functions in the model provided good estimates of monthly recharge. Recharge estimates were very similar to results from U.S. Geological Survey models in most cases, although peak years were under-represented. Future plans include recoding the model so that it can be used as spreadsheet, generalizing the model so that it can be used in other karst aquifers, and integrating the model with rainfall-runoff simulation software.

Reference: Wanakule, Nisai, and Robert Anaya, *A Lumped Parameter Model for the Edwards Aquifer* (TR 163), TWRI, Texas A&M University, College Station, TX, 1994.

NOTE: This technical report is available free by calling TWRI at (409) 845-1851.

Related articles in *New Waves*:

SW Texas State Developing Edwards Aquifer Simulation Model
TWRI Studies Provide Data to Help Manage Edwards Aquifer
Related technical report:
Water and Solute Flow in a Highly-Structured Soil (TR-161)

Revenue Neutral Pricing System that Uses "Feebates" to Increase Water Conservation

Researcher: Robert Collinge, Economics and Finance Division, University of Texas at San Antonio, San Antonio, TX.

Problem: Municipal water rates are often designed to meet a series of conflicting objectives. For example, they must not produce too much profit for a utility and be "revenue neutral." They should promote efficient water use, but should not impose a hardship on low income residents. Alternative pricing systems that do a better job of addressing these and other concerns need to be explored.

Objectives: To devise and evaluate a pricing structure that is revenue neutral and optimizes water conservation.

Background Information: This research was undertaken because there are flaws in the pricing structure currently used by most utilities. For example, increasing block rates give large numbers of low volume water users little reason to conserve because rates are so low. Command and control regulations (use of water police during droughts) are expensive and inefficient. The proposed "feebate" system consists of three components. First, the rate structure is designed to be revenue neutral and is based solely on the utility's costs to produce, treat, and distribute water. Second, water users are given an allocation or entitlement of a given amount of water they can use each month. The total amount of water allocated to all of a utility's customers should equal the available supply. Third, surcharges or penalties are assessed if individuals use more water than they are allocated. Rebates are granted if consumers use less than the amount they are allotted. Fees for excessive use pay for the rebates, hence the term "feebates." The amount of the

penalties and rebates per unit cost would be steeper when too much water is being used and could be lessened as demands are relaxed.

Case Studies: Many hypothetical simulations were evaluated. As an example, a city with 250,000 customers may estimate its actual cost of water at $1.50 per 100 cubic feet (cf). Each user is allocated 400 cf of water monthly. To reduce water demands by a third, fees and penalties of $1.98 per 100 cf would have to be levied. Low water users in such a system would see a dramatic savings in this system if feebates were in effect. For example, under a typical water rate structure, a water user would only face a $9 difference if he used as little as 100 cf or as much as 700 cf. With the feebate in place, that difference in his bill jumps to roughly $20 (a rebate of $0.44 if just 100 cf are used versus a penalty of $20 if 700 cf are consumed). This type of pricing system allows consumers a great deal of individual freedom to choose how much water they will use. It also provides the added benefit of defining how much economic value individuals place on water use.

Reference: Collinge, Robert, "Optimal Conservation by Municipal Water Customers: A Revenue Neutral Feebate System," *Proceedings of Conserv 93: The New Water Agenda*, pp. 707-717, American Water Works Association.

The Impact of Barge Traffic and Natural Forces on Erosion at the Aransas National Wildlife Refuge

Researchers: J. Zhang, F. Ting, D. Hershberger, H. Yu, and C.A. Spell, Civil Engineering Department, Texas A&M University, College Station, TX.

Texas A&M researchers and graduate students took boats like this one into the Waterway to gather data on forces that cause erosion.

Problem: Erosion is currently threatening the stability of inland marshes that serve as feeding and nesting grounds for endangered whooping cranes that migrate to the Aransas National Wildlife Refuge each Winter. It is necessary to understand the relative roles that natural forces and ship and barge traffic through the nearby Gulf Intracoastal Waterway play in causing increased erosion to occur.

Objectives: To determine the characteristics of wind waves and ship-induced flows and to assess their potential to cause erosion of the banks of the refuge.

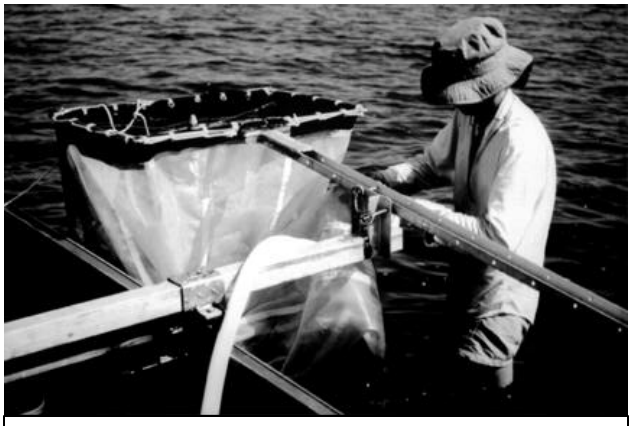
Methods: Two sites were studied near a shallow navigation channel at the mouth of the refuge: an area at the north end of the refuge between a boat launch and McMullen Lake, and a site on a narrow peninsula at Sundown Bay in the center of the refuge. Both sites had experienced erosion problems previously. A number of conditions including wave characteristics, wind speed and direction, and the speed that ships barges traveled through the Waterway were measured by field observations. Stakes were marked along the shore to chart specifically where erosion was occurring. Observations were recorded during seven visits to the refuge from September 1992 to August 1993 so that year-round conditions could be studied. Existing computer simulation models such as ACES were utilized to estimate wind speed and direction and waves generated by ship and barge traffic. The modeling results were compared to field data. Records on wind and ship travel were used to generate annual and seasonal predictions using regression analysis methods. Finally, data on wind and ship waves were combined to determine their contributions to bank erosion.

Results: Waves and storm surges generated by ships appear to be the dominant cause of bank erosion in confined portions of the refuge. For barges and tugs, the major forces are from surges due to blockage. Transverse flows are probably the most significant cause of erosion. They occur when heavily loaded barges make near-shore waters recede. On the other hand, shrimp boats, other work boats, and pleasure craft cause only negligible surges.

Reference: Zhang, J., F. Ting, D. Hershberger, H. Yu, and C.A. Spell, *Bank Erosion on the Gulf Intracoastal Waterway at the Aransas National Wildlife Refuge*, Texas A&M University Civil Engineering Department Report, 1993.

UT Marine Science Institute Study Focuses on Factors that Influence Survival of Young Redfish

What are the factors that cause many young redfish to die while a few survive and flourish? Better understanding those interactions is the focus of an ATP/ARP project awarded to G. Joan Holt and Scott Holt of the University of Texas Marine Science Institute at Port Aransas.



Part of this project will involve gathering fiel ddata on water levels, sea temperatures, and salinity near the Aransas Pass inlet.

For example, larval fish don't exercise much control about which direction they swim -- they're usually swept from one area to another by strong winds and tides. Biological factors such as the dates that many fish were born may also play a major role in which fish will ultimately survive.

In the study, the researchers hope to gather data on both physical and biological factors that affect the survival of juvenile redfish during the

spawning period that runs from August to October. Field studies will be concentrated on an area near the Aransas Pass inlet, which is a site that all eggs and larvae that flow into the estuary must migrate through.

Field data will be collected continuously on water levels, sea temperatures, and salinity. At the same time, estimates of spawning density will be made and will be combined with data on birthdate distribution and growth characteristics of individual fish that have survived. The end result will be a conceptual model of how hydrologic and weather-related events affect the mortality of young fish as they migrate from coastal areas into estuaries.

For details, call G. Joan Holt at (512) 749-6716 or Scott Holt at (512) 749-6715.

UT Study to Use High Tech Imaging, to Map Aquifers

Researchers at the University of Texas at Austin hope to take advantage of new "high tech" methods to trace the movement of water and contaminants in aquifers and other below-ground media.

The study is being led by Ekwere Peters of the Petroleum Engineering Department. The research consists of using x-ray computed tomography (similar to a CT or "cat scan" used in hospitals) and nuclear magnetic resonance imaging to measure the physical properties and flow paths associated with underground geologic formations. Experiments will be conducted in well characterized geologic cores. Images will be produced to obtain information on the distributions of fluid like groundwater, pollutants, and oil and gas reserves.

After tests have been performed using experimental data, field scale studies will be performed using sites with a variety of geologic formations. Graphics and maps that display the structure of the formations and flow paths will be produced. Peters believes that the process could lead to an improved understanding of subsurface geology and could help accurately identify the location of groundwater reserves, contaminants, and oil and gas formations.

For details, call Peters at (512) 471-1224.

UH Scientists Study Feasibility of System that Uses "Micelles," Ultrafiltration to Treat Water Pollutants

In many areas of Texas, there is a need to treat and remove toxic chemicals from contaminated groundwater, industrial wastewater, and oilfield brines. In particular, solutions are needed that are cost-effective and efficient.

An ATP/ARP project awarded to researchers at the University of Houston will investigate the feasibility of a continuous, easily scalable, and environmentally friendly separation process to treat these wastes.

Lead scientists in the study are Raj Rajagopalan and K.K. Mohanty of the UH Chemical Engineering Department. The goal of the study is to assess the performance of a micellar-enhanced (molecular) ultrafiltration system. The technology takes advantage of the thermodynamic properties of micelles on surfactants that are formed in water. The researchers believe the micelles encapsulate organic solutes within their core and that the head groups of micelles may absorb complex pollutants. Later, the polluted micelles can be disposed by ultrafiltration with the use of membranes.

In the study, biodegradable surfactants will be used. Information on the solubility of contaminants in micelles, partition coefficients, and membrane characteristics will be determined. Advanced analytical techniques such as x-ray scattering, dynamic light scattering, and semi-equilibrium analyses will be used to learn more about how micelles absorb and treat pollutants. The process will include bench-scale and flow-through experiments and simulation modeling.

Eventually, the researchers hope this system may be commercialized to economically treat contaminated waste streams. For details, call Rajagopalan at (713) 743-4316.

Better Understanding Salinity Levels, Patterns, in Galveston Bay is Focus of UT Investigation

Although understanding the processes that influence the salinity of bays and estuaries is vital to properly manage those resources, the science of p redicting salinity with computer simulation models is far from exact.

However, a new ATP/ARP project awarded to George Ward of the University of Texas at Austin Civil Engineeri ng Department hopes to use a recently developed database to better predict salinity patterns in Galveston Bay.

Ward says that one of the major problems that now limit most salinity studies is that not enough data is available. Ward hopes to overcome th is obstacle by taking advantage of a 40-year database that was recently assembled for the Galveston Bay National Estuary Program. The database includes nearly 100,000 measurements from Galveston Bay. He will use the data to examine how the shape of the ba y (hydrography) and the presence of the Houston Ship Channel and variables such as weather conditions, freshwater inflows, sea level rise, and tides affect the concentration and distribution of salinity in the Bay. Ward plans to perform both statistical a nd deterministic analyses utilizing time series and event response methods. The information should help scientists and water managers better understand and cope with water quality in the Bay. For details, call Ward at (512) 471-0114.

Texas A&M Scientists Work to Develop, Transfer, Risk Estimates of Dairy Pollution

A study by researchers at Texas A&M University will provide information to dairy operators, consultants, and water agencies, on how to better predict pollution risks from dairies.

Lead scientists on the project are Don Vietor of the Soil and Crop Sciences Department and Paul Thompson of the Biotechnology, Policy and Ethics Center. Cooperators in the study include Joe McFarland of the Texas Agricultural Experiment Station in Stephenville, and John Sweeten of the Agricultural Engineering Department. The Brazos River Authority, Science Applications International, Inc., and individual dairy operators will also support the project.

The goal of the study is to transfer a technology called probability risk assessment (PRA) to consultants and others that can help dairy managers estimate pollution risks. Previously, the researchers had developed computer-based PRA strategies that focus on individual events that could lead to lagoon overflows and dairy pollution. Natural events (like rainfall) and management decisions are organized into a "tree" diagram. Inputs into the system include information on daily rainfall frequency and distribution, runoff, lagoon levels, and other factors. Risk estimates are derived by multiplying the frequency of polluting events by the amount of waste generated per event.

This phase of the project consists of developing frequency and probability estimates for nutrient runoff and infiltration that can result from effluent irrigation, lagoon overflows and other natural and management events. Case studies will be conducted for dairies in Erath and Rusk counties. Classroom exercises, workshops and publications will be developed so that PRA can be demonstrated. It is hoped that as many as 25% of the dairies in Texas will utilize and benefit from the PRA framework.

For details, call Vietor at (409) 845-5753 or Thompson at (409) 845-5434.

Texas A&M, Texas Tech Study to Assess How Dietary Proteins Can Boost Redfish Growth

An ATP/ARP research project at Texas A&M University will examine how dietary proteins affect the growth of redfish in commercial aquaculture systems.

The principle investigator is Duncan MacKenzie of the Biology Department. Other scientists that will be involved are Delbert Gatlin of the Wildlife and Fisheries Sciences Department and Nathan Collie of the Texas Tech University Biology Department.

The goal of the study is to determine how proteins in fish diets impact the amount of thyroid hormones produced in juvenile redfish. The study will also examine how these thyroid hormones stimulate growth and influence how nutrients are absorbed.

In the project, the researchers will evaluate the impact of diets with different protein contents on increases in weight and length and organ growth; thyroid hormone production and intestinal growth; and the transport of amino acids and glucose across the intestine. The studies may help aquaculture managers more accurately define the levels of protein that are needed in redfish diets to achieve targeted levels of growth.

The project will be coordinated with efforts of a commercial red drum aquaculture plant and research facilities operated by the University of Texas Marine Science Institute.

For details, call MacKenzie at (409) 845-7701.

Texas A&M to Study if Change from Grasslands to Range Plants, Trees May Add to Global Climate Change

Many scientists and policy makers are concerned about global climate change and global warming. Typically, the causes of this climate change are attributed to man-made impacts such as increased carbon dioxide emissions from cars and industries.

Now, an ATP/ ARP project has been awarded to a Texas A&M University researcher to study global climate change from a distinctly different perspective.

The research will measure the amount of hydrocarbon gasses that are emitted by grasses and woody plants such as mesquite and oak at the LaCopita Research Station in South Texas.

Steve Archer, a researcher in the Rangeland Ecology and Management Department, is collaborating with scientists at the National Center for Atmospheric Research in Boulder, CO in the project. The goal is to investigate if woody shrubs and trees that have replaced grasses in much of Texas are contributing hydrocarbons to the atmosphere. The concern is that the hydrocarbon emissions may adversely influence global warming and ozone levels.

In many arid and semiarid regions of Texas, ecosystems that were traditionally dominated by grasses have been replaced by shrubs and woody plants. Often, the change has come after large numbers of cattle were allowed to graze on grasslands for some time. The researchers believe that the increased amount of shrubs and trees may significantly increase emissions of non-methane hydrocarbons or NMHCs (such as terpene, isoprene, and aromatics). These compounds affect ozone levels and the lifespan of greenhouse gases.

The research will be performed on the LaCopita Research Station in South Texas near Alice. The project will quantify the amount of NMHCs that are emitted by grasses and woody plants such as mesquite and oak under controlled and field conditions. Information will be gathered to determine how light conditions, water stress, temperature, and nutrient availability are influenced by NMHC gases. Data from these studies will be used in geographic information systems and ecosystem models to evaluate the potential impact of past, present, and future changes in land cover on the global climate.

For details, call Archer at (409) 845-0283.

Texas A&M Biologists Use Video to Study Marine Life

What are natural changes in the population of plants and animals on reefs over time and how can they be distinguished from man-made events like oil spills? The classical ways to study the number of seaweeds, barnacles, corals, and other reef dwellers have been tedious and may in fact damage the reefs. Texas A&M University biologists are showing that recording the organisms with a video camera is quicker and enables biologists to avoid tramping through delicate growths.

New software developed by Mary Wicksten and students in the Biology Department enables biologists to record images and spoken comments from video cameras. The software generates fixed numbers of random points that can automatically estimate the amount and type of vegetation, habitat, and aquatic life. These data can be used in sophisticated statistical analyses. The system has been tested on a jetty near Port Aransas, where it detected the zonation of organisms according to exposure to surf and wave action. An unexpected find was that an annual invasion of small crabs was feeding on small oysters and barnacles. The system performed well in a survey of the fauna attached to an offshore oil platform, and indicated that the fauna was comprised largely of a stinging sponge instead of corals and barnacles that were expected.

Wicksten hopes that the system can be combined with CD-ROM technology so that multimedia data sets can be developed. For details, call Wicksten at (409) 845-3388.

Texas Tech Develops Inexpensive Soil Moisture Sensors

Researchers at Texas Tech University are developing inexpensive monitors to measure soil moisture.

Purnendu Dasgupta of the Biochemistry Department has been the lead investigator in the project. The study consists of placing inexpensive sensors below ground in fields to measure humidity in the atmosphere so that soil moisture can be calculated.

Recently, Dasgupta has investigated the electronics needed for fast voltammetry. A sensor has been developed that consists of a blunt-ended hypodermic needle cathode. The cathode contains a concentric insulating tube and a wire anode. The technology utilizes a protective film made of a composite of cellulose acetate and nylon that allows water to flow, while restricting the transport of ions and low molecular weight chemicals. The sensor is placed in a sheath that protrudes beyond the sensor tip. The gap between the tip and the sheath is filled with talc and barium sulfate, which serves as a conduit between the soil and the sensor.

Field tests by Dasgupta and Huiliang Huang of Tech's Chemistry and Biochemistry Department, and Jesse Yeh of South Plains College in Levelland show that the sensor is capable of making reliable moisture measurements between the wilting point and the field capacity of the soil. The sensors appear to perform well after having been buried under the soil for many months. In the future, the researchers hope to connect the sensors

to a radio telemetry device so that data can be transmitted to remote locations. The information could make irrigation more efficient by telling irrigators the exact amount of water they need.

Dasgupta said a package of four sensors and the electronics needed to run the system should sell for about $100. Replacement sensors should sell for $5 to $10, depending on the number that are manu

UTD Uses Radar to Map Aquifers

Researchers at the University of Texas at Dallas are adapting the use of ground-penetrating radar (GPR) to map aquifer formations. GPR waves are used to define the geometry of groundwater formations and streambeds. This study focused on developing an algorithm to numerically model GPR data for use in 2-dimensional groundwater models. George McMechan and Jun Cai of UTD's Center for Lithospheric Studies collected nine GPR profiles from an Austin Chalk formation in Dallas County. The site provided a good test because it has many changes in elevation, is fractured and layered, and is overlain with stream sediments. A ray based algorithm was used to synthesize the GPR profiles. The model performed well, but had difficulty accounting for structures that were off the survey line. Wave effects were not included. The algorithm can be used in 3-dimensional models and may be useful for characterizing fractured carbonate aquifers. For details, call McMechan at (214) 690-2419.

Texas A&M Researcher Surveys Boaters, Rafters, Fishermen in Big Bend National Park

A Texas A&M University researcher has been surveying recreational water users in the scenic Big Bend National Park to find out more about how they view the quality of the Rio Grande within the park.

Bill Stewart (left) of Texas A&M University surveyed people who use the waters of the Big Bend National Park for recreation. At the same time, researcher Ron Kaiser (right) gathered information on water quality needs.

Bill Stewart of the Recreation, Parks and Tourism Sciences Department, has been working on the survey with K.A. Yarborough and J.R. Skiles of the National Park Service's Big Bend office.

The studies have included a trend survey of 16,500 permits that documented river use from 1983 to 1993; a survey of boaters who obtained private river use permits; a survey of visitors who obtained overnight permits to camp at designated sites near the river; and a survey of patrons of commercial outfitters. The information will be used

to help park managers develop a river use management plan.

Results of the trend survey reveal that 1985 was the peak year for park use. One of the most interesting aspects of the study is that most users of the park travel one canyon segment at a time. As a result, there are many different types of recreational use and specific water needs that tourists want in various segments of the park. For example, people that float the Boquillas segment of the river were most likely to report that a feeling of solitude was extremely important. Fishing was essential to tourists in the Rio Vista and San Vincente reaches of the Rio Grande. Nuisances caused by livestock (manure and excess grazing) were noted as a problem by visitors to the Boquillas section.

The report recommends that an advanced reservation system for river use permits be considered; that Park staffers be more informed about field conditions and sites along the Rio Grande, and that cooperation with Mexican authorities be increased so that the river can be better managed.

Stewart produced a report about the project. For details, call him at (409) 845-5330.

HARC Study Uses Satellite Data to Map Flood-Prone Areas

Researchers with the Houston Advanced Research Center recently conducted a pilot study to determine if it is feasible to use satellite images and data to monitor development in flood-prone areas.

The research was carried out by John Hill, the Director of HARC's Environmental Information Systems Laboratory. The study was funded by the Federal Emergency Management Agency.

The project consisted of utilizing satellite images of northwest Harris County that were taken from 1987 to 1992. Data from these images were used to document the location of new commercial and residential development in flood hazard zones. The information was then entered into a geographic information system (GIS).

Hill says this procedure requires less labor and is more accurate than previous methods, which typically consisted of driving through and visually inspecting floodplains. The GIS could be especially valuable in rapidly analyzing the effects of flooding. He is now determining if the GIS can be expanded to include information on pollution sources, property ownership, historic weather conditions, and flood frequency.

For more information, call Hill at (713) 363-7999.

UT Medical School Study Suggests that Cryptosporidium may be Hard to Control

A new study by a researcher at the University of Texas Medical School at Houston suggests that new treatment methods may have to be used to control the *Cryptosporidium* parasite.

Herbert DuPont reported the results of a study he performed for the U.S. Environmental Protection Agency at a meeting of the Association of American Physicians earlier this year.

DuPont's research shows that about half the people that are infected by the parasite become ill. Fifteen of the volunteers that were exposed to the parasite were infected within 11 days. The study also suggests that *Cryptosporidium* may be difficult and costly to control. For example, chlorine will not kill the parasite. Only heat and filtration are effective against it.

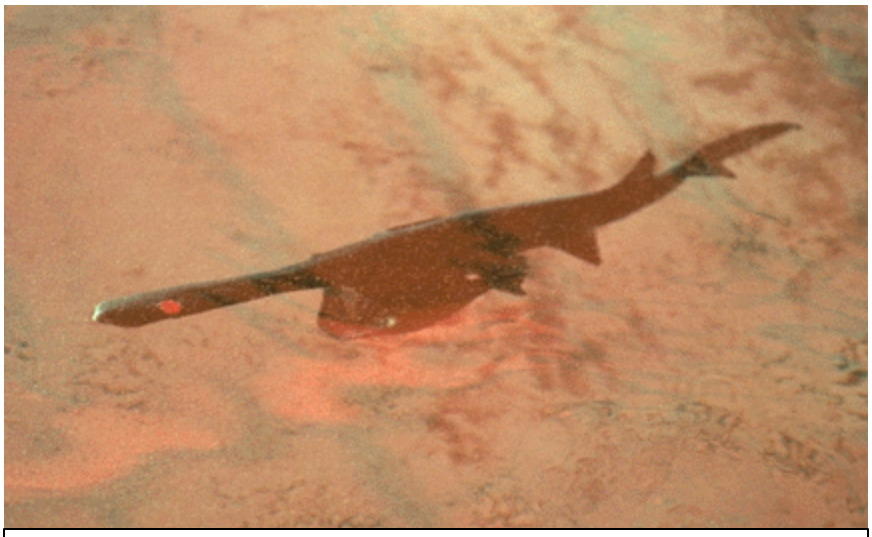
Cryptosporidium became a household word last year when it caused diarrhea and flu-like symptoms in more than 400,000 Milwaukee residents. Major outbreaks have also been reported in San Antonio and other cities. The parasite occurs when animal or human sewage flows into a water supply.

DuPont says that urgent needs are to determine how much cryptosporidium occurs in different water systems, and to identify the role that contaminated water plays in causing the disease to become widespread.

Helping Restore Paddlefish is Goal of Sam Houston State University, TPWD Efforts

Biologists at Sam Houston State University are working with the Texas Parks and Wildlife Department (TPWD) to restore paddlefish to the Trinity River near Huntsville.

Andrew Dewees of Sam Houston State University (SHSU) Biology Department is coordinating the effort, which consists of a year-long study of water quality and food communities in the Upper Trinity River. Sam Houston students Alex Moldenhauer and Bobby Brown have gathered samples of phytoplankton and water quality parameters such as pH, dissolved oxygen, conductivity, and flow rates. This information will be combined with data from other East Texas rivers and will eventually be used to determine if conditions are appropriate for paddlefish to be reintroduced.



Biologists at Sam Houston State University are working with the Texas Parks and Wildlife Department to restore paddlefish to the Trinity River.

Preliminary data analysis suggest that water quality and plankton in the river are adequate to support paddlefish. SHSU scientists and students are working with Veronica Pittman of TPWD, who is coordinating the Paddlefish Recovery Plan. Currently, paddlefish are an endangered species but there is hope they can be restored to Texas waters.

For details, call Dewees at (409) 294-1540.

Comprehensive Plan Proposed to Protect Galveston Bay Habitat, Water Quality

The Galveston Bay National Estuary Program (GBNEP) has proposed a sweeping plan to restore the Bay by protecting wetlands, improving water and sediment quality, and balancing human and animal use of the resource.

Wetlands are a key part of the proposal. The plan notes that 30,000 acres of wetlands have been lost since the 1950s and recommends that 15,000 acres of wetlands be restored or created. The plan also proposes that by-catch (the unintentional capture of fish by commercial shrimpers) be reduced; that "exotic" aquatic species that could enter the Bay be controlled; and that water conservation be encouraged to increase the amount of fresh water flowing into the Bay.

Before the plan can be implemented, it has to be approved by Governor Ann Richards and the U.S. Environmental Protection Agency. The plan recommends that a Galveston Bay Office of the Texas Natural Resource Conservation Commission be created. That office could then seek additional funding to carry out the plan's mandates.

A draft plan, *The Galveston Bay: A Comprehensive Conservation and Management Plan,* that contains preliminary management recommendations is now being circulated for public comment. If you would like to receive a summary of the plan or the full document, please call the GBNEP at (713) 332-9937.

TAEX Soil Test Kits Help Consumers Apply Correct Amount of Fertilizer

The Texas Agricultural Extension Service is promoting the use of soil test kits to help homeowners optimize the amount of fertilizer they apply to their lawns.

Bill Knoop of the Texas Agricultural Extension Service recommends that homeowners should not apply fertilizer to their lawns until they know the amount of nutrients their landscapes need. Applying the proper amount of fertilizer can lessen the risk of nutrient runoff from landscapes after heavy rains.

To help consumers know how much fertilizer to apply, TAEX has developed a soil test kit. The free kit includes simple and easy to follow directions, a plastic bag for the soil sample, an information card, and a prepaid mailer. A fee of $13 covers the cost of the soil analysis, preparation of a nutrient summary, and postage.

Consumers will receive individually prepared reports that describe the nutrients that are present in the soil and which blend of fertilizer, if any, needs to be applied.

The test kits are available at many TAEX offices and at retail nurseries and garden stores. If you need more information, contact your local Extension office or Knoop at (214) 231-5362.

General Land Office Plan Would Increase Protection for Texas Coast

A coordinated plan to manage Texas' 367-mile coast has been proposed by the General Land Office.

Under the terms of a 480-page draft plan that is now being circulated, a seven-member council would have the authority to keep destructive and polluting activities in check. The council would be comprised of the directors of Texas' five major environmental agencies, a coastal official, and a resident from the region.

The overall goal of the plan is to bring together the various state agencies that have authority over the coast and to make sure that they work together when permits for water rights, wastewater, development and industries are considered. If approved by the Legislature, the Plan would also make Texas eligible for $2.4 million annually in federal assistance to protect beaches and sand dunes from erosion.

The GLO says the plan is needed because more than 60% of the coast is being disturbed by man's activities; because of the presence of 10 deep draft ports and coastal barge facilities, and because more than 33% of Texas residents live within 100 miles of the coast.

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New TWRI Reports Deal with Edwards Aquifer Management Model, Reservoir Modeling

A Lumped Parameter Model for the Edwards Aquifer (TR 163) was written by Nisai Wanakule and Robert Anaya of the Edwards Aquifer Research and Data Center at Southwest Texas State University (see abstracts section of this newsletter for details).

Reservoir and River System Reliability Considering Water Rights and Water Quality (TR 165) was written by Ralph Wurbs, Gerardo Sanchez-Torres, and David Dunn of the Texas A&M University Civil Engineering Department. The report focuses on the use of a simulation model -- the Texas A&M University Water Rights Analysis Program or TAMUWRAP -- to assess reservoir management strategies in the Brazos River Basin. The report includes an overview of the Texas water law system, outlines the type of simulation input data that is needed to run the model, and evaluates water management strategies that may be effective in the watershed. Simulation results are presented from a case study that was performed on the basin.

Other reports that have been published recently by TWRI include *Farmers, Lenders and Water Districts Response to Texas' Low Interest Loan Program for Water Conservation in Agriculture (TR 164)* by Ron Lacewell of Texas A&M University; Effectiveness of Native Species Buffer Zones for Nonstructural Treatment of Urban Runoff *(TR 156)* by Roger Glick and Tom Thurow of Texas A&M University; and *Water and Solute Flow in a Highly Structured Soil* by Kevin McInnes of Texas A&M University *(TR 161).*

TWRI has also begun producing another newsletter series titled *Texas Water Savers*. This newsletter series will focus on urban, industrial, and residential conservation. The first issue was printed and mailed in May. To receive a free copy of the first issue of *Texas Water Savers* or a free subscription to any of TWRI's newsletters or for information on any other TWRI publication, call the Institute at (409) 845-1851.

TWDB Studies Examine Water Quality, Quantity in Ogallala Aquifer

New studies dealing with the quality and quantify of water of the Ogallala Aquifer have recently been published by the Texas Water Development Board (TWDB).

Water Quality Evaluation of the Ogallala Aquifer (Report 342) was written by TWDB geologist Janie Hopkins. The report presents results of a program that sampled 700 wells in the region from 1989 to 1992. Generally, the results suggest that the average levels of dissolved solids, chloride, and fluoride are all much higher in wells in the southern portion of the aquifer. Nitrate was found in 15% of the wells that were surveyed in the southern part of the study area, and selenium was found in the region.

The High Plains Aquifer System of Texas: 1980 to 1990 Overview and Projections (Report 341) was written by TWDB geologists Darrell Peckham and John Ashworth. According to the report, the amount of groundwater pumped for irrigation dropped by 17% and irrigated acreage in the region declined by 1.4 million acres between 1979 and 1989. An updated aquifer simulation model was applied to predict future conditions and indicated that slightly more water will be available, although the amount of groundwater pumped will still likely exceed recharge.

To order either report, call the TWDB at (512) 463-8337.

Texas A&M Press Book Highlights Freese and Nichols

Freese and Nichols engineers inspect a water system in Breckenridge, TX in 1921.

The history of one of Texas' oldest civil engineering firms and the water projects they developed is the focus of a new book from the Texas A&M University Press. The book, *A Century in the Works: Freese and Nichols Consulting Engineers*, was written by Simon Freese and Deborah Sizemore. The book describes Freese and Nichols' efforts to build Fort Worth's first sanitary sewer in 1922, and their work in designing and constructing flood control and water supply reservoirs, advanced wastewater treatment plants, drinking water systems, and other environmental works. The book provides insights into public attitudes that helped create the Texas water plan, and struggles to bring surface water to West Texas. To order, call the Texas A&M University Press at 1 (800) 826-8911.

New Reports Summarize USGS Activity in Texas, Assess Groundwater Withdrawals

A number of new publications are available from the U.S. Geological Survey (USGS).

Many recent USGS reports were produced that focus specifically on Texas. These include *Summary of Water-Resources of the USGS in Texas* (FY 1989-92); *Groundwater Withdrawals, Water Levels, and Groundwater Quality in the Houston District* (1985-89); *Reconnaissance Investigation of the Geology and Hydrogeology of Lackland Air Force Base*; *Hydrogeology, Geochemistry, and Quality of Water of the Basin and Oak Spring Areas of the Chisos Mountains, Big Bend National Park*; and *Configuration of the Base of the Edwards-Trinity Aquifer System and Hydrogeology of the Underlying Pre-Cretaceous Rocks (West Central Texas)*.

The USGS also recently produced its updated version of *Estimated Water Use in the U.S.* (1990). The report includes detailed state-by-state information on total water use, surface and ground water use, and use for specific categories. According to the study, groundwater pumping was 7,880 billion gallons per day (BGD), while freshwater withdrawals total 17,300 BGD.

Information on ordering any of these reports can be obtained by calling the USGS Austin office at (512) 873-3020.

UTPA Researcher Assesses Geothermal, Geopressured Groundwater in Lower Rio Grande

A researcher at the University of Texas-Pan American has helped publish a study that identifies geopressured, geothermal, and saline groundwater resources in South Texas. Robert Rodgers of the UTPA Geology Department was a co-investigator in the study, which was funded by the Texas Water Development Board. The lead engineering firm in the project was Kleber Denny Inc. of San Antonio.

The overall goal was to determine if geothermal and geopressured brackish and saline groundwater supplies can be treated for use in irrigation or as drinking water. Previous studies had shown that these resources exist, but had not quantified how much water was available. Rodgers' role in the study consisted of assessing and quantifying the supplies of geothermal and geopressured groundwater in the region. He found that ample quantities of deep geopressured and geothermal groundwater appear to be available, and that they may contain enough thermal energy to power desalting units. Automatically desalting fluids in the geopressured and geothermal units does not appear to be practical now.

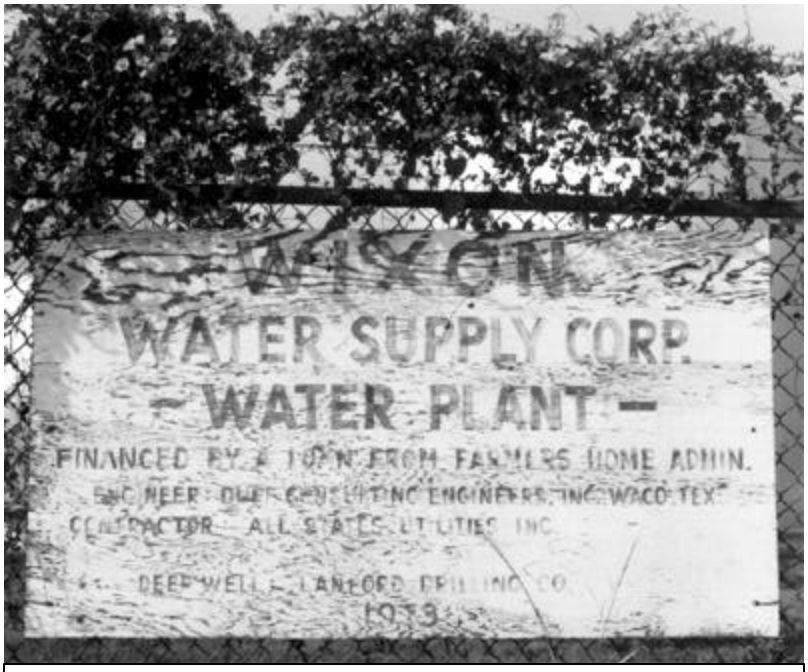
The study also assessed the feasibility of using reverse osmosis, electrodialysis and distillation to treat brackish and saline water in Hidalgo and Cameron counties. It recommended that test drilling be performed to determine the quality, depth, and availability of brackish groundwater in the region and suggests that economic analyses be

performed to identify which desalting methods are most feasible. As a result of the study, a utility in the area is investigating if desalting brackish groundwater is practical.

For details, call Rodgers at UTPA at (210)381-3523.

ETSU Study Asks if Rural Water Systems Are Communities

Many rural Texans rely on water supply corporations for drinking water. An East Texas State University study asks, "Do rural residents think of their water suppliers as just a utility or do these systems provide a sense of community?"



The Wixon Water Supply Corporation north of Bryan-College Station is typical of many rural water suppliers. Studies at East Texas State University have investigated how these systems build a sense of "community" in rural areas.

The project was an M.S. Thesis by William Cook of the Sociology Department. Cook did his research under the direction of R.N. Singh, who heads ETSU's Center for Rural Texas Water Studies. Cook reanalyzed data from 98 interviews that Singh conducted to study customers' perceptions of the performance of rural water systems. Singh's studies were sponsored by TWRI. Key variables that affected whether customers felt that their systems represented a community were identified. Variables included customer knowledge, the number of years they had been served, monthly water bills, and the cost of water. Other factors included whether individuals attended annual meetings, held leadership positions in the systems, and experienced management or water quality problems. Socioeconomic factors such as race, income, gender and age were also studied.

Results suggest that customers who believed that rural water systems led to a sense of community were knowledgeable about their systems, had been served by a system more than 11 years, attended annual meetings, and held leadership positions. Those with water bills of more than $101 monthly and those who believed water bills were too high also believed rural water companies provided a sense of community. Cook's thesis was published in 1992. For details, call Singh at (903) 886-5324.

Rio Grande Water Quality Study Being Conducted by Texas A&M International University

Researchers at Texas A&M International University in Laredo are heading a team effort to learn more about the water quality in the Rio Grande.

Thomas Vaughan of the Biology Department is leading the study, in cooperation with James Earhart of Laredo Community College and Adrian Montemayor of the City of Laredo.

The project began last September. The researchers are conducting monthly rapid bioassessments using macroinvertebrates such as mayflies, stoneflies, caddisflies, dragonflies, and damselflies. Samples are being taken at four sites representing upstream areas that are relatively unaffected by pollution, downtown sites, an area next to the construction site for Nuevo Laredo's wastewater treatment plant, and a site 18 miles downstream near the Webb-Zapata County line. Traditional water quality testing for fecal coliform bacteria and other parameters is also being conducted. One of the goals of the study is to develop a database about the current quality of the river, before Nuevo Laredo's new wastewater plant comes on line next year.

Surprisingly, the researchers say their results suggest that the highest levels of fecal coliform bacteria are being detected at the downstream site. Nuevo Laredo now discharges all of its raw sewage into the Rio Grande. Half the raw sewage (12.5 millions of gallons per day) flows to a point just upstream from the site where a new wastewater plant is being built. The raw sewage seems to follow the Mexican side of the Rio Grande until it flows a sizeable distance downstream, where the fecal coliform levels increase.

Vaughan says that organisms such as some mayflies cannot tolerate pollution, while others like gnats and midges can live in poorer quality waters. The study team will continue to test the population of these species to determine if water quality has improved after the treatment plant begins operating.

For details, call Vaughan at (210) 722-8001, ext. 474.

TAES, USDA, Baylor Researchers Team Up to Study Baseflows from Groundwater Systems

The amount and timing of baseflows are an important yet largely misunderstood measure of the amount of water that flows from local groundwater systems to nearby streams. Baseflows begin after significant amounts of rain fall and continue until the next major storm.

To better define baseflows in Texas aquifers, researchers with the Texas Agricultural Experiment Station (TAES) at Temple are now working with scientists with the U.S. Department of Agriculture Research Service (USDA/ARS) and Baylor University (BU). Lead researchers in the project include Ranjan Muttiah and R. Srinivisan of TAES-Temple, Jeff Arnold of USDA/ARS and Peter Allen of the BU Geology Department.

The project involves detailed data analyses. First, baseflows had to be separated from total streamflows. Later, baseflow recession curves were developed so that drainage rates from local, shallow, aquifers into streams could be estimated. Baseflow days define the time period in which baseflow occurs. Muttiah says learning more about baseflows is valuable. For example, baseflows can account for half the total streamflow in many Texas streams. Information about baseflows can be used to better understand the amount of water expected during a drought, aquifer recharge characteristics, and the role of aquifers in providing recharge. Baseflows actively circulate groundwater, respond rapidly to changes in recharge and discharge, have short travel times, and are sensitive to non-point source pollution.

A major product of the research is a revised map of baseflow days that was generated by a Geographic Information System. The map displays precisely areas with specific baseflows. It shows that north, northwest and southeast regions of Texas typically have fewer baseflow days than the rest of the State.

For details, call Muttiah at (817) 770-6670 or Allen at (817) 755-2361.