New Waves
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## *TWRI Report Assesses High Salinity Levels in Rio Grande*

Increasing salinity levels in the Texas portion of the Rio Grande above Amistad Dam may threaten the amount of water that can be used for drinking or crop irrigation, according to a new study from the Texas Water Resources Institute (TWRI).

The report, *Flow, Salts, and Trace Elements in the Rio Grande: A Review*, was co-authored by TAES scientists Seiichi Miyamoto and Lloyd Fenn of the Texas A&M University Agricultural Research and Extension Center at El Paso, and Dariusz Swietlik of the Texas A&M University-Kingsville Citrus Research Center at Weslaco. The report was developed by synthesizing and interpreting existing information.

Miyamoto says that salinity is the major factor that limits how water can be used in the region. The highest salinity levels in the Rio Grande occur from Fort Quitman to Presidio (2,000 to 5,000 milligrams per liter or mg/l) and where the Pecos River enters the Rio Grande (2,000 to 4,000 mg/l).

Salinity levels above Amistad Dam have increased since the 1950s. In places, they are greater than U.S. Environmental Protection Agency (EPA) limits for drinking water and guidelines for water quality needed to irrigate high value crops. Salinity problems in Amistad Reservoir are getting worse.

"The continuing increase in salinity levels in Amistad Reservoir is of concern," Miyamoto said, "because it may limit how water can be used in this arid region. The standard way of lowering high salinity levels is by providing increased freshwater flows but that's not viable here because

*Seiichi Miyamoto (kneeling) and Lloyd Fenn observe water quality in the Rio Grande.*

water supplies and surface water runoff are limited." Alternative solutions to reduce salinity levels include minimizing flows of saline water by developing brine diversion dams, or reusing saline water to irrigate salt-tolerant grasses and crops.

Miyamoto says that worsened water quality could have negative implications for high value agricultural production in the Middle and Lower Rio Grande. Many crops grown in the region including chile and green peppers, onions, pecans, citrus, and peaches can thrive when salinity levels are moderate, but production could decrease if too much salinity occurs. The report includes information on the flow of the Rio Grande and its tributaries, levels of salts and trace elements, and compares existing contaminant levels in the river to water quality standards.

The report recommends that studies are needed on how to manage irrigation return flows, control salinity and limit salt loads, manage sodium inputs, and trace element monitoring. The report (TR-169) is available free from TWRI by calling (409) 845-1851. Miyamoto's phone number is (915) 859-9111. Swietlik can be called at (210) 968-2132.

## *TWRI Funds 3 Projects; Prepares Changes*

Congress is now contemplating major changes in the way it funds the National Institutes for Water Research (NIWR) that may affect the Texas Water Resources Institute. TWRI Director Wayne Jordan says the Institute is taking steps to adjust to these changes, reposition itself, and find ways these new policies could benefit Texas.

During the past five years, Congress has cut the amount of federal funds each institute receives annually from $110,000 to current levels of roughly $78,000. These funds support water research and technology transfer programs at universities throughout Texas and the U.S. Now, Congress is proposing to further reduce the amount of federal money that is allocated to only $28,000 annually beginning in September 1996. While this sounds negative, it would create a $2.7 million pool that would support a nationally competitive grant program. Research projects chosen under this national competition would be administered by the water research institute in each state.

Jordan believes that the changes Congress is considering may actually provide a short-term benefit to Texas water researchers. "We know that there are many outstanding scientists working with water issues at Texas universities. Because of the number of universities and scientists that perform water research and the quality of their work, this could increase the number of projects awarded to Texas." Jordan cautioned that the long-term effect may be that some institutes that are not well supported by their states could be closed and this could erode Congressional support for the program.

The cuts in federal support from $110,00 to $78,000 have limited the number of projects TWRI can support, Jordan said. As a result, TWRI is now able to support only three on-going projects:

Ann Kenimer of the Texas A&M University Agricultural Engineering Department and Joe McFarland of the Texas A&M University Agricultural Research and Extension

Center at Stephenville are evaluating the use of wetlands to improve water quality in agricultural operations. This project involves developing a constructed wetland research site near Stephenville and evaluating the performance of this system to treat agricultural nonpoint source pollutants. Data from this project will be used to develop quantifiable, numeric criteria that are needed to determine if wetlands are a viable best management strategy to treat specific agricultural water quality problems.

David Maidment of the Civil Engineering Department at the University of Texas at Austin is creating a spatial water balance for Texas. Maidment is partitioning precipitation data into evaporation, runoff, and groundwater recharge over a grid of Texas. The project will develop digital maps of Texas on a 6-mile grid that will include elements of the hydrologic cycle and factors that influence the water balance. An annual and monthly spatial water balance will be created for the Lavaca-Navidad watershed in South Texas as a case study.

TWRI will continue to support its technology transfer program, which is headed by Ric Jensen. This involves producing newsletters, developing of TWRI's World Wide Web site, and working with public school teachers to provide them with research information.

## *TWRI Study Proposes New Method to Predict Nitrogen Mineralization in Soils; May Improve Fertilizer Use Recommendations*

The Texas Water Resources Institute (TWRI) has just published a technical report that describes new methods to predict nitrogen mineralization in soils. The study, *Soil Nitrogen Mineralization Potential for Improved Fertilizer Recommendations and Decreased Nitrate Contamination of Groundwater* (TR-171), was co-authored by researcher Frank Hons of the Texas A&M University Soil and Crop Sciences Department and graduate students Richard Haney and Alan Franzluebbers.

The report focuses on ways to measure nitrogen mineralization, which is the natural release of nitrogen from decaying soil organic matter. Nitrogen mineralization occurs continually throughout the year, but the amount of nitrogen that is released can vary based on soil types, climate, and agricultural management techniques employed by farmers. There are concerns that groundwater quality can be lessened if too much nitrogen is available in soils and is converted to nitrate.

"Nitrogen is one of the tools farmers use most often to improve crop yields, but it can also pose threats to water quality," Hons says, "so it's important to be able to specify how much nitrogen needs to be applied in forms growing crops really need. If you can accurately estimate nitrogen mineralization, there's a much better likelihood that excess applications of nitrogen can be avoided and environmental threats can be minimized.

The report describes how the researchers evaluated different existing methods and developed new and improved techniques to measure nitrogen mineralization. This included gathering surface and subsurface soil samples from College Station, Corpus Christi, Overton, and Stephenville that were used for agricultural activities. They then used a variety of techniques to measure nitrogen mineralization, including short- and

long-term aerobic laboratory incubations, arginine ammonification, and carbon mineralization. Results of the report suggest that measuring carbon dioxide emissions from soils that have been air-dried and later rewetted is a rapid, reliable way to measure potential nitrogen mineralization. Measuring carbon dioxide evolution was correlated to mineralization and was directly related to microbial activity in soils.

Hons says this research could have a number of practical benefits to agricultural producers. "Widespread use of this method could provide more accurate and more rapid estimates of nitrogen and carbon mineralization in different soils. By using this information, agricultural producers can apply precisely enough nitrogen fertilizer to maximize yields, while decreasing water pollution risks."

TWRI is a unit of the Texas Agricultural Experiment Station and is located on the main Texas A&M University campus in College Station. The report is available free by contacting TWRI at (409) 845-8151 or TWRI@tamu.edu. Hons can be contacted at (409) 845-4620.

## *Recreational, Aesthetic Values Play Key Roles in Influencing Property Values, According to New TWRI Report*

If you talk with most real estate agents, they'll often tell you that three factors are critically important to consider when selling or buying a home -- location, location and location.

According to a new technical report by the Texas Water Resources Institute (TWRI), location and the recreational and aesthetic benefits that come with it may be especially important in transactions influencing property values near Texas lakes.

The report, "Effects of Lower Colorado River Authority (LCRA) Lakes on Riparian Property Values," was written by Lonnie Jones of the Texas A&M University Agricultural Economics Department and Notie Lansford of the Agricultural Economics Department at Oklahoma State University.

The research focused on the recreational and aesthetic value of properties surrounding Lake Austin and Lake Travis in Central Texas, which are located on the Colorado River. Water levels in each lake are affected by LCRA management strategies. For example, the average monthly water level in Lake Travis has varied by 50 feet since 1976, in part because LCRA must move waters out of the lakes to supply downstream customers.

In the project, the researchers sought to identify how such factors as distance from the lake, lake levels, access to lake recreation, scenic views of the lake, and physical characteristics of houses and lot sizes influence property values. First, they assembled data on 609 sales of lakeside property from Lake Austin and 593 sales from Lake Travis from 1988 through 1990. Data were originally collected by the Travis County Appraisal District. They then analyzed this data to assemble information on such recreational and aesthetic values as the distance between properties and the lakes, bluffs, scenic views of the lakes and nearby hills, and the lake level at the time properties were sold.

Jones says the research confirms that lakefront location is a key variable that influences property values. "This research shows that properties closest to these lakes provided great opportunities for recreation," Jones said. "Homeowners were willing to pay premiums of $60,000 to $100,000 to purchase sites with these features." However, Jones noted that while recreational features strongly influenced properties within 1,000 feet of a lake, those benefits were much less apparent for properties sited 2,000 feet from a shoreline.

Surprisingly, Jones said the research suggests that the water level in the lakes at the time houses were bought or sold also strongly influenced property values. "Our research suggests that most lakeside residences sell for $3,000 to $8,000 more if the water level in the lake is near its long-term average. Sale prices often decreased when lake levels were six feet or more lower than normal, in part because recreational values were less apparent."

The research also shows that the total value of lakeside recreational benefits is more than $65 million for Lake Austin and more than $49 million for Lake Travis.

Jones says that his research suggests that policy makers may want to examine how water is allocated in the region. For example, under Texas water law municipalities, irrigators, and others have clearly defined water rights. However, water rights have not been established for recreational water use. As a result, levels in these and other lakes fluctuates widely as downstream users demand that water be released for their needs.

"In the future, as competition for water from the Colorado River increases, individuals or government agencies may want to purchase water rights from agriculture and other users to keep water in these lakes and stabilize lake levels," Jones says. "Increased property values associated with normal lake levels could help offset the costs of purchasing those water rights."

The report, TR-170, is available free by calling TWRI at (409) 845-1851. Jones can be contacted at (409) 845-2336.

## *Hydrology, Salinity, and Water Quality in the Rio Grande*

**Authors:** Seiichi Miyamoto and Lloyd Fenn, Texas A&M University Agricultural and Research Center at El Paso, and Dariusz Swietlik, Texas A&M University-Kingsville Citrus Center, Weslaco, TX.

**Problem:** There are concerns that water quality in the Rio Grande may be deteriorating due to increased populations moving into the region, buildup of industries, and agricultural production. A review of existing literature and databases is needed to assess if degradation of the Rio Grande is occurring.

**Objectives:** 1) To review existing published and unpublished reports from federal, state, and regional agencies about flows, salinity levels, and trace elements in the Rio Grande, and 2) t o determine the possible sources of these contaminants.

**Methodology:** Much of the data in this study was obtained from the International Boundary and Water Commission (IBWC). Most of the data were collected from 1969 to 1989. This included annual flows of the Rio Grande and its tributaries at gauging stations from Elephant Butte Reservoir, NM, to Brownsville; annual recorded and estimated surface inflows from Texas and Mexico; recorded and estimated diversions for agricultural irrigation, municip al and industrial use, and irrigated acreage. Water quality information was obtained from IBWC, including 1989 data on salinity, sodicity, chlorides, and sulfate levels. Linear regressions were used to develop annual mean salinity levels, relationships be tween salinity and flows, and salt load balances at key gauging stations since 1969. Data on levels of boron, barium, molybdenum, selenium, arsenic, cadmium, curium, copper, lead, mercury, nickel, arsenic and zinc were obtained from a 1982 U.S. Geological Survey (USGS) study. Data on trace element levels in free water and pore water, levels of dissolved minerals and heavy metals in filtered water and digested whole water, and retention of trace elements in sediments of the Rio Grande river bed were suppli ed by the USGS, the Texas Water Commission, and the Texas Water Development Board. Water quality in the river was compared to regulatory standards and guidelines for irrigation of specific crops, and drinking water for humans and livestock.

**Results:** Total inflow into the Texas-Mexico portion of the Rio Grande has averaged 3.65 million acre-feet (MAF) annually since 1969. Roughly 60% of the inflow originates in Mexico. The largest flows (2.43 MAF) occur below Falcon Dam. The highest salinity of t he Rio Grande (2,000 to 5,000 milligrams per liter or mg/l) occurs from Fort Quitman to Presidio, and where the Pecos River joins the Rio Grande (2,000 to 4,000 mg/l). Salinity levels below Presidio decrease to only 860 mg/l below the confluence of the Ri o Grande and Rio Conchos because of increased flows. Salinity in this stretch of the river is increasing at an annual rate of 15 to 18 mg/l. If these trends continue through the year 2004, salinities will be double 1969 levels. Annual salt load of the Rio Grande is estimated at 1.84 million tons between Fort Quitman and Amistad Dam, and g 1.17 million tons from Amistad and Falcon Dam. Saline tailwater from the Rio Grande project and the Pecos River contributes half the salt load above Amistad Dam, but pro vides only 21% of the flow. Trace element levels are lower than human and livestock drinking water standards. Levels of trace elements in Rio Grande sediments are below average leve ls in most western states, except for mercury and lead. Salinity is the ma jor factor that may limit the full use of Rio Grande waters above Amistad Dam. Increasing salinity levels may limit the use of waters for irrigation of such high value crops as chile and green peppers, oranges, grapefruit, and pecans.

**Reference:** Miyamoto, S., L. Fenn, and D. Swietlik, *Flow, Salts, and Trace Elements in the Rio Grande: A Review* (TR-169), TWRI, Texas A&M University, College Station, TX.

## *Developing a Geographic Information System for the Rio Grande Coastal Plain*

**Authors:** Jerry Wermund and Thomas Tremblay, Bureau of Economic Geology (BEG), University of Texas (UT) at Austin ; Gene Paull, Geography and Geology Department, UT-Brownsville, and Eric Rieken, Physics and Geology Department, UT-Pan American.

**Problem:** Improved management tools to deal with water scarcity, water quality and other issues are needed along the Texas-Mexico border. Geographic information systems (GIS) have been identified as a technology that may be useful in managing waters along the Rio Grande delta plain (RGDP) and other border areas. Major advantages of GIS technologies are that they allow data to be analyzed spatially, and they are useful in analyzing relationships between different natural resource issues.

**Objectives:** To develop a GIS for the RGDP that includes information on such natural resource issues as land use and land cover, climate, geology, soils, surface hydrology, and groundwater flows, as well as information on transportation, population, water districts, and other political subdivisions.

**Methodology:** For this study, the RGDP is defined as a 5,087-square mile watershed that extends along the river. The boundaries of the area are: 1) As far north as the "Big Ditch" (the northern-most canal that drains floods from the Rio Grande; 2) South to Canal Rode and Canal Anzalacias; 3) As far West as the junction of the Rio San Juan and Rio Grande near Rio Grande City and Camargo, and 4) East to Mullet Island near Port Mansfield. A spatial database at a scale of 1: 100,000 is being constructed. Information was obtained from many federal agencies in the U.S. and Mexico. High altitude aerial photographs, satellite images, and digitized maps were utilized to develop information on land use and land cover data. A UT BEG report, *Environmental Geologic Atlas of the Texas Coastal Zone*, provided geologic data. Soils information was obtained from the Texas Agricultural Experiment Station's Blackland Research Center. U.S. Geological Survey quadrangle digital line graphs and topographic maps developed by Mexican federal agencies were the source for hydrologic information. The researchers hope to add a groundwater layer to the GIS that would include such information as potentiometric surfaces.

**Results:** The RGDP GIS is a compilation of specific data sets for this region. Existing data were processed into seamless data sets that span the watershed. Hard copy Mexican maps were converted into GIS files for hydrographic and transportation layers. Results suggest this may be useful to analyze water deliveries and potential shortages in Mexico, where large populations exist and high water demands are likely. The U.S. portion of the GIS was easier to develop than the Mexico portion, because more data was available.

**Reference:** Wermund, E.G., T. Tremblay, G. Paull, and E. Rieken, "GIS Base Data for Water Management for the Rio Grande Delta Plain," in *Proceedings of the 1995 Water for Texas Conference*, TWRI, College Station, TX.

## *Using Rapid Bioassessments to Measure Water Quality*

**Authors:** Lendon Gilpin and Glenn Longley, Edwards Aquifer Research and Data Center, Southwest Texas State University, San Marcos, TX.

**Problem:** The U.S. Environmental Protection Agency (EPA) and other agencies use rapid bioassessments to determine if streams are biologically impaired. Rapid bioassessments provide information on how aquatic organisms are affected by pollution. When used with traditional water quality studies, they provide a thorough picture of water quality. This study was funded by the U.S. Department of Agriculture/ Natural Resources Conservation Service (USDA/ NRCS).

**Objectives:** To examine the extent that six streams in five watersheds of the Brazos River Basin are being degraded due to agricultural row crop production, grazing and ranching, and urban activities.

**Methodology:** This study began in October 1993. Information in this paper includes data through August 1994. Eight sites were selected for the study. All of these sites are in the Little River watershed, which is a major tributary to the Brazos River. The study sites included: 1) Willis Creek near Granger in Williamson County, which is in an area used for row crop agriculture; 2) Donahoe Creek near Bartlett in Williamson County, which is in an area used for row crop agriculture; 3) Rumsey Creek near Salado in Bell County, which is in an area used for livestock grazing; 4) Buttermilk Creek near Salado in Bell County, which is in an area used for livestock grazing; 5) Upper Nolan Creek near Belton in Bell County, which is in an area near urban activities; 6) Lower Nolan Creek near Belton in Bell County, which is in an area near urban activities; 7) Lower Big Elm Creek near Red Ranger in Bell County, which is in an area used for row crop agriculture, and 8) Upper Big Elm Creek near Troy in Bell County, which is in an area used for row crop agriculture. At each site, physical, chemical and bacteriological data were collected every 40 days. Temperature, dissolved oxygen (DO) and pH data were taken in the field. Fecal coliform, fecal streptococcus, total organic carbon, conductivity, nitrate, nitrite, ammonia, sulfate, phosphate, chlorides, turbidity, and total suspended solids were analyzed in the lab. Water samples were collected twice for pesticide analysis. Specific tests were conducted for aldrin, lindane, chlordane, dieldrin, endosulfan, heptachlor, and methoxychlor. Benthic macroinvertebrate samples were gathered at 40-day intervals and were collected with a 4' x 2' kick screen. The substrate upstream of the kick screen was disturbed and organisms were dislodged and washed into a net. Samples were gathered in fast- and slow-moving waters. Samples were placed on screens and sorted according to biological orders on-shore until 100 organisms were collected. In laboratory studies, samples were sorted to family, genus, and species levels. Macroinvertebrate families were classified based on how tolerant they are to water pollution. A modified matrix was used to define how macroinvertebrate populations relate to water quality. Fish samples were collected four times using an electroshocking unit and were classified according to species, tolerance to pollution, and trophic levels.

**Results:** Nolan Creek is the only water body in this study for which Texas has established stream standards. Standards that have been set for various segments of the

Brazos River basin were used for comparison purposes. Average sulfate levels were higher than Brazos River stream standards at sites 1, 5, 6 and 7. Twice, fecal coliform levels were higher than Brazos River stream standards at sites 1 and 2. Low DO levels were observed at sites 1, 2 and 7. Combined ammonia and nitrate levels were consistently greater than 1 milligram per liter (mg/l) at sites 1, 2, 5, 6 and 7, and exceeded the 1 mg/l criteria four times at sites 3, 4, and 8. Pesticide residues were within Texas water quality standards. Exceptions included heptachlor (site 4), chlordane (sites 5 and 7), and dieldrin (all sites). Results of the rapid bioassessments showed that sites 1, 2, 3, 5 and 7 were "moderately impaired." Sites 4 and 6 were typically "moderately impaired," but were not impaired on three dates. Water quality at site 8 was ranked as not impaired based on average sampling data. Site 2 was classified as "severely impaired" in August 1994 after vegetation was cleared and soils were disturbed. Fish data show that sites 1, 2, 3 and 6 were classified as fair to good, while site 4 ranged from poor to fair. Site 8 was classified as poor to good while site 5 scored poor. Sites 5, 6, 7 displayed low numbers of species, while sites 1, 2, 7 and 8 had low numbers of darters and catfish. The study continued through August 1995 and a final report was provided to NRCS in October 1995.

**Reference:** Gilpin, L., and G. Longley, "A Rapid Bioassessment Study of Central Texas Watersheds," in *Proceedings of the 1995 Water for Texas Conference*, TWRI, College Station, TX 1995.

## *Limiting Herbicide Runoff with Vegetative Filter Strips*

**Authors:** Dennis Hoffman and Thomas Gerik, Texas Agricultural Experiment Station Blackland Research Center, Temple, TX.

**Problem:** Vegetative filter strips are designed to remove sediments, nutrients, herbicides, and organic matter from stormwater runoff in rural and urban settings. Reducing runoff pollution is important in agricultural areas in much of Central Texas, where Blackland clay soils are highly erodible and traditional herbicide levels are applied. More work needs to be done to assess the effectiveness of using grasses and crops as filter strips in agricultural settings.

**Objectives**: To determine the effectiveness of permanent grass and winter wheat strips in trapping herbicides, and to assess the economic feasibility of implementing this technology.

**Methodology:** This research was conducted in conjunction with the U.S. Department of Agriculture/ Agricultural Research Service (USDA/ ARS) Grassland, Soil and Water Research Laboratory in Temple. Study sites included nine watersheds. Each watershed measured 150' x 435.' The watersheds were constructed and implemented to sample and monitor field runoff. In each watershed, three 30' wide filter strips of permanent grass, winter wheat, and corn were established. The strips were planted at intervals of 0, 140 and 290' from a weir and were sited parallel to a catchment terrace. Urea and diammonium phosphate were applied to the surface to supply nitrogen and phosphorous. Atrazine, cyanazine, and metolachlor were applied as preemergent herbicides. Runoff was measured and sampled during rainfall events to determine the amount and quality of

water leaving each field. Herbicide levels were determined from composite samples taken at 5', 15', and 25' upslope from the filter strips during storm events. Levels of nutrients and herbicides were monitored 15, 30, 60 and 120 days after planting. Soil core samples were taken and analyzed to determine if herbicides were migrating down through the soil and into groundwater supplies.

**Results:** This study shows that atrazine, metolachlor and cyanazine were not mobile in these soils. Significant herbicide levels were not detected deeper than 6 inches in the soil profile. Characteristics of Houston black clay soil -- pH levels greater than 8, high soil temperatures, and high levels of soil moisture -- generally reduce herbicide half-life to less than 90 days for atrazine and metolachlor and roughly 21 days for cyanazine. Results show that 15' and 30' wide filter strips of Coastal Bermuda grass were effective at intercepting herbicides and that these filter strips reduced runoff volume by 60%. Herbicide levels in wheat and grass filter strips were significantly lower than areas that were planted completely to corn. The filter strips were shown to be effective in reducing total herbicide applications and runoff, even when land area taken out of production to make room for the filter strips was considered.

**Reference:** Hoffman, Dennis, and Thomas Gerik, "Use of Contour Grass and Wheat Filter Strips to Reduce Runoff Losses of Herbicides," in *Proceedings of the 1995 Water for Texas Conference*, TWRI, College Station, TX.

## *Changes in Cation and Isotope Levels in Stormwater Runoff*

**Authors:** David P. Robertson and Robert T. Gregory, Stable Isotope Laboratory, Geology Department, Southern Methodist University, Dallas TX.

*David Robertson stands next to a stormwater pipe which has been undercut by White Rock Creek. Urbanization of North Dallas has resulted in increased intensity of stormwater runoff events in the creek. The erosion of the channel sidewalls enhanced by the vigorous runoff events provides an unlimited supply of sediment which is filling up White Rock Lake.*

**Problem:** The White Rock Creek watershed occupies parts of Collin and Dallas Counties and flows into White Rock Lake in Dallas before joining the Trinity River. The watershed is now mostly urbanized and this impacts stormwater runoff quality in the basin.

**Objectives:** 1) To examine variations in cation concentrations and stable isotope ratios during stormwater runoff events in the White Rock Creek watershed, and 2) to assess the relationship of these changes to relative proportions of surface and groundwater flows.

**Background Information:** The watershed covers 66 square miles. The creek flows in entrenched meanders cutting recent surface deposits or Austin Chalk. White Rock Creek is a perennial gaining stream fed mainly by a surficial aquifer localized along the contact between the weathered zone and Austin Chalk bedrock. Active erosion, enhanced by urbanization, supplies sediments to White Rock Lake and has reduced the capacity of the lake by 50%. Intense storms can increase flows from as little as 10 cubic feet per second (cf/s) during baseflow to more than 1,000 cf/s during storms.

**Methodology:** Samples from two storms were analyzed. The first storm was in June, 1994, after a wet period. The second storm (August, 1994) occurred after a two week drought and soils were dry. Samples were taken from the creek at 10-15 minute intervals at the U.S. Geological Survey (USGS) gauging station. Water samples were analyzed for alkalinity, pH, levels of cations including calcium, magnesium, silicon, strontium, sodium and barium, and for oxygen and hydrogen isotope ratios. Storm event values were compared with baseflows. Chemical and isotopic hydrograph separations were performed to assess the percent of storm flows that result from rainfall and enhanced groundwater flow. Because the drainage area is urbanized, chemical and isotopic hydrographs of White Rock Creek provide a natural laboratory to test if rainfall and baseflow account for chemical and isotopic changes observed during a storm.

**Results:** In the June storm, three pulses of rain increased streamflow from a baseflow value of 15 cf/s to a crest at 577 cf/s. The August storm increased flows from baseflow value of 12 cf/s to 2,720 cf/s in six hours. The rains that produced these storms were chemically-diluted with respect to the creek, and depleted in the heavy stable hydrogen and oxygen isotopes, compared to creek baseflow. In both storms, the most intense chemical dilution and depletion of heavy isotopes occurred on the rising limb of the storm hydrograph. Hydrograph separation indicated that 75% of the water in the stream was rainwater. As the stream hydrograph continued to rise, the percent of apparent rainwater dropped to 60% at peak flows. When the conditions were dry before the storm, labile cation levels began to rise after peak dilution. After a wet period, the concentrations remained near peak dilution values past the crest of the storm flow.

**Discussion:** Standard hydrograph separations suggest that groundwater discharge increased 100 fold during a storm event to represent up to 40% of the baseflow. This is below average for chemical and isotopic hydrographs performed on less urbanized drainages. This suggests that urbanization may increase the contribution of rainwater to stormflows. Increased groundwater discharge into White Creek during a storm event is difficult to reconcile with the physical properties of the drainage. Runoff may be enriched in heavy isotopes as rainwater evaporates on hot paved surfaces and mixes with standing water mobilized during the runoff event. These processes mimic increased groundwater flows. Behavior of cation levels during storms after wet and dry periods suggests that dissolution of labile materials from the surfaces of particles transported into the creek occurs on time scales shorter than a runoff event. Transport processes affect the chemical and isotopic concentrations runoff in ways that bias hydrograph separations and produce excess estimates of groundwater flows.

**Reference:** Robertson, D.P. and Gregory, R.T., "Variations in Major Cation Concentration and Stable Isotope Ratios During Stormwater Runoff Events in White Rock Creek, Dallas, TX," in *Proceedings of the 1995 TWRI Water for Texas Conference, TWRI, College Station, TX*.

## *Texas A&M, USDA/ ARS Team Up to Test Use of Wind Turbines to Pump Water for Irrigation*

In the arid West Texas farmlands of Glassock, Reagan, and Upton counties, energy costs to pump groundwater for irrigation can be significant. Now, a team of scientists from the Texas A&M University (TAMU) System and the U.S. Department of Agricu lture's Agricultural Research Service (USDA/ ARS) has installed two modern wind turbines to determine if they can supply sufficient groundwater for irrigation and lower pumping costs.

The efforts are led by Joe Henggeler of the Texas Agricultural Extension Service (TAEX) in Fort Stockton and R. Nolan Clark at USDA/ ARS at Bushland. TAMU Agricultural Engineering graduate student Saiful Molla has been working with Henggeler in the field. Don Reddell of the TAMU Agricultural Engineering Department is working with Molla to develop computer software to monitor the turbines, fact sheets, and other information. The work is being funded by a grant from the Governor's Energy Office a nd the Robert S. Conly Wind Energy Endownment, which is administered by the TAMU Agricultural Engineering Department.

In July, two wind turbines were installed at farms in St. Lawrence and Garden City. The depth to groundwater was 150' at Garden City and 300' at St. Lawrence. Rotors on each turbine have a diameter of 23' and include three fiberglass blades. They are mounted on 100' high towers and the blades automatically rotate to produce as much wind power as possible. At each site, data on wind spe eds, flow rates, pumping lifts are being gathered. Information about the amount of energy produced by each turbine are being collected. At the same time, similar data and information on energy consumption is being recorded from a conventional pumping plan t located near the turbines. The turbines will power 7.5 horsepower (hp) submersible motors with submersible pumps that will provide water for irrigation.

Currently, there are roughly 100,000 irrigated acres in the region. It costs about $50,000 ann ually to pump groundwater for irrigation at each farm in the region. Purchasing and installing a wind turbine can cost $25,000 or more. Henggeler feels that installing wind turbines could reduce energy use by 30,000 kilowatt hours annually and energy cost s by 15%. The project may prolong the region's groundwater supply and save irrigators money

and could reduce peaks in energy use throughout the region. Henggeler feels this technology may also be applicable in areas where farmers pump water out of reservo irs and rivers. For details, contact Henggeler at (915) 336-7541, Reddell at (409) 845-3903 or Clark at (806) 356-5734.

## *Microwatershed Approach May be Best Way to Limit*

The Brazos River Authority (BRA) has proposed a new "non-regulatory" strategy to deal with non-point source pollution that emphasizes setting in-stream water quality standards.

J. Tom Ray, who manages water quality for BRA, says that the agency will first focus on controlling non-point pollution in the Bosque and Leon River watersheds. To do this, BRA established a watershed protection program that will survey community leaders and citizens in each watershed. The information will be used to help BRA determine which stream segments need special protection, and the water quality that local residents desire. Ray says it often may be easy to improve water quality and meet consumer demands.

Research by the Texas Institute for Applied Environmental Research at Tarleton State University (TSU) helped the BRA identify this management strategy. TSU stormwater sampling in the Upper North Bosque River suggests the best way to prevent non-point pollution may be to design site specific best management practices (BMPs) for individual microwatersheds where major non-point pollutants could be isolated. Water quality sampling at the mouth of each microwatershed would determine if BMPs are effective. BRA suggests that levels of nitrogen and phosphorus could be used to assess how well BMPs are performing. Ray says this approach has two major advantages: it may reduce non-point pollution and it may avoid cumbersome regulations by involving citizens at the large and small watershed scale.

For details, call BRA at (817) 776-1441.

## *USGS Publishes Trinity River NAWQA Reports*

The U.S. Geological Survey (USGS) has published detailed a two-volume study of water quality in the Trinity River watershed. The studies were part of the USGS National Water Quality Assessment (NAWQA). The reports include: *Water Quality Assessment of the Trinity River Basin -- Review and Analysis of Available Pesticide Information* (1968-91) by R.L. Ulery and M.F. Brown, and *Water Quality Assessment of the Trinity River Basin --Analysis of Available Information on Nutrients and Suspended Sediments* (1974-91) by Peter Van Metre and David Reutter. The USGS has published fact sheets that summarize both reports. The reports include information on characteristics and use of key pesticides, a review and analysis of pesticide, nutrient and suspended solids data, nutrient and pesticide loads, the spatial distribution of nutrients and pesticides.

For more information or to order these reports, contact the USGS Austin District at (512) 873-3020.

## *Austin Engineers Assess "Channel Losses" in Texas Streams*

It's obvious that all the water flowing in a river won't make it downstream. That's because many factors including permitted diversions, human and livestock use, evaporation, evapotranspiration, and flows into aquifers result in "lost" water. These channel losses are not typically accounted for when reservoir system yields are considered.

*HDR engineers gathered field data from the Frio River (above) and other sites to assess channel losses.*

As a result, Samuel Vaugh, Kenneth Choffel, and Kelly Kaatz of HDR Engineering in Austin have been trying to estimate channel losses in Texas rivers to get a better idea of how much water is actually available at downstream sites. In general, the method involves analyzing gauged streamflow records at upstream and downstream points, estimating runoff, and making adjustments for permitted diversions and return flows.

Recently, HDR has conducted case studies on channel losses. A review of the Choke Canyon/ Lake Corpus Christi reservoir system revealed that channel losses may account for 18% of the total yield (36,000 acre-feet or AF annually). Another project involved assessing how construction of recharge dams over the Edwards Aquifer may impact freshwater inflows into the Nueces Estuary. These results suggest that the recharge dams could store 45,000 AF per year, while only reducing inflows by 7,000 AF annually. HDR evaluated how channel losses could reduce return flows from San Antonio to Coleto Creek Reservoir. This analysis suggests that channel losses could reduce return flows before they reached the reservoir. For details, contact HDR at (512) 912-5100.

## *TWDB Studies Groundwater Systems, Reservoir Evaporation*

Groundwater resources, reservoir management, and water allocation are a few of the topics now being researched by the Texas Water Development Board (TWDB). John Ashworth, a geologist with TWDB's Water Resources Planning Division, presented an overview of current Board research at the 1995 Water for Texas Conference.

TWDB staff are now evaluating groundwater resources along the Rio Grande in the El Paso-Juarez and Dell City area and in the Salt Basin that extends along the Texas-Mexico border from the Guadalupe Mountains to Marfa. Other groundwater research focuses on the Edwards Aquifer, Central Texas Paleozoic groundwater systems, the Carrizo-Wilcox

system in East Texas, and the Gulf Coast aquifer. The goal of many of these studies is to characterize water quality and flow patterns, and to determine how much water is available. TWDB also maintains a statewide groundwater monitoring network that annually collects water level measurements from more than 7,500 wells statewide and water quality data from 600 wells. Other TWDB research includes projects to more accurately calculate evaporation rates from lakes and rivers, and strategies that use conditional probability analyses to better manage reservoirs.

For more details, contact Ashworth at (512) 936-0872 or "ashworth@twdb.state.tx.us"

## *TWRI Fellowships Enhance Ph.D. Research at Texas A&M*

A TWRI program to train future scientists is attracting graduate students to Texas A&M to pursue water-related research. TWRI's Ph.D. Fellowship program has existed in its current form for less than five years. Training of students has been one of the main three focus areas of TWRI and other members of the National Institutes for Water Research since 1964.

"The focus of this program is to build a nationally competitive fellowship program to attract outstanding Ph.D. candidates to study at Texas A&M University," says TWRI Director Wayne Jordan.

The process works this way. TWRI sends posters and other recruiting material about the program to universities with undergraduate and M.S. programs. Postcards are attached to each poster that students can fill out to provide information on which fields they want to pursue. Once the postcards arrive at TWRI, they are sent to Texas A&M University graduate academic advisers who try to match prospective students with faculty members involved in water research. If the students are academically qualified and are offered a departmental graduate assistantship, advisors submit the student's qualifications to the Fellowship Committee for evaluation.

"We feel this program assists Texas A&M in recruiting outstanding Ph.D. candidates," Jordan said. "The fellowship increases the financial support to a level where economic considerations need not influence where students choose to go to school for graduate study."

So far, five fellowships have been awarded. Currently, four Ph.D. fellowship recipients are enrolled at Texas A&M University: Janice Stroud and Kathryn Merrill in the Agricultural Economics Department; Mary Paasch in the Agricultural Engineering Department, and Deanna Cross of the Plant Pathology and Microbiology Department. Previously, Ron Fix was awarded a TWRI fellowship in the Geography Department.

"We hope many more students and graduate programs will take advantage of this program," Jordan said.

The fellowship requires a GPR of 3.3 and a minimum GRE score of 1,250. Fellowship winners receive a salary supplement of $4,000 annually in addition to their graduate assistantships and $1,000 per year for research. Only U.S. citizens are eligible. Research from the fellowships may be published as technical reports. For more information, contact TWRI at (409) 845-1851 or "twri@tamu.edu"

## *Technical Reports, Newsletters, Available from TWRI*

Many new technical reports, newsletters, and conference proceedings are available from TWRI.

Recent technical reports include: *Water Supply Planning Using an Expert Geographic Information System* (TR-162) by Daene McKinney, John Burgin, and David Maidment of the University of Texas at Austin; *Flow, Salts, and Trace Elements in the Rio Grande* (TR-169) by Seiichi Miyamoto and Lloyd Fenn of the Texas Agricultural Experiment Station at El Paso, and Dariusz Swietlik of the Texas A&M University-Kingsville Citrus Center; *Effects of Lower Colorado River Authority Lakes on Riparian Property Values* (TR-170) by Lonnie Jones of Texas A&M University (TAMU) and Notie Lansford of Oklahoma State University, *Soil Mineralization Potential for Improved Fertilizer Recommendations and Decreased Nitrogen Contamination of Groundwater* (TR-171) by Alan Franzluebbers, Richard Haney, and Frank Hons of TAMU, *Farm-Level Evaluation of Agricultural Profit and Groundwater Quality: Texas Seymour Aquifer* (TR-168) by Manzoor Chowdhurry, Ron Lacewell, Bruce McCarl, Teo Ozuna, Verel Benson, Bill Harris and Paul Dyke of TAMU, and *Legal and Institutional Barriers to Water Marketing in Texas* (TR-167) by Ron Kaiser of TAMU.

TWRI also publishes three other quarterly newsletters: *Texas Water Resources, Texas On-Site Insights*, and *Texas Water Savers*. The new issue of *Texas Water Resources* focuses on WWW resources about water issues in Texas. Many articles in this issue were presented at the 1995 TWRI Water for Texas Conference. That proceedings is available from TWRI for $30.

## *EPA Report Describes Toxic Pollution Along Rio Grande*

A report documenting the presence of toxic substances along the Rio Grande has been published.

The report, *Binational Study Regarding the Presence of Toxic Substances in the Rio Grande/ Rio Bravo and its Tributaries Along the Border Portion Between the U.S. and*

*Mexico*, was published in September 1994. Agencies participating in the report include the International Water and Boundary Commission, the U.S. Environmental Protection Agency, the Texas Natural Resources Conservation Commission, the Texas Parks and Wildlife Department, the Texas Department of Health, the Mexico National Water Commission.

The report includes sections describing the study area, testing methods, and results of analyses concerning such topics as the presence of toxic chemicals in water, sediment, and fish tissue samples; assessments of macrobenthic and fish communities, and sites and toxic chemicals of potential concern.

More details about this report are available by contacting Carl Young at EPA at (214) 665-6645.

## *Rice U. Proceedings Focuses on Houston Ship Channel*

A report that describes water quality issues associated with the Houston Ship Channel has been published by Rice University.

The report, *Proceedings of the Houston Ship Channel Symposium: An Environmental Success Story?*, was published by Rice's Energy and Environmental Systems Institute (EESI). The report was edited by EESI Executive Director Hanadi Rifai

Sections of the report deal with such issues as historical and current perspectives; shipping and commerce, water, sediment and air quality, efforts to restore wetlands habitat and water quality in areas affected by the Channel, and future plans to protect water quality.

The report includes papers written by Neal Armstrong and George Ward of the University of Texas at Austin, and Hanadi Rifai of Rice University, Cynthia Howard of the University of Houston at Clear Lake.

Limited free copies are available. For more information, contact Rifai at (713) 527-4685 or 'rifai@rice.edu"

## *UTEP Researcher Co-Authors Study on Border Water Policies*

A new report that examines water policy issues along the U.S. Mexico border has been co-authored by a researcher at the University of Texas-El Paso (UTEP).

*Resolving Water Disputes Along the U.S.-Mexico Border: The Case of Paso del Norte*, was co-authored by Richard Bath of the UTEP Political Science Department and Janet Tanski of the Economics Department of the University of New Mexico. The report was published earlier this year by the Border Research Institute at New Mexico State University.

The 40-page report describes a history of water disputes in Paso del Norte, which consists of the Texas-New Mexico section of the U.S.-Mexico border. It also describes the roles of various state, federal and Mexican agencies that regulate natural resources in the region. Maybe most importantly, the book describes an administrative, political, and legal framework for solving surface and ground water disputes in the region, and recommends specific steps that can be taken to manage border resources more effectively.

For more information, call Bath at (915) 747-7980. The Center can be contacted at (505) 646-3524 or "bri@dante.nmsu.edu"

## Two Eagles: Dos Aguilas *Presents Spectacular View*

A visually stunning book about the natural resources along the U.S.-Mexico border has been published by the University of California-Berkeley Press.

The 205-page book, *Two Eagles: Dos Aguilas -- the Natural World of the United States - Mexico Borderlands*, was written by Peter Steinhart and features photographs by Tupper Ansel Blake.

The book describes environmental quality in border ecosystems. Considerable attention is spent discussing the habitats and species in the Rio Grande watershed, water quality issues, and how man's activities have changed the region. The book describes other Texas ecosystems including Big Bend National Park, Dolan Falls, Santa Helena Canyon, Sierra del Carmen in the Chihuahan Desert, the Sabal Pine Forest

in the Lower Rio Grande Valley, and the Chisos Mountains.

The Nature Conservancy assisted in publishing the book. It can be ordered by calling (800) 822-6657.

## *Springflow Augmentation, Runoff, Are Topics of UT Studies*

Methods to enhance springflows and control runoff from highway construction are the topics of new technical reports produced by the Center for Research in Water Resources at the University of Texas at Austin.

*Springflow Augmentation of Comal Springs and San Marcos Springs -- Phase I Feasibility Study* (CRWR 247) was written by Daene McKinney and John Sharp, Jr. It addresses such issues as historical hydrologic trends, hydrogeology of the Edwards Aquifer, the aquatic habitats at both springs, sources of water for augmentation, and alternative augmentation methods. The report also analyzes the feasibility of such augmentation strategies as injection wells, regionally and locally enhanced surface recharge, and directly adding water to spring-fed lakes.

*A Review and Evaluation of Literature Pertaining to the Quantity and Control of Pollution from Highway Runoff and Construction* (CRWR 239, 2nd Edition) was written by Michael Barrett, Robert Zuber, E.R. Collins III, Joseph Malina, Jr., Randall Charbeneau and George Ward. This updated report contains information about the impact of highway runoff on water quality, control of sediments during construction, and predicting runoff with computer models.

Other recent reports deal with the use of supercritical water oxidation to treat pollutants including: *Modeling Subsurface Biodegradation of Non-Aqueous Phase Liquids* (CRWR 257) by Phillip deBlanc, McKinney, and Gerald Speitel, Jr.; *Cyclone Performance for the Separation of Solids from Supercritical Water Oxidation Effluents* (CRWR 256) by Chrysti Laspidou and Earnest Gloyna; and *Solubility of Potassium Hydroxide and Potassium Phosphate in Supercritical Water* (CRWR 255) by William Wofford and Gloyna. Another new report, *Porous Medium Advection-Dispersion Modeling in a Geographic Information System* (CRWR 253), was written by John Tauxe.

For more information, call the Center at (512) 471-3131.

## **Barton Springs Eternal** *Describes an Austin Treasure*

It's hard to imagine anything that Austin area residents value more than Barton Springs. The clear, pristine waters of the Springs provide an ideal location for swimming, wading and relaxing. However, as Austin grows and becomes more urbanized, it becomes more challenging to keep Barton Springs pollution-free.

A book from the Hill Country Foundation, *Barton Springs Eternal: The Soul of A City,* discusses many of these issues with splendid writing and historical and intriguing photographs. The book was edited by Turk Pipkin and Marshall Frech. It describes how the springs have been used since Austin was settled, the role Barton Springs played in

Austin's development, technical issues including recharge, discharge and water quality, endangered species that use the springs, and politics and policies that influence how the springs are maintained and protected. The book includes many oral histories from individuals whose lives have been touched by the springs as well as short essays by prominent Texans.

The book and a newly published map showing Barton Springs and other environmentally sensitive ecoregions in Austin are available from the Hill County Foundation at (512) 478-5743.

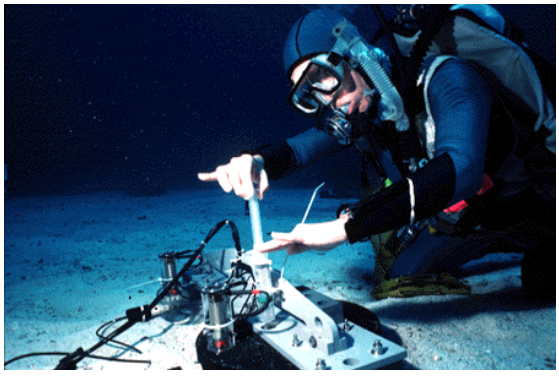
## *Managing Livestock, Poultry Wastes is Aim of TAEX Report*

A proceedings that focuses on managing manure and wastewater from livestock and poultry operations to protect water quality has been published by the Texas Agricultural Extension Service (TAEX). *Innovations and New Horizons in Livestock and Poultry Manure Management* summarizes a September 1995 conference in Austin. The proceedings were edited by Joe McFarland of the Texas Agricultural Experiment Station at Stephenville. The conference was chaired by John Sweeten of the Texas A&M University (TAMU) Agricultural Engineering Department.

The proceedings cover watershed planning and management, innovative and alternative systems including constructed wetlands, and composting solids. University contributors include Larry Hauck and Anne McFarland of Tarleton State University; Bobby Stewart of West Texas A&M University; and Sweeten, Vincent Haby, Marty Baker, and Eric Chasteen of TAEX. Copies of the proceedings are available for $10 by contacting the TAEX Agricultural Engineering Department at (409) 845-7451.

## *Texas A&M Oceanographers Use Benthic Organisms to Measure Ecosystem Health*

Oceanographers at Texas A&M University are developing a classification system that could gauge the health of near coastal waters by examining the metabolism of the communities of bottom dwelling or benthic organisms.



The studies are being carried out by researchers Gilbert Rowe, John Morse and Gregory Boland, graduate students Liz Cruz-Kaegi, Craig Cooper and Soon Mo An, and research affiliate Elva Escobar from the National University of Mexico. The group plants small incubation chambers on the floor of rivers and coastal waters to incubate the diverse assemblage of organisms living in the mud or sand. The chambers allow the team to estimate dissolved oxygen and carbon dioxide levels and oxygen demands, and concentrations of nitrate, nitrite, ammonium, phosphate, silicate, and methane. The team

has conducted field studies in Trinity Bay, Offatts Bayou, the Mississippi River plume, and the Flower Gardens Coral Reef National Sanctuary.

Preliminary results suggest that ecosystems can be classified in one of seven broad categories, based on the sediment respiratory quotient (the amount of carbon dioxide produced versus the level of oxygen gas that is consumed). This appears to be a function of the input of organic matter, oxygen concentration and available light. These seven states range from very healthy ecosystems (photoautotropic and oligotrophic) to those that are marginally healthy (mesotrophic, chemotrophic and hypertrophic) and those that are in poor health (thiotrophic and dystrophic).

The research suggests that many benthic ecosystems often shift from being healthy to unhealthy and back again over short time periods. The Upper Trinity Bay can change from being oxygen-deficient to oxygen producing in only a few days, depending on water clarity. Rowe believes that it is useful to sample, characterize, and classify individual ecosystems according to the benthic metabolism, and the organisms they contain. Then, rapid changes and ecosystem shifts from one state to another can be used as indicators that the environment is being stressed, that contaminants are being introduced, or that remedial action is having a positive effect. Classifying benthic ecosystems enhances the ability to quantitatively assess the affects of water management strategies.

For details, contact Rowe at (409) 845-4092 "growe@astra.tamu.edu"

## *UTEP Shares Water Information Across Texas-Mexico Border*

It's a sad but undeniable fact that natural resources like water don't recognize political boundaries. No where is that more apparent than in the metropolitan El Paso-Juarez area along the Texas-Mexico border.

The fact that surface and groundwater resources straddle the border causes many potential complications. Groundwater laws differ greatly between the U.S. and Mexico. Water and wastewater treatment practices on one side of the border can easily affect the quality of water both countries share.

In an effort to solve some of these problems, the University of Texas at El Paso (UTEP) is working with the Autonomous University of the City of Juarez (UACJ) to develop a joint research and information program. The program, the Binational Water Program/ Programa Binacional de Agua (PROBIDA) is a joint effort between the UTEP Center for Environmental Resource Management and the UACJ and was established in 1992. PROBIDA Directors are Stephen

Riter of UTEP and Ma del Rosario Diaz of UACJ.

So far, the program has been active in many areas. In the planning phase PROBIDA developed a transboundary network of policy makers, planners and researchers; organized legal and technical documents into a user friendly English/Spanish database and library, and worked to create a formal binational structure to share information and plans. PROBIDA is successful because it is nonthreatening, binational, and it relies on regional cooperation.

PROBIDA is now working on a transboundary resource and environmental inventory and GIS for the border region, developing a computer information transfer system for local water planners and policy makers, and conducting an outreach program on low-tech water purification strategies. For details, contact Nancy Lowery or Riter at UTEP at (915) 747-5494. Lowery's e-mail address is "nlowery@mail.utep.edu"

## *TAMU-CC Scientists Locate Abandoned Wells on Padre Island*

A team of university scientists and a private company have begun a joint effort to assess the environmental impact of abandoned oil and gas production wells on groundwater quality at the Padre Island National Seashore.

Oil and gas exploration on North Padre Island has been ongoing since 1951. As of January 1994, there were 44 abandoned oil and gas sites in the National Seashore. Seashore officials wanted to determine if these wells posed a threat to groundwater quality on the island.

The study is led by Rick Hay and Alfredo Romero of the Center for Water Supply Studies at Texas A&M University-Corpus Christi (TAMU-CC) and Tommy McDonald of the Geochemical and Environmental Research Group at Texas A&M University (GERG). Hunter Environmental Consulting (HEC) is also participating.

In the project, Hay and Romero are leading efforts to install monitoring wells, perform an electromagnetic (EM) survey, and will assist HEC with site delineation. McDonald will lead efforts to analyze organic constituents, including hydrocarbons, in the groundwater. A private laboratory will analyze metal levels in groundwater samples. HEC will perform site evaluations and assessments.

Total Scanning Fluorescence (TSF) will be used to identify the type of aromatic hydrocarbons that are present. Gas Chromatograph (GC)/ Total Recoverable Hydrocarbon analysis will identify hydrocarbon compounds and

furnish a quantitative value for each site. GC/ Mass Spectrometry (GC/MS) will be used to analyze suspect hydrocarbons in soil and water samples. PCB analysis will be performed on soil samples, and chloride concentrations will be determined for groundwater samples.

The researchers intend to produce definitive data park officials can use to evaluate the present groundwater conditions at the abandoned oil and gas production sites, and identify specific pollution sources. The researchers will also develop an electronic database that park managers can use. This study will begin in September 1995 and be completed by November 1996.

## *UH Researchers Probe Variations in Gulf Coast Aquifers*

Throughout the Houston area and the Texas Gulf Coast, clay soils are widespread. Many experts believe the hydrogeology of these soils and their ability to prevent contaminants from migrating into groundwater supplies is highly variable. A study by scientists at the University of Houston (UH) is using high-tech methods to determine variations in the hydrogeology of the upper Beaumont clay formation. These soils are clay-rich, fluvial, delta formations that are normally associated with sediment buildup from rivers.

The studies were conducted by Regina Capuano of the UH Geosciences Department and Alan Hinks of the Houston consulting firm of Rust, Lichliter, Jameson. The research was performed at the UH Coastal Center, 35 miles south of Houston. Five monitor well nests were installed. Each nest included screened monitor wells that were installed 20', 40', 60' and 80' below ground. Vertical movement of groundwater between the well casing and the borehole was limited by packing bentonite at 2.5' intervals before the wells were installed. Small diameter risers were used to reduce the amount of groundwater needed to fill a well. Water levels were measured weekly from January 1993 to January 1994. Groundwater samples were tested for pH, conductivity, dissolved oxygen, chlorides, carbonate, sulfate, sodium, calcium, magnesium and silica.

Capuano says this study developed a detailed three-dimensional profile of the groundwater system because of the sophisticated techniques that were used. Three dimensional profiles of the unconfined aquifer, leaking confined units, unconfined and semi-confined units were identified. Large spatial variations in hydrogeologic properties and significant temporal variations in water levels and hydraulic gradients were observed. Capuano said this study shows that groundwater chemistry, which is often used to define aquifers, may provide false results in cases like this were the hydrogeology is complex. For details, contact Capuano at (713) 743-3426 or "capuano@uh.edu"

## *Rice U. Examines Sustainable Ecosystems in "Two Lagunas"*

A multi-disciplinary research team at Rice University is focusing on the future of sustainable development in the Lower Laguna Madre. The project focuses on the "Two Lagunas", which stretches from Del Rio/Ciudad Acuna past Brownsville/ Matamoros where the Rio Grande empties into the Gulf of Mexico. The project considers issues in watersheds on both sides of the border that may lessen water quality. So far, much of the

work is preliminary. Rice U. researchers are now characterizing existing ecosystems in the region, including data on watersheds, hydrology, and biological species. Once these data have been gathered and compiled, a geographic information system will be created that can be used for computer models dealing with specific problems facing the region including increased needs for wastewater treatment, exploding population growth, rapid industrialization as a result of the North American Free Trade Agreement (NAFTA), and maintaining coastal waterways. The research is being coordinated by Hanadi Rifai of the Energy and Environmental Systems Institute. Others taking part in the project include Paul Harcombe, Jon Evans, and Kris Johnson from the Evolutionary Biology Department; Phil Bedient, Mark Wiesner, and James Blackburn from the Environmental Science and Engineering Department; John Anderson, H.C. Clark and Robert Dunbar from the Geology Department; Stephen Klineberg from the Sociology Dept., and Tamara Ledley and Arthur Few from the Physics Department. For details, contact Rifai at (713) 527-4685 or at "Rifai@Rice.edu"

## *Tarleton Researchers Link Land Use to Water Quality*

Throughout Central Texas, pollution runoff from dairies is a major water quality concern. There are 94 dairies in the region with a combined herd size of more than 30,000 milk cows. In a recent non-point source pollution assessment, the Upper North Bosque River was classified as having water quality problems because of dairy wastes. Anne McFarland and Larry Hauck of the Texas Institute for Applied Environmental Research with Tarleton State University (TSU) are examining this problem. They want to assess if other land use features and practices are influencing water quality in the region.

The project consists of gathering data on the size and hydrology of streams that feed into the North Bosque, small flood-retention dams constructed by the U.S. Department of Agriculture/Natural Resources Conservation Service (USDA/ NRCS), slopes, and soils. Later, information on land use was determined using Landsat satellite imagery, verified through field surveys, and input into a geographic information system (GIS) using GRASS (Geographic Resources Analysis Support System) software. USDA data was used to determine the location and size of peanut fields. Fields where dairy wastes were applied were identified from records from the Texas Natural Resource Conservation Commission. Soils were classified according to runoff and infiltration characteristics. Estimates were made of the number of dairies and milk cows in the drainage area above eight reservoirs in the watershed. McFarland and Hauck sampled the reservoirs monthly for total suspended solids, total nitrogen, nitrates, ammonia, phosphates, phosphorus, conductivity, turbidity, and chlorophyll. They analyzed the results using multi-variate analysis and other techniques.

This study is important because it provides a way to compare runoff from dairies with other sources of contaminants, and it provides a framework for GIS analyses. McFarland says the number of milk cows and the amount of acreage used for waste application are the two factors linked most strongly to water quality in lakes in the region. Surprisingly, the research shows many of the small lakes in the watershed are nitrogen limited. Stormwater sampling in nearby streams has been incorporated into an expanded analysis

that will be published soon. For details, contact McFarland at (817) 968-9581 or "mcfarla@tiaer.tarleton.edu" or Hauck at (817) 968-9567 or "hauck@tiaer.tarleton.edu"

## *Texas A&M Examines Policies to Protect Pristine Rivers*

Has Texas done enough to protect pristine rivers and streams in parks? That's the question being explored by researcher Ron Kaiser and graduate student Jeff Darrow of the Texas A&M University Recreation, Park and Tourism Sciences Department. Kaiser and Darrow examined ways states can protect pristine natural resource waters. One way is a federal designation known as the "outstanding national resource waters" (ONRW), which originated in the Clean Water Act of 1972. This designation refers to high quality waters in parks and wildlife refuges. Once waters are designated as an ONRW, their quality cannot be degraded over the long-term. They compared strategies used by different states to protect these waters and analyzed options Texas may want to pursue.

Kaiser and Darrow found that there are many ways states can protect high quality waters. They can use language in the Clean Water Act to designate ONRWs without using a formal process or criteria. Texas is in this category but has yet not designated any ONRWs. They can use a standard process to identify ONRWs, and designate them for federal protection. Safe drinking water protection, estuariane inflow, instream flow maintenance, and endangered species habitat protection can be used to protect pristine waters.

Kaiser says the research suggests that Texas may want to develop numerical criteria to identify ONRWs. State agencies may want to propose and consider the merits of ONRWs individually. In 1994, four sites were proposed at the same time and all were dropped. Texas may want to consider adopting flexible standards to allow water quality to be degraded for social and economical development, or may want to create outstanding state resource waters. For details, contact Kaiser at (409) 845-5303 or "rkaiser@rpts.tamu.edu

## *TWDB Awards Eight Research Grants Worth $450,000*

The Texas Water Development Board (TWDB) recently announced that it will fund eight research projects. Grant funds supplied by TWDB will total more than $450,000, while roughly $241,000 in matching funds will be provided by the recipients. Work on the grants began September 1 and will continue through August 31, 1997.

Investigations that were awarded to university researchers or teams involving university scientists include:

* "Evaluation of Economic and Reliable Methods of Brine Management" to Kleber Denny, Inc. of Houston, Wesley James of the Texas A&M University Civil Engineering Department, Andrew Swift of the Mechanical Engineering Department at the University of Texas at El Paso, J. McNutt and Associates, and Ionics, Inc.;

* "Effects of Brush Management on Water Yield from Rangelands on the Edwards Plateau," to William Dugas and Ranjan Muttiah of the Texas Agricultural Experiment Station Blackland Research Center at Temple, TX;

* "Evaluation of Dry-Year Option Water Transfers from Agricultural to Urban Use," to Bruce McCarl, Lonnie Jones, and Ronald Lacewell of the Texas A&M University Agricultural Economics Department;

* "Valuing and Managing Water Supply Reliability," to Ron Griffin and James Mjelde of the Texas A&M University Agricultural Economics Department

* "A Manual for Crop Consumptive Water Use and Free-Water Evaporation for the State of Texas," to John Borrelli, Clifford Fedler, Robert Sweazy, and James M. Gregory of the Civil Engineering Department Texas Tech University;

Studies that were awarded to water districts and consultants including the following:

* "Social and Economic Impact of Water Transfers," to the Medina County Underground Water Conservation District, G.E. Rothe Company, Inc. of Hondo, BBC Research and Consulting of Denver, CO, and R.L. Masters of San Antonio;

* "Model Agreements for Water Sales," to Booth, Ahrens, and Werekenthin, P.C. of Austin,

* "Rainwater Harvesting Manual: A Regional Approach for Texas," to Gail Vittori of the Center for Maximum Potential Building Systems in Austin,

In future issues of *New Waves*, we'll provide detailed information on these research projects. For details, contact Philippa Butts of TWDB at (512) 463-8005.