WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN TEXAS-- FISCAL YEAR 1987

Compiled by Alicia A. Mitchell

U.S. GEOLOGICAL SURVEY
Open-File Report 88-100

Austin, Texas
1988

UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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MESSAGE FROM THE DISTRICT CHIEF

The Water Resources Division of the U.S. Geological Survey has neither regulatory nor developmental authority. Instead, it has the principal responsibility within the Federal Government of providing hydrologic information and appraising the Nation's water resources. Hydrologic information and results of water-resources appraisals conducted by the Geological Survey are made available equally to all interested parties and contribute to descriptions of the location, quantity, quality, and use of water resources and to predictions of the effects of water development on the future availability and quality of water supplies. Planners and managers use this information to locate, design, and operate water-supply facilities such as reservoirs, well fields, and water-treatment plants; to identify effective strategies for protecting the quality of water resources from contamination by toxic or noxious wastes and for locating, designing, and operating waste-disposal facilities; and to allocate available water resources on the bases of court decrees, interstate compacts, international treaties, and water law.

To accomplish its responsibility of providing hydrologic information, the Texas District of the Geological Survey, in cooperation with approximately 68 Federal, State, and local agencies, has established and operates a vast Statewide program for the collection and analysis of hydrologic, water-use, and related information, including the quantity and quality of surface and ground water, and precipitation. In addition to these activities, the Geological Survey plans and conducts a wide variety of cooperative and Federally-funded investigative projects in Texas in order to address high priority water-resources issues and problems in the State and to develop a better understanding of the impact of human activities and natural phenomena on hydrologic systems.

Texas is not without major water-quantity and quality problems. Rapid industrialization and population growth have resulted in steadily increasing water requirements and water-quality problems. In much of the State, available storage capacity in existing surface-water reservoirs is barely sufficient to meet water demands during critical droughts. Extensive development of ground water has resulted in severe problems in some areas. In the Texas High Plains, the rate of water use from the High Plains (Ogallala) aquifer greatly exceeds the rate of natural recharge. In the Houston-Galveston area, large-scale pumpage of ground water has resulted in land-surface subsidence. In these and other areas, large-scale pumpage also is increasing the potential for saline-water intrusion.

Water-quality problems, both natural and man-made, affect a significant part of the State's surface-water resources. Problems of naturally occurring salinity are particularly severe in headwater reaches of the Red, Colorado, Brazos, and Pecos Rivers. In some areas, this problem may be aggravated by the disposal of brines resulting from the production of oil and gas. In other reaches downstream from densely populated urban centers, such as Dallas, Fort Worth, Houston, and San Antonio, urban runoff and the inflow of waste effluents are degrading the quality of water in streams and reservoirs. In the past several years, the issue of both ground- and surface-water quality has greatly expanded in Texas. Entities are becoming increasingly concerned about problems related to toxic substances in subsurface disposal sites, effects of municipal

and industrial effluents in streams and reservoirs, potential impacts of oil and gas development, quality of recharge water to aquifers, potential intrusion of salinewater due to large scale pumpage, and quality of urban and agricultural runoff.

Within the constraints of diminishing State and Federal funds, the Texas District is striving to maintain an adequate hydrologic data program and to strengthen the investigative program in order to address the priority water-resources issues and problems in the State.

Charles W. Boning
District Chief
U.S. Geological Survey
Austin, Texas

WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY

IN TEXAS--FISCAL YEAR 1987

Compiled by
Alicia A. Mitchell

U.S. GEOLOGICAL SURVEY ORIGIN

The U.S. Geological Survey (USGS) was established by an act of Congress on March 3, 1879, to provide a permanent Federal agency to conduct the systematic and scientific classification of the public lands and to examine the geological structure, mineral resources, and products of national domain. An integral part of that original mission includes publishing and disseminating the earth science information needed to understand, to plan the use of, and to manage the Nation's energy, land, mineral, and water resources.

Since 1879, the research and fact-finding role of the USGS has grown and been modified to meet the changing needs of the Nation it serves. As part of that evolution, the USGS has become the Federal Government's largest earth-science research agency, the Nation's largest civilian mapmaking agency, the primary source of data on the Nation's surface- and ground-water resources, and the employer of the largest number of professional earth scientists. Today's programs serve a diversity of needs and users. Programs include:

- Conducting detailed assessments of the energy and mineral potential of the Nation's land and offshore areas.
- Investigating and issuing warnings of earthquakes, volcanic eruptions, landslides, and other geologic and hydrologic hazards.
- Conducting research on the geologic structure of the Nation.
- Studying the geologic features, structure, processes, and history of the other planets of our solar system.
- Conducting topographic surveys of the Nation and preparing topographic and thematic maps and related cartographic products.
- Developing and producing digital cartographic data bases and products.
- Collecting data on a routine basis to determine the quantity, quality, and use of surface and ground water.
- Conducting water-resources appraisals in order to describe the consequences of alternative plans for developing land and water resources.
- Conducting research in hydraulics and hydrology and coordinating all Federal water-data acquisition.
- Using remotely sensed data to develop new cartographic, geologic, and hydrologic research techniques for natural resources planning and management.
- Providing earth-science information through an extensive publications program and a network of public access points.

Along with its continuing commitment to meet the growing and changing earth-science information needs of the Nation, the USGS remains dedicated to its original mission to collect, analyze, interpret, publish, and disseminate information about the natural resources of the Nation--providing "earth science in the public service."

BASIC MISSION AND PROGRAM OF THE WATER RESOURCES DIVISION

The mission of the Water Resources Division is to provide the hydrologic information and understanding needed for the optimum utilization and management of the Nation's water resources for the overall benefit of the people of the United States.

This is accomplished, in large part, through cooperation with other Federal and non-Federal agencies, by:

- Collecting, on a systematic basis, data needed for the continuing determination and evaluation of the quantity, quality, and use of the Nation's water resources.
- Conducting analytical and interpretive water-resource appraisals describing the occurrence, availability, and the physical, chemical, and biological characteristics of surface and ground water.
- Conducting supportive basic and problem-oriented research in hydraulics, hydrology, and related fields of science to improve the scientific basis for investigations and measurement techniques and to understand hydrologic systems sufficiently well to quantitatively predict their response to stress, either natural or manmade.
- Disseminating the water data and the results of these investigations and research through reports, maps, computerized information services, and other forms of public releases.
- Coordinating the activities of Federal agencies in the acquisition of water data for streams, lakes, reservoirs, estuaries, and ground waters.
- Providing scientific and technical assistance in hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Power Commission, and to international agencies on behalf of the Department of State.

TEXAS DISTRICT

Water-resources activities in Texas include collecting hydrologic data, performing interpretive studies, and conducting research. This report describes the activities of the Water Resources Division of the U.S. Geological Survey in Texas for fiscal year 1987 (October 1986 to September 1987).

The Geological Survey's activities related to water resources in Texas are under the general direction of Charles W. Boning, District Chief. The Texas District Office is in the Federal Building, 300 East Eighth Street, Austin, Texas 78701. The program is executed by professional, technical, and administrative staffs in the Austin District Office; Fort Worth, Houston, San Angelo, San Antonio, and Wichita Falls Subdistrict Offices; and Austin and El Paso Field Headquarters Offices. An organizational chart of the Texas District is shown in figure 1.

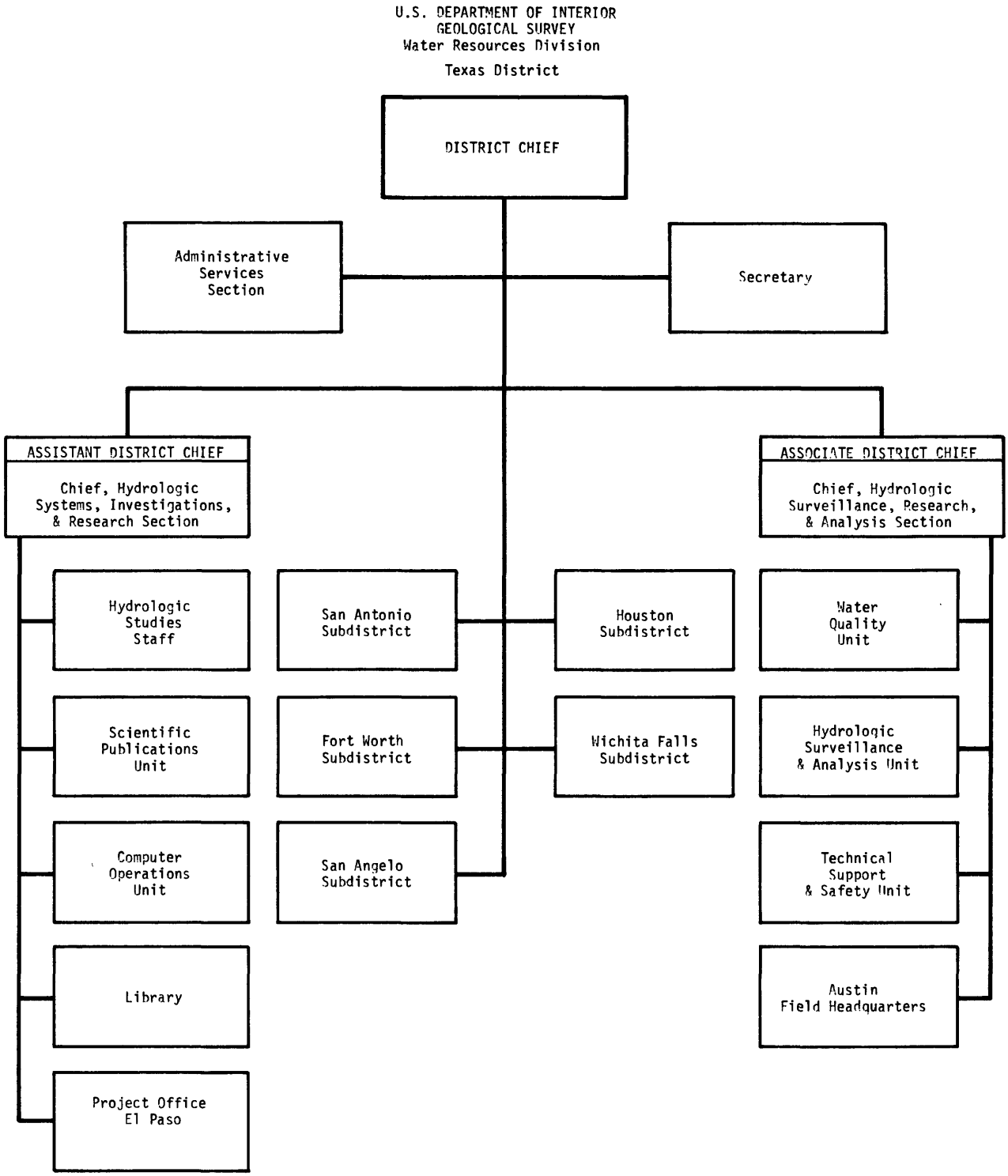

Figure 1.--Organizational chart of the Texas District.

Copies of published and unpublished records, hydrologic data, and some reports may be requested from or through the District Office. Information regarding provisional records of stream discharge prior to publication and other hydrologic data collected within their respective areas may be obtained from the Subdistrict Offices in San Angelo, San Antonio, Fort Worth, Houston, and Wichita Falls, and Field Headquarters in Austin and El Paso. Requests for information should be addressed as follows:

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Cooperating Agencies

The collection of water-resources data and the conduct of interpretive hydrologic investigations are accomplished in cooperation with Federal, State, and local agencies. Those agencies cooperating with the Texas District of the Geological Survey during fiscal year 1987 are:

Federal

Federal Emergency Management Agency
International Boundary and Water Commission, United States and Mexico, U.S. Section
National Park Service
U.S. Air Force, Occupational and Environmental Health Laboratory
U.S. Air Force, Air Training Command
U.S. Army Corps of Engineers, Fort Worth District, Texas
U.S. Army Corps of Engineers, Galveston District, Texas
U.S. Army Corps of Engineers, Tulsa District, Oklahoma
U.S. Army, Fort Bliss, Texas
U.S. Army, Fort Hood, Texas
U.S. Bureau of Reclamation
U.S. Fish and Wildlife Service
U.S. Geological Survey

State

Texas Water Commission. Larry R. Soward, Executive Director; Paul Hopkins, Chairman; Ralph Roming and John O. Houchins, Commissioners.

Texas Water Development Board. M. Regional Arnold III, Executive Administrator: Louie Welch, Chariman; Stuart S. Coleman, Vice Chairman; George M. McCleskey, Glen E. Roney, Thomas M. Dunning, and Charles W. Jenness, Members.

Pecos River Commission. William E. Hale, Commissioner representing the United States and Chairman; B.L. Moody, Commissioner representing Texas; and W. Gerrels, Commissioner representing New Mexico.

Sabine River Compact Administration. J.B. Furrh, Jr., Commissioner representing the United States and Chairman; Raymond J. Palmer and Marty J. Chalbert for Louisiana; and J.T. McMahon and Danny Choate for Texas.

Local

City of:

Abilene	Gainesville	Nacogdoches
Arlington	Garland	Runaway Bay
Austin	Georgetown	San Angelo
Carrollton	Graham	Wichita Falls
Corpus Christi	Houston	
Fort Stockton	Lubbock	

Bexar-Medina-Atascosa Counties Water Improvement District No. 1
Brazos River Authority
City Public Service Board of San Antonio
Coastal Industrial Water Authority
Colorado River Municpal Water District
Dallas/Fort Worth Airport
Dallas Public Works Department
Dallas Water Utilities Department
Edwards Underground Water District
El Paso Public Service Board

Fort Bend County
Franklin County Water District
Galveston County
Greenbelt Muncipal and Industrial Water Authority
Guadalupe-Blanco River Authority
Harris County Flood Control District
Harris-Galveston Coastal Subsidence District
Lower Colorado River Authority
Lower Neches Valley Authority
North Central Texas Municipal Water Authority
Northeast Texas Municipal Water District
Orange County
Red Bluff Water Power Control District
Sabine River Authority of Texas
San Antonio City Water Board
San Antonio Department of Environmental Management
San Antonio River Authority
San Jacinto River Authority
Tarrant County Water Control and Improvement District No. 1
Texas Department of Highways and Public Transportation
Titus County Fresh Water Supply District No. 1
Trinity River Authority
Upper Guadalupe River Authority
Upper Neches River Municipal Water Authority
Upper Trinity Basin Water Quality Compact
West Central Texas Municipal Water District
Wichita County Water Improvement District No. 2

Continuing Hydrologic-Data Collection Programs

Hydrologic-data stations at selected locations throughout Texas are used by the Geological Survey to collect records of stream discharge and stage, reservoir and lake storage, ground-water levels, well and spring discharge, quality of surface and ground water, and suspended sediment loads. Each year, new stations are added and others are terminated; thus, the Water Resources Division has both a current and historical file of hydrologic data for the State. All data collected are stored in the Geological Survey's WATSTORE (National Water Data Storage and Retrieval System) and are available on request. These data can be retrieved in machine-readable form or in the form of computer-printed tables or graphs, statistical summaries, and digital plots. Assistance in the acquisition of information from WATSTORE can be obtained from the District Chief, Water Resources Division in Austin.

The number and type of hydrologic-data stations in Texas during 1987 are given in table 1. All active (January 1987) streamflow, reservoir content, and daily- or continuous-streamflow or reservoir water-quality stations are shown in plate 1. In addition to the stream-gaging stations, the Geological Survey operates 53 continuous-precipitation stations for investigative studies in local areas. Some hydrologic data also are collected for short periods of time in support of investigative studies. These data are published in interpretative reports and are not included in the continuing programs.

The International Boundary and Water Commission, United States and Mexico, operates all streamflow stations on the Rio Grande and near the mouth of its principal tributaries at and downstream from El Paso, Texas. Records collected at these stations are published in an annual bulletin by the Commission and may be obtained from the International Boundary and Water Commission, United States Section, P. O. Box 20003, El Paso, Texas 79998.

Continuing hydrologic data programs are summarized in the following pages. Location maps are shown where appropriate.

Table 1.--Hydrologic-data stations, 1987

Station classification	Total
Surface-water stations	
Discharge:	
a. Continuous record	365
b. Partial record	86
Stage only--streams:	
a. Continuous record	36
b. Partial record	0
Stage only--lakes and reservoirs:	
a. Continuous record	71
b. Partial record	0
Quality:	
a. Continuous record	89
b. Scheduled, long-term operations	208
c. Short-term or project stations	11
Ground-water stations	
Water levels:	
a. Continuous record	34
b. Scheduled, long-term operations	1,035
c. Short-term or project stations	64
Quality:	
a. Scheduled long-term operations	239
b. Short-term or project stations	44

Table 1.--Hydrologic-data stations, 1987--Continued

Station classification	Total
Precipitation stations	
Quantity	53
Quality	2
Sediment stations	
Daily sampling	0
Periodic sampling:	
a. NASQAN	27
b. Other	6
c. Total sediment stations (a + b minus stations in both)	33
Data collection platforms (DCP)	
Operated by U.S. Geological Survey	187
Operated by others	4
Streams or reservoirs	187
Water quality	24
Precipitation	22

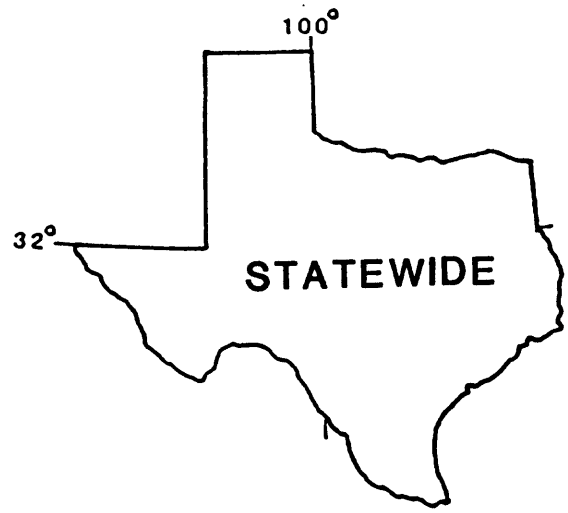
TX 00-001 SURFACE-WATER DATA PROGRAM

COOPERATING AGENCIES : Most of the agencies shown in the list of cooperators.

PROJECT CHIEFS: Jack Rawson and B.C. Massey, District Office, Austin

PERIOD OF PROJECT : Continuing

LOCATION : Statewide



Program: Under the surface-water data program, involving many local, State, and Federal agencies, data are collected for use in surveillance, planning, design, hazard warning, operation, and management in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. Data are collected to satisfy needs for current purposes such as assessments, compact and legal requirements, and research or hydrologic studies. The program also supports studies to define the statistical properties of, and trends in, the occurrence of water in streams, lakes, estuaries, etc. Partial-record gaging is used instead of complete record gaging where it serves data needs. The adequacy of the hydrologic network is reviewed annually and modified as necessary to meet data needs and funding constraints. Surface-water records are computed on a continuing basis and the data are published annually.

A three-phase network analysis has been completed. In the first phase of the study, completed in 1984, data uses and funding for present stations were analyzed. In the second phase, completed in 1986, determinations were made on the feasibility of providing information for specific locations without operating gaging stations. In the third phase, completed in 1986, the strategies considered for minimizing the uncertainty in streamflow information were evaluated. Uncertainty functions were computed for a representative sample of stations in order to relate a realistic value of error to the frequency of discharge measurements. The causes for lost stage records were documented. A final report will be prepared by Headquarters, documenting the results of network analysis studies conducted by the Water Resources Division.

Reports in preparation:

U.S. Geological Survey, 1988, Water resources data--Texas, water year 1987, Arkansas River, Red River, Sabine River, Neches River, and Trinity River basins and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 87-1.

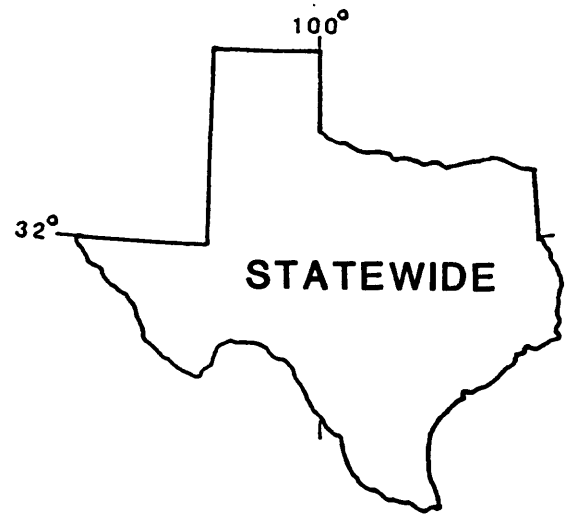
U.S. Geological Survey 1988, Water resources data--Texas, water year 1987, San Jacinto River, Brazos River, and San Bernard River basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 87-2.
------ 1988, Water resources data--Texas, water year 1987, Colorado River, Lavaca River, Guadalupe River, Nueces River, and Rio Grande basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 87-3.

Reports approved or published, 1987

Carrillo, E.R., Buckner, H.D., and Rawson, Jack, 1987, Index of surface-water stations in Texas, January 1987: U.S. Geological Survey Open-File Report 87-468, 16 p.
Mitchell, A.A., 1987, Water-resources activities of the U.S. Geological Survey in Texas--Fiscal years 1985-86: U.S. Geological Survey Open-File Report 86-602, 96 p.
Sladek, Gail J., 1987, Water-Resources reports prepared by the U.S. Geological Survey, Texas District, 1973-86: U.S. Geological Survey Open-File Report 87-228, 40 p.
U.S. Geological Survey, 1987, Water resources data--Texas, water year 1986, Arkansas River, Red River, Sabine River, Neches River, and Trinity River basins and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 86-1, 463 p.
------ 1987, Water resources data--Texas, water year 1986, San Jacinto River, Brazos River, and San Bernard River basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 86-2, 413 p.
------ 1987, Water resources data--Texas, water year 1986, Colorado River, Lavaca River, Guadalupe River, Nueces River, and Rio Grande basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 86-3, 405 p.

TX 00-002 GROUND-WATER DATA PROGRAM

COOPERATING AGENCIES : City of Austin,
U.S. Air Force,
Air Training Command
U.S. Army,
Fort Bliss,
City of Houston,
Edwards Underground
Water District,
El Paso Public
Service Board,
Harris-Galveston
Subsidence District,
Orange County,
San Antonio City
Water Board



PROJECT CHIEF: Jack Rawson,
District Office,
Austin

PERIOD OF PROJECT : Continuing

LOCATION : Statewide

Program: Water levels in wells, discharge of springs and wells, and water-quality data are key characteristics in monitoring ground-water conditions and trends. The continuing hydrologic data from local subprojects TX 00-00210 (Houston ground water), TX 00-00211 (El Paso ground water), TX 00-00213 (San Antonio ground water), TX 00-00222 (Orange County ground water), and TX 00-00263 (Subsidence, Houston area) are collected, compiled, and reported under project TX 00-002 ground-water data program (table 1). In addition to these subprojects, data collection networks are operated in the Austin and Ft. Bliss areas. Technical assistance in evaluating the geohydrology at selected U.S. Air Force bases is being provided to the U.S. Air Force, Air Training Command. A statewide ground-water monitoring program is operated by the Texas Water Development Board. These data are available from the Board.

Reports in preparation: See projects TX 00-00210, TX 00-00211, TX 00-00213, TX 00-00222, and TX 00-00263.

Reports approved or published, 1987: See projects TX 00-00210, TX 00-00211, TX 00-00213, TX 00-00222, and TX 00-00263.

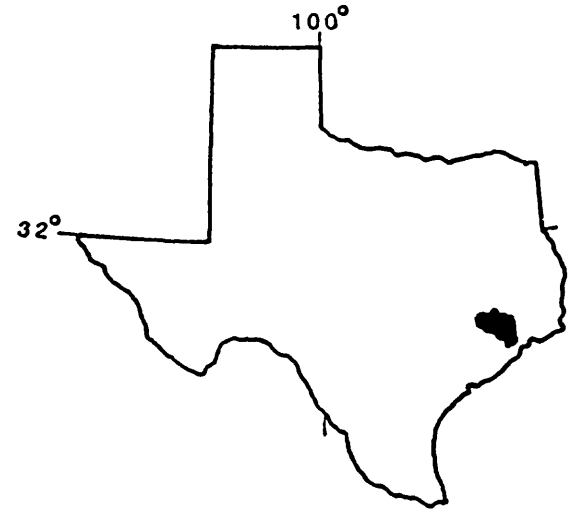
TX 00-00210 GROUND-WATER STUDIES IN THE GREATER HOUSTON AREA

COOPERATING AGENCY : City of Houston

PROJECT CHIEF: James F. Williams, III, Subdistrict Office, Houston

PERIOD OF PROJECT : Continuous since December 1930

LOCATION : Southeast Texas



Problem: Continued ground-water withdrawals in the Houston area cause lower ground-water levels, water-quality changes, and subsidence in heavily pumped localities. Ground-water data are needed to keep abreast of development and to provide data and understanding needed for future planning.

Objective: To provide current up-to-date information on the status of freshwater in the aquifers underlying the greater Houston area and to relate water levels and water-quality changes to increasing ground-water withdrawals in the area.

Approach: Operate and maintain a ground-water level network; inventory new large-diameter wells; inventory annual municipal, industrial, and irrigation pumpage; collect water samples for chemical analysis; continue publication of data; analyze and interpret data; and define cause and effect relationships.

Progress: Hydrologic data have been collected throughout the designated network. Maps of water-level changes and altitudes of the potentiometric surfaces of the Chicot and Evangeline aquifers have been published annually. Five-year updates (1980-84) of data collected have been compiled and published.

Plans: Continue the collection of water-level, new well, and pumpage data. Water samples will be collected annually from 40 wells in areas near salt domes, chloride concentrations will be determined and specific conductance will be measured. Maps of water-level changes and potentiometric altitudes will be prepared annually. The next 5-year update describing the effects of ground water development will include the period 1985-89. Water-level and well-schedule data will be entered into WATSTORE.

Reports in preperation: None.

Reports approved or published, 1987:

Williams, James F., III, Coplin, L.S., Ranzau, C.E., Lind, W.B., Bonnet, C.W., and Locke, G.L., (in press), Records of wells, drillers' logs, water-level measurements, and chemical analyses of ground-water in Harris and Galveston Counties, Texas, 1980-87: U.S. Geological Survey Open-File Report 87-378.

Reports approved or published, 1987--Continued

Williams, James F., III, Lind, W.B., and Coplin, L.S., 1987, Approximate altitude of water-levels in the Chicot and Evangeline aquifers in the Houston area, Texas, Spring 1987: U.S. Geological Survey Open-File Report 87-233, 2 sheets.

Williams, James F., III, and Ranzau, C.E., Jr., 1987, Ground-water withdrawals and changes in ground-water levels, and land-surface subsidence in the Houston district, Texas, 1980-84: U.S. Geological Survey Water-Resources Investigations Report 87-4153, 56 p.

Williams, James F., III, Ranzau, C.E., Jr., and Lind, W.B., 1987, Approximate water-levels changes in wells completed in the Chicot and Evangeline aquifers, 1977-87 and 1986-87, and measured compaction, 1973-87, in the Houston-Galveston region: U.S. Geological Survey Open-File Report 87-108, 7 sheets.

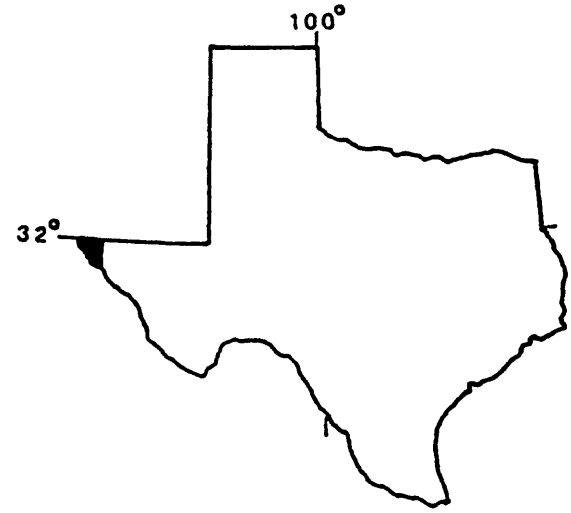
TX 00-00211 GROUND-WATER STUDIES IN THE EL PASO AREA

COOPERATING AGENCY : El Paso Public Service Board
U.S. Army, Fort Bliss

PROJECT CHIEF: Donald E. White, Project Office, El Paso

PERIOD OF PROJECT : Continuous since January 1930

LOCATION : West Texas



Problem: Supplying water for the continued growth in El Paso, Ciudad Juarez, Mexico, and Fort Bliss Military Reservation is stressing the ground-water resources from which the majority of their water supplies are obtained. The potential for salinewater encroachment and land-surface subsidence is increasing with increased pumping from the Hueco bolson and Mesilla bolson aquifers.

Objective: To provide current information on the quantity and quality of water in the aquifers underlying the greater El Paso area.

Approach: Operate and maintain a ground-water level network, with modifications as appropriate; inventory new large diameter wells; collect water samples for chemical analysis; determine withdrawals; and publish the data.

Progress: Hydrologic data have been collected throughout the area.

Plans: Continue the collection of water-level, water-quality, new-well, and pumpage data. Prepare a data summary report to present the data collected since the last summary data report.

Reports in preparation:

White, D.E., Hydrologic data summary of ground-water data in the El Paso area, Texas, 1977-86: U.S. Geological Survey Open-File Report.

Reports approved or published, 1987: None

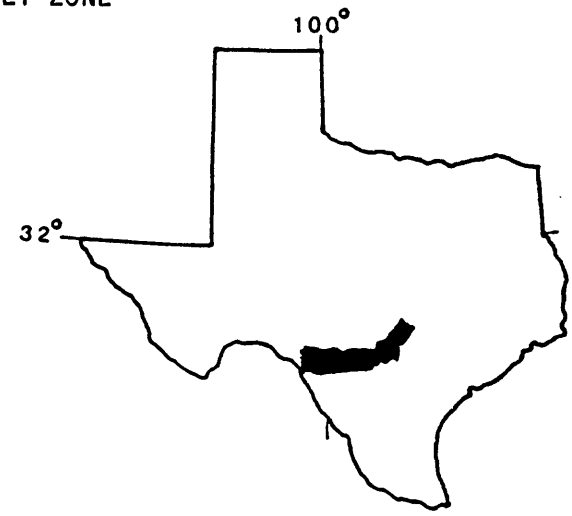
TX 00-00213 GROUND-WATER STUDIES OF THE SAN ANTONIO AREA AND BALCONES FAULT ZONE

COOPERATING AGENCIES : Edwards Underground Water District,

PROJECT CHIEF: Paul L. Rettman, Subdistrict Office, San Antonio

PERIOD OF PROJECT : Continuous since January 1949

LOCATION : South central Texas



Problem: The Edwards aquifer supplies nearly all of the water in the six-county area from Brackettville in Kinney County to Kyle in Hays County, an area about 180 miles long and from 5 to 40 miles wide. Because the Edwards aquifer supplies large quantities of water for irrigation and is the sole source of water for approximately 1.5 million people, it has been designated by the U.S. Environmental Protection Agency as a sole-source aquifer. Projected growth and increasing water demands on the aquifer may cause water levels to decline until virtually all spring flows cease. Increased pumpage from the aquifer also may result in the encroachment of mineralized water into its freshwater zone. In addition, rapid urban development in or adjacent to the recharge area will increase the possibilities for pollutants to enter the aquifer. Consequently, a broad ground-water and water-quality data base is essential for present and long-range planning for the development and management of the aquifer.

Objective: To appraise quantitatively the ground-water resources in the Edwards and associated limestones, to continue to investigate the cause-effect relationships operating in the Edwards aquifer, and to determine the extent of contamination.

Approach: The following approach is used: Measuring water levels; compiling and analyzing water-stage records; collecting and compiling records of rainfall; inventorying municipal, industrial, military, and irrigation pumpage and spring discharge; determining recharge to the Edwards aquifer; collecting water samples for chemical and tritium analyses and inorganic, biologic, pesticide, and minor element determinations; and mapping subsurface geology.

Progress: Hydrologic data were collected and compiled from a network of stream-gaging stations and wells as scheduled. Monitoring to date has not shown any significant change in the quality of ground water throughout most of the aquifer. There are, however, localized areas contaminated by trace concentrations of organic compounds. The extent and number of localized areas of contamination can be expected to increase as urban development alters the quality of runoff

in the recharge zone of the aquifer. Because of concern that increased withdrawals from the aquifer may result in the encroachment of mineralized water in the freshwater zone of the aquifer, a program was begun in 1984 to resample wells along the "bad-water" line in order to detect changes in water quality as the potentiometric head in the aquifer changes.

Plans: Plans include the following activities: Collecting water-level and pumpage data, inventorying wells; collecting water samples to determine the possible pollution of water in the aquifer from urban development and from the encroachment of mineralized water into the freshwater zone; preparing a basic-data report; and entering current and historic data into the Survey's computerized data base WASTORE.

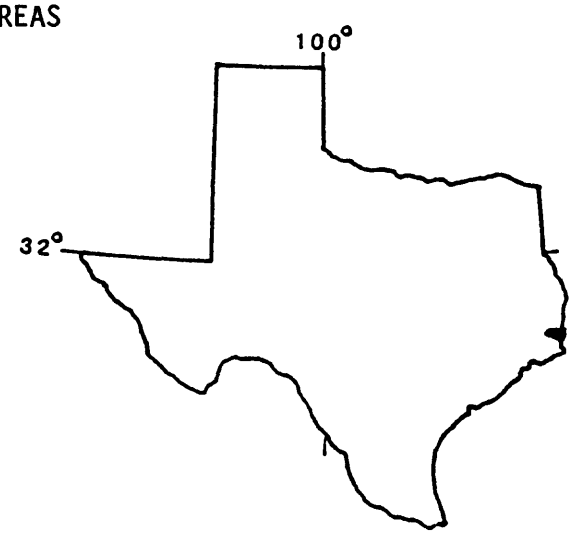
Reports in preparation:

Ozuna, G.B., and others, 1988, Hydrologic data of the Edwards aquifer, San Antonio area, Texas, 1986: U.S. Geological Survey Open-File Report.
Roddy, W.R., Water-quality of the Edwards aquifer system in the San Antonio area: U.S. Geological Survey Water Resources Investigations Report.

Reports approved or published, 1987:

Burchett, C.R., Rettman, P.L., and Boning, C.W., 1986, The Edwards aquifer, extremely productive, but....a sole source water supply for San Antonio and surrounding counties in south-central Texas: Edwards Underground Water District Report, 38 p.
Ozuna, G.B., Nalley, G.M., and Bowman, M.N., 1987, Compilation of hydrologic data for the Edwards aquifer, San Antonio area, Texas, 1986, with 1934-85 summary: Edwards Underground Water District Bulletin 45, 163 p., 5 plates.

TX 00-00222 GROUND-WATER STUDIES IN ORANGE COUNTY AND ADJACENT AREAS



COOPERATING AGENCY : Orange County

PROJECT CHIEF: Charles W. Bonnet, Subdistrict Office, Houston

PERIOD OF PROJECT : Continuous since September 1967.

LOCATION : East Texas

Problem: Pumpage of ground water for industrial and municipal use in Orange County has resulted in saltwater encroachment in some heavily pumped areas. A continued program of ground-water data collection is needed to define the areas impacted and to provide data for guidance in future development of ground water in the county and prevention of saltwater intrusion.

Objective: To collect and analyze ground-water data in the Orange County area and provide the county with current, up-to-date information on its ground-water resources; and to monitor the freshwater-saltwater interface.

Approach: To operate and maintain a network of observation wells for monitoring changes in water levels and changes in chemical quality, especially chlorides; to inventory all new, large-capacity wells and compile drillers' logs; to conduct an annual inventory of pumpage for municipal and industrial use; and to continue publication of data and correlate current data with previously collected data.

Progress: Water samples were collected from observation wells in the fall of each year and analyzed to determine changes in chemical properties. Water levels were measured in the spring and in the fall to record the effects of ground-water withdrawals in the summer. The annual pumpage inventory was conducted, and the inventory of new wells was continued.

Plans: Continue data collection with emphasis on saltwater encroachment, which is the principal ground-water problem in the study area.

Reports in preparation: None.

Reports approved or published, 1987:

Bonnet, C.W., and Williams, James F., III, (in press), Development of ground water resources in the Orange County area, Texas and Louisiana, 1980-Spring of 1985: U.S. Geological Survey Water-Resources Investigations Report 87-4158.

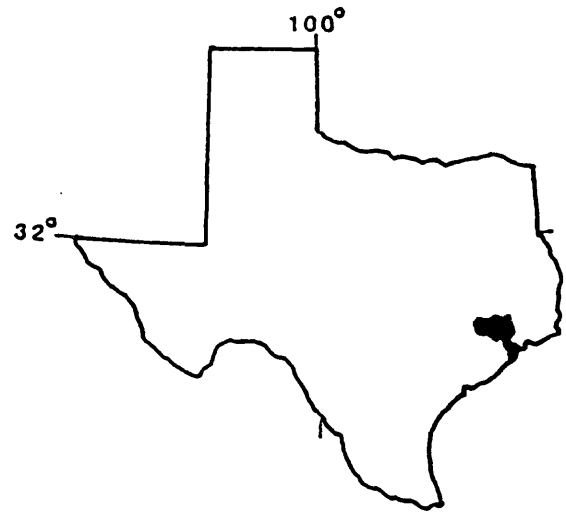
TX 00-00263 SUBSIDENCE STUDIES ALONG THE TEXAS GULF COAST

COOPERATING AGENCY : Harris-Galveston Coastal Subsidence District

PROJECT CHIEF: James F. Williams, III, Subdistrict Office, Houston

PERIOD OF PROJECT : Continuous since October 1976

LOCATION : Southeast Texas



Problem: A large part of the Texas Gulf Coast is experiencing land-surface subsidence. In the northern part of the Gulf Coast, an area of about 1,355 square miles has subsided 1 foot or more since 1943. The area of maximum subsidence is near Pasadena where 9 feet of subsidence occurred between 1943 and 1978. As a result of subsidence, some low-lying areas along Galveston Bay are subject to inundation by normal tides, and an even larger part of the region may be subject to catastrophic flooding by hurricane tides. Recent faulting has been related to ground-water withdrawal. Subsidence and faulting may be altering drainage patterns in upland watersheds.

Objectives: To determine the magnitude and extent of land-surface subsidence due to the withdrawals of ground water and to determine the possible relationship between faulting, land-surface subsidence, and drainage changes at elevations not subject to flooding by tidal waters.

Approach: Continue the data-collection and research effort including the following: Data collection at the network of extensiometers; annual resurveying of the network of marks to measure horizontal strain and preliminary analysis of these data; updating specific unit-compaction values, investigating the relationship of aquifer conditions and ground-water withdrawals; and determining changes in drainage patterns.

Progress: Data have been collected to measure compaction, horizontal strain, and changes in stress at a network of sites. A comprehensive report has been prepared describing subsidence to 1980.

Plans: Hydrologic, horizontal survey, and extensometer data collection will be continued to better define the relationship between ground-water withdrawal and land-surface subsidence. Analysis of horizontal strain data and localized subsidence effects on drainage is planned. A report describing subsidence during the 1906-87 period with emphasis on the 1977-87 period will be prepared in 1988. A report of subsidence and water-level changes during 1987 will be prepared for the annual hearing of the Harris-Galveston Coastal Subsidence District in March 1988.

Reports in preparation:

Gabrysch, R.K., 1988, Update of the relationship of land-surface subsidence and ground-water withdrawals in the Houston region, 1987: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None.

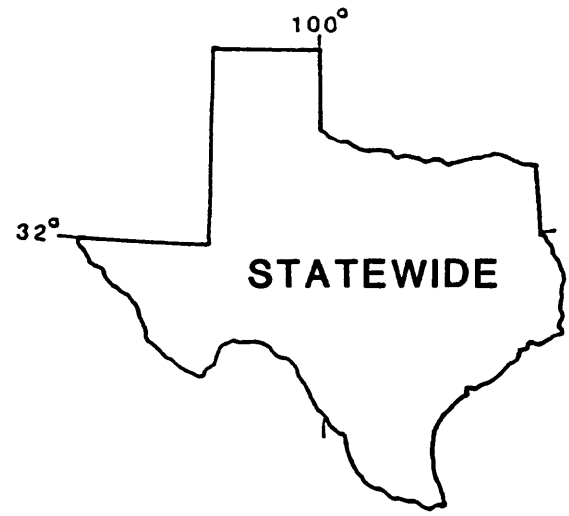
TX 00-003 QUALITY OF WATER DATA PROGRAM

COOPERATING AGENCIES : Most of the agencies shown in the list of cooperators

PROJECT CHIEF: Frank Wells, District Office, Austin

PERIOD OF PROJECT : Continuous

LOCATION : Statewide



Program: Data collected for the water-quality program is used to help inventory, assess, and plan the proper development, management, and utilization of the water resources of the State. Rapid economic growth, population expansion, and increasing use of water for municipal, industrial, and agricultural purposes could cause the quality of the State's water to be degraded. Changes in atmospheric composition due to increased use of fossil fuels may lead to acid precipitation and alteration of the quality of runoff. Continuing development of areas around lakes and reservoirs may result in increases of nutrients, eutrophication, and related nuisance conditions. Ninety-seven of the approximately 200 water-quality monitoring sites are part of the NASQAN (National Stream-Quality Accounting Network), which is used to detect nationwide trends in water quality throughout the United States.

The adequacy of the continuing water-quality data program is reviewed annually and modified as necessary to provide a baseline of selected chemical, biological, and physical data required to satisfy local, State, and national needs.

Reports in preparation:

U.S. Geological Survey, 1988, Water resources data--Texas, water year 1987, Arkansas River, Red River, Sabine River, Neches River, and Trinity River basins and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 87-1.

------- 1988, Water resources data--Texas, water year 1987, San Jacinto River, Brazos River, and San Bernard River basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 87-2.

------- 1988, Water resources data--Texas, water year 1987, Colorado River, Lavaca River, Guadalupe River, Nueces River, and Rio Grande basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 87-3.

Reports approved or published, 1987:

Goss, R.L., 1987, Statistical and graphical summaries of selected water-quality and streamflow data from the Trinity River near Crockett, Texas, 1964-85: U.S. Geological Survey Open-File Report 87-393, 21 p.

Liscum, Fred, Goss, R.L., Paul, E.M., 1987, Effects on water quality due to flood-water detention by Barker and Addicks Reservoirs, Houston, Texas: U.S. Geological Survey Water-Resources Investigations Report 86-4356, 96 p.

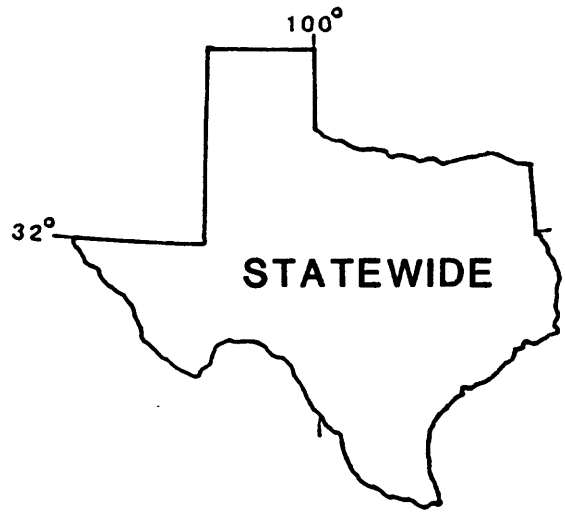
TX 00-004 SEDIMENT DATA PROGRAM

COOPERATING AGENCIES : U.S. Army Corps of Engineers

PROJECT CHIEF: Freeman L. Andrews, District Office, Austin

PERIOD OF PROJECT : Continuous

LOCATION : Statewide



Program: Data collected in the sediment data continuing program are used for inventorying and defining sediment concentrations and discharges in rivers and streams. Rapid economic growth, population expansion, brush clearing, construction, and changes in land use could cause a change in the averages and trends in concentration, discharge, and particle size of sediment being transported by the rivers and streams. Sediment data are obtained from a network of about 41 stations, under varying flow conditions, to define particle size distribution of suspended sediment and bed material.

This continuing sediment data program is reviewed annually and modified as necessary to provide a base for specific studies by Federal, State, and local agencies.

Reports in preparation:

U.S. Geological Survey, 1988, Water resources data--Texas, water year 1987, Arkansas River, Red River, Sabine River, Neches River, and Trinity River basins and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 87-1.

------ 1988, Water resources data--Texas, water year 1987, San Jacinto River, Brazos River, and San Bernard River basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 87-2.

------ 1988, Water resources data--Texas, water year 1987, Colorado River, Lavaca River, Guadalupe River, Nueces River, and Rio Grande basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 87-3.

Andrews, Freeman L., 1987, Monthly and annual suspended-sediment loads in the Brazos River at Richmond, Texas, 1966-86 water years, U.S. Geological Survey Water Resources Investigations Report.

Reports approved or published, 1987:

Leibbrand, Norman F., 1987, Estimated sediment deposition in Lake Corpus Christi, Texas, 1972-85: U.S. Geological Survey Open-File Report 87-239, 26 p.

U.S. Geological Survey, 1987, Water resources data--Texas, water year 1986, Arkansas River, Red River, Sabine River, Neches River, and Trinity River basins and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 86-1, 463 p.

------ 1987, Water resources data--Texas, water year 1986, San Jacinto River, Brazos River, and San Bernard River basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 86-2, 413 p.

------ 1987, Water resources data--Texas, water year 1986, Colorado River, Lavaca River, Guadalupe River, Nueces River, and Rio Grande basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 86-3, 405 p.

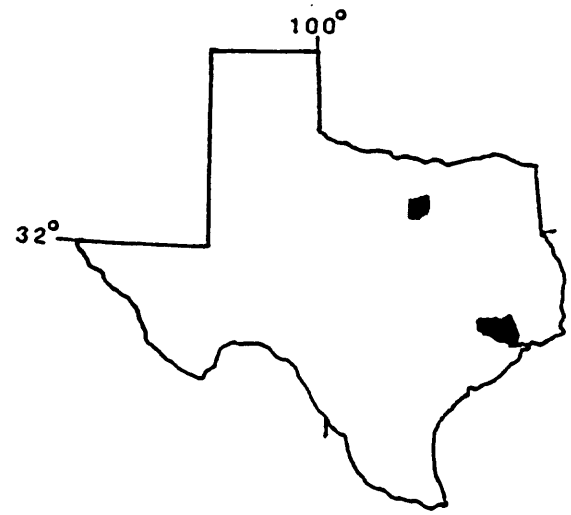
TX 00-005 NATIONAL TRENDS NETWORK STATIONS

COOPERATING AGENCY : U.S. Geological Survey

PROJECT CHIEF: Frank C. Wells, District Office, Austin

PERIOD OF PROJECT : Continuous since 1983

LOCATION : Northeast central and southeast central Texas



Problem: There is a potential for damage to the environment from acid rain and more knowledge of precipitation chemistry and resulting effects on the environment in the Nation are necessary to help avert future problems.

Objective: To determine variations in atmospheric deposition that occur on a week-to-week basis, and collect wet and dry deposition products for analysis of elements and compounds that can contribute to the chemical composition of surface waters.

Approach: Monitoring stations were established as part of the National Trends Network. Personnel maintain stations, make onsite measurements, process samples, and submit samples to an analytical laboratory. Data retrievals are verified and reports on the results are prepared.

Progress: Two monitoring stations have been established in the Fort Worth Subdistrict and in the Houston Subdistrict. The data are collected on a weekly basis.

Plans: Plans are to continue to collect data from the two sites and transmit samples of atmospheric deposition to the laboratory for analysis. Reports will be prepared at the regional and national levels.

Reports in preparation: None.

Reports approved or published, 1987:

Lins, Harry F., Lamfear, Kenneth J., and Schertz, Terry L., 1987, Patterns of acid despoition variability in the eastern United States, 1981-84: U.S. Geological Survey Open-File Report 87-454, 16 p.

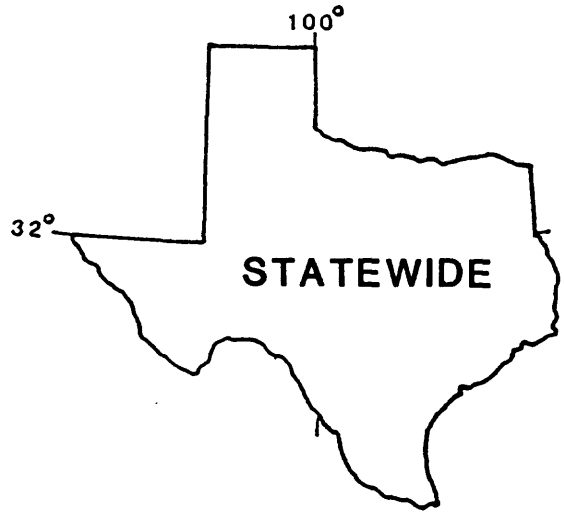
TX 00-006 FLOOD INVESTIGATIONS

COOPERATING AGENCY : Federal Emergency Management Agency

PROJECT CHIEF: B. C. Massey, District Office, Austin

PERIOD OF PROJECT : Continuing

LOCATION : Statewide



Problem: The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 provides a flood insurance program. The Federal Emergency Management Agency (FEMA) needs to know the extent of flooding for given recurrence intervals in selected areas to determine applicable flood insurance premium rates.

Objectives: To conduct the necessary hydrologic and hydraulic evaluations and studies of areas assigned by FEMA and to report the results.

Approach: To conduct the necessary evaluations by making surveys by ground or photogrammetric methods and applying appropriate engineering techniques. Determine flood-discharge frequency relationships using historical information. Determine water-surface profiles using step-backwater streamflow models or by other acceptable methods. Furnish the results in reports to FEMA.

Progress: The Hood County Limited Detail Federal Insurance Study was completed and submitted to FEMA in March, 1987. Limited Detail flood insurance studies are now in progress for Kaufman and Hunt Counties, and for the cities of Del Rio, Poteet, and Alpine. Field data collection for these studies is about 95 percent complete and computer data files are now being prepared for the hydraulics computations. The completion dates for these studies range from Sept. 1987 for the city of Poteet study to March 1989 for the Kaufman County study.

Plans: The work effort in the next few months will be directed toward completing the hydraulic computations and preparing the maps.

Reports in progress: None.

Reports approved or published, 1987: None.

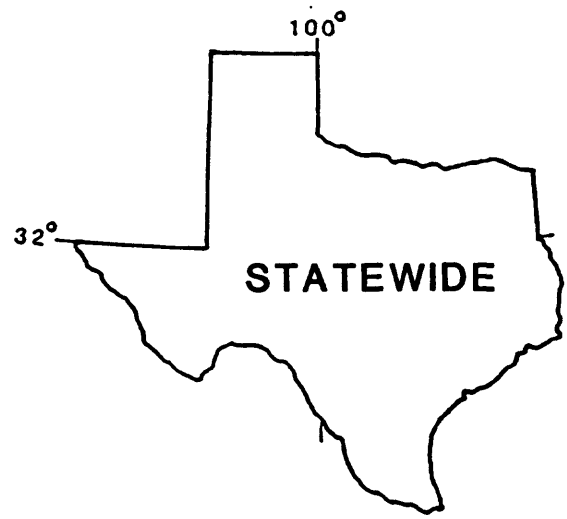
TX 78-007 WATER-USE DATA PROGRAM

COOPERATING AGENCIES : Texas Water Development Board,
City of Houston,
Federal,
Edwards Underground Water District,
El Paso Public Service Board,
Harris-Glaveston Coastal, Subsidence District,

PROJECT CHIEF: Dee L. Lurry,
District Office,
Austin

PERIOD OF PROJECT : Continuing

LOCATION : Statewide



Problem: Texas waters are undergoing increasing demands for domestic, industrial, agricultural, and other uses, and concerns for greater protection of water quality are increasing. Adequate information on uses of water, to complement that being collected to describe the quantity and quality of water, will ultimately aid decision makers in resolving many critical water problems such as resource allocation, environmental impact, energy development, and resource development.

Objectives: The primary objective of this project is to transfer water-use data from the Texas Water Development Board (TWDB) computerized data base to the USGS National Water-Use Data System (NWUDS). A secondary objective is to continue a program at the State level that collects and compiles water-use data and develop and operate a State-level computer data handling system to disseminate data to local users. A third objective is to estimate annual water use for 12 categories for inclusion in reports on water use in Texas and use by U.S. Geological Survey project personnel.

Approach: The project responsibilities are divided between the USGS and TWDB. Direction, management, and standards development to meet the national needs will be the responsibility of the USGS while the State needs will be the responsibility of the TWDB. The major operational responsibilities of the USGS include developing computer software for reformatting and recoding the water-use data from TWDB computer tapes for loading to NWUDS and loading the data set to NWUDS for a recent and complete year. The major operational responsibility of the TWDB is to copy selected water-use data to computer tape(s) from existing TWDB data files.

estimation. Annually, the TWDB has prepared a computerized data tape for use by the USGS. Water use for 1985 for 12 categories was assimilated by U.S. Geological Survey personnel and submitted to Reston for inclusion in the national water use report entitled "Estimated use of water in the United States, 1985."

Plans: The TWDB is continuing to collect water-use data by identified categories. The Geological Survey will also prepare an atlas for publication which will present the latest available State water use data.

Reports in preparation:

Barber, N.L., Slade, R.M., Jr., and Lurry, Dee L., Estimated water use in Texas, 1985: U.S. Geological Survey Hydrologic Investigations Atlas.
Lurry, Dee L., 1987, Statistical summary of water use in Texas, 1985: U.S. Geological Survey Open-File Report.

Reports approved or published, 1987: None.

Hydrologic Investigative and Research Programs

To accomplish the mission of conducting analytical and interpretive water-resources appraisals and basic and problem-oriented research, the Geological Survey conducts the hydrologic investigative and research programs. These programs may concentrate on either the ground-water, surface-water, or quality of water disciplines or integrate any combination of them. Often specialized data-collection efforts are part of the individual program. The areal extent for a study ranges from a county or smaller area to several states. These programs generally are 1 to 5 years in duration, but may last over 10 years if substantial data collection is required. Each program is concluded with one or more interpretive reports. Often intermediate data reports are published.

The investigative and research programs in Texas are described in the following pages. The summaries include currently funded projects as well as other projects that have reports in preparation or published in 1987.

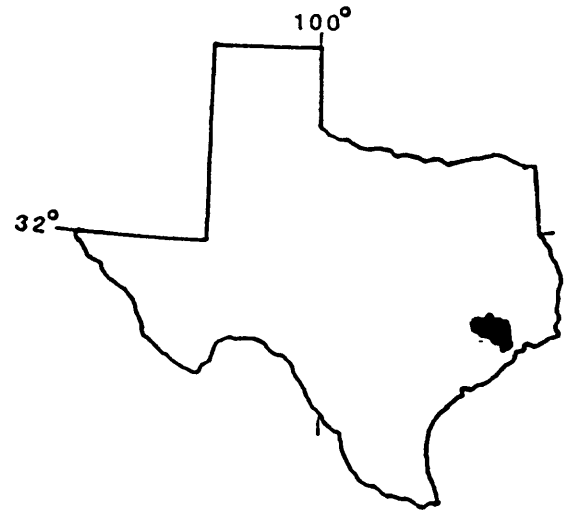
TX 65-028 URBAN HYDROLOGY STUDY IN THE HOUSTON METROPOLITAN AREA

COOPERATING AGENCIES : City of Houston

PROJECT CHIEF: Fred Liscum, Subdistrict Office, Houston

PERIOD OF PROJECT : July 1964 to September 1988

LOCATION : Southeast Texas



Problem: The city of Houston experiences severe flood problems associated with storm runoff. The quality of water discharged from urbanized areas is of concern also. Additional hydrologic data are needed to make adequate decisions for controlling peak runoff, for establishing land-use practices to minimize the adverse impacts of runoff water quality on receiving streams and assessing land-surface subsidence and urbanization on flooding magnitude and frequency.

Objectives: To collect hydrologic data for studies to determine the effects of urbanization on flood discharge and total runoff with variations in rainfall patterns, rainfall intensity, and drainage areas; to delineate actual floods to determine flood hazard areas; to provide water-quality data for selected areas of differing land use from water samples collected during runoff events that differ by season and magnitude; to establish techniques for predicting flood frequencies in an urbanizing area; and to determine the effects of various land uses on the water quality of storm runoff.

Approach: Drainage basins with different hydrologic characteristics were instrumented to collect simultaneous rainfall-runoff data. Field surveys were conducted to determine areas affected by unusual floods. Water-quality samples were collected in selected areas to reflect the relation between water quality, land use, season, and flood magnitude. Regression analyses will be used to determine possible relations between flood-peak magnitude or flood-runoff volumes and drainage-basin characteristics. Mathematical models will be used to determine the effects of urbanization in this coastal area.

Progress: Hydrologic data have been collected for 19 years at approximately 30 stations gaging flow from watersheds ranging from 0.1 to 182 square miles in size. Reconnaissance water-quality data were collected for 1968 to 1978. Beginning in 1979, detailed water-quality data were collected from stations with definable land uses. These data have been presented in data publications and analyzed in reports presenting techniques to predict flood frequencies and to estimate the quantity and quality of runoffs from this urbanizing area.

Plans: Most of the hydrologic data-collection effort came to an end in fiscal year 1984. Water-quality data at several sites where land use can be defined will continue to be collected. A report presenting the effects of urbanization on the surface-water hydrologic response of the area will be completed.

Future plans include reports on (1) statistical summary and review of the hydrologic data, and (2) predicting contributions to receiving channel water quality from single land-use nonpoint sources.

Reports in preparation:

Liscum, Fred, Effects of urbanization on surface-water hydrologic response in a coastal urban area, Houston, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Liscum, Fred, Bruchmiller, J.P., and Brown, D.W., Statistical summary of hydrologic data for urban studies in the Houston, metropolitan area, Texas, 1964-84: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987:

Liscum, Fred, Bruchmiller, J.P., Brown, D.W., and Paul, E.M., 1987, Hydrologic data for urban studies in the Houston metropolitan area, Texas, 1984: U.S. Geological Survey Open-File Report 86-608, 190 p.

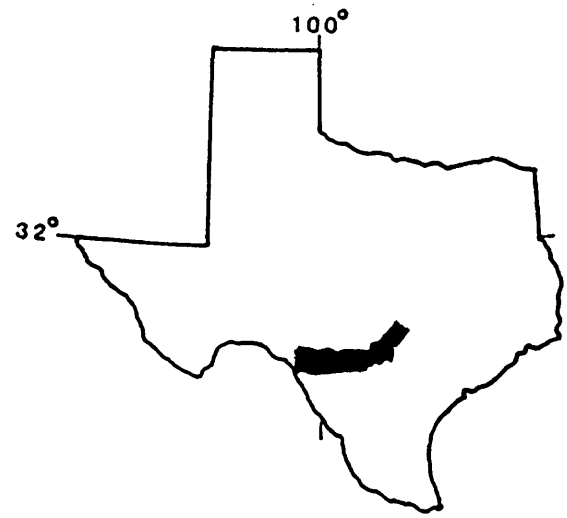
TX 70-032 LIMESTONE HYDROLOGY STUDY, SAN ANTONIO AREA

COOPERATING AGENCIES : San Antonio City Water Board, Texas Water Development Board

PROJECT CHIEF: Robert W. Maclay, Subdistrict Office, San Antonio

PERIOD OF PROJECT : October 1970 to September 1985

LOCATION : Southwest central Texas



Problem: The Edwards aquifer is the major source of water for over 1 million people in the San Antonio area. There is a need for detailed information concerning this aquifer which can be used by agencies concerned with water management. Some of the questions that need to be answered are: (1) What is the storage capacity of the Edwards aquifer reservoir at levels below the historic low water conditions; (2) to what extent will highly mineralized water move into the freshwater zone if water levels are lowered; (3) can management of the aquifer by selective pumping and/or recharge keep Comal and San Marcos Springs flowing at reasonable rates; (4) what are the possibilities for artificial recharge; and (5) what is the best way of integrating the use of ground water and surface water for the greatest dependable supply of water.

Objectives: (1) To document a mathematical ground-water flow model of the Edwards aquifer in the San Antonio area to test hydrologic concepts and improve the understanding of the aquifer system, (2) to quantify transmissivities and storage coefficients, and (3) to develop a tool by which to evaluate the data-collection program.

Approach: Knowledge previously acquired on the nature of stratification of the Edwards Limestone, the areal distribution of the depositional regions of the lower Cretaceous rocks, and the locations of major vertical offsets of the Edwards along faults will be interpreted as to their hydrologic significance, and these interpretations are to be incorporated into the conceptual model of the aquifer.

The numerical modeling phase will consist of steady-state simulations of the eastern half, the western half, and the complete system. The model will be calibrated by comparing computed water levels with measured water levels for a year (1973) when annual recharge approximately equaled annual discharge. Simulation of spring flow, water levels, and the water balance are used as the basis for evaluating the quality of calibration and the acceptance or rejection of hydrogeologic concepts. The effects of internal barriers, the validity of the model routing patterns of ground-water flow, the possible occurrence of

Project summary: The project has been completed. A numerical model of the Edwards aquifer in the San Antonio area that incorporated a representation of the anisotropic property of the aquifer caused by specific barrier faults was documented. The model demonstrated the highly significant effect of barrier faults on retaining ground-water storage within the unconfined aquifer and on the local direction of ground-water flow. Three major flow regions within the San Antonio area were identified using computer-generated flux vectors that represent magnitude and direction from each cell block.

The model tested concepts relating to specific structural controls on direction of ground-water flow and demonstrated the great significance of the Knippa gap on the control of ground-water flow from Uvalde and Medina Counties. Calibration of the model that incorporated a specific yield of 5 percent provided an acceptable solution of computed heads and springflows. The model studies indicated that additional underflow may occur to the Edwards aquifer from the Lower Glen Rose in the vicinity of the Haby Crossing fault in northeastern Medina County and in the vicinity of the Hueco Springs fault in Comal County. Model studies also indicated that unmeasured outflow of ground water from the aquifer may occur in the vicinity of Tom Nunn Hill, east of the town of Uvalde.

Reports in progress: None.

Reports approved or published, 1987:

Maclay, R.W. and Land, L.F., 1987, Simulation of flow in the Edwards aquifer, San Antonio region, Texas, and refinement of storage and flow concepts: U.S. Geological Survey Open-File Report 86-532, 86 p.

Maclay, R.W., and Land, L.F., (in press) Simulation of flow in the Edwards aquifer, San Antonio region, Texas, and refinement of storage and flow concepts: U.S. Geological Survey Water-Supply Paper.

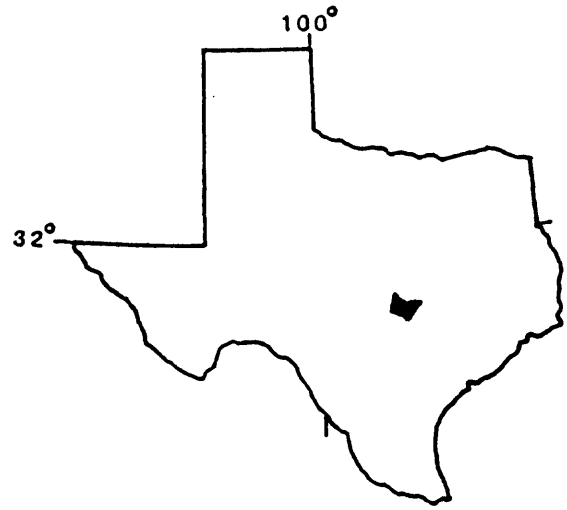
TX 75-060 URBAN HYDROLOGY STUDY IN THE AUSTIN METROPOLITAN AREA

COOPERATING AGENCY : City of Austin

PROJECT CHIEF: Raymond M. Slade, Jr., District Office, Austin

PERIOD OF PROJECT : Surface-water study, September 1974 to September 1986. Ground-water study, October 1978 to September 1983

LOCATION : Central Texas



Surface-Water Study:

Problem: Urban hydrology studies throughout the Nation have shown that increases in impervious cover resulting from urbanization generally tend to increase the magnitude and peak flows of surface runoff, and the development of land tends to cause degradation of the quality of runoff. City officials are concerned about the possible adverse effects of increasing urbanization on the quantity and quality of storm runoff in the Austin area. Relationships between measures of urbanization (density, land use, etc.) and storm runoff volumes and rates, and water-quality characteristics are needed. This information is needed to help minimize the environmental impacts and to provide criteria for controlling urban flooding and water-quality degradation.

Objectives: To determine the magnitude and frequency of flood peaks, to determine the effects of urban development and watershed characteristics on flood peaks, to determine the water-quality characteristics of selected watersheds with different land uses, and to describe the water-quality characteristics of Lake Austin and Town Lake.

Approach: Drainage basins are instrumented to collect rainfall and runoff data; water-quality samples of runoff are being analyzed for nutrients, physical organic and inorganic compounds, indicator bacteria, inorganic chemical constituents, minor elements, and pesticides. Modeling and statistical techniques were used to develop a procedure for estimating flooding in ungaged watersheds. Statistical techniques are being used to relate water-quality characteristics to land use. This project is closely related to project TX 82-076 (completed).

Progress: Hydrologic and water-quality data have been gathered and published in annual data reports. A report which meets the first two objectives of this study has been completed. Drafts of reports for the last two objectives have been prepared. The last data report is in review.

Reports in preparation:

Andrews, F.L., and others, Water quality of Lake Austin and Town Lake in the Austin area, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Gordon, J.D., Jr., and others, Hydrologic data for urban studies in the Austin metropolitan area, 1986: U.S. Geological Survey Open-File Report.

Veenhuis, J.E., and Slade, R.M., Jr., Analysis of storm-runoff quality for small watersheds in the Austin area, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987:

Gordon, J.D., Pate, D.L., Dorsey, M.E., 1987, Hydrologic data for urban studies in the Austin, Texas, metropolitan area, 1985: U.S. Geological Survey Open-File Report 87-224, 170 p.

Ground-Water Study:

Problem: Barton Springs is a major recreational area. Specific ground-water information concerning recharge, storage, movement, and discharge is needed to provide criteria for regulating development within the aquifer area so that the ground-water resources can be preserved. Of particular interest is Barton Springs because it is a major recreational area, is the major point of discharge from the Edwards aquifer, and is a source of water for the city.

Objective: To appraise quantitatively the ground-water resources of the Edwards aquifer that relate to Barton Springs and to determine the effect of urbanization on the quality and quantity of the water in the Edwards aquifer.

Approach: Hydrologic characteristics of the aquifer are being determined by drilling test holes, inventorying geophysical and drillers' logs, measuring water levels, and inventorying pumpage and springs. Water-quality data from wells are collected to define areal and temporal variations in the ground-water quality. Mathematical modeling techniques were used to test and develop concepts and determine how the aquifer will respond to stresses. This study is closely related to projects TX 82-072 (completed), TX 84-089, and TX 85-093.

Project summary: Two reports published prior to 1987 present the results of this study. One report presents the hydrogeologic characteristics of the study area. The hydrogeologic framework, as well as data and information concerning recharge, ground-water movement, and discharge are discribed. The quality of recharge, ground water, and discharge waters is described also. The second report describes a ground-water model that was used to determine the hydraulic characteristics of the aquifer. Population projections were used to estimate future water-use demands of the aquifer, which were used with the hydraulic characteristics to estimate future ground-water levels.

Reports in preparation: None.

Reports approved or published, 1987: None.

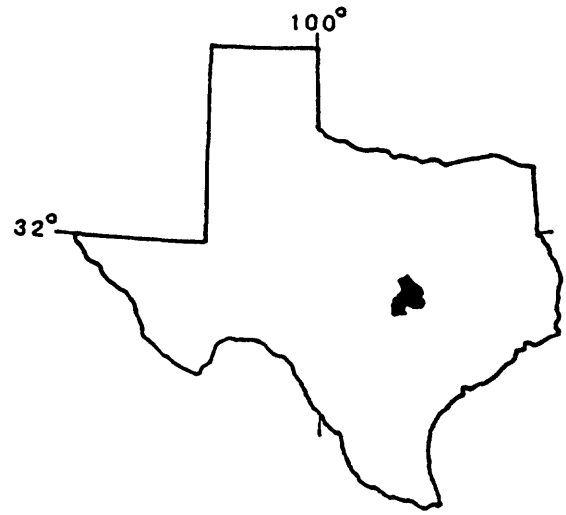
TX 78-067 GROUND-WATER RESOURCES OF THE EDWARDS AQUIFER SYSTEM
NORTHERN TRAVIS, SOUTHERN BELL, AND WILLIAMSON COUNTIES

COOPERATING AGENCY : Texas Water Development Board

PROJECT CHIEF: Raymond M. Slade, Jr., District Office, Austin

PERIOD OF PROJECT : March 1978 to September 1984

LOCATION : Central Texas



Problem: The Edwards aquifer in the three-county area is the principal source of water for Georgetown, Round Rock, and many other incorporated areas and is used by various commercial and industrial developments and rural residents. The aquifer is in an area of the very rapid population growth. As the need for development of the aquifer for water supplies becomes more pressing, it is necessary to understand the hydrologic system. Knowledge of expected response of the aquifer to potential stresses is needed to allow the opportunity to properly plan for development of the resource.

Objectives: To appraise quantitatively the ground-water resources of the Edwards aquifer system in northern Travis, southern Bell, and Williamson Counties, and to provide the data and criteria to assess potential stresses on the aquifer for present and long-range planning of water use and management.

Approach: To collect and analyze existing geologic and hydrologic data and refine previous geohydrologic evaluations and interpretations by measuring water levels in wells, pumpage, and spring discharge; drill new test wells and use borehole geophysical logging to provide detailed data on the subsurface geology; and collect water samples for inorganic chemical constituents, indicator bacteria, physical organics and inorganics, nutrients, pesticides, and minor element analysis. A ground-water flow model of the aquifer will be prepared as an aid to better understand and define the system.

Project Summary: Two reports present the results of this study. The first report presented the hydrogeologic framework of the study area, using hydrogeologic sections, structure, and thickness maps of the aquifer. Also presented are the water use, ground-water levels and charges in those levels, the quality of the ground water, and interrelationships of streamflow with the aquifer. The second report uses the information from the first report, and develops the concepts of ground-water recharge, movement, and discharge.

Reports in Preparation:

Slade, R.M., Jr., Hydrologic concepts of ground-water recharge, movement, and discharge of the Edwards aquifer in northern Travis, Williamson, and Bell Counties: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None.

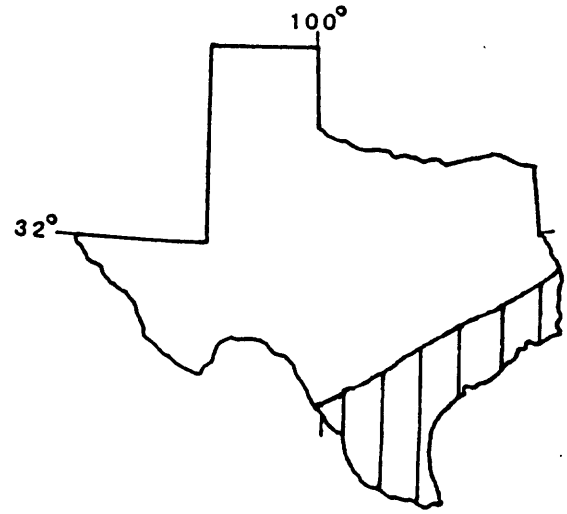
TX 82-075 WEST GULF COAST REGIONAL AQUIFER-SYSTEM ANALYSIS (RASA)--TEXAS AQUIFER SYSTEM

COOPERATING AGENCY : U.S. Geological Survey

PROJECT CHIEF: Paul Ryder, District Office, Austin

PERIOD OF PROJECT : March 1982 to September 1988

LOCATION : Texas Gulf Coast



Problem: The Texas part of the West Gulf Coast (WGC) Regional Aquifer-System Analysis (RASA) has areas of large ground-water development that have problems associated with large declines of aquifer head, land subsidence, and saltwater intrusion. Other areas within the Texas part have significant potential for additional development of ground water, but the effects of large increases in projected developments are not known.

Objective: (1) To support the multistate WGC-RASA program, the Texas District will contribute in the definition and determination of the interrelationship of the major and minor aquifer systems of Tertiary and Quarternary ages, (2) to participate in the development of a computerized data base, (3) to correlate the continuity of aquifers with adjacent states, (4) to develop and calibrate ground water flow models, and (5) to estimate future water needs to estimate the aquifer's response to future withdrawals.

Approach: Identification and delineation of aquifers and confining-beds shall be accomplished by development of hydrologic sections, review of published information, and development of a data base and identification of aquifer parameters and confining-bed characteristics. These will be used to develop digital-computer models that will be coordinated on a regional scale (intra-State) and used as tools in the overall planning and management efforts of the area's ground-water resources.

Progress: A report entitled "Hydrogeology and predevelopment flow in the Texas Gulf Coast Aquifer Systems" was approved as WRIR 87-4248. The report, which contains 71 figures and 13 tables, describes the hydrogeologic framework and the simulated flow system prior to development.

An outline with a list of tables and illustrations was prepared for the Professional Paper, which will be the final report for the project. Calibration of a transient model that includes a land-surface subsidence code is nearing completion.

Plans: Hydrostratigraphic dip (four) and strike (two) sections will be completed and a report submitted for review and approval. An areal transient model of the Texas Gulf Coast aquifer system will be calibrated. Results of the model simulation will be presented in a Professional Paper. Extensive use of PSTAT and SURFACE II is expected for data analysis and report illustrations.

Reports in preparation:

Baker, E.T., Jr., Stratigraphic and hydrogeologic framework of part of the Coastal Plain of Texas: U.S. Geological Survey Water Resources Investigations Report.

Ryder, Paul D., Ardis, Ann S., Hydrology of flow in the Texas Gulf Coast aquifer system: U.S. Geological Survey Professional Paper.

Reports approved or published, 1987:

Garza, Sergio, Jones, B.D., and Baker, E.T., Jr., 1987, Approximate potentiometric surfaces for the aquifers of the Texas Coastal Uplands system, 1980: U.S. Geological Survey Hydrologic Investigations Atlas 704, 1 sheet.

Ryder, Paul D., (in press), Hydrogeology and predevelopment flow in the Texas Gulf Coast aquifer systems: U.S. Geological Survey Water-Resources Investigations Report 87-4248.

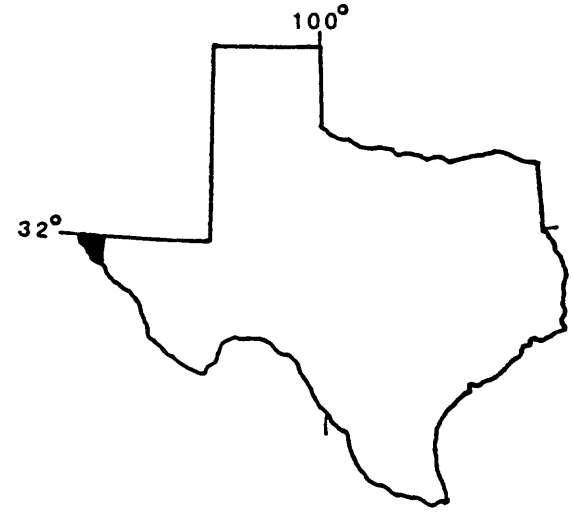
TX 83-080, 081 SOLUTE-TRANSPORT MODELING OF GROUND WATER IN THE HUECO BOLSON, EL PASO-FORT BLISS AREA

COOPERATING : El Paso Public Service Board, Texas Water Development Board, Department of the Army-Fort Bliss, Texas

PROJECT CHIEF: George Groschen, District Office, Austin

PERIOD OF PROJECT : October 1982 to September 1985

LOCATION : West Texas



Problem: Over 10 million acre-feet of fresh ground water in the Hueco bolson is being depleted. The quality of the freshwater is threatened by the intrusion of salinewater that almost surrounds the freshwater reservoir. Furthermore, there is interest in recharging the aquifer with treated wastewater. The potential for contamination due to continued and increased pumpage is unknown. The hydrologic relationship between the salinewater and the freshwater is poorly understood.

Objectives: (1) To define and quantify the hydrologic effects of historic and projected pumping through the use of a solute-transport ground-water flow model; (2) to use this model to determine the movement of salinewater; and (3) to determine the model's reliability and parameter sensitivity and recommend procedures for improving its reliability and accuracy.

Approach: Review of previous studies, especially Meyer (1976), to develop a conceptual model of the hydrologic system and to compile data; set up the revised Geological Survey three-dimensional Heat and Solute Transport model; calibrate and test the transport model for reliability and accuracy; and use the model to simulate pumping stress to predict salinity and water levels for selected water-withdrawal plans.

Progress: The simulations of the movement of salinewater in the Hueco Bolson aquifer indicate that the historical movement of salinewater has been confined to the zone near and underneath the Rio Grande. The sediments of the Rio Grande contain slightly saline to salinewater over most of the study area. The primary cause for movement of the salinewater is the large quantities of water withdrawn from the freshwater zone of the aquifer. The data available for calibrating the simulated movement of salinewater is inadequate to accurately assess the small amount of simulated historical movement. Simulations of pumping stresses expected to the year 2000, indicate that the salinewater movement will continue primarily near the Rio Grande. Water levels in the aquifer will decline more than 200 to 250 feet below the estimated predevelopment conditions. This fact

created a limitation on the length of time that could be simulated using projections of pumping into the future. Test simulations of pumping around one and two wells showed that even under various poorly defined aquifer conditions, upconing of saline water probably will not occur. The length of most municipal well screens in the aquifer prevent obtaining accurate information on the actual source of increased salinity to some wells. The test simulations and field information indicate that lateral transport along or near the water table is the most likely route of salinewater to wells. The report will be submitted for approval in 1988.

Plans: The report should be approved and published in 1988. The report will be sent to Fort Bliss for review before final approvel.

Reports in preparation:

Groschen, G.E., Numerical-simulation analysis of solute transport in ground water in the Hueco bolson, El Paso-Fort Bliss area, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None.

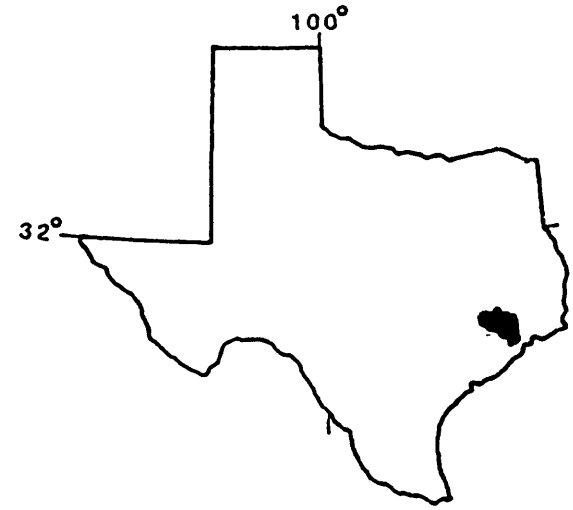
TX 83-082 NEAR REAL-TIME FLOOD ROUTING ALONG CYPRESS CREEK, HARRIS COUNTY

COOPERATING AGENCY : Harris County Flood Control District

PROJECT CHIEF: Fred Liscum, Subdistrict Office Houston

PERIOD OF PROJECT : January 1983 to September 1987

LOCATION : Texas Gulf Coast area



Problem: Some of the most intense urban growth in the Houston metropolitan area is occurring in northern Harris County. Cypress Creek, a 300-square-mile basin, flows through this urbanizing area before discharging into Lake Houston. Typical of southeast Texas, the area is relatively flat, and in urban areas, the channel has been rectified to improve conveyance. With a high degree of urbanization and its continued increase, flood warning methods are needed to aid local agencies in warning residents of impending flooding.

Objective: To develop a procedure for routing floods using near real-time hydrologic data in the lower reach of Cypress Creek.

Approach: The selected modeling approach includes the use of a distributed hydrologic-based watershed model and a hydraulic-based streamflow routing model. The storm rainfall driven watershed model will be applied independently in the upper and lower parts of the basin to generate inflow data needed by the routing model. The routing model will describe the magnitude and timing of the flood wave at selected points along the streams. Near-time storm-rainfall data will be used by the watershed model to generate inflow to the routing model.

Progress: A network of seven streamflow gages and four rain gages has been established in the Cypress Creek basin. Preliminary runs have been made of the computer programs which compose the two models, a distributed hydrologic-based watershed model and a hydraulic-based streamflow routing model. Data for calibration of these models have been obtained. Hydrologic data will be collected for the gage network throughout the length of the project.

Plans: Final model calibrations and preparation of a computer code to interface the real-time data-collection network of the cooperator with the models were prepared. Plans are to finalize the modeling system and prepare a detailed report documenting the model and procedures required to run the system.

Reports in preparation:

Liscum, Fred, Near-real time simulation of floods along Cypress Creek, Houston, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None.

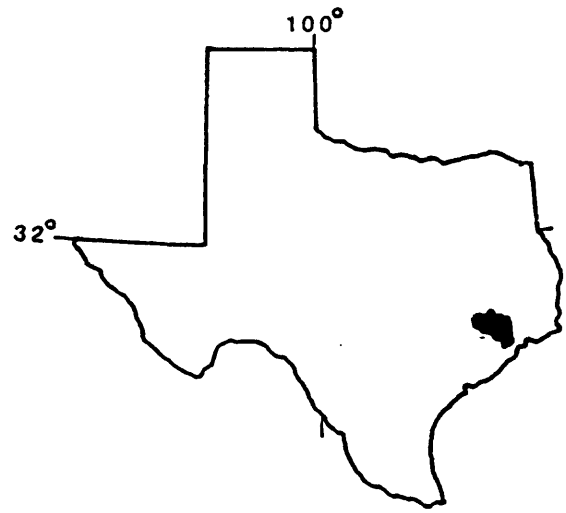
TX 83-083 POTENTIAL IMPACT OF THE TRINITY RIVER ON THE WATER QUALITY OF LAKE HOUSTON

COOPERATING AGENCY : City of Houston

PROJECT CHIEF: Fred Liscum, Subdistrict Office, Houston

PERIOD OF PROJECT : October 1983 to September 1989

LOCATION : Southeast Texas



Problem: Rapid growth in the Houston metropolitan area is resulting in increased demand for industrial and municipal water supplies. Because of the problems associated with ground-water development and the limit of these resources, additional surface water must be made available to insure an adequate supply. Current plans for providing additional water include diversions of surface water from the Trinity River through Luce Bayou into Lake Houston. Diversion of nutrient-laden water from the Trinity River may adversely affect the quality of water in Lake Houston.

Objectives: (1) To define the areal and temporal variations in water quality and stratification patterns in Lake Houston under current conditions; (2) to define the areal and temporal variations in quality of inflows to Lake Houston from streams in the San Jacinto River basin; (3) to relate the quality of inflows to the water quality in Lake Houston; (4) to define the temporal variations in the quality of water available for diversion from the lower Trinity River; and (5) to predict the potential impact of diversions from the Trinity River on the water quality of Lake Houston.

Approach: The study is designed to measure the quantity and quality of the natural inflow into Lake Houston from major streams, to collect comparable data on the Trinity River, near the planned point of diversion, and to determine the seasonal and areal variations of the chemical, physical, and biological characteristics of the water in Lake Houston. The periodic analysis and interpretation of the data will relate the response of the water quality in Lake Houston to its natural inflows using multiple regression techniques and the lake's predicted response to mixing natural inflows with diversion of Trinity River water using a dynamic lake model.

Progress: All gaging stations have been built and are operational. In addition, samples have been collected for six runoff events and four from low-flow conditions.

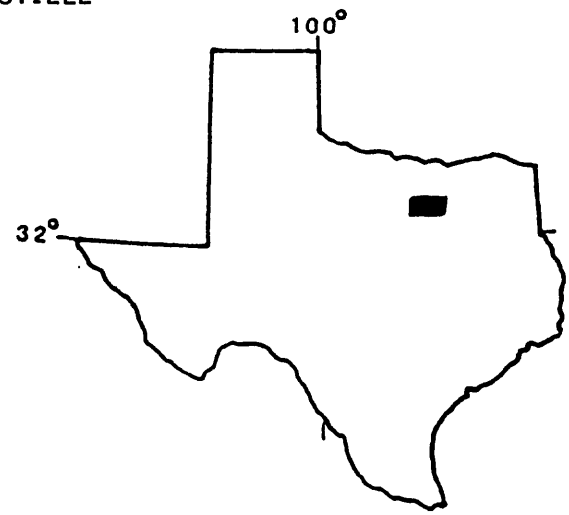
Plans: To continue the data collection program and to prepare a report summarizing data collected through March 1987. Long-term plans include the preparation of a report on the development, presentation, and evaluation of a procedure to predict the impact of the diversion water on the lake.

Reports in preparation:

Goss, R.L., and Liscum, Fred, Potential impact of transferring water from the Trinity River into Lake Houston, southeastern Texas....an interim report: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None.

TX 84-084 SOURCES AND INFLOW OF NUTRIENTS INTO LAKE LEWISVILLE



COOPERATING AGENCY : Dallas Water Utilities Department

PROJECT CHIEF: W. Scott Gain, Subdistrict Office, Fort Worth

PERIOD OF PROJECT : October 1983 to September 1988

LOCATION : Northeast Texas

Problem: Lake Lewisville is located on the northern fringes of the rapidly growing Dallas-Fort Worth metropolitan area and is currently a major source of water for Dallas. During summers, algal blooms in the lake often result in taste and odor problems and consequently increase the cost of water treatment for the city. Before appropriate actions may be taken for the management of the lake's water quality, the source of nutrient loading must be identified and evaluated in terms of magnitude of input, effect on lake nutrient dynamics, and management feasibility.

Objectives: (1) To evaluate potential nitrogen, phosphorus, and organic carbon loading by streams tributary to Lake Lewisville; (2) to identify the streams having the most nutrients; (3) to determine annual loads of nitrogen and phosphorus from three of those streams; and (4) to evaluate the relative importance of point and nonpoint sources to loads of nitrogen and phosphorus contributed to the lake.

Approach: The study includes the collection of two unique data sets. The first is the results of field and lab analyses on samples collected in each of two synoptic surveys--one survey at low flow and one at high flow. During synoptic surveys, samples were collected and discharges were measured at each of 30 sites on streams within the drainage basin of Lake Lewisville. The synoptic sampling data, along with other data previously published for major streams in the basin were intended to meet the study's first two objectives.

The second data set collected includes the results of more comprehensive sampling at three sites identified in the synoptic surveys as having potentially a great effect on the quality of water in the lake. Runoff from four storms in each of three years at each of these sites will be used to calculate annual loads to the lake. These data, in addition to reported loads by waste-water treatment plants discharging into Lake Lewisville, will be used to meet the third and fourth study objectives.

Progress: The low-flow synoptic sampling was completed in March 1984 and the high-flow sampling in March 1985. The three sites for storm runoff sampling were selected and sampling began in April 1985. Automatic samplers were installed at these sites during the summer of 1985. Sampling continued through September 1987.

Plans: A data report is being prepared for the data collected during the two synoptic samplings. Preparation of a final interpretative report of all data collected has begun and this report should be completed by the end of fiscal year 1988.

Reports in preparation:

Gain, W. Scott, Physical and nutrient data from two water-quality surveys of Lake Lewisville watershed, north-central Texas, 1984-85, U.S. Geological Survey Open-File Report.

------ Water quality characteristics in and inflow to Lake Lewisville, Dallas, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None

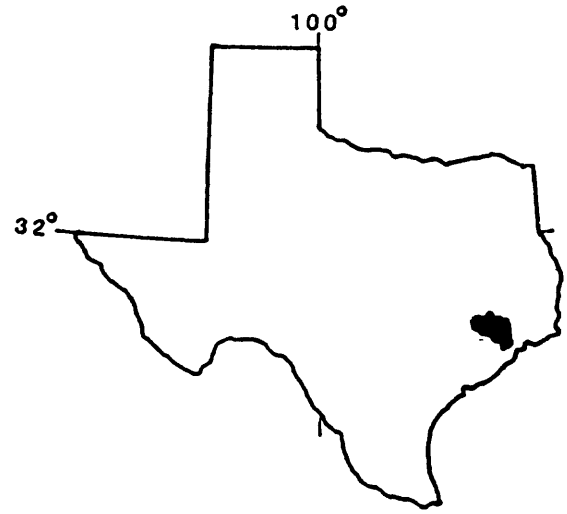
TX 84-085 ASSESSMENT OF WATER QUALITY AND CONTAMINATION PROBLEMS WITHIN THE GULF COAST AQUIFERS

COOPERATING AGENCY : U.S. Geological Survey

PROJECT CHIEF: Jeffrey L. Strause, Subdistrict Office, Houston

PERIOD OF PROJECT : January 1984 to September 1985

LOCATION : Southeast Texas



Problem: In an attempt to improve knowledge about the problem of contamination to the Nation's ground water and the trends and influence of man's activities, the Geological Survey has undertaken a national program that will closely study 14 areas. The Gulf Coast aquifer in the Houston area was selected as one of the study areas. In this area, about 500 million gallons of water per day are pumped from lenticular deposits of sand and clay. During preliminary investigations, contaminants have been found at shallow depths, but not in the major aquifers.

Objectives: The objectives are (1) to describe the ambient ground-water quality, including organics and minor elements in a small but typical and diverse area of the Gulf Coast aquifer, (2) to document the occurrence, if any, location, concentrations, and sources of contamination, and (3) to develop a hypothesis regarding the factors controlling the occurrence, movement, and fate of identified contaminants.

Approach: Ambient water quality was described from existing data and data collected in a reconnaissance sampling program. Data were from the U.S. Geological Survey, the Texas Department of Water Resources, and the Texas Health Department. The chemical quality data, relevant well data, and associated geophysical and hydraulic data were entered into computerized data bases. A reconnaissance sampling was performed to determine major inorganic-ion concentrations, selected nutrients, minor elements, and to identify the presence of selected organic constituents. These data were hydrologically and statistically analyzed to determine areal and vertical distribution of constituents.

Progress: The study area is located in the recharge area of the Chicot aquifer, one of two major producing aquifers in the Houston area. Land uses in this area include irrigated agricultural, highly developed residential, commercial and light industrial, and rural areas.

Data for about 600 chemical analyses from 400 wells were compiled. Statistical and graphical analyses were performed, and a report was prepared

detailing the change in hydrochemical facies between the Chicot and Evangeline aquifers in the study area. Minor elements and organic substances were found to be mostly at concentrations of less than 10 micrograms per liter. Gross alpha radioactivities of greater than 20 piocuries per liter were found in a small part of north central Harris County, mostly in wells screened to depths of about 900 to 1,100 feet. The final report has been prepared and is in review.

Plans: Plans are to complete review and obtain approval of the report.

Reports in preparation:

Strause, J.L., Ground-water quality in the recharge area to the Chicot aquifer near Houston, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None.

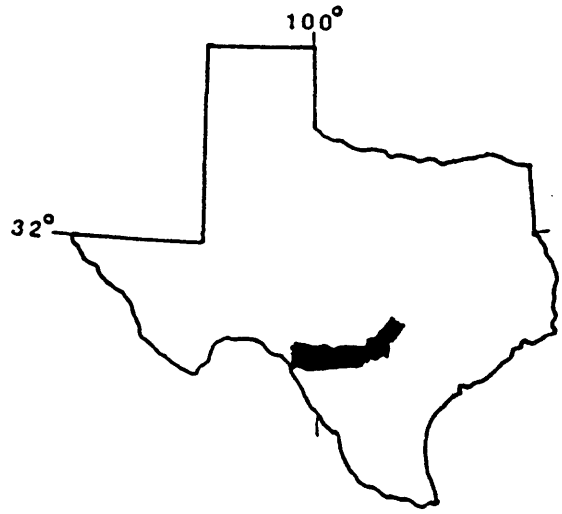
TX 84-086 ASSESSMENT OF WATER QUALITY AND CONTAMINATION PROBLEMS WITHIN THE EDWARDS AQUIFER

COOPERATING AGENCY : U.S. Geological Survey

PROJECT CHIEF: Paul Buszka, District Office, Austin

PERIOD OF PROJECT : January 1984 to September 1986

Location : Southwest-central Texas



Problem: The extent of contamination of the Nation's ground water is largely undefined. Furthermore, the trends and influence of man's activities on ground water are poorly understood. In an attempt to gain this knowledge, the Geological Survey has undertaken a national program to study the relation of hydrogeology and land use to ground-water quality in 14 regions typical of a variety of hydrogeologic settings. The Edwards aquifer, San Antonio area, was selected as one of the sites for intensive study. The Edwards aquifer is the sole source of drinking water for the city of San Antonio and is a major source of supply for six rural counties. The quality of water in the aquifer historically has been suitabale for most all uses. The detection of manmade chlorinated hydrocarbons in ground water from several wells near San Antonio and Uvalde, and the presence of coliform bacteria in other wells in the area indicate that the aquifer is vulnerable to contamination. Carbonate aquifers such as the Edwards are highly susceptible to ground-water contamination where pollutant inputs coincide with open and connected conduits.

Objectives: To assess the quality of water within the Edwards aquifer in the San Antonio area with respect to selected inorganic and organic elements and compounds, bacteria, and properties that may indicate present or potential contamination. This includes: (1) The hydrogeologic characteristics and land-use practices that can effect ground-water chemistry; (2) the general inorganic and organic chemical character of ground water with particular attention to trace elements, pesticides, and volatile organic compounds; (3) the relation between ground-water flow, land use, and water quality; and (4) a brief description of the areas where ground-water contamination has occurred or may occur.

Approach: Water-quality data consisting of laboratory analyses of ground-water samples were compiled from the existing USGS-WATSTORE database and supplemented by analyses from 54 additional wells sampled during 1984 and 1985. An aquifer zone in the vicinity of each well was classified using tritium data from Pearson and Rettman (1976), hydrochemical facies data from Maclay and others (1980), and hydrogeologic data from Maclay and Small (1984). Land-use data derived from a 1978 Texas Department of Water Resources study, and field visits by

USGS personnel were used to classify the major land use associated with each well. Nonparametric-statistical procedures were used to test whether land use and aquifer zone were correlated with the distribution of selected chemical constituents.

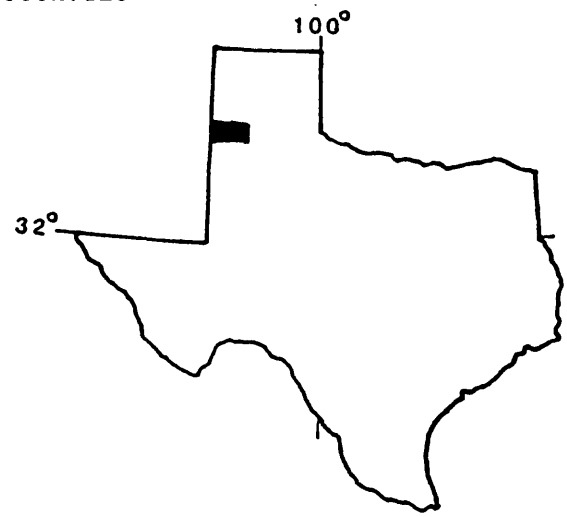
Project summary: In general, ground water in the Edwards aquifer has not been significantly degraded by land-use activities. Greatest nitrate plus nitrite concentrations were spatially associated with ground water that contains relatively high tritium concentrations and in the cultivated agricultural area of central Uvalde County and in northern Bexar County. Detections of total coliform bacteria in ground water were mainly associated with wells in the unconfined zone. Most of the occurrences in ground water of tetrachlorethylene, 1, 2-(trans)-dichloroethylene and trichlorofluoromethane were associated with two sources, a landfill in north-central San Antonio and a small area east of Uvalde. Occurrences of concentrations of lead greater than 5 micrograms per liter and zinc concentrations greater than 100 micrograms per liter in ground water from the unconfined zone of the aquifer were associated with small volumes of presampling pumpage.

Reports in preparation: None.

Reports approved or published, 1987: None.

Buszka, P.M., (in press), Relation of water quality of the Edwards aquifer to hydrogeology and land use, San Antonio region, Texas: U.S. Geological Survey Water-Resources Investigations Report 87-4116.

TX 84-087 RETURN FLOW FROM IRRIGATION IN CASTRO AND PARMER COUNTIES



COOPERATING AGENCY : U.S. Geological Survey

PROJECT CHIEF: Gary W. Mackey, District Office, Austin

PERIOD OF PROJECT : October 1983 to September 1985

LOCATION : Northwest Texas

Problem: The amount of water returning to the aquifer from that which was pumped for irrigation needs to be determined to improve our understanding of the long-term availability of ground water.

Objectives: To establish, test, and apply procedures to determine the amount of return flow from applied irrigation water.

Approach: Pumpage, rate of application, crop types, and irrigated acreage from 1983 to 1984 will be measured from about 110 randomly selected wells. The major steps are: Devise procedure for estimating irrigation application for 1975-83; construct water-level change maps for 5- and 10-year periods; statistically evaluate differences in the maps; prepare specific-yield maps and compute change in ground-water storage from specific-yield data and water-level change maps; and estimate irrigation return flow for January 1975 to January 1984 from the difference between pumpage and change in groundwater storage.

Project summary: Because historical irrigation pumpage data in the High Plains of Texas were unavailable, an approach based upon crop consumptive-use patterns was employed to estimate pumpage from 1974 through 1983 for two counties located in the Texas High Plains. Due to the unreliability of irrigated acreage data, two different sources were used to obtain estimates for total irrigated acreage and individual irrigated crop acreage. Reported sources of irrigated acreage consistently provided larger values than data obtained from interpreted LANDSAT imagery. Total estimated pumpage for the 9-year period was 11,269,000 acre-feet and 8,914,000 acre-feet based upon reported crop acreage data and LANDSAT acreage data, respectively. Change-in-storage was found to total 5,168,000 acre-feet for 9 years. The difference between irrigation pumpage and change-in-storage approximates irrigation return flow. Return flow for the 9 years was approximately 6 million acre-feet and 4 million acre-feet based upon reported crop acreage data and LANDSAT acreage data, respectively. This volume is 54 percent estimated reported pumpage and 42 percent pumpage estimated from LANDSAT data.

Reports in preparation: None

Reports approved or published, 1987:

Mackey, Gary W., 1987, Comparison of irrigation pumpage and change in water storage in the High Plains aquifer in Castro and Parmer Counties, Texas, 1975-83: U.S. Geological Survey Water-Resources Investigations Report 87-4032, 48 p.

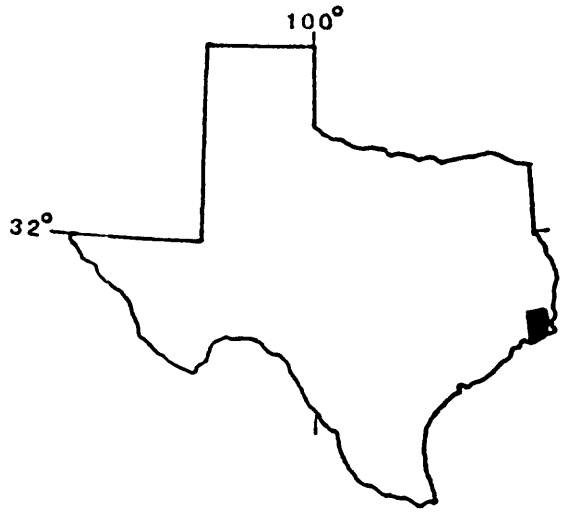
TX 84-088 SURFACE-WATER HYDROLOGY OF THE SALT BAYOU IN SOUTHEAST TEXAS

COOPERATING AGENCY : Texas Parks and Wildlife

PROJECT CHIEF: J. C. Fisher, Subdistrict Office, Houston

PERIOD OF PROJECT : January 1984 to September 1986

LOCATION : Southeast Texas



Problem: The Salt Bayou basin in southeast Texas is a complex marshland ecosystem. Much of the basin has been reserved by the State to maintain this ecosystem. The basin contains both the McFaddin National Wildlife Refuge and the Sea Rim State Park. The refuge, maintained by the U.S. Fish and Wildlife Service, serves as a primary breeding ground for shellfish.

The construction of the Gulf Intracoastal Waterway and the Port Arthur Canal has interrupted the historical saltwater-freshwater exchange pattern for the basin ecosystem. The increased salinity of the marsh has caused concern that shellfish productivity will be adversely affected in the McFaddin National Wildlife Refuge. In order to correct the problem, the construction of controlled structures has been proposed at the three inflows to the area, Keith Lake, Shell Lake, and Star Lake. These structures are intended to help control the saltwater-freshwater exchange by reducing saltwater inflow into the area.

Improved knowledge of the hydrology of the basin, particularly the saltwater freshwater relationships, is needed to aid in the assessment and possible future enhancement of the basins' shellfish community.

Objectives: To define the water budget and flow patterns and magnitudes at the major outlet to the Intracoastal Waterway. Specific goals of the study are to: Define the water budget for the basin; determine velocity profiles for the inflows over several complete tide cycles; and define salinity profiles for the main channel in the refuge.

Approach: One stage, two stage-discharge, and one stage-velocity gages were installed. Salinity profiles were determined, and six 24-hour surveys at selected points were obtained to collect bi-hourly discharge, velocity, specific conductance, and temperature. The Fish and Wildlife Service collected biological data over a tidal cycle. Salinity-profile data were obtained by traversing the main channels. Additional water-budget data are available from Sea Rim State Park.

Progress: A substantial effort was made to estimate periods of missing velocity data at the Salt Bayou and Keith Lake sites. Statistical relationships of stage, rates of change of stage, and velocity were developed. Reasonable estimates were obtained at the Keith Lake site only. A draft of the report has been prepared.

Plans: Plans are to complete the data report.

Reports in preparation:

Fisher, J.C., Hydrologic data of MacFaddin National Wildlife Refuge and Sea Rim State Park, Oct. 1985 to March 1986: U.S. Geological Survey Open-File Report.

Reports approved or published, 1987: None.

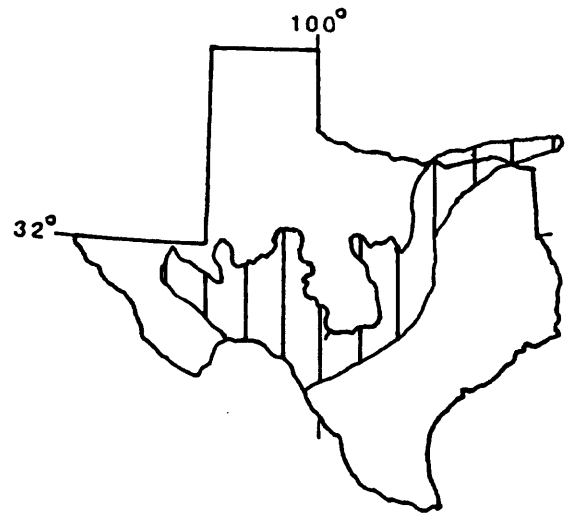
TX 85-090 EDWARDS-TRINITY REGIONAL AQUIFER-SYSTEM ANALYSIS (RASA)

COOPERATING AGENCY : U.S. Geological Survey

PROJECT CHIEF: Peter Bush, District Office, Austin

PERIOD OF PROJECT : October 1985 to October 1993

LOCATION : Central Texas, southeast Oklahoma, southwest Arkansas



Problem: Continued use of water from the Edwards-Trinity regional aquifer system will lower water levels, reduce streamflows, and possibly cause deterioration of water quality in the aquifers. Lower water levels in aquifers will reduce springflow and discharge to streams in discharge areas and may increase aquifer recharge from streams in recharge areas. In some areas, poor-quality water occurs in aquifers or zones of aquifers adjacent to pumping centers and continued pumping may cause movement of poor-quality water toward water supplies.

Objectives: To provide a better understanding of the water-yielding potential of the Edwards-Trinity regional aquifer system. The specific objectives are to describe the aquifer system by determining the hydrologic framework on a regional scale, describe the regional water chemistry and use the water chemistry to identify and understand the patterns of ground-water flow, and describe the regional flow system based on simulation.

Approach: A multidisciplinary approach will be used. Geologists will construct a regional hydrogeologic framework that divides the aquifer system into mappable permeability units. Ground-water modelers will use the hydrogeologic framework to construct digital flow models on regional and subregional scales. Geochemists will describe the water chemistry and interpret the flow system based on the water chemistry. Different interpretations or hypotheses of the structure of the aquifer system and patterns of flow suggested by geologic, hydrologic, and geochemical studies will be tested with the digital models.

Progress: The project area was divided into a southern area and a northern area. The southern area is being studied first. A suite of "best available" electric logs for the southern area was identified and purchased to serve as a basis for construction of hydrogeologic sections throughout the southern area.

A computerized geochemical database for the entire project area was compiled. Work began on evaluating the analyses for applicability to mapping the major dissolved constituents in the southern area and for interpreting the chemical evolution of ground water along flowpaths.

The decision was made to use the MODFE finite-element model to simulate the ground-water flow system in the southern area. A 28-month transient calibraton period was selected primarily on the basis of availability of water-level data. Work began on determining the boundary conditions and developing computerized databases of the hydrologic inputs and system properties necessary to run the model.

The planning report for the study was written, approved, and published. The decision was made to use the geographic information system ARC/INFO to manipulate and relate various types of spatial data.

Plans: Plans are to (1) complete the hydrogeologic sections for the southern project area; (2) develop a strategy for determining the areal distribution of permeability using the sections and other geophysical and lithologic data; (3) map the tops and bottoms of regional aquifers on the basis of permeability; (4) develop a correlation chart for the southern area and; complete the evaluation of available geochemical data for the southern area.

If additional sampling is warranted in order to understand and relate geochemical processes to the flow system, an appropriate sampling program will be designed and conducted. Plans also are to design the finite-element network primarily on the basis of geologic structure, topography, and the locations of streams and springs; learn to use ARC/INFO to manipulate the areal distributions of model hydrologic inputs and system properties; complete the development of model hydrologic inputs and system properties; and begin model calibration.

Reports in preparation: None.

Reports approved or published, 1987:

Bush, Peter W., 1986, Planning report for the Edwards-Trinity regional aquifer-system analysis, central Texas, southeast Oklahoma, and southwest Arkansas: U.S. Geological Survey Water Resources Investigations Report 86-4343, 15 p.

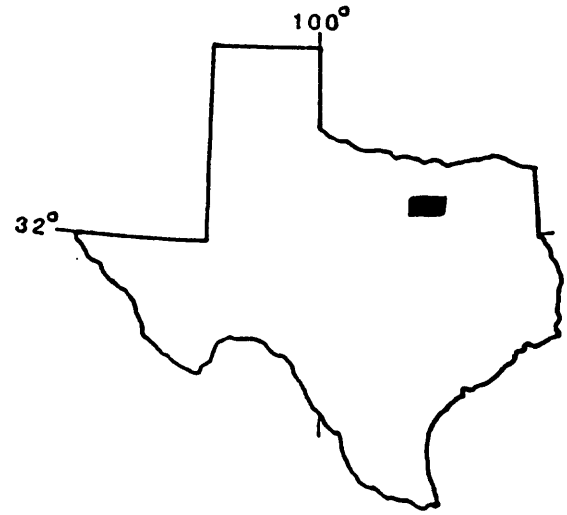
TX 85-091 WATER QUALITY OF CEDAR CREEK RESERVOIR, NORTH-CENTRAL TEXAS

COOPERATING AGENCY : Tarrant County Water Control and Improvement District No. 1

PROJECT CHIEF: Norman Leibbrand
District Office, Austin

PERIOD OF PROJECT : October 1984 to September 1986

LOCATION : North-central Texas



Problem: Projections by the Texas Water Development Board indicate that by the year 2000, water use in Dallas and Tarrant Counties will be nearly 1 million acre-feet per year, up about 50 percent from 1980. Ninety-five percent of the water used in 1980 was obtained from surface-water supplies. Lake Worth, Lake Arlington, and Benbrook Lake currently serve as the principal source of municipal and industrial water for the Fort Worth metropolitan area. Increased demands have caused water managers in the Fort Worth and Arlington areas to supplement the supplies from Cedar Creek Reservoir, approximately 80 miles southeast.

Objectives: To summarize and explain the variations of selected chemical and characteristics of water in Cedar Creek Reservoir. Specific objectives include: Provide a brief description of Cedar Creek Reservoir and surrounding environment; define the amount of water withdrawn from the reservoir; define seasonal and areal variations in concentrations of dissolved solids, chloride, sulfate, hardness, iron, manganese, and selected nutrients during the 1977-84 water years.

Approach: Comprehensive water-quality data have been collected during winter, spring, and summer since January 1977. Data have been collected at appoximately 10-foot depth intervals at approximately 10 sampling locations at the lake to define variations in water quality.

Analysis of these data was done using the SAS (Statistical Analysis System) which is interfaced with the USGS WATSTORE computer files. SAS programs have been developed by District personnel to compute seasonal average concentrations of constituents at varying depths, and to compute volume-weighted average concentrations of constituents.

Project summary: Thermal stratification in Cedar Creek Reservoir usually begins in late winter or early spring and persists until late fall. Thermal stratification or summer stagnation causes significant seasonal and areal variations in

concentrations of dissolved oxygen and in other dissolved and suspended constituents. Oxygen used in the decay of organic matter is not replenished during summer stagnation, and water below depths of 30 feet usually contains less than 2 milligrams per liter of dissolved oxygen.

The volume-weighted average concentrations of dissolved solids, dissolved sulfate, and dissolved chloride were less than 140 milligrams per liter, 30 milligrams per liter, and 25 milligrams per liter respectively. The water was soft to moderately hard ranging between 55 and 75 milligrams per liter as calcium carbonate.

Barium and arsenic were the most commonly found elements in detectable concentrations of the 10 trace elements studied. Of 22 water samples collected for trace elements analysis, 15 contained barium in concentrations ranging from 40 to 300 micrograms per liter, and 19 contained arsenic in concentrations ranging from 1 to 26 micrograms per liter.

Reports in preparation: None

Reports approved or published, 1987:

Leibbrand, Norman F., and Gibbons, W.J., (in press), Water quality of Cedar Creek Reservoir in northeast central Texas, 1977-87: U.S. Geological Survey Water-Resources Investigations Report 87-4231.

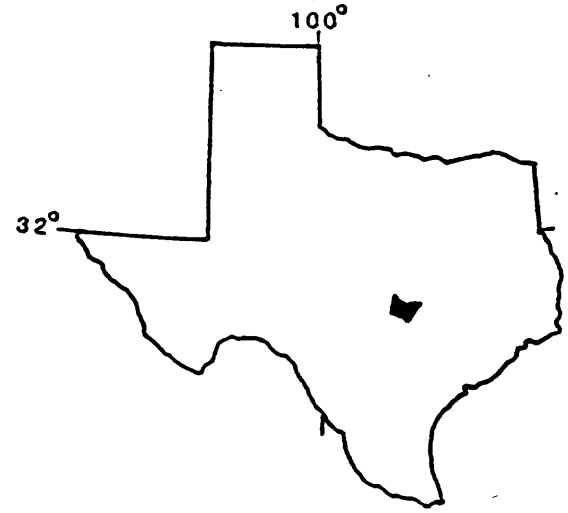
TX 85-093 ATTENTUATION OF SELECTED POLLUTANTS IN THE UNSATURATED ZONE OF THE EDWARDS AQUIFER, AUSTIN AREA

COOPERATING AGENCY : City of Austin

PROJECT CHIEF: Paul M. Buszka
District Office,
Austin

PERIOD OF PROJECT : March 1985 to September 1992

LOCATION : Central Texas



Problem: The Edwards aquifer of central Texas is a major freshwater resource that supplies much or all the water needs of many municipalities, industries, businesses, farms, and recreation centers. Because of the rapid population growth in the area overlying the aquifer and more recently in the recharge zone, concern is being expressed about the pollution potential from storm-water runoff that enters the aquifer. The potential for contamination of the Edwards aquifer through the storm-water runoff and aquifer recharge process, and the attenuation of pollutants in the subsurface are poorly understood. To prevent long-term implications of ground-water pollution, knowledge of the movement of selected pollutants and the capacity of the subsurface material to attenuate the concentrations of pollutants is needed. The Edwards aquifer, predominantly composed of limestone that is locally fractured, faulted, and solution-riddled, appears to be highly vulnerable to contamination.

Objective: To develop an understanding of the process affecting the quality of water as water migrates from the streambed to the saturated zone. The water quality characteristics of major interest are nonconservative pollutants including organics, nitrogen and phosphorus, trace metals, and fecal bacteria. Supporting objectives are to collect field and laboratory data and define the quality of water in the vertical profile in the unsaturated zone, and to develop a means of estimating the attenuation of pollutants in untested areas. Several types of water will be tested; each typical of storm-water runoff from a given land use.

Approach: The scope of the investigation will be limited to areas along streams following storm-runoff, when most of the recharge occurs. This investigation is research in nature and, consequently, the stated objective is not assured. The project will be conducted in phases and advancement to the next phase will require the satisfactory completion of the current phase. The project consists of three supporting elements. All of the elements will be investigated concurrently and include: study, development, statement, and testing of hypotheses; laboratory (batch or column), experiments; and field experiments using a suite of wells open to bedding planes and solution openings that are believed to be temporarily saturated after storms.

Progress: Installation of well casing and continuous monitoring equipment for water level, electrical conductance, and temperature is complete in five wells at a site on Williamson Creek. Changes in water level were observed in three of the wells during and shortly after major runoff in the creek. Saturated conditions developed within several hours of major increases in creek stage in one well screened in the unsaturated zone from 30 to 40 feet below land surface. Water-quality sampling during and after storms in March, May, and June revealed no substantial changes in ground-water chemistry from prestorm conditions in two wells screened in separate, permanantly saturated zones at about 95 and 130 feet below land surface, respectively. The nutrient composition of ground water differed from that observed in the creek during the initial stage increase after rainfall, and was somewhat similar to creek samples during periods of no change and declining stage. Examination of current and historical water chemistry data from Williamson Creek revealed an association between elevated concentrations of total nitrogen species, total suspended solids, and discharge. These prelimiary data suggest that runoff-related contamination of ground water by nutrients may be limited by their association with suspended material and potential mixing between recharge originating during the rising and stable or falling stage.

Other progress on establishing a conceptual framework for unsaturated-zone flow in carbonate rock has been made through a search of existing literature. Ground-water chemistry data from several storm-related samplings of wells in the unconfined zone have been entered into a computer data file. This file will be used for analysis of regional impacts of recharge chemistry on ground water.

Plans: Plans for the coming year include selection of a second site to validate concepts of unsaturated flow developed through the Williamson Creek site. Potential candidates for the second site include a retention basin at a major regional mall that receives parking-log runoff, and a spray irrigation site where secondary-treated domestic effluent is applied over a segment of aquifer with thin soil cover. The presence of large-scale porosity at shallow depth will be explored using geophysical techniques. Wells and instrumentation will then be installed and monitored at the site. Monitoring of the Williamson Creek site will continue through this fiscal year. Analytical techniques for examination of core samples for evidence of sorbed contaminants will also be pursued.

Reports in preparation:

Buszka, P.M., Water movement and changes in water quality in the unsaturated zone of the Edwards aquifer, Austin, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None.

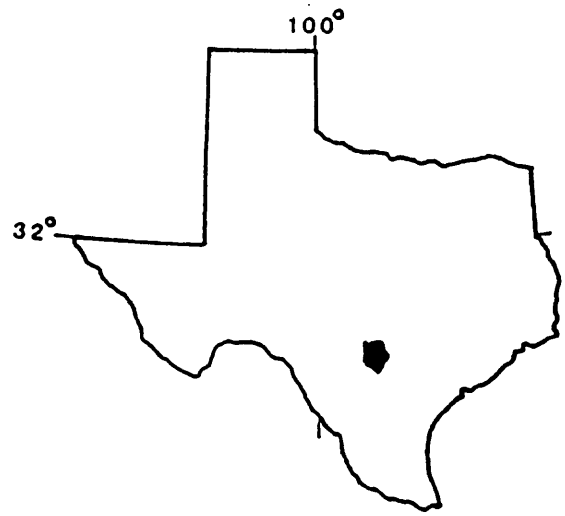
TX 85-094 HYDROLOGIC CONTROLS AFFECTING GROUND-WATER MOVEMENT IN THE VICINITY OF THE "BAD-WATER" LINE IN THE EDWARDS AQUIFER, SAN ANTONIO AREA

COOPERATING AGENCIES : San Antonio City Water Board, Edwards Underground Water District, and Texas Water Development Board

PROJECT CHIEF: George Groschen
Subdistrict Office,
San Antonio

PERIOD OF PROJECT : October 1984 to September 1986

LOCATION : South-central Texas



Problem: Salinewater intrusion from the downdip boundary of the Edwards aquifer into the freshwater is hydraulically possible. Significant movement of the salinewater would be more likely to occur during periods of low water levels when gradients across the transition zone could increase. A drought condition creates a situation where larger-than-normal amounts of water will be withdrawn from the aquifer causing additional lowering of water levels and possible reversal of the present gradient toward Comal Springs. The increase in water withdrawal, lower recharge, and resulting low-water levels will create a condition where the encroachment of the salinewater is most likely to occur.

Objectives: To delineate in the three-dimensional shape of an interface between the freshwater and salinewater, to obtain data on the vertical and horizontal circulation near the "bad-water line," and to establish permanent monitoring wells to determine transient changes in water quality.

Approach: A test drilling program is designed whereby three different clusters of wells are drilled in the aquifer. A well cluster is located in the freshwater zone, in the transient zone between the fresh and saline zones, and another in the saline zone. Extensive testing of formation was conducted at each cluster. Tests include vertical flow tests and aquifer yield tests. Geophysical logging provided porosity, lithology, and water-quality information to determine vertical and lateral variations.

Progress: Drilling, testing, and well installation were completed in March 1986. The salinewater site wells indicate that there is some vertical stratification in dissolved solids. The concentration of dissolved solids is greatest at the bottom below the regional dense member, and least just below the Georgetown Formation. Flow is apparently greatest from the formations above the regional dense member which is located almost midway down the section of rocks. The transition zone wells indicate that the rocks below the regional dense member are not strongly connected hydraulically with other sections of the aquifer.

Generally, water from the deep transition site well has slightly higher salinity than the water from the salinewater site wells. Water from the shallow transition site well sometimes has lower salinity than the freshwater site wells and often has the highest head of all the wells. Likewise, the deep transition site well often has the lowest hydraulic head. Freshwater-equivalent heads yield no significant information, but indications are that the density contrasts, relative to the dip of the rocks of the aquifer, may be a controlling factor in movement along the line of the transect. The deep freshwater-site well has a dissolved-solids concentration between saline and freshwater. The two freshwater-site wells react quickly and strongly to pumping stresses in the aquifer.

The data report has been completed and printed. The preliminary interpretative report draft is almost complete and will require some editing and finishing work prior to colleague review.

Plans: Plans are to complete the preparation of the interpretative report.

Reports in preparation:

Groschen, G.E., Preliminary results from a study of the flow and salinity at a salinewater/freshwater interface in the Edwards aquifer, San Antonio region, Texas: U.S. Geological Survey Water Resources Investigations Report.

Reports approved or published, 1987:

Pavlicek, Diane J., Small, Ted A., Rettman, Paul L., 1987, Hydrologic data from a study of the freshwater zone/salinewater zone interface in the Edwards aquifer, San Antonio region, Texas: U.S. Geological Survey Open-File Report 87-389, 108 p.

Maclay, R.W. and Land, L.F., 1987, Simulation of flow in the Edwards aquifer, San Antonio region, Texas, and refinement of storage and flow concepts: U.S. Geological Survey Open-File Report 86-532, 86 p.

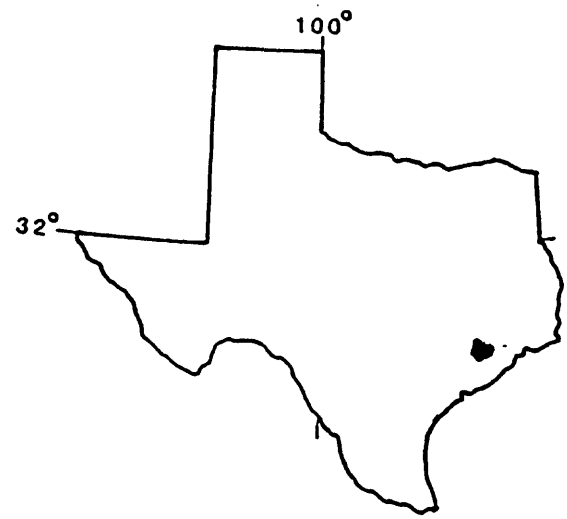
TX 86-095 EFFECTS OF GROUND-WATER DEVELOPMENT ON FORT BEND COUNTY

COOPERATING AGENCY : Fort Bend County

PROJECT CHIEF: Glenn Locke, Subdistrict Office, Houston

PERIOD OF PROJECT : October 1985 to September 1987

LOCATION : East-central Texas



Problem: Fort Bend County is one of the fastest growing counties in the United States and is dependent entirely on ground water for supply. An investigation of the ground-water resources of Fort Bend County was conducted by the U.S. Geological Survey in 1968-69. Since 1969, the increased development in Fort Bend County and the growth of Houston has required increased production of ground water. Fort Bend County has been impacted by declines of water levels, land-surface subsidence, and possibly, encroachment of saltwater from salt domes and by updip migration. Although the city of Houston has only one water well in Fort Bend County, declines in water levels in Fort Bend County due to pumpage in adjacent Harris County have been significant. Two large (25 to 30 million gallons per day) well fields in Fort Bend County, which have been planned by Houston, cause concern to Fort Bend County officials. Information on the current and potential impact of development is needed for planning purposes, which may include the creation of a subsidence control district.

Objectives: To update information collected in 1968-69, to determine the impact of recent development of ground water in Fort Bend County and the western part of Harris County, and to delineate the areas most susceptible to land-surface subsidence.

Approach: Well inventory, pumpage inventory, and water-level measurement networks will be updated and expanded as necessary to provide adequate control in critical areas. A limited program of sampling wells in areas near salt domes, particularly the Blue Ridge Dome, will be instituted to monitor any salinity changes. Maps of water-level altitudes and changes since the county report (1969) will be made. Available data on land-surface subsidence will be compiled. Areas most susceptible to land-surface subsidence will be described based on clay thickness (determined in this study) and compressibility (from studies in adjacent areas).

Progress: Illustrations have been completed and text for the report is almost complete.

Plans: Plans are to complete the final report.

Reports in preparation:

Locke, G.L., Ground-water development and conditions in Fort Bend County, Texas, 1986: U.S. Geological Survey Water Resources Investigations Report.

Reports approved or published, 1987: None.

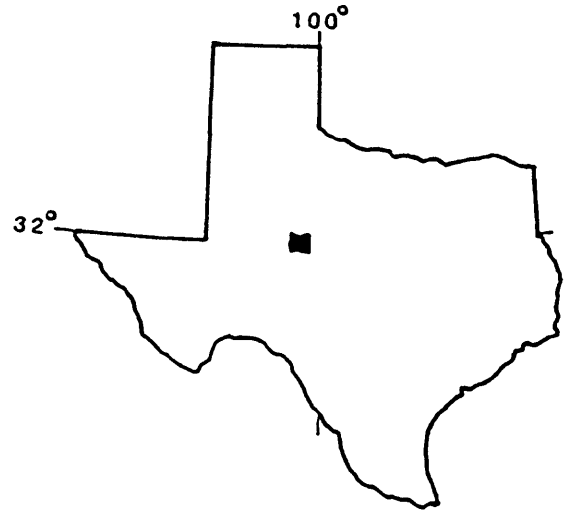
TX 86-096 GROUND-WATER CONTRIBUTION OF SALINITY IN THE UPPER COLORADO RIVER

COOPERATING AGENCY : Colorado River Municipal Water District

PROJECT CHIEF: Raymond M. Slade, Jr. District Office, Austin

PERIOD OF PROJECT : October 1985 to September 1988

LOCATION : Central Texas



Problem: A basin-wide study of the quality of surface water by the U.S. Geological Survey indicated that significant increasing trends in the concentration of dissolved solids are occurring in a 40-mile reach of the Colorado River upstream from E.V. Spence Reservoir. From October 1972 to September 1982 the flow-adjusted concentration of dissolved solids in the Colorado River at Colorado City increased at an average rate of more than 270 mg/L per year. Similarly, the flow-adjusted concentration of dissolved solids in Beals Creek near Westbrook increased at an average rate of more than 270 mg/L per year. Several studies indicate that discharge of ground water contributes significantly to the salinity of the Colorado River upstream from E.V. Spence Reservoir. However, the large increasing trends of salinity in surface waters after 1972 is strong presumptive evidence that the inflow of saline ground water between Colorado City and the E.V. Spence Reservoir has resulted from causes other than the natural discharge of shallow ground water.

Objectives: To delineate the source areas of saline ground-water inflow and quantify the quality and quantity of ground water to the study reaches, to identify and describe the aquifer(s) that may contribute water to the streams, to determine the historical ground-water conditions in the aquifer, to determine the current ground-water conditions, to locate and describe oil field activities, and to investigate the feasibility of using indirect techniques to identify specific sites of salinewater discharge.

Approach: The general approach follows: Conduct several base-flow reconnaissance of the quantity and quality of streamflow in the reaches; map the aquifers that crop out or underlie the study area as to areal extent, thickness, and depth, utilizing geologic maps, drillers' logs, geophysical logs, field observations, and existing technical literature. Emphasis will be on those aquifers that may discharge salinewater; conduct a literature search; retrieve from computer storage water-level, water-quality, and related data in the study area, and tabulate and analyze such data to detect any significant changes or trends; locate and inventory selected water wells and springs, including public

supply, industrial, irrigation, and rural-domestic or stock wells; collect about 50 water samples from the inventoried wells and analyze the water for major inorganic chemical constituents; locate and plot on maps all wells drilled in the search for oil and gas in the area; tabulate the quantity of saltwater disposed, and indicate the methods of disposal; tabulate data on secondary or enhanced recovery operations; and test indirect methods of locating salinewater in the shallow subsurface by first locating a known source of salinewater discharge at the land surface.

Progress: All of the data collection and items identified in the "Approach" section have been completed.

Plans: Interpretation of data and information is being made. A report containing data, findings, and conclusions from the study will be prepared.

Reports in preparation:

Slade, R.M., Jr., Areas and sources of salinity in the upper Colorado River basin, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None

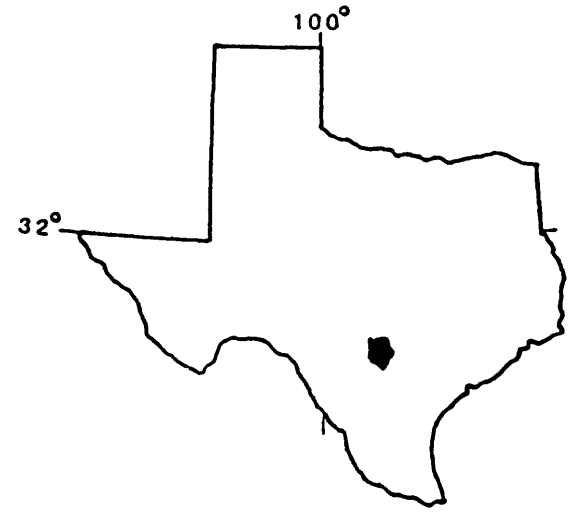
TX 86-098 LIMESTONE HYDROLOGY PROFESSIONAL PAPERS,
THE EDWARDS AQUIFER, SAN ANTONIO AREA

COOPERATING AGENCY : San Antonio City Water Board

PROJECT CHIEF: Robert W. Maclay, Subdistrict Office, San Antonio

PERIOD OF PROJECT : October 1985 to September 1986

LOCATION : Central Texas



Problem: The Edwards aquifer is one of the most important limestone aquifers in the United States. It is a highly permeable and productive aquifer that has been designated the sole source of water supply for San Antonio and other towns in south-central Texas. The area needs for water are increasing rapidly, and this growth is projected to accelerate dramatically as the corridor between San Antonio and Austin undergoes expected population, agricultural, and industrial expansion.

For the past 80 years, the Geological Survey has collected, analyzed, and published a great deal of information concerning the Edwards aquifer and the streams which recharge the aquifer.

A consolidation of previously published reports in an integrated publication by the Survey needs to be prepared in order to allow the work of the Survey to be available to a large and diverse audience concerned about understanding the Edwards aquifer.

Objectives: To prepare a single document on the hydrology of the Edwards aquifer in the San Antonio area that integrates current knowledge and scientific intuition concerning the hydrology of the aquifer. The intended audience of the report primarily will be the practitioner in the field of water resources and the technical reader. The report will be prepared as a Professional Paper, and will serve as a source and guide of the current understanding of and information about the hydrology of the Edwards aquifer.

Approach: All previously published reports and data and the current understanding of the hydrogeologic characteristics of the Edwards aquifer will be used in this project.

Progress: The draft of the report has been prepared and is in review.

Plans: Complete the review and approval of the report.

Reports in preparation:

Maclay, R. W., Hydrologic evolution of the Edwards aquifer in the San Antonio area, Texas: U.S. Geological Survey Professional Paper.

Reports approved or published, 1987: None.

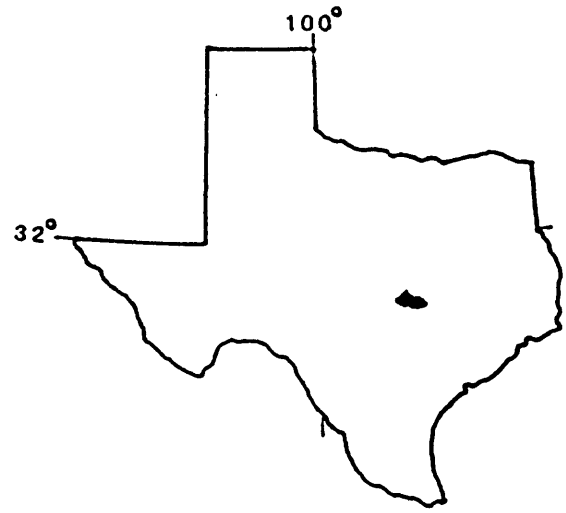
TX 86-099 RECHARGE CHARTERISTICS IN THE GEORGETOWN FORMATION IN THE GEORGETOWN AREA

COOPERATING AGENCY : Texas Water Development Board

PROJECT CHIEF: Larry F. Land, District Office, Austin

PERIOD OF PROJECT : March 1986 to September 1988

LOCATION : Central Texas



Problem: The Texas Water Development Board (TWDB) adopted rules for regulating activities that have the potential for causing pollution of the Edwards aquifer in Williamson County. During public hearings prior to the adoption of the Williamson County rules, several questions were raised about the hydrology of the Edwards aquifer and the extent of the "recharge zone." Most of these questions were related to recharge, specifically the possible flow of water through the Georgetown Formation, which directly overlies the Edwards aquifer. In order to address the issue of possible recharge to the Edwards through the Georgetown Formation, the TWDB agreed to an additional study of the Edwards (Balcones fault zone) aquifer at and in the immediate vicinity of the city of Georgetown.

Objective: To determine if the Edwards aquifer is recharged by infiltration of rain and streamflow through the Georgetown and Kiamichi Formations in the vicinity of Georgetown. If infiltration does occur, a secondary objective is to determine how readily water migrates vertically through these formations and what are the geologic features that convey the water from the surface to the main producing zone of the aquifer.

Approach: The primary approach is to install three clusters of three observation wells each. Each well will be open to a different stratum. Sites are to be located near the downdip limit of the exposure of the Georgetown Formation. Water-level maps will be prepared from data collected from a network of wells that are to be inventoried and selected for this purpose. The network will emphasize wells near streams. A network of sites along the major streams and tributaries will be selected to determine where streamflow gains and losses occur. Emphasis will be placed on finding sites at or near contacts between geologic formations. These streamflow surveys (three per year for the first two years) will coincide with the ground-water level mapping. Water samples will be collected and chemically analyzed for the standard inorganic constituents from each of the newly drilled observation wells and from 5 to 10 other wells and stream sites. Finally, detailed maps for each of the surface- and

ground-water surveys, hydrographs at observation wells, water chemistry, geologic and hydraulic data, and geologic maps will be used to make the analyses and interpretations.

Progress: The data-collection program has been completed and a data report has been prepared. A preliminary analysis of the hydrologic and geologic data of the Georgetown Limestone suggests that water does not readily move in the formation.

Plans: Review and publish the data report. A report will be prepared that describes the vertical movement of water in the Georgetown Limestone.

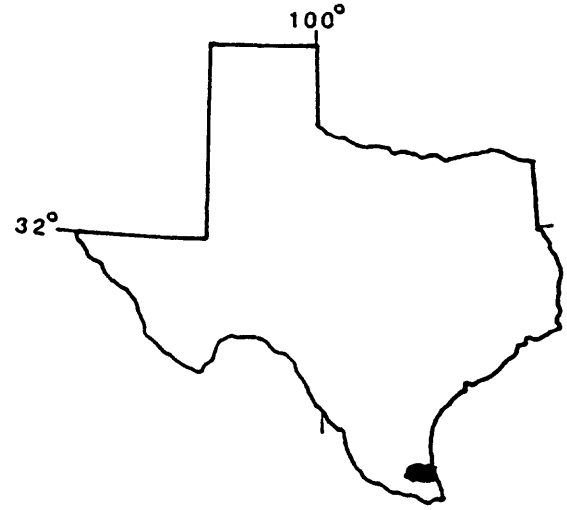
Reports in preparation: None.

Land, L.F. and Dorsey, M.E., Recharge to the Edwards aquifer through the Georgetown Limestone near Georgetown, Williamson County Texas: U.S. Geological Survey Water-Resources Investigation Report.

Reports approved or published, 1987: None.

Dorsey, M.E., and Slagle, D.L., 1987, Hydrologic and geologic data for the Edwards aquifer recharge zone near Georgetown, Williamson County, Texas, 1986-87, U.S. Geological Survey Water-Resources Investigations Report 87-691, 66 p.

TX 86-100 IRRIGATION DRAINAGE QUALITY OF THE LOWER RIO GRANDE VALLEY



COOPERATING AGENCY : U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service

PROJECT CHIEF: Frank C. Wells, District Office, Austin

PERIOD OF PROJECT : February 1986 to October 1987

LOCATION : South Texas

Problem: During the last several years, there has been increasing concern about the quality of irrigation drainage waters and its potential effects on human health, fish, and wildlife. To address the irrigation drainage quality issues, the Department of Interior will conduct studies to determine the extent of contamination in (1) project irrigation or drainage facilities constructed or managed by the Department, (2) National Wildlife Refuge areas managed by the Department, and (3) other migratory species management areas that receive water from Department-funded projects.

Objectives: To determine from existing information and field screening studies whether irrigation drainage waters have caused or have the potential to cause harmful effects on human health, fish, wildlife, or other water users; to conduct more detailed investigations if information indicates an existing or a high potential for harmful effects; to plan a process to identify a cost effective solution if study and evaluation indicate corrective action is justified; and to have the Department implement corrective action if necessary.

Approach: Collect existing data from State, local, and other Federal agencies and design a field screening study to evaluate the extent of contamination in irrigation drainage waters. The field screening study is designed to do extensive sampling at 15 locations in the lower Rio Grande Valley and the Laguna Atascosa National Wildlife Refuge for selected metals and pesticides in water and bed sediments. At four locations, water samples will be collected for GC-MS analysis to identify toxic organics associated with the agri-chemical industry. In addition, 3 of the 15 stations will be selected for sampling of pesticides during a storm.

Project summary: Data collected in the lower Rio Grande valley and Laguna Atascosa National Wildlife Refuge field-screening study indicate that concentrations of dissolved minor elements in water are relatively small. Concentrations of dissolved boron increased significantly from west to east.

No chlorophenoxy herbicides were detected in water during the June 1986 sampling. Simazine, prometone, and atrizine were the only triazine herbicides detected, and concentration of these compounds did not exceed 0.8 micrograms per liter. DDE, the only organochlorine insecticide detected in water, was found at two locations at concentrations of 0.01 micrograms per liter. Methyl parathion, malathion, and diazinon were the only organophosphorus compounds detected in the June 1986 sampling, and the maximum concentrations of these compounds were 0.75, 0.71, and 0.26 micrograms per liter, respectively. Three pesticide samples collected in August 1986 indicate that the types of pesticides collected during runoff were similar to those detected during the June 1986 sampling. The exception was that the herbicide 2, 4-D was detected during runoff.

No organophosphorus insecticides, polychlorinated napthalenes, or polychlorinated biphenyl compounds were detected in four bed-sediment samples. DDE, an organochlorine insecticide, was detected in all four samples at concentrations ranging from 0.2 to 34 micrograms per kilogram. Data collected by U.S. Fish and Wildlife Service in 1985 indicate that DDE was detected in approximately 75 percent of the bed sediments analyzed.

Toxaphene was detected in 12 fish samples; detectable concentrations ranged from 0.98 to 5.1 micrograms per gram, wet weight. DDT also was detected in 12 fish samples with concentrations ranging from 0.021 to 0.066 microgram per gram, wet weight. DDD was detected in 21 fish samples, and cocentrations ranged from 0.015 to 0.16 microgram per gram, wet weight. DDE was detected in all 22 fish samples, and concentrations ranged from 0.36 to 9.9 micrograms per gram, wet weight. The maximum concentrations of DDD and DDT exceeded the 1980-81 baseline concentrations. The median and maximum concentrations of DDE and toxaphene exceeded the 1980-81 baseline concentrations. The largest concentrations of DDE, DDD, and toxaphene in fish tissue were all taken from samples collected at the Main Floodway (Llano Grande) near Progreso.

Plans: Complete the review and publication of the report.

Reports in preparation: None.

Reports approved or published, 1987:

Wells, F.C., Jackson, Gerry A., Rogers, William J., (in press), Reconnaissance investigation of water-quality bottom sediment, and biota associated with irrigation in the lower Rio Grande valley and Laguna Atascosa National Wildlife Refuge, Texas, 1986-87: U.S. Geological Survey Water-Resources Investigations Report.

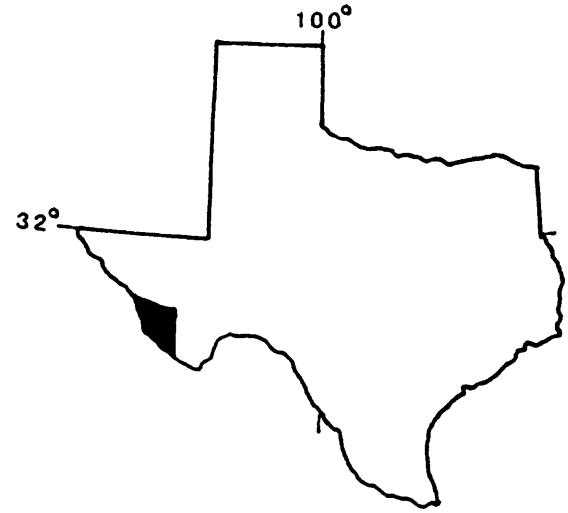
TX 86-101 GEOHYDROLOGY OF THE WATER RESOURCES OF OAK SPRING, BIG BEND NATIONAL PARK

COOPERATING AGENCY : National Park Service

PROJECT CHIEF: Ernest T. Baker, Jr., District Office, Austin

PERIOD OF PROJECT : June 1986 to September 1988

LOCATION : West Texas



Problem: Oak Spring is the sole source of water for a major developed area in Big Bend National Park. There is concern that water may migrate from sewage lagoons to the aquifer that supplies Oak Springs and thus, could contaminate this important spring. There is also concern regarding the ability of Oak Spring to continue to provide sufficient quantities of water for the developed area.

Objective: (1) To describe the hydrology of the aquifer supplying Oak Spring, (2) to determine the source of water supplying the spring and determine if the source includes the sewage lagoons, (3) to determine the quality of water in the aquifer, (4) to determine the direction and rate of ground-water movement, (5) to determine the changes in water quality in the aquifer between the lagoons and the spring, and (6) to determine the factors that influence the quantity and quality of water from the spring.

Approach: The approach includes the following: Map the surface geology related to Oak Spring; study the subsurface geologic features controlling water movement using test drilling and geophysical surveys (borehole and surface). Test holes will define hydraulic properties of the aquifer and serve to monitor water quality; collect water samples from springs, test wells, lagoons, and other sources, and analyze samples for a wide range of constituents and properties and compare the results with historical data; estimate the water budget of the aquifer supplying the spring. Recorders will be installed in Oak Spring and observation wells.

Progress: Test drilling was conducted in the basin area along Oak Creek to determine if the basin fill is an aquifer, and if it is, to monitor, by means of observation wells, the effects of the sewage lagoons on the aquifer. The basin fill was believed to be a possible source of water to Oak Spring, which could be effected by possible pollutants from the lagoons or by the heavy use of the basin by park visitors. Test drilling showed that the basin fill is not saturated in the area where the lagoons are located. Seismic investigations,

which were conducted in the basin substantiated the test drilling. Seismic work was also conducted at Oak Spring and this revealed the depths to the water table and bedrock. Water samples were collected from Oak Spring and other important sites for very detailed analysis in an effort to trace the source of the water at Oak Spring and to detect any changes in the water quality. A continuous springflow recorder was installed at Oak Spring and continuous fluctuation in flow are being recorded.

Plans: Test drilling is planned for the Oak Spring area to assist in identifying the aquifer supplying the spring. Data on the wells should help establish the direction and rate of ground-water movement. Tracers may be used in the wells to help define flow paths and water velocities. Additional seismic profiles may be deemed necessary to supplement the well drilling. Additional water sampling will be conducted in Oak Springs, wells, and other significant sites to determine the source of the Oak Spring water and to determine if the source includes the sewage lagoons. All of the data collected will be interpreted and included in a final report.

Reports in Preparation:

Baker, E.T., Jr., Buszka, P.M., and Woodward, D.G., Geohydrology and ground-water quality of the Chisos basin and the potential for contamination of the Oak Springs, Big Bend National Park, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None.

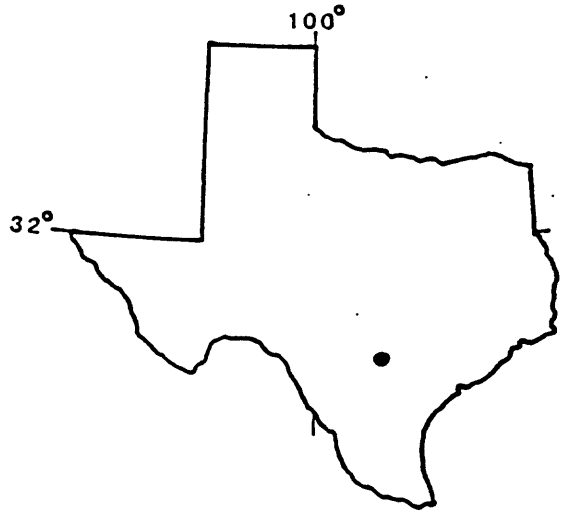
TX 87-102 KELLY AIR FORCE BASE INSTALLATION RESTORATION PROGRAM, PHASE II, STAGE 3

COOPERATING AGENCY : U.S. Air Force, Occupational and Environmental Health Laboratory

PROJECT CHIEF: George B. Ozuna, Subdistrict Office, San Antonio

PERIOD OF PROJECT : October 1986 to September 1988

LOCATION : Southwest Texas



Problem: The Installation Restoration Program (IRP) of the Department of Defense (DOD) is a comprehensive program that identifies hazardous waste sites and evaluates the risks they pose to public health and the environment on active, inactive, or formerly used DOD property objectives.

Objectives: (1) To confirm the presence or absence of contamination within two specific sites of investigation; (2) to determine the extent and degree of contamination and the potential for migration of those contaminants, if possible; (3) to identify public health and environmental hazards of migrating pollutants based on State or Federal standards for those contaminants, and (4) to delineate additional investigations that might be required.

Approach: Wells for monitoring water levels and for collecting water samples were drilled and installed at each of the study sites. Soil borings were drilled, sampled, and then plugged to determine soil contamination. Aquifer tests were performed on all monitoring wells to determine the hydrogeologic characteristics of the local aquifer. Finally, a synoptic survey of water-level measurements in the monitoring wells was conducted to determine the configuration of the potentiometric surface of the ground water in the shallow aquifer.

The water quality, the soil quality, and all the hydrogeologic data will be analyzed and interpreted to make estimates of the magnitude, extent, and direction that detected contaminants are moving. The data will also be used to identify potential environmental consequences of discovered contamination, based upon State and Federal standards.

Progress: The monitoring wells and soil borings at the two sites at Kelly Air Force Base have been completed. Chemical analyses of water and soil samples, the synoptic survey of water levels, and aquifer tests have also been completed.

Plans: Plans are to prepare a preliminary data report and an interpretive report.

Reports in preparation:

Ozuna, George B., Ground-water contamination at two sites at Kelly Air Force Base, Texas: U.S. Geological Survey Water-Resources Investigations Report.

U.S. Geological Survey, Installation Restoration Program, Phase II, Stage 3: U.S. Geological Survey Open-File Report.

Reports approved or published, 1987: None.

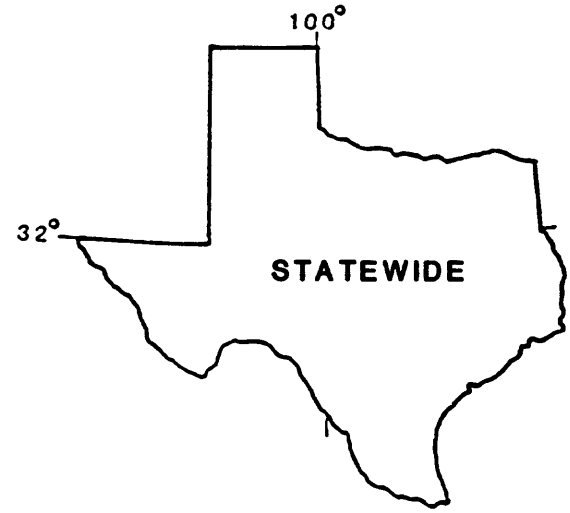
TX 87-103 TRENDS IN WATER-QUALITY DATA

COOPERATING AGENCY : U.S. Geological Survey

PROJECT CHIEF: Terry L. Schertz, District Ofice, Austin

PERIOD OF PROJECT : October 1986 to October 1987

LOCATION : Statewide



Problem: A network of water-quality stations on streams in Texas has been operated by the U.S. Geological Survey in cooperation with the Texas Water Development Board and other State, Federal, and local agencies. Over 500 stations were included in the network for at least 5 years during 1968-86, with about 75 stations included for the entire period. The data have been collected at periodic intervals, but the frequency of data collection has varied over the years from weekly, to monthly, to bimonthly, and quarterly due to changes in the network design and funding. Examination of this extensive data base for the occurrence of spatial and temporal trends in water-quality parameters is needed to determine what impact such factors as oil-field activity and population growth have had on the quality of water in Texas.

Objectives: (1) To select sites from the Texas water-quality data base that have the appropriate characteristics necessary for trend detection, (2) to develop the methods needed to process extensive data sets with complicated patterns of variability and produce temporal trend results, and (3) to examine temporal trend results for evidence of regional patterns. The procedures developed and tested in this project are intended to serve as a prototype for future studies of large water-quality networks.

Approach: Data analysis will be done for the selected sites using a combination of subjective decisions and automated procedures designed to handle trend detection in large, complex data sets. (The procedures used in this project are intended. The chemical parametes to be considered will include inorganic, trace metal, and nutrient and pesticide constituents. Physical parameters such as water temperature, pH, dissolved oxygen, specific conductance, and biological oxygen demand will also be included for trend detection.

Progress: Based on the criteria established, 185 stations were selected from approximately 500 possible stations. The computer program development is nearing completion after a decision to revise the code to incorporate new methods for use with censored parameters.

Plans: All programming and data processing should be complete by the end of February 1988. A rough draft of "Methods of trend detection in long-term, variable water-quality data" will be ready for review by the end of April 1988. A rough draft of "Trends in water-quality data in Texas" will be ready for review by mid-July 1988.

Reports in preparation:

Schertz, Terry L., 1988, Trends in water-quality data in Texas: U.S. Geological Survey Water-Resources Investigations Report.

------ 1988, Methods of trend detection in long-term, variable water-quality data: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None.

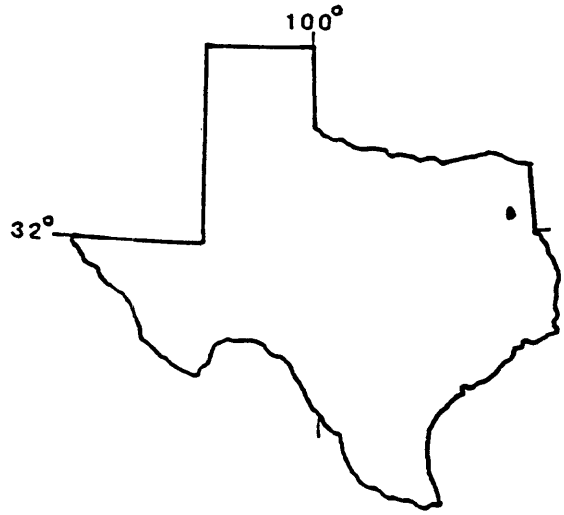
TX 87-104 WATER SURFACE AND FLOW PATTERN OF A MAJOR FLOOD AT THE TEXAS HIGHWAY 43 CROSSING OF THE SABINE RIVER

COOPERATING AGENCY : Texas Department of Highways and Public Transportation

PROJECT CHIEF: Dennis R. Myers, Subdistrict Office Fort Worth

PERIOD OF PROJECT : January 1987 to September 1988

LOCATION : Northeast Texas



Problem: Texas Highway 43 is overtopped by 10-year recurrence interval floods on the Sabine River. The Texas Department of Highways and Public Transportation (TDHαPT) plans to raise the elevation of the highway and to reconstruct the bridges to safely withstand floods having a 50-year recurrence interval. The new bridge and embankment designs have been prepared and approved, but construction has been delayed pending environmental and historical assessments. An opportunity exists to evaluate the designs by utilizing a mathematical simulation of the flood flows to determine if the cost of the construction can be reduced.

Objectives: (1) To assess the proposed bridge and embankment designs in conveying runoff from floods having a 50-year recurrence interval, (2) to explore a more efficient design with respect to the placement and height of the bridges and embankments, and (3) to compare the designs to a no-highway alternative.

Approach: The study will involve the use of a two-dimensional finite-element surface-water flow model (FESWMS). Given the inflow and outflow at the limits of the reach, topography and roughness of the floodplain, and geometry of the bridges and embankments, the model can compute the depth and velocity in two dimensions at each node of a network of elements. The network of elements can be sufficiently detailed to adequately represent the opening of the bridges, the location of the embankment, and the location of the main channel. The results from the model can be used to map the water surface, flow distribution, and the velocity patterns in the flood plain and in and around the bridge openings. The model simulation will assume steady-state conditions.

Progress: A 6-mile segment of the Sabine River with the proposed changes in the bridges on State Highway 43 has been simulated with a two-deminsional surface-water model. A comparison of the simulated discharge with the standard computations showed a variation of only a few percent.

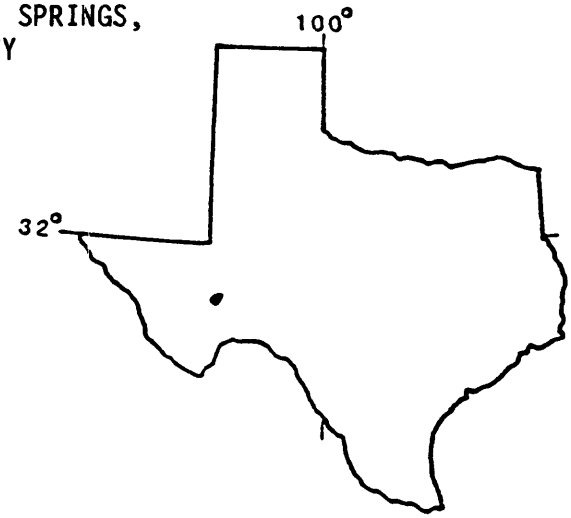
Plans: Conduct sensitivity and alternative bridge opening simulations, and prepare the final report.

Report in preparation:

Gilbert, J., and Myers, D.R., Simulation of the water surface and flow pattern of major floods at the Texas Highway 43 crossing of the Sabine River, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None.

TX 87-105 CURRENT AND HISTORIC HYDROLOGIC CONDITIONS OF THE EDWARDS-TRINITY AQUIFER AND COMANCHE SPRINGS, PECOS COUNTY



COOPERATING AGENCY : City of Fort Stockton

PROJECT CHIEF: Ted A. Small, Subdistrict Office, San Antonio

PERIOD OF PROJECT : January 1987 to January 1989

LOCATION : West Texas

Problem: The city of Fort Stockton depends on water from the Edwards-Trinity aquifer as an important source of water supply. However, the ground-water resources in Pecos County are limited to the extent that water levels at times have been extremely low and flow from Comanche Springs has been greatly diminished. Hydrologic information and understanding is needed to properly manage the limited ground-water resources of Pecos County.

Objectives: (1) To determine the water levels at which Comanche Springs flows freely; (2) to determine the pumping rates and water-level declines at which flow from Comanche Springs begins to diminish; (3) to determine the pumping rates that led to recent low water levels; and (4) to describe the current water-level and water-quality characteristics of the aquifer.

Approach: Following a data review and literature search, water levels are measured in a number of wells and water samples for chemical analyses are collected from about 35 wells.

Progress: The current water levels were tabulated and mapped for comparison with historic water levels and water levels during periods of heavy pumping. Some areas of significant change have been determined and the cause for change identified. Measured water levels (January-February 1987) were higher than they have been for a number of years due to abnormally high late-autumn rainfall and low pumping rates. However, Comanche Springs ceased to flow in March following the start of irrigation pumping.

Plans: Water qualities will be tabulated and mapped when the analyses are returned from the laboratory. After data analyses are complete, a water-resources investigation report will be prepared.

Reports in preparation:

Small, T.A., Current and historic hydrologic conditions of the Edwards-Trinity aquifer and Comanche Springs, Pecos County, Texas: U.S. Geological Survey Water-Resources Investigations Report.

Reports approved or published, 1987: None.

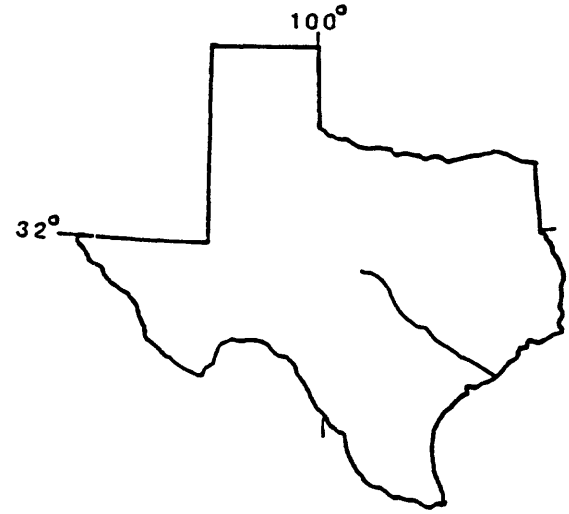
TX 87-106 FLOW RELATIONSHIPS BETWEEN THE LOWER COLORADO RIVER AND REGIONAL AQUIFERS

COOPERATING AGENCY : Lower Colorado River Authority

PROJECT CHIEF: Dennis G. Woodward, District Office, Austin

PERIOD OF PROJECT : July 1987 to September 1988

LOCATION : Central Texas



Problem: Water in the Colorado River travels about 560 miles from where it enters San Saba County to where it discharges into the Gulf of Mexico. Along this reach, the river flows either directly on or over several regional aquifers. Along certain subreaches of the river, ground water from the regional aquifers flows into the river valley and provides recharge to the Colorado River; along other subreaches, water in the river may seep downward through the river valley and provide recharge to the aquifer(s). The exchange of water between the river and the aquifers will become increasingly important when the Lower Colorado River Authority will have to operate under a River Master Plan, which is scheduled to begin in 1991.

Objectives: (1) To identify those subreaches of the lower Colorado River through which water can flow at a significant rate between the river and the underlying regional aquifers, and (2) to determine the present pattern (or flow direction) of water between the river and the regional aquifers. The scope of the study does not include quantifying the flow rates.

Approach: The study consists of two components: (1) Define and delineate the regional aquifers in the study area; existing geologic and hydrogeologic data are expected to provide the necessary information; and (2) compile and analyze data for determination of river subreaches which have significant ground-water gains and losses; this includes mapping the local potentiometric surface of each regional aquifer in and near the river valley, analyzing the ground-water flow directions of each regional aquifer near the river valley, and determining the lateral extent of those subreaches gaining ground water and losing surface water. Existing water-level data from the files of the U.S. Geological Survey and the Texas Water Development Board will be used to prepare the potentiometric maps.

Progress: Water-level data were obtained from a variety of State and U.S. Geological Survey reports and were plotted to prepare preliminary potentiometric maps; the maps reflect conditions in the mid-60's to mid- to late-70's. Most of the regional aquifers are included in these maps. These preliminary maps indicate that the Colorado River is being recharged by regional aquifers throughout most of its reach in the study area; however, it appears that the river may be discharging water to the Chicot aquifer in the central part of Wharton County. Water-level hydrographs have been prepared from selected observation wells included in the State's monitoring network. The location of wells used in this study are being plotted from county well-location maps prepared by the Texas Department of Water-Resources.

Plans: Complete the preparation of the report.

Report in preparation:

Woodward, D.G., Flow relationships between the lower Colorado River and regional aquifers, Texas: U.S. Geological Survey, Water-Resources Investigations Report.

Reports approved or published, 1987: None.

REPORTS PUBLISHED OR APPROVED FOR PUBLICATION IN FISCAL YEAR 1987

Bonnet, C.W., and Williams, James F., III, (in press), Development of groundwater resources in the Orange County area, Texas and Louisiana, 1980-spring of 1985: U.S. Geological Survey Water-Resources Investigations Report 87-4158.

Burchett, C.R., Rettman, P.L., and Boning, C.W., 1986, The Edwards aquifer, extremely productive, but....a sole-source water supply for San Antonio and surrounding counties in south-central Texas: Edwards Underground Water District Report, 38 p.

Bush, Peter W., 1986, Planning report for the Edwards-Trinity regional aquifer-system analysis, central Texas, southeast Oklahoma, and southwest Arkansas: U.S. Geological Survey Water-Resources Investigations Report 86-4343, 15 p.

Buszka, P.M., (in press), Relation of water quality of the Edwards aquifer to hydrogeology and land use, San Antonio region, Texas: U.S. Geological Survey Water-Resources Investigations Report 87-4116.

Carrillo, E.R., Buckner, H.D., and Rawson, Jack, 1987, Index of surface-water stations in Texas, January 1987: U.S. Geological Survey Open-File Report 87-468, 16 p.

Dorsey, M.E., and Slagle, D.L., 1987, Hydrologic and geologic data for the Edwards aquifer recharge zone near Georgetown, Williamson County, Texas, 1986-87, U.S. Geological Survey Water-Resources Investigations Report 87-691, 66 p.

Garza, Sergio, Jones, B.D., and Baker, E.T., Jr., 1986, Approximate potentiometric surfaces for the aquifers of the Texas Coastal Uplands system, 1980: U.S. Geological Survey Hydrologic Investigations Atlas 704, 1 sheet.

Gordon, J.D., Pate, D.L., Dorsey, M.E., 1987, Hydrologic data for urban studies in the Austin, Texas, metropolitan area, 1985: U.S. Geological Survey Open-File Report 87-224, 170 p.

Goss, R.L., 1987, Statistical and graphical summaries of selected water-quality and streamflow data from the Trinity River near Crockett, Texas, 1964-85: U.S. Geological Survey Open-File Report 87-393, 21 p.

Holzer, Thomas L. and Gabrysch, Robert K., 1987, Effects of water-level recoveries on fault creep, Houston, Texas: Ground Water, July-August 1987, v. 25, no. 4, p. 392-397.

Leibbrand, Norman F., 1987, Estimated sediment deposition in Lake Corpus Christi, Texas, 1972-85: U.S. Geological Survey Open-File Report 87-239, 26 p.

Leibbrand, Norman F., and Gibbons, W.J., (in press), Water quality of Cedar Creek Reservoir in northeast central Texas, 1977-87: U.S. Geological Survey Water-Resources Investigations Report 87-4231.

Lins, Harry F., Lamfear, Kenneth J., and Schertz, Terry L., 1987, Patterns of acid despoition variability in the eastern United States, 1981-84: U.S. Geological Survey Open-File Report 87-454, 16 p.

Liscum, Fred, Bruchmiller, J.P., Brown, D.W., and Paul, E.M., 1987, Hydrologic data for urban studies in the Houston metropolitan area, Texas, 1984: U.S. Geological Survey Open-File Report 86-608, 190 p.

Liscum, Fred, Goss, R.L., Paul, E.M., 1987, Effects on water quality due to flood-water detention by Barker and Addicks Reservoirs, Houston, Texas: U.S. Geological Survey Water-Resources Investigations Report 86-4356, 96 p.

Mackey, Gary W., 1987, Comparison of irrigation pumpage and change in water storage in the High Plains aquifer in Castro and Parmer Counties, Texas, 1975-83: U.S. Geological Survey Water-Resources Investigations Report 87-4032, 48 p.

Maclay, R.W. and Land, L.F., 1987, Simulation of flow in the Edwards aquifer, San Antonio region, Texas, and refinement of storage and flow concepts: U.S. Geological Survey Open-File Report 86-532, 86 p.

Maclay, R.W., and Land, L.F., (in press), Simulation of flow in the Edwards aquifer, San Antonio region, Texas, and refinement of storage and flow concepts: U.S. Geological Survey Water-Supply Paper.

Mitchell, Alicia A., 1987, Water-resources activities of the U.S. Geological Survey in Texas--Fiscal years 1985-86: U.S. Geological Survey Open-File Report 86-602, 96 p.

Ozuna, G.B., Nalley G.M., and Bowman, M.N., 1987, Compilation of hydrologic data for the Edwards aquifer, San Antonio area, Texas, 1986, with 1934-85 summary: Edwards Underground Water District Bulletin 45, 163 p., 5 plates.

Pavlicek, Diane J., Small, Ted A., Rettman, Paul L., 1987, Hydrologic data from a study of the freshwater zone/salinewater zone interface in the Edwards aquifer, San Antonio region, Texas: U.S. Geological Survey Open-File Report 87-389, 108 p.

Ryder, Paul D., (in press), Hydrologeology and predevelopment flow in the Texas Gulf Coast aquifer systems: U.S. Geological Survey Water-Resources Investigations Report 87-4248.

Schertz, Terry, 1987, Methods of trend detection in long-term, variable water-quality data: Proceedings (EOS) of the 1987 Fall Meeting of the American Geophysical Union, San Francisco, Calif., Dec. 6-11, 1987, Abstract.

Sladek, Gail J., 1987, Water-Resources reports prepared by the U.S. Geological Survey, Texas District, 1973-86: U.S. Geological Survey Open-File Report 87-228, 40 p.

Strause, J.L., 1988, Texas surface-water resources in National Water Summary 1986--Hydrologic events and surface-water resources: U.S. Geological Survey Water-Supply Paper 2325.

U.S. Geological Survey, 1987, Water-Resources data--Texas, water year 1986, Arkansas River, Red River, Sabine River, Neches River, and Trinity River basins and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 86-1, 463 p.

------ 1987, Water-Resources data--Texas, water year 1986, San Jacinto River, Brazos River, and San Bernard River basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 86-2, 413 p.

------ 1987, Water-Resources data--Texas, water year 1986, Colorado River, Lavaca River, Guadalupe River, Nueces River, and Rio Grande basins, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX 86-3, 405 p.

Veenhuis, Jack E., Gannett, David G., 1986, The effects of urbanization on floods in the Austin metropolitan area, Texas: U.S. Geological Survey Water-Resources Investigations Report 86-4069, 66 p.

Welborn, C.T. and Veenhuis, Jack E., 1987, Effects of runoff controls on the quantity and quality of urban runoff at two locations in Austin, Texas: U.S. Geological Survey Water-Resources Investigations Report 87-4004, 101 p.

Wells, F.C., Jackson, Gerry A., Rogers, William J., (in press), Reconnaissnce investigation of water-quality bottom sediment, and biota associated with irrigation in the lower Rio Grande valley and Laguna Atascosa National Wildlife Refuge, Texas, 1986-87: U.S. Geological Survey Water-Resources Investigations Report.

Williams, James F., III, Coplin, L.S., Ranzau, C.E., Lind, W.B., Bonnet, C.W., and Locke, G.L., (in press), Records of wells, drillers' logs, water-level measurements, and chemical analyses of ground-water in Harris and Galveston Counties, Texas, 1980-87: U.S. Geological Survey Open-File Report 87-378.

Williams, James F., III, Lind, W.B., and Coplin, L. S., 1987, Approximate altitude of water-levels in the Chicot and Evangeline aquifers in the Houston area, Texas, Spring 1987: U.S. Geological Survey Open-File Report 87-233, 2 sheets.

Williams, James F., III, and Ranzau, C.E., Jr., 1987, Ground-water withdrawals and changes in ground-water levels, ground-water quality, and land-surface subsidence in the Houston district, Texas, 1980-84: U.S. Geological Survey Water-Resources Investigations Report 87-4153, 56 p.

Williams, James F., III, Ranzau, C.E., Jr., and Lind, W.B., 1987, Approximate water-level changes in wells completed in the Chicot and Evangeline aquifers, 1977-87 and 1986-87, and measured compaction, 1973-87, in the Houston-Galveston region: U.S. Geological Survey Open-File Report 87-108, 7 sheets.

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12201 Sunrise Valley Drive
Reston, VA 22092

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Individual topographic quadrangle maps are shown on "State Indexes to Topographic Maps," which are free on application. These indexes also show commercial dealers in each State.

Maps for all areas including Puerto Rico, The Virgin Islands, Alaska, Hawaii, Guam, and American Samoa may be ordered from:

U.S. Geological Survey
Map Distribution
Federal Center, Bldg. 41
Box 25286
Denver, CO 80225

Book reports of the Geological Survey are available over the counter at the following Geological Survey Office, which is an authorized agent of the Superintendent of Documents:

Public Inquiries Office
U.S. Geological Survey
Federal Building, Rm 1C45
1100 Commerce Street
Dallas, TX 75242
PH: (214) 767-0198

Topographic maps of Texas may be inspected at:

U.S. Geological Survey
Texas District Office
300 East 8th Street
Austin, TX 78701