A contribution of the National Water–Quality Assessment Program

Water-Quality Assessment of the Trinity River Basin, Texas—Ground-Water Quality of the Trinity, Carrizo-Wilcox, and Gulf Coast Aquifers, February–August 1994

Water-Resources Investigations Report 99–4233

U.S. Department of the Interior
U.S. Geological Survey

Blank Page

U.S. Department of the Interior
U.S. Geological Survey

Water-Quality Assessment of the Trinity River Basin, Texas—Ground-Water Quality of the Trinity, Carrizo-Wilcox, and Gulf Coast Aquifers, February–August 1994

By David C. Reutter and David D. Dunn

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 99–4233

A contribution of the National Water-Quality Assessment Program

Austin, Texas
2000

U.S. DEPARTMENT OF THE INTERIOR
Bruce Babbitt, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

For additional information write to

District Chief
U.S. Geological Survey
8027 Exchange Dr.
Austin, TX 78754–4733
E-mail: dc_tx@usgs.gov

Copies of this report can be purchased from

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver, CO 80225–0286
E-mail: infoservices@usgs.gov

FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional- and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the U.S. Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of more than 50 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch

Robert M. Hirsch
Chief Hydrologist

Blank Page

CONTENTS

Figures

Tables

VERTICAL DATUM

Sea level: In this report “sea level” refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Water-Quality Assessment of the Trinity River Basin, Texas—Ground-Water Quality of the Trinity, Carrizo-Wilcox, and Gulf Coast Aquifers, February–August 1994

David C. Reutter *and* David D. Dunn

Abstract

Ground-water samples were collected from wells in the outcrops of the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers during February–August 1994 to determine the quality of ground water in the three major aquifers in the Trinity River Basin study unit, Texas. These samples were collected and analyzed for selected properties, nutrients, major inorganic constituents, trace elements, pesticides, dissolved organic carbon, total phenols, methylene blue active substances, and volatile organic compounds as part of the U.S. Geological Survey National Water-Quality Assessment Program. Quality-control practices included the collection and analysis of blank, duplicate, and spiked samples.

Samples were collected from 12 shallow wells (150 feet or less) and from 12 deep wells (greater than 150 feet) in the Trinity aquifer, 11 shallow wells and 12 deep wells in the Carrizo-Wilcox aquifer, and 14 shallow wells and 10 deep wells in the Gulf Coast aquifer. The three aquifers had similar water chemistries—calcium was the dominant cation and bicarbonate the dominant anion. Statistical tests relating well depths to concentrations of nutrients and major inorganic constituents indicated correlations between well depth and concentrations of ammonia nitrogen, nitrite plus nitrate nitrogen, bicarbonate, sodium, and dissolved solids in the Carrizo-Wilcox aquifer and between well depth and concentrations of sulfate in the Gulf Coast aquifer. The tests indicated no significant correlations for the Trinity aquifer.

Concentrations of dissolved solids were larger than the secondary maximum contaminant level of 500 milligrams per liter established for drinking water by the U.S. Environmental Protection Agency in 12 wells in the Trinity aquifer, 4 wells in the Carrizo-Wilcox aquifer, and 6 wells in the Gulf Coast aquifer. Iron concentrations were larger than the secondary maximum contaminant level of 300 micrograms per liter in at least 3 samples from each aquifer, and manganese concentrations were larger than the secondary maximum contaminant level of 50 micrograms per liter in at least 2 samples from each aquifer. The pesticides atrazine, deethyl atrazine, and pp'-DDE were detected in at least one sample from each aquifer. Diazinon was detected in 11 Trinity aquifer samples and 4 Carrizo-Wilcox aquifer samples. Each aquifer had one detection of a volatile organic compound—benzene in the Trinity aquifer, trichlorofluoromethane in the Carrizo-Wilcox aquifer, and trichloromethane in the Gulf Coast aquifer.

INTRODUCTION

The U.S. Geological Survey (USGS) began full implementation of the National Water-Quality Assessment (NAWQA) Program in 1991 at 20 major hydrologic areas, called study units. The primary purposes of the NAWQA program are to describe the status of and trends in the quality of the Nation's water resources and to provide a sound understanding of the natural and human factors affecting water quality (Leahy and others, 1990). The nationally consistent, integrated assessment of chemical, physical, and biological resources will provide water managers and policy makers with information for directing water-quality management programs and for evaluating the effectiveness of these programs. Gilliom and others (1995) present a complete description of the NAWQA objectives and design.

The NAWQA Program is composed of study-unit investigations. The study units selected encompass

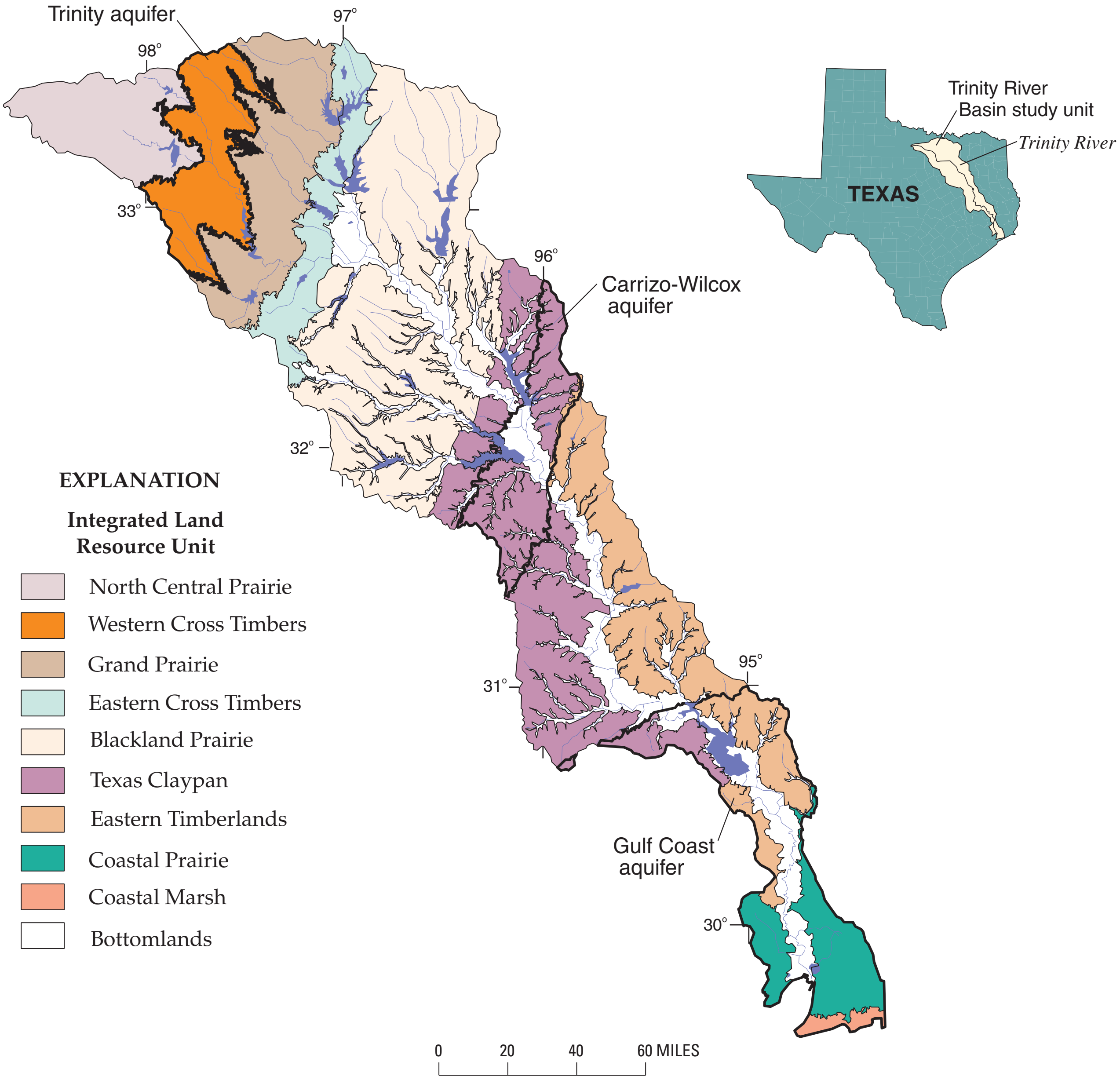


Figure 1. Location of major aquifers in relation to Integrated Land Resource Units in the Trinity River Basin study unit.

one or more major river basins and aquifers. When fully implemented, more than 50 study units will be distributed across the Nation. Combined, they encompass about one-half of the conterminous United States and 60 to 70 percent of the population and national water use. The Trinity River Basin study unit in east Texas (fig. 1) was among the first set of 20 NAWQA study units to be fully implemented.

Purpose and Scope

This report describes the ground-water quality of the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit. Water samples were collected from wells in the outcrops of the aquifers during February–August 1994 (24 wells in the Trinity aquifer, 23 wells in the Carrizo-Wilcox aquifer, and 24 wells in the Gulf Coast aquifer) and analyzed for selected properties, nutrients, major inorganic constituents, trace elements, pesticides, dissolved organic carbon, total phenols, methylene blue active substances, and volatile organic compounds. The classification of water types within each aquifer is shown in relation to well depth by trilinear diagrams. The range and distribution of selected inorganic constituents and trace elements are shown by boxplots. Statistical tests were done to identify relations between selected constituents and well depths. Water quality also is compared among aquifers.

Physiographic and Hydrogeologic Setting

The Trinity, Carrizo-Wilcox, and Gulf Coast aquifers are the three major aquifers in the Trinity River Basin study unit. Each aquifer is within distinct land resource units defined by Ulery and others (1993) as Integrated Land Resource Units (ILRU). The ILRUs are based on the physiography of the land and describe characteristics of topography, geology, vegetation, and soil.

The Trinity aquifer is within the northwestern section of the study unit and delineates the boundary of the Western Cross Timbers ILRU (fig. 1). The Western Cross Timbers is characterized by residential urban areas and rural areas of pasture and rangeland for cattle with some crop and woodlands. Oil and gas exploration is the major nonagricultural industry in this area. The terrain is generally level to undulating. The soils consist of weakly cemented sand and unconsolidated loamy material. Most of the soils in this area are well drained and have low to moderate permeability (U.S. Department of Agriculture, 1989).

The Carrizo-Wilcox aquifer, in the central part of the study unit is composed of the Texas Claypan and Bottomlands ILRUs (fig. 1). The Texas Claypan consists of soils derived from sediment of Tertiary age and have high shrink/swell potential. Cropland and pastures dominate this rural area, although hardwood trees such as oak and elm are common. The terrain is generally level to undulating. The soils consist of sandy or loamy material, are moderately well drained, and have very low to moderate permeability (U.S. Department of Agriculture, 1974–75, 1979). The Bottomlands, which consists mainly of alluvial sediment of Quaternary age, deposited over the flood plain of the Trinity River and its tributaries (Ulery and others, 1993), overlies part of the Carrizo-Wilcox aquifer (fig. 1). Wells in the Bottomlands were not selected for this study.

The Gulf Coast aquifer is in the lower part of the study unit in the Texas Claypan, Eastern Timberlands, Coastal Prairie, Coastal Marsh, and Bottomlands ILRUs (fig. 1). The Eastern Timberlands consists of a mixture of pine and hardwood forests with terrain varying from rolling plains to rolling hills. The Coastal Prairie consists of grasses and is dominated by cattle ranching as well as sorghum, soybean, and rice farming. The terrain is generally level. The Coastal Marsh consists of wet lowland areas and is used primarily for cattle ranching. The soils consist of clayey to loamy material in the Coastal Prairie and Coastal Marsh and fine sandy loam in the Eastern Timberlands. The soils of the Coastal Prairie and Coastal Marsh have very low to low permeabilities and drain poorly (U.S. Department of Agriculture, 1976). The soils of the Eastern Timberlands and Bottomlands are moderately drained and have low to high permeabilities (U.S. Department of Agriculture, 1988).

Trinity Aquifer

The Trinity aquifer consists of a southward-trending band within the Trinity River Basin study unit that extends from Montague and Cooke Counties in the north to Parker and Tarrant Counties in the south (fig. 2). Aquifer thickness is as much as 400 feet (ft) in the study unit. The recharge, mostly from infiltration of precipitation, averages about 30 inches (in.) annually to this aquifer system. The ground water is naturally discharged to underlying confining units and to the saline zones of the aquifer and is artificially discharged from flowing or pumping wells. Transmissivity is highly variable in the Trinity aquifer, ranging from 250 to greater than 1,500 feet squared per day (ft^2/d) (Baker and others, 1990).

Carrizo-Wilcox Aquifer

The Carrizo-Wilcox aquifer consists of the Carrizo Sand and the Wilcox Group. Substantial movement of water occurs between the Carrizo Sand and Wilcox Group; thus, the two units are commonly treated as one aquifer system.

The Carrizo-Wilcox aquifer consists of a southward-trending band within the Trinity River Basin study unit that extends from Van Zandt County in the north to Leon County in the south (fig. 3). Aquifer thickness is as much as 2,600 ft in the study unit

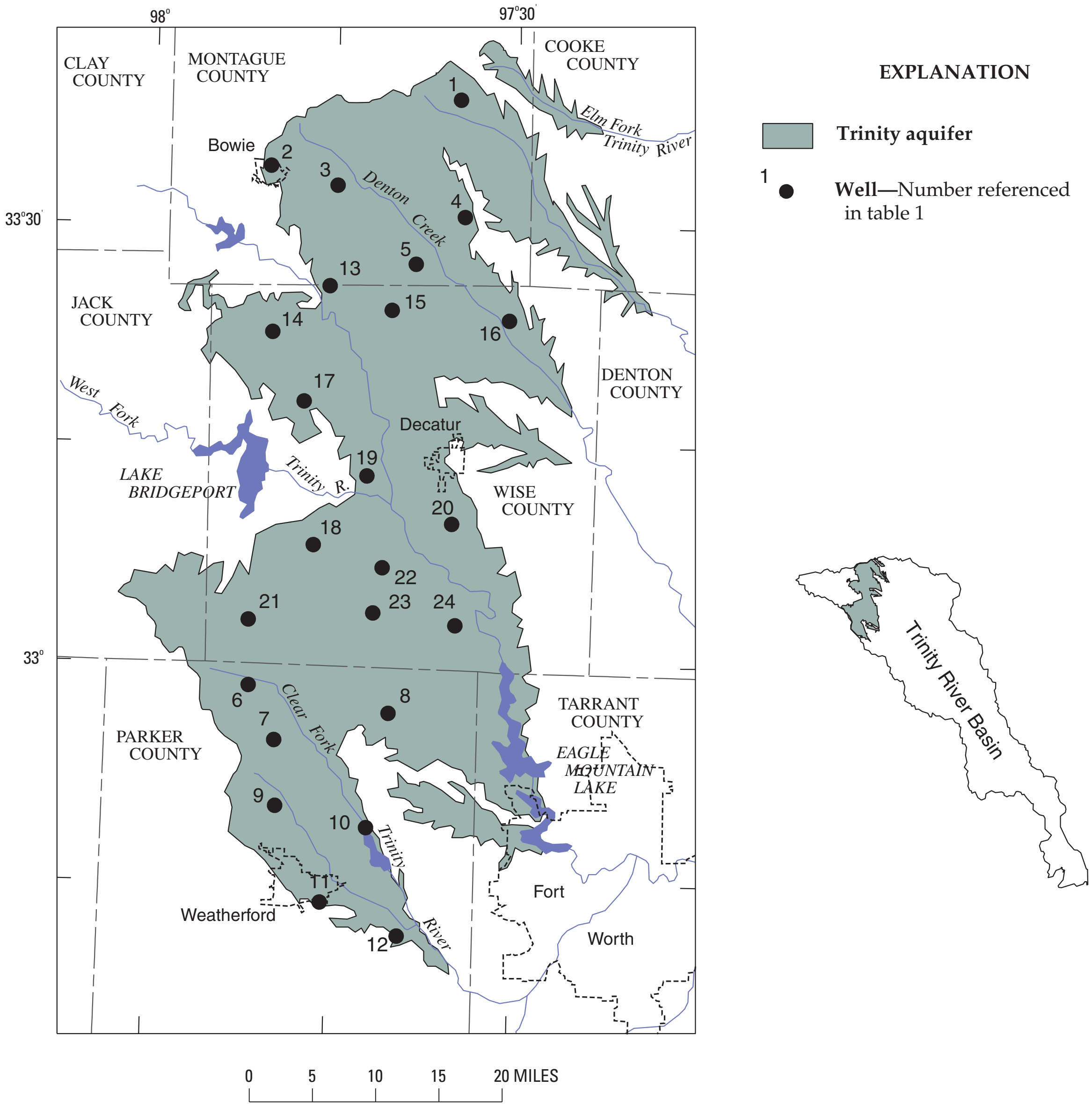


Figure 2. Location of wells sampled in the outcrop of the Trinity aquifer.

(Peckham and others, 1963). The recharge, mostly from infiltration of precipitation, averages about 40 in. annually to this aquifer system. Because the aquifer has a shallow water table, a substantial amount of water is discharged into local streams. Generally, the ground water moves toward the Trinity River within the study unit. Transmissivity is highly variable in the aquifer, ranging from about 700 to 2,500 ft^2/d in the Carrizo Sand and from about 200 to 4,000 ft^2/d in the Wilcox Group (Rettman, 1987; William F. Guyton and Associates, 1972).

Gulf Coast Aquifer

The Gulf Coast aquifer consists of the Chicot, Evangeline, and Jasper aquifers. Within the Trinity River Basin study unit, the Gulf Coast aquifer extends from Walker, Trinity, and Polk Counties in the north to Chambers County in the south (fig. 4).The recharge, mostly from infiltration of precipitation, averages about 50 in. annually to this aquifer system. Thickness of the Chicot aquifer is as much as 400 ft in the study unit (Baker, 1983); transmissivity ranges from 3,000 to

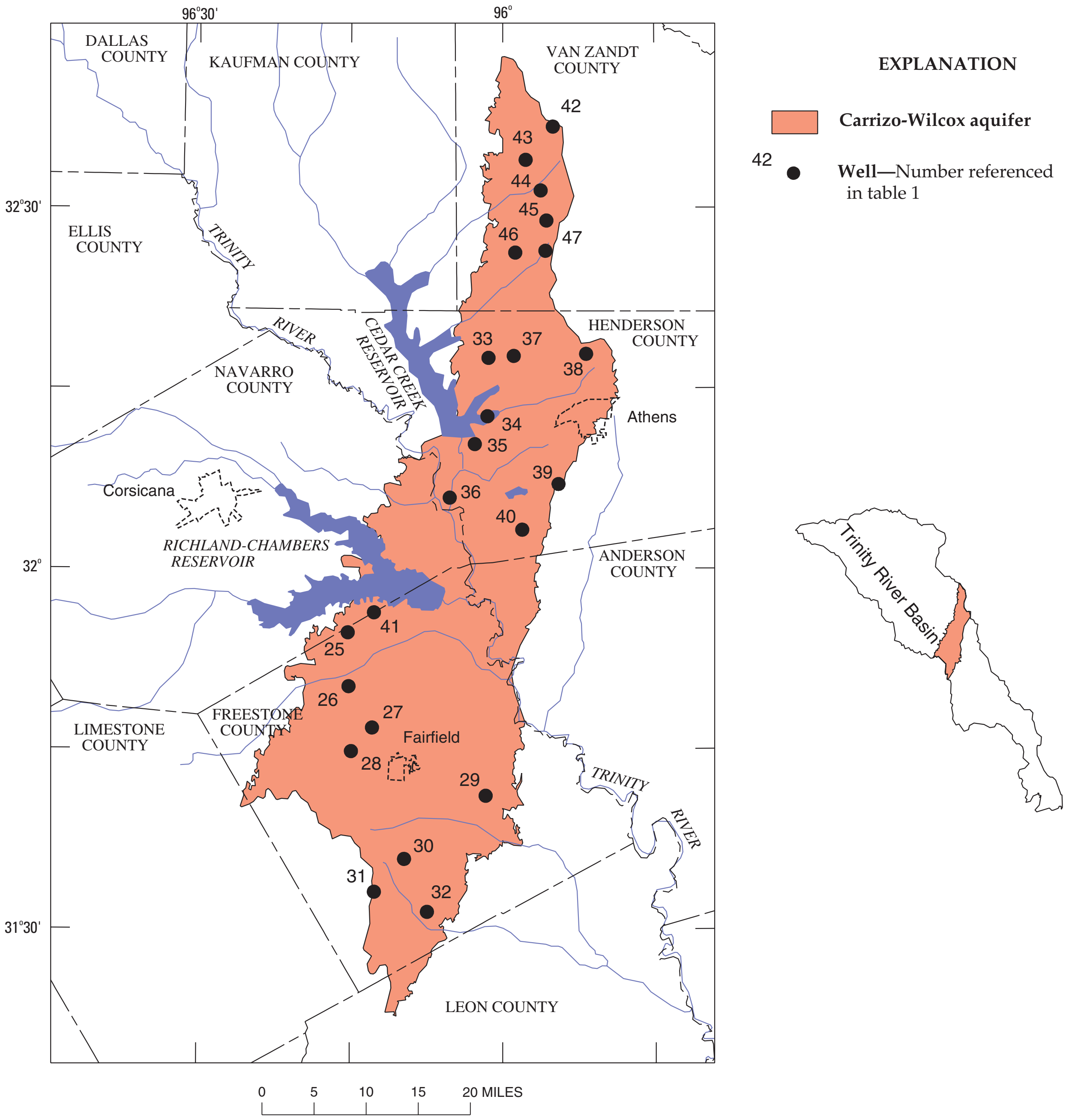


Figure 3. Location of wells sampled in the outcrop of the Carrizo-Wilcox aquifer.

9,000 ft^2/d (Carr and others, 1985). Thickness of the Evangeline aquifer is as much as 400 ft in the study unit (Baker, 1983); transmissivity ranges from 3,000 to 15,000 ft^2/d (Carr and others, 1985). Thickness of the Jasper aquifer is as much as 1,000 ft in the study unit; transmissivity ranges from 2,500 to 10,000 ft^2/d (Baker, 1983).

Acknowledgments

The authors wish to thank the well owners who aided the study by permitting the USGS to collect water samples from their wells. The owners of these wells are public and industrial water-supply corporations as well as individual land owners.

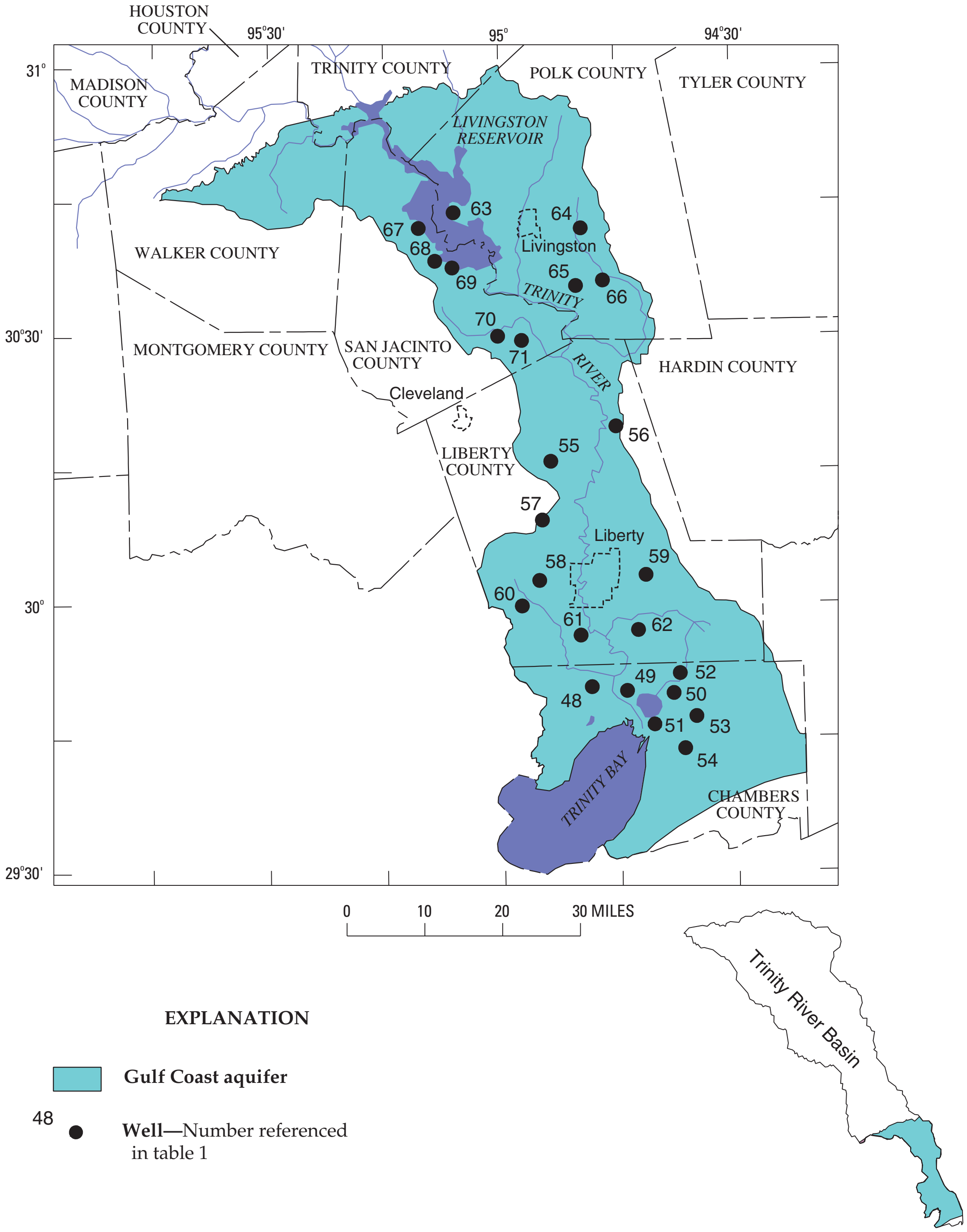


Figure 4. Location of wells sampled in the outcrop of the Gulf Coast aquifer.

DATA-COLLECTION METHODS

Wells were selected for sampling to represent the overall water-quality characteristics of all three aquifers. Special equipment-decontamination and sampling procedures were followed to ensure the samples collected represent only the water quality and conditions of each aquifer.

Well Selection

Criteria for well selection included water use as public or residential supply wells and a well depth of less than 200 ft. To ensure an even distribution of wells over the sampling area, some wells not used for public or residential supply or deeper than 200 ft were randomly selected. Wells selected for sampling consist of public and industrial water-supply wells and private residential wells. Well depths range from 21 to 490 ft, and well diameters range from 2 to 36 in. The 36-in. diameter wells are older, hand-dug residential-supply wells.

All wells selected for sampling are located within the outcrop areas of the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit. Well locations and land-surface altitudes were determined from USGS 7-1/2-minute quadrangle topographic maps (scale 1:24,000). Well locations were verified by plotting them on 1:250,000-scale maps of surficial geology (University of Texas, Bureau of Economic Geology, 1967; 1968a, b; 1970; 1982; 1987). Most wells are included in the State of Texas well inventory maintained by the Texas Water Development Board (TWDB). Descriptive well information was obtained from the TWDB well inventory, direct field measurements, and from well owners.

Wells in this report are referred to by local well numbers and USGS site identification numbers. The local well-numbering system was developed by the TWDB for use throughout Texas. Under this system, each 1-degree quadrangle is given a number consisting of two digits. These are the first two digits in the well number. Each 1-degree quadrangle is divided into 7-1/2-minute quadrangles, which are given two-digit numbers from 01 to 64. These are the third and fourth digits of the well number. Each 7-1/2-minute quadrangle is divided into 2-1/2-minute quadrangles, which are given a single-digit number from 1 to 9. This is the fifth digit of the well number. Finally, each well within a 2-1/2-minute quadrangle is given a two-digit number in the order in which it was inventoried, starting with 01. These are the last two digits of the well number. A two-letter prefix identifies the county: DH, Chambers; KA, Freestone; LT, Henderson; SB, Liberty; TR, Montague; TY, Navarro; UP, Parker; UT, Polk; WU, San Jacinto; YS, Van Zandt; and ZR, Wise. The USGS site identification number consists of 15 digits. The first 6 digits denote degrees, minutes, and seconds of latitude; the next 7 digits denote degrees, minutes, and seconds of longitude; and the last 2 digits (assigned sequentially) identify the well within a 1-second grid.

Well locations are shown in figures 2–4. Descriptive well data are listed in table 1 at the end of this report. Boxplots depicting the distribution of well depths sampled are shown in figure 5.

Sampling Methods

Each well was purged of stagnate water before the sample collection began. For private and industrial wells, water was purged from the well until (1) the water volume discharged equalled at least three times the original water volume in the well, and (2) selected water properties (specific conductance, pH, temperature, dissolved oxygen, and alkalinity) in the discharge stream had stabilized. All public supply wells were in use at the time of sampling, and no stagnant water was thought to be in the wells. However, sampling from these wells did not start until the selected properties stabilized. Water properties were recorded at 5-minute intervals during the purging process.

The sampling procedure was established to allow minimal contact of the sample with the atmosphere. Teflon tubes with stainless-steel connections were hooked directly onto the existing faucet system. In most cases, the faucet connections were within 5 ft of the well. The sample water exited the Teflon-tube system in an enclosed chamber made of a PVC-tube frame and polyethylene bags. Glue was not used to construct the PVC-tube frame. All filtering and bottling were performed within the sampling chamber. Samples were preserved within preservation chambers constructed similarly to the sampling chamber. The sampling teams wore powder-free latex gloves throughout the entire sampling procedure.

Samples were collected for analysis of nutrients, major inorganic constituents, trace elements, pesticides, dissolved organic carbon (DOC), total phenols, methylene blue active substance (MBAS), and volatile organic compounds (VOC). Samples were collected using the USGS parts per billion protocol (M.T., Koterba, U.S. Geological Survey, oral commun., 1993). The filtration, preservation, and container requirements for the samples are described in table 2 at the end of this report. The samples were stored in ice chests, chilled to a temperature of 4 degrees Celsius (°C), and mailed overnight to the USGS National Water Quality Laboratory (NWQL) in Arvada, Colo. The type of analyses performed for each of the samples and the method detection limit (MDL) for each constituent are listed in table 2. The MDL is the minimum concentration of a substance that can be identified, measured, and reported with a 99-percent confidence that the constituent concentration is larger than zero (U.S. Environmental Protection Agency, 1992).

All sample-wetted equipment was decontaminated before each well visit using the following procedure:

1. Disassemble equipment into individual components.
2. Soak equipment in warm tap water and phosphorous-free detergent for 30 minutes and scrub with a nonmetallic brush.
3. Rinse equipment with tap water until free of soap residue.
4. Rinse the non-metallic components with 5-percent hydrochloric acid.
5. Rinse the equipment three to four times with deionized water.
6. Rinse any equipment used for sampling organic compounds with methanol.
7. Allow equipment to air dry.
8. Wrap metallic components in aluminum foil and seal in plastic bags.
9. Place small Teflon components in Teflon bags.
10. Connect Teflon tubes and stainless-steel connections to themselves and place in plastic bags.

The organic carbon filter assembly was kept separate from the other equipment and was decontaminated using the following procedure:

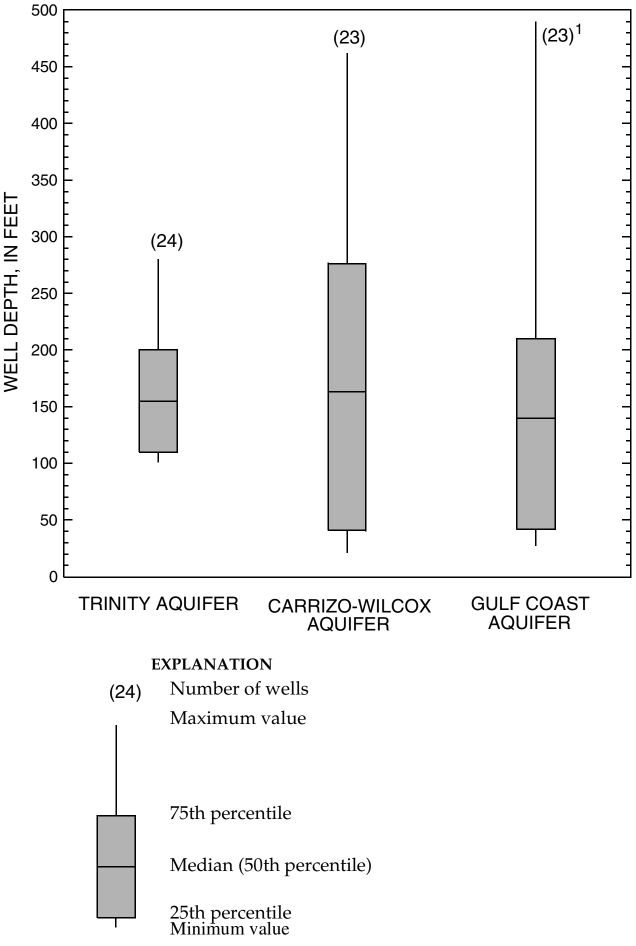
11. Disassemble into individual components.
12. Rinse with deionized water and scrub thoroughly.
13. Rinse with organic-free water.
14. Wrap in aluminum foil and seal in plastic bags.

Throughout the decontamination process, powder-free latex gloves were worn by the cleaning crew. The gloves were changed after completion of each step or if the gloves were possibly contaminated.

Quality Control

Quality-control (QC) samples were collected to assess the adequacy of general water-quality sampling and analysis procedures and to identify factors that might have produced discrepancies in the data. Quality-assurance procedures used at the NWQL constituted the laboratory quality assessment program implemented for this study. The QC samples included field blanks, duplicate samples, and VOC spikes.

Field blanks were submitted to the NWQL to determine if contaminants were introduced into the samples during the collection process and to document the extent of contamination. Undetected contamination in a sample can bias data interpretation. Inorganic-free water and organic-free water, certified by the NWQL, were used to detect contamination problems associated with collection of nutrient, major ion, trace element, pesticide, DOC, MBAS, or VOC samples. The inorganic- and organic-free water went through the same collection and shipping processes as the sampled ground water.



[1] Depth to one well not known

Figure 5. Distributions of depths for wells sampled in the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit.

The NWQL analysis detected 12 inorganic constituents, 4 organic constituents, and MBAS in the field blanks (table 3 at the end of this report). Although calcium, silica, and magnesium each were detected in at least one field blank, the concentrations were less than 10 percent of the smallest concentration of that constituent in the ground-water samples. The detections and concentrations of nitrite nitrogen, aluminum, copper, lead, zinc, and MBAS in the ground-water samples, however, are potentially inaccurate. Field-blank concentrations of these constituents were similar to some concentrations in the ground-water samples. The ground-water concentrations were not adjusted in this report to compensate for the detected field-blank constituents.

Seven sequential duplicate samples were collected (table 4 at the end of this report) during the 1994 ground-water sampling. These samples were collected and analyzed to determine the variability of constituent concentrations caused by sample processing and by ambient changes in water quality over short time periods. Sequential duplicate samples were collected at each selected well immediately after the first ground-water sample was collected using the same sampling procedure. The relative percent difference (RPD) was computed for each constituent of the duplicate set using the formula

$$RPD = |100 \times (Sample1 - Sample2)|/((Sample1 + Sample2)/2).$$

A large RPD might be computed when the sample concentration is similar to the MDL.

Concentrations of organic constituents detected in sequential duplicate samples were similar. In only one duplicate sample set was a pesticide (diazinon) detected in one sample but not detected in the other.

Three additional samples were collected from one well in each of the three aquifers and spiked with a matrix of known concentrations of VOCs. Two samples were spiked onsite by the sampling team, and one sample was spiked at the NWQL. The spikes are used to assess recoveries from field matrices and to assist in evaluating the bias of the constituent concentration. The analysis of the VOC-spiked samples detected all constituents added to the matrix, although the precision and the recovery rates varied. The duplicate field-spiked samples produced similar concentrations; however, the samples spiked at the NWQL consistently produced larger concentrations and greater recovery rates (table 5 at the end of this report), most likely because of the longer period of time between field spiking and analyzing the samples than between lab spiking and analyzing the samples.

GROUND-WATER QUALITY

Water samples were collected from 71 wells and were analyzed by the NWQL for nutrients, major inorganic constituents, trace elements, pesticides, DOC, total phenols, MBAS, and VOCs. In addition, specific conductance, pH, temperature, dissolved oxygen, and alkalinity were measured at the well sites.

The chemistry of ground water often reflects the mineral composition of the material that the water contacts. The chemistry of the ground water can change as the ground water travels farther and deeper into an aquifer. The physical conditions of the ground water such as pH, temperature, and dissolved oxygen content also can change as the water travels through an aquifer because of geochemical processes with the rock. When a specific mineral is undersaturated, dissolution is possible; when a specific mineral is oversaturated, precipitation is possible. In this report, samples were divided into two groups—samples collected from shallow wells (wells completed to depths of 150 ft or less) and samples collected from deep wells (wells completed to depths greater than 150 ft) for the analyses of selected inorganic constituents.

Trilinear diagrams were used to classify the dominant water type within the aquifers. The water type is based on the chemical composition of the major ions. The diagrams indicate the water chemistry by the proportions of select ions to the total ion content.

The Spearman rank-correlation test was used to identify relations between selected nutrients and well depth and between selected major inorganic constituents and well depth. The Spearman correlation (rho) is a statistical test that is a measure of linear and nonlinear correlations between variables (Helsel and Hirsch, 1992). A positive rho indicates increasing concentration with greater well depth, and a negative rho indicates decreasing concentration with greater well depth.

Trinity Aquifer

Water samples were collected for chemical analysis from 24 wells (12 shallow, depths ranging from 101 to 150 ft; and 12 deep, depths ranging from 160 to 280 ft) in the Trinity aquifer. Trilinear diagrams of the major inorganic constituents in Trinity aquifer wells indicate that calcium bicarbonate water was dominant in shallow wells. No dominant cation was apparent in deep wells; however, the dominant anion was bicarbonate (fig. 6).

Only one sample had a detectable concentration of the carbonate anion (app. 1).

The Spearman rank-correlation tests indicated no significant correlations (p-value less than 0.05) between nutrient concentrations and well depth (table 6 at the end of this report); however, the dominant nitrogen species in shallow wells was nitrite plus nitrate nitrogen and the dominant nitrogen species in deep wells was ammonia nitrogen (fig. 7). The median concentration of ammonia nitrogen was 0.04 mg/L for shallow wells and 0.12 mg/L for deep wells. The median concentration of nitrite plus nitrate nitrogen was 2.3 mg/L for shallow wells and 0.18 mg/L for deep wells. All total phosphorus and orthophosphate phosphorus concentrations, which were detected in less than one-half of the samples, also were less than or slightly larger than the MDL (fig. 7).

Specific conductance, pH, temperature, dissolved oxygen, and alkalinity of the samples were measured at each well (app. 1). Specific conductance for the 24 Trinity aquifer wells ranged from 510 to 4,590 microsiemens per centimeter at 25 degrees Celsius (μS/cm) with a median of 882 μS/cm. pH ranged from 6.6 to 9.1 standard units with a median of 7.1 standard units. Water temperature ranged from 13.5 to 21.0 °C with a median of 19.5 °C. Dissolved oxygen concentrations ranged from less than 1.0 to 4.1 milligrams per liter (mg/L) with a median of 0.9 mg/L for the 14 wells measured. Dissolved oxygen could not be measured at 10 wells because of equipment problems. Alkalinity (as $CaCO_3$) ranged from 130 to 430 mg/L with a median of 335 mg/L.

The Spearman rank-correlation tests indicated no significant correlations between the major inorganic constituent concentrations and well depth (table 6). The dissolved solids concentrations ranged from 310 to 2,820 mg/L with a median of 515 mg/L (fig. 8). Dissolved solids concentrations in 12 samples were larger than the secondary maximum contaminant level (SMCL) of 500 mg/L established for drinking water by the U.S. Environmental Protection Agency (1996). Dissolved chloride concentrations were larger than the SMCL of 250 mg/L in 3 samples, and dissolved iron concentrations were larger than the SMCL of 300 micrograms per liter (μg/L) in 3 samples (app. 1). Concentrations of major inorganic constituents in the 24 samples from the Trinity aquifer were less than the maximum contaminant level (MCL), if applicable, established for drinking water by the U.S. Environmental Protection Agency (1996).

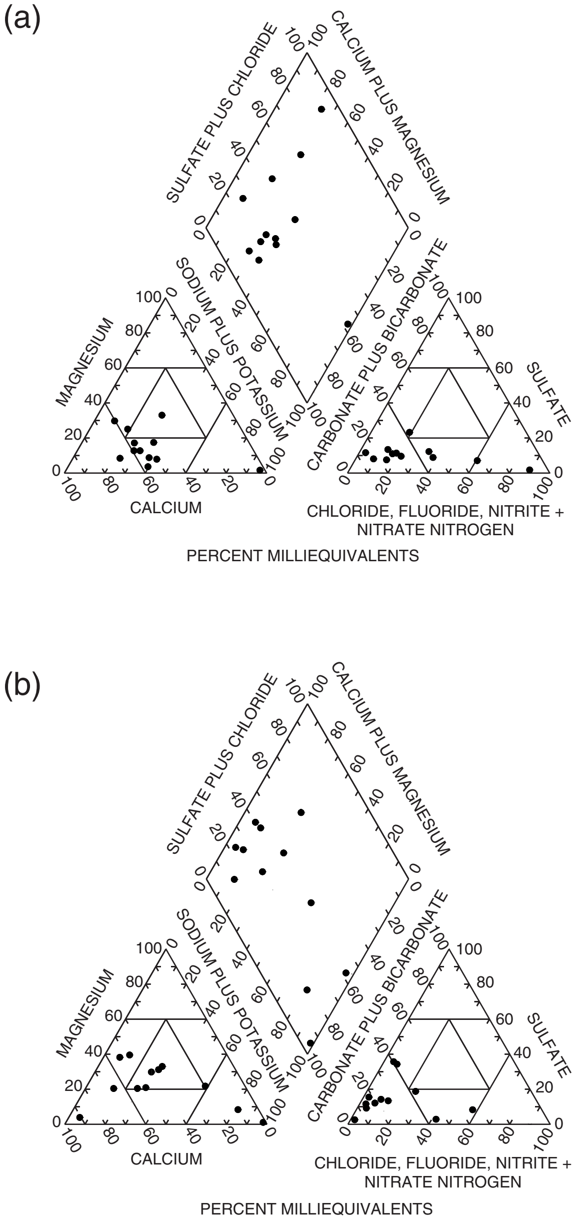


Figure 6. Trilinear diagrams of major constituents in samples from Trinity aquifer wells (a) 150 feet deep or less and (b) greater than 150 feet deep.

Twelve of the seventeen trace elements analyzed were detected at least once in the Trinity aquifer samples (fig. 9). Antimony, beryllium, cadmium, cobalt, and silver were not detected in any samples (app. 1). Barium was detected in every sample; the median barium concentration of 94 μg/L was the largest for a trace element in the Trinity aquifer samples. Median concentrations of arsenic, lead, molybdenum, selenium, and uranium were less than the MDL of 1 μg/L. Manganese

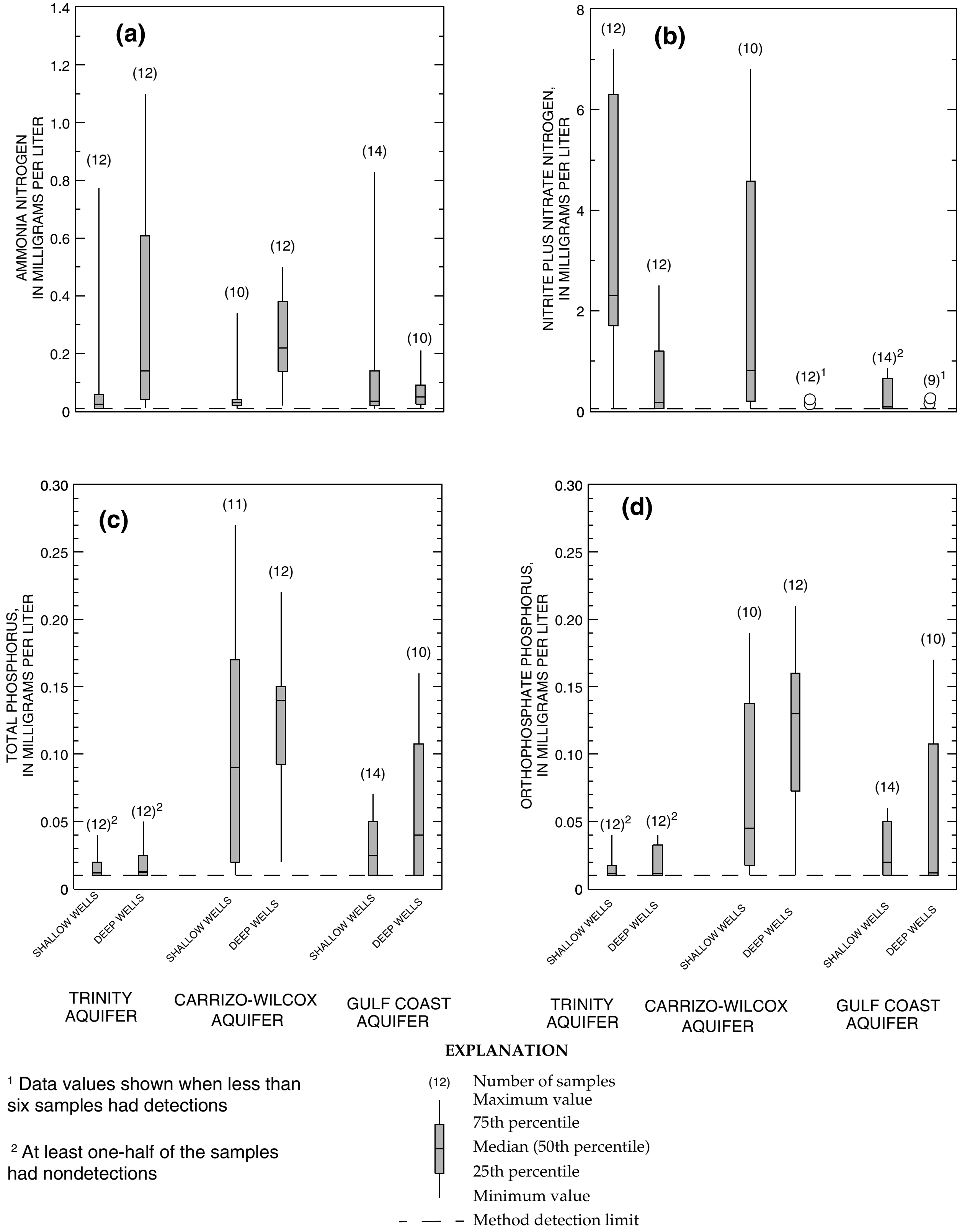
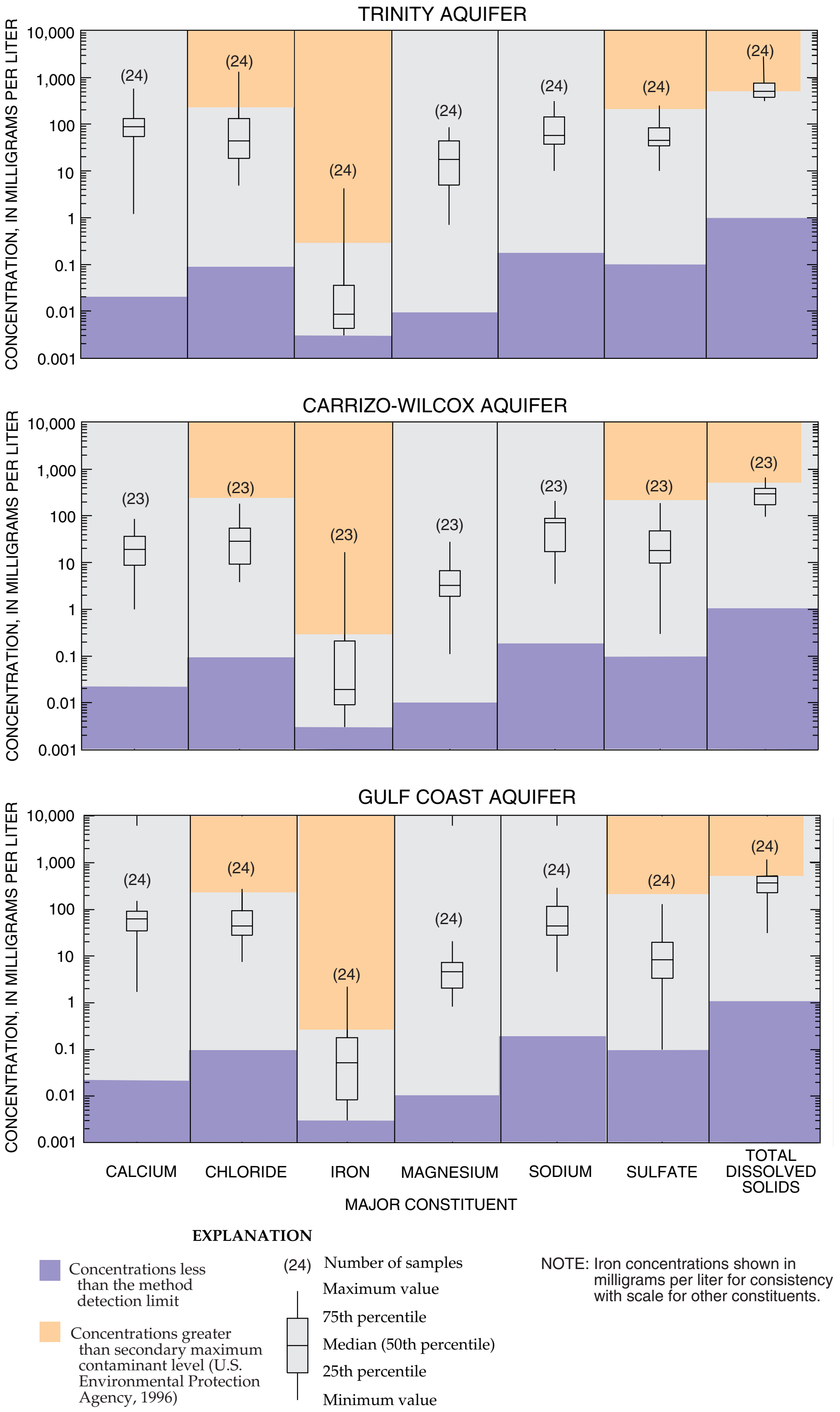


Figure 7. Range and distribution of concentrations of (a) ammonia nitrogen, (b) nitrite plus nitrate nitrogen, (c) total phosphorus, and (d) orthophosphate phosphorus in samples from wells in the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit.



NOTE: Iron concentrations shown in milligrams per liter for consistency with scale for other constituents.

Figure 8. Range and distribution of concentrations of major constituents in samples from wells in the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit.

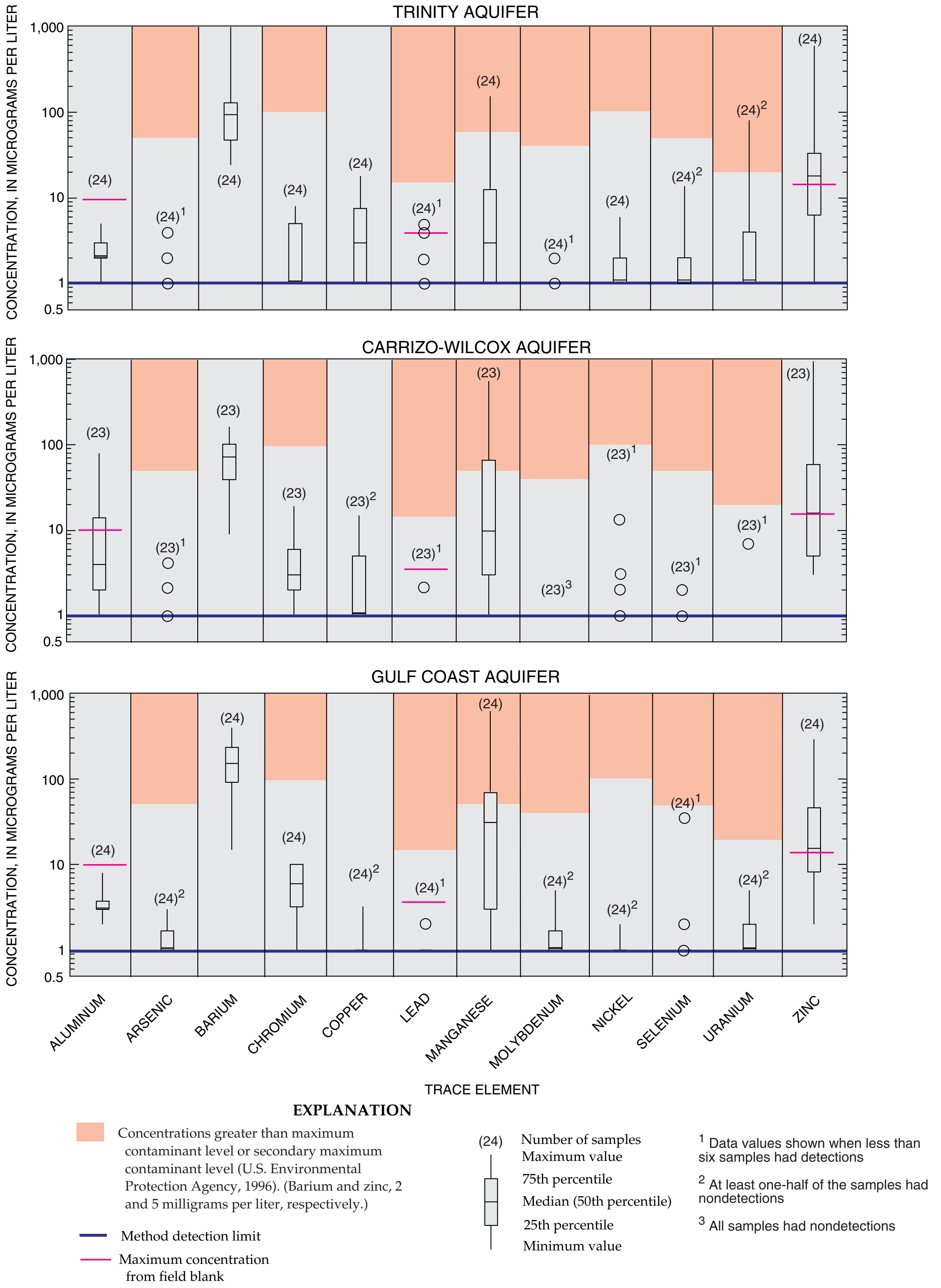


Figure 9. Range and distribution of concentrations of trace elements in samples from wells in the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit.

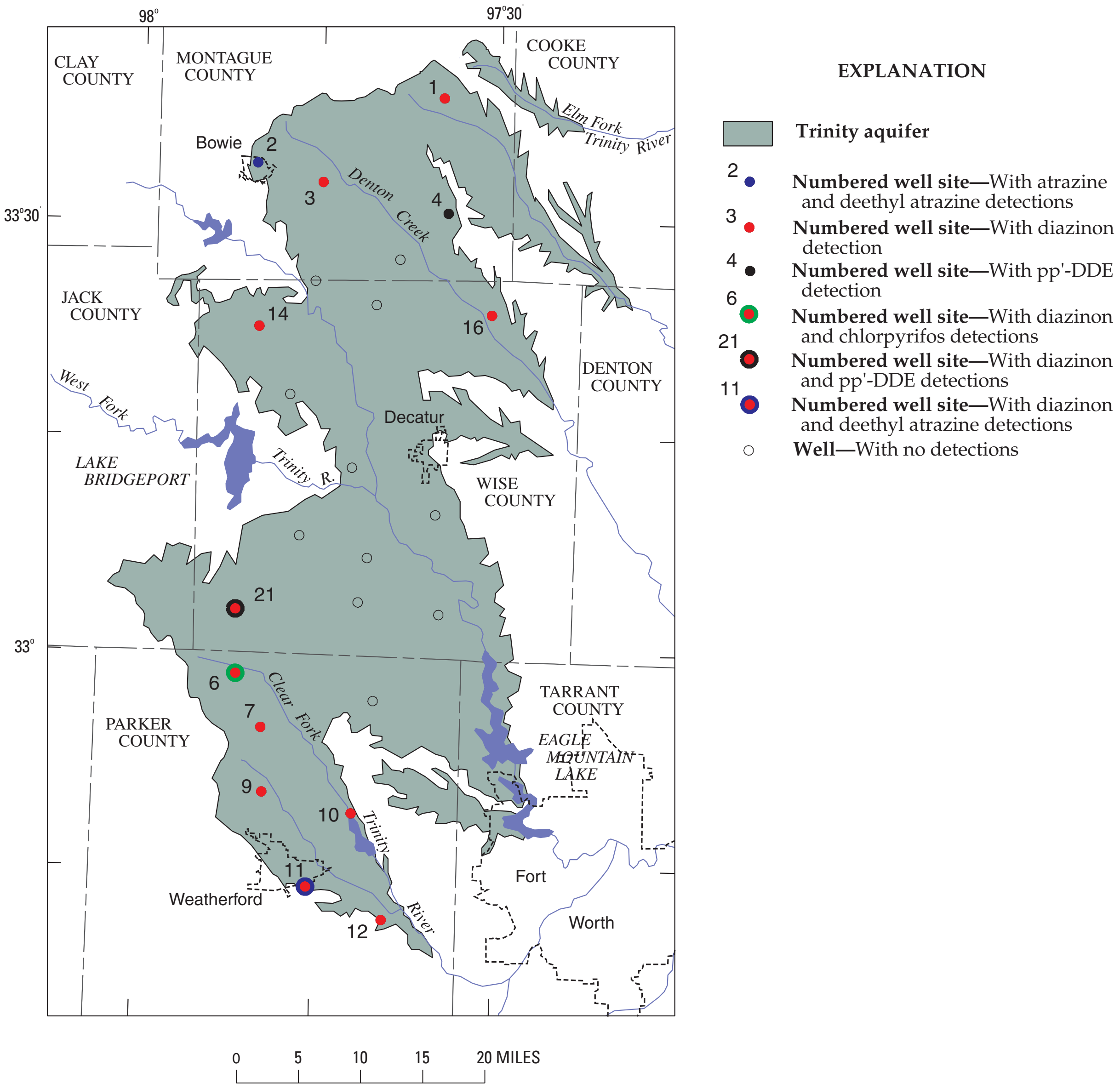


Figure 10. Location of wells in the Trinity aquifer with pesticide detections in a sample.

was the only trace element analyzed with concentrations (in two samples) larger than the SMCL of 50 µg/L (U.S. Environmental Protection Agency, 1996). Uranium was detected in 12 samples, with a concentration in 1 sample of 93 µg/L, which is larger than the proposed MCL of 20 µg/L (U.S. Environmental Protection Agency, 1996). Aluminum and zinc were detected in all samples with median concentrations of 2 and 18 µg/L, respectively. The aluminum and zinc concentrations in the well samples, however, are potentially inaccurate because of the consistent detection of these elements in field blanks at concentrations as large as 10 µg/L for aluminum and 15 µg/L for zinc (fig. 9).

Four pesticides and one pesticide by-product were detected in samples from 13 Trinity aquifer wells (fig. 10), with depths from 101 to 235 ft. Although the Trinity aquifer generally lies in a rural setting, diazinon (an insecticide more commonly associated with urban areas) was detected in 11 samples (app. 1). However, the wells in which diazinon was detected were at or near the

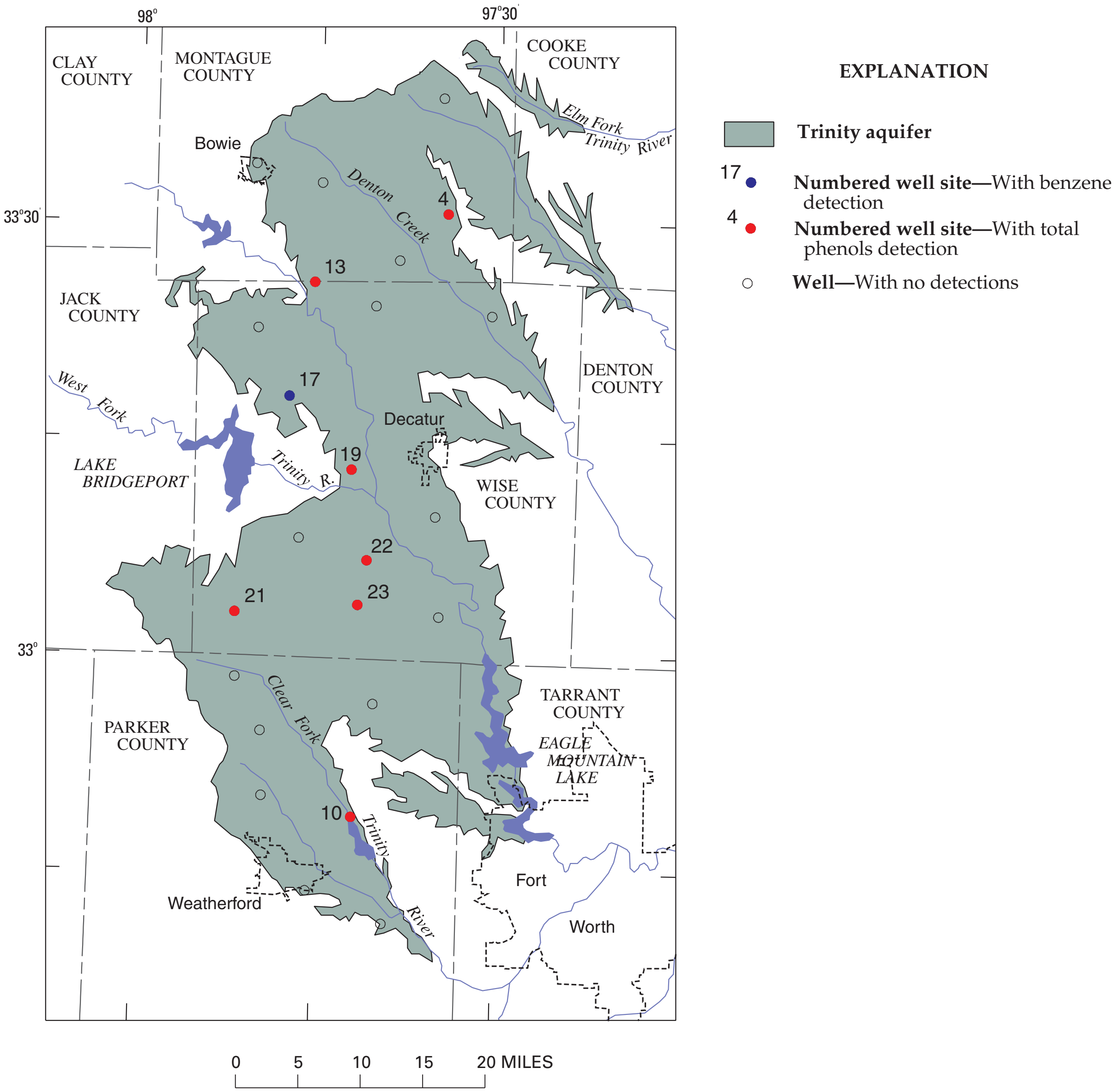


Figure 11. Location of wells in the Trinity aquifer with total phenols or volatile organic compound detections in a sample.

residence of the land owner. Diazinon also was detected in one of the field blanks although environmental samples collected immediately before and after the field blank detected no diazinon. Chlorpyrifos was detected in one well at a concentration of 0.005 µg/L; atrazine (a herbicide) and its by-product, deethyl atrazine, were detected in one well at concentrations of 0.021 and 0.023 µg/L, respectively (app. 1). The insecticide metabolite pp'-DDE was detected in two samples at concentrations less than the MDL of 0.006 µg/L; thus concentrations of 0.001 µg/L were considered to be estimates.

DOC was detected in 23 of 24 Trinity aquifer samples, at concentrations ranging from 0.2 to 1.8 mg/L and a median of 0.5 mg/L. Because this constituent was frequently detected in the field blanks, actual concentrations in the aquifer samples might be slightly less than reported. Total phenols were detected in seven samples (fig. 11). Phenols are synthetic organic compounds that are highly soluble in water. These compounds are highly toxic to humans and animals and are a component of various antiseptics, disinfectants, germicides, and preservatives. No concentrations detected in the Trinity aquifer samples approached the lifetime health advisory (HA) of 4,000 µg/L established by the U.S. Environmental Protection Agency (1996). The lifetime HA is the concentration of a chemical in drinking water that is not expected to cause any adverse carcinogenic effects in adults over a lifetime of exposure. MBAS are synthetic detergents that can enter a ground-water system through the discharge of individual wastewater-disposal (septic) systems. A concentration of about 1 mg/L of MBAS can cause foaming of water and, therefore, is an aesthetic concern. MBAS were detected in 3 of the 24 samples; however, no concentrations were as much as 1 mg/L. In addition, all MBAS concentrations detected were less than the largest concentration detected in one of the field blanks (0.11 mg/L, table 3). The aquifer sample concentrations could, therefore, be attributed to sample contamination. The only VOC detected was benzene (fig. 11), which was detected in one well at a concentration of 0.4 µg/L (app. 1).

Carrizo-Wilcox Aquifer

Samples were collected for chemical analysis from 23 wells (11 shallow, depths ranging from 21 to 147 ft; and 12 deep, depths ranging from 160 to 462 ft) in the Carrizo-Wilcox aquifer. Trilinear diagrams of the major inorganic constituents indicate that most of the shallow well samples were calcium bicarbonate water (fig. 12). Most of the deep well samples, however, were dominated by sodium plus potassium/bicarbonate water.

The Spearman rank-correlation tests indicated significant correlations (p-value less than 0.05) between ammonia nitrogen and well depth and between nitrite plus nitrate nitrogen and well depth (table 7 at the end of this report). Concentrations of ammonia nitrogen increased with greater well depth, and concentrations of nitrite plus nitrate nitrogen decreased with greater well depth (fig. 7). Ammonia plus organic nitrogen was detected in 8 deep well samples but in only 2 shallow well samples (app. 1). Nitrite plus nitrate nitrogen was detected in 9 shallow well samples but in only 2 deep well samples. Ammonia nitrogen is the dominant nitrogen species in the ammonia plus organic constituent, as concentrations of ammonia plus organic nitrogen tend to be mostly ammonia nitrogen. Likewise, nitrate is the dominate nitrogen species in the nitrite plus nitrate constituent, as concentrations of nitrite plus nitrate tend to be mostly nitrate.

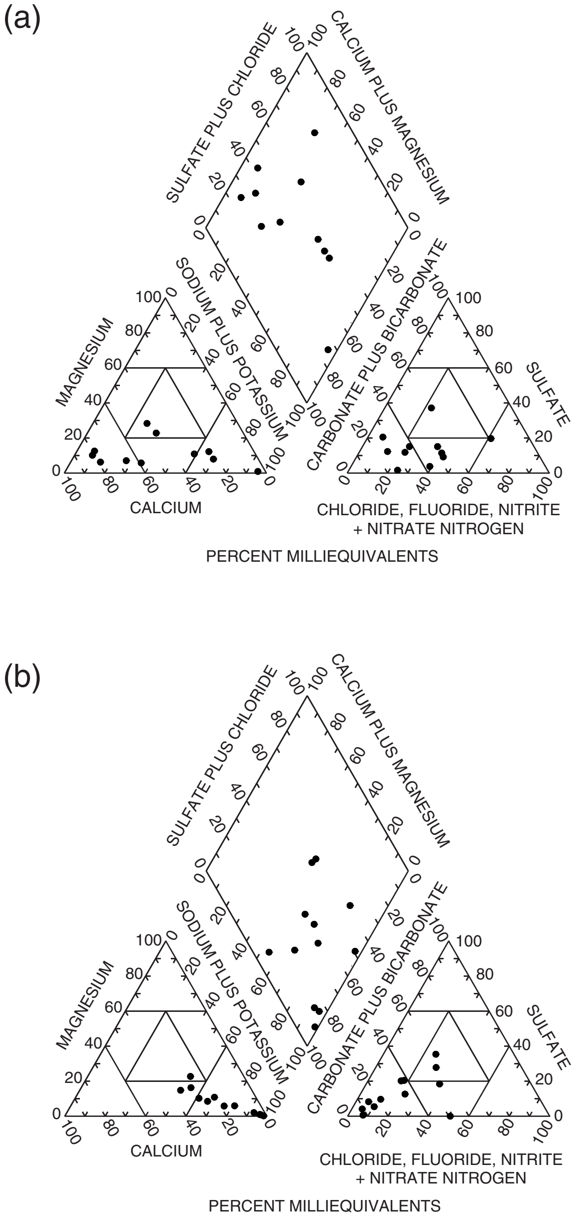


Figure 12. Trilinear diagrams of major constituents in samples from Carrizo-Wilcox aquifer wells (a) 150 feet deep or less and (b) greater than 150 feet deep.

The Spearman rank-correlation tests indicated no significant correlation between total phosphorus and well depth or between orthophosphate phosphorus and well depth (table 7). Total phosphorus and orthophosphate phosphorus were detected in most samples, although no concentrations were larger than 1.00 mg/L (app. 1). In 18 of the 19 samples in which both total phosphorus and orthophosphate phosphorus were detected, the concentration of orthophosphate phosphorus was equal or almost equal to the concentration of total phosphorus, indicating that total phosphorus was dominated by orthophosphate.

Specific conductance, pH, temperature, dissolved oxygen, and alkalinity of the samples were measured at each well (app. 1). Specific conductance for the 23 Carrizo-Wilcox aquifer wells ranged from 128 to 1,120 μS/cm with a median of 456 μS/cm. pH ranged from 5.8 to 9.0 standard units with a median of 7.6 standard units. Water temperature ranged from 18.5 to 24.0 °C with a median of 21.0 °C. Dissolved oxygen concentrations were small in this aquifer, ranging from less than 1.0 to 2.2 mg/L with a median of 0.2 mg/L. Alkalinity (as $CaCO_3$) ranged from 10 to 260 mg/L with a median of 150 mg/L.

The Spearman rank-correlation tests indicated significant correlation between well depth and concentrations of bicarbonate, sodium, and dissolved solids (table 7). With the exception of two shallow wells, the largest concentrations of bicarbonate, sodium, and dissolved solids were mostly in deep wells (app. 1). The dissolved solids concentrations ranged from 95 to 656 mg/L (app. 1) with a median of 293 mg/L (fig. 8). Concentrations of dissolved solids were larger than the SMCL of 500 mg/L in 4 samples, and concentrations of dissolved iron were larger than the SMCL of 300 μg/L in 4 samples (app. 1).

Thirteen of the seventeen trace elements analyzed were detected in at least one sample (fig. 9, antimony and cobalt not shown). Aluminum, barium, chromium, and zinc were detected in all samples. The aluminum and zinc concentrations are potentially inaccurate because of the consistent detections of these elements in field blanks at concentrations as large as 10 μg/L for aluminum and 15 μg/L for zinc (fig. 9). The median concentration of barium (72 μg/L) was the largest of any trace element analyzed in this aquifer; the median concentrations of antimony, arsenic, cobalt, copper, lead, nickel, selenium, and uranium were less than the MDL of 1 μg/L. Beryllium, cadmium, molybdenum, and silver were not detected in any samples. Manganese was the only trace element at concentrations larger than the SMCL of 50 μg/L (U.S. Environmental Protection Agency, 1996). Manganese concentrations were larger than 50 μg/L in eight samples (app. 1). All other trace element concentrations were less than their respective MCL or SMCL.

Four pesticides and one pesticide by-product were detected in samples from seven Carrizo-Wilcox aquifer wells (fig. 13), with depths from 30 to 429 ft. Atrazine and deethyl atrazine were detected in one well at concentrations of 0.013 and 0.011 μg/L, respectively. Diazinon was detected in four wells; the largest concentration was 0.017 μg/L (app. 1). Prometon, a herbicide, was detected in one well with a concentration of 0.008 μg/L. All of these pesticides were detected in samples from the northern part of the aquifer (fig. 13). The insecticide metabolite pp'-DDE, detected in one well (fig. 13) at a concentration less than the MDL of 0.006 μg/L, was estimated at 0.001 μg/L.

DOC was detected in 20 samples (app. 1) at concentrations ranging from 0.2 to 2.6 mg/L with a median of 0.55 mg/L. Total phenols were detected in nine samples (fig. 14) at concentrations ranging from 2 to 10 μg/L (app. 1). All concentrations were less than the lifetime HA of 4,000 μg/L (U.S. Environmental Protection Agency, 1996). MBAS were detected in one sample at a concentration of 0.04 mg/L, less than concentrations detected in some field blanks and less than the concentration at which water foaming begins (1 mg/L). Trichlorofluoromethane, a solvent and the only VOC detected (fig. 14), had a concentration of 0.3 μg/L in one well (app. 1).

Gulf Coast Aquifer

Samples were collected for chemical analysis from 24 wells in the Gulf Coast aquifer. Thirteen wells are shallow (depths ranging from 27 to 150 ft); 10 wells are deep (depths ranging from 180 to 490 ft). One well of unknown depth also was considered a shallow well. Trilinear diagrams of the major inorganic constituents indicate that most of the shallow well samples ranged from calcium plus magnesium/bicarbonate water to sodium plus potassium/chloride water (fig. 15). Most of the deep well samples also were calcium plus magnesium/bicarbonate or sodium plus potassium/bicarbonate water.

The Spearman rank-correlation tests indicated no significant correlations (p-value less than 0.05) between nutrient concentrations and well depth (table 8 at the end of this report). Ammonia nitrogen was detected in 18 samples, and nitrite plus nitrate nitrogen was detected in 7 samples (app. 1). Total phosphorus and orthophosphate phosphorus were detected in most samples. In 11 of the 13 samples in which both total phosphorus and orthophosphate phosphorus were detected,

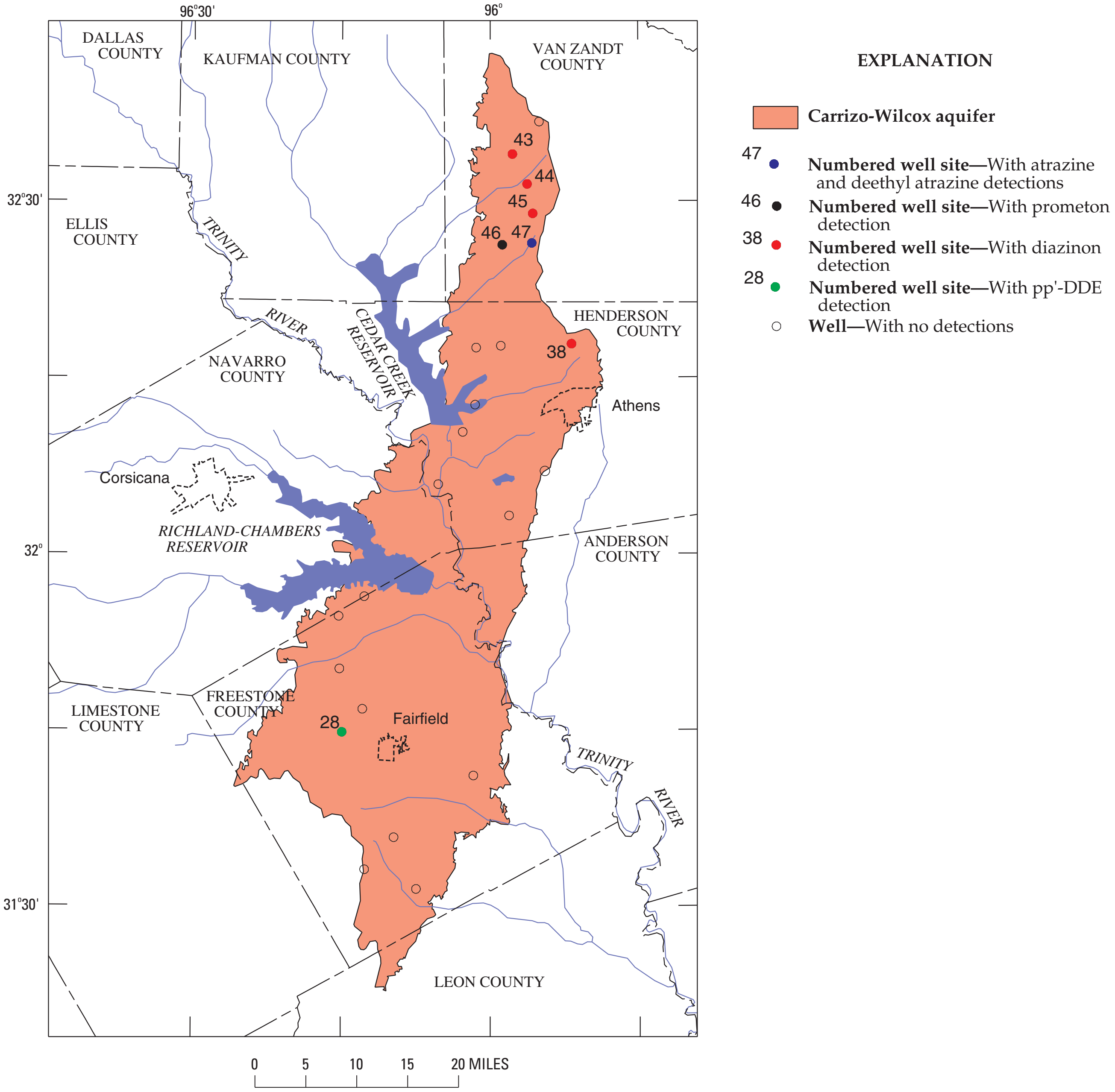


Figure 13. Location of wells in the Carrizo-Wilcox aquifer with pesticide detections in a sample.

the concentration of orthophosphate phosphorus was equal or almost equal to the concentration of total phosphorus.

Specific conductance, pH, temperature, dissolved oxygen, and alkalinity of the samples were measured at each well (app. 1). Specific conductance for the 24 Gulf Coast aquifer wells ranged from 45 to 1,950 µS/cm with a median of 597 µS/cm. pH ranged from 5.1 to 8.0 standard units with a median of 7.0 standard units. Water temperature ranged from 21.5 to 26.5 °C with a median of 22.5 °C. Dissolved oxygen concentrations were small in this aquifer, ranging from less than 1.0 to 3.6 mg/L with a median of 0.2 mg/L. Alkalinity (as $CaCO_3$) ranged from 6.0 to 500 mg/L with a median of 240 mg/L.

The Spearman rank-correlation tests for major inorganic constituents indicated a significant correlation only between sulfate and well depth (table 8). The

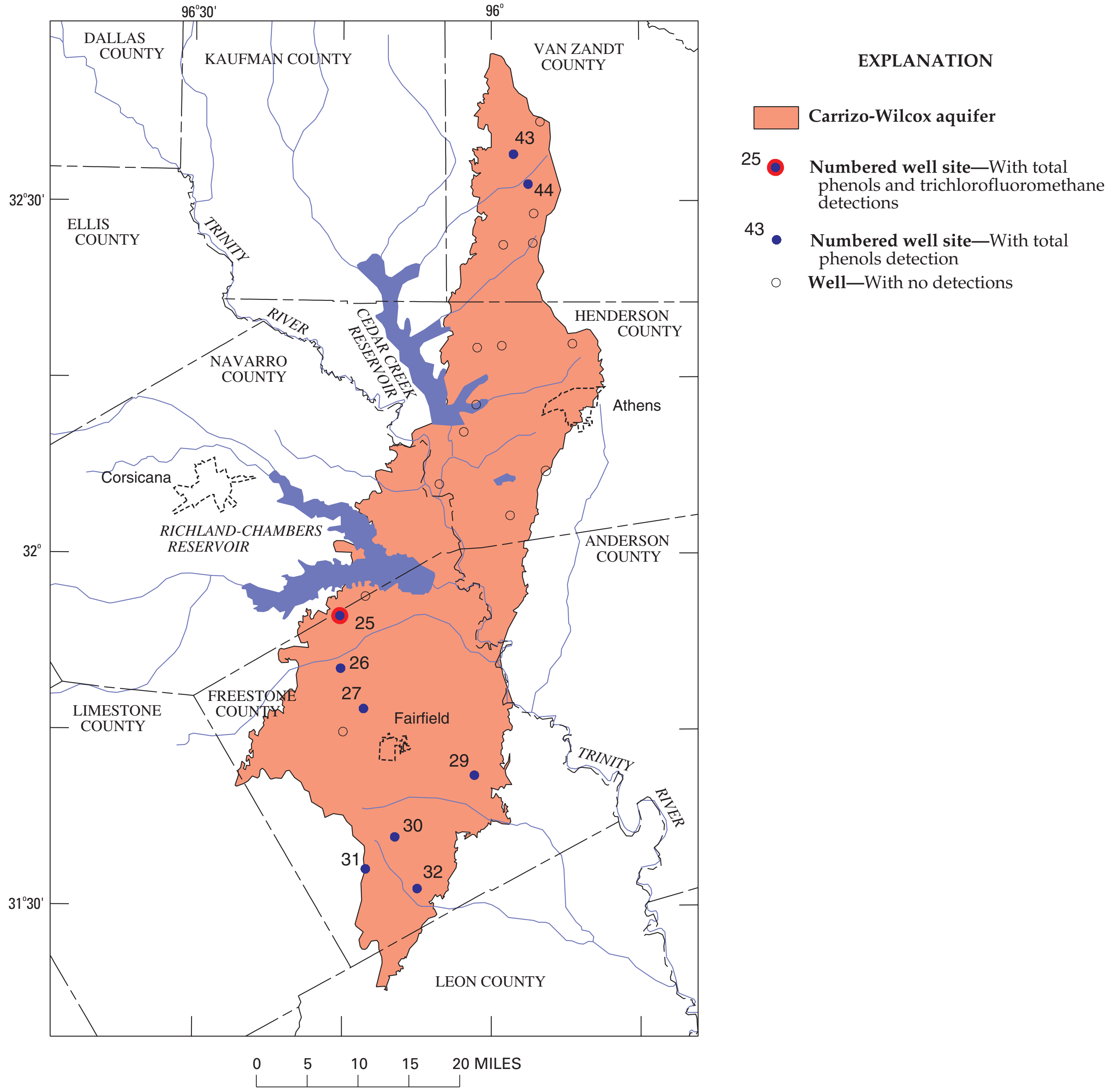


Figure 14. Location of wells in the Carrizo-Wilcox aquifer with total phenols or volatile organic compound detections in a sample.

smallest sulfate concentrations were mostly in deep wells (app. 1). The dissolved solids concentrations ranged from 31 to 1,150 mg/L with a median of 364 mg/L (fig. 8). Dissolved solids concentrations were larger than the SMCL of 500 mg/L in six samples (app. 1). Dissolved chloride concentrations were larger than the SMCL of 250 mg/L in 2 samples, and dissolved iron concentrations were equal to or larger than the SMCL of 300 µg/L in 4 samples.

Twelve of the seventeen trace elements analyzed were detected at least once in the Gulf Coast aquifer samples (fig. 9). Aluminum, barium, chromium, manganese, and zinc were detected in all or most of the samples (app. 1). The aluminum and zinc concentrations are potentially inaccurate because of the consistent detections of these elements in field blanks at concentrations as large as 10 µg/L for aluminum and 15 µg/L for zinc (fig. 9). The median concentration of barium (155 µg/L) was the largest for trace elements detected in this aquifer; median concentrations of arsenic, copper, lead, molybdenum, nickel, selenium, and uranium were all less than the MDL of 1 µg/L. Antimony, beryllium, cadmium, cobalt, and silver were not detected in any samples. Manganese was the only trace element analyzed at concentrations larger than the MCL or SMCL (fig. 9). Manganese concentrations in seven samples were equal to or larger than the SMCL of 50 µg/L (U.S. Environmental Protection Agency, 1996).

Five pesticides and one pesticide by-product were detected in samples from five Gulf Coast aquifer wells (fig. 16). Bentazon, a herbicide, was detected in one well at a concentration of 0.86 µg/L (app. 1). Atrazine and deethyl atrazine were detected in one well at concentrations of 0.21 and 0.031 µg/L, respectively. Chlorpyrifos was detected in one well at a concentration of 0.005 µg/L. Two compounds were detected at concentrations less than their MDLs—the insecticide metabolite pp'-DDE in one well at an estimated concentration of 0.001 µg/L and metribuzin in another well at an estimated concentration of 0.003 µg/L. The MDLs for pp'-DDE and metribuzin were 0.006 and 0.004 µg/L, respectively. All pesticides detected were in samples from shallow wells.

DOC was detected in 22 of the 23 samples collected, ranging from 0.1 to 1.8 mg/L (app. 1) with a median of 0.4 mg/L. Total phenols were detected in three samples (fig. 17) at concentrations ranging from 2 to 6 µg/L (app. 1). All concentrations were less than the lifetime HA of 4,000 µg/L (U.S. Environmental Protection Agency, 1996). MBAS were detected in three samples at concentrations less than the maximum concentration in the field blanks (0.11 mg/L, table 3). These MBAS possibly could be attributed to a contamination source. Trichloromethane, used as a solvent and as a refrigerant, was the only VOC detected (fig. 17). This VOC was detected in two wells at concentrations of 0.2 and 0.5 µg/L (app. 1), as well as in two field blanks at a concentration of 0.3 µg/L (table 3).

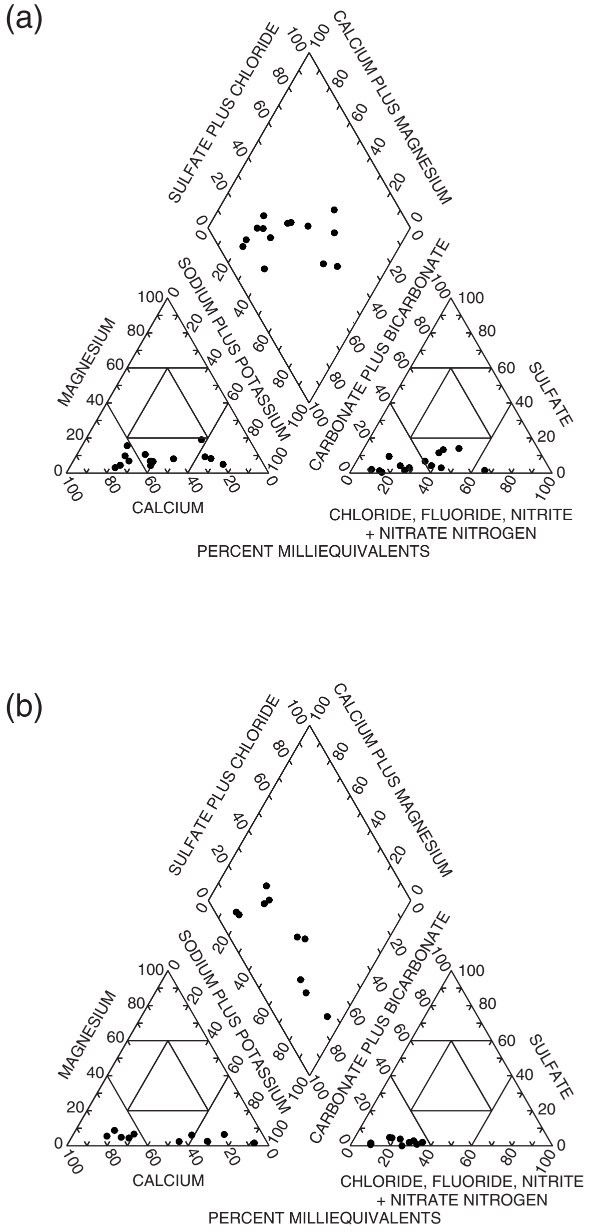


Figure 15. Trilinear diagrams of major constituents in samples from Gulf Coast aquifer wells (a) 150 feet deep or less and (b) greater than 150 feet deep.

Comparisons Among Aquifers

Although the aquifers have recharge zones within different ILRUs, the water chemistries of these aquifers are very similar. Calcium is the dominant cation, and bicarbonate is the dominant anion in all three aquifers (figs. 6, 12, 15).

Concentrations of nitrite plus nitrate nitrogen tended to be larger in the shallow wells of the three aquifers (fig. 7). The largest concentration (7.20 mg/L) was detected in the Trinity aquifer, and the smallest concentration (0.50 mg/L) was detected in the Gulf Coast aquifer. All concentrations of nitrite plus nitrate nitrogen in samples from the three aquifers were less than the MCL

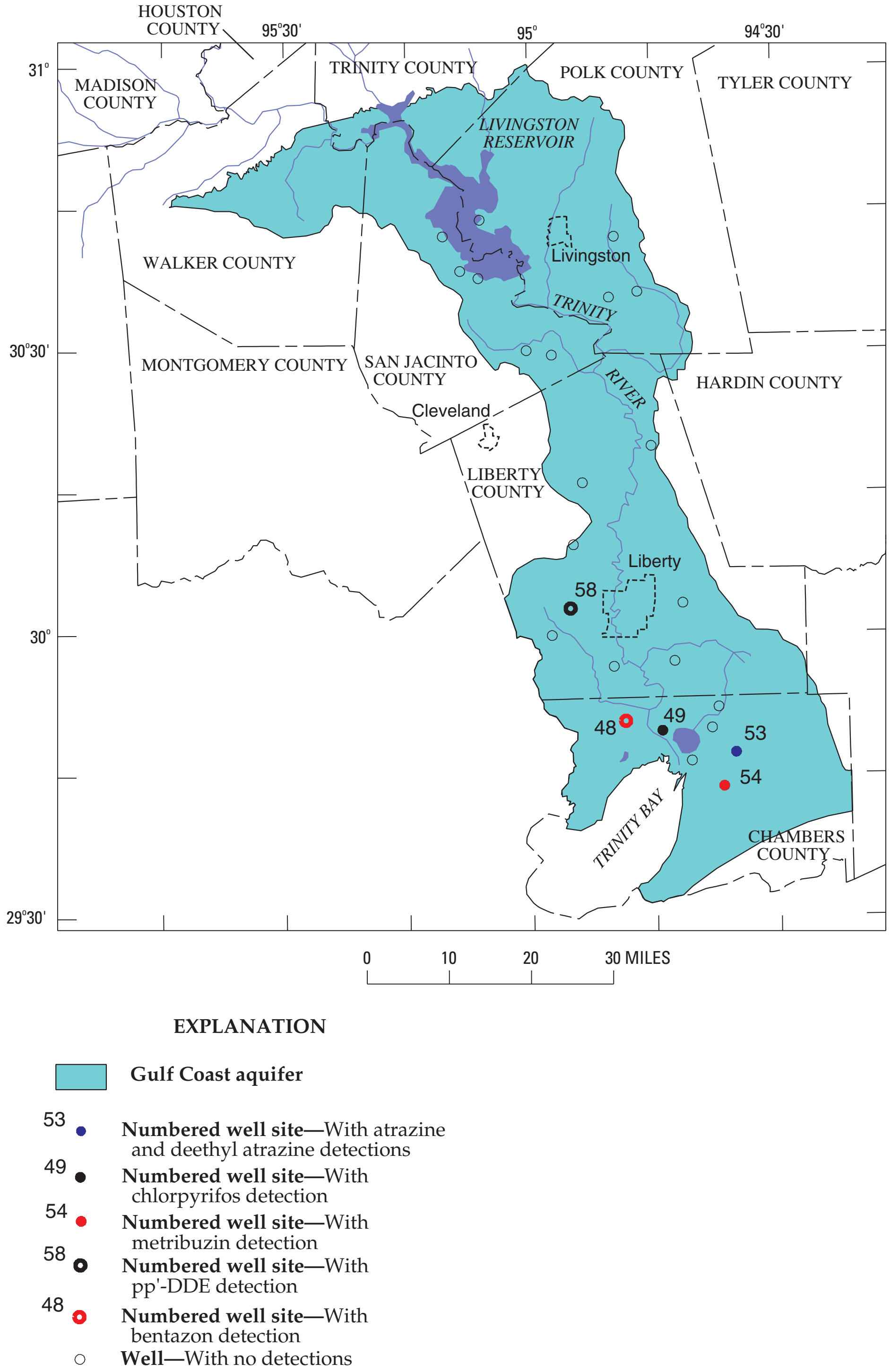


Figure 16. Location of wells in the Gulf Coast aquifer with pesticide detections in a sample.

of 10 mg/L established for drinking water by the U.S. Environmental Protection Agency (1996).

The largest concentrations of total phosphorus (ranging from 0.020 to 0.270 mg/L) were in samples from the Carrizo-Wilcox aquifer (fig. 7). Samples from the Trinity aquifer had the smallest total phosphorus concentrations (ranging from 0.010 to 0.050 mg/L); more than one-half the samples had nondetections

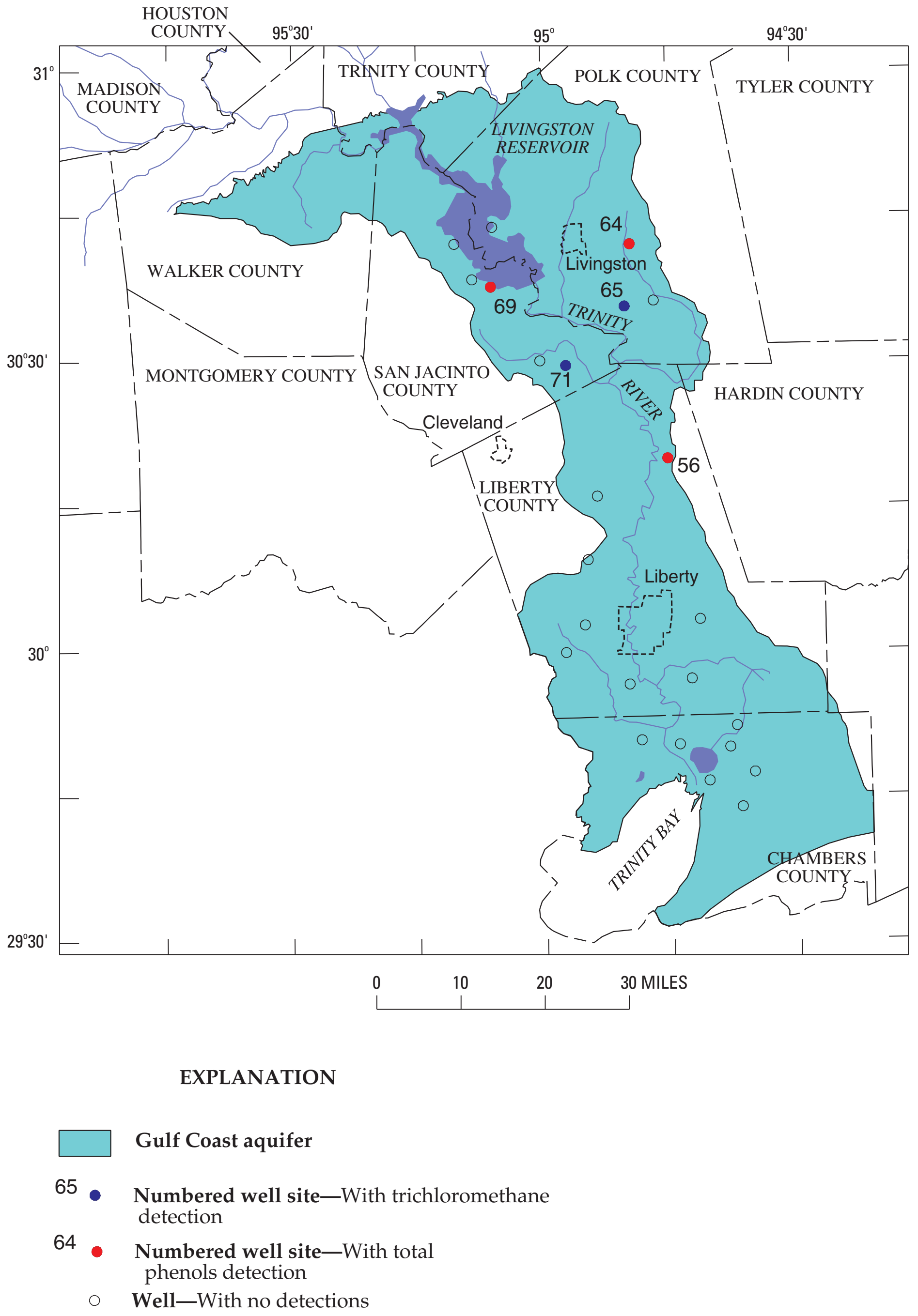


Figure 17. Location of wells in the Gulf Coast aquifer with total phenols or volatile organic compound detections in a sample.

(fig. 7). Concentrations of orthophosphate phosphorus were similar to concentrations for total phosphorus—the largest concentrations in the Carrizo-Wilcox aquifer (ranging from 0.010 to 0.210 mg/L) and the smallest concentrations in the Trinity aquifer (ranging from 0.010 to 0.040 mg/L); more than one-half the Trinity aquifer samples had nondetections (fig. 7). Concentrations of orthophosphate phosphorus also tended to be larger in the deep wells of the three aquifers.

Dissolved iron concentrations were larger than the SMCL of 300 µg/L in at least two samples collected from each aquifer (app. 1). However, concentrations of major inorganic constituents were larger than the SMCL more frequently in samples from the Trinity aquifer than in samples from the Carrizo-Wilcox and Gulf Coast aquifers (fig. 8).

Concentrations of antimony, beryllium, cadmium, cobalt, and silver were similar among the three aquifers—all nondetections except one antimony and two cobalt detections in the Carrizo-Wilcox aquifer (app. 1). Concentrations of arsenic and lead also were similar among the three aquifers—mostly nondetections and at least 5 arsenic detections and 1 lead detection, respectively, in each aquifer. Barium was detected in all samples and manganese in most samples from the three aquifers. Barium also had the largest median concentration of all trace elements detected in each of the three aquifers (fig. 9). The barium probably is controlled by the saturation equilibrium of barite ($BaSO_4$), although ground water in areas of oil and gas drilling could have larger concentrations of barium (Hem, 1989). Oil and gas production is common in the vicinity of some of the wells. Each aquifer also had at least two samples with manganese concentrations larger than the SMCL of 50 μg/L (U.S. Environmental Protection Agency, 1996). Because of the sample contamination problems associated with aluminum and zinc, no comparisons of these elements were made among the aquifers.

Slight differences among the aquifers also are apparent for some trace elements. Arsenic was detected in 5 samples in the Trinity aquifer (3 shallow wells, 2 deep wells); in 5 samples in the Carrizo-Wilcox aquifer (1 shallow well, 4 deep wells); and in 10 samples in the Gulf Coast aquifer (3 shallow wells, 7 deep wells) (app. 1). Selenium was detected in 10 samples in the Trinity aquifer (8 shallow wells, 2 deep wells); in 3 samples from shallow wells in the Carrizo-Wilcox aquifer; and in 4 samples in the Gulf Coast aquifer (2 shallow wells, 2 deep wells). With the exception of selenium concentrations of 14 μg/L in a deep Trinity well and 35 μg/L in a shallow Gulf Coast well, detections of both trace elements were mostly at concentrations only slightly larger than the MDLs of 1 μg/L. Copper was detected more often in the Trinity aquifer (11 shallow wells, 8 deep wells) than in the Carrizo-Wilcox aquifer (10 shallow wells, 1 deep well) or Gulf Coast aquifer (5 shallow wells, 2 deep wells), but more often in shallow wells than in deep wells in all three aquifers. The median copper concentration in the Trinity aquifer was 3 μg/L, compared to median copper concentrations in the Carrizo-Wilcox and Gulf Coast aquifers that were less than the MDL of 1 μg/L (fig. 9).

Few pesticides or VOCs were detected in any of the aquifers. The pesticide diazinon had the most detections (6 shallow wells, 5 deep wells) and largest concentrations (0.009 to 0.085 μg/L) in samples from the Trinity aquifer. Diazinon was detected in 1 shallow well and 3 deep wells in the Carrizo-Wilcox aquifer at concentrations ranging from 0.003 to 0.017 μg/L; diazinon was not detected in the Gulf Coast aquifer. The source of this pesticide is likely its application in the immediate area of the wells sampled. Most of the pesticides and VOCs detected in the three aquifers were only slightly larger than the MDL. Surface-water samples collected within the recharge areas of these aquifers had a larger number of pesticide detections with larger concentrations (Brown, 1996; Shipp, 1995; Ulery and Brown, 1994). Concentrations in surface-water samples ranged from 2.3 μg/L for diazinon and 2.0 μg/L for atrazine in the Woodbine aquifer recharge area to 6.0 μg/L for atrazine in the Carrizo-Wilcox aquifer recharge area. Most pesticides applied to the surface probably are transported by surface runoff rather than by percolation into the ground-water system.

SUMMARY

Water samples were collected during February–August 1994 from 71 wells in the outcrops of three aquifers in the Trinity River Basin study unit in Texas as part of the USGS National Water-Quality Assessment Program. Samples were analyzed for selected properties, nutrients, major inorganic constituents, trace elements, pesticides, dissolved organic carbon, total phenols, methylene blue active substances, and volatile organic compounds from 24 wells in the Trinity aquifer, 23 wells in the Carrizo-Wilcox aquifer, and 24 wells in the Gulf Coast aquifer. Most of the sampled wells were public and industrial water-supply wells and private residential wells.

Quality-control samples also were submitted for laboratory analysis. Quality-control samples included field blanks, duplicates, and VOC spikes. Field blank samples had detections of nitrite nitrogen, aluminum, copper, lead, zinc, and MBAS; therefore, detections and concentrations of these constituents in well samples were potentially inaccurate. The duplicate samples produced similar constituent concentrations. The recovery rates from VOC spikes varied; concentrations were larger and recovery rates greater from laboratory-spiked samples than from field-spiked samples. The variation in recovery rates might be attributed to the longer time between field spiking and analysis than between laboratory spiking and analysis.

Samples were collected from 12 shallow wells (150 ft or less) and from 12 deep wells (greater than 150 ft) in the Trinity aquifer. Calcium bicarbonate water was dominant in shallow wells. In deep wells, no cationic constituent dominated; however, bicarbonate was the dominant anionic constituent. The Spearman rank-correlation tests indicated no significant correlations between nutrient concentrations and well depth; however, nitrite plus nitrate nitrogen was the dominant nitrogen species in shallow wells, and ammonia nitrogen was the dominant nitrogen species in deep wells. Total phosphorus and orthophosphate phosphorus were detected in less than one-half of the samples. Dissolved solids concentrations in 12 Trinity aquifer samples were larger than the SMCL of 500 mg/L established for drinking water by the U.S. Environmental Protection Agency. Dissolved chloride and dissolved iron concentrations were larger than the SMCLs of 250 mg/L and 300 μg/L, respectively, in three samples each. Concentrations of all major inorganic constituents in the Trinity aquifer samples were less than the respective MCLs established for drinking water by the U.S. Environmental Protection Agency. Barium had the largest median concentration (94 μg/L) of the trace elements analyzed. Manganese concentrations were larger than the SMCL of 50 μg/L in two samples. Aluminum and zinc were detected in all samples but also were detected in the field blank samples. The pesticides atrazine, deethyl atrazine, and chlorpyrifos were each detected in at least 1 sample; diazinon was detected in 11 samples. The pesticide metabolite pp'-DDE, detected at less than the MDL of 0.006 μg/L in two samples, had estimated concentrations of 0.001 μg/L for both samples. Benzene was the only VOC detected.

Samples were collected from 11 shallow wells and from 12 deep wells in the Carrizo-Wilcox aquifer. Calcium bicarbonate water was dominant in shallow wells, and sodium plus potassium/bicarbonate water was dominant in deep wells. The Spearman rank-correlation tests indicated significant correlations between ammonia nitrogen and well depth and between nitrite plus nitrate nitrogen and well depth. Concentrations of ammonia nitrogen increased with greater well depth, and concentrations of nitrite plus nitrate nitrogen decreased with greater well depth. Nitrite plus nitrate nitrogen was dominant in shallow wells; ammonia nitrogen was dominant in deep wells. Orthophosphate phosphorus was dominant in the 18 samples in which both total phosphorus and orthophosphate phosphorus were detected. The Spearman rank-correlation tests indicated significant correlation between well depth and concentrations of bicarbonate, sodium, and dissolved solids—the largest concentrations of these constituents were mostly in deep wells. Four samples had dissolved solids concentrations larger than the SMCL of 500 mg/L, and four samples had dissolved iron concentrations larger than the SMCL of 300 μg/L. Barium had the largest median concentration (72 μg/L) of the trace elements analyzed. Eight samples had manganese concentrations larger than the SMCL of 50 μg/L. Aluminum and zinc were detected in most samples but also were detected in the field blank samples. The pesticides atrazine, deethyl atrazine, and prometon were each detected in at least 1 sample; diazinon was detected in 4 samples. pp'-DDE, detected in one sample at less than the MDL, had an estimated concentration of 0.001 μg/L. Trichlorofluoromethane was the only VOC detected.

Samples were collected from 14 shallow wells and from 10 deep wells in the Gulf Coast aquifer. Calcium plus magnesium/bicarbonate to sodium plus potassium/chloride waters were dominant in shallow wells, and calcium plus magnesium/bicarbonate to sodium plus potassium/bicarbonate waters were dominant in deep wells. The Spearman rank-correlation tests indicated no significant correlations between nutrient concentrations and well depth. Ammonia nitrogen was detected in 18 samples, and nitrate nitrogen was detected in 7 samples. Orthophosphate phosphorus was dominant in 11 samples in which both total phosphorus and orthophosphate phosphorus were detected. The Spearman rank-correlation tests indicated a significant correlation between sulfate and well depth—the smallest sulfate concentrations were mostly in deep wells. Six samples had dissolved solids concentrations larger than the SMCL of 500 mg/L. Dissolved chloride concentrations were larger than the SMCL of 250 mg/L in 2 samples; dissolved iron concentrations were equal to or larger than the SMCL of 300 μg/L in 4 samples. Barium had the largest median concentration (155 μg/L) of the trace elements analyzed in the Gulf Coast aquifer. Seven samples had manganese concentrations equal to or larger than the SMCL of 50 μg/L. Aluminum and zinc were detected in all samples and also were detected in the field blank samples. The pesticides atrazine, bentazon, deethyl atrazine, and chlorpyrifos were each detected in at least one sample. pp'-DDE and metribuzin, each detected in one sample at less than their MDLs of 0.006 and 0.004 μg/L, respectively, had estimated concentrations of 0.001 μg/L of pp'-DDE and 0.003 μg/L of metribuzin. Trichloromethane was the only VOC detected.

Comparison of the aquifers indicated similar water chemistries—calcium was the dominant cation and bicarbonate was the dominant anion in all three aquifers. Concentrations of nitrite plus nitrate nitrogen tended to be larger in the shallow wells of all three aquifers, but all concentrations were less than the MCL of 10 mg/L. Concentrations of orthophosphate phosphorus tended to be larger in the deep wells of the three aquifers. Dissolved iron concentrations were larger than the SMCL of 300 μg/L in at least two samples from each aquifer. Barium was detected in all samples and manganese in most samples from the three aquifers. Manganese concentrations in at least two samples from each aquifer were larger than the SMCL of 50 μg/L. Few pesticides or VOCs were detected in the three aquifers. Diazinon was detected most frequently and in the largest concentrations in the Trinity aquifer. The source of this pesticide is likely its application in the immediate area of the wells sampled.

REFERENCES

Baker, Bernard, Duffin, Gail, Flores, Robert, and Lynch, Tad, 1990, Evaluation of water resources in part of north-central Texas: Texas Water Development Board Report 318, 67 p.

Baker, E.T., Jr., 1983, Hydrology of the Jasper aquifer in the Southeast Texas Coastal Plain: U.S. Geological Survey Open-File Report 83–677, 68 p.

Brown, M.F., 1996, Water-quality assessment of the Trinity River Basin, Texas—Pesticides in a coastal prairie agricultural area 1994–95: U.S. Geological Survey Open-File Report 96–124, 6 p.

Carr, J.E., Meyer, W.R., Sandeen, W.M., and McLane, I.R., 1985, Digital models for simulation of ground-water hydrology of the Chicot and Evangeline aquifers along the Gulf Coast of Texas: Texas Department of Water Resources Report 289, 101 p.

Gilliom, R.J., Alley, W.M., and Gurtz, M.E., 1995, Design of the National Water-Quality Assessment Program—Occurrence and distribution of water-quality conditions: U.S. Geological Survey Circular 1112, 33 p.

Helsel, D.R., and Hirsch, R.M., 1992, Studies in environmental science 49—Statistical methods in water resources: New York, Elsevier, 522 p.

Hem, J.D., 1989, Study and interpretation of the chemical characteristics of natural water (3d ed.): U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Koterba, M.T., Wilde, F.D., and Lapham, W.W., 1995, Ground-water data-collection protocols and procedures for the National Water-Quality Assessment Program—Collection and documentation of water-quality samples and related data: U.S. Geological Survey Open-File Report 95–399, 113 p.

Leahy, P.P., Rosenshein, J.S., and Knopman, D.S., 1990, Implementation plan for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 90–174, 10 p.

Peckham, R.C., Souders, V.L., Dillard, J.W., and Baker, B.B., 1963, Reconnaissance investigation of the ground-water resources of the Trinity River Basin, Texas: Texas Water Commission Bulletin 6309, 110 p.

Rettman, P.L., 1987, Ground-water resources of Limestone County, Texas: Texas Water Development Board Report 299, 97 p.

Shipp, A.A., 1995, Water-quality assessment in the Trinity River Basin, Texas—Pesticide occurrence in streams, winter and spring 1994: U.S. Geological Survey Fact Sheet FS–160–95, 2 p.

Ulery, R.L., and Brown, M.F., 1994, Water-quality assessment of the Trinity River Basin, Texas—Review and analysis of available pesticide information, 1968–91: U.S. Geological Survey Water-Resources Investigations Report 94–4218, 88 p.

Ulery, R.L., Van Metre, P.C., and Crossfield, A.S., 1993, Trinity River Basin, Texas: American Water Resources Association, Water Resources Bulletin, v. 29, no. 4, p. 685–711.

U.S. Department of Agriculture, 1974, Soil survey of Navarro County, Texas: Soil Conservation Service, 69 p.

______1975, Soil survey of Anderson County, Texas: Soil Conservation Service, 92 p.

______1976, Soil survey of Chambers County, Texas: Soil Conservation Service, 53 p.

______1979, Soil survey of Henderson County, Texas: Soil Conservation Service, 125 p.

______1988, Soil survey of Polk and San Jacinto Counties, Texas: Soil Conservation Service, 180 p.

______1989, Soil survey of Wise County, Texas: Soil Conservation Service, 198 p.

U.S. Environmental Protection Agency, 1992, Guidelines establishing test procedures for the analysis of pollutants (Appendix B to Part 136—Definition and procedure for the determination of the method detection limit): U.S. Code of Federal Regulations, Title 40, p. 565–567.

______1996, Drinking water regulations and health advisories: Washington, D.C., Office of Water, EPA 822–R–96–001, 11 p.

University of Texas, Bureau of Economic Geology, 1967, Geologic atlas of Texas, Sherman sheet: Austin, scale 1:250,000.

______1968a, Geologic atlas of Texas, Beaumont sheet: Austin, scale 1:250,000.

______1968b, Geologic atlas of Texas, Palestine sheet: Austin, scale 1:250,000.

______1970, Geologic atlas of Texas, Waco sheet: Austin, scale 1:250,000.

______1982, Geologic atlas of Texas, Houston sheet: Austin, scale 1:250,000.

______1987, Geologic atlas of Texas, Dallas sheet: Austin, scale 1:250,000.

William F. Guyton and Associates, 1972, Ground-water conditions in Anderson, Cherokee, Freestone, and Henderson Counties, Texas: Texas Water Development Board Report 150, 335 p.

Table 1. Description of wells sampled in the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit

[Well reference no. in bold indicates deep well (depth greater than 150 feet), all others are shallow wells (depth 150 feet or less). ft, feet; in., inches; PVC, polyvinyl chloride; S, steel; --, not available; C, concrete]

Well reference no. (figs. 2–4)	USGS site identification no.	Local well no.	Altitude of land surface (ft above sea level)	Depth of well (ft below land surface)	Depth to water level (ft below land surface)	Casing material	Casing diameter (in.)
			Trinity aquifer				
1	333842097345201	TR–19–20–801	1,100	128	25.8	PVC	4
2	333402097503001	TR–19–26–402	1,143	110	50	S	6
3	333245097445801	TR–19–27–404	1,050	140	--	PVC	4
4	333041097342301	TR–19–28–805	1,000	174	--	PVC	5
5	332726097382301	TR–19–35–602	1,010	190	--	PVC	7.88
6	325829097513601	UP–32–02–104	1,150	160	38.0	S	5
7	325445097492501	UP–32–02–801	1,145	200	65	PVC	4
8	325641097400401	UP–32–03–501	890	200	--	S	5
9	325015097491401	UP–32–10–204	1,100	110	31.8	S	4
10	324850097414501	UP–32–11–504	925	101	16.5	PVC	4
11	324341097452601	UP–32–18–302	1,030	220	55.3	PVC	4
12	324127097390501	UP–32–19–606	865	210	40.1	PVC	5
13	332552097452801	ZR–19–34–605	955	110	--	S	5
14	332240097500801	ZR–19–34–704	970	110	--	PVC	4
15	332415097401801	ZR–19–35–801	960	200	--	PVC	4
16	332338097303601	ZR–19–36–901	852	235	--	PVC	4
17	331757097472601	ZR–19–42–608	970	127	68.9	S	7
18	330808097462801	ZR–19–50–903	860	115	2.1	PVC	4
19	331254097420901	ZR–19–51–201	820	102	26.7	PVC	4
20	330941097350601	ZR–19–52–701	882	240	20.7	PVC	4.5
21	330258097514201	ZR–19–58–405	990	106	22.7	PVC	4
22	330638097404601	ZR–19–59–203	765	185	4.1	PVC	4
23	330332097412801	ZR–19–59–501	775	150	--	PVC	6
24	330245097344201	ZR–19–60–506	725	280	45	PVC	4.5

Table 1. Description of wells sampled in the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit—Continued

Well reference no. (figs. 2–4)	USGS site identification no.	Local well no.	Altitude of land surface (ft above sea level)	Depth of well (ft below land surface)	Depth to water level (ft below land surface)	Casing material	Casing diameter (in.)
			Carrizo-Wilcox aquifer				
25	315440096150001	KA–39–06–903	380	21	9.9	PVC	6.0
26	315011096150901	KA–39–14–302	340	126	--	S	4.0
27	314645096125001	KA–39–15–703	405	462	104	S	6.0
28	314447096145401	KA–39–23–101	370	242	--	--	4
29	314105096014001	KA–39–24–603	480	21	6.5	C	36
30	313530096094001	KA–39–31–305	475	119	61.6	PVC	4.5
31	313305096131401	KA–39–31–411	490	395	--	--	--
32	313125096072501	KA–39–32–703	465	43	27.1	C	36
33	321730096012401	LT–33–48–905	410	240	38.4	--	--
34	321239096013001	LT–33–56–305	350	147	--	S	4
35	321020096024501	LT–33–56–509	340	200	105	PVC	4.0
36	320342096025501	LT–33–64–105	290	85	30.7	S	4
37	321740095585401	LT–34–41–405	400	260	131	PVC	8
38	321750095514501	LT–34–42–409	460	429	--	PVC	4.0
39	320700095543001	LT–34–57–307	455	275	--	S	4.0
40	320313095580401	LT–34–57–401	380	180	98.9	--	4
41	315620096124001	TY–39–07–406	385	160	--	PVC	4.0
42	323615095561501	YS–34–25–208	530	26	8.7	C	36
43	323345095584501	YS–34–25–402	490	30	22.0	C	36
44	323125095561401	YS–34–25–804	490	280	19.5	PVC	4
45	322855095554001	YS–34–33–205	520	428	--	S	4
46	322615095584501	YS–34–33–402	460	34	--	C	36
47	322624095554601	YS–34–33–502	545	45	11	PVC	4.0

Table 1. Description of wells sampled in the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit—Continued

Well reference no. (figs. 2–4)	USGS site identification no.	Local well no.	Altitude of land surface (ft above sea level)	Depth of well (ft below land surface)	Depth to water level (ft below land surface)	Casing material	Casing diameter (in.)
			Gulf Coast aquifer				
48	295043094483801	DH–64–10–211	33	38	--	PVC	2.0
49	295015094440701	DH–64–11–106	12	27	--	PVC	2.0
50	294957094380801	DH–64–11–611	27	140	--	PVC	4.0
51	294628094403901	DH–64–11–801	22	113	17.9	S	8
52	295210094371801	DH–64–12–110	28	36	6.0	C	36
53	294720094351501	DH–64–12–710	27	42	--	PVC	8.0
54	294345094364501	DH–64–20–102	18	42	--	PVC	4.0
55	301558094533801	SB–61–41–904	111	86	--	PVC	4.0
56	301950094451001	SB–61–42–605	90	210	--	PVC	2.0
57	300954094561001	SB–61–49–809	97	190	--	PVC	2.0
58	300240094551401	SB–61–57–508	81	--	6.17	S	4.0
59	300312094414201	SB–61–59–511	70	100	--	PVC	2.0
60	295950094573101	SB–64–01–109	67	180	--	PVC	4.0
61	295630094500001	SB–64–02–402	47	240	--	PVC	2.0
62	295703094423601	SB–64–03–404	32	27	--	PVC	2.0
63	304350095055701	UT–60–24–111	155	190	--	PVC	4.0
64	304200094492801	UT–61–18–519	315	345	--	S	12.0
65	303534094501001	UT–61–26–114	222	180	--	PVC	2.0
66	303609094464001	UT–61–26–303	218	80	38.7	PVC	4.0
67	304207095103001	WU–60–23–509	140	210	--	C	4.0
68	303826095082401	WU–60–23–907	135	210	1.9	PVC	4.0
69	303740095061001	WU–60–24–704	132	98	--	PVC	2.0
70	303000095002001	WU–60–40–315	165	490	178	S	9.0
71	302930094571501	WU–61–33–216	100	150	--	PVC	2.0

Table 2. National Water Quality Laboratory method detection limits for properties and constituents analyzed in samples from the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit

[From Koterba and others (1995). mL, milliliters; <, less than; MDL, method detection limit; µS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µm, micrometers; SPE, solid-phase extraction; L, liters]

Schedule 2750
Analyzed: major inorganics in ground water
Sample requirement: 250 mL, filtered, acidified with HNO_3 to pH <2; 250 mL, unfiltered, nonacidified; 500 mL, filtered, nonacidified
Container requirements: 250- and 500-mL polyethylene bottles, field-rinsed; 250-mL polyethylene bottle, acid-rinsed

Property or constituent	MDL	Property or constituent	MDL
Specific conductance, laboratory	1 µS/cm	Magnesium, dissolved	0.01 mg/L
pH, laboratory	.1 standard unit	Potassium, dissolved	.1 mg/L
Alkalinity, as $CaCO_3$, laboratory	1 mg/L	Silica, dissolved	.01 mg/L
Calcium, dissolved	.02 mg/L	Sodium, dissolved	.20 mg/L
Chloride, dissolved	.1 mg/L	Solids, residue on evaporation, dissolved at 180 °C	1 mg/L
Fluoride, dissolved	.10 mg/L	Sulfate, dissolved	.10 mg/L
Iron, dissolved	3 µg/L	Manganese, dissolved	1 µg/L

Schedule 2752
Analyzed: nutrients in ground water
Sample requirements: 125 mL passed through a 0.45-µm filter, chilled to 4 °C
Container requirements: 125-mL brown polyethylene bottle, field-rinsed

Nutrient	MDL (mg/L)	Nutrient	MDL (mg/L)
Nitrogen, ammonia, dissolved	0.01	Nitrogen, nitrite plus nitrate, dissolved	0.05
Nitrogen, nitrite, dissolved	.01	Phosphorus, total, dissolved	.01
Nitrogen, ammonia plus organic, dissolved	.20	Phosphorus, orthophosphate, dissolved	.01

Schedule 2703
Analyzed: trace elements in ground water filtered through a 0.45-µm filter
Sample requirements: 250 mL, filtered, acidified with HNO_3 to pH <2
Container requirements: 250-mL polyethylene bottle, acid-rinsed

Property or trace element	MDL	Property or trace element	MDL
Specific conductance, laboratory	1 µS/cm	Copper, dissolved	1 µg/L
pH, laboratory	.1 standard unit	Lead, dissolved	1 µg/L
Aluminum, dissolved	1 µg/L	Manganese, dissolved	1 µg/L
Antimony, dissolved	1 µg/L	Molybdenum, dissolved	1 µg/L
Arsenic, dissolved	1 µg/L	Nickel, dissolved	1 µg/L
Barium, dissolved	1 µg/L	Selenium, dissolved	1 µg/L
Beryllium, dissolved	1 µg/L	Silver, dissolved	1 µg/L
Cadmium, dissolved	1 µg/L	Uranium, dissolved	1 µg/L
Chromium, dissolved	1 µg/L	Zinc, dissolved	1 µg/L
Cobalt, dissolved	1 µg/L		

Table 2. National Water Quality Laboratory method detection limits for properties and constituents analyzed in samples from the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit—Continued

Schedule 2001

Analyzed: pesticides in filtered ground water extracted on C-18 SPE cartridge and analyzed by gas chromatography/mass spectrometry

Sample requirement: 1 L filtered through a 0.7-μm glass fiber filter, chilled at 4 °C

Container requirement: 1-L baked amber glass bottle

Pesticide (common name)	MDL[1] (μg/L)	Pesticide (common name)	MDL[1] (μg/L)
Alachlor (Lasso)	0.002 (ND)	Malathion	0.005 (ND)
Atrazine (AAtrex)	.001	Metolachlor	.002 (ND)
Atrazine, deethyl-	.002	Metribuzin	.004 (ND)
Azinphos, methyl-	.001 (ND)	Molinate	.004 (ND)
Benfluralin	.002 (ND)	Napropamide	.003 (ND)
Butylate	.002 (ND)	Parathion	.004 (ND)
Carbaryl (Sevin)	.003 (ND)	Parathion, methyl-	.006 (ND)
Carbofuran (Furadan)	.003 (ND)	Pebulate	.004 (ND)
Chlorpyrifos (Dursban)	.004	Pendimethalin	.004 (ND)
Cyanazine	.004 (ND)	Permethrin, *cis*-	.005 (ND)
DCPA (Dacthal)	.002 (ND)	Phorate	.002 (ND)
pp'-DDE	.006	Prometon	.018 (ND)
Diazinon	.002	Pronamide	.003 (ND)
Dieldrin	.001 (ND)	Propachlor	.007 (ND)
2,6-Diethylaniline	.003 (ND)	Propanil	.004 (ND)
Disulfoton (Disyston)	.017 (ND)	Propargite	.013 (ND)
EPTC (Eptam)	.002 (ND)	Simazine	.005 (ND)
Ethalfluralin	[2].004 (ND)	Tebuthiuron	.010 (ND)
Ethoprop	.003 (ND)	Terbacil	.007 (ND)
Fonofos	.003 (ND)	Terbufos	.013 (ND)
HCH, *alpha*-	.002 (ND)	Thiobencarb	.002 (ND)
HCH, *gamma*- (Lindane)	.004 (ND)	Triallate	.001 (ND)
Linuron	.002 (ND)	Trifluralin	.002 (ND)

[1] (ND) indicates nondetections for all samples from the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers.

[2] 0.009 for Trinity aquifer samples.

Schedule 2050

Analyzed: pesticides in filtered ground water extracted on Carbopak-B SPE cartridge and analyzed by high-performance liquid chromatography/ultraviolet spectoscopy

Sample requirement: 1 L water filtered through a 0.7-μm glass fiber filter, chilled at 4 °C

Container requirement: 1-L baked amber glass bottle

Pesticide (common name)	MDL[1] (μg/L)	Pesticide (common name)	MDL[1] (μg/L)
2,4-D	0.035 (ND)	Aldicarb sulfone	0.016 (ND)
2,4-DB	.035 (ND)	Aldicarb sulfoxide	.021 (ND)
2,4,5-T	.035 (ND)	Bentazon	.014
Acifluorfen (Blazer)	.035 (ND)	Bromacil	.035 (ND)
Aldicarb	.016 (ND)	Bromoxynil	.035 (ND)

Table 2. National Water Quality Laboratory method detection limits for properties and constituents analyzed in samples from the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit—Continued

Schedule 2050—Continued

Pesticide (common name)	MDL[1] (μg/L)	Pesticide (common name)	MDL[1] (μg/L)
Carbaryl (Sevin)	.003 (ND)	Linuron	0.002 (ND)
Carbofuran (Furadan)	.003 (ND)	MCPA	.05 (ND)
Carbofuran, 3-hydroxy-	.014 (ND)	MCPB	.035 (ND)
Chloramben (Amiben)	.05 (ND)	Methiocarb	.026 (ND)
Chlorothalonil	.035 (ND)	Methomyl	.017 (ND)
Clopyralid	.05 (ND)	1-Naphthol	[2].007 (ND)
Dacthal, mono-acid-	.017 (ND)	Neburon	.015 (ND)
Dicamba (Weedmaster)	.035 (ND)	Norflurazon	.024 (ND)
Dichlobenil	.02 (ND)	Oryzalin (Surflan)	.019 (ND)
Dichlorprop (2,4-DP)	.032 (ND)	Oxamyl	.018 (ND)
Dinoseb (DNBP)	.035 (ND)	Picloram	.05 (ND)
Diuron	0.02 (ND)	Propham (IPC)	.035 (ND)
4,6-Dinitro, *o*-cresol (DNOC)	.035 (ND)	Propoxur	.035 (ND)
Esfenvalerate (Asana XL)	.019 (ND)	Silvex (2,4,5-TP)	.021 (ND)
Fenuron	.013 (ND)	Triclopyr	.05 (ND)
Fluometuron	.035 (ND)		

[1] (ND) indicates nondetections for all samples from the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers.

[2] 0.003 for Gulf Coast aquifer samples.

Lab Code 0052
Analyzed: total phenols in unfiltered ground water
Container requirement: 1-L bottle

Constituent	MDL
Phenols, total	1 μg/L

Lab Code 0096
Analyzed: methylene blue active substances (MBAS)
Container requirement: 250-mL polyethylene bottle

Constituent	MDL
Methylene blue active substances	0.02 mg/L

Schedule 2090
Analyzed: volatile organic compounds by purge and trap gas chromatography/mass spectrometry
Sample requirements: three 40-mL vials completely filled to exclude air bubbles, acidified to pH <2 with 2 drops of a 1:1 ratio of HCl and water per vial, and chilled at 4 °C
Container requirement: 40-mL amber glass septum cap vial

Volatile organic compound (common name)	MDL[1] (μg/L)	Volatile organic compound (common name)	MDL[1] (μg/L)
Benzene	0.2	Benzene, isopropyl-	0.2 (ND)
Benzene, 1,2,3-trichloro-	.2 (ND)	Benzene, bromo-	.2 (ND)
Benzene, 1,2,4-trichloro-	.2 (ND)	Benzene, chloro-	.2 (ND)
Benzene, 1,2,4-trimethyl-	.2 (ND)	Benzene, dimethyl- (Xylene)	.2 (ND)
Benzene, 1,2-dichloro-	.2 (ND)	Benzene, ethyl-	.2 (ND)
Benzene, 1,3,5-trimethyl-	.2 (ND)	Benzene, 1-methyl-4-isopropyl-	.2 (ND)
Benzene, 1,3-dichloro-	.2 (ND)	Benzene, methyl- (Toluene)	.2 (ND)
Benzene, 1,4-dichloro-	.2 (ND)	Benzene, *n*-butyl-	.2 (ND)
Benzene, 1-chloro-2-methyl-	.2 (ND)	Benzene, *n*-propyl-	.2 (ND)
Benzene, 1-chloro-4-methyl-	.2 (ND)	Benzene, *sec*-butyl-	.2 (ND)

Table 2. National Water Quality Laboratory method detection limits for properties and constituents analyzed in samples from the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit—Continued

Schedule 2090—Continued

Volatile organic compound (common name)	MDL[1] (μg/L)	Volatile organic compound (common name)	MDL[1] (μg/L)
Benzene, *tert*-butyl-	.2 (ND)	Methane, dibromo-	0.2 (ND)
Ethane, 1,1,1,2-tetrachloro-	.2 (ND)	Methane, dibromochloro-	.2 (ND)
Ethane, 1,1,1-trichloro-	.2 (ND)	Methane, dichloro-	.2 (ND)
Ethane, 1,1,2,2-tetrachloro-	.2 (ND)	Methane, dichlorobromo-	.2 (ND)
Ethane, 1,1,2-trichloro-	.2 (ND)	Methane, dichlorodifluoro-	.2 (ND)
Ethane, 1,1-dichloro	.2 (ND)	Methane, tetrachloro-	.2 (ND)
Ethane, 1,2-dibromo- (EDB)	.2 (ND)	Methane, tribromo- (Bromoform)	.2 (ND)
Ethane, 1,2-dichloro-	.2 (ND)	Methane, trichloro- (Chloroform)	.2
Ethane, chloro-	.2 (ND)	Methane, trichlorofluoro-	.2
Ethane, trichlorotrifluoro- (113 Freon)	.2 (ND)	Ether, methyl *tert*-butyl- (MTBE)	.2 (ND)
Ethylene, 1,1-dichloro-	0.2 (ND)	Naphthalene	.2 (ND)
Ethylene, chloro- (vinyl chloride)	.2 (ND)	Propane, 1,2,3-trichloro-	.2 (ND)
Ethylene, *cis*-1,2-dichloro-	.2 (ND)	Propane, 1,2-dibromo-3-chloro- (DBCP)	[2]1.0 (ND)
Ethylene, tetrachloro-	.2 (ND)	Propane, 1,2-dichloro-	.2 (ND)
Ethylene, *trans*-1,2-dichloro-	.2 (ND)	Propane, 1,3-dichloro-	.2 (ND)
Ethylene, trichloro-	.2 (ND)	Propane, 2,2-dichloro-	.2 (ND)
Hexachlorobutadiene	.2 (ND)	Propene, 1,1-dichloro-	.2 (ND)
Methane, bromo-	.2 (ND)	Propene, *cis*-1,3-dichloro-	.2 (ND)
Methane, bromochloro-	.2 (ND)	Propene, *trans*-1,3-dichloro-	.2 (ND)
Methane, chloro-	.2 (ND)	Styrene	.2 (ND)

[1] (ND) indicates nondetections for all samples from the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers.

[2] 0.2 and 1.0 for Trinity aquifer samples.

Table 3. Constituents detected in field blanks, number of detections, and maximum concentrations

[mg/L, milligrams per liter; μg/L micrograms per liter]

Constituent	No. of detections/ no. of field blanks	Maximum concen-tration	Constituent	No. of detections/ no. of field blanks	Maximum concen-tration
Nitrogen, ammonia, dissolved	5/6	0.03 mg/L	Copper, dissolved	2/6	1 μg/L
Nitrogen, nitrite, dissolved	2/6	.01 mg/L	Lead, dissolved	2/6	4 μg/L
Phosphorus, total, dissolved	1/6	.02 mg/L	Zinc, dissolved	4/6	15 μg/L
Bromide, dissolved	1/6	.01 mg/L	Diazinon, dissolved	1/6	.011 μg/L
Calcium, dissolved	5/5	.15 mg/L	Fenuron, dissolved	1/6	.01 μg/L
Iron, dissolved	1/5	6 μg/L	Organic carbon, dissolved	5/5	.3 mg/L
Magnesium, dissolved	1/5	.01 mg/L	Methylene blue active substance (MBAS)	3/5	.11 mg/L
Silica, dissolved	3/5	.03 mg/L	Trichloromethane	2/5	.3 μg/L
Aluminum, dissolved	5/5	10 μg/L			

Table 4. Concentrations of inorganic constituents detected in quality-control sequential duplicate samples from the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit

[mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; µg/L, micrograms per liter; °C, degrees Celsius; RPD, relative percent difference; <, less than; >, greater than; --, no data]

Local well no.	Date	Bromide, dissolved (mg/L)	Calcium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Hardness, total (mg/L as $CaCO_3$)	Iron, dissolved (µg/L)	Magnesium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Silica, dissolved (mg/L)	Sodium, dissolved (mg/L)	Solids, residue at 180 °C, dissolved (mg/L)	Sulfate, dissolved (mg/L)
Trinity aquifer													
TR–19–35–602	3–05–94	0.28	150	24	0.1	640	4,400	65	3.3	22	24	840	250
TR–19–35–602	3–05–94	.24	150	24	.1	650	4,100	66	3.4	22	24	850	250
RPD		15	0	0	0	1.5	7.1	1.5	2.9	0	0	1.2	0
Carrizo-Wilcox aquifer													
LT–34–57–307	4–19–94	.05	8.9	3.8	.2	35	930	3	3.1	21	17	108	.5
LT–34–57–307	4–19–94	.04	8.9	3.5	.1	35	800	3	3.2	21	18	102	.7
RPD		22	0	8.2	67	0	15	0	3.0	0	5.7	5.7	33
YS–34–25–804	4–27–94	.04	3.9	7.7	.2	14	12	.93	1.9	14	76	218	15
YS–34–25–804	4–27–94	.04	4.1	7.6	.1	14	10	.98	1.9	15	78	215	15
RPD		0	5.0	1.3	67	0	18	5.2	0	6.8	2.6	1.3	0
Gulf Coast aquifer													
DH–64–11–106	7–29–94	.88	150	180	.1	400	13	6.9	1.8	28	120	754	27
DH–64–11–106	7–29–94	.89	150	170	.1	400	13	6.9	1.7	28	120	750	27
RPD		1.1	0	5.7	0	0	0	0	5.7	0	0	.5	0
DH–64–20–102	8–09–94	.52	100	1,150	.4	340	300	21	5.5	22	270	1,150	130
DH–64–20–102	8–09–94	.51	100	1,150	.4	340	320	21	5.4	22	270	1,150	130
RPD		2.0	0	0	0	0	6.5	0	1.8	0	0	0	0
SB–64–01–109	7–25–94	.33	84	150	.7	250	320	8.9	.9	26	160	690	12
SB–64–01–109	7–25–94	.34	84	140	.8	250	340	9.3	1.0	27	160	666	13
RPD		3.0	0	6.8	13	0	6.1	4.3	10	3.8	0	3.5	8.0
WU–61–33–216	7–13–94	.16	51	42	.2	150	<3	5.9	2.4	22	34	262	3.8
WU–61–33–216	7–13–94	.16	48	42	.2	140	<3	5.7	2.6	21	34	267	3.9
RPD		0	6.0	0	0	6.9	0	3.4	8.0	4.6	0	1.9	2.6

Table 4. Concentrations of inorganic constituents detected in quality-control sequential duplicate samples from the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit—Continued

Local well no.	Date	Aluminum, dissolved (µg/L)	Antimony, dissolved (µg/L)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)	Beryllium, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Lead, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)
Trinity aquifer													
TR–19–35–602	3–05–94	2	<1	<1	990	<1	<1	<1	<1	3	<1	140	<1
TR–19–35–602	3–05–94	2	<1	<1	>1,000	<1	<1	<1	<1	2	<1	140	<1
RPD		0	0	0	>1	0	0	0	0	40	0	0	0
Carrizo-Wilcox aquifer													
LT–34–57–307	4–19–94	4	<1	<1	28	<1	<1	1	<1	2	1	<1	<1
LT–34–57–307	4–19–94	--	--	<1	28	<1	<1	2	<1	2	--	--	--
RPD		--	--	0	0	0	0	67	0	0	--	--	--
YS–34–25–804	4–27–94	3	<1	2	94	<1	<1	<1	<1	9	<1	52	<1
YS–34–25–804	4–27–94	4	<1	--	--	--	--	--	--	--	--	--	--
RPD		28	0	--	--	--	--	--	--	--	--	--	--
Gulf Coast aquifer													
DH–64–11–106	7–29–94	2	<1	<1	97	<1	<1	2	<1	<1	<1	11	<1
DH–64–11–106	7–29–94	2	<1	--	--	--	--	--	--	--	<1	12	<1
RPD		0	0	--	--	--	--	--	--	--	0	8.7	0
DH–64–20–102	8–09–94	3	<1	<1	29	<1	<1	2	<1	<1	<1	26	<1
DH–64–20–102	8–09–94	3	<1	<1	31	<1	<1	2	<1	<1	<1	24	<1
RPD		0	0	0	6.6	0	0	0	0	0	0	8.0	0
SB–64–01–109	7–25–94	3	<1	<1	99	<1	<1	10	<1	<1	<1	690	<1
SB–64–01–109	7–25–94	<1	<1	<1	98	<1	<1	11	<1	3	<1	690	<1
RPD		>100	0	0	1	0	0	0	0	>100	0	0	0
WU–61–33–216	7–13–94	2	<1	1	97	<1	<1	10	<1	<1	<1	170	2
WU–61–33–216	7–13–94	--	--	<1	97	<1	<1	12	<1	<1	<1	180	2
RPD		--	--	0	0	0	0	18	0	0	0	5.7	0

Table 4. Concentrations of inorganic constituents detected in quality-control sequential duplicate samples from the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit—Continued

Local well no.	Date	Nickel, dissolved (μg/L)	Sele-nium, dissolved (μg/L)	Silver, dissolved (μg/L)	Uranium, dissolved (μg/L)	Zinc, dissolved (μg/L)	Nitrogen, ammonia, dissolved (mg/L)	Nitrogen, nitrite, dissolved (mg/L)	Nitrogen, ammonia plus organic, dissolved (mg/L)	Nitrogen, nitrite plus nitrate, dissolved (mg/L)	Phos-phorus, total, dissolved (mg/L)	Ortho-phos-phorus, dissolved (mg/L)	Alkalinity, (mg/L as $CaCO_3$)
Trinity aquifer													
TR–19–35–602	3–05–94	2	<1	<1	<1	12	0.14	0.02	<0.2	0.074	0.01	<0.01	417
TR–19–35–602	3–05–94	2	<1	<1	<1	6	--	--	--	--	--	--	--
RPD		0	0	0	0	67	--	--	--	--	--	--	--
Carrizo-Wilcox aquifer													
LT–34–57–307	4–19–94	1	6	<1	13	590	.160	<.010	<.20	<.050	.020	.020	76
LT–34–57–307	4–19–94	--	--	--	--	643	--	--	--	--	--	--	--
RPD		--	--	--	--	8.6	--	--	--	--	--	--	
YS–34–25–804	4–27–94	<1	<1	<1	<1	15	.290	.010	.30	.063	.120	.140	162
YS–34–25–804	4–27–94	--	--	--	--	20	--	--	--	--	--	--	--
RPD		--	--	--	--	29	--	--	--	--	--	--	--
Gulf Coast aquifer													
DH–64–11–106	7–29–94	<1	<1	<1	<1	15	.030	<.010	<.20	<.050	.06	.05	394
DH–64–11–106	7–29–94	<1	<1	<1	<1	18	.020	<.010	<.20	<.050	.05	.05	395
RPD		0	0	0	0	18	40	0	0	0	18	0	.2
DH–64–20–102	8–09–94	2	<1	<1	2	290	.52	<.01	.60	<.05	.06	.06	386
DH–64–20–102	8–09–94	2	<1	<1	2	249	.52	<.01	.50	<.05	.07	.06	386
RPD		0	0	0	0	15	0	0	18	0	15	0	0
SB–64–01–109	7–25–94	<1	<1	<1	<1	210	.09	<.01	<.2	<.05	.01	<.01	390
SB–64–01–109	7–25–94	<1	<1	<1	<1	121	--	--	--	--	--	--	406
RPD		0	0	0	0	54	--	--	--	--	--	--	4.0
WU–61–33–216	7–13–94	<1	<1	<1	2	14	<.010	<.010	<.20	.076	.07	<.01	173
WU–61–33–216	7–13–94	<1	<1	<1	<1	--	<.010	<.010	<.20	.069	<.010	<.01	160
RPD		0	0	0	>67	--	0	0	0	9.0	--	0	7.7

Table 5. Percent recoveries of volatile organic compound spiked samples from the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers in the Trinity River Basin study unit

[FS, field spike; FSR, field spike replicate; LS, laboratory spike]

Local well no.	Date	Time	Spike type	Dibromo-chloro-methane, total (percent recovery)	Chloro-ethylene, total [vinyl chloride] (percent recovery)	1,4-Dichloro-benzene, total (percent recovery)	Dichloro-bromo-methane, total (percent recovery)	1,2-Dichloro-ethane, total (percent recovery)	1,1-Dichloro-ethylene, total (percent recovery)	Ethyl-benzene, total (percent recovery)
Trinity aquifer										
ZR–19–36–901	3–08–94	1313	FS	56	35	75	56	65	45	56
		1314	FSR	52	39	70	56	70	45	52
		1312	LS	65	96	90	74	87	95	72
Carrizo-Wilcox aquifer										
LT–34–41–405	4–22–94	1102	FS	65	61	75	61	70	60	60
		1101	FSR	56	52	70	52	61	50	52
		1103	LS	74	104	90	74	83	90	76
Gulf Coast aquifer										
SB–61–49–809	7–26–94	1253	FS	61	78	75	74	96	75	64
		1254	FSR	65	61	80	70	96	60	60
		1252	LS	65	83	85	78	96	80	68

Local well no.	Date	Time	Spike type	Methyl tert-butyl ether, total [MTBE] (percent recovery)	Tetrachloro-ethylene, total (percent recovery)	Tetrachloro-methane, total (percent recovery)	Tribromo-methane, total [bromoform] (percent recovery)	1,1,1-Trichloro-ethane, total (percent recovery)	Trichloro-ethylene, total (percent recovery)
Trinity aquifer									
ZR–19–36–901	3–08–94	1313	FS	68	48	40	55	55	65
		1314	FSR	76	44	36	55	55	60
		1312	LS	92	72	68	65	90	100
Carrizo-Wilcox aquifer									
LT–34–41–405	4–22–94	1102	FS	72	56	44	70	60	65
		1101	FSR	68	44	40	65	55	60
		1103	LS	88	72	64	85	85	90
Gulf Coast aquifer									
SB–61–49–809	7–26–94	1253	FS	92	52	64	65	85	80
		1254	FSR	96	48	52	65	70	70
		1252	LS	100	60	68	70	90	90

Table 6. Rank correlations between well depth and concentrations of nutrients and major inorganic constituents in the Trinity aquifer samples

[positive rho, increasing concentration with depth; negative rho, decreasing concentration with depth; p-value, significance level]

Constituent	No. of samples	Spearman rank correlation (rho)	p-value	Significant at 95-percent level
Nitrogen, ammonia, dissolved	24	0.13	0.56	no
Nitrogen, ammonia plus organic, dissolved	24	.17	.44	no
Nitrogen, nitrite plus nitrate, dissolved	24	–.35	.10	no
Phosphorus, total, dissolved	24	–.01	.92	no
Phosphorus, orthophosphate, dissolved	24	.07	1.00	no
Bicarbonate, dissolved	24	–.27	.19	no
Calcium, dissolved	24	–.07	.73	no
Chloride, dissolved	24	–.09	.66	no
Magnesium, dissolved	24	.02	.92	no
Sodium, dissolved	24	.05	.82	no
Dissolved solids	24	.18	.39	no
Sulfate, dissolved	24	.37	.07	no

Table 7. Rank correlations between well depth and concentrations of nutrients and major inorganic constituents in the Carrizo-Wilcox aquifer samples

[positive rho, increasing concentration with depth; negative rho, decreasing concentration with depth; p-value, significance level]

Constituent	No. of samples	Spearman rank correlation (rho)	p-value	Significant at 95-percent level
Nitrogen, ammonia, dissolved	23	0.56	0.006	yes
Nitrogen, ammonia plus organic, dissolved	23	.31	.14	no
Nitrogen, nitrite plus nitrate, dissolved	23	–.77	.0002	yes
Phosphorus, total, dissolved	23	.17	.44	no
Phosphorus, orthophosphate, dissolved	23	.37	.08	no
Bicarbonate, dissolved	23	.60	.002	yes
Calcium, dissolved	23	–.39	.06	no
Chloride, dissolved	23	.16	.44	no
Magnesium, dissolved	23	–.04	.86	no
Sodium, dissolved	23	.62	.001	yes
Dissolved solids	23	.46	.03	yes
Sulfate, dissolved	23	.05	.79	no

Table 8. Rank correlations between well depth and concentrations of nutrients and major inorganic constituents in the Gulf Coast aquifer samples

[positive rho, increasing concentration with depth; negative rho, decreasing concentration with depth; p-value, significance level]

Constituent	No. of samples	Spearman rank correlation (rho)	p-value	Significant at 95-percent level
Nitrogen, ammonia, dissolved	24	–0.04	0.87	no
Nitrogen, ammonia plus organic, dissolved	24	–.07	.75	no
Nitrogen, nitrite plus nitrate, dissolved	24	–.36	.12	no
Phosphorus, total, dissolved	24	.34	.13	no
Phosphorus, orthophosphate, dissolved	24	.24	.29	no
Bicarbonate, dissolved	24	–.09	.67	no
Calcium, dissolved	24	–.34	.10	no
Chloride, dissolved	24	–.35	.10	no
Magnesium, dissolved	24	–.39	.06	no
Sodium, dissolved	24	–.11	.62	no
Dissolved solids	24	–.28	.19	no
Sulfate, dissolved	24	–.48	.02	yes

Blank Page

Appendix 1.
Water-Quality Data for Trinity, Carrizo-Wilcox, and Gulf Coast Aquifers

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers

[Well reference no. in bold indicates deep well (depth greater than 150 feet), all others are shallow wells (depth 150 feet or less). Data for pesticides and volatile organic compounds listed only if detected in at least one aquifer. For complete listing of all pesticides and volatile organic compounds analyzed, see table 2. µS/cm, microsiemens per centimeter at 25 °C; °C, degrees Celsius; mg/L, milligrams per liter; <, less than; --, no data; $CaCO_3$, calcium carbonate; µg/L, micrograms per liter]

Well reference no. (figs. 2–4)	Local well no.	Date	Specific conductance, (µS/cm)	pH (standard units)	Temperature, water (°C)	Dissolved oxygen (mg/L)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Total phosphorus, dissolved (mg/L as P)	Phosphorus, orthophosphate, dissolved (mg/L as P)
						Trinity aquifer						
1	TR–19–20–801	3–05–94	853	7.0	19.5	4.1	0.060	0.020	<0.20	6.20	<0.010	0.010
2	TR–19–26–402	3–22–94	4,590	6.8	19.0	--	.060	.010	<.20	7.20	<.010	<.010
3	TR–19–27–404	3–07–94	2,260	6.9	19.5	--	.050	<.010	<.20	7.00	.020	<.010
4	TR–19–28–805	3–05–94	710	7.0	18.5	.1	.380	<.010	.40	<.050	<.010	<.010
5	TR–19–35–602	3–05–94	1,240	6.7	19.5	.2	.140	.020	<.20	.074	.010	<.010
6	UP–32–02–104	3–24–94	1,190	7.1	21.0	--	.100	<.010	<.20	1.20	<.010	.010
7	UP–32–02–801	3–23–94	738	7.3	21.0	1.2	.110	<.010	.30	.180	.050	.040
8	UP–32–03–501	3–24–94	702	9.1	20.0	1.2	.010	.010	<.20	.061	.040	.040
9	UP–32–10–204	3–23–94	914	7.1	21.0	--	.010	.020	<.20	1.70	.020	<.010
10	UP–32–11–504	3–21–94	575	7.1	20.0	.4	.390	.010	.40	<.050	<.010	<.010
11	UP–32–18–302	3–24–94	773	7.0	20.5	--	.010	<.010	<.20	1.30	<.010	<.010
12	UP–32–19–606	3–25–94	601	8.1	17.5	.7	.620	.010	.70	.120	<.010	<.010
13	ZR–19–34–605	3–04–94	619	6.9	13.5	--	.030	<.010	<.20	4.10	.020	.030
14	ZR–19–34–704	3–04–94	911	6.9	16.5	2.9	.020	<.010	<.20	2.30	<.010	.020
15	ZR–19–35–801	3–08–94	1,070	7.0	19.0	.1	.140	<.010	<.20	<.050	<.010	<.010
16	ZR–19–36–901	3–08–94	628	7.5	17.0	.6	.570	<.010	.60	.390	.010	<.010
17	ZR–19–42–608	3–03–94	1,220	7.4	20.5	--	<.010	<.010	<.20	1.90	<.010	<.010
18	ZR–19–50–903	3–03–94	617	7.4	20.0	--	.010	<.010	<.20	.990	<.010	<.010
19	ZR–19–51–201	3–06–94	510	6.6	20.5	--	.050	.020	<.20	6.30	.040	.040
20	ZR–19–52–701	2–28–94	2,380	6.8	18.0	--	.020	<.010	<.20	2.50	.030	.040
21	ZR–19–58–405	3–25–94	1,120	7.2	19.0	1.9	.020	<.010	<.20	1.80	<.010	.010
22	ZR–19–59–203	3–02–94	1,390	7.3	20.0	2.9	1.10	<.010	1.0	<.050	<.010	<.010
23	ZR–19–59–501	3–02–94	1,390	8.3	19.0	1.1	.790	<.010	.70	<.050	<.010	<.010
24	ZR–19–60–506	3–01–94	1,300	9.0	19.0	.2	.040	<.010	<.20	.310	.010	.010

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Carbonate, dissolved (mg/L as CO_3)	Bicar-bonate, dissolved (mg/L as HCO_3)	Alkalinity, (mg/L as $CaCO_3$)	Bromide, dissolved (mg/L as Br)	Calcium, dissolved (mg/L as Ca)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Hardness, total (mg/L as $CaCO_3$)	Iron, dissolved (μg/L as Fe)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)
					Trinity aquifer—Continued						
1	<1	407	330	0.12	110	26	0.50	410	5	33	4.6
2	<1	230	190	8.4	570	1,300	.20	1,600	59	43	4.6
3	<1	429	350	1.5	250	450	.10	810	15	46	2.0
4	<1	412	340	.12	100	12	.20	330	370	19	2.4
5	<1	527	430	.28	150	24	.10	640	4,400	65	3.3
6	<1	424	350	.81	90	140	.20	410	6	45	3.0
7	<1	334	270	.31	82	49	.10	280	<3	19	1.6
8	31	391	370	.050	1.2	5.0	.30	6	<3	.71	.60
9	<1	436	360	.34	94	46	.40	290	4	13	.80
10	<1	324	270	.050	70	6.3	.20	210	39	9.2	1.6
11	<1	393	320	.15	150	24	.20	390	10	4.0	.60
12	<1	307	250	.030	12	4.9	.30	55	10	6.1	1.9
13	<1	272	220	.25	71	31	<.10	190	<3	2.8	1.0
14	<1	406	330	.54	100	68	.30	290	7	10	1.7
15	<1	432	360	.18	110	30	.20	500	320	55	3.7
16	<1	327	270	.12	62	16	.10	220	27	16	2.7
17	<1	400	330	1.1	140	160	<.10	510	<3	38	4.3
18	<1	336	280	.18	62	17	.60	210	5	14	2.4
19	<1	160	130	.30	49	43	<.10	140	5	4.7	2.6
20	<1	517	420	3.0	200	500	.10	850	8	86	2.8
21	<1	514	420	.45	86	64	.30	420	3	49	2.9
22	<1	472	390	1.1	53	210	.20	280	160	36	3.8
23	<1	503	410	.38	7.0	96	.10	29	9	2.9	2.3
24	--	461	380	.51	3.9	110	1.2	19	10	2.2	1.1

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Silica, dissolved (mg/L as SiO_2)	Sodium, dissolved (mg/L as Na)	Solids, residue at 180 °C, dissolved (mg/L)	Sulfate, dissolved (mg/L as SO_4)	Aluminum, dissolved (µg/L as Al)	Antimony, dissolved (µg/L as Sb)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)
Trinity aquifer—Continued											
1	17	18	496	59	2	<1	<1	81	<1	<1.0	<1
2	18	220	2,820	37	2	<1	<1	990	<1	<1.0	<1
3	22	130	1,390	75	2	<1	<1	270	<1	<1.0	2
4	24	23	420	35	2	<1	<1	90	<1	<1.0	<1
5	22	24	840	250	2	<1	<1	28	<1	<1.0	1
6	20	82	700	87	2	<1	<1	130	<1	<1.0	5
7	21	44	430	45	2	<1	1	96	<1	<1.0	5
8	8.8	160	423	10	4	<1	<1	29	<1	<1.0	5
9	19	59	498	34	2	<1	<1	130	<1	<1.0	7
10	16	37	337	35	3	<1	<1	81	<1	<1.0	4
11	12	10	473	58	2	<1	<1	110	<1	<1.0	6
12	12	110	363	46	3	<1	<1	24	<1	<1.0	5
13	21	56	370	35	2	<1	<1	95	<1	<1.0	<1
14	21	79	531	45	2	<1	1	110	<1	<1.0	<1
15	18	30	674	200	3	<1	<1	32	<1	<1.0	1
16	20	41	360	39	3	<1	<1	120	<1	<1.0	<1
17	17	51	692	53	2	<1	4	240	<1	<1.0	1
18	18	52	358	26	5	<1	<1	77	<1	<1.0	<1
19	25	45	310	29	3	<1	<1	71	<1	<1.0	<1
20	26	150	1,480	100	1	<1	<1	140	<1	<1.0	2
21	25	87	652	62	2	<1	2	94	<1	<1.0	8
22	20	180	758	20	2	<1	2	200	<1	<1.0	<1
23	12	310	836	160	3	<1	<1	59	<1	<1.0	1
24	9.1	290	772	120	5	<1	<1	35	<1	<1.0	<1

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Manganese, dissolved (µg/L as Mn)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)	Selenium, dissolved (µg/L as Se)	Silver, dissolved (µg/L as Ag)	Uranium, dissolved (µg/L as U)	Zinc, dissolved (µg/L as Zn)	Atrazine, dissolved (µg/L)	Deethyl atrazine, dissolved (µg/L)
						Trinity aquifer—Continued						
1	<1	8	<1	<1	<1	1	2	<1.0	7.0	35	--	--
2	<1	3	<1	4	<1	6	<1	<1.0	<1.0	12	0.021	0.023
3	<1	5	<1	<1	<1	4	2	<1.0	4.0	18	<.001	<.002
4	<1	<1	<1	48	<1	2	<1	<1.0	<1.0	31	<.001	<.002
5	<1	2	<1	140	<1	2	<1	<1.0	<1.0	590	<.001	<.002
6	<1	<1	<1	3	1	1	<1	<1.0	<1.0	14	<.001	<.002
7	<1	3	<1	3	<1	<1	1	<1.0	1.0	11	<.001	<.002
8	<1	<1	<1	<1	<1	<1	<1	<1.0	<1.0	1	<.001	<.002
9	<1	5	2	<1	<1	1	3	<1.0	7.0	48	<.001	<.002
10	<1	<1	<1	13	1	<1	<1	<1.0	1.0	19	<.001	<.002
11	<1	7	5	<1	1	2	<1	<1.0	4.0	9	<.001	.004
12	<1	11	<1	4	<1	<1	<1	<1.0	<1.0	90	<.001	<.002
13	<1	2	<1	<1	<1	1	2	<1.0	2.0	4	<.001	<.002
14	<1	6	<1	<1	<1	1	1	<1.0	3.0	5	<.001	<.002
15	<1	2	<1	120	<1	1	<1	<1.0	<1.0	23	<.001	<.002
16	<1	1	<1	16	1	<1	<1	<1.0	<1.0	19	<.001	<.002
17	<1	8	<1	12	<1	2	3	<1.0	93	8	<.001	<.002
18	<1	2	<1	2	<1	1	<1	<1.0	1.0	12	<.001	<.002
19	<1	15	<1	3	<1	<1	1	<1.0	<1.0	96	<.001	<.002
20	<1	18	1	<1	<1	4	14	<1.0	5.0	27	<.001	<.002
21	<1	9	1	<1	<1	1	6	<1.0	13	5	<.001	<.002
22	<1	<1	<1	27	<1	<1	<1	<1.0	<1.0	44	<.001	<.002
23	<1	3	4	4	1	<1	<1	<1.0	<1.0	18	<.001	<.002
24	<1	3	<1	1	2	<1	<1	<1.0	<1.0	4	<.001	<.002

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Benta-zon, dissolved (μg/L)	Chlor-pyrifos, dissolved (μg/L)	pp'-DDE, dissolved (μg/L)	Diazinon, dissolved (μg/L)	Metribu-zin, dissolved (μg/L)	Pro-meton, dissolved (μg/L)	Organic carbon, dissolved (mg/L as C)	Phenols, total (μg/L)	Methylene blue active substance (mg/L)	Benzene, total (μg/L)	Trichloro-fluoro-methane, total (μg/L)	Trichloro-methane, total (chloroform) (μg/L)
Trinity aquifer—Continued												
1	<0.014	--	--	0.074	--	--	1.8	<1	<0.02	<0.2	<0.2	<0.2
2	<.014	<0.004	<0.006	<.002	<0.004	<0.018	.7	<1	<.02	<.2	<.2	<.2
3	<.014	<.004	<.006	.011	<.004	<.018	.6	<1	<.02	<.2	<.2	<.2
4	<.014	<.004	[1].001	<.002	<.004	<.018	.3	2	<.02	<.2	<.2	<.2
5	<.014	<.004	<.006	<.002	<.004	<.018	--	<1	.02	<.2	<.2	<.2
6	<.014	.005	<.006	.085	<.004	<.018	.5	<1	<.02	<.2	<.2	<.2
7	<.014	<.004	<.006	.015	<.004	<.018	.5	<1	<.02	<.2	<.2	<.2
8	<.014	<.004	<.006	<.002	<.004	<.018	.3	<1	<.02	<.2	<.2	<.2
9	<.014	<.004	<.006	.055	<.004	<.018	.4	<1	<.02	<.2	<.2	<.2
10	<.014	<.004	<.006	.009	<.004	<.018	.5	13	<.02	<.2	<.2	<.2
11	<.014	<.004	<.006	.056	<.004	<.018	.8	<1	<.02	<.2	<.2	<.2
12	<.014	<.004	<.006	.057	<.004	<.018	.4	<1	<.02	<.2	<.2	<.2
13	<.014	<.004	<.006	<.002	<.004	<.018	.5	3	<.02	<.2	<.2	<.2
14	<.014	<.004	<.006	.015	<.004	<.018	.7	<1	<.02	<.2	<.2	<.2
15	<.014	<.004	<.006	<.002	<.004	<.018	.5	<1	<.02	<.2	<.2	<.2
16	<.014	<.004	<.006	.012	<.004	<.018	.4	<1	<.02	<.2	<.2	<.2
17	<.014	<.004	<.006	<.002	<.004	<.018	.6	<1	<.02	.4	<.2	<.2
18	<.014	<.004	<.006	<.002	<.004	<.018	.3	<1	<.02	<.2	<.2	<.2
19	<.014	<.004	<.006	<.002	<.004	<.018	.4	2	.07	<.2	<.2	<.2
20	<.014	<.004	<.006	<.002	<.004	<.018	1.3	--	<.02	<.2	<.2	<.2
21	<.014	<.004	[1].001	.016	<.004	<.018	.7	2	<.02	<.2	<.2	<.2
22	<.014	<.004	<.006	<.002	<.004	<.018	.2	1	<.02	<.2	<.2	<.2
23	<.014	<.004	<.006	<.002	<.004	<.018	.5	4	<.02	<.2	<.2	<.2
24	<.014	<.004	<.006	<.002	<.004	<.018	.4	<1	.02	<.2	<.2	<.2

[1] Estimated.

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Local well no.	Date	Specific conductance, (µS/cm)	pH (standard units)	Temperature, water (°C)	Dissolved oxygen (mg/L)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Total phosphorus, dissolved (mg/L as P)	Phosphorus, orthophosphate, dissolved (mg/L as P)
						Carrizo-Wilcox aquifer						
25	KA–39–06–903	4–08–94	232	6.6	19.5	1.7	0.020	<0.010	<0.20	4.40	0.160	0.160
26	KA–39–14–302	4–08–94	1,030	6.3	19.5	<.1	.340	.010	.40	.056	.170	.040
27	KA–39–15–703	4–06–94	556	8.7	22.5	--	.020	.010	<.20	<.050	.160	.170
28	KA–39–23–101	4–06–94	624	7.7	20.5	.1	.500	.020	.50	<.050	.140	.120
29	KA–39–24–603	4–05–94	236	7.1	18.5	2.2	.030	.020	<.20	4.20	<.010	<.010
30	KA–39–31–305	4–07–94	1,120	6.9	22.0	<1.4	.020	.010	<.20	.720	<.010	.010
31	KA–39–31–411	4–04–94	640	7.6	24.0	.1	.280	.010	.40	<.050	.060	.070
32	KA–39–32–703	4–05–94	128	5.8	20.0	--	.030	.020	<.20	5.10	.020	.020
33	LT–33–48–905	4–20–94	481	7.4	22.0	1.4	.430	.020	.40	.140	.150	.160
34	LT–33–56–305	4–21–94	471	9.0	21.0	.1	.060	<.010	<.20	<.050	.090	.130
35	LT–33–56–509	4–20–94	1,010	8.3	22.0	.2	.410	<.010	.40	<.050	.100	.110
36	LT–33–64–105	4–21–94	456	7.6	20.5	--	.040	<.010	<.20	6.80	.170	.190
37	LT–34–41–405	4–22–94	540	8.1	22.0	.2	.240	<.010	.20	<.050	.140	.160
38	LT–34–42–409	4–26–94	270	7.8	21.5	<.1	.200	.010	.20	<.050	.090	.080
39	LT–34–57–307	4–19–94	158	7.7	21.0	.1	.160	<.010	<.20	<.050	.020	.020
40	LT–34–57–401	4–19–94	333	8.7	23.0	.2	.040	<.010	<.20	<.050	.140	.150
41	TY–39–07–406	4–18–94	515	6.3	22.5	.1	.130	<.010	<.20	<.050	.150	<.010
42	YS–34–25–208	4–25–94	208	7.6	19.0	--	.020	.010	.20	.250	.030	.030
43	YS–34–25–402	4–27–94	403	6.4	21.5	--	.020	<.010	<.20	.660	.100	.100
44	YS–34–25–804	4–27–94	353	8.2	21.0	1.2	.290	.010	.30	.063	.120	.140
45	YS–34–33–205	4–26–94	1,030	8.5	24.0	.2	.180	<.010	.20	<.050	.220	.210
46	YS–34–33–402	4–22–94	234	6.6	20.5	--	--	--	<.20	--	.270	--
47	YS–34–33–502	4–25–94	260	6.1	20.0	.8	<.010	<.010	<.20	.900	.050	.050

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Carbonate, dissolved (mg/L as CO_3)	Bicarbonate, dissolved (mg/L as HCO_3)	Alkalinity, (mg/L as $CaCO_3$)	Bromide, dissolved (mg/L as Br)	Calcium, dissolved (mg/L as Ca)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Hardness, total (mg/L as $CaCO_3$)	Iron, dissolved (μg/L as Fe)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)
					Carrizo-Wilcox aquifer—Continued						
25	<1	63	52	0.18	9.6	20	0.20	33	39	2.1	0.80
26	<1	258	210	.41	87	86	.20	330	4,900	28	2.7
27	8	276	230	.080	3.3	20	.40	11	12	.69	1.1
28	<1	184	150	.31	47	85	.20	170	320	12	3.7
29	<1	68	56	.040	34	16	<.10	99	9	3.3	.90
30	<1	316	260	.70	48	160	1.2	190	3	16	1.2
31	<1	243	200	.15	37	36	.10	130	200	8.1	5.4
32	<1	12	10	.060	9.4	9.3	.10	38	7	3.6	3.9
33	<1	180	150	.11	19	29	.30	73	140	6.1	3.0
34	5	210	180	.13	3.5	41	.10	11	5	.54	.90
35	<1	222	180	.26	24	86	<.10	88	93	6.7	2.6
36	<1	182	150	.090	70	19	<.10	190	<3	3.4	3.2
37	<1	216	180	.15	19	42	.10	63	220	3.7	2.8
38	<1	134	110	.050	15	11	.10	50	210	3.1	4.2
39	<1	90	74	.050	8.9	3.8	.10	35	930	3.0	3.1
40	7	191	170	.030	1.0	6.4	.10	3	8	.11	.50
41	<1	137	110	.38	23	55	.50	110	17,000	12	2.8
42	<1	89	73	.010	29	4.4	<.10	80	36	1.9	2.8
43	<1	160	130	.10	50	33	.10	140	18	3.0	1.7
44	<1	196	160	.040	3.9	7.7	.20	14	12	.93	1.9
45	6	290	250	.54	4.9	180	.30	16	17	1.0	1.9
46	<1	76	62	.030	34	8.0	<.10	96	9	2.6	1.2
47	<1	72	59	.20	15	30	.10	51	19	3.3	4.1

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Silica, dissolved (mg/L as SiO_2)	Sodium, dissolved (mg/L as Na)	Solids, residue at 180 °C, dissolved (mg/L)	Sulfate, dissolved (mg/L as SO_4)	Aluminum, dissolved (µg/L as Al)	Antimony, dissolved (µg/L as Sb)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)
					Carrizo-Wilcox aquifer—Continued						
25	45	34	175	12	80	<1	<1	44	<1	<1.0	4
26	35	77	656	190	1	<1	<1	45	<1	<1.0	10
27	12	120	323	15	10	<1	<1	25	<1	<1.0	7
28	23	74	409	59	1	<1	<1	160	<1	<1.0	8
29	12	3.7	130	3.6	5	1	<1	74	<1	<1.0	2
30	34	160	652	48	1	<1	<1	100	<1	<1.0	20
31	21	88	387	61	1	<1	1	49	<1	<1.0	7
32	31	4.1	95	9.8	40	<1	<1	84	<1	<1.0	2
33	27	71	296	47	2	<1	<1	11	<1	<1.0	2
34	13	100	282	3.9	6	<1	<1	28	<1	<1.0	6
35	14	170	583	160	6	<1	<1	100	<1	<1.0	4
36	25	13	293	26	3	<1	<1	30	<1	<1.0	5
37	24	89	321	33	3	<1	<1	110	<1	<1.0	3
38	19	43	175	13	3	<1	1	100	<1	<1.0	2
39	21	17	102	.50	4	<1	<1	97	<1	<1.0	2
40	12	76	207	7.4	9	<1	<1	9	<1	<1.0	4
41	47	49	319	71	7	<1	4	75	<1	<1.0	3
42	11	12	133	20	60	<1	<1	47	<1	<1.0	2
43	74	33	317	31	2	<1	<1	72	<1	<1.0	2
44	14	76	218	15	3	<1	<1	29	<1	<1.0	2
45	12	210	574	.30	4	<1	2	44	<1	<1.0	4
46	28	3.5	168	10	10	<1	2	151	<1	<1.0	1
47	50	31	180	18	40	<1	<1	39	<1	<1.0	2

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Cobalt, dissolved (μg/L as Co)	Copper, dissolved (μg/L as Cu)	Lead, dissolved (μg/L as Pb)	Manganese, dissolved (μg/L as Mn)	Molybdenum, dissolved (μg/L as Mo)	Nickel, dissolved (μg/L as Ni)	Selenium, dissolved (μg/L as Se)	Silver, dissolved (μg/L as Ag)	Uranium, dissolved (μg/L as U)	Zinc, dissolved (μg/L as Zn)	Atrazine, dissolved (μg/L)	Deethyl atrazine, dissolved (μg/L)
Carrizo-Wilcox aquifer—Continued												
25	<1	15	<1	2	<1	<1	2	<1.0	<1.0	18	<0.001	<0.002
26	<1	1	<1	180	<1	<1	<1	<1.0	<1.0	63	<.001	<.002
27	<1	1	<1	10	<1	<1	<1	<1.0	<1.0	4	<.001	<.002
28	<1	<1	<1	67	<1	<1	<1	<1.0	<1.0	3	<.001	<.002
29	<1	2	<1	10	<1	2	<1	<1.0	<1.0	950	<.001	<.002
30	<1	2	2	<1	<1	<1	2	<1.0	7.0	17	<.001	<.002
31	<1	<1	<1	28	<1	<1	<1	<1.0	<1.0	8	<.001	<.002
32	2	11	<1	3	<1	3	1	<1.0	<1.0	16	<.001	<.002
33	<1	<1	<1	100	<1	<1	<1	<1.0	<1.0	490	<.001	<.002
34	<1	<1	<1	13	<1	<1	<1	<1.0	<1.0	4	<.001	<.002
35	<1	<1	<1	52	<1	<1	<1	<1.0	<1.0	5	<.001	<.002
36	<1	5	<1	<1	<1	<1	<1	<1.0	<1.0	88	<.001	<.002
37	<1	<1	<1	80	<1	<1	<1	<1.0	<1.0	3	<.001	<.002
38	<1	<1	<1	69	<1	<1	<1	<1.0	<1.0	170	<.001	<.002
39	<1	<1	<1	52	<1	<1	<1	<1.0	<1.0	46	<.001	<.002
40	<1	<1	<1	10	<1	<1	<1	<1.0	<1.0	7	<.001	<.002
41	7	<1	<1	570	<1	14	<1	<1.0	<1.0	34	<.001	<.002
42	<1	6	<1	<1	<1	<1	<1	<1.0	<1.0	59	<.001	<.002
43	<1	10	<1	9	<1	1	<1	<1.0	<1.0	8	<.001	<.002
44	<1	<1	<1	11	<1	<1	<1	<1.0	<1.0	15	<.001	<.002
45	<1	<1	<1	10	<1	<1	<1	<1.0	<1.0	5	<.001	<.002
46	<1	3	<1	<1	<1	<1	<1	<1.0	<1.0	27	<.001	<.002
47	<1	5	<1	5	<1	1	<1	<1.0	<1.0	10	.013	.011

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Benta-zon, dissolved (μg/L)	Chlor-pyrifos, dissolved (μg/L)	pp'-DDE, dissolved (μg/L)	Diazinon, dissolved (μg/L)	Metribu-zin, dissolved (μg/L)	Pro-meton, dissolved (μg/L)	Organic carbon, dissolved (mg/L as C)	Phenols, total (μg/L)	Methylene blue active substance (mg/L)	Benzene, total (μg/L)	Trichloro-fluoro-methane, total (μg/L)	Trichloro-methane, total (chloroform) (μg/L)
Carrizo-Wilcox aquifer—Continued												
25	<0.014	<0.004	<0.006	<0.002	<0.004	<0.018	0.6	5	<0.02	<0.2	0.3	<0.2
26	<.014	<.004	<.006	<.002	<.004	<.018	.6	6	<.02	<.2	<.2	<.2
27	<.014	<.004	<.006	<.002	<.004	<.018	.4	8	<.02	<.2	<.2	<.2
28	<.014	<.004	[1].001	<.002	<.004	<.018	.5	--	<.02	<.2	<.2	<.2
29	<.014	<.004	<.006	<.002	<.004	<.018	.5	2	<.02	<.2	<.2	<.2
30	<.014	<.004	<.006	<.002	<.004	<.018	1.0	3	<.02	<.2	<.2	<.2
31	<.014	<.004	<.006	<.002	<.004	<.018	1.0	2	<.02	<.2	<.2	<.2
32	<.014	<.004	<.006	<.002	<.004	<.018	.5	2	<.02	<.2	<.2	<.2
33	<.014	<.004	<.006	<.002	<.004	<.018	.3	<1	<.02	<.2	<.2	<.2
34	<.014	<.004	<.006	<.002	<.004	<.018	.4	<1	<.02	<.2	<.2	<.2
35	<.014	<.004	<.006	<.002	<.004	<.018	.7	<1	<.02	<.2	<.2	<.2
36	<.014	<.004	<.006	<.002	<.004	<.018	--	<1	<.02	<.2	<.2	<.2
37	<.014	<.004	<.006	<.002	<.004	<.018	--	<1	<.02	<.2	<.2	<.2
38	--	<.004	<.006	.013	<.004	<.018	.4	<1	<.02	<.2	<.2	<.2
39	<.014	<.004	<.006	<.002	<.004	<.018	.2	<1	<.02	<.2	<.2	<.2
40	<.014	<.004	<.006	<.002	<.004	<.018	.4	<1	<.02	--	--	--
41	<.014	<.004	<.006	<.002	<.004	<.018	.8	<1	<.02	<.2	<.2	<.2
42	<.014	<.004	<.006	<.002	<.004	<.018	2.6	<1	<.02	<.2	<.2	<.2
43	<.014	<.004	<.006	.004	<.004	<.018	1.5	9	.04	<.2	<.2	<.2
44	<.014	<.004	<.006	.003	<.004	<.018	.5	10	<.02	<.2	<.2	<.2
45	<.014	<.004	<.006	.017	<.004	<.018	1.0	<1	<.02	<.2	<.2	<.2
46	<.014	<.004	<.006	<.002	<.004	.008	--	<1	<.02	<.2	<.2	<.2
47	<.014	<.004	<.006	<.002	<.004	<.018	.9	<1	<.02	<.2	<.2	<.2

[1] Estimated.

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Local well no.	Date	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Dissolved oxygen (mg/L)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Total phosphorus, dissolved (mg/L as P)	Phosphorus, orthophosphate, dissolved (mg/L as P)
						Gulf Coast aquifer						
48	DH–64–10–211	8–09–94	799	6.8	22.5	0.2	0.030	<0.010	<0.20	<0.050	0.020	<0.010
49	DH–64–11–106	7–29–94	1,300	6.7	22.5	.2	.020	<.010	<.20	<.050	.050	.050
50	DH–64–11–611	7–28–94	561	7.0	21.5	.2	.140	<.010	<.20	<.050	.050	.050
51	DH–64–11–801	8–08–94	1,870	7.1	22.5	--	.830	<.010	1.1	<.050	.050	.050
52	DH–64–12–110	8–10–94	1,470	7.4	22.0	.2	.030	<.010	<.20	<.050	<.010	<.010
53	DH–64–12–710	8–08–94	630	7.5	22.5	--	.040	<.010	<.20	.860	.030	.030
54	DH–64–20–102	8–09–94	1,950	7.3	23.0	.6	.520	<.010	.50	<.050	.070	.060
55	SB–61–41–904	7–14–94	341	6.9	26.5	--	<.010	<.010	<.20	<.050	.010	.020
56	SB–61–42–605	7–26–94	237	6.1	24.5	.4	.030	<.010	<.20	<.050	.050	.060
57	SB–61–49–809	7–26–94	716	6.9	24.0	.1	.050	<.010	.20	<.050	<.010	.010
58	SB–61–57–508	7–25–94	703	6.8	22.5	1.4	.020	<.010	<.20	.070	.060	.060
59	SB–61–59–511	8–10–94	760	7.3	25.5	.2	.040	<.010	<.20	<.050	.040	.020
60	SB–64–01–109	7–25–94	1,190	6.9	22.5	.9	.090	<.010	<.20	<.050	.010	<.010
61	SB–64–02–402	7–27–94	750	8.0	23.5	.1	.090	<.010	<.20	<.050	.100	.100
62	SB–64–03–404	7–27–94	423	6.0	22.5	1.0	.140	.010	<.20	.650	<.010	.010
63	UT–60–24–111	7–28–94	878	7.0	21.5	.1	.130	<.010	<.20	.054	.030	.010
64	UT–61–18–519	7–15–94	328	7.4	22.0	--	<.010	<.010	<.20	.050	<.010	<.010
65	UT–61–26–114	7–14–94	241	6.6	22.0	3.6	<.010	<.010	<.20	<.050	.160	.170
66	UT–61–26–303	7–13–94	45	5.1	21.5	--	<.010	<.010	<.20	.690	<.010	<.010
67	WU–60–23–509	7–11–94	585	7.4	23.0	.2	.210	<.010	<.20	<.050	.050	<.010
68	WU–60–23–907	7–11–94	361	6.4	23.0	--	<.010	<.010	<.20	--	.130	.130
69	WU–60–24–704	7–12–94	598	7.1	24.5	.1	.050	<.010	<.20	<.050	<.010	<.010
70	WU–60–40–315	7–12–94	567	7.8	23.5	3.2	.090	<.010	<.20	<.050	.020	<.010
71	WU–61–33–216	7–13–94	458	7.3	24.0	2.1	<.010	<.010	<.20	.069	<.010	<.010

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Carbonate, dissolved (mg/L as CO_3)	Bicarbonate, dissolved (mg/L as HCO_3)	Alkalinity, (mg/L as $CaCO_3$)	Bromide, dissolved (mg/L as Br)	Calcium, dissolved (mg/L as Ca)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Hardness, total (mg/L as $CaCO_3$)	Iron, dissolved (μg/L as Fe)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)
					Gulf Coast aquifer—Continued						
48	<1	395	320	0.23	120	44	0.30	320	170	4.6	0.60
49	<1	465	380	.88	150	180	.10	400	13	6.9	1.8
50	<1	297	240	.10	72	28	.40	230	450	11	1.2
51	<1	609	500	.61	92	290	.40	310	2,300	19	2.3
52	<1	413	340	.33	56	200	.90	170	210	8.5	1.0
53	<1	266	220	.25	83	46	.20	230	8	5.3	1.6
54	<1	458	380	.52	100	320	.40	340	300	21	5.5
55	<1	122	100	.12	36	40	.20	100	26	2.7	1.0
56	<1	94	77	.080	31	24	.10	83	94	1.3	2.2
57	<1	310	250	.19	92	72	.30	250	180	5.9	1.1
58	<1	408	330	.090	110	26	.10	290	<3	2.8	.70
59	<1	414	340	.080	85	44	.50	240	40	6.3	4.7
60	<1	475	390	.33	84	150	.70	250	320	8.9	.90
61	<1	359	300	.090	10	69	1.4	31	33	1.5	.90
62	<1	121	100	.23	33	52	<.10	98	160	3.8	2.0
63	<1	355	290	.36	78	100	.40	210	68	2.7	3.7
64	<1	183	150	.060	47	11	.10	130	<3	3.5	4.0
65	<1	130	110	.040	39	7.9	<.10	100	<3	1.7	2.8
66	<1	8	6.0	.040	1.7	7.5	<.10	8	<3	.83	.20
67	<1	279	230	.15	35	38	.30	95	10	1.9	5.8
68	<1	156	130	.12	47	28	.10	130	74	1.9	3.2
69	<1	253	210	.21	82	59	.20	240	68	7.4	4.0
70	<1	290	240	.12	22	36	.40	74	31	4.6	2.3
71	<1	200	160	.16	51	42	.20	150	<3	5.9	2.4

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Silica, dissolved (mg/L as SiO_2)	Sodium, dissolved (mg/L as Na)	Solids, residue at 180 °C, dissolved (mg/L)	Sulfate, dissolved (mg/L as SO_4)	Aluminum, dissolved (µg/L as Al)	Antimony, dissolved (µg/L as Sb)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)
Gulf Coast aquifer—Continued											
48	20	47	491	39	4	<1	<1	240	<1	<1.0	10
49	28	120	754	27	2	<1	<1	99	<1	<1.0	10
50	25	29	323	3.7	3	<1	<1	260	<1	<1.0	6
51	20	290	1,050	27	3	<1	<1	400	<1	<1.0	10
52	18	240	874	92	4	<1	<1	60	<1	<1.0	10
53	29	39	338	12	4	<1	<1	160	<1	<1.0	6
54	22	270	1,150	130	3	<1	1	97	<1	<1.0	10
55	32	28	217	11	4	<1	<1	84	<1	<1.0	2
56	36	11	173	3.2	3	<1	1	34	<1	<1.0	3
57	32	49	429	6.8	3	<1	2	91	<1	<1.0	8
58	23	38	425	7.7	3	<1	<1	170	<1	<1.0	10
59	27	69	462	1.8	3	<1	1	320	<1	<1.0	10
60	26	160	690	12	3	<1	1	300	<1	<1.0	10
61	17	160	435	<.10	4	<1	<1	71	<1	<1.0	7
62	17	42	244	22	3	<1	<1	120	<1	<1.0	5
63	34	110	512	3.7	3	<1	<1	210	<1	<1.0	7
64	32	12	200	2.6	3	<1	2	180	<1	<1.0	3
65	28	8.2	148	.80	3	<1	<1	130	<1	<1.0	3
66	11	4.6	31	.30	8	<1	<1	15	<1	<1.0	1
67	35	90	366	13	3	<1	3	180	<1	<1.0	6
68	46	21	224	6.5	2	<1	3	94	<1	<1.0	4
69	33	32	362	8.9	3	<1	2	330	<1	<1.0	3
70	17	98	335	14	3	<1	2	190	<1	<1.0	4
71	22	34	262	3.8	2	<1	<1	150	<1	<1.0	5

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Manganese, dissolved (µg/L as Mn)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)	Selenium, dissolved (µg/L as Se)	Silver, dissolved (µg/L as Ag)	Uranium, dissolved (µg/L as U)	Zinc, dissolved (µg/L as Zn)	Atrazine, dissolved (µg/L)	Deethyl atrazine, dissolved (µg/L)
Gulf Coast aquifer—Continued												
48	<1	<1	<1	82	<1	2	<1	<1.0	2.0	10	<0.001	<0.002
49	<1	4	<1	26	<1	2	1	<1.0	2.0	15	<.001	<.002
50	<1	<1	<1	220	<1	<1	<1	<1.0	<1.0	57	<.001	<.002
51	<1	<1	<1	210	1	<1	<1	<1.0	<1.0	8	<.001	<.002
52	<1	<1	<1	50	5	1	<1	<1.0	5.0	8	<.001	<.002
53	<1	3	<1	3	<1	<1	35	<1.0	3.0	57	.21	.031
54	<1	<1	<1	690	<1	<1	<1	<1.0	<1.0	290	<.001	<.002
55	<1	<1	<1	41	<1	<1	<1	<1.0	<1.0	15	<.001	<.002
56	<1	1	<1	12	<1	<1	2	<1.0	<1.0	17	<.001	<.002
57	<1	<1	<1	310	<1	<1	<1	<1.0	<1.0	110	<.001	<.002
58	<1	1	<1	<1	<1	1	<1	<1.0	1.0	19	<.001	<.002
59	<1	<1	<1	27	<1	<1	<1	<1.0	3.0	25	<.001	<.002
60	<1	<1	<1	170	2	<1	<1	<1.0	2.0	210	<.001	<.002
61	<1	<1	<1	36	5	<1	<1	<1.0	<1.0	16	<.001	<.002
62	<1	1	<1	3	<1	2	<1	<1.0	<1.0	120	<.001	<.002
63	<1	<1	<1	47	<1	1	<1	<1.0	<1.0	5	<.001	<.002
64	<1	<1	<1	<1	<1	<1	<1	<1.0	3.0	23	<.001	<.002
65	<1	5	<1	<1	<1	<1	<1	<1.0	<1.0	9	<.001	<.002
66	<1	3	2	2	<1	<1	<1	<1.0	<1.0	9	<.001	<.002
67	<1	<1	<1	42	4	<1	<1	<1.0	<1.0	17	<.001	<.002
68	<1	<1	<1	10	<1	1	1	<1.0	5.0	2	<.001	<.002
69	<1	<1	<1	45	<1	1	<1	<1.0	2.0	5	<.001	<.002
70	<1	<1	<1	12	3	<1	<1	<1.0	<1.0	8	<.001	<.002
71	<1	<1	<1	<1	2	<1	<1	<1.0	1.0	14	<.001	<.002

Appendix 1. Water-quality data for Trinity, Carrizo-Wilcox, and Gulf Coast aquifers—Continued

Well reference no. (figs. 2–4)	Benta-zon, dissolved (µg/L)	Chlor-pyrifos, dissolved (µg/L)	pp'-DDE, dissolved (µg/L)	Diazinon, dissolved (µg/L)	Metribu-zin, dissolved (µg/L)	Pro-meton, dissolved (µg/L)	Organic carbon, dissolved (mg/L as C)	Phenols, total (µg/L)	Methylene blue active substance (mg/L)	Benzene, total (µg/L)	Trichloro-fluoro-methane, total (µg/L)	Trichloro-methane, total (chloroform) (µg/L)
Gulf Coast aquifer—Continued												
48	0.86	<0.004	<0.006	<0.002	<0.004	<0.018	1.5	<1	<0.02	<0.2	<0.2	<0.2
49	<.014	.005	<.006	<.002	<.004	<.018	.8	<1	<.02	<.2	<.2	<.2
50	<.014	<.004	<.006	<.002	<.004	<.018	.4	<1	<.02	<.2	<.2	<.2
51	<.014	<.004	<.006	<.002	<.004	<.018	1.8	<1	<.02	<.2	<.2	<.2
52	<.014	<.004	<.006	<.002	<.004	<.018	.5	<1	<.02	<.2	<.2	<.2
53	<.014	<.004	<.006	<.002	<.004	<.018	.8	<1	<.02	<.2	<.2	<.2
54	<.014	<.004	<.006	<.002	.003	<.018	.4	<1	<.02	<.2	<.2	<.2
55	<.014	<.004	<.006	<.002	<.004	<.018	--	--	--	<.2	<.2	<.2
56	<.014	<.004	<.006	<.002	<.004	<.018	.1	6	<.02	<.2	<.2	<.2
57	<.014	<.004	<.006	<.002	<.004	<.018	.2	<1	.03	<.2	<.2	<.2
58	<.014	<.004	[1].001	<.002	<.004	<.018	.4	<1	<.02	<.2	<.2	<.2
59	<.014	<.004	<.006	<.002	<.004	<.018	.2	<1	<.02	<.2	<.2	<.2
60	<.014	<.004	<.006	<.002	<.004	<.018	.6	<1	.03	<.2	<.2	<.2
61	<.014	<.004	<.006	<.002	<.004	<.018	.8	<1	.02	<.2	<.2	<.2
62	<.014	<.004	<.006	<.002	<.004	<.018	.8	<1	<.02	<.2	<.2	<.2
63	<.014	<.004	<.006	<.002	<.004	<.018	.4	<1	<.02	<.2	<.2	<.2
64	<.014	<.004	<.006	<.002	<.004	<.018	.1	2	<.02	<.2	<.2	<.2
65	<.014	<.004	<.006	<.002	<.004	<.018	.1	<1	<.02	<.2	<.2	.2
66	<.014	<.004	<.006	<.002	<.004	<.018	<.1	<1	<.02	<.2	<.2	<.2
67	<.014	<.004	<.006	<.002	<.004	<.018	.2	<1	<.02	<.2	<.2	<.2
68	<.014	<.004	<.006	<.002	<.004	<.018	.1	<1	<.02	<.2	<.2	<.2
69	<.014	<.004	<.006	<.002	<.004	<.018	.1	2	<.02	<.2	<.2	<.2
70	<.014	<.004	<.006	<.002	<.004	<.018	.1	<1	<.02	<.2	<.2	<.2
71	<.014	<.004	<.006	<.002	<.004	<.018	.3	<1	<.02	<.2	<.2	.5

---

[1] Estimated.