

# **HYDROGEOLOGIC AND WATER-QUALITY DATA FROM WELLS NEAR THE HUECO BOLSON RECHARGE PROJECT AREA, EL PASO, TEXAS, 1990 AND 1991**

**By Robert D. Brock, Paul M. Buszka, and Edward M. Godsy**

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## CONVERSION FACTORS, VERTICAL DATUM, ABBREVIATED WATER-QUALITY UNITS, AND ABBREVIATIONS

Multiply	By	To obtain
acre-foot (acre-ft)	0.001233	cubic hectometer
foot (ft)	0.3048	meter
foot per second (ft/s)	0.3048	meter per second
foot squared per day (ft <sup>2</sup> /d)	0.09290	meter squared per day
gallon (gal)	3.785	liter
gallon per minute (gal/min)	0.06308	liter per second
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
million gallons per day (Mgal/d)	0.04381	cubic meter per second
<b>Temperature</b>		
degree Celsius (°C)	°F = 1.8 (°C) + 32	degree Fahrenheit (°F)

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

**Per mil:** A unit expressing the ratio of stable-isotopic abundances of an element in a sample to those of a standard material. Per mil units are equivalent to parts per thousand. Stable-isotopic ratios are calculated as follows:

$$\delta X = \left( \frac{R(\text{sample})}{R(\text{standard})} - 1 \right) \times 1,000,$$

where X is the heavier stable isotope, and

R is the ratio of the heavier, less abundant stable isotope to the lighter stable isotope in a sample or standard.

The  $\delta$  values for stable-isotopic ratios discussed in this report are referenced to the following standard materials:

Element	R	Standard identity and reference
oxygen	oxygen-18/oxygen-16 ( $\delta^{18}\text{O}$ )	Vienna-Standard Mean Ocean Water (Fritz and Fontes, 1980, p. 11)
hydrogen	hydrogen-2/hydrogen-1 or deuterium/protium ( $\delta\text{D}$ )	Vienna-Standard Mean Ocean Water (Fritz and Fontes, 1980, p. 13)
carbon	carbon-13/carbon-12 ( $\delta^{13}\text{C}$ )	National Institute of Standards and Technology number 20; Solehofen limestone (Fritz and Fontes, 1980)

### Abbreviated water-quality units:

$\mu\text{g/L}$ , microgram per liter	mg, milligram
$\mu\text{L}$ , microliter	mg/L, milligram per liter
$\mu\text{m}$ , micrometer	mL, milliliter
$\mu\text{S/cm}$ , microsiemens per centimeter at 25 °C	mm, millimeter
	ng/L, nanogram per liter

### Abbreviations:

AODC, acridine orange direct counts of bacteria	RPD, relative percent difference
DOC, dissolved organic carbon	SOC, suspended organic carbon
HBRP, Hueco Bolson Recharge Project	SVOC, semivolatile organic compound
MBAS, methylene blue active substance	THM, trihalomethane
MPN, most probable number	TOC, total organic carbon
NWQL, U.S. Geological Survey, National Water Quality Laboratory, Arvada, Colorado	USEPA, U.S. Environmental Protection Agency
PVC, polyvinyl chloride	USGS, U.S. Geological Survey
QA, quality assurance	VOC, volatile organic compound

# Hydrogeologic and Water-Quality Data from Wells near the Hueco Bolson Recharge Project Area, El Paso, Texas, 1990 and 1991

By Robert D. Brock, Paul M. Buszka, and Edward M. Godsy

## Abstract

Tertiary-treated wastewater currently (1991) is being injected into the Hueco bolson aquifer at a site in northeastern El Paso, Texas, to supplement the quantity of available freshwater. Hydrologic data were compiled and water-quality and bacterial data were collected from existing wells near the Hueco Bolson Recharge Project (HBRP) in August and September 1990 and 1991.

Borehole tracer tests indicated upward ground-water flow in nearly all tested intervals of several observation wells. The cumulative volume of injected water was less than the volume produced from wells adjacent to the HBRP area. Water levels in three production wells, located more than 1.5 miles from the injection wells, declined at rates comparable to those observed before injection operations. Water levels in wells located within 0.75 mile of the injection-well pipeline declined at a slower rate after HBRP injection operations had begun. Between 1985 and 1991, water levels in observation wells located within 700 feet of an injection well either did not appreciably decline, or declined at smaller rates than water levels in more distant production wells.

Trihalomethane compounds were detected in water from 8 of the 16 observation and production wells sampled in 1990 and in 10 of the 17 wells sampled in 1991. Concentrations of trihalomethane compounds in these samples ranged from 0.05 to 1.9  $\mu\text{g/L}$  (micrograms per liter) in 1990 and from 0.05 to 1.4  $\mu\text{g/L}$  in 1991. Concentrations of trihalomethane compounds in samples of injected

water from two wells were 27.8 and 34.6  $\mu\text{g/L}$  respectively, in 1991. Dibromomethane and dichloromethane were detected in water from injection wells and from observation wells within about 700 feet of the injection wells.

Aerobic bacteria were determined to be the only bacteria type present in ground water except for samples from two wells, which also contained denitrifying bacteria. The populations of aerobic bacteria determined in ground water ranged from 80 to more than 160,000 most probable number of organisms per milliliter of sample.

## INTRODUCTION

El Paso is dependent on ground water pumped from the Hueco bolson aquifer for 65 percent of its water supply (Knorr and Cliett, 1985, p. 428). The amount of freshwater stored in this aquifer is projected to decrease, from an estimated 10 million acre-ft in 1980 to approximately 3 million acre-ft by 2030, because of estimated increases in population and industrial demand (White, 1983, p. 69). To supplement available supplies of freshwater, tertiary-treated wastewater currently (1991) is being injected into the Hueco bolson aquifer at a tertiary treatment plant that is part of the HBRP in northeastern El Paso. The injection of the tertiary-treated wastewater is being conducted by the El Paso Water Utilities-Public Service Board.

Before injection, municipal wastewater from northeast El Paso is treated to meet or exceed U.S. Environmental Protection Agency (USEPA) primary drinking water standards by a combination of the following techniques: (1) primary clarification; (2) biological treatment with granular activated carbon under aerobic and anaerobic conditions; (3) lime treatment;

(4) ozone disinfection; (5) pH-adjusted filtration through granular activated carbon; and (6) chlorination. The treated wastewater typically contains 0.78 to 0.92 mg/L of DOC (White and Sladek, 1990, p. 35). Chlorination of waters containing DOC can produce appreciable concentrations of a group of carcinogenic compounds known as trihalomethanes or THM's (Thurman, 1985, p. 227-228).

Between 1987 and 1989, the sum of THM compounds (dichlorobromomethane, bromoform, chloroform, and dibromochloromethane) in the treated municipal wastewater ranged from 10 to 26 µg/L (Roger Sperka, El Paso Water Utilities-Public Service Board, written commun., 1990). The USEPA standard stating that the sum of THM compounds not exceed 100 µg/L in public drinking water supplies is scheduled for review and is subject to revision by 1993 (Mark McCasland, U.S. Environmental Protection Agency, Dallas, Texas, written commun., 1992).

The U.S. Geological Survey (USGS), in cooperation with the El Paso Water Utilities-Public Service Board, Texas Water Development Board, and U.S. Department of the Interior, U.S. Bureau of Reclamation, compiled hydrogeologic data and collected water samples from existing injection, observation, and production wells to describe: (1) the hydrogeologic framework of the Hueco bolson aquifer near the HBRP; (2) the presence and distribution of injected wastewater and its associated constituents; (3) the water-quality effects of wastewater injection; and (4) the redox environment of the aquifer near the HBRP.

## Purpose and Scope

This report presents hydrogeologic and water-quality data collected from existing HBRP injection, observation, and production wells in August and September 1990 and 1991. Information concerning the study area, data collection and analysis methods, and description of the wells sampled also are included in the report.

## Description of the Study Area

The study area is located in northeast El Paso (fig. 1). El Paso is located in westernmost Texas, along the international border with Mexico, which is formed by the Rio Grande. El Paso is dominated by three types

of geographic features: valleys, bolsons, and mountains. A bolson is "an extensive, flat alluvium-floored basin into which drainage flows centripetally with gentle gradients toward a playa or central depression" (Bates and Jackson, 1987, p. 79). El Paso has a sunny dry climate with hot summers and mild winters. The annual average temperature is 63 °F, and annual precipitation averages 7.8 in.

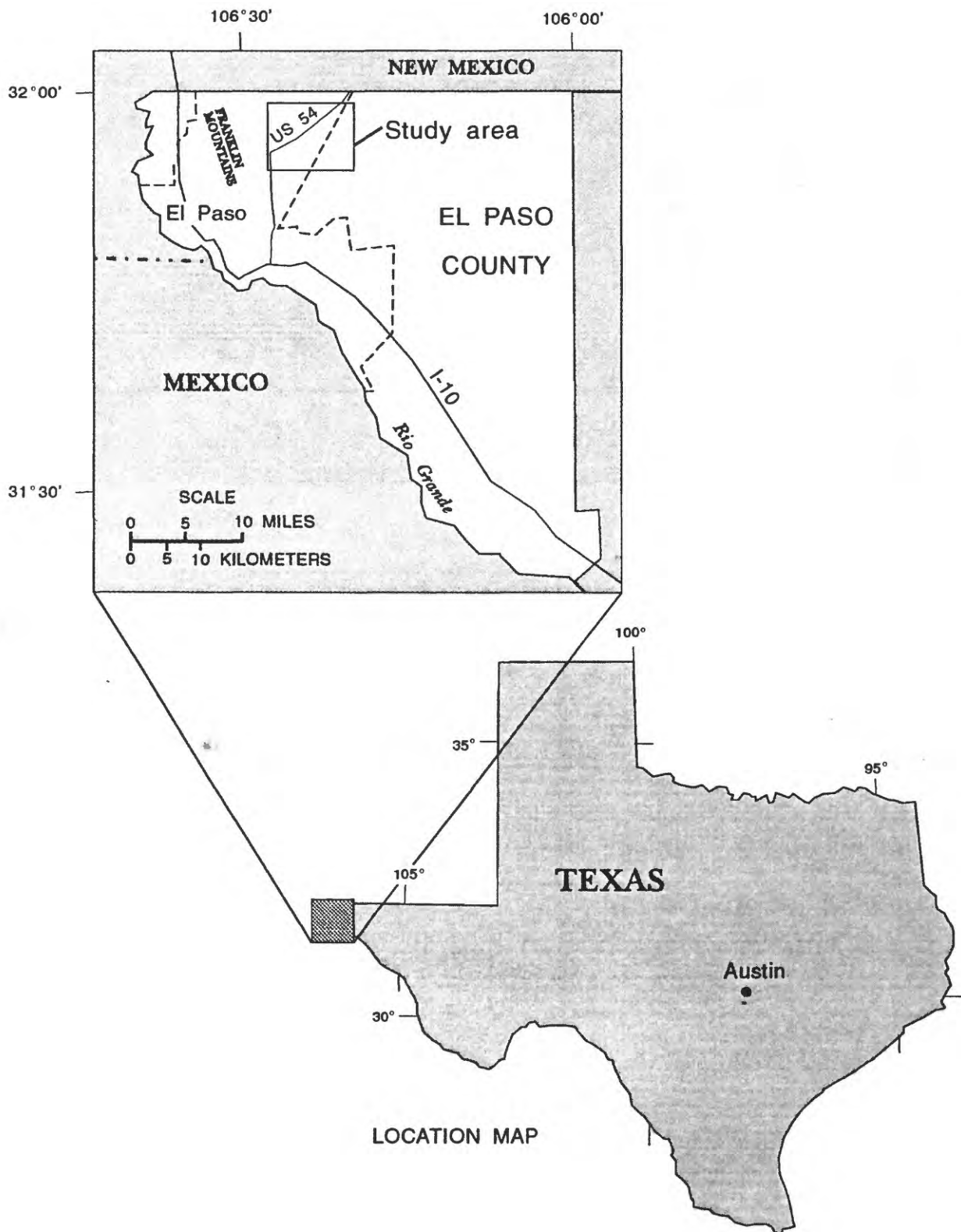
The HBRP injection system includes a 10 Mgal/d advanced water reclamation plant, a pipeline system, and 10 injection wells. The HBRP area (fig. 2) includes the 10 injection wells and the system of observation and production wells. After sewage, which is primarily domestic in origin, is pumped to the reclamation plant and treated to potable quality, it is pumped into the aquifer through a series of injection wells (Knorr and Cliett, 1985). Production wells are located a minimum of 0.25 mi north and 0.75 mi south of the injection well pipeline (fig. 2). From 1985-89, approximately 7.6 billion gal of treated wastewater were injected into the aquifer (White and Sladek, 1990, p. 4). Wells were spaced and flow was controlled so that the residence time, the time between injection and withdrawal by production wells, would be at least 2 years. Results from preliminary modeling studies indicate that there is at least a 6-year residence time for injected wastewater in the aquifer (Knorr and Cliett, 1985, p. 450).

## Previous Investigations

Information on the geology, hydrology, and water quality of the Hueco bolson aquifer is contained in reports by Knowles and Kennedy (1956), McLean (1970), Meyer (1976), Garza and others (1980), Gates and others (1980), White (1983), and Orr and White (1985). White and Sladek (1990) presented a detailed summary of hydrogeologic testing at the HBRP and an annual summary of the volumes of water injected by the project from 1985-89.

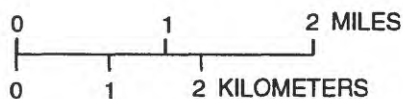
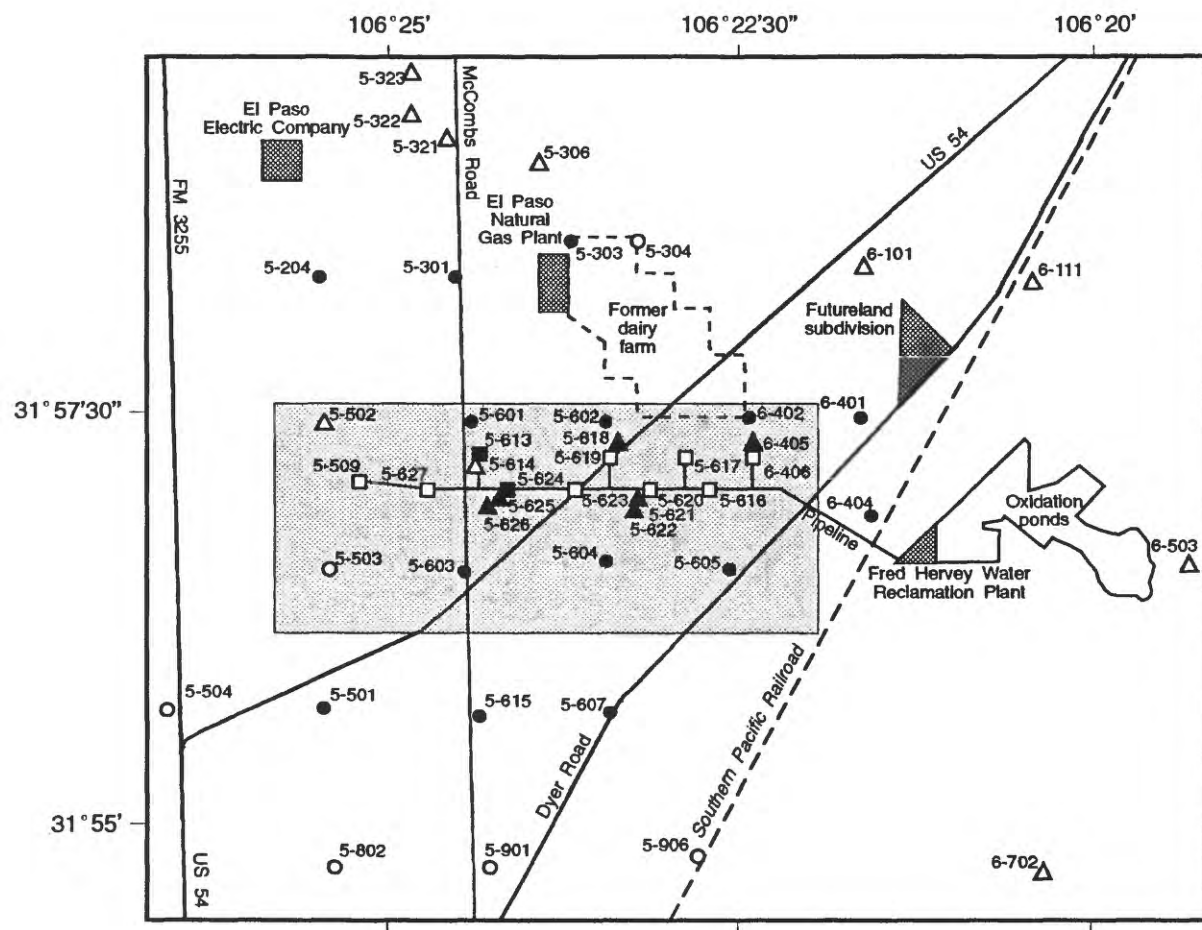
## Well-Numbering System

The well-numbering system used in this report was developed by the Texas Water Development Board for use throughout the State. Under this system, wells are assigned a two-letter county prefix and a seven-digit well number. This number, with the El Paso Water










**Figure 1.** Location of the study area.





# EXPLANATION

-  HUECO BOLSON RECHARGE PROJECT AREA
- 5-509  INJECTION WELL AND NUMBER
- 5-613  SAMPLED INJECTION WELL AND NUMBER
- 5-614  OBSERVATION WELL AND NUMBER
- 6-405  SAMPLED OBSERVATION WELL AND NUMBER
- 5-901  PRODUCTION WELL AND NUMBER
- 5-204  SAMPLED PRODUCTION WELL AND NUMBER

*Note: Well number consists of last four digits of the Texas well-numbering system*

**Figure 2.** Location of wells in northeast El Paso in and near the Hueco Bolson Recharge Project area.

Utilities-Public Service Board well identification number in parentheses, is shown in the tables. Because this project covers a small area, all of the wells mentioned in this report have identical county prefixes (JL), 1-degree quadrangle numbers (49), and the first digit of the 7.5 minute quadrangle number (0). Therefore, the wells discussed in the figures and text were identified only by the last four digits of the State well number.

## **HYDROGEOLOGIC DATA**

Available hydrogeologic data for the area near the HBRP include: (1) borehole geophysical data from this and previous investigations; (2) determinations of aquifer parameters from aquifer tests in selected wells and previous aquifer simulations; (3) results of borehole tracer tests for selected observation wells; and (4) records of ground-water production, treated-water injection, and water-level measurements from January 1985 to March 1991. These hydrogeologic data provide information needed to define the hydrogeologic framework of the Hueco bolson aquifer near the HBRP.

### **Data-Collection Methods**

Borehole geophysical data were collected using the following methods: spontaneous potential, resistivity, natural gamma, caliper, gamma-gamma, neutron, borehole tracer tests, and borehole fluid-temperature and fluid-resistivity logs. The types of geophysical logs that have been run on selected wells near the HBRP area are listed in table 1. Some of the hydrogeologic information that can be derived from the logs are listed in table 2 (Keys and MacCary, 1971). Spontaneous potential and resistivity logs of El Paso Water Utilities-Public Service Board production wells near the HBRP area were run by Schlumberger Limited (table 1). Spontaneous potential, resistivity, caliper, borehole tracer tests, and borehole fluid-temperature and fluid-resistivity logs were run for selected injection and observation wells by the El Paso Water Utilities-Public Service Board. Natural gamma, gamma-gamma, and neutron logs were run on observation wells 5-621, 5-622, 5-625, 5-626, and 6-405 by the USGS, New Mexico District. These nuclear logs and the fluid-resistivity and fluid-temperature logs were run in cased boreholes. All other geophysical logs were run after each borehole was completed, but before well casing was installed. Geophysical logging data (additional to that presented

in this report) from production wells and test holes are available in the files of the El Paso Water Utilities-Public Service Board (Roger Sperka, El Paso Water Utilities-Public Service Board, written commun., 1991).

Transmissivity data were obtained from interpretations by Myers (1969), Meyer (1976), and from the files of the El Paso Water Utilities-Public Service Board (Roger Sperka, El Paso Water Utilities-Public Service Board, written commun., 1991). Transmissivity estimates reported by Myers are derived from water-level recovery data from individual wells pumped for more than 24 hours before the aquifer test. These wells currently (1991) are used for public water supply. The transmissivity data were used in model simulations of ground-water flow near the HBRP area as reported by Meyer (1976).

Borehole tracer tests were run to determine the presence of vertical flow in selected observation wells that were screened from above the water table to their completion depth. Vertical flow in a well bore can indicate whether a sample collected at a discrete depth represents the water quality at that depth or the chemistry of a mixture of water from deeper or more shallow zones. The tests were conducted by injecting a small volume of fluorescein dye into the well bore at a known depth and time. A borehole television camera was used to view the arrival of the fluorescein dye at a known depth, above or below the tracer injection depth. The approximate velocity of water flowing in the well bore was calculated using the difference between the injection time and the time of first tracer arrival and the distance between the tracer injection and observation depths. Positive velocities represent upward flow and negative velocities represent downward flow. Observation wells that were evaluated using the borehole tracer tests include 5-618, 5-621, 5-622, 5-625, 5-626, and 6-405.

The volume of water injected into the aquifer by the HBRP, volume of water produced from wells closest to the injection wells, and the details of well construction were provided by the El Paso Water Utilities-Public Service Board (Roger Sperka, El Paso Water Utilities-Public Service Board, written commun., 1991). Water levels were measured with weighted steel tape by El Paso Water Utilities-Public Service Board and USGS personnel in selected observation and production wells. Water-level measurements were referenced to a point of known altitude on each well.

**Table 1.** Geophysical logs run for selected wells near the Hueco Bolson Recharge Project area

Well number <sup>1</sup>	Type of geophysical log	Well number <sup>1</sup>	Type of geophysical log
<u>Injection wells<sup>2</sup></u>		<u>Observation wells<sup>3</sup>--Continued</u>	
JL-49-05-509 (RW-10)	Spontaneous potential, resistivity	JL-49-05-622 (OB-4B)	Spontaneous potential, resistivity, natural gamma, gamma-gamma, neutron, borehole tracer tests, borehole fluid temperature and fluid resistivity
JL-49-05-613 (RW-8)	Spontaneous potential, resistivity, caliper		
JL-49-05-616 (RW-2)	Spontaneous potential, resistivity, caliper		
JL-49-05-617 (RW-3)	Spontaneous potential, resistivity	JL-49-05-625 (OB-7A)	Spontaneous potential, resistivity, natural gamma, gamma-gamma, neutron, borehole tracer tests, borehole fluid temperature and fluid resistivity
JL-49-05-619 (RW-5)	Spontaneous potential, resistivity		
JL-49-05-620 (RW-4)	Spontaneous potential, resistivity, caliper		
JL-49-05-623 (RW-6)	Spontaneous potential, resistivity	JL-49-05-626 (OB-7B)	Spontaneous potential, resistivity, natural gamma, gamma-gamma, neutron, borehole tracer tests, borehole fluid temperature and fluid resistivity
JL-49-05-624 (RW-7)	Spontaneous potential, resistivity		
JL-49-05-627 (RW-9)	Spontaneous potential, resistivity		
JL-49-06-406 (RW-1)	Spontaneous potential, resistivity, caliper	JL-49-06-405 (OB-1)	Spontaneous potential, resistivity, natural gamma, gamma-gamma, neutron, borehole tracer tests, borehole fluid temperature and fluid resistivity
<u>Observation wells<sup>3</sup></u>		<u>Production wells<sup>4</sup></u>	
JL-49-05-614 (OB-8)	Spontaneous potential, resistivity	JL-49-05-603 (32)	Spontaneous potential, resistivity
JL-49-05-618 (OB-5)	Spontaneous potential, resistivity, borehole tracer tests, borehole fluid temperature and fluid resistivity		
JL-49-05-621 (OB-4A)	Spontaneous potential, resistivity, natural gamma, caliper, gamma-gamma, neutron, borehole tracer tests, borehole fluid temperature and fluid resistivity	JL-49-05-604 (34)	Spontaneous potential, resistivity

<sup>1</sup> El Paso Water Utilities-Public Service Board well numbers are in parentheses.

<sup>2</sup> Logs were run by the El Paso Water Utilities-Public Service Board.

<sup>3</sup> Spontaneous potential, caliper, borehole fluid-temperature and fluid-resistivity logs were run by the El Paso Water Utilities-Public Service Board; all other logs were run by the U.S. Geological Survey, New Mexico District.

<sup>4</sup> Logs were run by Schlumberger Limited.

**Table 2.** Hydrogeologic information derived from geophysical logs

[Modified from Keys and MacCary, 1971]

Type of geophysical log	Application or information derived
Spontaneous potential, resistivity	Stratigraphic correlation, lithology, porosity
Natural gamma	Stratigraphic correlation of clay/argillaceous units
Caliper	Borehole diameter
Gamma-gamma, neutron	Stratigraphic correlation, porosity, lithology-mineralogy (indirectly)
Borehole tracer tests	Determine vertical movement of water within borehole; determine yields of major water-producing zones
Borehole fluid temperature	Determine temperature of formation fluid; temperature gradients; locate water-producing zones
Borehole fluid resistivity	Determine resistivity of formation fluid

## Results

Data from selected geophysical logs of observation wells, located south of the line of injection wells, are presented in figures 3 through 6.

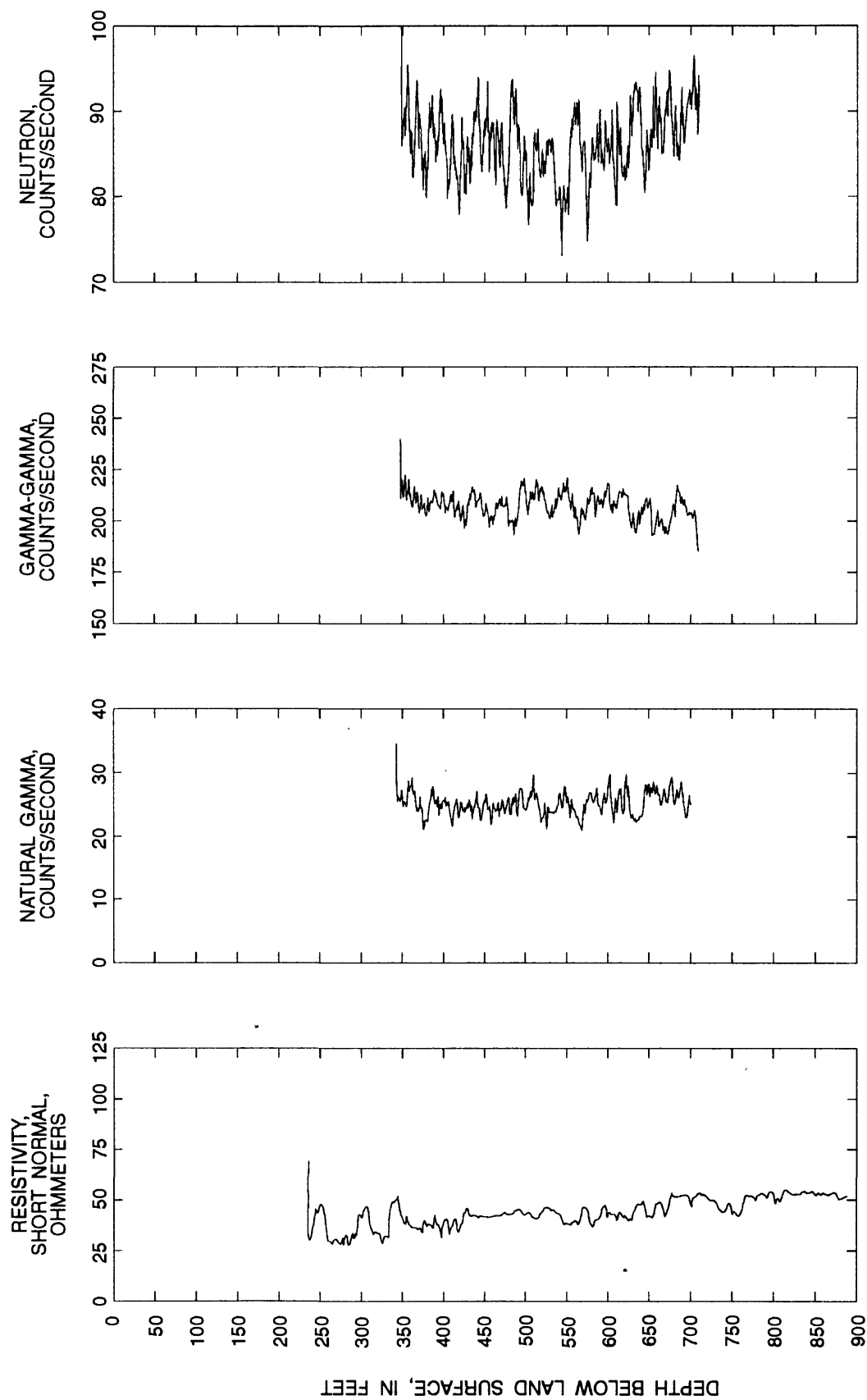
Aquifer-test data for wells near the HBRP are summarized in table 3. All transmissivity tests were interpreted using the Theis recovery method (Myers, 1969; Roger Sperka, El Paso Water Utilities-Public Service Board, written commun., 1991). When the pre-test water level was within or lower than the first screened interval, that water level was used to compute the length of the tested interval for transmissivity determinations. Transmissivity values determined from these tests ranged from 4,220 to 32,100 ft<sup>2</sup>/d. Transmissivity estimates from ground-water modeling of the Hueco bolson aquifer in the HBRP area ranged from less than 6,680 ft<sup>2</sup>/d, in the part of the aquifer between the Franklin Mountains and McCombs Road, to more than 20,000 ft<sup>2</sup>/d in an area near wells 5-602, 5-603, and 5-604 (Meyer, 1976, fig. 1, fig. 8, p. 16). The specific yield of the aquifer in the HBRP area has been estimated to range from 0.15 to 0.22, based on model simulations by Garza and others (1980, p. 10). The storage coefficient of the aquifer in the HBRP area has been estimated to range between 0.0001 to 0.0004 (Meyer, 1976, p. 15).

The results of the borehole tracer tests indicated the prevalence of substantial upward-directed flow in nearly all tested intervals of observation wells 5-618, 5-621, 5-622, 5-625, 5-626, and 6-405 (table 4). Vertical flow rates were smallest typically at, or near, the bottom of the screened interval, and near the uppermost

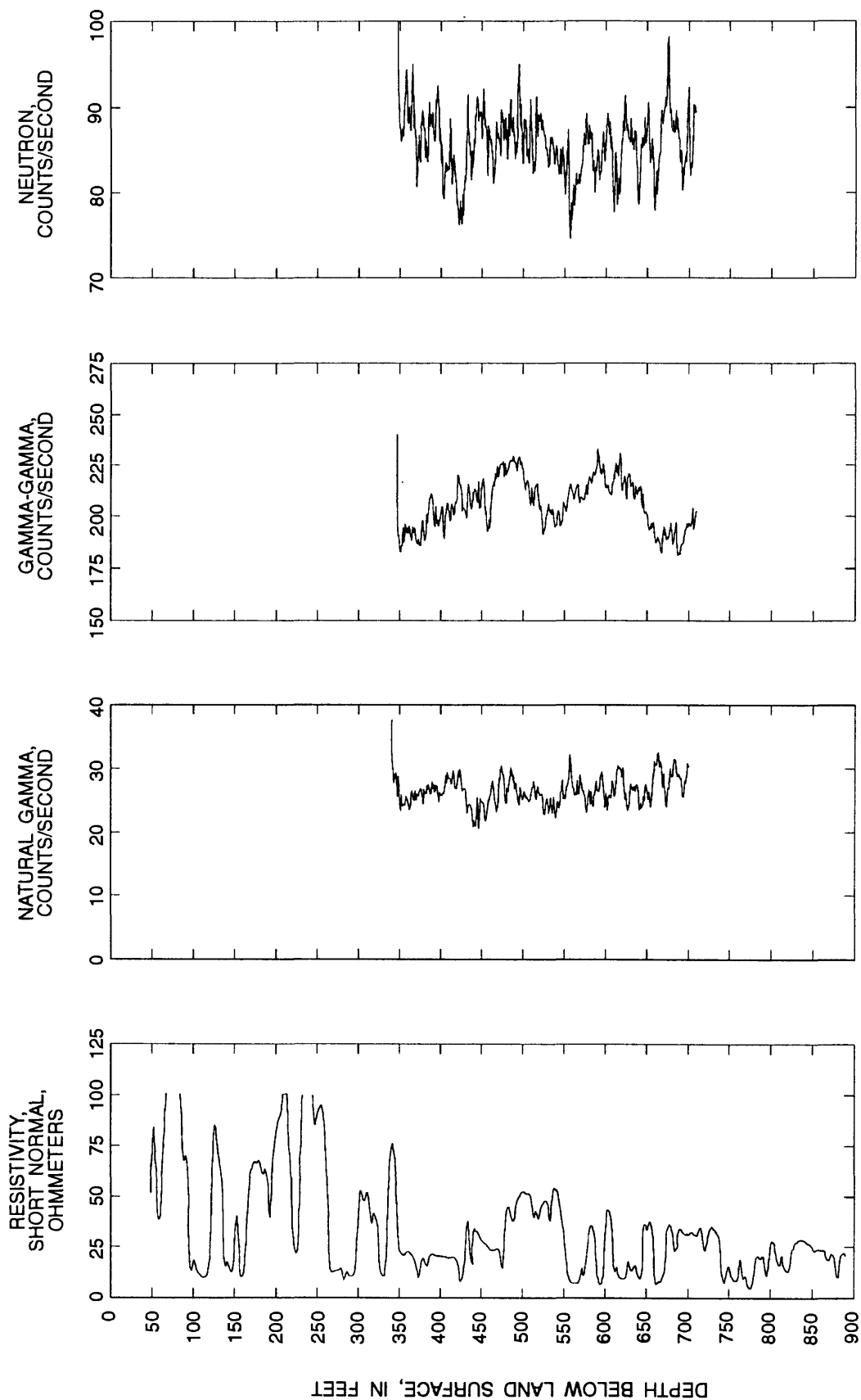
tested interval. Vertical flow was not observed in well 5-626 between 380 and 400 ft below land surface, and in well 6-405 at 614 ft below land surface. The largest vertical flow observed, 1.1 ft/s, was in well 5-626 between 652 and 663 ft below land surface.

Tertiary-treated wastewater from the Fred Hervey Water Reclamation Plant (fig. 2) has been injected into the Hueco bolson aquifer since May 1985. The cumulative volume of treated water injected into the aquifer always has been less than the cumulative volume withdrawn from wells adjacent to the HBRP area (fig. 7). The differences between volumes of water injected and withdrawn typically are less during the spring and summer than during the fall and winter. Volume of treated water injected into the aquifer by individual HBRP wells is shown in figure 8. White and Sladek (1990) summarized data for the total volume of water treated at the plant and injected into the aquifer between 1985-89. The volume of ground water withdrawn from wells in the HBRP area is shown in figure 9. Data on volumes of treated water injected into the aquifer, ground-water production, and water levels measured at selected wells are available from the files of the El Paso Water Utilities-Public Service Board (Roger Sperka, El Paso Water Utilities-Public Service Board, written commun., 1991).

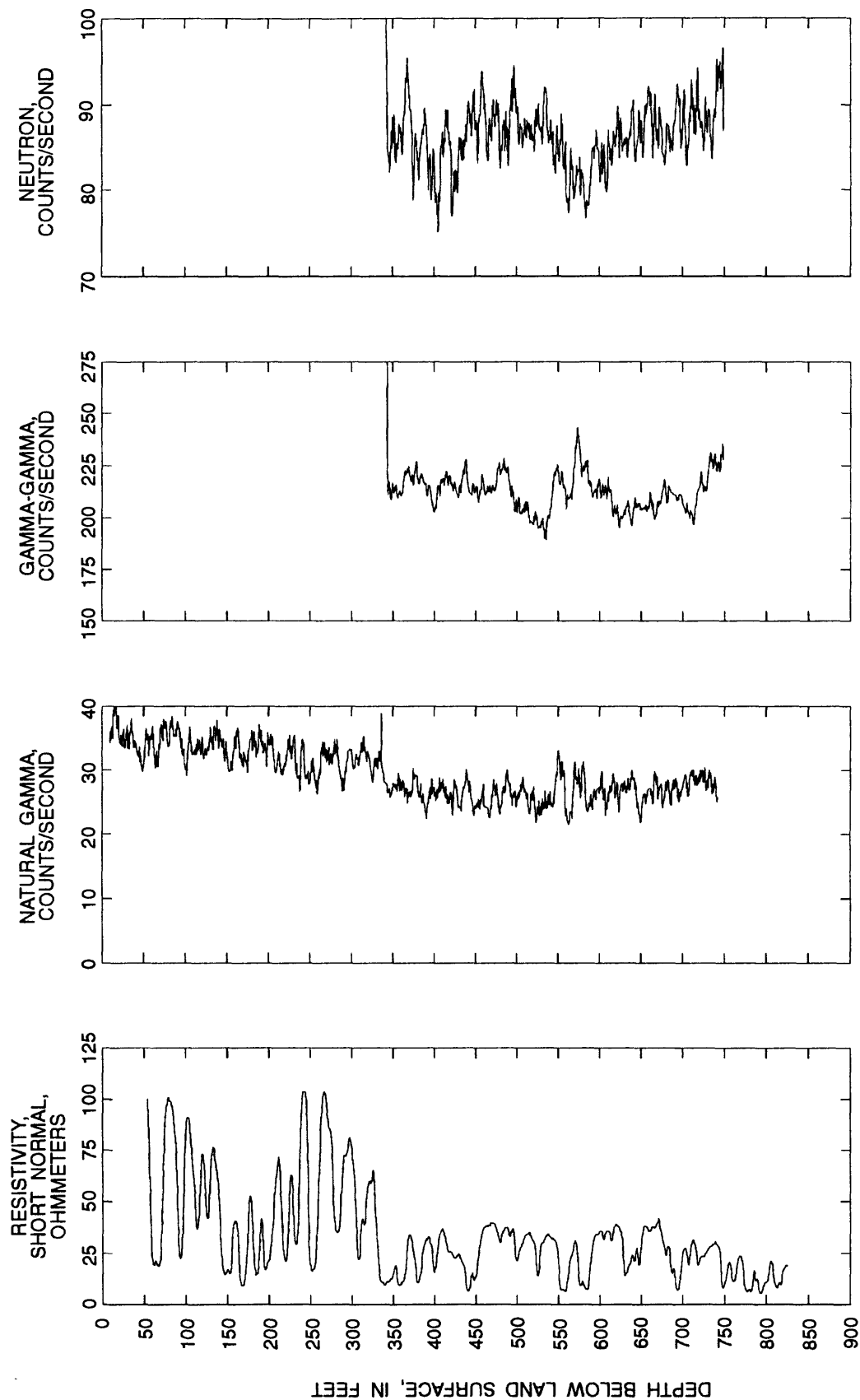
Water levels measured in production and observation wells in northeastern El Paso are plotted against time in figure 10. Water levels in three production wells, located more than 1.5 mi north (5-204 and 5-301) and south (5-607) of the injection wells, declined at rates comparable to those observed before HBRP injection operations began (fig. 10A). Water



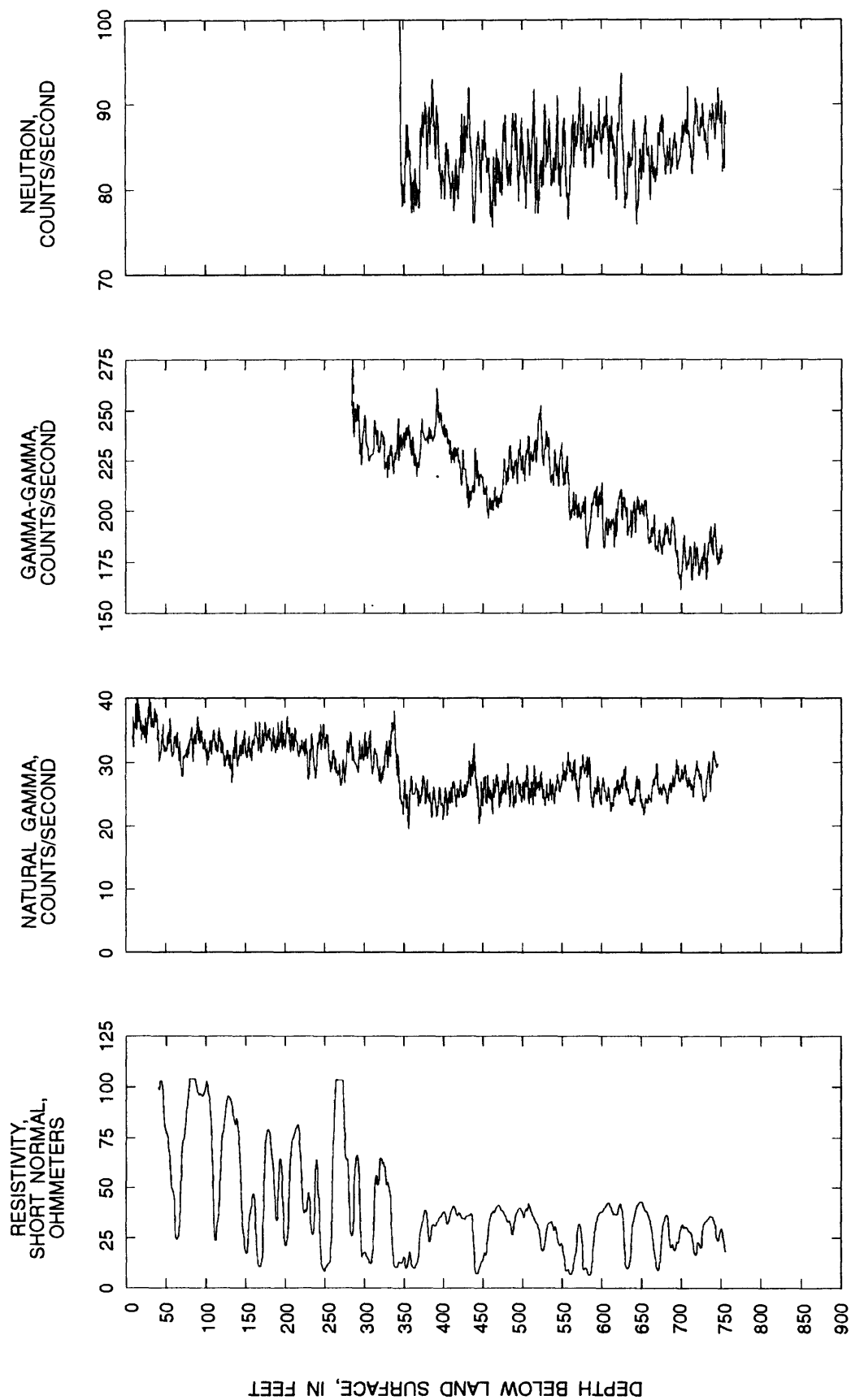
**Figure 3.** Selected geophysical logs from observation well 5-621 in the Hueco Bolson Recharge Project area, El Paso, Texas.



**Figure 4.** Selected geophysical logs from observation well 5-622 in the Hueco Bolson Recharge Project area, El Paso, Texas.

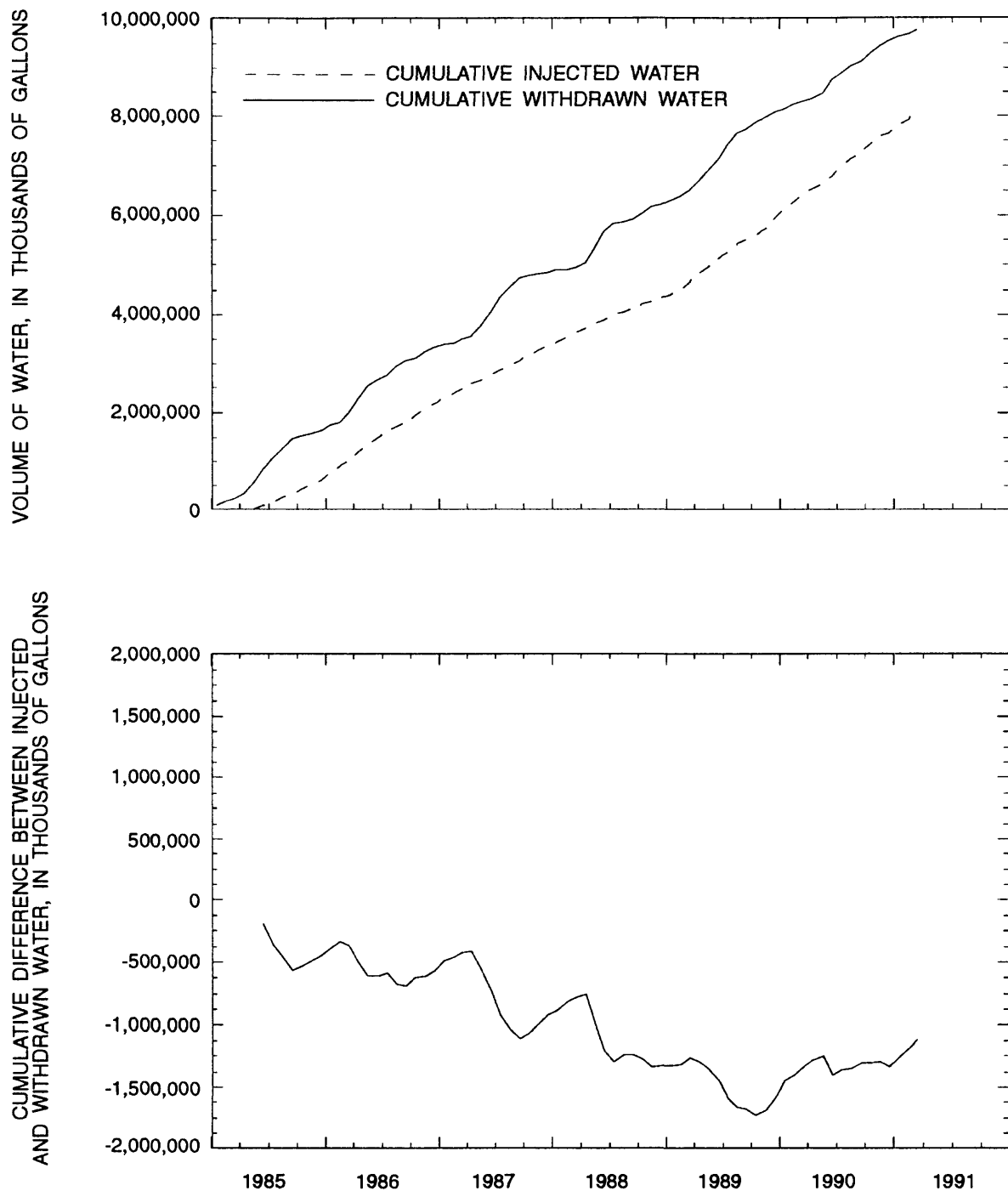


**Figure 5.** Selected geophysical logs from observation well 5-625 in the Hueco Bolson Recharge Project area, El Paso, Texas.



**Figure 6.** Selected geophysical logs from observation well 5-626 in the Hueco Bolson Recharge Project area, El Paso, Texas.





**Figure 7.** Cumulative volumes of injected water from the Hueco Bolson Recharge Project area, El Paso, Texas, water withdrawn from adjacent wells, and the cumulative difference between injected and withdrawn water volumes.

levels in wells 5-601, 5-605, and 6-402, which are located within 0.75 mi of the injection-well pipeline, declined at a slower rate after HBRP injection operations began (fig. 10B). Water levels in observation wells located within about 700 ft of an injection well (figs. 10C, and 10D), either did not appreciably decline, or declined at smaller rates between 1985 and 1991, than did water levels in more distant production wells.

The trend in the altitude of water levels in observation well 6-405 was similar to the trend in the volume of water injected at well 6-406 minus the volume of water withdrawn from production well 6-402 (fig. 11). The trend in the altitude of water levels in observation well 5-614 was similar to the trend in the volume of water injected at well 5-613 minus the volume of water withdrawn from production well 5-601 (fig. 12). Water levels in observation wells 5-621 and 5-622 increased during periods when more water was injected and decreased during periods when less water was injected at well 5-620 (fig. 13). Water levels in observation wells 5-625 and 5-626 increased during periods when more water was injected and decreased during periods when less water was injected at well 5-624 (fig. 14). Water levels in a well outside the HBRP, observation well 5-607, also are shown on figures 13 and 14.

## **WATER-QUALITY DATA**

### **Description of Wells Sampled**

The location of wells sampled is shown in figure 2. Characteristics of wells are given in table 5 (at end of report). Samples were collected in August and September 1990 by USGS personnel at 1 injection well, 6 observation wells, and 11 production wells. Samples were collected in August and September 1991 by USGS personnel at 2 injection wells, 6 observation wells, and 11 production wells. The wells sampled were selected to characterize the chemistry and microbiology of injected water and ground water in and near the HBRP area.

Well 5-613 was the only injection well sampled in 1990. The well was sampled on three occasions during 1 week to define changes in the chemistry of the injected water. Injection wells 5-613 and 5-624 were sampled in 1991. Well 5-624 was sampled on two occasions. On August 27, 1991, the well was sampled during normal injection operations. On September 8, 1991, 2 days after injection stopped, an existing turbine pump in the injection well was turned on, and the well was

sampled three times in 6 hours while pumping water from the aquifer. The samples were collected after 24,000, 182,000, and 336,000 gal of water had been pumped from the aquifer.

The observation wells that were sampled in 1990 and 1991 were 5-618, 5-621, 5-622, 5-625, 5-626, and 6-405. Wells 5-621, 5-622, 5-625, and 5-626 were sampled at two depths along their screened interval to define depth-related differences in water chemistry. These sampled depths were selected based on data obtained from spontaneous potential and resistivity logs of the wells.

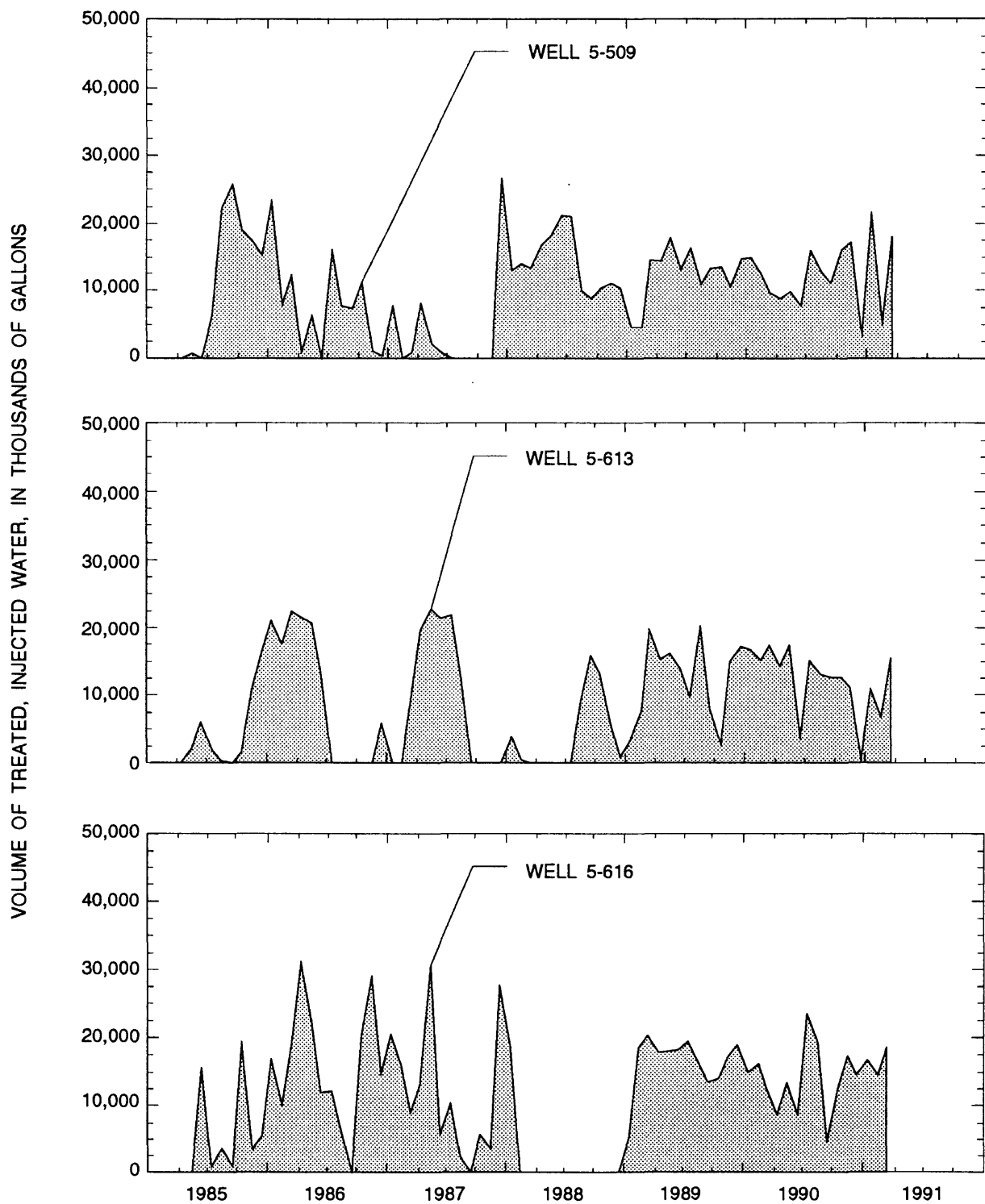
Production wells 5-204, 5-301, 5-601, 5-602, and 6-402, located north of the injection well pipeline, were sampled in 1990 (fig. 2). Production wells 5-204, 5-303, 5-601, 5-602, 6-401, 6-402, and 6-404, located north of the injection well pipeline, were sampled in 1991.

Production wells, 5-603, 5-604, 5-605, 5-501, 5-607, and 5-615, located south of the injection well pipeline, were sampled in 1990. Production wells 5-603, 5-605, 5-607, and 5-615 were sampled in 1991.

### **Data Collection and Analysis Methods**

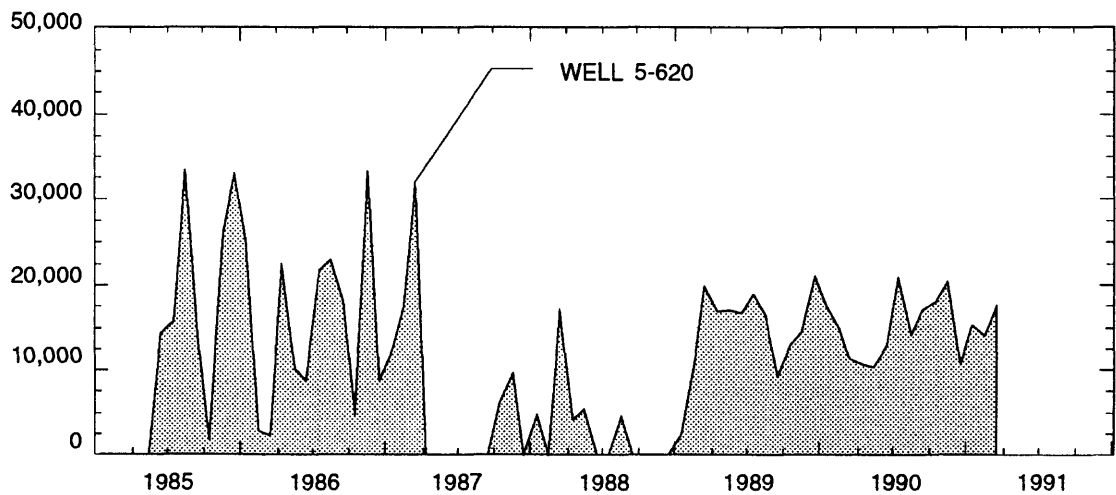
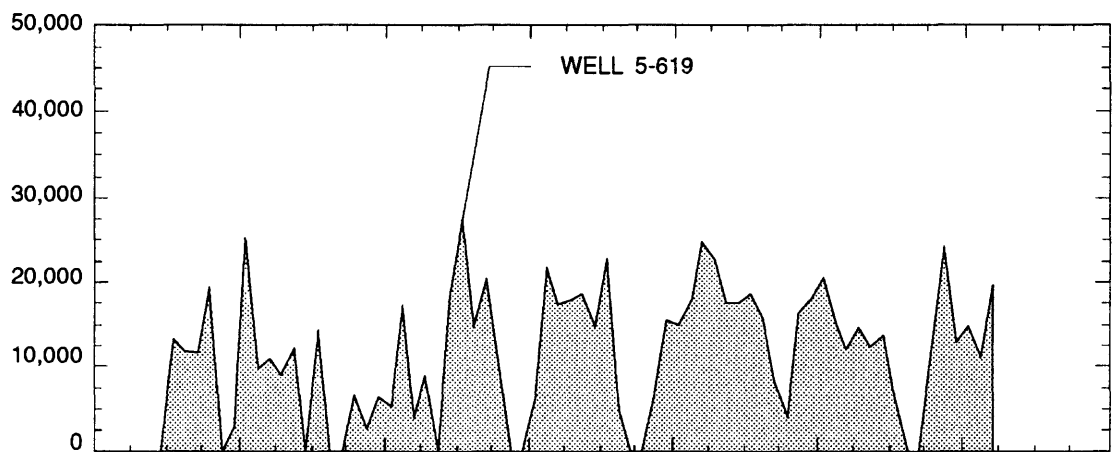
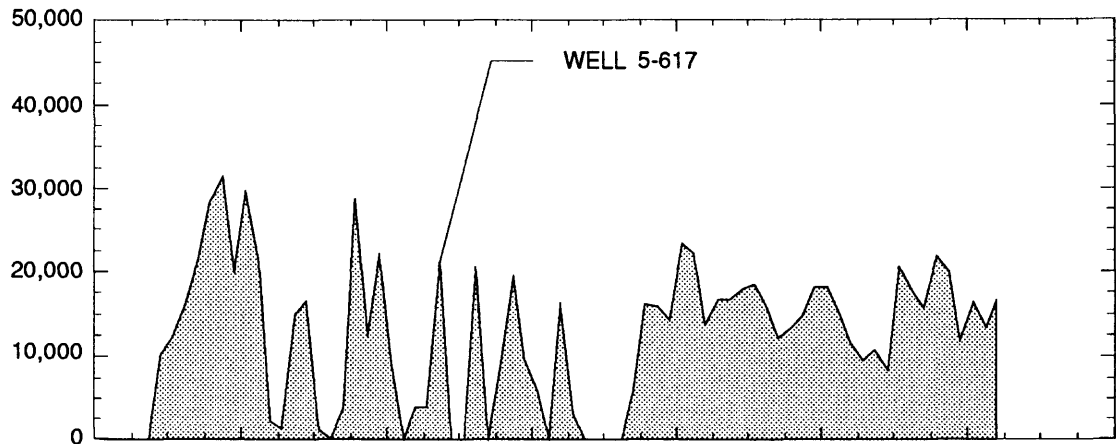
Water samples were collected in 1990 for inorganic analyses, which included major ions, trace elements, nutrients, and the stable-isotopic ratios of oxygen, hydrogen, and carbon; for organic analyses, which included dissolved organic carbon (DOC), suspended organic carbon (SOC), methylene blue active substances (MBAS), volatile organic compounds (VOC), and semivolatile organic compounds (SVOC); and for bacterial analyses, which included acridine orange direct counts of bacteria (AODC), aerobic bacteria, denitrifying bacteria, anaerobic bacteria, sulfate-reducing bacteria, and methanogenic bacteria. Water samples also were collected in 1991 for inorganic analyses, which included major ions, trace elements, nutrients, and the stable-isotopic ratios of oxygen and hydrogen; and for organic analyses, which included total organic carbon (TOC), DOC, and VOC.

Prior to sample collection, at least three bore volumes of water were pumped from a sampled well using a submersible pump. The existing in-well pump was used for purging the production wells. For observation wells, a submersible pump was lowered into the well approximately 50 ft below the water surface. After the three bore volumes of water were removed, pumping continued until measurements of specific conductance,



**Figure 8.** Volume of treated water injected into the Hueco bolson aquifer by wells in the Hueco Bolson Recharge Project area, El Paso, Texas.

VOLUME OF TREATED, INJECTED WATER, IN THOUSANDS OF GALLONS



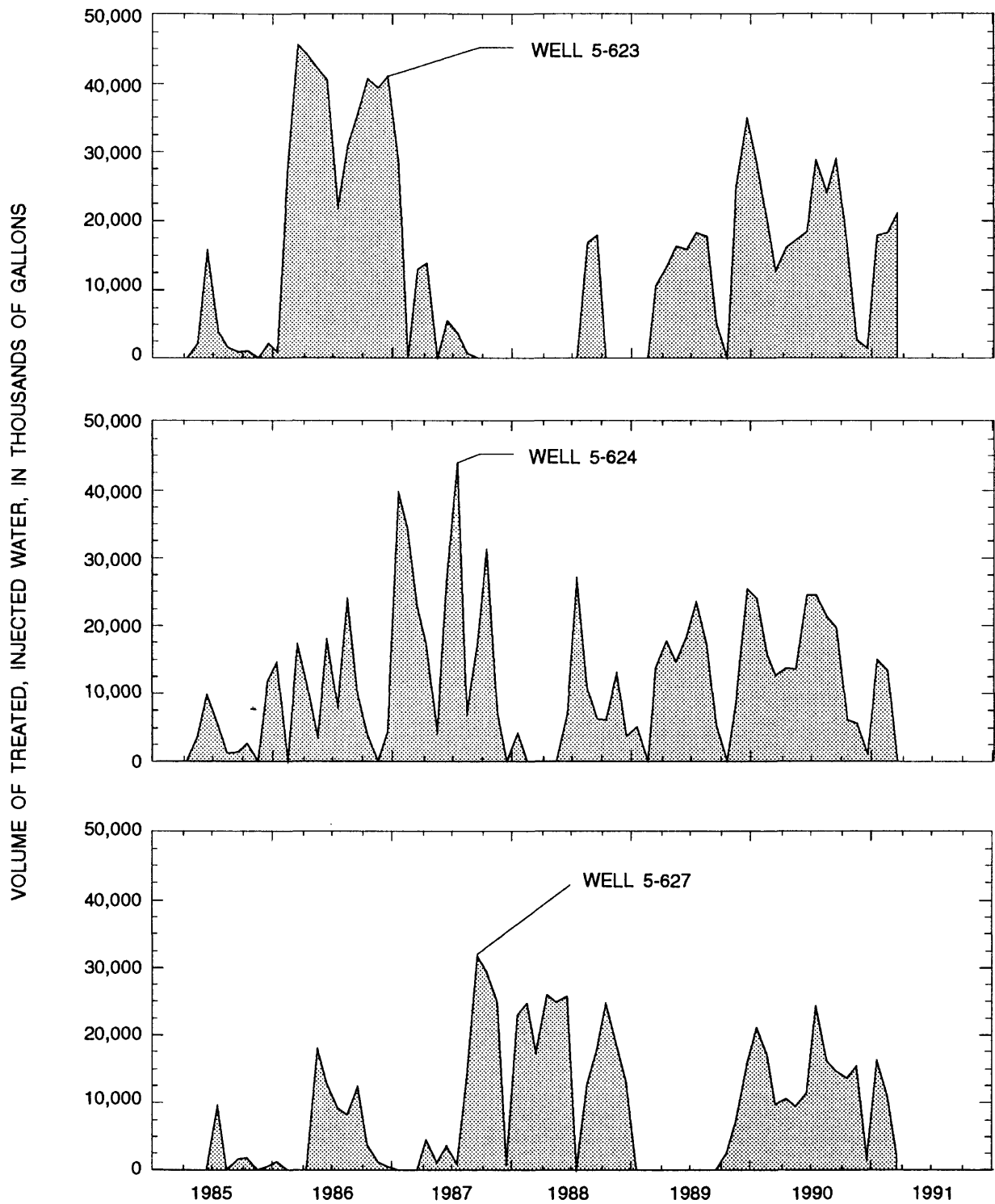
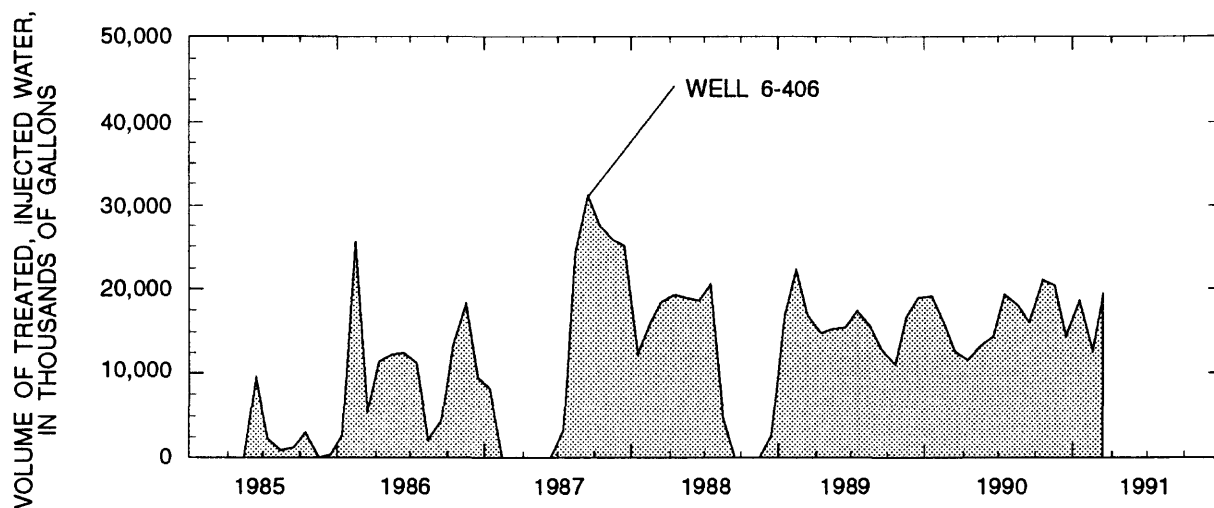


Figure 8.--Continued.



pH, water temperature, and dissolved-oxygen concentration of the water had stabilized before samples were collected (Wood, 1976).

Composite samples were collected from the injection and production wells from faucets at the well head. Samples were collected for inorganic analyses through a section of polyvinyl chloride (PVC) tubing. Samples requiring filtration were passed through a 142-mm diameter, 0.45- $\mu$ m pore-size inert filter, using a peristaltic pump. The filtering system was cleaned with distilled water prior to filtering each sample. Samples collected for organic analyses were collected through dedicated sections of cleaned and heated copper tubing connected to the faucet at the well head. Samples for bacterial analyses were collected using methods modified from Godsy and Ehrlich (1978). Samples were collected from the observation wells with a stainless-steel, wireline-activated thief sampler. The sampler and 10 ft of steel cable above the device were cleaned with pesticide-grade methanol and distilled water prior to sampling each well. The sampler was rinsed with sample water once before a sample was collected.

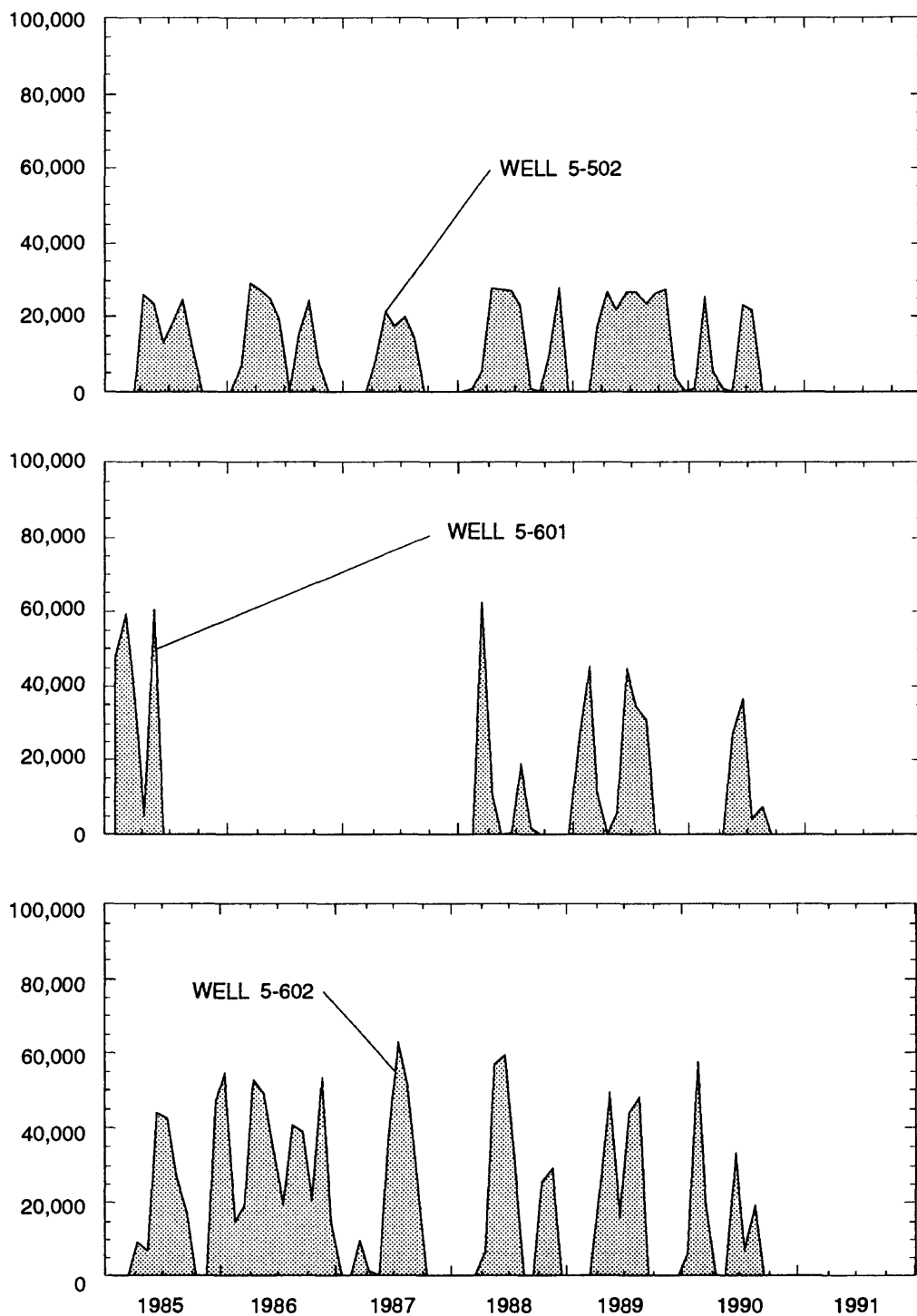
Concentrations of selected nutrients and unstable constituents were determined at each well site on filtered water samples using field colorimetric methods

adapted for use on a Hach model DR/2000 spectrophotometer (Hach Company, 1989). As part of each method, analysis of a reagent blank that was prepared using deionized water was performed to determine the contribution to the final result from the reagents. The contribution of the reagents to the final result was used to calibrate the response level of the spectrophotometer. The spectrophotometer was calibrated according to manufacturer's specifications.

All chemical analyses except for the isotopic analyses were performed by the USGS, National Water Quality Laboratory (NWQL), Arvada, Colorado. The stable isotopic ratios of carbon ( $\delta^{13}\text{C}$ ) were determined by Lloyd D. White (U.S. Geological Survey, National Research Program, Western Region). The stable isotopic ratios of oxygen ( $\delta^{18}\text{O}$ ) and hydrogen ( $\delta\text{D}$ ) were determined by the Reston, Virginia, Stable Isotope Laboratory of the USGS. The specific analytical methods used and their method-reporting limit, sample volume, preservation and bottle requirements, and holding times are described in table 6 (at end of report). An explanation of the preservation and bottle-requirement codes that were used in table 6 are listed in table 7.

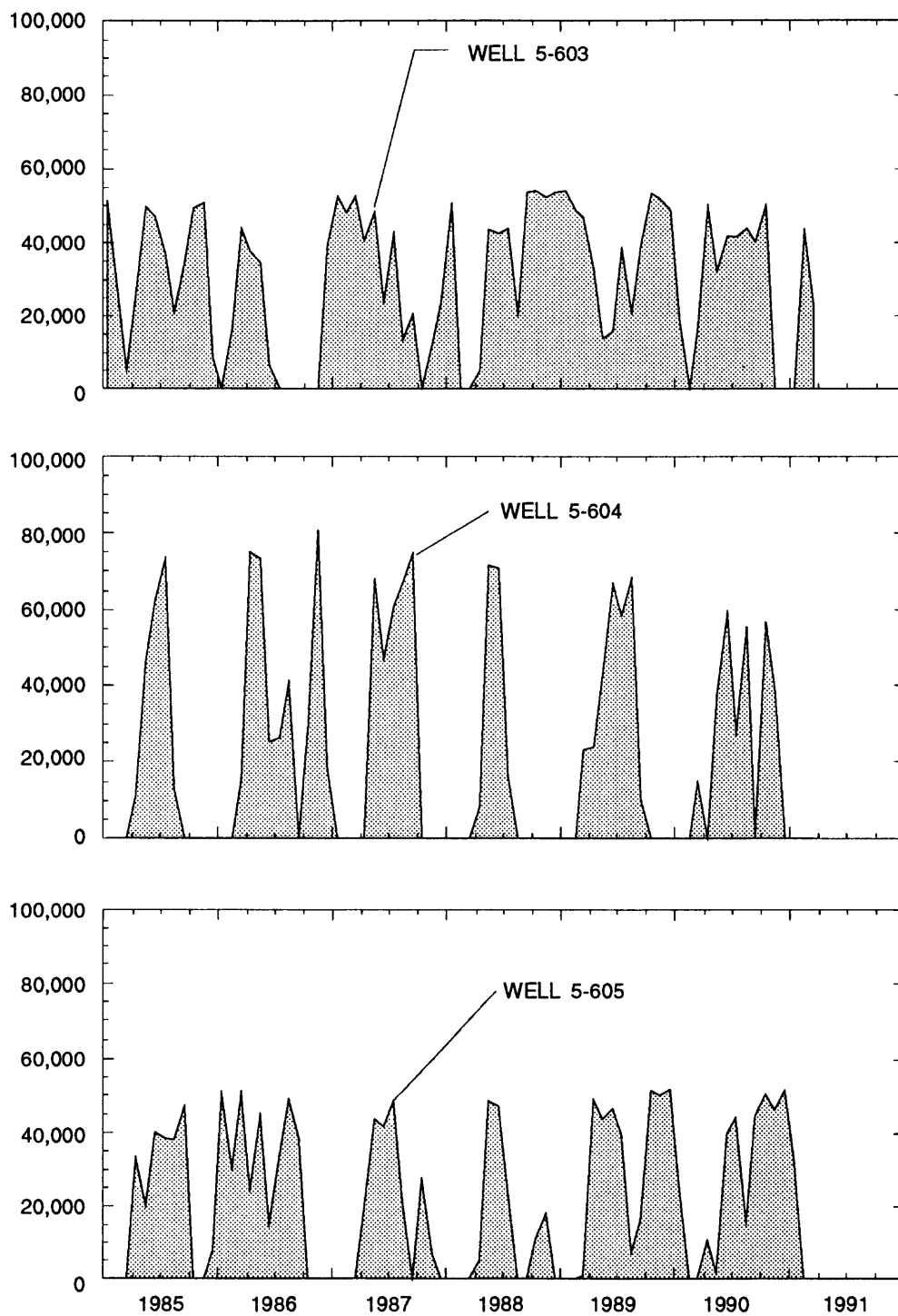
All bacterial analyses were made by E.M. Godsy (U.S. Geological Survey, National Research Program,

MONTHLY GROUND-WATER WITHDRAWALS, IN THOUSANDS OF GALLONS

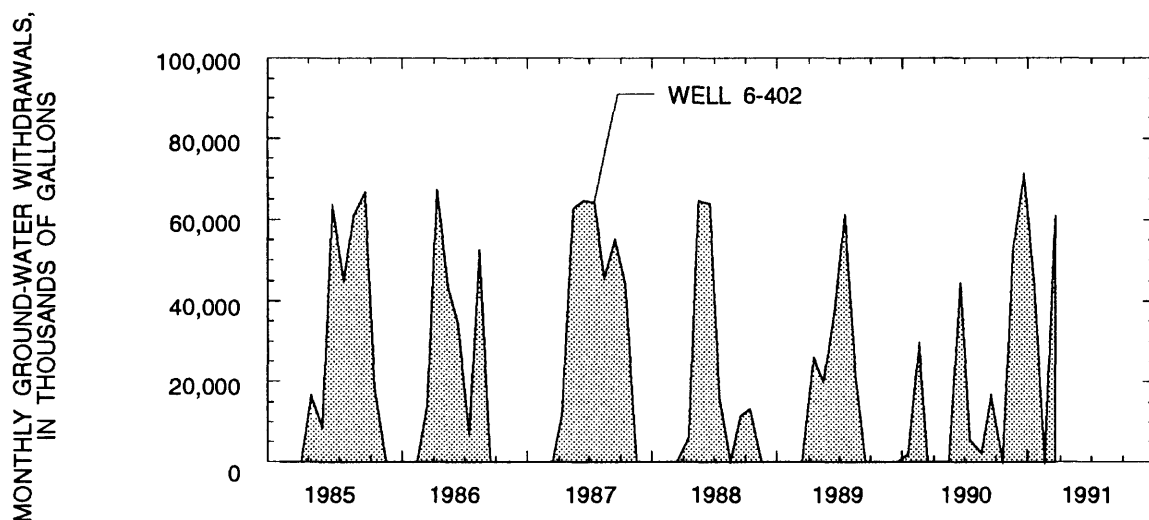


**Figure 9.** Volume of water withdrawn from the Hueco bolson aquifer by wells in the Hueco Bolson Recharge Project area, El Paso, Texas.

MONTHLY GROUND-WATER WITHDRAWALS, IN THOUSANDS OF GALLONS







**Figure 9.--Continued.**

Western Region). Subsamples for six viable bacterial determinations were removed from each of the water samples within 48 hours of their arrival at the laboratory. Subsamples were removed for the direct counting of the total number of bacteria present by AODC (Wilson and others, 1983). A five-tube most probable number (MPN) series was used to determine: (1) bacteria capable of rapid heterotrophic aerobic growth in nutrient liquid media, using Standard Methods Broth (BBL Microbiology Systems, Cockeysville, Maryland); (2) denitrifying bacteria (Stanier and others, 1966); (3) bacteria capable of anaerobic fermentative growth in nutrient liquid media, using prereduced, anaerobically sterilized peptone-yeast extract-glucose broth (Holdeman and Moore, 1972); (4) sulfate reducing bacteria, incubated for 6 weeks, using prereduced, anaerobically sterilized prepared American Petroleum Institute broth (Difco Laboratories, Livonia, Michigan); and (5) methanogenic bacteria based on the presence of methane in the head space above the medium after 6 weeks incubation, as determined by gas chromatography (Godsy, 1980).

### Quality Assurance

The quality assurance (QA) objectives for accuracy, precision, completeness, and representativeness were developed prior to sample collection. The QA objectives for accuracy, precision, and completeness for field and laboratory analyses are summarized in table 8. These objectives represent the minimum acceptable standards for all field and laboratory data. Data for a particular analysis that did not meet the project QA objectives still are reported in the data tables but are so noted in the text.

The accuracy of field measurements and laboratory analytical data was evaluated by a combination of factors. The accuracy of field measurements was evaluated by the use of standard methods of analysis with the appropriate calibration standards. These methods represent currently accepted techniques of water analysis. The accuracy of the laboratory analytical data collected for inorganic constituents was evaluated by the use of standard methods and blind-reference samples submitted to the NWQL by the Branch of Quality Assurance of the USGS. Blind-reference samples also

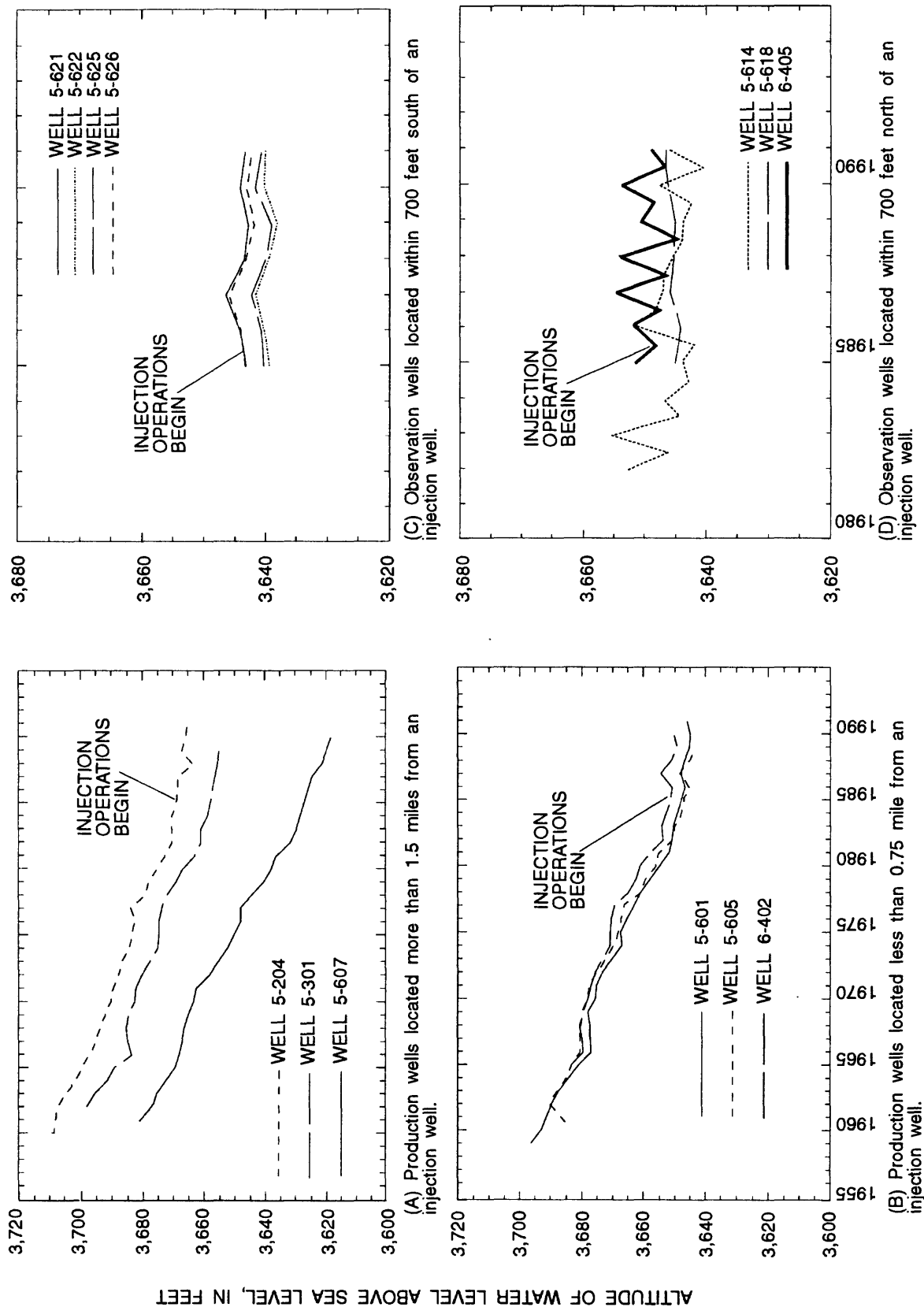
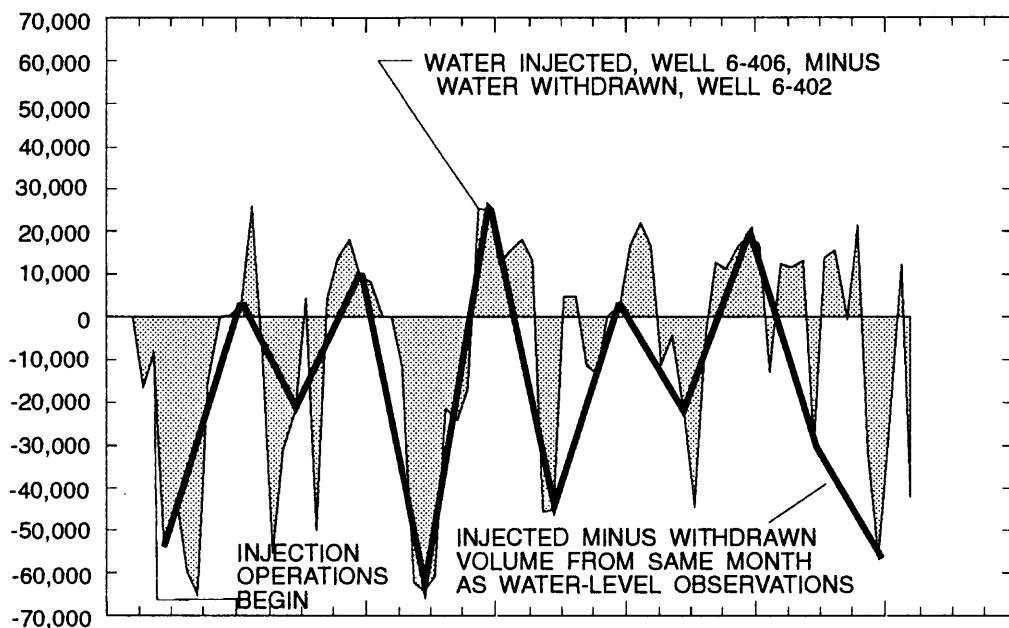
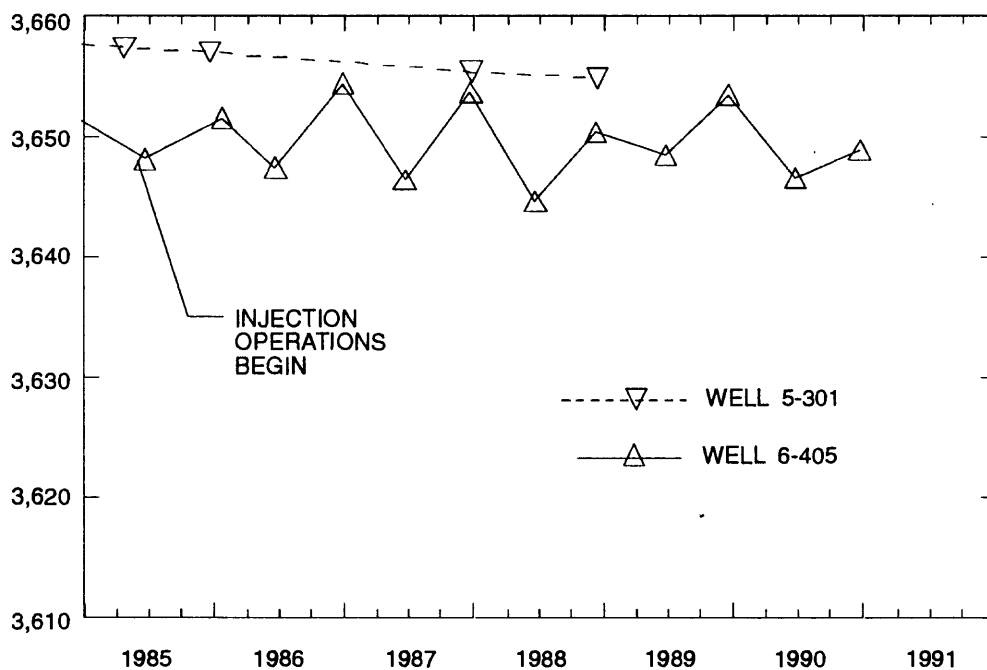


Figure 10. Water-level hydrographs for wells in and near the Hueco Bolson Recharge Project area, El Paso, Texas.

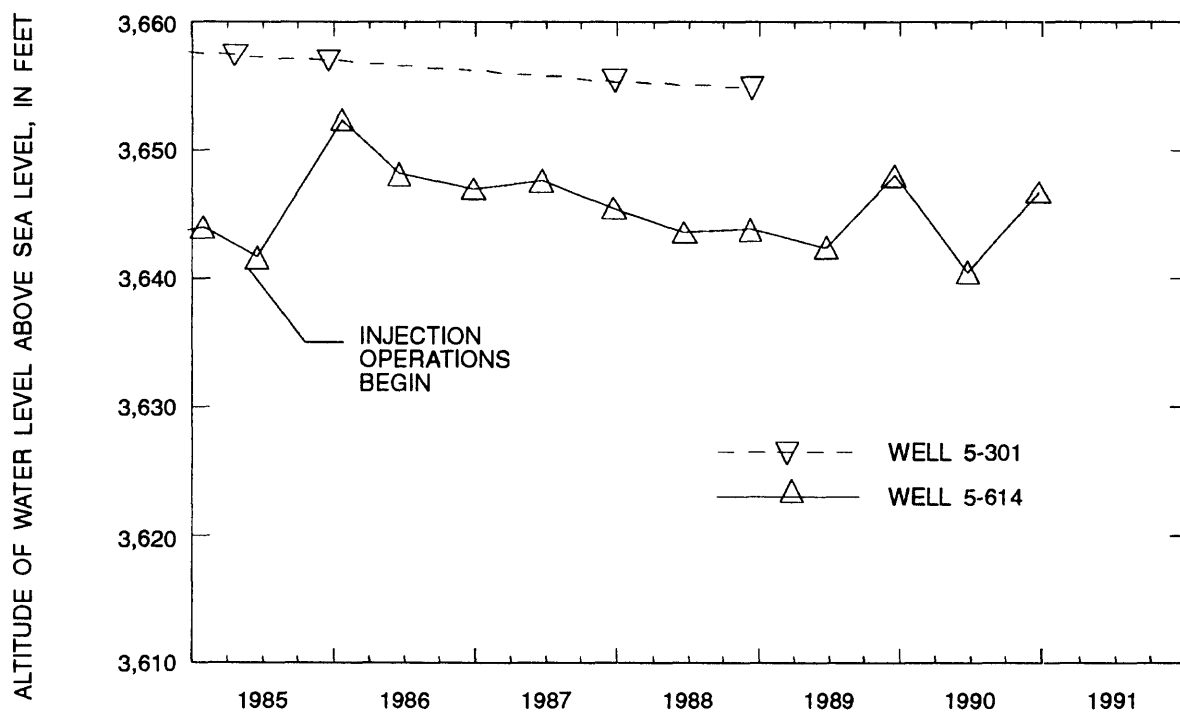
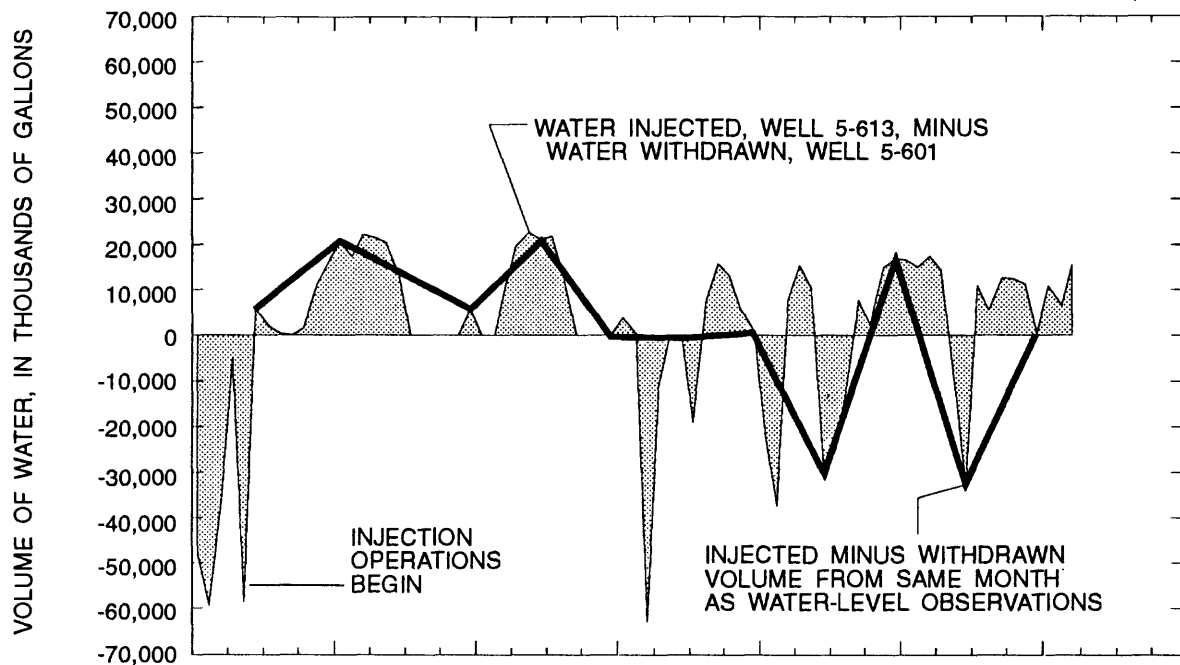
VOLUME OF WATER, IN THOUSANDS OF GALLONS



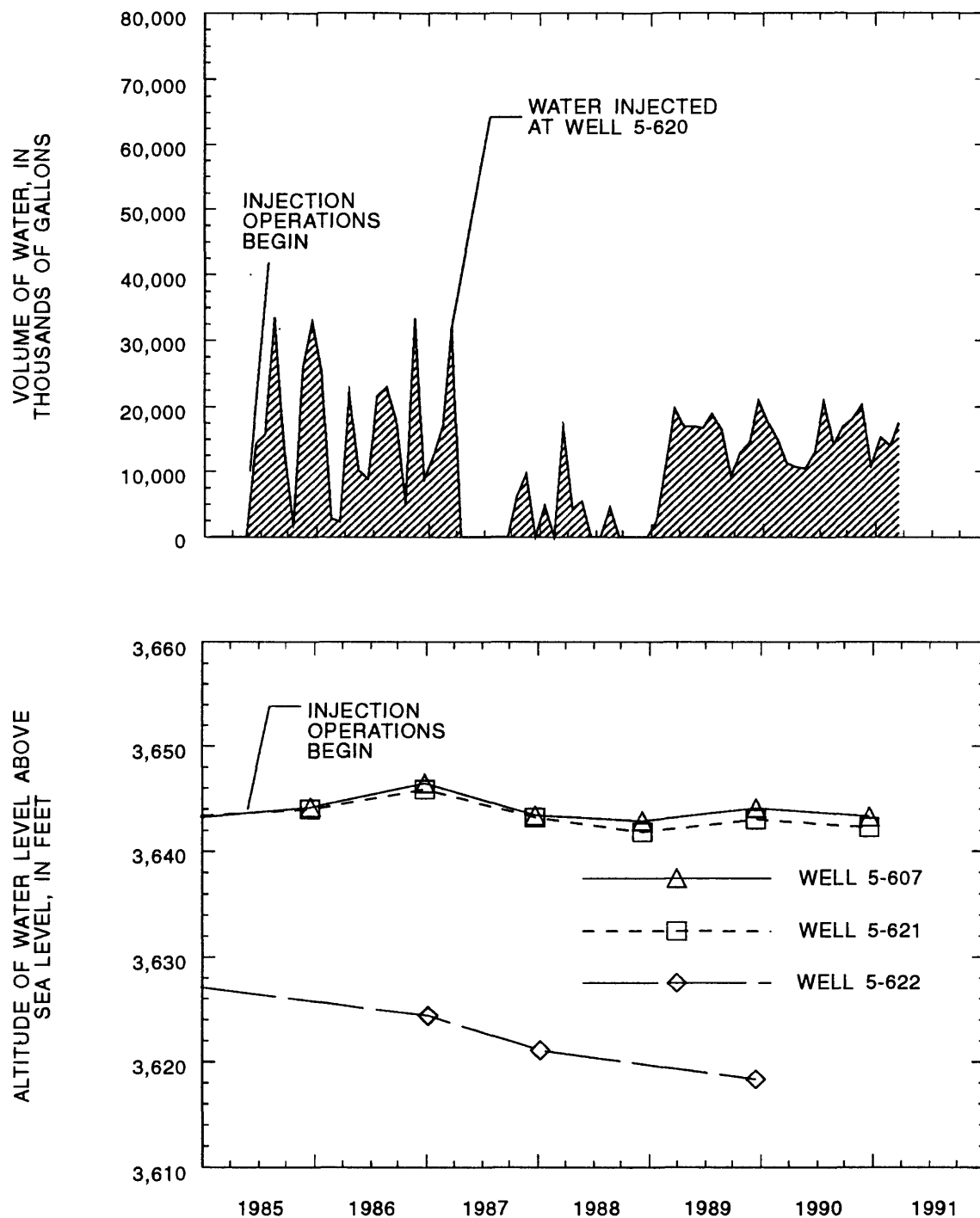
ALTITUDE OF WATER LEVEL ABOVE SEA LEVEL, IN FEET



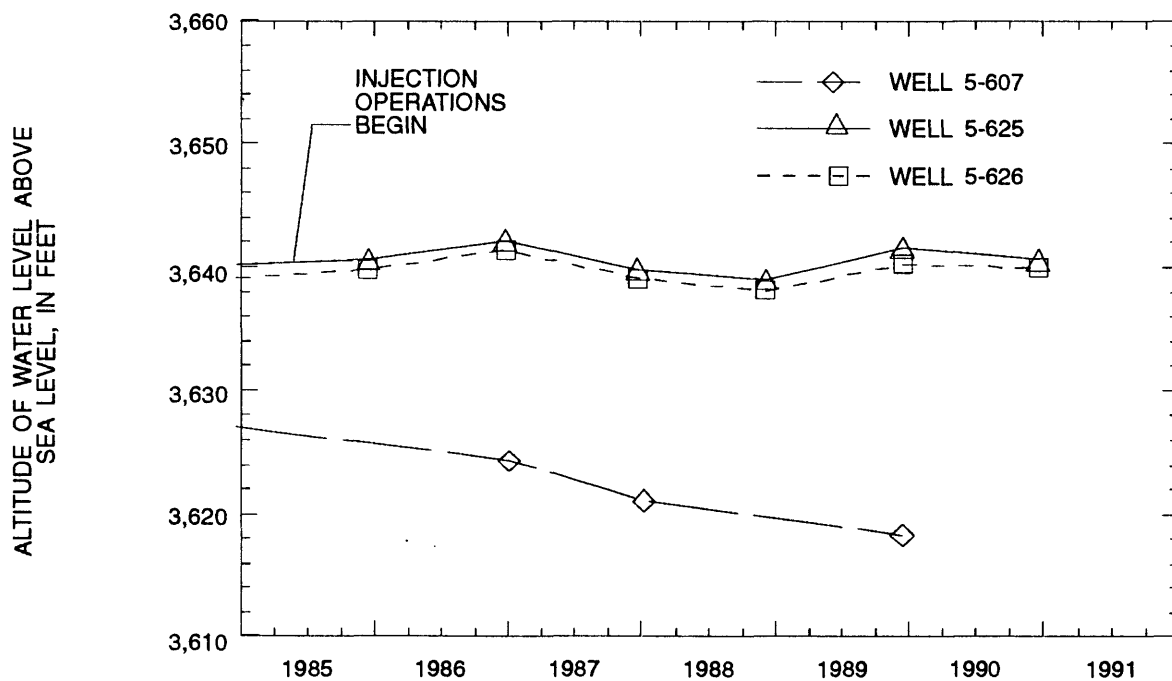
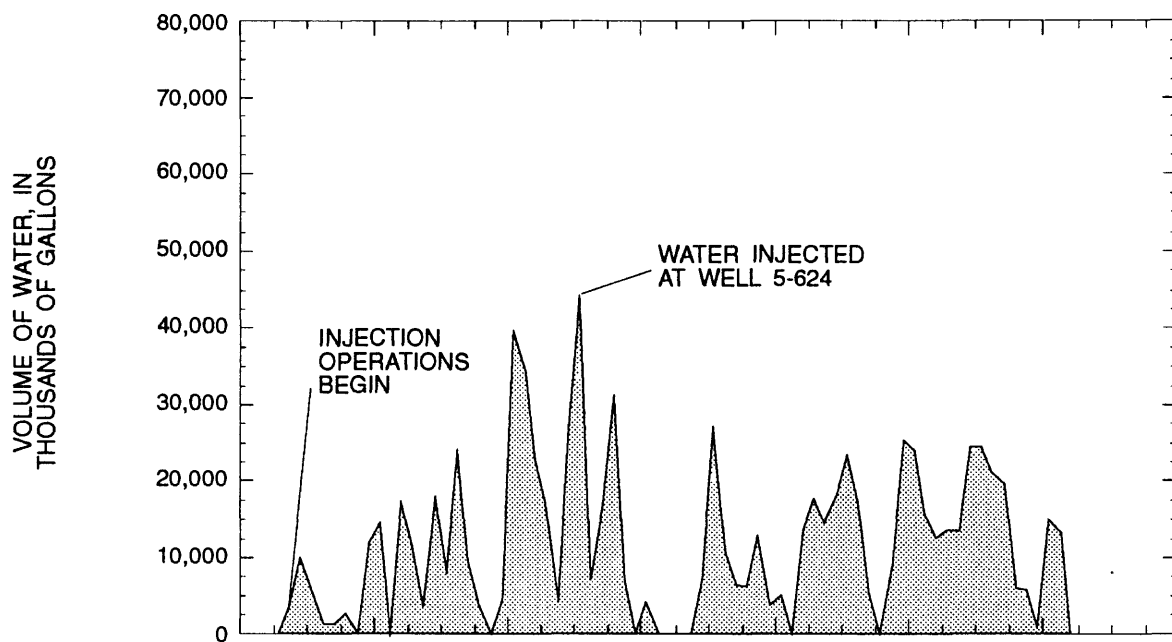
**Figure 11.** Difference between volumes of water injected at well 6-406 and water withdrawn from well 6-402, and water levels in wells 5-301 and 6-405 in and near the Hueco Bolson Recharge Project area, El Paso, Texas.



**Figure 12.** Difference between volumes of water injected at well 5-613 and water withdrawn from well 5-601, and water levels in wells 5-301 and 5-614 in and near the Hueco Bolson Recharge Project area, El Paso, Texas.



**Figure 13.** Volumes of water injected at well 5-620 and water levels in wells 5-607, 5-621, and 5-622 in and near the Hueco Bolson Recharge Project area, El Paso, Texas.



**Figure 14.** Volumes of water injected at well 5-624 and water levels in wells 5-607, 5-625, and 5-626 in and near the Hueco Bolson Recharge Project area, El Paso, Texas.

**Table 3.** Compilation of aquifer-test data from wells near the Hueco Bolson Recharge Project area[ft, feet; gal/min, gallons per minute; ft<sup>2</sup>/d, feet squared per day; --, no data]

Well number <sup>1</sup>	Pretest water level below land surface (ft)	Discharge (gal/min)	Length of tested interval <sup>2</sup> (ft)	Transmissivity <sup>3</sup> (ft <sup>2</sup> /d)
<u>Injection wells</u>				
JL-49-05-613 (RW-8)	345.6	1,045	464	16,700
JL-49-05-619 (RW-5)	354.4	--	527	32,100
JL-49-05-620 (RW-4)	350.3	--	528	25,500
<u>Observation wells</u>				
JL-49-05-306 (61)	375.0	1,200	228	14,200
JL-49-05-614 (OB-8)	342.8	1,045	467	21,800
JL-49-06-101 (57)	324.7	600	226	9,330
<u>Production wells</u>				
JL-49-05-204 (41)	407.1	1,400	108	11,500
JL-49-05-301 (42)	373.6	1,400	297	16,400
JL-49-05-501 (31)	400.0	1,000	330	4,370
JL-49-05-504 (52)	454.3	1,065	698	4,220
JL-49-05-601 (36)	352.0	1,300	350	18,300
JL-49-05-602 (35)	372.2	1,750	327	22,900
JL-49-05-603 (32)	337.8	1,610	319	20,300
JL-49-05-604 (34)	334.4	2,000	468	27,400
JL-49-05-605 (44)	365.6	2,000	403	19,100
JL-49-05-607 (40)	291.0	1,500	535	14,700
JL-49-06-401 (59)	376.5	1,000	75	18,000

<sup>1</sup> El Paso Water Utilities-Public Service Board well number is in parentheses.<sup>2</sup> Length of tested interval differs from the screened interval when the pretest water level is within or lower than the first screened interval.<sup>3</sup> Analytical method used for transmissivity determination was the Theis-recovery method (Myers, 1969, p. 2-7; Roger Sperka, El Paso Water Utilities-Public Service Board, written commun., 1992).

were submitted to the NWQL, along with samples from this project, in 1991. The blind-reference samples have a wide range of concentrations and are submitted in direct proportion to the total number of requests made for those analyses (Lucey, 1989). Blind-reference sample results from the NWQL, during the period that environmental samples from this project were analyzed, were used to evaluate the accuracy of the laboratory analytical data. If the results of the blind samples for a particular constituent were within three standard

deviations of the most probable concentration, then the data from the collected samples were determined to meet the accuracy objectives of the project for that constituent. Blind-reference samples containing bromide and iodide were not available. The accuracy of bromide and iodide analyses was evaluated by the use of standard methods of analyses only. The accuracy of determinations of stable isotopic ratios of carbon, oxygen, and hydrogen also was evaluated by the use of standard methods of analyses only.

**Table 4.** Results of borehole tracer tests in observation wells near the Hueco Bolson Recharge Project area, August 1990

[Positive velocity represents upward flow in well bore; ft, feet; ft/s, feet per second; (c), indicates initial observation of tracer pulse from a different depth; <, less than]

Well number <sup>1</sup>	Depth of tracer injection (ft)	Depth of tracer observation (ft)	Time to tracer arrival (seconds)	Vertical velocity (ft/s)
JL-49-05-618 (OB-5)	547	540	28	0.3
	547	540	20	.4
	568	561	18	.4
	580	573	20	.4
JL-49-05-621 (OB-4A)	449	439	104	.1
	574	564	75	.1
JL-49-05-622 (OB-4B)	451	446	22	.2
	566	561	20	.3
	575	570	41	.1
	591	586	37	.1
	385	380	60	.1
	405	400	90	.1
JL-49-05-625 (OB-7A)	665 (c)	655	23	.4
	674	669	15	.3
	698	693	24	.2
	706	701	20	.3
	562 (c)	552	30	.3
	575	570	15	.3
	588 (c)	578	31	.3
	603 (c)	590	40	.3
	608	603	15	.3
	365	360	45	.1
	387	377	25	.4
	410 (c)	400	65	.2
	424	419	24	.2
	450	445	25	.2
JL-49-05-626 (OB-7B)	570 (c)	545	90	.3
	575	570	9	.6
	663 (c)	652	10	1.1
	691	686	10	.5
	692	687	10	.5
	485 (c)	467	98	.2
	492	487	12	.4
	565 (c)	535	150	.2
	575	570	10	.5
	380	382	65	<.1
	400	395	135	<.1
	444 (c)	434	30	.3
	451	446	23	.2
JL-49-06-405 (OB-1)	557	554	45	.1
	614	614	70	<.1
	618	616	30	.1

<sup>1</sup> El Paso Water Utilities-Public Service Board well number is in parentheses.



**Table 7.** Explanation of preservation and bottle-requirement codes used in table 6

[&lt;, less than; mL, milliliters; °C, degrees Celsius; VOA, volatile organic analysis; L, liter]

Code	Explanation
FU	Polyethylene bottle, field rinsed. Filter sample.
RU	Polyethylene bottle, field rinsed. Untreated sample.
FA	Polyethylene bottle, acid rinsed. Filter sample and acidify with nitric acid (HNO <sub>3</sub> ) to pH < 2.
FC	250-mL brown polyethylene bottle, field rinsed. Filter sample. Add mercuric chloride (HgCl <sub>2</sub> ) solution, chill and maintain at 4 °C.
PPT	Precipitate.
LC	Lab code.
LC 0114	125-mL glass bottle. Chill and maintain at 4 °C.
LC 0113	125-mL glass bottle. Filter sample using silver filter. Chill and maintain at 4 °C. Filter may be retained for LC 0305.
LC 0305	Petri dish. Retain sample on silver filter. Chill and maintain at 4 °C. Record volume filtered.
RCB	250-mL polyethylene bottle, field rinsed. Chill and maintain at 4 °C.
GCV	40-mL VOA vial with hole cap and Teflon-faced septum. Fill to overflowing with no headspace or air bubbles. Chill and maintain at 4 °C.
GCC	1-L glass bottle. Chill and maintain at 4 °C.

**Table 8.** Quality-assurance objectives for measured data

[RPD, relative percent difference; °C, degrees Celsius; mg/L, milligram per liter; RSD, relative standard deviation]

Property or constituent	Accuracy	Precision <sup>1,2</sup>	Completeness (percent)
Specific conductance	±5 percent of meter range	RPD within 20 percent	90
pH	±0.2 standard unit	RPD within 20 percent	90
Water temperature	±0.5 °C	RPD within 20 percent	90
Dissolved oxygen	±1 mg/L	RPD within 20 percent	90
Alkalinity	±5 percent of most probable concentration	RPD within 20 percent	90
Constituents	±3 standard deviations of most probable concentration	RPD within method-reporting limits as referenced in table 6	90

$$^1 \text{ For duplicate measurements, } RPD = \frac{C_1 - C_2}{\bar{C}} \times 100,$$

where  $C_1$  and  $C_2$  are the concentrations of duplicates 1 and 2, and  $\bar{C}$  is the average concentration.

$$^2 \text{ For three or more duplicates, RSD is used rather than RPD: } RSD = \frac{SD}{\bar{C}},$$

where SD is the standard deviation, and  $\bar{C}$  is the average concentration.

The accuracy of the laboratory analytical data collected for selected organic constituent determinations (including TOC, DOC, halomethanes and other VOC, and SVOC) was evaluated by the use of standard methods of analyses, surrogate/spike recoveries, and

USEPA check samples (VOC only). If the recovery of the surrogate/spike or check sample (that was analyzed, along with the samples from this project) was within three standard deviations of the laboratory-established average recoveries, then the data from the collected

samples were determined to meet the accuracy objectives of the project. The accuracy of the SOC and MBAS analyses data was evaluated by the use of a standard method of analysis.

The precision of field measurements of physical properties was evaluated by duplicate measurements of specific conductance, pH, water temperature, and dissolved oxygen. The precision of laboratory analytical data was evaluated by randomly submitted duplicate samples. If the relative percent difference (RPD) of duplicate samples was within 20 percent, then the data from the collected samples were determined to meet the precision objectives of the project. The precision of bacterial analyses was evaluated by the use of a five-tube MPN series.

Completeness was evaluated by dividing the number of valid analyses (those meeting the accuracy and precision objectives) by the number of samples analyzed, and multiplying by 100 to give a percent value. If the calculated result was greater than or equal to 90 percent, then the data from the collected samples were determined to be complete.

Representativeness of field data was evaluated by the use of standard methods of measurement and sample collection. Representativeness of laboratory analytical data was evaluated by the use of appropriate preservation techniques, adherence to the prescribed holding times, the use of field and laboratory blanks, and the use of field spikes. If these conditions were met, then the data from the collected samples were determined to accurately represent the characteristics of the aquifer.

Field spikes for the halomethane compounds were prepared from a spike mixture (which contained seven halomethane compounds) that was obtained from the NWQL. Field spikes and matrix spikes had a final concentration of 200 ng/L of each of the spike compounds in 1990. Field spikes were prepared using reagent water. Matrix spikes were prepared using ground-water samples from selected wells. Field spikes and matrix spikes had a final concentration of 500 ng/L of each of the spike compounds in 1991.

Reagent water (U.S. Environmental Protection Agency, 1990) was used as a trip blank to accompany selected samples (which were collected for VOC analyses) to determine if any contaminants were introduced into the samples during shipping. Equipment blanks were collected by rinsing the stainless-steel thief sampler with reagent water after it was cleaned. Other equipment blanks were collected by rinsing the copper

tubing/faucet assembly with reagent water. The rinses were analyzed for VOC and SVOC to determine if the samples were being contaminated by either the sampling equipment or previous samples. Equipment blanks for bacterial analyses were collected by rinsing the sampling equipment with sterilized water, collecting the rinse water, and analyzing it in the same manner as the other samples.

## Results

### Physical Properties, Major Ions, and Trace Elements

The specific conductance of water from injection, observation, and production wells ranged from 478 to 2,070  $\mu\text{S}/\text{cm}$  in 1990 and from 469 to 3,110  $\mu\text{S}/\text{cm}$  in 1991 (table 9, at end of report). Samples from wells 5-602, 5-613, 5-625, 6-402, and 6-405 had specific conductances greater than 1,000  $\mu\text{S}/\text{cm}$  in 1990. Samples from wells 5-303, 5-621, 5-625, 6-402, 6-404, and 6-405 had specific conductances greater than 1,000  $\mu\text{S}/\text{cm}$  in 1991. The pH of the water samples ranged from 7.2 to 8.1 in 1990, and from 7.0 to 8.0 in 1991. In 1990, the pH values in injected water from well 5-613 were slightly more acidic (7.2) than the range of pH values of water from the observation and production wells (7.3 to 8.1). All water samples contained dissolved oxygen concentrations ranging from 1.1 to 6.3 mg/L in 1990, and from 0.7 to 5.9 mg/L in 1991. The project QA objectives were met for all physical properties measured.

Analyses for major ions included calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, chloride, fluoride, bromide, iodide for 1990 only, and silica. The sum of the dissolved-solid constituents ranged from 289 to 1,113 mg/L in 1990, and from 298 to 1,690 mg/L in 1991 (table 10, at end of report). Sodium and chloride generally contribute most of the equivalent charge to the sampled waters. Concentrations of bromide and iodide were all less than 0.6 mg/L.

The project QA objectives were met for all major ions except for the following analyses: (1) the accuracy objective for fluoride analyses was not met in 1990 as determined by analysis of blind-reference samples by the NWQL (T.J. Maloney, U.S. Geological Survey, Branch of Quality Assurance, written communication, 1991); (2) the precision objective was not met for fluoride analyses from duplicate samples from well 6-402 in 1990; and (3) the completeness objective was

not met for fluoride analyses in 1990 because the accuracy objective was not met.

Aluminum concentrations (1991 only) ranged from less than 10 to 40  $\mu\text{g/L}$  in 1991 (table 10). Boron concentrations ranged from 70 to 680  $\mu\text{g/L}$  in 1990, and from 80 to 360  $\mu\text{g/L}$  in 1991 (table 10). The project QA objectives were met for all trace element analyses.

### Nutrients and Field Colorimetric Analyses

Nutrients analyzed include: nitrite; nitrite plus nitrate; nitrogen, ammonia; nitrogen, ammonia plus organic; phosphorus; and phosphorus, orthophosphate. The results of these analyses are given in table 11 (at end of report). Concentrations of nitrite plus nitrate in injected water ranged from 2.3 to 2.8  $\text{mg/L}$  in 1990, and from 2.4 to 3.3  $\text{mg/L}$  in 1991. Concentrations of nitrite plus nitrate in water from observation and production wells ranged from 1.2 to 6.4  $\text{mg/L}$  in 1990, and from 0.6 to 3.3  $\text{mg/L}$  in 1991. Concentrations of phosphorous, orthophosphate, in injected water ranged from 0.35 to 0.40  $\text{mg/L}$  in 1990, and from 0.58 to 0.75  $\text{mg/L}$  in 1991. Concentrations of phosphorus, orthophosphate, in water pumped from injection well 5-624 ranged from 0.58 to 0.59  $\text{mg/L}$  on September 8, 1991. Concentrations of phosphorus, orthophosphate, in other water samples ranged from less than 0.01 to 0.02  $\text{mg/L}$  in 1990 and 1991.

The project QA objectives were met for all nutrient data except for the following analyses: (1) the accuracy objective for nitrite analyses was not met in 1990 as determined by blind-reference sample results from the NWQL (T.J. Maloney, U.S. Geological Survey, Branch of Quality Assurance, written commun., 1991); (2) the precision objective was not met for nitrogen, ammonia plus organic analyses for duplicate samples from wells 5-603, 5-605, and 6-402 in 1990, and for duplicate samples from wells 5-613 and 6-402 in 1991; (3) the precision objective was not met for nitrogen, ammonia analyses for duplicate samples from well 5-603 in 1990; (4) the precision objective was not met for phosphorous analyses for duplicate samples from wells 5-605 and 6-402 in 1990, and for duplicate samples from well 6-402 in 1991; and (5) the completeness objective was not met for nitrite analyses in 1990 because the accuracy objective was not met. The constituents that did not meet the precision objective were detected at or near the reporting limit of the analytical method. Relatively high RPD's are expected near the

reporting limit (T.J. Maloney, U.S. Geological Survey, Branch of Quality Assurance, written commun., 1991).

The results of semiquantitative, field colorimetric analyses of free chlorine; nitrate; nitrite; nitrogen, ammonia; total iron; and ferrous iron are given in table 12 (at end of report). Nitrite was detected by field colorimetric analyses at concentrations ranging from 0.01 to 0.09  $\text{mg/L}$  in 1990 and 1991 analyses. No QA objectives were developed for the field colorimetric methods.

### Stable-Isotopic Ratios

The isotopic data are reported as the relative abundances of two stable isotopes of an element in a sample with respect to those in a standard reference sample. The reference samples used for the computation of the stable isotopic ratios were (1) Vienna Standard Mean Ocean Water for  $\delta^{18}\text{O}$  and  $\delta\text{D}$ , and (2) a carbonate standard derived from fossil remains of *Belemnitella americana* from the Pee Dee Formation in South Carolina for  $\delta^{13}\text{C}$ . The computational methods, descriptions of the reference standards, and methods of interpreting isotopic data are presented in more detail by Fritz and Fontes (1980).

The values of  $\delta^{18}\text{O}$ ,  $\delta\text{D}$ , and  $\delta^{13}\text{C}$  in water from injection, observation, and production wells in 1990 ranged from -10.05 to -9.00 per mil, -70.5 to -63.0 per mil, and -12.6 to -5.4 per mil, respectively (table 13, at end of report). The values of  $\delta^{18}\text{O}$ , and  $\delta\text{D}$  in the injected water and in water from observation and production wells in 1991 ranged from -10.25 to -9.05 per mil, and from -70.5 to -64.5 per mil, respectively (table 13). The project QA objectives were met for all stable isotopic data.

### Organic Carbon and Methylene Blue Active Substances

The DOC, SOC, and MBAS concentrations in water from injection, observation, and production wells in 1990 ranged from 0.3 to 1.6  $\text{mg/L}$ , less than 0.1 to 0.3  $\text{mg/L}$ , and less than 0.02 to 0.06  $\text{mg/L}$ , respectively (table 14, at end of report). The TOC and DOC concentrations in 1991 ranged from less than 0.1 to 1.8  $\text{mg/L}$  and 0.2 to 2.6  $\text{mg/L}$ , respectively (table 14).

The project QA objectives were met for all organic carbon and MBAS data except for the following analyses: (1) the precision objective was not met for DOC analyses in duplicate samples from wells

5-603 and 5-605 in 1990 and for duplicate samples from well 6-402 in 1991; (2) the precision objective was not met for TOC analyses for duplicate samples from well 6-402 in 1991; and (3) the precision objective was not met for MBAS analyses for duplicate samples from well 5-603 in 1990. DOC and MBAS concentrations in these wells were within 10 times the reporting limit of the analytical method. Relatively high RPD's commonly are determined for concentrations of duplicate samples that are near the reporting limit (T.J. Maloney, U.S. Geological Survey, Branch of Quality Assurance, oral commun., 1991). Organic carbon determinations in 1991 from wells 5-204, 5-607, 5-624, 6-402, and 6-404 had DOC concentrations that were more than 0.2 mg/L greater than their TOC concentrations.

### **Volatile and Semivolatile Organic Compounds**

In 1990, THM compounds were detected in water from 8 of the 16 observation and production wells sampled (table 15, at end of report). In water samples from observation and production wells where THM compounds were detected, the sum of the THM compounds ranged from 0.05 to 1.9  $\mu\text{g/L}$ . Concentrations of THM compounds in 4 samples of water from injection well 5-613 ranged from 18.4 to 26.7  $\mu\text{g/L}$ . Two halomethane compounds, dibromomethane and dichloromethane, were detected in water and from injection wells and from observation wells within about 700 ft of the injection wells.

In 1991, THM compounds were detected in water from 10 of the 17 observation and production wells sampled, including production wells 5-303, 5-601, 5-605, and 6-402. In water samples from observation and production wells where THM compounds were detected, the sum of the THM compounds ranged from 0.05 to 1.4  $\mu\text{g/L}$ . Concentrations of THM compounds in 1991 in samples of water from injection wells 5-613 and 5-624 were 27.8 and 34.6  $\mu\text{g/L}$ , respectively. Concentrations of THM compounds in 1991 in pumped samples from well 5-624, ranged from 0.33 to 0.36  $\mu\text{g/L}$ .

The project QA objectives were met for all samples submitted for selected-ion monitoring analyses of VOC data except for the precision objective, which was not met for duplicate trichlorofluoromethane determinations from well 5-613 in 1990. The results of the QA samples submitted for VOC analysis are listed in table 15. The concentrations of the VOC in the reagent-

water spike in 1990 ranged from 42 to 260 ng/L, and the recoveries were within the limits of the analytical method, except for trichlorofluoromethane. Because trichlorofluoromethane is a gas at room temperature, low recoveries can occur (D.L. Rose, U.S. Geological Survey, National Water Quality Laboratory, written commun., 1990). The concentrations of the VOC in the 1990 matrix-water spike ranged from 190 to 350 ng/L. The concentrations of the VOC in the matrix-water spike were larger than intended. The data indicated an error in the spiking procedure because chloroform was the only compound detected in the sample from well 5-605, which was used as the matrix water. Dichloromethane was detected in the trip and equipment blanks at concentrations greater than the reporting limit.

The concentrations of the VOC in the reagent-water spike, which was spiked using a 100- $\mu\text{L}$  syringe, ranged from 331 to 504 ng/L in 1991. The concentrations of the VOC in the matrix-water spike, which was added to water samples using a 100- $\mu\text{L}$  pipette, ranged from 240 to 400 ng/L in 1991. The recoveries for both spikes are within the limits of the analytical method, except for trichlorofluoromethane in the matrix spike (D.L. Rose, U.S. Geological Survey, National Water Quality Laboratory, written commun., 1991). Dichloromethane was detected in the trip and equipment blanks at concentrations greater than the reporting limit.

In addition to the VOC's listed in table 15, water samples were analyzed for other VOC's, which are listed in table 6. The only other VOC's detected in the samples were tetrachloroethene, which was detected in duplicate samples from well 6-402 in 1990 at a concentration of 130 ng/L, and toluene, which was detected in well 6-401 in 1991 at a concentration of 0.6  $\mu\text{g/L}$  (U.S. Geological Survey, Austin, Texas, unpub. data). A hydrocarbon sheen was noted in the water obtained from well 6-401 in 1991 during sampling. The project QA objectives were met for all other VOC analyses. No other VOC was detected in the trip and equipment blanks in concentrations greater than the reporting limit.

The water samples from injection, observation, and production wells were analyzed for 54 methylene-chloride extractable SVOC's in 1990, which are listed in table 6. The only SVOC detected was bis (2-ethylhexyl) phthalate, a chemical used extensively as a plasticizer. Bis (2-ethylhexyl) phthalate was detected in samples collected from wells 5-622 and 5-301, with

concentrations of 6 µg/L and 7 µg/L, respectively. Plastic tubing was not used in sample collection equipment. The project QA objectives were met for all SVOC analyses. The SVOC's were not detected in the equipment blanks in concentrations above the reporting limit.

### Bacterial Analyses

The procedures used to assay bacterial populations in ground water are based on the assumption that the majority of all bacterial types present on the aquifer solids were dislodged by pumping and were entrained in the water moving toward the well bore (Godsy and Ehrlich, 1978). Processes such as sorption and size-based exclusion may impede bacterial movement through the aquifer and affect the bacterial populations that are determined by these methods (Bouwer and others, 1981).

The results of the bacterial analyses are given in table 16 (at end of report). The AODC present in water from observation and production wells ranged from 2,200 organisms per mL at well 5-204, to 770,000 organisms per mL at 430 ft below land surface at well 5-622. Two samples of water from injection well 5-613 contained AODC (1,500 organisms/mL and 1,800 organisms/mL) in amounts that were comparable to that of the equipment blank (800 organisms/mL). The AODC's in all the water samples were below the minimum number required for statistical validity of the ADOC method. The largest AODC's in all samples collected were in five of six samples from observation wells taken within 2 days after the well was purged.

Aerobic bacteria were determined to be the only bacteria type present in all samples except well 5-621, sampled at 640 ft below land surface, and well 6-405. These two wells contained denitrifying bacteria in addition to aerobic bacteria. Aerobic bacteria populations in ground water ranged from 80 MPN/mL, in well 5-622 at 690 ft below land surface, to greater than 160,000 MPN/mL, in water from wells 5-622, 5-625, and 5-626 (table 16).

The numbers of denitrifying bacteria were substantially greater than the analytical detection limit of 0.2 MPN/mL in a sample from well 6-405. Anaerobic, sulfate-reducing, and methanogenic bacteria were not detected in any of the samples. Bacteria were not detected in the equipment blank except AODC counted bacteria. The accuracy, precision, completeness, and representativeness objectives of this project were met for all bacterial analyses.

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**Table 5. Characteristics of wells**

[ft, feet; in., inches; gal/min, gallons per minute; --, no data]

Well number <sup>1</sup>	Land-surface elevation above sea level (ft)	Well depth below land surface (ft)	Diameter (in.)		Pump setting below land surface (ft)	Pumping rate (gal/min)	Water level below land surface (ft)		Screened depths below land surface (ft) and remarks
			Well casing	Well screen		Recent and year measured	Original and date measured	Recent and date measured	
Injection wells									
JL-49-05-509 (RW-10)	4,032	658	26 16	16	460	--	391.80 09/05/84	--	351 to 411, 441 to 521, 556 to 576, 618 to 658
JL-49-05-613 (RW-8)	3,990	810	24 18	18 16	--	--	343.57 05/18/81	--	188 to 810
JL-49-05-616 (RW-2)	4,000	829	26 16	16	430	--	356.20 04/30/84	--	279 to 299, 324 to 344, 431 to 511, 541 to 602, 642 to 702, 749 to 829
JL-49-05-617 (RW-3)	4,002	835	26 16	16	430	--	358.20 06/04/84	--	329 to 349, 439 to 499, 525 to 565, 589 to 609, 629 to 649, 735 to 835
JL-49-05-619 (RW-5)	3,997	881	26 16	16	430	--	354.40 06/18/84	--	320 to 380, 413 to 453, 474 to 534, 554 to 574, 651 to 711, 801 to 881
JL-49-05-620 (RW-4)	3,990	878	26 16	16	430	--	320.25 07/02/84	--	284 to 304, 409 to 529, 625 to 645, 660 to 700, 773 to 813, 838 to 878
JL-49-05-623 (RW-6)	3,984	740	26 16	16	430	--	348.65 07/13/84	--	193 to 273, 308 to 568, 640 to 740
JL-49-05-624 (RW-7)	3,982	780	26 16	16	430	--	--	--	270 to 330, 385 to 425, 460 to 540, 586 to 666, 700 to 780
JL-49-05-627 (RW-9)	4,004	632	26 16	16	460	--	367.30 08/24/84	--	316 to 356, 391 to 471, 512 to 632
JL-49-06-406 (RW-1)	4,008	767	26 16	16	430	--	362.10 03/29/84	--	296 to 336, 403 to 543, 627 to 767
Observation wells									
JL-49-05-306 (61)	4,051	603	18	18	--	--	356.02 01/03/67	381.66 12/20/90	391 to 603; not connected to system
JL-49-05-321	4,054	500	4	4	--	--	379.69 12/06/88	384.42 12/12/90	300 to 500
JL-49-05-322	4,050	500	4	4	--	--	369.45 12/06/88	373.27 12/12/90	300 to 500
JL-49-05-614 (OB-8)	3,989	810	24 4	4	--	--	336.33 12/19/81	342.26 12/18/90	315 to 810
JL-49-05-618 (OB-5)	3,999	705	6	6	--	--	353.87 12/19/84	352.69 12/18/90	327 to 621, 663 to 705
JL-49-05-621 (OB-4A)	3,988	709	6	6	--	--	344.79 12/19/84	344.71 12/18/90	352 to 709

Footnote at end of table.

Table 5. Characteristics of wells--Continued

Well number <sup>1</sup>	Land-surface elevation above sea level (ft)	Well depth below land surface (ft)	Diameter (in.)		Pump setting below land surface (ft)	Pumping rate (gal/min)	Water level below land surface (ft)		Screened depths below land surface (ft) and remarks
			Well casing	Well screen		Recent and year mea-sured	Original and date measured	Recent and date mea-sured	
Observation wells--Continued									
JL-49-05-622 (OB-4B)	3,986	709	6	6	--	--	342.65 12/19/84	343.74 12/18/90	352 to 625, 646 to 709
JL-49-05-625 (OB-7A)	3,982	751	6	6	--	--	341.67 12/20/84	347.31 12/18/90	331 to 751
JL-49-05-626 (OB-7B)	3,983	751	6	6	--	--	343.89 12/20/84	343.00 12/18/90	331 to 751
JL-49-06-101 (57)	4,065	551	18	18	--	--	320.67 12/29/65	--	336 to 551; not connected to system
JL-49-06-111 (HB-6)	4,014	560	6	6	--	--	307.66 02/05/85	311.12 12/20/90	337 to 537; plugged at 417 in 1987
JL-49-06-405 (OB-1B)	4,009	710	6	6	--	--	357.45 12/19/84	360.06 12/18/90	353 to 710
JL-49-06-503 (HB-5)	3,976	601	6	6	--	--	272.10 12/29/82	277.25 12/19/90	284 to 586
JL-49-06-906	4,005	550	10.75	10.75	--	--	--	324.60 12/19/90	316 to 418, 472 to 489, 509 to 529
Production wells									
JL-49-05-204 (41)	4,041	515	18	18	--	1,055 1988	331.58 01/05/60	375.59 12/20/90	359 to 515
JL-49-05-301 (42)	4,015	671	18	18 12	420	1,410 1988	317.06 01/08/62	360.12 12/13/88	320 to 505, 507 to 671
JL-49-05-303 (53)	4,044	870	18	18 12	480	1,449 1988	338.00 05/16/55	384.40 12/19/90	380 to 870
JL-49-05-304 (54)	4,055	753	18	18 12	--	--	338.00 07/15/55	380.97 12/09/90	377 to 753; not connected to system
JL-49-05-501 (31)	4,000	730	18	18 12	540	873 1988	320.00 12/25/56	379.55 12/23/83	319 to 498, 500 to 730
JL-49-05-502	4,042	567	4	4	--	--	336.54 06/26/40	402.29 12/12/89	342 to 381, 440 to 461, 474 to 492, 502 to 524
JL-49-05-504 (52)	4,130	1,152	18	18 12	660	744 1988	449.50 12/28/63	510.06 01/07/91	461 to 1,152
JL-49-05-601 (36)	3,996	690	18	18 12	480	1,456 1988	299.43 01/06/59	349.92 12/19/90	350 to 690
JL-49-05-602 (35)	4,005	699	18	18 12	460	1,365 1988	309.98 01/06/59	357.01 12/19/90	354 to 699
JL-49-05-603 (32)	3,983	657	18	18 12	480	1,206 1988	293.74 01/06/59	351.62 12/18/90	335 to 506, 508 to 657
JL-49-05-604 (34)	3,970	802	18	18 12	440	1,670 1988	279.45 02/13/58	381.97 12/19/90	325 to 500, 501 to 802

Footnote at end of table.



**Table 5. Characteristics of wells--Continued**

Well number <sup>1</sup>	Land-surface elevation above sea level (ft)	Well depth below land surface (ft)	Diameter (in.)		Pump setting below land surface (ft)	Pumping rate (gal/min)	Water level below land surface (ft)		Screened depths below land surface (ft) and remarks
			Well casing	Well screen		Recent and year measured	Original and date measured	Recent and date measured	
Production wells--Continued									
JL-49-05-605 (44)	3,986	769	18	18 12	440	1,115 1988	300.65 08/12/60	343.10 12/13/88	324 to 769
JL-49-05-607 (40)	3,925	826	18	18 12	460	1,441 1988	244.10 12/14/60	306.65 12/14/89	308 to 826
JL-49-05-615 (29A)	3,958	920	16	16	440	1,429 1988	320.58 12/14/82	328.58 12/18/90	557 to 677, 717 to 797, 836 to 920
JL-49-05-802 (26)	3,967	830	18	18 12	460	1,012 1988	320.26 01/31/73	355.54 12/18/90	360 to 464, 467 to 820
JL-49-05-901 (28)	3,942	727	18	18 12	430	923 1988	257.60 01/06/59	325.72 12/19/90	348 to 447, 449 to 727
JL-49-05-906 (62)	3,923	950	18	18 12	480	1,909 1988	252.34 03/16/66	300.40 12/04/89	330 to 950
JL-49-06-401 (59)	3,998	451	18	18	--	--	308.36 12/29/65	334.81 12/19/90	348 to 451; not connected to system
JL-49-06-402 (56)	4,013	670	18	18 12	450	1,458 1988	329.89 01/04/65	362.79 12/12/90	352 to 670
JL-49-06-404	3,998	683	14	14	420	--	335.00 08/23/75	--	396 to 676

<sup>1</sup> El Paso Water Utilities-Public Service Board well number is in parentheses.

**Table 6.** Analytical method, method-reporting limit, sample volume, preservation and bottle requirements, and holding times for water samples

[USGS, U.S. Geological Survey; SH, lab schedule; LC, lab code; mL, milliliters; mg/L, milligram per liter; mg, milligrams; µg/L, micrograms per liter; SMOW, standard mean ocean water; --, not applicable; PDB, Pee Dee Belemnite; L, liter; ng/L, nanograms per liter]

USGS schedule or lab code	Constituent	Analytical method <sup>1</sup>	Method- reporting limit	Sample volume, preservation and bottle-requirement code <sup>2</sup>	Holding time <sup>3</sup> (days)
SH 1022 plus LC 1183, LC 1284	Major ions and trace elements:			250 mL FU, 100 mL RU, 250 mL FA	
	Calcium, dissolved	I-1152-85	0.1 mg/L	"	42
	Magnesium, dissolved	I-1447-85	.1 mg/L	"	42
	Sodium, dissolved	I-1735-85	.1 mg/L	"	42
	Potassium, dissolved	I-1630-85	.1 mg/L	"	42
	Sulfate, dissolved	I-2057-85	1 mg/L	"	28
	Chloride, dissolved	I-2057-85	.1 mg/L	"	28
	Fluoride, dissolved	I-2057-85	.1 mg/L	"	28
	Bromide, dissolved	I-2057-85	.01 mg/L	"	28
	Iodide, dissolved	I-2057-85	.001 mg/L	"	28
	Silica, dissolved as SiO <sub>2</sub>	I-1702-85	.1 mg/L	"	42
	Aluminum, total	I-1051-85	10 µg/L	"	42
	Boron, dissolved	I-1114-85	.01 µg/L	"	42
SH 0230 plus LC 0162	Nutrients:			250 mL FC	8
	Nitrite, dissolved as N	I-2540-85	.01 mg/L	"	
	Nitrite plus nitrate, dissolved as N	I-2545-85	.10 mg/L	"	
	Nitrogen, ammonia, dissolved as N	I-2522-85	.01 mg/L	"	
	Nitrogen, ammonia plus organic, dissolved as N	I-2552-85	.20 mg/L	"	
	Phosphorous, dissolved as P	I-2600-85	.01 mg/L	"	
	Phosphorous, dissolved orthophosphate as P	I-2601-85	.01 mg/L	"	
LC 0489	Oxygen-18/oxygen-16 (δ <sup>18</sup> O), aqueous, per mil relative to SMOW	Epstein and Mayeda (1953)	.15 per mil	60 mL RU	--
LC 0300	Deuterium/protium (δD), aqueous, per mil relative to SMOW	Coplin and others (1991)	1.5 per mil	60 mL RU	--
LC 0440	Carbon-13/carbon-12 (δ <sup>13</sup> C), aqueous, per mil relative to PDB	Gleason and others (1969)	.2 per mil	250 mg PPT, RU	--
LC 0114	Carbon, organic, total as C	O-3100-83	.1 mg/L	100 mL LC 0114	28

Footnotes at end of table.

**Table 6.** Analytical method, method-reporting limit, sample volume, preservation and bottle requirements, and holding times for water samples--Continued

USGS schedule or lab code	Constituent	Analytical method <sup>1</sup>	Method- reporting limit	Sample volume, preservation and bottle-requirement code <sup>2</sup>	Holding time <sup>3</sup> (days)
LC 0113	Carbon, organic, dissolved as C	O-1100-83	0.1 mg/L	100 mL LC 0113	28
LC 0305	Carbon, organic, suspended as C	O-7100-83	.1 mg/L	100 mL LC 0305	28
LC 0096	Methylene blue active substances, total recoverable	O-3111-83	.02 mg/L	250 mL RCB	14
SH 1391	Volatile organic compounds:	O-3115-83		3x40 mL GCV	14
	Benzene	"	.2 µg/L	"	
	Bromochloromethane	"	.2 µg/L	"	
	Dichlorobromomethane	"	.2 µg/L	"	
	Bromoform	"	.2 µg/L	"	
	Bromomethane	"	.2 µg/L	"	
	Carbon tetrachloride	"	.2 µg/L	"	
	Chlorobenzene	"	.2 µg/L	"	
	Chloroethane	"	.2 µg/L	"	
	2-Chloroethyl vinyl ether	"	.2 µg/L	"	
	Chloroform	"	.2 µg/L	"	
	Chloromethane	"	.2 µg/L	"	
	Dibromochloromethane	"	.2 µg/L	"	
	1,2-Dibromoethane	"	.2 µg/L	"	
	1,2-Dichlorobenzene	"	.2 µg/L	"	
	1,3-Dichlorobenzene	"	.2 µg/L	"	
	1,4-Dichlorobenzene	"	.2 µg/L	"	
	Dichlorodifluoromethane	"	.2 µg/L	"	
	1,2-Dibromoethene	"	.2 µg/L	"	
	1,1-Dichloroethane	"	.2 µg/L	"	
	1,2-Dichloroethane	"	.2 µg/L	"	
	1,1-Dichloroethene	"	.2 µg/L	"	
	1,2-trans-Dichloroethene	"	.2 µg/L	"	
	Dichloromethane	"	.2 µg/L	"	
	1,2-Dichloropropane	"	.2 µg/L	"	
	Cis-1,3-Dichloropropene	"	.2 µg/L	"	
	Trans-1,3-Dichloropropene	"	.2 µg/L	"	
	1,3-Dichloropropene	"	.2 µg/L	"	
	Ethylbenzene	"	.2 µg/L	"	

Footnotes at end of table.

**Table 6.** Analytical method, method-reporting limit, sample volume, preservation and bottle requirements, and holding times for water samples--Continued

USGS schedule or lab code	Constituent	Analytical method <sup>1</sup>	Method- reporting limit	Sample volume, preservation and bottle-requirement code <sup>2</sup>	Holding time <sup>3</sup> (days)
SH 1391	Volatile organic compounds:--Continued	O-3115-83		3x40 mL GCV	14
	Ethenylbenzene	"	0.2 µg/L	"	
	Methylene chloride	"	.2 µg/L	"	
	Styrene	"	.2 µg/L	"	
	1,1,2,2-Tetrachloroethane	"	.2 µg/L	"	
	Tetrachloroethene	"	.2 µg/L	"	
	Toluene	"	.2 µg/L	"	
	1,1,1-Trichloroethane	"	.2 µg/L	"	
	1,1,2-Trichloroethane	"	.2 µg/L	"	
	Trichloroethene	"	.2 µg/L	"	
	Trichlorofluoromethane	"	.2 µg/L	"	
	Vinyl chloride	"	.2 µg/L	"	
	Xylenes, mixed	"	.2 µg/L	"	
	Volatile organic compounds, selected-ion monitoring method:	E-501.3		3x40 mL GCV	14
	Bromochloromethane	"	20 ng/L	"	
	Dichlorobromomethane	"	20 ng/L	"	
	Bromoform	"	20 ng/L	"	
	Chloroform	"	20 ng/L	"	
	Dibromochloromethane	"	20 ng/L	"	
	Dibromomethane	"	20 ng/L	"	
	Dichloromethane	"	20 ng/L	"	
	Trichlorofluoromethane	"	50 ng/L	"	
SH 1383	Methylene chloride-extractable semivolatile organic compounds:	O-3117-83, O-3118-83		1 L GCC	<sup>4</sup> 2/45
	Acenaphthene	"	5.0 µg/L	"	
	Acenaphthylene	"	5.0 µg/L	"	
	Anthracene	"	5.0 µg/L	"	
	Benzo (a) anthracene	"	10.0 µg/L	"	
	Benzo (b) fluoranthene	"	10.0 µg/L	"	
	Benzo (k) fluoranthene	"	10.0 µg/L	"	
	Benzo (g,h,i) perylene	"	10.0 µg/L	"	
	Benzo (a) pyrene	"	10.0 µg/L	"	

Footnotes at end of table.

**Table 6.** Analytical method, method-reporting limit, sample volume, preservation and bottle requirements, and holding times for water samples--Continued

USGS schedule or lab code	Constituent	Analytical method <sup>1</sup>	Method- reporting limit	Sample volume, preservation and bottle-requirement code <sup>2</sup>	Holding time <sup>3</sup> (days)
SH 1383	Methylene chloride-extractable semivolatile organic compounds--Continued	O-3117-83, O-3118-83		1 L GCC	42/45
	4-Bromophenol phenylether	"	5.0    µg/L	"	
	Butyl benzyl phthalate	"	5.0    µg/L	"	
	bis (2-Chloroethoxy) methane	"	5.0    µg/L	"	
	bis (2-Chloroethyl) ether	"	5.0    µg/L	"	
	bis (2-Chloroisopropyl) ether	"	5.0    µg/L	"	
	bis (2-Ethylhexyl) phthalate	"	5.0    µg/L	"	
	2-Chloronaphthalene	"	5.0    µg/L	"	
	2-Chlorophenol	"	5.0    µg/L	"	
	4-Chlorophenyl phenyl ether	"	5.0    µg/L	"	
	Chrysene	"	10.0   µg/L	"	
	Dibenzo (a,h) anthracene	"	10.0   µg/L	"	
	1,2-Dichlorobenzene	"	5.0    µg/L	"	
	1,3-Dichlorobenzene	"	5.0    µg/L	"	
	1,4-Dichlorobenzene	"	5.0    µg/L	"	
	2,4-Dichlorophenol	"	5.0    µg/L	"	
	Diethyl phthalate	"	5.0    µg/L	"	
	2,4-Dimethylphenol	"	5.0    µg/L	"	
	4,6-Dinitro-ortho-cresol	"	30.0   µg/L	"	
	Dimethyl phthalate	"	5.0    µg/L	"	
	Di-n-butyl phthalate	"	5.0    µg/L	"	
	2,4-Dinitrophenol	"	20.0   µg/L	"	
	2,4-Dinitrotoluene	"	5.0    µg/L	"	
	2,6-Dinitrotoluene	"	5.0    µg/L	"	
	Di-n-octylphthalate	"	10.0   µg/L	"	
	Fluoranthene	"	5.0    µg/L	"	
	Fluorene	"	5.0    µg/L	"	
	Hexachlorobenzene	"	5.0    µg/L	"	
	Hexachlorobutadiene	"	5.0    µg/L	"	
	Hexachlorocyclopentadiene	"	5.0    µg/L	"	
	Hexachloroethane	"	5.0    µg/L	"	
	Indeno (1,2,3-cd) pyrene	"	10.0   µg/L	"	
	Isophorone	"	5.0    µg/L	"	

Footnotes at end of table.

**Table 6.** Analytical method, method-reporting limit, sample volume, preservation and bottle requirements, and holding times for water samples--Continued

USGS schedule or lab code	Constituent	Analytical method <sup>1</sup>	Method- reporting limit	Sample volume, preservation and bottle-requirement code <sup>2</sup>	Holding time <sup>3</sup> (days)
SH 1383	Methylene chloride-extractable semivolatile organic compounds:--Continued	O-3117-83, O-3118-83		1 L GCC	<sup>4</sup> 2/45
	Naphthalene	"	5.0 µg/L	"	
	Nitrobenzene	"	5.0 µg/L	"	
	2-Nitrophenol	"	5.0 µg/L	"	
	n-Nitrosodimethylamine	"	5.0 µg/L	"	
	n-Nitroso-n-propylamine	"	5.0 µg/L	"	
	n-Nitrosuphenylamine	"	5.0 µg/L	"	
	Para-chloro-meta cresol	"	30.0 µg/L	"	
	Pentachlorophenol	"	30.0 µg/L	"	
	Phenanthrene	"	5.0 µg/L	"	
	Phenol	"	5.0 µg/L	"	
	Pyrene	"	5.0 µg/L	"	
	1,2,4-Trichlorobenzene	"	5.0 µg/L	"	
	TA2,4,6-Trichlorophenol	"	20.0 µg/L	"	

<sup>1</sup> Analytical method numbers preceded by I are from Fishman and Friedman (1989); method numbers preceded by O are from Wershaw and others (1987); and method numbers preceded by E are from the U.S. Environmental Protection Agency (1983).

<sup>2</sup> See table 7 for explanation of codes.

<sup>3</sup> Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods if data are on file to show that the specific types of samples under study are stable for the longer time.

<sup>4</sup> Extraction within 2 days, analysis within 45 days of extraction.

**Table 9.** Physical properties of water from injection, observation, and production wells, 1990 and 1991[ $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 °C; °C, degrees Celsius; mg/L, milligrams per liter]

Well number <sup>1</sup>	Date sampled	Physical properties, 1990			
		Specific conductance (μS/cm)	pH (standard units)	Temperature (°C)	Dissolved oxygen (mg/L)
<u>Injection well</u>					
JL-49-05-613 (RW-8) - injected	08/29/90	1,180	7.2	30.5	6.3
	08/31/90	1,080	7.2	30.5	5.5
	09/01/90	1,080	7.2	30.0	5.8
<u>Observation wells</u>					
JL-49-05-618 (OB-5)	08/28/90	652	7.9	27.0	1.5
JL-49-05-621 (OB-4A)	08/25/90	997	7.6	25.5	5.9
JL-49-05-622 (OB-4B)	08/24/90	870	7.8	27.5	3.5
JL-49-05-625 (OB-7A)	08/27/90	1,010	7.6	27.0	4.7
JL-49-05-626 (OB-7B)	08/27/90	680	7.9	27.0	2.3
JL-49-06-405 (OB-1)	08/28/90	1,060	7.8	26.0	3.6
<u>Production wells</u>					
JL-49-05-204 (41)	08/30/90	857	7.8	29.0	1.7
JL-49-05-301 (42)	08/23/90	637	7.9	26.0	3.7
JL-49-05-501 (31)	08/23/90	779	7.8	27.5	4.5
JL-49-05-601 (36)	08/30/90	829	7.7	26.0	4.6
JL-49-05-602 (35)	08/22/90	2,070	7.3	25.0	4.3
JL-49-05-603 (32)	08/21/90	699	7.9	26.5	2.4
JL-49-05-604 (34)	08/22/90	951	7.8	25.5	4.0
JL-49-05-605 (44)	09/01/90	973	7.9	25.0	4.2
JL-49-05-607 (40)	08/20/90	478	8.1	25.0	4.0
JL-49-05-615 (29A)	08/31/90	827	7.8	27.0	1.1
JL-49-06-402 (56)	09/01/90	1,090	7.9	25.0	4.9

Footnotes at end of table.

**Table 9.** Physical properties of water from injection, observation, and production wells, 1990 and 1991--Continued

Well number <sup>1</sup>	Date sampled	Physical properties, 1991			
		Specific conductance (μS/cm)	pH (standard units)	Temperature (°C)	Dissolved oxygen (mg/L)
<u>Injection wells</u>					
JL-49-05-613 (RW-8) - injected	08/25/91	960	7.6	31.0	5.3
JL-49-05-624 (RW-7) - injected	08/27/91	996	7.6	30.9	5.6
JL-49-05-624 (RW-7) - pumped <sup>2</sup>	09/08/91	943	7.6	30.4	3.4
JL-49-05-624 (RW-7) - pumped <sup>3</sup>	09/08/91	928	7.6	30.8	4.9
JL-49-05-624 (RW-7) - pumped <sup>4</sup>	09/08/91	927	7.5	31.1	5.1
<u>Observation wells</u>					
JL-49-05-618 (OB-5)	08/30/91	<sup>5</sup> 683	8.0	27.0	1.2
JL-49-05-621 (OB-4A)	08/29/91	<sup>5</sup> 1,030	7.3	25.5	2.9
JL-49-05-622 (OB-4B)	08/29/91	<sup>5</sup> 876	7.6	27.0	2.6
JL-49-05-625 (OB-7A)	08/27/91	<sup>5</sup> 1,050	7.6	26.5	4.5
JL-49-05-626 (OB-7B)	08/27/91	733	7.8	26.7	1.4
JL-49-06-405 (OB-1)	08/30/91	<sup>5</sup> 1,040	7.6	26.5	2.8
<u>Production wells</u>					
JL-49-05-204 (41)	08/23/91	<sup>5</sup> 891	7.8	29.5	1.7
JL-49-05-303 (53)	09/07/91	<sup>5</sup> 3,110	7.8	27.9	.7
JL-49-05-601 (36)	08/26/91	<sup>5</sup> 940	7.8	25.9	5.9
JL-49-05-602 (35)	09/10/91	<sup>5</sup> 783	7.9	26.3	1.9
JL-49-05-603 (32)	08/25/91	663	7.9	27.1	2.3
JL-49-05-605 (44)	09/07/91	828	7.9	25.3	4.3
JL-49-05-607 (40)	08/24/91	469	7.0	25.0	3.8
JL-49-05-615 (29A)	08/27/91	808	7.9	28.2	1.2
JL-49-06-401 (59)	09/09/91	782	7.9	24.2	5.9

Footnotes at end of table.



**Table 9.** Physical properties of water from injection, observation, and production wells, 1990 and 1991--Continued

Well number <sup>1</sup>	Date sampled	Physical properties, 1991			
		Specific conductance (μS/cm)	pH (standard units)	Temperature (°C)	Dissolved oxygen (mg/L)
<u>Production wells--Continued</u>					
JL-49-06-402 (56)	08/24/91	1,005	7.9	25.8	4.0
JL-49-06-404	09/06/91	1,026	7.9	24.9	5.2

<sup>1</sup> El Paso Water Utilities-Public Service Board well number is in parentheses.

<sup>2</sup> Sample produced after 24,000 gallons of water were pumped from the aquifer.

<sup>3</sup> Sample produced after 182,000 gallons of water were pumped from the aquifer.

<sup>4</sup> Sample produced after 336,000 gallons of water were pumped from the aquifer.

<sup>5</sup> Laboratory specific conductance.

**Table 10.** Concentrations of major ions and trace elements in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)

[mg/L, milligrams per liter; <, less than; --, no data; µg/L, micrograms per liter; NA, not applicable to these wells. Most probable concentration of constituent in blind-reference sample is in brackets.]

	Well number <sup>1</sup>		
	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected
Date sampled	08/29/90	08/31/90	08/31/90 (duplicate)
Concentrations of major ions, in mg/L			
Cations			
Calcium, dissolved	56	56	57
Magnesium, dissolved	1.5	1.4	1.4
Sodium, dissolved	170	160	160
Potassium, dissolved	16	16	16
Anions			
Bicarbonate	186	178	178
Carbonate	<1	<1	<1
Sulfate, dissolved	100	110	110
Chloride, dissolved	190	180	180
Fluoride, dissolved	.70	.90	1.0
Bromide	.17	.14	.17
Iodide	.019	.065	.036
Silica, dissolved	27	25	25
Solids, sum of constituents <sup>2</sup>	653	637	638
Concentrations of trace element, in µg/L			
Boron, dissolved as B	340	290	300
Footnotes at end of table.			

**Table 10. Concentrations of major ions and trace elements in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued**

	Well number <sup>1</sup>									
	Observation wells									
	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-625 (OB-7A)	JL-49-05-625 (OB-7A)	JL-49-05-626 (OB-7B)	JL-49-05-626 (OB-7B)
Date sampled	08/28/90	08/25/90	08/29/90	08/24/90	08/29/90	08/27/90	08/27/90	08/27/90	08/28/90	08/28/90
Depth sampled (feet below land surface)	NA	430	640	430	690	430	605	430	605	NA
Concentrations of major ions, in mg/L										
Cations										
Calcium, dissolved	30	53	51	46	46	51	50	31	32	36
Magnesium, dissolved	6.3	11	11	9.3	9.0	13	13	8.2	8.4	8.0
Sodium, dissolved	90	150	160	110	110	140	150	92	94	150
Potassium, dissolved	6.1	7.4	7.4	7.0	7.3	12	13	10	10	7.1
Anions										
Bicarbonate	99	220	222	128	128	207	209	139	129	193
Carbonate	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sulfate, dissolved	29	99	99	65	67	100	99	47	43	82
Chloride, dissolved	140	160	160	150	150	170	150	110	120	160
Fluoride, dissolved	.40	.40	.40	.40	.40	.20	.30	.60	.60	.40
Bromide	.15	.19	.21	.23	.12	.21	.21	.16	.03	.23
Iodide	.014	.029	.028	.019	.023	.028	.030	.024	.007	.022
Silica, dissolved	33	34	34	35	35	34	34	33	33	34
Solids, sum of constituents <sup>2</sup>	384	623	632	486	488	622	613	400	405	573
Concentrations of trace element, in µg/L										
Boron, dissolved as B	80	300	290	140	140	260	260	120	120	210

Footnotes at end of table.

**Table 10. Concentrations of major ions and trace elements in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued**

		Well number <sup>1</sup>									
		Production wells									
		JL-49-05-204 (41)	JL-49-05-301 (42)	JL-49-05-501 (31)	JL-49-05-601 (36)	JL-49-05-602 (35)	JL-49-05-603 (32)	JL-49-05-603 (32)	JL-49-05-604 (34)	JL-49-05-605 (44)	JL-49-05-605 (44)
Date sampled		08/30/90	08/23/90	08/23/90	08/30/90	08/22/90	08/21/90	08/21/90 (duplicate)	08/22/90	09/01/90	09/01/90 (duplicate)
Concentrations of major ions, in mg/L											
Cations											
Calcium, dissolved	33	29	34	48	150	28	28	28	53	52	52
Magnesium, dissolved	7.3	6.2	14	13	29	7.8	7.8	7.8	12	10	10
Sodium, dissolved	130	80	110	110	220	100	100	100	100	120	120
Potassium, dissolved	8.5	6.1	3.5	11	9.5	9.0	9.0	9.0	7.5	6.6	6.6
Anions											
Bicarbonate	165	140	215	156	162	165	165	165	103	93	93
Carbonate	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sulfate, dissolved	83	43	68	110	190	66	66	67	65	28	28
Chloride, dissolved	140	80	93	130	400	90	90	89	190	240	240
Fluoride, dissolved	90	.70	1.4	.70	.60	.80	.80	.80	.50	.20	.40
Bromide	.18	.16	.18	.23	.52	.17	.17	.17	.29	--	.23
Iodide	.026	.019	.018	.065	.061	.022	.022	.022	.029	--	.017
Silica, dissolved	33	33	31	30	35	33	33	34	32	32	31
Solids, sum of constituents <sup>2</sup>	517	347	461	530	1,114	416	416	417	511	535	534
Concentrations of trace element, in µg/L											
Boron, dissolved as B	110	100	90	230	680	120	120	110	120	--	80

Footnotes at end of table.

**Table 10. Concentrations of major ions and trace elements in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued**

	Well number <sup>1</sup>			
	Production wells--Continued			
Date sampled	JL-49-05-607 (40)	JL-49-05-615 (29A)	JL-49-06-402 (56)	JL-49-06-402 (56)
	08/20/90	08/31/90	09/01/90	09/01/90 (duplicate)
Concentrations of major ions, in mg/L				
Cations				
Calcium, dissolved	20	30	51	51
Magnesium, dissolved	5.3	8.8	10	10
Sodium, dissolved	67	120	150	150
Potassium, dissolved	6.9	9.6	6.7	6.6
Anions				
Bicarbonate	135	155	96	96
Carbonate	<1	<1	<1	<1
Sulfate, dissolved	41	59	20	20
Chloride, dissolved	51	140	290	290
Fluoride, dissolved	.70	.60	.50	.30
Bromide	.15	.14	.26	.26
Iodide	.017	.041	.019	.019
Silica, dissolved	31	33	32	31
Solids, sum of constituents <sup>2</sup>	290	478	608	606
Concentrations of trace element, in µg/L				
Boron, dissolved as B	90	100	80	70

Footnotes at end of table.

**Table 10. Concentrations of major ions and trace elements in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued**

	Well number <sup>1</sup>						
	Injection wells						
	JL-49-05-613 (RW-8) <sup>1</sup> Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-624 (RW-7) Injected	JL-49-05-624 (RW-7) pumped <sup>3</sup>	JL-49-05-624 (RW-7) pumped <sup>4</sup>	JL-49-05-624 (RW-7) pumped <sup>5</sup>
Date sampled	08/25/91	08/25/91 (duplicate)	08/25/91 (duplicate)	08/27/91	09/08/91	09/08/91	09/08/91
Concentrations of major ions, in mg/L							
Cations							
Calcium, dissolved	48	47	48	50	52	51	53
Magnesium, dissolved	2.3	1.7	2.0	2.2	1.9	1.7	2.0
Sodium, dissolved	160	150	150	160	150	150	150
Potassium, dissolved	14	15	18	15	16	17	17
Anions							
Bicarbonate	203	203	203	204	223	211	212
Carbonate	<1	<1	<1	<1	<1	<1	<1
Sulfate, dissolved	97	78	90	89	97	81	82
Chloride, dissolved	140	120	140	150	160	160	160
Fluoride, dissolved	.80	.90	1.0	.90	.70	.60	.70
Bromide	--	--	--	.22	.21	.21	.21
Silica, dissolved	30	28	28	31	29	29	29
Solids, sum of constituents <sup>2</sup>	592	541	577	599	617	594	598
Concentrations of trace elements, in µg/L							
Aluminum, total as Al	20	20	20	20	<10	10	10
Boron, dissolved as B	280	270	280	270	300	280	290

Footnotes at end of table.

**Table 10. Concentrations of major ions and trace elements in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued**

	Well number <sup>1</sup>									
	Observation wells									
	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-625 (OB-7A)	JL-49-05-625 (OB-7A)	JL-49-05-625 (OB-7B)	JL-49-05-626 (OB-7B)	JL-49-06-405 (OB-1)	
Date samples	08/30/91	08/29/91	08/29/91	08/29/91	08/27/91	08/27/91	08/27/91	08/27/91	08/30/91	
Depth samples (feet below land surface)	NA	605	430	605	430	605	430	605	NA	
Concentrations of major ions, in mg/L										
Cations										
Calcium, dissolved	31	48	48	48	53	49	33	36	39	
Magnesium, dissolved	5.9	9.2	9.0	9.3	14	12	7.1	8.4	8.0	
Sodium, dissolved	98	160	120	120	150	150	93	100	170	
Potassium, dissolved	5.8	7.2	6.5	6.8	10	11	8.9	9.3	6.4	
Anions										
Bicarbonate	106	220	148	151	219	216	141	152	200	
Carbonate	<1	<1	<1	<1	<1	<1	<1	<1	<1	
Sulfate, dissolved	31	89	70	66	93	100	50	40	85	
Chloride, dissolved	130	140	150	140	140	160	130	130	160	
Fluoride, dissolved	.60	.50	.40	.50	.60	.50	.80	.70	.70	
Bromide	--	--	--	--	.25	--	.18	.18	--	
Silica, dissolved	31	31	33	33	31	32	30	30	32	
Solids, sum of constituents <sup>2</sup>	386	594	510	498	600	621	422	429	600	
Concentrations of trace elements, in µg/L										
Aluminum, total as Al	<10	20	20	<10	<10	10	40	<10	<10	
Boron, dissolved as B	90	360	170	170	290	280	120	110	250	

Footnotes at end of table.

**Table 10. Concentrations of major ions and trace elements in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued**

		Well number <sup>1</sup>										
		Production wells										
		JL-49- 05-204 (41)	JL-49- 05-303 (53)	JL-49- 05-601 (36)	JL-49- 05-602 (35)	JL-49- 05-602 (35)	JL-49- 05-602 (35) (duplicate)	JL-49- 05-603 (32)	JL-49- 05-605 (44)	JL-49- 05-607 (40)	JL-49- 05-615 (29A)	JL-49- 06-401 (59)
Date sampled		08/23/91	09/07/91	08/26/91	09/10/91	09/10/91		08/25/91	09/07/91	08/24/91	08/27/91	09/09/91
Concentrations of major ions, in mg/L												
Cations												
Calcium, dissolved	34		140	54	42	42	42	29	52	21	31	59
Magnesium, dissolved	7.7		26	13	8.2	8.2	8.2	7.8	9.9	5.6	7.0	9.6
Sodium, dissolved	130		410	110	95	95	93	100	110	71	120	110
Potassium, dissolved	8.7		13	12	5.8	5.8	5.8	8.4	7.5	6.6	8.9	7.3
Anions												
Bicarbonate	151		67	155	108	108	108	168	90	131	149	88
Carbonate	<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sulfate, dissolved	86		55	120	40	40	40	68	29	44	58	28
Chloride, dissolved	140		980	130	170	170	160	84	240	54	140	270
Fluoride, dissolved	.90		.50	.70	.60	.60	.60	.80	.50	.80	.90	.50
Bromide	--		--	--	--	--	--	--	--	--	--	--
Silica, dissolved	35		33	33	31	31	31	33	32	31	33	30
Solids, sum of constituents <sup>2</sup>	517		1,690	549	446	446	434	414	525	298	472	558
Concentrations of trace elements, in µg/L												
Aluminum, total as Al	<10		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Boron, dissolved as B	120		80	270	120	120	120	120	90	100	110	80

Footnotes at end of table.



**Table 10. Concentrations of major ions and trace elements in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued**

	Well number <sup>1</sup>				Quality-assurance samples			
	Production wells--Continued							
	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-404	Blind-reference sample	Blind-reference sample	Blind-reference sample	Blind-reference sample
Date sampled	08/24/91	08/24/91	08/24/91	09/06/91	08/29/91	08/29/91	09/10/91	
Date prepared		(duplicate)	(duplicate)					
Concentrations of major ions, in mg/L								
Cations								
Calcium, dissolved	49	48	50	80	35 [33]	34 [33]	37 [36]	
Magnesium, dissolved	9.4	7.4	8.3	14	17 [16]	16 [16]	17 [17]	
Sodium, dissolved	150	140	150	140	43 [44]	42 [44]	54 [54]	
Potassium, dissolved	6.2	5.8	5.8	7.8	2.5 [2.6]	2.6 [2.6]	3.0 [2.6]	
Anions								
Bicarbonate	100	100	100	77	-- --	-- --	-- --	
Carbonate	<1	<1	<1	<1	-- --	-- --	-- --	
Sulfate, dissolved	27	28	24	28	110 [104]	96 [104]	110 [104]	
Chloride, dissolved	260	270	240	360	32 [29]	29 [29]	45 [43]	
Fluoride, dissolved	.60	.80	.70	.50	1.3 [1.1]	1.2 [1.1]	1.2 [1.2]	
Bromide	--	--	--	--	-- --	-- --	-- --	
Silica, dissolved	32	30	30	31	9.8 [10.2]	9.8 [10.2]	13 [13]	
Solids, sum of constituents <sup>2</sup>	584	579	558	699	-- --	-- --	-- --	
Concentrations of trace elements, in µg/L								
Aluminum, total as Al	<10	<10	<10	<10	-- --	-- --	-- --	
Boron, dissolved as B	90	90	90	80	-- --	-- --	-- --	

<sup>1</sup> El Paso Water Utilities-Public Service Board well identification number is in parentheses.

<sup>2</sup> Bicarbonate concentration converted to carbonate concentration for computation of solids concentration by dividing by 2.03.

<sup>3</sup> Sample produced after 24,000 gallons of water were pumped from the aquifer.

<sup>4</sup> Sample produced after 182,000 gallons of water were pumped from the aquifer.

<sup>5</sup> Sample produced after 336,000 gallons of water were pumped from the aquifer.

**Table 11. Concentrations of nutrients in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)**

[mg/L, milligrams per liter; <, less than; NA, not applicable to these wells; --, no data. Most probable concentration of constituent in blind-reference sample is in brackets.]

	Well number <sup>1</sup>			
	Injection wells			
	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected
Date sampled	08/29/90	08/31/90	08/31/90 (duplicate)	09/01/90
Concentrations of nutrients, in mg/L				
Nitrite, dissolved as N	<0.01	<0.01	<0.01	<0.01
Nitrite plus nitrate, dissolved as N	2.3	2.8	2.8	2.4
Nitrogen, ammonia, dissolved as N	<.01	.02	.02	<.01
Nitrogen, ammonia plus organic, dissolved as N	.40	.40	.30	.40
Phosphorus, dissolved as P	.40	.38	.38	.41
Phosphorus, dissolved orthophosphate as P	.40	.38	.35	.40

**Table 11.** Concentrations of nutrients in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued

	Well number <sup>1</sup>													
	Observation wells													
	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-625 (OB-7A)	JL-49-05-625 (OB-7A)	JL-49-05-626 (OB-7B)	JL-49-05-626 (OB-7B)	JL-49-06-405 (OB-1)			
Date sampled	08/28/90	08/25/90	08/29/90	08/24/90	08/29/90	08/27/90	08/27/90	08/27/90	08/27/90	08/28/90	08/28/90	08/28/90	08/28/90	08/28/90
Depth sampled (feet below land surface)	NA	430	640	430	690	430	605	430	605	605	NA			
Concentrations of nutrients, in mg/L														
Nitrite, dissolved as N	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01			
Nitrite plus nitrate, dissolved as N	1.5	2.8	2.8	2.0	2.1	2.9	2.8	1.8	1.7	2.3				
Nitrogen, ammonia, dissolved as N	.02	<.01	.01	.01	.02	.06	.05	.04	.01	<.01				
Nitrogen, ammonia plus organic, dissolved as N	.40	.30	.60	.30	.50	.70	.60	.20	.30	.30				
Phosphorus, dissolved as P	<.01	.01	.02	.01	<.01	.04	<.01	<.01	<.01	<.01				
Phosphorus, dissolved orthophosphate as P	<.01	<.01	.02	<.01	<.01	.02	<.01	<.01	.01	<.01				

Footnotes at end of table.

**Table 11. Concentrations of nutrients in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued**

	Well number <sup>1</sup>									
	Production wells									
	JL-49-05-204 (41)	JL-49-05-301 (42)	JL-49-05-501 (31)	JL-49-05-601 (36)	JL-49-05-602 (35)	JL-49-05-603 (32)	JL-49-05-603 (32)	JL-49-05-604 (34)		
Date sampled	08/30/90	08/23/90	08/23/90	08/30/90	08/22/90	08/21/90	08/21/90 (duplicate)	08/22/90		
Concentrations of nutrients, in mg/L										
Nitrite, dissolved as N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
Nitrite plus nitrate, dissolved as N	1.2	1.7	1.3	2.4	6.4	1.5	1.5	3.5		
Nitrogen, ammonia, dissolved as N	.02	<.01	.01	.02	<.01	1.5	<.01	.02		
Nitrogen, ammonia plus organic, dissolved as N	<.20	.20	<.20	.20	.60	<.20	.30	.60		
Phosphorus, dissolved as P	<.01	.01	.01	.01	<.01	<.01	<.01	<.01		
Phosphorus, dissolved orthophosphate as P	.01	<.01	<.01	.01	<.01	<.01	<.01	.01		

**Table 11. Concentrations of nutrients in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued**

	Well number <sup>1</sup>					
	Production wells--Continued					
	JL-49-05-605 (44)	JL-49-05-605 (44)	JL-49-05-607 (40)	JL-49-05-615 (29A)	JL-49-06-402 (56)	JL-49-06-402 (56)
Date sampled	09/01/90	09/01/90 (duplicate)	08/20/90	08/31/90	09/01/90	09/01/90 (duplicate)
Concentrations of nutrients, in mg/L						
Nitrite, dissolved as N	<.01	<.01	<.01	<.01	<.01	<.01
Nitrite plus nitrate, dissolved as N	2.0	2.0	2.1	1.3	1.8	1.8
Nitrogen, ammonia, dissolved as N	<.01	<.01	<.01	.02	<.01	<.01
Nitrogen, ammonia plus organic, dissolved as N	.30	.50	.40	.20	.20	.40
Phosphorus, dissolved as P	<.01	.02	.02	<.01	.03	<.01
Phosphorus, dissolved orthophosphate as P	<.01	<.01	<.01	--	<.01	<.01

Footnotes at end of table.

**Table 11.** Concentrations of nutrients in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued

	Well number <sup>1</sup>					
	Injection wells					
	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-624 (RW-7) Injected	JL-49-05-624 (RW-7) pumped <sup>2</sup>	JL-49-05-624 (RW-7) pumped <sup>3</sup>
Date sampled	08/25/91	08/25/91 (duplicate)	08/25/91 (duplicate)	08/27/91	09/08/91	09/08/91
Concentrations of nutrients, in mg/L						
Nitrite, dissolved as N	<0.01	<0.01	<0.01	<0.01	0.03	<0.01
Nitrite plus nitrate, dissolved as N	3.3	3.2	3.2	2.4	3.2	2.8
Nitrogen, ammonia, dissolved as N	<0.01	<0.01	<0.01	<0.01	.02	<0.01
Nitrogen, ammonia plus organic, dissolved as N	.50	.20	.40	.60	.50	.50
Phosphorus, dissolved as P	.75	.71	.73	.72	.61	.62
Phosphorus, dissolved orthophosphate as P	.75	.74	.72	.73	.59	.58

**Table 11.** Concentrations of nutrients in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued

		Well number <sup>1</sup>									
		Observation wells									
		JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-625 (OB-7A)	JL-49-05-625 (OB-7A)	JL-49-05-626 (OB-7B)	JL-49-05-626 (OB-7B)	JL-49-06-405 (OB-1)
Date sampled		08/30/91	08/29/91	08/29/91	08/29/91	08/29/91	08/27/91	08/27/91	08/27/91	08/27/91	08/30/91
Depth sampled (feet below land surface)		NA	430	430	430	605	430	605	430	605	NA
Concentrations of nutrients, in mg/L											
Nitrite, dissolved as N		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite plus nitrate, dissolved as N		1.6	3.3	2.2	2.2	2.2	3.1	3.0	1.7	1.7	2.8
Nitrogen, ammonia, dissolved as N		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	.02	<0.01	<0.01
Nitrogen, ammonia plus organic, dissolved as N		<20	.30	.50	.40	.40	<20	.40	.50	<20	.40
Phosphorus, dissolved as P		<0.01	.02	<0.01	<0.01	<0.01	.01	.01	.02	<0.01	<0.01
Phosphorus, dissolved orthophosphate as P		<0.01	.02	<0.01	<0.01	<0.01	<0.01	<0.01	.02	<0.01	<0.01

Footnotes at end of table.

**Table 11. Concentrations of nutrients in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued**

	Well number <sup>1</sup>										
	Production wells										
	JL-49-05-204 (41)	JL-49-05-303 (53)	JL-49-05-601 (36)	JL-49-05-602 (35)	JL-49-05-602 (35)	JL-49-05-603 (32)	JL-49-05-605 (44)	JL-49-05-607 (40)	JL-49-05-615 (29A)	JL-49-06-401 (59)	
Date sampled	08/23/91	09/07/91	08/26/91	09/10/91	09/10/91	08/25/91	09/07/91	08/24/91	08/27/91	09/09/91	
Concentrations of nutrients, in mg/L					(duplicate)						
Nitrite, dissolved as N	<.01	<.01	0.01	<.01	<.01	<.01	<.01	<.01	0.01	<.01	
Nitrite plus nitrate, dissolved as N	1.2	.6	2.6	1.8	1.8	1.5	2.0	2.2	1.3	2.3	
Nitrogen, ammonia, dissolved as N	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
Nitrogen, ammonia plus organic, dissolved as N	<.20	.20	.40	.20	.20	.30	.30	.30	.60	.40	
Phosphorus, dissolved as P	<.01	.01	<.01	<.01	<.01	.01	<.01	.01	<.01	<.01	
Phosphorus, dissolved orthophosphate as P	<.01	<.01	.02	<.01	<.01	<.01	<.01	<.01	.02	<.01	



**Table 11. Concentrations of nutrients in water from injection, observation, and production wells (1990 and 1991), and quality-assurance samples (1991)--Continued**

	Well number <sup>1</sup>				Quality-assurance samples		
	Production wells--Continued				Blind-reference sample	Blind-reference sample	Blind-reference sample
	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-404			
Date sampled	08/24/91	08/24/91	08/24/91	09/06/91			
Date prepared		(duplicate)	(duplicate)		08/29/91	08/29/91	09/10/91
Concentrations of nutrients, in mg/L							
Nitrite, dissolved as N	<.01	<.01	<.01	<.01	0.06 [0.06]	0.06 [0.06]	0.20 [0.20]
Nitrite plus nitrate, dissolved as N	1.8	1.8	1.8	2.0	.52 [.58]	.53 [.58]	.88 [.97]
Nitrogen, ammonia, dissolved as N	<.01	<.01	<.01	<.01	.21 [.20]	.21 [.20]	.50 [.50]
Nitrogen, ammonia plus organic, dissolved as N	.30	<.20	<.20	.30	.50 [.55]	.60 [.55]	.90 [.82]
Phosphorus, dissolved as P	.01	<.01	<.01	<.01	.47 [.49]	.48 [.49]	.58 [.62]
Phosphorus, dissolved orthophosphate as P	<.01	<.01	<.01	<.01	.34 [.36]	.33 [.36]	.47 [.48]

<sup>1</sup> El Paso Water Utilities-Public Service Board well identification number is in parentheses.

<sup>2</sup> Sample produced after 24,000 gallons of water were pumped from the aquifer.

<sup>3</sup> Sample produced after 182,000 gallons of water were pumped from the aquifer.

<sup>4</sup> Sample produced after 336,000 gallons of water were pumped from the aquifer.

**Table 12. Concentrations of selected constituents in water from injection, observation, and production wells as determined using field colorimetric methods, 1990 and 1991**

[mg/L, milligrams per liter; <, less than; --, no data; µg/L, micrograms per liter; NA, not applicable to these wells]

	Well number <sup>1</sup>	
	Injection wells	
	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected
Date sampled	08/29/90	08/31/90
Concentrations, in mg/L		
Chlorine, free, total as Cl <sub>2</sub>	0.05	0.08
Nitrate, total as N	1.6	2.5
Nitrite, total as N	.04	.04
Nitrogen, ammonia, total as N	<.01	<.01
Concentrations, in µg/L		
Iron, total as Fe	20	40
Iron, ferrous as Fe	10	<10
		20
		<10
		0.02
		2.8
		.01
		--

**Table 12.** Concentrations of selected constituents in water from injection, observation, and production wells as determined using field colorimetric methods, 1990 and 1991--Continued

Well number <sup>1</sup>											
Observation wells											
	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-625 (OB-7A)	JL-49-05-625 (OB-7A)	JL-49-05-626 (OB-7B)	JL-49-05-626 (OB-7B)	JL-49-06-405 (OB-1)	
Date sampled	08/28/90	08/25/90	08/29/90	08/24/90	08/29/90	08/27/90	08/27/90	08/27/90	08/28/90	08/28/90	
Depth sampled (feet below land surface)	NA	430	640	430	690	430	605	430	605	NA	
Concentrations, in mg/L											
Chlorine, free, total as Cl <sub>2</sub>	0.01	<0.01	0.03	0.05	0.07	0.04	0.02	0.04	0.04	0.08	
Nitrate, total as N	1.3	2.4	2.4	2.1	1.9	2.6	2.3	2.6	1.3	1.9	
Nitrite, total as N	.03	.04	.09	.04	.02	.05	.09	.05	.08	.07	
Nitrogen, ammonia, total as N	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
Concentrations, in µg/L											
Iron, total as Fe	20	100	30	20	20	30	20	30	20	70	
Iron, ferrous as Fe	<10	30	<10	30	20	10	30	10	20	30	

Footnotes at end of table.

**Table 12.** Concentrations of selected constituents in water from injection, observation, and production wells as determined using field colorimetric methods, 1990 and 1991--Continued

	Well number <sup>1</sup>											
	Production wells											
	JL-49-05-204 (41)	JL-49-05-301 (42)	JL-49-05-501 (31)	JL-49-05-601 (36)	JL-49-05-602 (35)	JL-49-05-603 (32)	JL-49-05-604 (34)	JL-49-05-605 (44)	JL-49-05-607 (40)	JL-49-05-615 (29A)	JL-49-06-402 (56)	
Date sampled	08/30/90	08/23/90	08/23/90	08/30/90	08/22/90	08/21/90	08/22/90	09/01/90	08/20/90	08/31/90	09/01/90	
Concentrations, in mg/L												
Chlorine, free, total as Cl <sub>2</sub>	0.03	0.03	0.04	0.02	0.07	0.02	0.04	0.01	0.02	0.03	<0.01	
Nitrate, total as N	.80	1.3	.70	2.1	6.7	.90	2.8	2.8	2.1	1.4	1.4	
Nitrite, total as N	.06	.06	.05	.04	.04	.04	.05	.07	.02	.03	.08	
Nitrogen, ammonia, total as N	<.01	<.01	<.01	<.01	<.01	--	<.01	<.01	--	<.01	<.01	
Concentrations, in µg/L												
Iron, total as Fe	10	10	10	<10	20	10	<10	30	10	10	60	
Iron, ferrous as Fe	<10	<10	<10	10	<10	<10	10	30	<10	<10	<10	

**Table 12. Concentrations of selected constituents in water from injection, observation, and production wells as determined using field colorimetric methods, 1990 and 1991--Continued**

	Well number <sup>1</sup>			
	Injection wells			
	JL-49-05-613 (RW-8) Injected	JL-49-05-624 (RW-7) Injected	JL-49-05-624 (RW-7) pumped <sup>2</sup>	JL-49-05-624 (RW-7) pumped <sup>4</sup>
Date sampled	08/25/91	08/27/91	09/08/91	09/08/91
Concentrations, in mg/L				
Chlorine, free, total as Cl <sub>2</sub>	0.06	0.07	0.03	0.06
Nitrate, total as N	4.6	1.6	2.0	1.8
Nitrite, total as N	.08	.08	.03	.04
Nitrogen, ammonia, total as N	<.01	<.01	--	--
Concentrations, in µg/L				
Iron, total as Fe	20	<10	140	50
Iron, ferrous as Fe	<10	<10	100	50
				30

Footnotes at end of table.

**Table 12. Concentrations of selected constituents in water from injection, observation, and production wells as determined using field colorimetric methods, 1990 and 1991--Continued**

		Well number <sup>1</sup>											
		Observation wells											
	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)
Date sampled	08/30/91	08/29/91	08/29/91	08/29/91	08/29/91	08/29/91	08/29/91	08/29/91	08/29/91	08/29/91	08/29/91	08/29/91	08/30/91
Depth sampled (feet below land surface)	NA	430	605	430	430	605	605	430	430	605	430	605	NA
Concentrations, in mg/L													
Chlorine, free, total as Cl <sub>2</sub>	0.05	0.16	0.04	0.11	0.07	0.08	0.07	0.08	0.07	0.07	0.07	0.07	0.15
Nitrate, total as N	1.5	4.4	--	2.2	--	2.7	2.7	2.7	2.7	2.7	1.5	1.3	4.1
Nitrite, total as N	.04	.09	.05	.07	.04	.01	.01	.01	.01	.01	.07	.06	.05
Nitrogen, ammonia, total as N													
	--	--	--	<.01	--	<.01	<.01	<.01	<.01	<.01	<.01	<.01	--
Concentrations, in µg/L													
Iron, total as Fe	20	10	30	20	<10	20	40	20	40	10	10	30	20
Iron, ferrous as Fe	<10	<10	<10	10	10	10	10	10	10	10	10	30	<10

**Table 12. Concentrations of selected constituents in water from injection, observation, and production wells as determined using field colorimetric methods, 1990 and 1991--Continued**

Well number <sup>1</sup>												
Production wells												
	JL-49-05-204 (41)	JL-49-05-303 (53)	JL-49-05-601 (36)	JL-49-05-602 (35)	JL-49-05-603 (32)	JL-49-05-605 (44)	JL-49-05-607 (40)	JL-49-05-615 (29A)	JL-49-06-401 (59)	JL-49-06-402 (56)	JL-49-06-404	
Date sampled	08/23/91	09/07/91	08/26/91	09/10/91	08/25/91	09/07/91	08/24/91	08/27/91	09/09/91	08/24/91		09/06/91
Concentrations, in mg/L												
Chlorine, free, total as Cl <sub>2</sub>	0.05	0.06	--	0.03	0.02	0.04	0.03	0.04	0.01	0.03		0.09
Nitrate, total as N	1.0	1.5	2.1	1.6	1.4	.70	2.0	.50	1.9	1.1		2.6
Nitrite, total as N	.02	.03	.05	.07	.02	.07	.02	.04	.01	.04		.05
Nitrogen, ammonia, total as N	<.01	--	.01	--	.02	--	<.01	<.01	--	.01		--
Concentrations, in µg/L												
Iron, total as Fe	30	150	<10	240	<10	<10	<10	20	--	20		10
Iron, ferrous as Fe	10	100	<10	<10	10	<10	<10	10	--	30		10

<sup>1</sup> El Paso Water Utilities-Public Service Board well identification number is in parentheses.

<sup>2</sup> Sample produced after 24,000 gallons of water were pumped from the aquifer.

<sup>3</sup> Sample produced after 182,000 gallons of water were pumped from the aquifer.

<sup>4</sup> Sample produced after 336,000 gallons of water were pumped from the aquifer.

**Table 13. Stable-isotopic ratios in water from injection, observation, and production wells, 1990 and 1991**

[NA, not applicable to these wells; --, no data]

Well number <sup>1</sup>						
Injection wells						
	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected
Date sampled	08/29/90	08/31/90	08/31/90 (duplicate)	08/31/90	08/31/90	09/01/90
Stable-isotopic ratios, per mil						
δ <sup>18</sup> O	-9.30	-9.00	-9.10	-9.10	-9.10	-9.10
δD	-64.5	-63.5	-63.0	-63.0	-66.0	-66.0
δ <sup>13</sup> C	-5.4	-5.6	-5.6	-5.6	-6.00	-6.00

Well number <sup>1</sup>									
Observation wells									
	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-625 (OB-7A)	JL-49-05-625 (OB-7A)	JL-49-05-626 (OB-7B)	JL-49-05-626 (OB-7B)	JL-49-06-405 (OB-1)
Date sampled	08/28/90	08/25/90	08/29/90	08/24/90	08/24/90	08/27/90	08/27/90	08/27/90	08/28/90
Depth sampled (feet below land surface)	NA	430	640	430	690	430	605	430	605
Stable-isotopic ratios, per mil									
δ <sup>18</sup> O	-9.50	-9.35	-9.35	-9.45	-9.50	-9.40	-9.45	-9.75	-9.75
δD	-69.0	-64.5	-67.5	-67.0	-65.0	-66.0	-66.0	-67.5	-67.5
δ <sup>13</sup> C	-8.7	-9.6	-9.6	-12.6	-12.4	-9.6	-9.6	-9.6	-8.3



**Table 13. Stable-isotopic ratios in water from injection, observation, and production wells, 1990 and 1991--Continued**

	Well number <sup>1</sup>					
	Production wells					
	JL-49-05-204 (41)	JL-49-05-301 (42)	JL-49-05-501 (31)	JL-49-05-601 (36)	JL-49-05-602 (35)	JL-49-05-603 (32)
Date sampled	08/30/90	08/23/90	08/23/90	08/30/90	08/22/90	08/21/90 (duplicate)
Stable-isotopic ratios, per mil						
δ <sup>18</sup> O	-9.95	-9.70	-9.70	-9.40	-9.30	-9.85
δD	-69.5	-67.0	-65.5	-66.0	-65.5	-69.0
δ <sup>13</sup> C	-9.0	-8.6	-8.5	-8.4	-12.1	-8.6

	Well number <sup>1</sup>					
	Production wells--Continued					
	JL-49-05-604 (34)	JL-49-05-605 (44)	JL-49-05-605 (44)	JL-49-05-607 (40)	JL-49-05-615 (29A)	JL-49-06-402 (56)
Date sampled	08/22/90	09/01/90	09/01/90 (duplicate)	08/20/90	08/31/90	09/01/90 (duplicate)
Stable-isotopic ratios, per mil						
δ <sup>18</sup> O	-9.60	-9.75	-9.70	-9.60	-10.05	-9.70
δD	-67.0	-69.0	-68.0	-66.5	-70.5	-67.5
δ <sup>13</sup> C	-8.70	-9.6	-8.60	-8.2	-8.5	-8.8

Footnotes at end of table.

**Table 13.** Stable-isotopic ratios in water from injection, observation, and production wells, 1990 and 1991 --Continued

	<b>Well number<sup>1</sup></b>						
	<b>Injection wells</b>						
	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-624 (RW-7) Injected	JL-49-05-624 (RW-7) pumped <sup>2</sup>	JL-49-05-624 (RW-7) pumped <sup>3</sup>	JL-49-05-624 (RW-7) pumped <sup>4</sup>
Date sampled	08/25/91	08/25/91 (duplicate)	08/25/91 (duplicate)	08/27/91	09/08/91	09/08/91	09/08/91
Stable-isotopic ratios, per mil							
$\delta^{18}\text{O}$	-9.35	-9.30	-9.30	-9.35	-9.25	-9.05	-9.25
$\delta\text{D}$	-65.0	-65.0	65.0	-65.5	-65.5	-65.0	-66.0

	<b>Well number<sup>1</sup></b>						
	<b>Observation wells</b>						
	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-621 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-625 (OB-7A)	JL-49-05-626 (OB-7B)	JL-49-05-626 (OB-7B) (OB-1)
Date sampled	08/30/91	08/29/91	08/29/91	08/29/91	08/27/91	08/27/91	08/30/91
Depth sampled (feet below land surface)	NA	430	605	430	605	430	605 NA
Stable-isotopic ratios, per mil							
$\delta^{18}\text{O}$	-9.75	-9.20	-9.20	-9.45	-9.50	-9.30	-9.10 -9.65 -9.40
$\delta\text{D}$	-67.5	-64.5	-65.5	-67.0	-66.5	-65.0	-64.5 -68.0 -66.0

**Table 13. Stable-isotopic ratios in water from injection, observation, and production wells, 1990 and 1991--Continued**

Well number <sup>1</sup>												
Production wells												
JL-49-05-204 (41)	JL-49-05-303 (53)	JL-49-05-601 (36)	JL-49-05-602 (35)	JL-49-05-602 (35)	JL-49-05-602 (35)	JL-49-05-603 (32)	JL-49-05-605 (44)	JL-49-05-607 (40)	JL-49-05-615 (29A)	JL-49-06-401 (59)		
Date sampled	08/23/91	09/07/91	08/26/91	09/10/91	09/10/91	09/10/91 (duplicate)	08/25/91	09/07/91	08/24/91	08/27/91	09/09/91	
Stable-isotopic ratios, per mil												
δ <sup>18</sup> O	-9.90	-10.25	-9.20	-9.70	-9.75	-9.80	-9.55	-9.60	-10.10	-9.55		
δD	-70.0	-70.0	-65.5	-66.5	-66.0	-68.5	-68.0	-68.0	-70.5	-66.5		
Well number <sup>1</sup>												
Production wells--Continued												
	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-404			
Date sampled	08/24/91	08/24/91 (duplicate)	08/24/91 (duplicate)	08/24/91 (duplicate)	08/24/91 (duplicate)	08/24/91 (duplicate)	08/24/91 (duplicate)	08/24/91 (duplicate)	09/06/91			
Stable-isotopic ratios, per mil												
δ <sup>18</sup> O	-9.55	-9.65	-9.55	-9.55	-9.55	-9.55	-9.55	-9.55	-9.55	-67.0		
δD	-67.5	-66.5	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-67.0	-66.5		

<sup>1</sup> El Paso Water Utilities-Public Service Board well identification number is in parentheses.

<sup>2</sup> Sample produced after 24,000 gallons of water were pumped from the aquifer.

<sup>3</sup> Sample produced after 182,000 gallons of water were pumped from the aquifer.

<sup>4</sup> Sample produced after 336,000 gallons of water were pumped from the aquifer.

**Table 14.** Concentrations of organic carbon and methylene blue active substances in water from injection, observation, and production wells, 1990 and 1991

[mg/L, milligrams per liter; NA, not applicable to these wells; --, no data; <, less than]

	Well number <sup>1</sup>			
	Injection wells			
	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected
Date sampled	08/29/90	08/31/90	08/31/90 (duplicate)	09/01/90
Concentrations, in mg/L				
Carbon, organic dissolved as C	1.4	1.2	1.3	1.1
Carbon, organic suspended as C	.1	.1	.1	.1
Methylene blue active substances	.02	.02	.02	.02

	Well number <sup>1</sup>									
	Observation wells									
	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-625 (OB-7A)	JL-49-05-625 (OB-7A)	JL-49-05-626 (OB-7B)	JL-49-05-626 (OB-7B)	JL-49-06-405 (OB-1)
Date sampled	08/23/90	08/25/90	08/29/90	08/24/90	08/24/90	08/27/90	08/27/90	08/27/90	08/28/90	08/28/90
Depth sampled (feet below land surface)	NA	430	640	430	690	430	605	430	605	NA
Concentrations, in mg/L										
Carbon, organic dissolved as C	0.9	0.7	1.2	1.2	--	0.7	1.3	1.6	0.4	0.6
Carbon, organic suspended as C	.1	.1	--	.1	0.1	.3	.1	.1	.1	.1
Methylene blue active substances	.04	.02	.02	.03	--	.02	.03	.04	.04	.03

Footnotes at end of table.

**Table 14.** Concentrations of organic carbon and methylene blue active substances in water from injection, observation, and production wells, 1990 and 1991--Continued

	Well number <sup>1</sup>				
	Production wells				
	JL-49-05-204 (41)	JL-49-05-301 (42)	JL-49-05-501 (31)	JL-49-05-601 (36)	JL-49-05-603 (32)
Date sampled	08/30/90	08/23/90	08/23/90	08/30/90	08/21/90 (duplicate)
Concentrations, in mg/L					
Carbon, organic dissolved as C	0.6	0.4	0.6	0.7	0.3
Carbon, organic suspended as C	<.1	.1	.1	.1	.1
Methylene blue active substances	.04	.05	.05	.03	.05

	Well number <sup>1</sup>				
	Production wells--Continued				
	JL-49-05-604 (34)	JL-49-05-605 (44)	JL-49-05-607 (40)	JL-49-05-615 (29A)	JL-49-06-402 (56)
Date sampled	08/22/90	09/01/90	08/20/90	08/31/90	09/01/90 (duplicate)
Concentrations, in mg/L					
Carbon, organic dissolved as C	1.1	0.3	1.3	0.4	0.4
Carbon, organic suspended as C	.2	--	.1	.1	.1
Methylene blue active substances	<.02	<.02	.06	.03	<.02

Footnotes at end of table.

**Table 14.** Concentrations of organic carbon and methylene blue active substances in water from injection, observation, and production wells, 1990 and 1991--  
Continued

	Well number <sup>1</sup>					
	Injection wells					
	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-624 (RW-7) Injected	JL-49-05-624 (RW-7) pumped <sup>2</sup>	JL-49-05-624 (RW-7) pumped <sup>4</sup>
Date sampled	08/25/91	08/25/91 (duplicate)	08/25/91 (duplicate)	08/27/91	09/08/91	09/08/91
Concentrations, in mg/L						
Carbon, organic total as C	1.4	1.4	1.4	1.6	1.8	1.2
Carbon, organic dissolved as C	1.6	1.4	1.5	2.6	1.3	1.1

	Well number <sup>1</sup>					
	Observation wells					
	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-625 (OB-7A)	JL-49-05-626 (OB-7B)
Date sampled	08/30/91	08/29/91	08/29/91	08/29/91	08/27/91	08/27/91
Depth sampled (feet below land surface)	NA	430	430	605	430	605
Concentrations, in mg/L						
Carbon, organic total as C	0.2	0.8	0.5	0.5	0.6	0.2
Carbon, organic dissolved as C	.3	.8	.6	.4	.5	.2
					430	605
					08/27/91	08/30/91
					NA	NA

**Table 14.** Concentrations of organic carbon and methylene blue active substances in water from injection, observation, and production wells, 1990 and 1991--Continued

	Well number <sup>1</sup>											
	Production wells											
	JL-49-05-204 (41)	JL-49-05-303 (53)	JL-49-05-601 (36)	JL-49-05-602 (35)	JL-49-05-602 (35)	JL-49-05-602 (35)	JL-49-05-603 (32)	JL-49-05-605 (44)	JL-49-05-607 (40)	JL-49-05-615 (29A)	JL-49-06-401 (59)	
Date sampled	08/23/91	09/07/91	08/26/91	09/10/91	09/10/91	09/10/91 (duplicate)	08/25/91	09/07/91	08/24/91	08/27/91	09/09/91	
Concentrations, in mg/L												
Carbon, organic total as C	0.2	0.1	0.2	0.2	0.2	0.1	0.1	<0.1	0.2	0.2	1.3	
Carbon, organic dissolved as C	.8	--	.4	.2	.2	.2	.3	.2	.5	.2	.3	

	Well number <sup>1</sup>			
	Production wells--Continued			
	JL-49-06-402 (56)	JL-49-06-402 (56)	JL-49-06-404 (56)	JL-49-06-404 (56)
Date sampled	08/24/91	08/24/91 (duplicate)	08/24/91 (duplicate)	09/06/91
Concentrations, in mg/L				
Carbon, organic total as C	0.2	0.1	0.1	<0.1
Carbon, organic dissolved as C	.5	.4	.3	.4

<sup>1</sup> El Paso Water Utilities-Public Service Board well identification number is in parentheses.  
<sup>2</sup> Sample produced after 24,000 gallons of water were pumped from the aquifer.  
<sup>3</sup> Sample produced after 182,000 gallons of water were pumped from the aquifer.  
<sup>4</sup> Sample produced after 336,000 gallons of water were pumped from the aquifer.

**Table 15.** Concentrations of selected volatile organic compounds in water from injection, observation, and production wells, and quality-assurance samples, 1990 and 1991

[Concentrations are in ng/L, ng/L, nanograms per liter; \*\*, U.S. Environmental Protection Agency Method 524 and U.S. Geological Survey method O-3115-83; µg/L, micrograms per liter; +, compound found in laboratory blanks at concentrations ranging from 20 to 570 ng/L; <, less than; NA, not applicable to these wells; --, no data. Concentrations reported are from volatile organic compounds and selected-ion monitoring method (E-501.3), unless noted, and are averages for duplicate analyses]

	Well number <sup>1</sup>			
	Injection well			
Date sampled	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected
	08/29/90	08/31/90	08/31/90 (duplicate)	09/01/90
Trihalomethane compounds				
Dichlorobromomethane	510	340	340	410
Bromoform	20,000 **	14,000 **	15,000 **	22,000 **
Chloroform	190	210	200	190
Dibromochloromethane	4,500 **	3,800	3,900	4,100
Sum of trihalomethane compounds, in µg/L	25.2	18.4	19.4	26.7
Other halogenated methane compounds				
Bromochloromethane	20	20	20	20
Dibromomethane	100	70	7	70
Dichloromethane	110 +	50 +	45 +	50 +
Trichlorofluoromethane	<50	160	70	<50

Footnotes at end of table.



**Table 15.** Concentrations of selected volatile organic compounds in water from injection, observation, and production wells, and quality-assurance samples, 1990 and 1991--Continued

	Well number <sup>1</sup>												
	Observation wells												
	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-625 (OB-7A)	JL-49-05-625 (OB-7A)	JL-49-05-626 (OB-7B)	JL-49-05-626 (OB-7B)	JL-49-06-405 (OB-1)	
Date sampled	08/28/90	08/25/90	08/29/90	08/24/90	08/24/90	08/24/90	08/24/90	08/27/90	08/27/90	08/27/90	08/28/90	08/28/90	
Depth sampled (feet below land surface)	NA	430	640	430	430	690	690	430	605	430	605	NA	
Trihalomethane compounds													
Dichlorobromomethane	90	1,300	1,300	760	970	570	720	40	60	1,000			
Bromoform	<20	<20	<20	<20	<20	<20	<20	<20	60	110	60		
Chloroform	70	590	620	370	420	470	510	50	50	490			
Dibromochloromethane	<20	<20	<20	<20	30	<20	<20	30	60	110			
Sum of trihalomethane compounds, in µg/L	.16	1.9	1.9	1.1	1.4	1.0	1.2	.18	.28	1.7			
Other halogenated methane compounds													
Bromochloromethane	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20		
Dibromomethane	<20	<20	<20	10	20	<20	<20	<20	<20	20	20		
Dichloromethane	<20 +	50 +	50 +	55 +	30 +	80 +	130 +	60 +	40 +	40 +	40 +		
Trichlorofluoromethane	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50		

Footnotes at end of table.

**Table 15.** Concentrations of selected volatile organic compounds in water from injection, observation, and production wells, and quality-assurance samples, 1990 and 1991--Continued

	Well number <sup>1</sup>							
	Production wells							
	JL-49-05-301 (42)	JL-49-05-501 (31)	JL-49-05-601 (36)	JL-49-05-602 (35)	JL-49-05-603 (32)	JL-49-05-603 (32) (duplicate)	JL-49-05-604 (34)	JL-49-05-605 (44)
Date sampled	08/23/90	08/23/90	08/30/90	08/22/90	08/21/90	08/21/90	08/22/90	09/01/90
Trihalomethane compounds								
Dichlorobromomethane	<20	<20	<20	<20	<20	<20	<20	<20
Bromoform	<20	<20	<20	<20	<20	<20	<20	<20
Chloroform	<20	<20	50	<20	<20	<20	<20	270
Dibromochloromethane	<20	<20	<20	<20	<20	<20	<20	<20
Sum of trihalomethane compounds, in µg/L	<.02	<.02	.05	<.02	<.02	<.02	<.02	.27
Other halogenated methane compounds								
Bromochloromethane	<20	<20	<20	<20	<20	<20	<20	<20
Dibromomethane	<20	<20	<20	<20	<20	<20	<20	<20
Dichloromethane	<20 +	<20 +	<20	<20 +	<20 +	<20 +	<20 +	<20
Trichlorofluoromethane	<50	<50	<50	<50	<50	<50	<50	<50

**Table 15.** Concentrations of selected volatile organic compounds in water from injection, observation, and production wells, and quality-assurance samples, 1990 and 1991--Continued

	Well number <sup>1</sup>				
	Production wells--Continued				
Date sampled	JL-49-05-605 (44)	JL-49-05-607 (40)	JL-49-05-615 (29A)	JL-49-06-402 (56)	JL-49-06-402 (56) (duplicate)
Trihalomethane compounds	09/01/90 (duplicate)	08/20/90	08/31/90	09/01/90	09/01/90 (duplicate)
Dichlorobromomethane	<20	<20	<20	<20	<20
Bromoform	<20	<20	<20	<20	<20
Chloroform	270	<20	<20	<20	<20
Dibromochloromethane	<20	<20	<20	<20	<20
Sum of trihalomethane compounds, in µg/L	.27	<.02	<.02	<.02	<.02
Other halogenated methane compounds					
Bromochloromethane	<20	<20	<20	<20	<20
Dibromomethane	<20	<20	<20	<20	<20
Dichloromethane	<20	<20 +	<20 +	<20 +	<20 +
Trichlorofluoromethane	<50	<50	<50	<50	<50

Footnotes at end of table.

**Table 15. Concentrations of selected volatile organic compounds in water from injection, observation, and production wells, and quality-assurance samples, 1990 and 1991--Continued**

	Quality-assurance samples				
	Reagent-water spike	Matrix-water spike	Trip blank	Trip blank	Equipment blank
Date prepared	08/22/90	09/01/90	08/20/90	09/01/90	09/01/90
Trihalomethane compounds					
Dichlorobromomethane	190	250	<20	<20	<20
Bromoform	260	350	<20	<20	<20
Chloroform	230	260	<20	<20	<20
Dibromochloromethane	220	340	<20	<20	<20
Sum of trihalomethane compounds, in µg/L	.9	1.2	<.02	<.02	<.02
Other halogenated methane compounds					
Bromochloromethane	240	280	<20	<20	<20
Dibromomethane	240	300	<20	<20	<20
Dichloromethane	200 +	290 +	30 +	30 +	30 +
Trichlorofluoromethane	42	190	<50	<50	<50

**Table 15.** Concentrations of selected volatile organic compounds in water from injection, observation, and production wells, and quality-assurance samples, 1990 and 1991--Continued

	Well number <sup>1</sup>				
	Injection wells				
	JL-49-05-613 (RW-8) injected	JL-49-05-624 (RW-7) injected	JL-49-05-624 (RW-7) pumped <sup>3</sup>	JL-49-05-624 (RW-7) pumped <sup>4</sup>	JL-49-05-624 (RW-7) pumped <sup>5</sup>
Date sampled	08/25/91	08/27/91	09/08/91	09/08/91	09/08/91
Trihalomethane compounds					
Dichlorobromomethane	740	820	50	60	90
Bromoform	20,000 **	26,000 **	<20	<20	<20
Chloroform	400	380	280	290	270
Dibromochloromethane	6,700 **	7,400 **	<20	<20	<20
Sum of trihalomethane compounds, in µg/L	27.8	34.6	.33	.35	.36
Other halogenated methane compounds					
Bromochloromethane	20	--	<20	<20	<20
Dibromomethane	80	--	<20	<20	<20
Dichloromethane	50 +	<20 +	230 +	220 +	200 +
Trichlorofluoromethane	<50	--	<50	<50	<50

Footnotes at end of table.

**Table 15. Concentrations of selected volatile organic compounds in water from injection, observation, and production wells, and quality-assurance samples, 1990 and 1991--Continued**

	Well number <sup>1</sup>											
	Observation wells											
	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-625 (OB-7A)	JL-49-05-625 (OB-7A)	JL-49-05-626 (OB-7B)	JL-49-05-626 (OB-7B)	JL-49-05-626 (OB-7B)	JL-49-06-405 (OB-1)	
Date sampled	08/30/91	08/29/91	08/29/91	08/29/91	08/29/91	08/27/91	08/27/91	08/27/91	08/27/91	08/27/91	08/30/91	
Depth sampled (feet below land surface)	NA	430	430	605	430	605	430	605	430	605	NA	
Trihalomethane compounds												
Dichlorobromomethane	150	560	530	950	900	190	350	60	130	700		
Bromoform	<20	<20	<20	<20	<20	<20	<20	<20	110	<20		
Chloroform	110	430	400	470	480	360	340	70	90	470		
Dibromochloromethane	<20	<20	<20	<20	<20	<20	<20	<20	60	<20		
Sum of trihalomethane compounds, in µg/L	.26	.99	.93	1.4	1.4	.55	.69	.13	.39	1.2		
Other halogenated methane compounds												
Bromochloromethane	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20		
Dibromomethane	<20	<20	<20	<20	<20	<20	<20	<20	20	<20		
Dichloromethane	90 +	90 +	100 +	110 +	90 +	100 +	110 +	70 +	100 +	130 +		
Trichlorofluoromethane	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50		

Footnotes at end of table.

**Table 15.** Concentrations of selected volatile organic compounds in water from injection, observation, and production wells, and quality-assurance samples, 1990 and 1991--Continued

	Well number <sup>1</sup>									
	Production wells									
	JL-49-05-204 (41)	JL-49-05-303 (53)	JL-49-05-601 (36)	JL-49-05-602 (35)	JL-49-05-603 (32)	JL-49-05-605 (44)	JL-49-05-607 (40)	JL-49-05-615 (29A)	JL-49-06-401 (59)	JL-49-06-402 (56)
Date sampled	08/23/91	09/07/91	08/26/91	09/10/91	08/25/91	09/07/91	08/24/91	08/27/91	09/09/91	08/24/91
Trihalomethane compounds										
Dichlorobromomethane	<20	20	<20	<20	<20	<20	<20	<20	<20	80
Bromoform	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Chloroform	<20	140	50	<20	<20	210	<20	<20	<20	50
Dibromochloromethane	<20	20	<20	<20	<20	<20	<20	<20	<20	20
Sum of trihalomethane compounds, in µg/L	<.02	.18	.05	<.02	<.02	.21	<.02	<.02	<.02	.15
Other halogenated methane compounds										
Bromochloromethane	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Dibromomethane	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Dichloromethane	40 +	30 +	40 +	50	30	100 +	40 +	40 +	120 +	50 +
Trichlorofluoromethane	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50

Footnotes at end of table.

**Table 15. Concentrations of selected volatile organic compounds in water from injection, observation, and production wells, and quality-assurance samples, 1990 and 1991--Continued**

	Well number <sup>1</sup>		Quality-assurance samples				
	Production wells-- Continued		Reagent- water spike	Matrix- water spike	Trip blank	Trip blank	Equipment blank
Date sampled	JL-49- 06-404	09/06/91					
Date prepared			08/27/91	09/10/91	08/27/91	08/30/91	08/27/91
Trihalomethane compounds							
Dichlorobromomethane	<20		491	390	<20	<20	<20
Bromoform	<20		504	400	<20	<20	<20
Chloroform	<20		427	320	<20	<20	<20
Dibromochloromethane	<20		424	370	<20	<20	<20
Sum of trihalomethane compounds, in µg/L	<.02		1.8	1.5	<.02	<.02	<.02
Other halogenated methane compounds							
Bromochloromethane	<20		442	340	<20	<20	<20
Dibromomethane	<20		447	350	<20	<20	<20
Dichloromethane	30		449 +	320 +	30 +	50 +	50 +
Trichlorofluoromethane	<50		331	240	<50	<50	<50

<sup>1</sup> El Paso Water Utilities-Public Service Board well identification number is in parentheses.

<sup>2</sup> Corrected value, compound found in matrix water used for spike.

<sup>3</sup> Sample produced after 24,000 gallons of water had been pumped from the aquifer.

<sup>4</sup> Sample produced after 182,000 gallons of water had been pumped from the aquifer.

<sup>5</sup> Sample produced after 336,000 gallons of water had been pumped from the aquifer.



**Table 16. Bacterial populations in water from injection, observation, and production wells, and quality-assurance sample, 1990**

[NA, not applicable to these wells; --, no data; mL, milliliter; MPN/mL, most probable number per milliliter; >, greater than; <, less than]

	Well number <sup>1</sup>		Well number <sup>1</sup>				
	Injection wells		Observation wells				
	JL-49-05-613 (RW-8) Injected	JL-49-05-613 (RW-8) Injected	JL-49-05-618 (OB-5)	JL-49-05-621 (OB-4A)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)	JL-49-05-622 (OB-4B)
Date purged	NA	NA	08/27/90	08/25/90	08/24/90	08/24/90	08/24/90
Date sampled	08/29/90	08/31/90	08/28/90	08/29/90	08/24/90	08/24/90	08/29/90
Depth sampled (feet below land surface)	--	--	NA	640	430	690	690
Acridine orange direct counts <sup>2</sup> , in organisms/mL	1,500	1,800	65,000	9,500	770,000	550,000	2,600
Aerobic bacteria, in MPN/mL <sup>3</sup>	79	11	35,000	1,400	>160,000	>160,000	80
Lower limits <sup>4</sup>	26	4	12,000	520	--	--	3
Upper limits <sup>4</sup>	240	31	100,000	3,800	--	--	240
Denitrifying bacteria, in MPN/mL	<2	<2	<2	2	<2	<2	<2
Lower limits	--	--	--	<2	--	--	--
Upper limits	--	--	--	1.4	--	--	--
Anaerobic bacteria, in MPN/mL	<2	<2	<2	<2	<2	<2	<2
Sulfate-reducing bacteria, in MPN/mL	<2	<2	<2	<2	<2	<2	<2
Methanogenic bacteria, in MPN/mL	<2	<2	<2	<2	<2	<2	<2

Footnotes at end of table.

**Table 16. Bacterial populations in water from injection, observation, and production wells, and quality-assurance sample, 1990--Continued**

	Well number <sup>1</sup>			Well number <sup>1</sup>			Quality- assurance sample
	Observation wells--Continued			Production wells			
	JL-49- 05-625 (OB-7A)	JL-49- 05-626 (OB-7B)	JL-49- 06-405 (OB-1)	JL-49- 05-204 (41)	JL-49- 05-603 (32)	JL-49- 05-604 (34)	
Date purged	08/26/90	08/26/90	08/28/90	08/30/90	08/21/90	08/22/90	NA
Date sampled	08/27/90	08/28/90	08/28/90	08/30/90	08/21/90	08/22/90	08/21/90
Depth sampled (feet below land surface)	605	605	NA	359-515	335-506 and 508-656	325-500 and 501-802	--
Acridine orange direct counts <sup>2</sup> , in organisms/mL	190,000	140,000	2,400	2,200	10,000	18,000	800
Aerobic bacteria, in MPN/mL <sup>3</sup>	>160,000	>160,000	2,300	180	24,000	9,400	<2
Lower limits <sup>4</sup>	--	--	880	67	8,900	3,200	--
Upper limits <sup>4</sup>	--	--	6,100	470	64,000	28,000	--
Denitrifying bacteria, in MPN/mL	<2	<2	790	<2	<2	<2	<2
Lower limits	--	--	26	--	--	--	--
Upper limits	--	--	2,400	--	--	--	--
Anaerobic bacteria, in MPN/mL	<2	<2	<2	<2	<2	<2	<2
Sulfate-reducing bacteria, in MPN/mL	<2	<2	<2	<2	<2	<2	<2
Methanogenic bacteria, in MPN/mL	<2	<2	<2	<2	<2	<2	<2

<sup>1</sup> El Paso Water Utilities-Public Service Board well identification number is in parentheses.

<sup>2</sup> The numbers of bacteria reported are below the minimum number required for statistical validity of the acridine orange direct counts method.

<sup>3</sup> The MPN is defined as the number of bacteria that, more probably than any other number, would give the results shown by the multiple-tube bacterial determinations. The MPN was calculated for each of the five-tube bacterial determinations using methods described in American Public Health Association (1985, p. 880-882).

<sup>4</sup> The lower and upper limits of the MPN are the 95-percent confidence limits of the distribution.