Distribution and Mass of Nitrate in the Unconfined Aquifer Beneath the Intensively Cultivated Area North of the Rio Grande, San Luis Valley, Colorado, 1997 through 2001

By Robert W. Stogner, Sr.

Prepared in cooperation with the
RIO GRANDE WATER CONSERVATION DISTRICT,
CENTER SOIL CONSERVATION DISTRICT, and the
COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

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CONVERSION FACTORS, DATUMS, ABBREVIATIONS, AND ACRONYMS

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
acre	0.004047	square kilometer
square foot (ft^2)	0.09290	square meter
square mile (mi^2)	2.590	square kilometer
	Volume	
acre-foot (acre-ft)	1,233	cubic meter
acre-foot (acre-ft)	0.001233	cubic hectometer
cubic foot (ft^3)	0.02832	cubic meter
	Flow Rate	
foot per day (ft/d)	0.3048	meter per day
cubic foot per day (ft^3/d)	0.02832	cubic meter per day
gallon per minute (gal/min)	0.06309	liter per second
	Mass	
ton, short (2,000 lbs)	0.9072	megagram
	Application Rate	
ton/mi^2/yr	3.503125	kg/ha/yr
lb/acre/yr	1.121	kg/ha/yr

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F = 1.8 (°C) +32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C = (°F – 32) /1.8

Vertical coordinates are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). Horizontal coordinates are referenced to the North American Datum of 1927 (NAD27).

Altitude, as used in this report, refers to the distance above or below NGVD29. NGVD29 can be converted to the North American Vertical Datum of 1988 (NAVD88) by using the National Geodetic Survey Conversion Utility at URL http://www.ngs.noaa.gov//TOOLS/Vertcon/vertcon.html

Concentrations of chemical constituents in water are given in milligrams per liter (mg/L)

BMP	Best-Management Practices
LRL	Laboratory Reporting Unit
mL	milliliter
CDPHE	Colorado Department of Public Health and Environment
CSCD	Center Soil Conservation District
USEPA	U.S. Environmental Protection Agency
NAWQA	National Water-Quality Assessment
NRCS	Natural Resources Conservation Service
NWQL	National Water Quality Laboratory
RGWCD	Rio Grande Water Conservation District
SLVWQDP	San Luis Valley Water Quality Demonstration Project
USGS	U.S. Geological Survey

Distribution and Mass of Nitrate in the Unconfined Aquifer Beneath the Intensively Cultivated Area North of the Rio Grande, San Luis Valley, Colorado, 1997 through 2001

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Abstract

Current (1997–2001) and historical (1948–49, 1968–69) nitrate-concentration and water-level data collected from wells completed in the unconfined aquifer in the intensively cultivated area north of the Rio Grande in south-central Colorado were used to determine the distribution and mass of nitrate and to determine short- and long-term trends in the concentration and mass of nitrate in the unconfined aquifer.

The distribution of nitrate concentrations in the unconfined aquifer indicates that nitrate concentrations increased considerably between the 1940s and 1990s and were relatively stable between 1997 and 2001. However, evaluation of estimates of mass of nitrate indicated increases in the estimated mass of nitrate in the unconfined aquifer from the 1940s (6,900 tons) to the late 1960s (34,000 tons) to the late 1990s (75,000 tons). Trend analyses indicated no significant trend in annual estimates of the mass of nitrate during 1997–2001, averaging 75,000 tons.

Ground-water samples collected from selected wells with large nitrate concentrations skewed the results of nitrate distribution and mass when nearby wells were not sampled. Estimates of nitrate mass varied by 3 to 8 percent when outliers were removed from the analysis.

Introduction

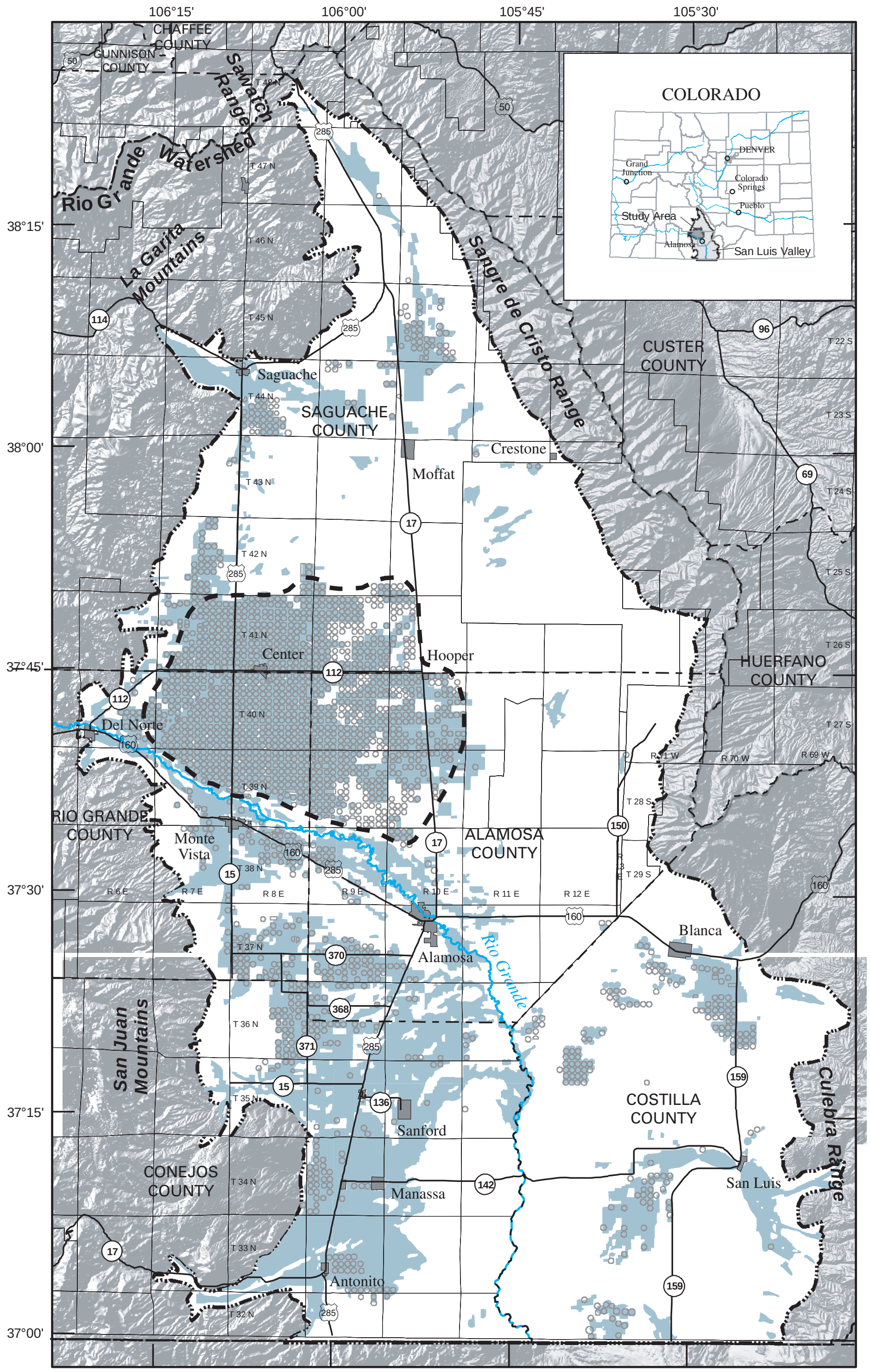
An evaluation of historical nitrate data in the San Luis Valley indicated that concentrations of nitrate (as nitrogen) measured in 1936 in ground water from the unconfined aquifer (Scofield, 1938) were less than the previously designated threshold background concentration of 3 mg/L (Stogner, 2001). Shortly after the introduction of mineral fertilizers in the San Luis Valley during the 1940s, nitrate (as nitrogen) concentrations in a few ground-water samples from the unconfined aquifer exceeded 3 mg/L (Powell, 1958). Later investigations (Emery and others, 1973; Edelmann and Buckles, 1984; Austin, 1993) identified areas in the intensively cultivated area north of the Rio Grande (fig. 1) in which concentrations of nitrate (as nitrogen) in ground water from the unconfined aquifer exceeded the U.S. Environmental Protection Agency (USEPA) Drinking Water Standard of 10 mg/L (U.S. Environmental Protection Agency, 1996).

The U.S. Geological Survey (USGS) conducted a study in cooperation with the Rio Grande Water Conservation District (RGWCD), Center Soil Conservation District (CSCD), and the Colorado Department of Public Health and Environment (CDPHE) to define the current (1997–2001) distribution and mass of nitrate (as nitrogen) in ground water of the unconfined aquifer in an intensively cultivated area, north of the Rio Grande in the San Luis Valley of south-central Colorado. The study also evaluated short- and long-term variations in nitrate concentrations and mass in ground water of the unconfined aquifer.

Purpose and Scope

This report describes the distribution of nitrate (as nitrogen) concentrations for 1936–50, 1968–69, and 1997–2001, and provides estimates of the mass of nitrate (as nitrogen) in the unconfined aquifer in the intensively cultivated area north of the Rio Grande for 1936–50, 1968–69, and 1997–2001. Seasonal, short-term (annual), and long-term temporal trends in the concentrations and mass of nitrate (as nitrogen) in the unconfined aquifer in the intensively cultivated area north of the Rio Grande also are described.

One-hundred forty-two large-capacity irrigation wells were selected for water-quality sampling. The study period was from May 1997 through August 2001. Ground-water samples were collected annually during June from all wells in the monitoring network to evaluate the distribution of nitrate (as nitrogen) in the unconfined aquifer. Additional ground-water samples were collected from selected wells in the monitoring network during the growing season from May through August of each year to evaluate seasonal variations in the concentration of nitrate (as nitrogen). Long-term variations in the distribution and mass of nitrate (as nitrogen) in the unconfined aquifer were evaluated by comparison to concentration distributions and mass estimates based on water-quality analyses of ground-water samples collected during 1936–50 (Scofield, 1938; Powell, 1958), 1968–69 (Emery and others, 1972), and 1997–2001 (fig. 2).



Base modified from U.S. Geological Survey digital data, 1:24,000
Roads and cities from Colorado Department of Transportation, 50,000, 1998
Universal Transverse Mercator, Zone 13, units feet
Central meridian 105° W
North American Datum, 1927

EXPLANATION

- Irrigated crop and pasture land
- San Luis valley boundary
- Study-area boundary
- Center-pivot irrigated cropland

0 3 6 9 12 15 MILES

0 5 10 15 KILOMETERS

Figure 1. Location of San Luis Valley, irrigated crop and pasture land, and study area, south-central Colorado.

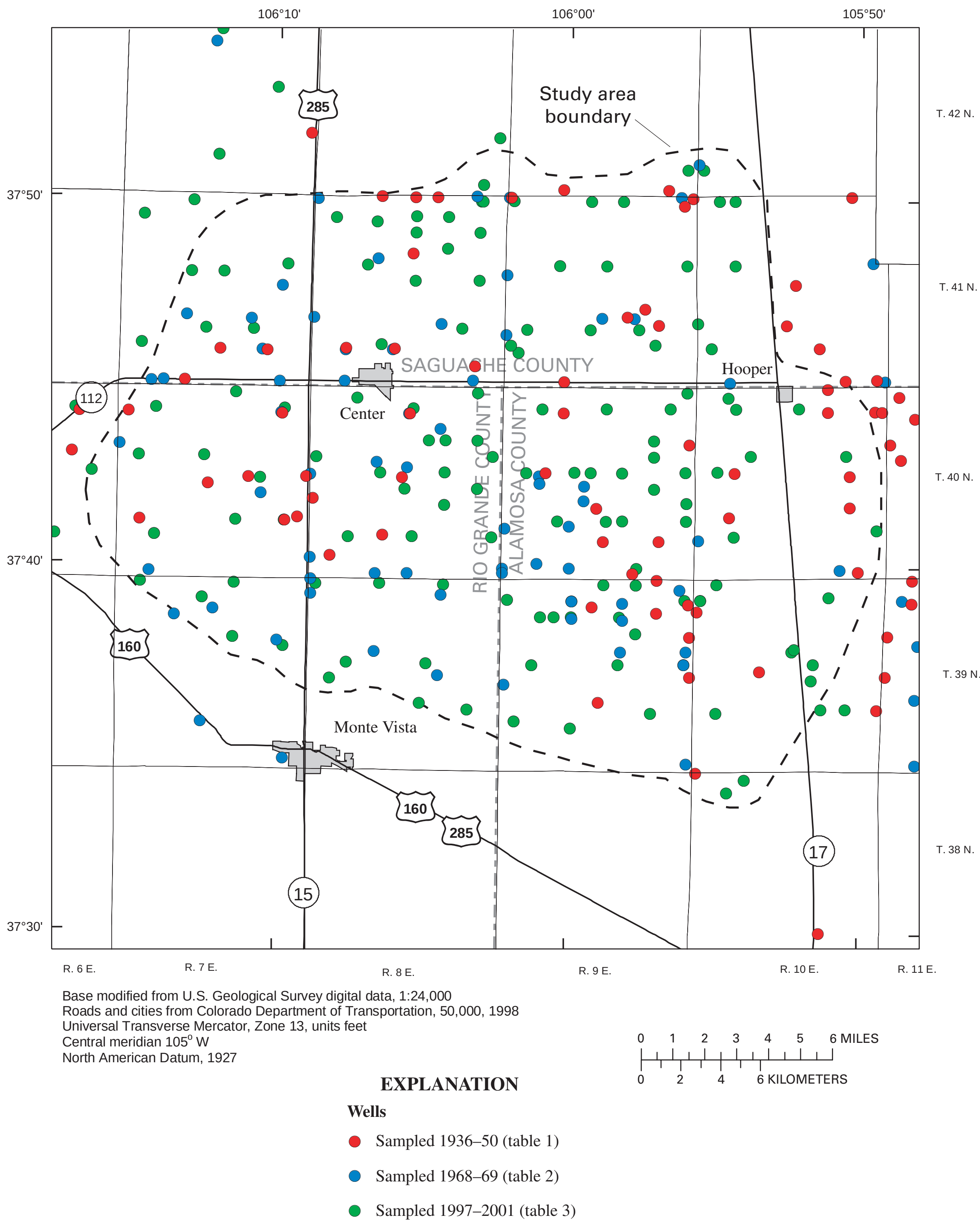


Figure 2. Location of wells in and near the study area sampled during 1936–50, 1968–69, and center-pivot irrigation wells sampled during 1997–2001.

Description of the San Luis Valley and Study Area

The San Luis Valley is an intermontane valley near the headwaters of the Rio Grande and is about 3,200 mi^2 in extent. The San Luis Valley is bound on the west by the La Garita and San Juan Mountains, with altitudes up to 14,000 ft; on the north by the Sawatch Range, with altitudes greater than 14,000 ft; and on the east by the Sangre de Cristo and Culebra Ranges, with altitudes greater than 14,000 ft. The valley narrows to the north as the La Garita Mountains and the Sawatch and Sangre de Cristo Ranges converge. The valley floor is relatively flat and has an average altitude of about 7,700 ft.

The climate of the San Luis Valley is arid to semiarid with cold winters and moderate summers, light precipitation, and abundant sunshine. Annual precipitation at Alamosa, near the center of the valley, averages about 7.1 inches (Western Regional Climate Center, 2003). Precipitation in the valley occurs most often in the form of light rain and thunderstorms during the spring and summer (April to October) (National Climate Data Center / National Oceanic and Atmospheric Administration, 2003, September 26, 2003). These storms generally originate in the mountains and then move across the valley. Winter snowfall, on the valley floor, generally is light but may linger on the ground for several days or weeks during the coldest months.

Precipitation in the form of snow in the adjacent mountains is the primary source of recharge water to the unconfined aquifer. Snowmelt runoff from the adjacent mountains either infiltrates directly to the unconfined and confined aquifers along the margins of the valley or infiltrates to the unconfined aquifer along the course of an intricate network of canals and ditches that convey water diverted from area rivers and creeks for irrigation of crops and pasture. Nitrate concentrations in surface water generally are less than 0.1 mg/L (Healy, 1997).

Irrigated agriculture has been integral to the economy of the valley since the 1850s. Currently (1997–2001), alfalfa, hay, wheat, barley, potatoes, and other vegetables are the primary crops. Most crops and pastures in the valley are irrigated because precipitation in the valley generally is insufficient to meet the crop-water requirements. Irrigated agriculture in the valley is dependent on ground water, primarily from the unconfined aquifer. Prior to the severe droughts of the 1930s and 1950s, most of the cropland and pasture was flood irrigated and fertilized by applying sheep and cattle manure. By 1981, much of the irrigated land north of the Rio Grande was converted from flood to irrigation by center-pivot sprinkler systems. Stogner (2001) provides a brief historical summary of water development and irrigation practices in the San Luis Valley.

The study area (fig. 1) is located in the western part of the San Luis Valley of south-central Colorado. The study area is north of the Rio Grande and encompasses about 370 mi^2 of the Rio Grande alluvial fan and includes about 10 percent of the valley and about 35 percent of the irrigated crop and pastureland in the valley. This area is intensively cultivated and has the greatest density of large-capacity irrigation wells and center-pivot sprinkler systems in the San Luis Valley and is referred to as the intensively cultivated area north of the Rio Grande.

Acknowledgments

Thanks are given to the employees of the records section of the Office of the State Engineer for their assistance and patience during several weeks of record review; the members of the field teams, including Fred Huss (RGWCD retired); Randy Ristau, Ron Riggenbach, and Bob Bach (San Luis Valley Water Quality Demonstration Project [SLVWQDP]); and Raida Paul-Knapp, James Sperry, Jeffery Koster (Natural Resource Conservation Service [NRCS]) for their diligent work contacting well owners and collecting samples. In addition, thanks are given to members of the liaison committee including Ralph Curtis (RGWCD), Jim Mietz (NRCS/CSCD), Allen Davey and Debbie Sarason (Davis Engineering, Inc., Alamosa, Colo.), and Kirk Thompson (Agro Engineering, Inc., Alamosa, Colo.) for their guidance during the project. Without the cooperation of irrigators and property owners, who permitted access to their irrigation systems for the collection of ground-water samples, this study would not have been possible.

Methods

Historical Data

Historical water-quality data for the unconfined aquifer are available for three periods—1936–50 (Scofield, 1938; Powell, 1958), 1968–69 (Emery and others, 1972), and 1981 (Edelmann and Buckles, 1984). Sampled wells ranged from less than 10 ft to greater than 100 ft in depth. Eighty-eight wells in and near the study area were sampled during 1936–50, most of which were sampled during 1948–49; generally these 88 wells were less than 25 ft in depth. Hereinafter, the 1936–50 period will be referred to simply as "1948–49." Samples from these wells indicated the quality of water near the upper part of the unconfined aquifer, which is the part of the aquifer most likely to be affected as a result of leaching of fertilizer from the surface. Samples from 72 of the 88 wells sampled in 1948–49 were included in the analyses for this report and are identified by an index number as used in Scofield (1938) and Powell (1958) (table 1 at back of report); however, wells that were considered too distant from the study area were not included. Eighty-five wells in or near the study area were sampled during 1968–69, and generally most were greater than 25 ft in depth. These deeper wells provided water-quality samples that more closely represented the average chemistry of ground water in the unconfined aquifer. Samples from 83 of the 85 wells were included in the analyses in this report and are identified by well location as used in Emery and others (1972) (table 2 at back of report); however, wells that were considered too distant from the study area were not included. Thirty-nine wells in or near the study area were sampled during 1981. Water-quality data from these wells were not included in the analyses due to the relatively small number of wells sampled.

Design of the Ground-Water Monitoring Network, 1997–2001

Only large-capacity irrigation wells, wells with yields generally greater than 100 gal/min, that supplied center-pivot irrigation systems were selected for inclusion in the ground-water monitoring network during the current study (1997–2001). Large-capacity irrigation wells were selected for the ground-water monitoring network, assuming that ground-water samples collected from large-capacity wells screened in at least 50 percent of the saturated interval of the aquifer would provide a sample that represented the average chemistry of ground water in the unconfined aquifer. Wells considered for inclusion in the ground-water monitoring network were selected from more than 1,000 large-capacity irrigation wells that currently (2001) are in operation in the intensively cultivated area north of the Rio Grande.

About 900 well logs and completion records of the Colorado Division of Water Resources were reviewed and compiled to select potential wells for inclusion in the ground-water monitoring network and to collect data to better define the top of the confining unit that separates the unconfined aquifer from the underlying confined-aquifer system. Wells were ranked based on completeness of available drillers well logs, construction information, and spatial distribution. Well owners then were contacted to request permission to include their well(s) in the ground-water monitoring network. In general, wells in the network were spaced at 2-mi intervals; however, there were areas where a 2-mi spacing was not achieved because permission to access the wells was not granted by the landowner. Additional wells were added to the network in 1998 in areas that were indicated to have large spatial variation in nitrate (as nitrogen) concentration. In these areas, an effort was made to have a 1-mi spacing between wells. During subsequent field visits, wells were inspected to ensure the following: (1) the wellhead was in good condition and free of obvious sources of contamination, (2) a backflow device was present, and (3) a sample point was present upstream from any chemical injection (chemigation) points. If a sample point was not present upstream from any chemigation point, consent of the well owner was obtained to install one. A total of 142 wells were included in the 1997–2001 network (table 3 at back of report). Wells are designated with an alphanumeric site identifier that provides landnet location information. For example, site identifier 38N10E05NE refers to a well in the northeast (NE) corner of section 5 of Township 38N, Range 10E.

Collection and Analyses of Ground-Water Samples

Ground-water samples were collected by personnel from the RGWCD, SLVWQDP, and NRCS, hereinafter referred to as “field personnel,” with direction from USGS personnel. Samples generally were collected after the wells had been pumping for several hours. Samples were collected in 125-mL brown polyethylene bottles as follows:

- Open sampling spigot and allow water to flow for 5 minutes;
- write sample date and time on sample bottle;
- using water from the sampling point, rinse the sample bottle three times, collect sample, and cap bottle;
- place sample bottle in cooler of ice and maintain sample at a temperature of about 4°C; and
- write sample date and time and other important information; for example, chemigation in progress or crop type, on field form (modified from Wilde and others, 1998).

Samples were submitted to the USGS National Water-Quality Laboratory (NWQL) in Denver, Colo., to determine the concentration of nitrate (as nitrogen).

Ground-water samples were collected from network-monitoring wells annually during June, hereinafter referred to as the “mass-sampling period.” Additional ground-water samples were collected from 9 to 27 wells numerous times during the growing season, May through August, hereinafter referred to as “the multisampling period,” to evaluate seasonal variations in nitrate (as nitrogen) concentration. Understanding seasonal variations in nitrate (as nitrogen) concentrations was necessary to evaluate potential errors in estimates of mass of nitrate (as nitrogen) based on timing of sample collection. A total of 704 ground-water samples were collected during the study. Concentrations of nitrate (as nitrogen) in 17 of the 704 (2.4 percent) samples were identified as outliers (samples with unusually high or low concentrations.) Outliers were defined as samples with concentrations greater or less than the mean concentration plus or minus 2 standard deviations for all samples analyzed from that particular well. Outliers were censored and not included in the spatial and temporal analyses to minimize under- or overestimating nitrate (as nitrogen) concentration and mass for a location.

Duplicate samples, prepared by field personnel concurrent with samples for analysis, were collected to test repeatability. In theory, the results from each sample should be the same; deviations describe laboratory precision or problems with field techniques. The results of duplicate samples from this study (table 4) were evaluated by computing relative percent differences (RPDs) between the initial and duplicate sample. The RPD was computed with the following equation:

$$RPD = \left[\frac{C_1 - C_2}{(C_1 + C_2)/2} \right] \times 100 \quad (1)$$

Table 4. Relative percent difference in duplicate samples.

[ID, identifier]

Site ID	Concentration of nitrate (as nitrogen), in milligrams per liter		Relative percent difference
	Initial sample	Duplicate sample	
39N0007E02NW	4.0	3.8	5.1
39N08E15SE	16.0	15.9	0.6
39N10E02SW	2.1	2.3	–7.0
40N09E005SW	13.8	14.1	–1.9
40N09E14NE	34.2	35.4	–3.5
41N09E02NE	4.3	4.2	2.1
41N09E06NW	11.6	11.4	1.6

where,

C_1 is concentration of initial sample, in milligrams per liter, and

C_2 is concentration of duplicate sample, in milligrams per liter.

The RPD between initial and duplicate samples ranged from –7.0 to 5.1 percent. RPDs within ±10 percent were considered acceptable.

Ground-water samples collected during 1997–2001 were analyzed for nitrite plus nitrate (as nitrogen), using the NWQL procedure 1975, method number I–2545–90, and described as Nitrogen, Nitrite plus Nitrate, colorimetry, cadmium reduction diazotization, automated-segmented flow (Fishman, 1993), with a laboratory reporting level (LRL) of 0.06 mg/L. Nitrite, the reduced form of nitrate, generally is found in the environment at much lower concentrations than nitrate, therefore, hereinafter, nitrite plus nitrate as nitrogen is referred to as “nitrate (as nitrogen).”

Geographic Information Systems

A Geographic Information System (GIS), ArcInfo version 8.3 (Environmental Systems Research Institute, Inc., 2002), was used to plot well locations, to prepare maps of hydrogeologic data, and to compute the volume of water and mass of nitrate (as nitrogen) in the unconfined aquifer for the 1948–49, 1968–69, and 1997–2001 periods. Maps were prepared of the altitude of and depth to the top of the confining unit that underlies the unconfined aquifer, the altitude of and depth to the water table, the saturated thickness of the unconfined aquifer, and the distribution of nitrate (as nitrogen) concentrations and variations in the concentration of nitrate (as nitrogen) in the unconfined aquifer. Unless explained otherwise, point values related to confining-unit altitude, water-quality data, depth to water, and water-table altitude were interpolated using the TOPOGRID command. TOPOGRID produces a grid using an iterative finite-difference interpolation technique that incorporates the spatial variability of the root mean-square error (RMS). Values at the center of a cell are estimated based on point data within a cell and(or) interpolation between nearby data points. For this study, the grids contained 41,355 cells, each representing a 500-ft by 500-ft square with an area of 250,000 ft^2. Errors in interpolation of grids were evaluated using the LATTICESPOT command. LATTICESPOT adds the interpolated cell value of a grid to the point coverage from which the values were interpolated. The difference between the discrete point value and the interpolated cell value then was computed. The mean error plus or minus 2 standard deviations was used to approximate the upper and lower limits in the range in error of the surfaces (grids). After values were estimated for each cell, contours were generated using the LATTICECONTOUR command. The computer-generated contours were inspected to ensure that they honored data-point values and edited, if necessary. The gridded data and contours then were used to develop maps using ArcMap, the mapping module of ArcInfo (Environmental Systems Research Institute, Inc., 2002).

Calculating Variations in Concentration of Nitrate (as Nitrogen)

The concentration and mass of nitrate (as nitrogen) in the unconfined aquifer were evaluated for seasonal and annual variations during 1997–2001 and for long-term variations from the 1940s through 2001.

The difference between the seasonal maximum and minimum concentration of nitrate (as nitrogen) was computed. Annual variations in concentration of nitrate (as nitrogen) during 1997–2001 were evaluated similarly, except that concentrations from samples collected during the annual mass-sampling period (June) of 1 year were subtracted from the concentration measured during the annual mass-sampling period in the subsequent year.

Annual variations in the concentrations of nitrate (as nitrogen) for 1997–2001 were used to evaluate short-term spatial variability in nitrate (as nitrogen) concentrations. To minimize apparent increases or decreases in nitrate (as nitrogen) concentration that were related to differences in the distribution of wells sampled in subsequent years, water-quality data were compared only for wells from which ground-water samples had been collected for both years. Because nitrate (as nitrogen) concentration values of the initial year were subtracted from the values of the subsequent year, a negative value indicates a decrease, and a positive value indicates an increase in concentration of nitrate (as nitrogen). The short-term variations in the concentration of nitrate (as nitrogen) were contoured in the GIS as discussed previously.

Long-term variations in the concentration of nitrate (as nitrogen) were evaluated by comparing the median concentration of nitrate (as nitrogen) for samples collected during 1997–2001 with concentrations of nitrate (as nitrogen) in ground-water samples collected during 1948–49 and 1968–69. Concentrations of nitrate (as nitrogen) for 1948–49 and 1968–69 and the median concentrations for 1997–2001 were estimated for a grid of 500-ft by 500-ft cells. The cell values for the 1948–49 and 1968–69 nitrate (as nitrogen) concentrations then were subtracted from cell values for the median 1997–2001 nitrate (as nitrogen) concentrations to calculate cell values representing the long-term difference in nitrate (as nitrogen) concentrations.

Estimation of the Mass of Nitrate (as Nitrogen) in the Unconfined Aquifer

Variations in the concentration of nitrate (as nitrogen) in ground water are a function of the nitrogen balance and water balance of the ground-water system. Nitrate (as nitrogen) concentrations can vary either as a result of changes in the amount of nitrate (as nitrogen) entering or leaving the system or the amount of water entering or leaving the system. To evaluate temporal variations in nitrate (as nitrogen) in the unconfined aquifer, it is necessary to determine the mass of nitrate (as nitrogen), which is computed as the volume of ground water multiplied by the nitrate (as nitrogen) concentration. The volume of water in the unconfined aquifer was estimated as the product of the saturated thickness and estimated effective porosity and area of the unconfined aquifer. Effective porosity is the ratio of the volume of interconnected pore space in a porous media to the total volume of the porous media. Effective porosity, as used in this analysis, should not be confused with specific yield. Specific yield, which is defined as the volume of water that drains from a saturated-porous media by gravity (Fetter, 1988), is less than effective porosity, because water clings to the porous media resulting in incomplete draining. The basin-fill deposits consist of coarse sands and gravels with an estimated effective porosity of 0.3 (McWhorter and Sunada, 1977; Freeze and Cherry, 1979; Ken Watts, U.S. Geological Survey, oral commun., 2000).

The GIS was used to compute the total volume of water (eq. 2) and mass of nitrate (as nitrogen) (eq. 3), assuming an effective porosity of 0.30. The total volume of water in the unconfined aquifer of the study area was estimated by summing the volumes for cells in the grid as:

$$V_{\mathrm{p}} = \sum_{i=1}^{n} A \times b \times \phi \qquad (2)$$

where,

V_p is total volume of pore water within the unconfined aquifer of the study area, in cubic feet;

A is surface area of grid cell, in square feet;

b is saturated thickness of grid cell, in feet;

ϕ is estimated effective porosity of 0.30, dimensionless;

n is total number of grid cells;

i is individual cell; and

Σ is summation of results for all grid cells.

The mass of nitrate (as nitrogen) in the unconfined aquifer of the study area was estimated by summing the mass for cells in the grid as:

$$M = \sum_{i=1}^{n} C \times K \times V \qquad (3)$$

where,

M is total mass of nitrate (as nitrogen) in the unconfined aquifer, in tons;

C is estimated concentration of nitrate (as nitrogen) within a grid cell, in milligrams per liter;

K is numeric constant to convert milligrams per liter to tons per cubic foot, 3.1213105×10^{-8};

V is total volume of pore water within a grid cell, in cubic feet;

n is total number of grid cells;

i is individual cell; and

Σ is summation of results for all grid cells.

Estimated Ground-Water Withdrawals

Determination of the amount of ground water pumped annually from the unconfined aquifer for irrigation is necessary to estimate the amount of nitrate (as nitrogen) removed annually from the unconfined aquifer. Understanding how much nitrate (as nitrogen) is removed annually from the unconfined aquifer as a result of pumpage is important to resource managers. In combination with long-term water-quality monitoring, information is available to resource managers that can be used to evaluate the effectiveness of implemented best-management practices (BMPs) in reducing the amount of nitrate (as nitrogen) in the unconfined aquifer.

The volume of water pumped from the unconfined aquifer for the 1998 growing season was estimated by GIS from crop distribution data and estimates of annual crop-water requirements (Scott Anderholm, U.S. Geological Survey, written commun., 1999). The distribution of crops was based on information from Ralph Curtis, (Rio Grande Water Conservation District, Alamosa, Colo., written commun., 1999). Estimated annual crop-water requirements of the individual crop types are 12 inches for potato and pastureland and 18 inches for grain, alfalfa, and vegetables (Kirk Thompson, Agro Engineering, Alamosa, Colo., oral commun., 1998). The previously prepared nitrate-concentration grid was transformed into a polygon coverage using the GRIDPOLY command of the GIS. The crop distribution and water-quality coverages then were joined using the INTERSECT command. Water use for 1998 was estimated on a cell-by-cell basis as the product of crop acreage and crop-water requirements. Water-use estimates are generalities and are based on the following: different varieties of crop types have similar water requirements, the amount of water applied by irrigators did not exceed crop-water requirements, and estimates of crop-water requirements were reasonable. The mass of nitrate (as nitrogen) removed during the 1998 irrigation season in a cell was estimated as the product of nitrate (as nitrogen) concentration (in milligrams per liter) in a cell, area (in square feet) of crops in a cell, conversion factor (6.242621×10^{-5}) to facilitate change in units of measure, and the estimated pumpage (in cubic feet) to meet water requirements of crops in a cell. The estimated mass of nitrate (as nitrogen) in individual grid cells was summed to compute an estimate of the total mass of nitrate (as nitrogen) removed from the unconfined aquifer by pumping during an irrigation season. Estimates of mass of nitrate (as nitrogen) removed from the unconfined aquifer are based on the assumption that nitrate (as nitrogen) removed from the unconfined aquifer by pumping is either consumed by the crop or stored in the unsaturated zone and not returned to the unconfined aquifer.

Hydrogeology

Ground water occurs under unconfined and confined conditions in the basin-fill deposits of the San Luis Valley. The unconfined aquifer is separated from the underlying, confined aquifer by a confining unit. The basin-fill deposits consist of several thousand feet of unconsolidated clay, silt, sand, and gravel, which were derived from erosion of the surrounding mountains, and are interbedded with volcanic and volcanoclastic rocks (Siebenthal, 1910; Emery and others, 1973; Huntley, 1979). Present (2001) saturated thickness of the unconfined aquifer ranges from about 50 to more than 120 ft. Saturated thickness of the unconfined aquifer varies in response to changes in the position of the water table, which varies in response to changes in rates of recharge and discharge of water to and from the aquifer. Powell (1958) reported that prior to the development of the system of irrigation canals in the 1880s, the water table of the unconfined aquifer along the western side of the San Luis Valley probably was near the top of the confining unit, 50 to 100 ft below current (2001) levels. The diversion of water from the Rio Grande and its tributaries since the 1880s has raised the water table and maintained an aquifer that contains large amounts of water. Detailed discussions of the geology of the San Luis Valley are available in Brister and Gries (1996), Burroughs (1981), McCalpin (1996), and Watkins (1996).

Confining Unit

The confining unit consists of a series of discontinuous, interbedded, clays, sands, and volcanic rocks locally known as the “Blue Clay.” The generalized altitude of the top of the confining unit was determined during this study to allow calculation of the saturated thickness of the unconfined aquifer. The generalized altitude and configuration of the top of the confining unit were approximated using driller’s logs for 340 wells within and near the study area. Information regarding well location, construction, and lithology, was tabulated. Land-surface altitude was estimated from 7.5-minute series topographic maps. Based on uncertainties in site location and interpolation of land-surface altitude from topographic maps, estimates of land-surface elevation were accurate to within ±5 ft. Lithology information and estimated land-surface altitude were used by the GIS to estimate the altitude of the top of the confining unit at the well. The altitude of the top of the confining unit was calculated by subtracting the depth to the top of the confining unit from the estimated altitude of the land surface. A map of the altitude of the top of the confining unit was computer generated and the information contoured using a contour interval of 20 ft. The generalized altitude and configuration of the top of the confining unit in the study area is shown in figure 3.

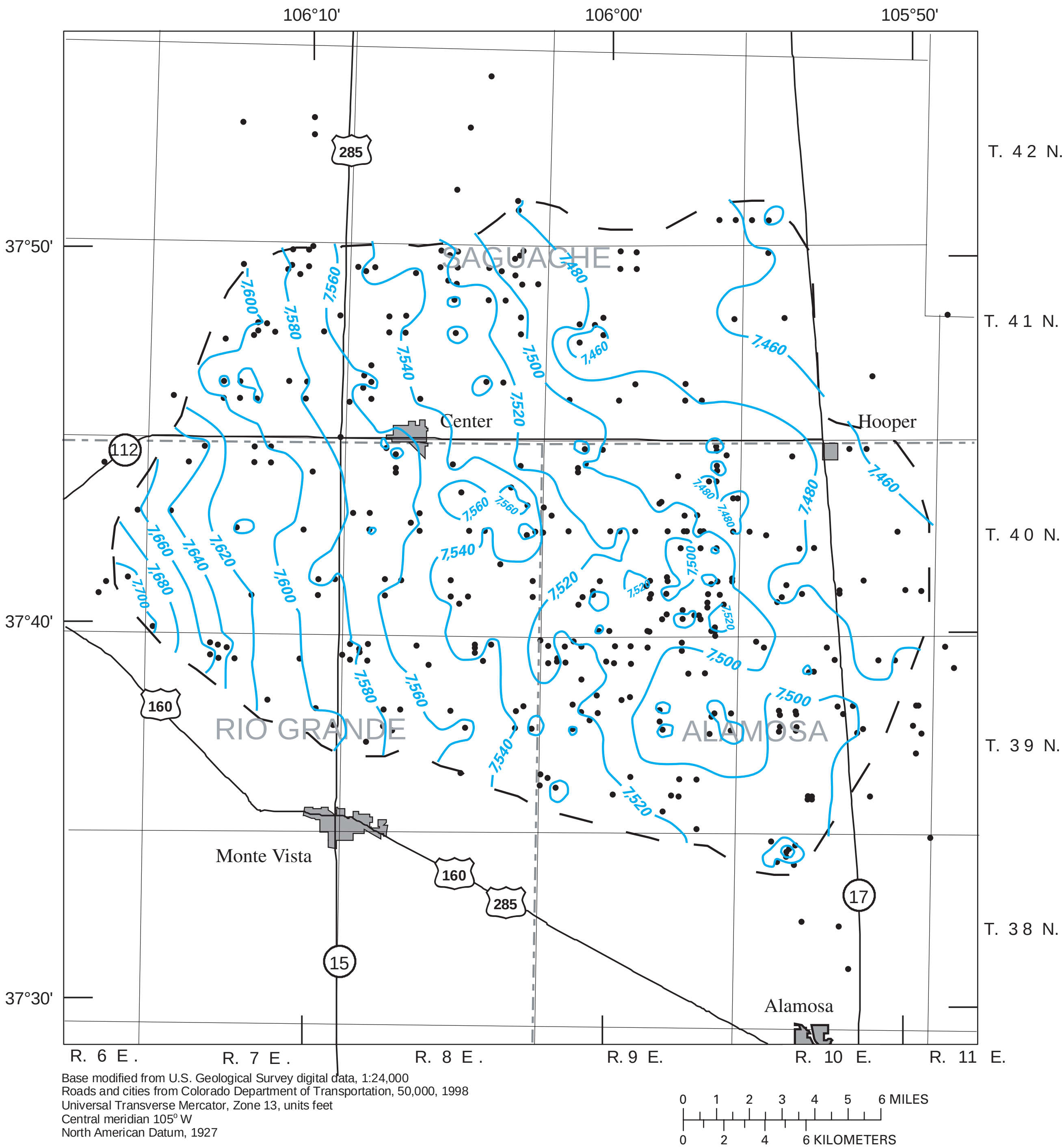
The surface of the confining unit in the study area generally slopes eastward from an altitude of about 7,700 ft along the southwestern part of the study area to about 7,450 ft along the northeastern part of the study area. This representation of the surface of the confining unit is similar to a representation created by the Rio Grande Decision Support System (Seitz and others, 2001).

Unconfined Aquifer

The unconfined aquifer is a significant water resource used for irrigation of crops in the study area. Ground water from the unconfined aquifer also is used by many rural homeowners for domestic supply. Recharge to the unconfined aquifer is primarily provided by infiltration of surface water diverted into the study area (Powell, 1958).

Depth-to-Water Table and Ground-Water Table Altitude

Depth to water was measured in monitoring wells by USGS and field personnel using either a graduated steel or electric water-sensing tape and by following standard protocols (U.S. Geological Survey, 1980, p. 2–8). The altitude of the water-table surface was calculated by subtracting the depth-to-water measurement at monitoring wells from the land-surface altitude at the monitoring wells. As previously discussed, contour maps of the depth to water, and altitude of the water table, during the water-quality mass-sampling period were prepared. The water-table maps (fig. 4) were used to determine the direction of regional ground-water flow.



EXPLANATION

Study-area boundary

7,460 **Structure contour—** Shows generalized altitude of top of confining unit. Contour interval 20 feet. Datum NGVD 1929

Well—Approximate location of center-pivot irrigation well

Figure 3. Generalized altitude of the top of the confining unit (Blue Clay).

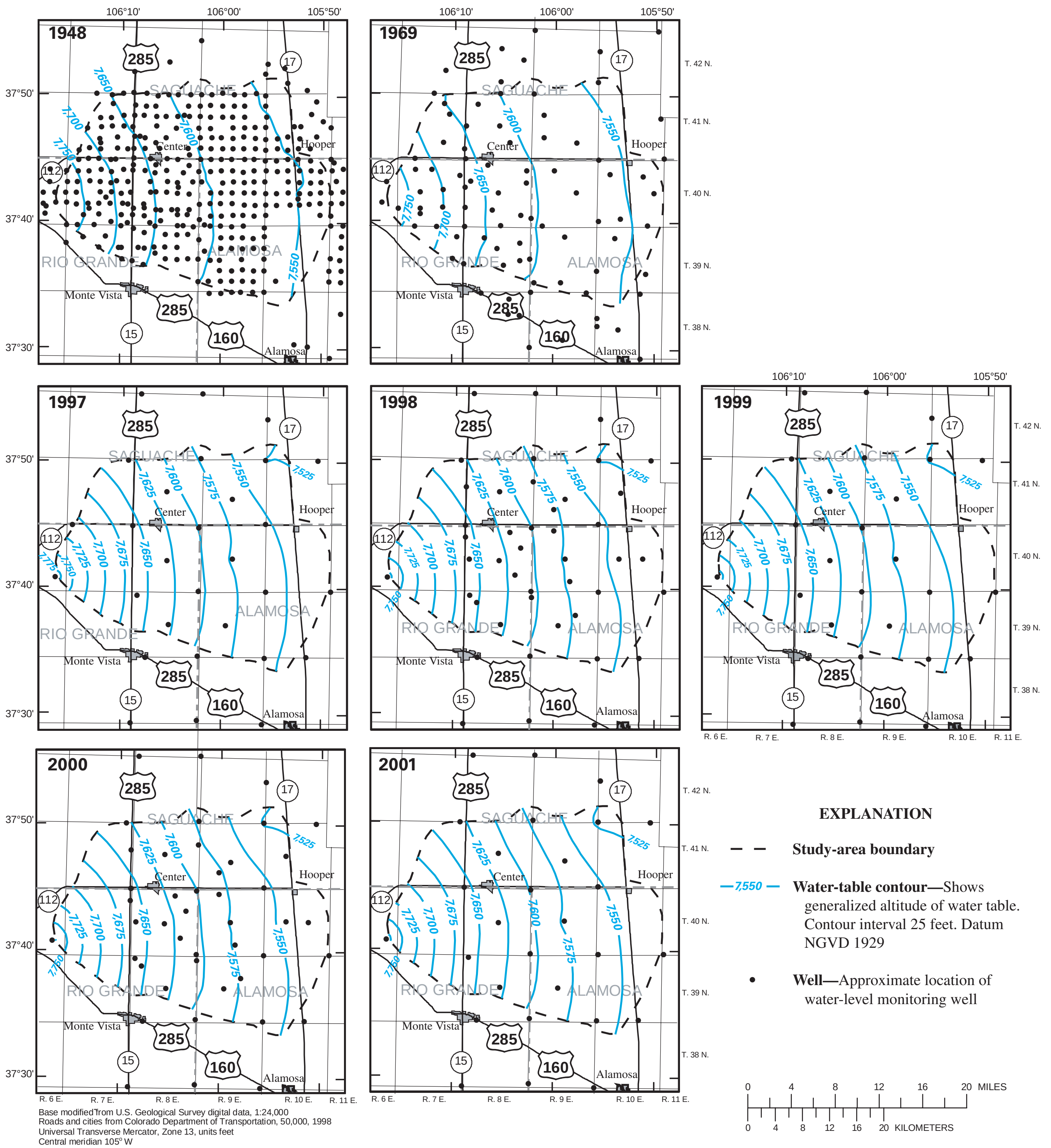


Figure 4. Generalized altitude of the water table during 1948, 1969, and June 1997–2001.

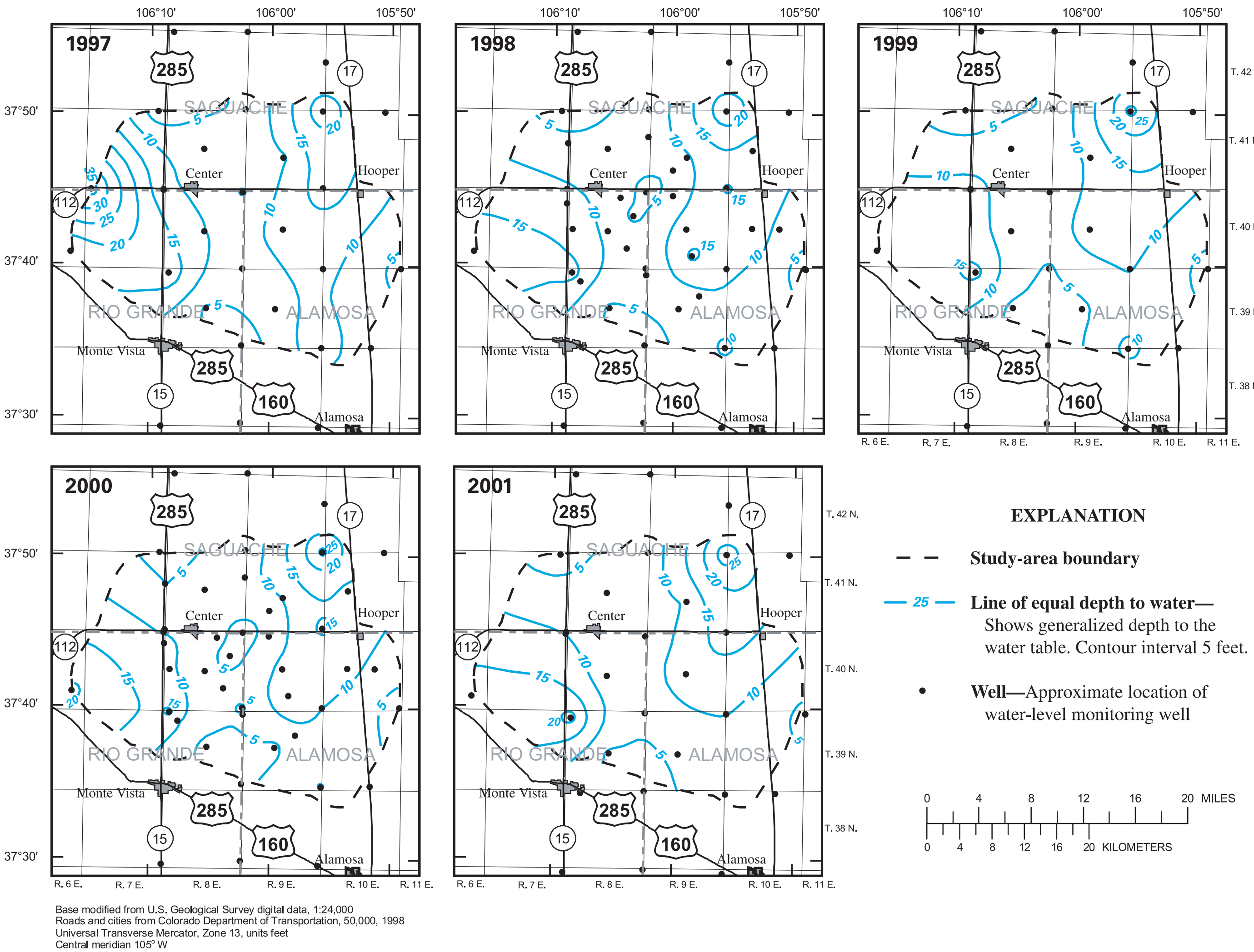


Figure 5. Depth to water of the unconfined aquifer during June 1997–2001.

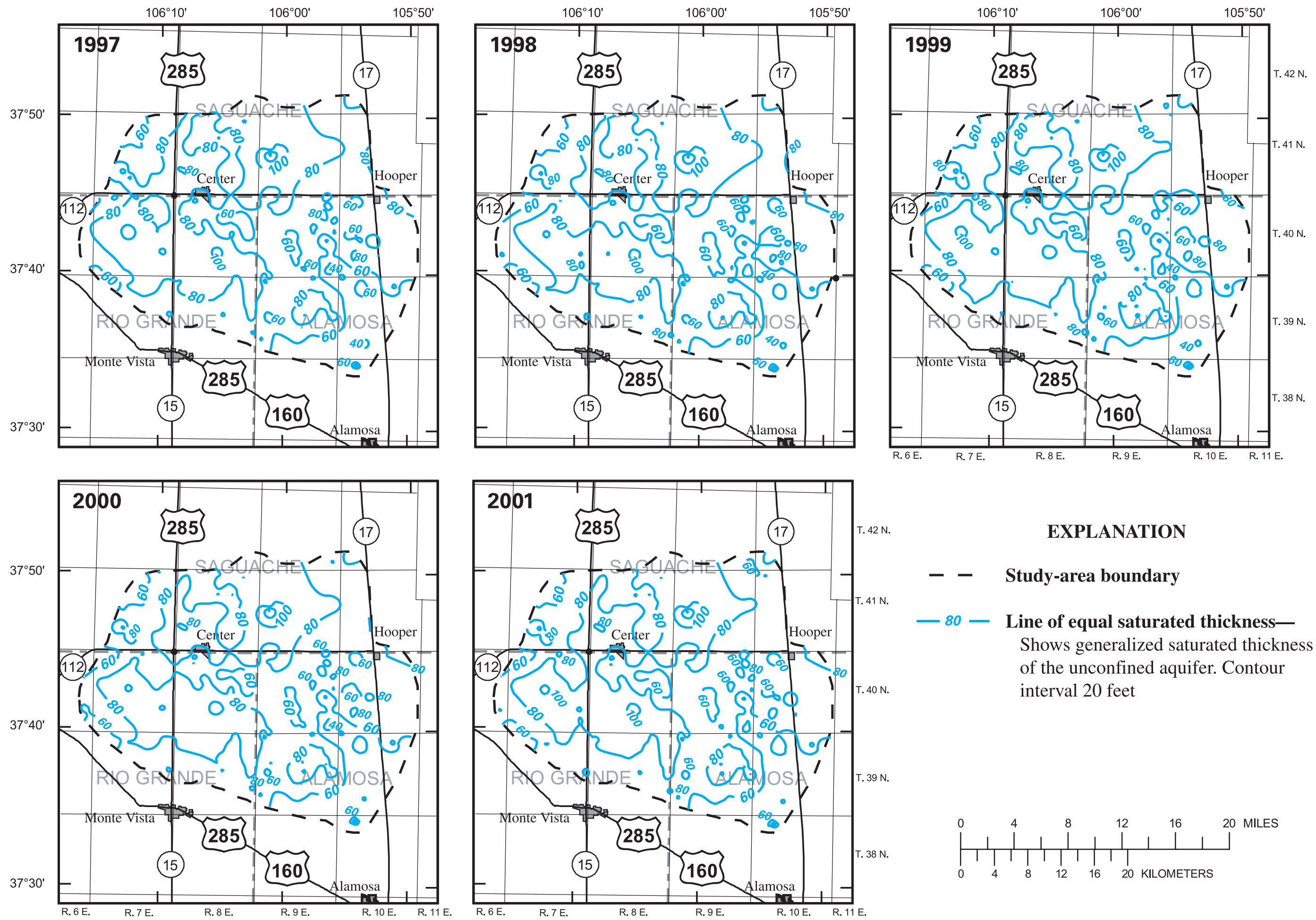
Depth to water (table 5 at back of report) during June of 1997–2001 ranged from less than 5 ft to more than 25 ft (fig. 5). The depth to water in the unconfined aquifer generally was least in the central and southeastern parts of the study area and greatest in the southwestern and northeastern parts of the study area. The depth to water varies in response to seasonal recharge and discharge. When discharge from the aquifer exceeds recharge, water levels decline, and when recharge exceeds discharge, water levels increase.

Saturated Thickness

The saturated thickness of the unconfined aquifer during the 1997–2001 annual mass-sampling periods was estimated by subtracting the altitude of the top of the confining-unit grid from the altitude of the 1997–2001 annual water-table surfaces for each cell in the grids. The saturated thickness of the unconfined aquifer is needed to compute the mass of nitrate (as nitrogen) in the unconfined aquifer. The saturated thickness (fig. 6) generally was least, about 40 ft, in the southeast, and greatest, about 80 to 100 ft, in the western and north-central parts of the study area. The saturated thickness of the unconfined aquifer at any location was similar from year to year during 1997–2001.

Hydraulic Gradients, Ground-Water Velocity, and Estimated Traveltime

The regional slope of the water table in the study area is from west to east (fig. 4). The slope of the water table (the hydraulic gradient) is greater in the west than in the east. Hydraulic gradient is a dimensionless ratio that is defined as "the change in static head (water level) per unit of distance in ... the direction generally understood to be that of the maximum rate of decrease in head" (Lohman and others, 1972, p. 8). A hydraulic gradient of 0.001 is equivalent to a 1-ft decrease in the water-table surface in a distance of 1,000 ft. Changes in the hydraulic gradient often are caused by changes in the hydraulic properties, saturated thickness, or local recharge and discharge conditions. The average hydraulic gradient from the western boundary of the study area to Highway 285 is about 0.0031;



Base modified from U.S. Geological Survey digital data, 1:24,000
Roads and cities from Colorado Department of Transportation, 50,000, 1998
Universal Transverse Mercator, Zone 13, units feet
Central meridian 105° W
North American Datum, 1927

Figure 6. Saturated thickness of the unconfined aquifer during June 1997–2001.

from Highway 285 to the boundary between Rio Grande and Alamosa Counties is about 0.002; from the boundary between Rio Grande and Alamosa Counties to the eastern boundary of Range 9 East is about 0.0015, and from the eastern boundary of Range 9 East to the eastern boundary of the study area is about 0.0008.

The minimum traveltime (t) for a molecule of ground water to traverse the study area was estimated along a west-to-east transect through Township 40 North, Ranges 7, 8, 9, and 10 East (New Mexico Meridian). Hydraulic gradients (change in head over a horizontal distance) from figure 4, average aquifer characteristics of transmissivity (T), and saturated thickness (b) were used in the following equations to estimate the Darcian or bulk velocity (q) and the seepage velocity (v):

$$q = -\left(T/b\right)\left(\Delta h/\Delta l\right) \tag{4}$$

$$v = q/\phi \tag{5}$$

where,

q is specific discharge through a unit area, in cubic feet per day per square foot;
T is transmissivity, in square feet per day (values used ranged from 6,700 to 23,450, Emery and others, 1973);
b is thickness of saturated aquifer, in feet (values used ranged from 60 to 100, fig. 6);
Δh is change in head, in feet;
Δl is change in horizontal distance, in feet;
v is seepage velocity, in feet per day, and
ϕ is estimated effective porosity, assumed to be 0.30.

$$t = L/v \tag{6}$$

where,

t is minimum traveltime, in days;
L is distance, in feet; and
v is seepage velocity, in feet per day.

The estimated theoretical time required for an unimpeded water particle to traverse from one side of a 0.5-mi^2 field to the other (2,640 ft) ranged from 4.6 years (Township 40 North, Range 8 East) to 19.9 years (Township 40 North, Range 10 East). The variation in estimated traveltime is due to the varying transmissivities and hydraulic gradients of the aquifer from west to east across the study area. Similar analyses (Eddy-Miller, 1993; Thompson and Loftis, 1995) conducted at the field scale in the northern part of the study area (Township 41 North, Range 8 East) resulted in estimates of 7.7 years and 9.6 years for a particle of water to traverse a 0.5-mi^2 field. Estimated time required to traverse the study area, a distance of about 23 mi, is about 400 years. To traverse the central part of the study area between Highway 285 and Highway 17, a distance of about 15 mi, where nitrate (as nitrogen) concentrations are greatest would require about 240 years. Given the high density of irrigation wells in the study area, it is unlikely that a water particle could traverse the study area without being affected by local-flow patterns that are caused by ground-water pumpage.

Estimated Volume of Water in Unconfined Aquifer

The volume of water in the unconfined aquifer beneath the study area was estimated for 1948–49, 1968–69, and each year during 1997–2001 based on saturated thickness and an assumed aquifer effective porosity of 0.3. During 1948–49, the estimated volume of water in the unconfined aquifer was 5,840,000 acre-ft. During 1948–49, farmers used a method of irrigation known as subirrigation. Water diverted from rivers and streams was used to flood agricultural fields. The widespread flooding of agricultural land caused the water table to rise to within the roots of growing crops. During 1968–69, the estimated volume of water in the unconfined aquifer was 5,640,000 acre-ft, a decrease of 200,000 acre-ft (about 3 percent) from 1948–49. The decrease in the volume of water in the unconfined aquifer coincided with the conversion from the practice of subirrigation to the installation and use of pumped wells to supply water to crops. The installation of pumped wells to irrigate crops during the 1940s through 1960s was followed by the installation of center-pivot sprinklers during the 1970s and 1980s. The estimated volume of water varied little from year to year during 1997–2001, from a minimum of 5,230,000 acre-ft in 1998 to a maximum of 5,290,000 acre-ft in 1997. The average-estimated volume of water in the unconfined aquifer between 1997–2001 was about 5,260,000 acre-ft, about 7 percent less than in 1968–69, and about 10 percent less than in 1948–49.

Distribution of Nitrate (as Nitrogen) in the Unconfined Aquifer

The distribution of nitrate (as nitrogen) was evaluated primarily for 1997–2001 to determine the current spatial variations in the distribution of nitrate (as nitrogen) in the unconfined aquifer. Secondly, historical data collected during 1948–49 and 1968–69 (Scofield, 1938; Powell, 1958; Emery and others, 1972) were used to estimate historical nitrate (as nitrogen) distributions and evaluate long-term variations in the distribution of nitrate (as nitrogen) in the study area. Although the wells sampled during 1948–49 and 1968–69 were not uniformly distributed, the estimations of nitrate (as nitrogen) distributions seem to be reasonable. Locations of wells from which ground-water samples were collected, and results from water-quality analyses from wells sampled during 1948–49, 1968–69 and during 1997–2001 were entered into the GIS (tables 1–3). As described earlier, grids of the water-quality data were contoured.

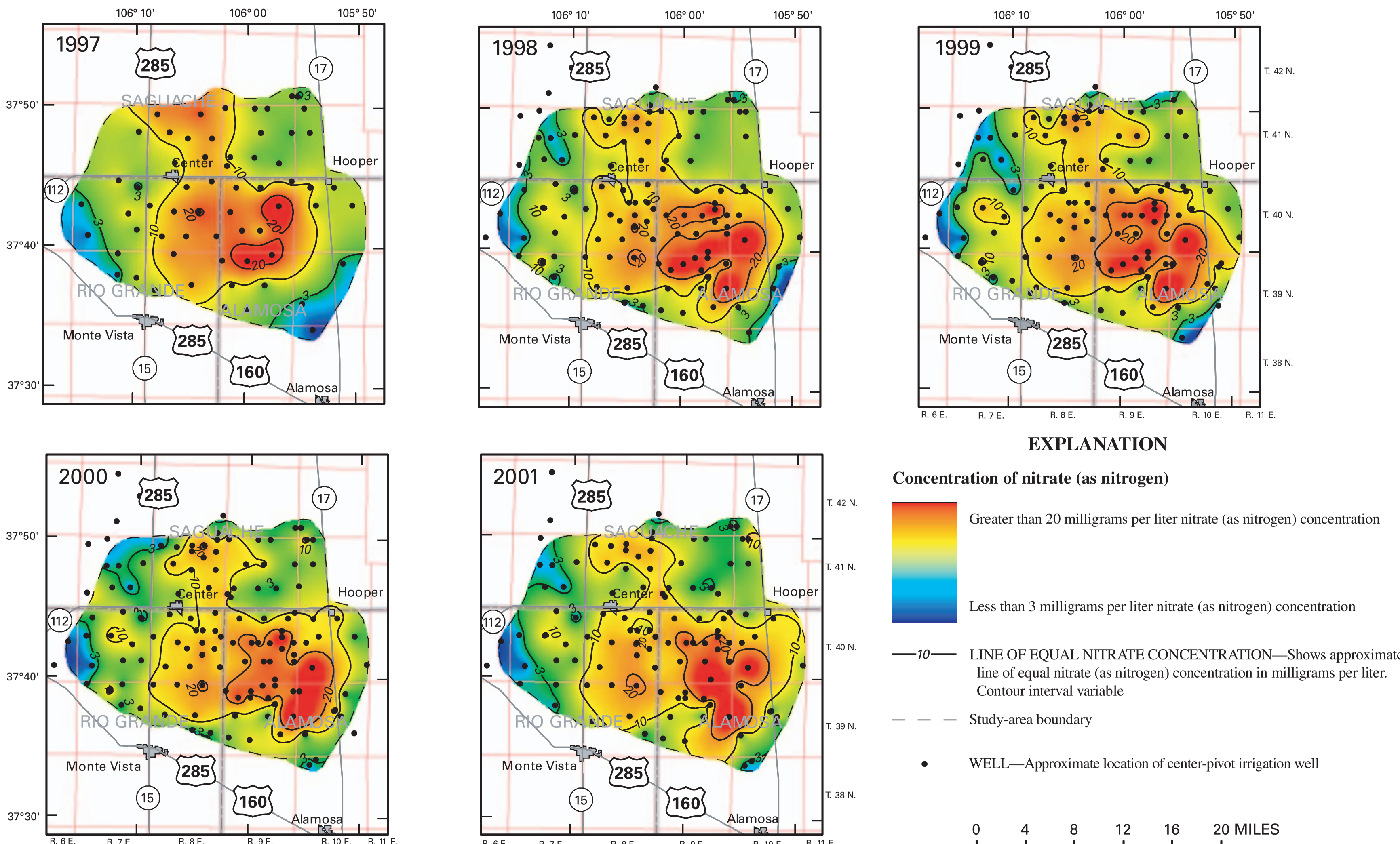
Stogner (1997) determined that nitrate (as nitrogen) concentrations in ground-water samples collected from shallow monitoring wells, which were completed in the upper 10 ft of the unconfined aquifer, in the study area differed substantially both spatially and temporally. Other studies of the unconfined aquifer in the San Luis Valley (Edelmann and Buckles, 1984; Ellerbroek and others, 1992; Sarason, 1998) also indicate that nitrate (as nitrogen) concentrations are stratified vertically—greater at the top of the aquifer than at the bottom. Although vertical stratification of nitrate (as nitrogen) concentration is not addressed in this study, the reader is advised that because of the possible vertical stratification of nitrate (as nitrogen) in ground water, ground-water samples collected from wells screened only near the top or near the bottom of the unconfined aquifer may have nitrate (as nitrogen) concentrations different than those depicted in figures and tables of this report, which represent the average concentration.

Distribution of Nitrate (as Nitrogen) During 1997–2001

Nitrate (as nitrogen) concentrations in ground-water samples collected from wells in and near the study area during 1997–2001 ranged from 0.2 to 65.7 mg/L (fig. 7, table 6). The concentration of nitrate (as nitrogen) exceeded 3 mg/L in ground-water samples collected from 121 of 142 wells (about 85 percent) sampled during this study (1997–2001), which has been considered the maximum background concentration for nitrate (as nitrogen) in the study area (Stogner, 2001). The concentration of nitrate (as nitrogen) exceeded 10 mg/L in ground-water samples collected from 84 of 142 wells (about 59 percent) sampled during this study, which is the State of Colorado (Colorado Department of Public Health and Environment, 2001) and USEPA's maximum contaminant level for drinking water (U.S. Environmental Protection Agency, 2003).

Spatial Variability

Review of the spatial distribution of nitrate (as nitrogen) in ground water in the unconfined aquifer in the study area (fig. 7), as indicated by lines of equal concentration, reveals an extensive area in which nitrate (as nitrogen) concentrations are



Base modified from U.S. Geological Survey digital data, 1:24,000
Roads and cities from Colorado Department of Transportation, 1:50,000, 1998
Universal Transverse Mercator projection, Zone 13, units feet
Central meridian 105°W
North American Datum, 1927

Figure 7. Approximate distribution of the concentration of nitrate (as nitrogen) in the unconfined aquifer during June 1997–2001.

Table 6. Statistical summary of results of analyses of ground-water samples collected from center-pivot wells in the San Luis Valley.

[mg/L, milligrams per liter]

Year	Number of wells sampled	Nitrate (as nitrogen) concentration, in milligrams per liter					Number of wells with sample concentrations greater than 3 mg/L	Number of wells with sample concentrations greater than 10 mg/L
		Minimum	Maximum	25th percentile	50th percentile	75th percentile		
1948-49	72	0.02	11.4	0.1	0.4	0.9	4	1
1968-69	84	0.1	31.4	1.2	3.6	6.8	42	8
1997	60	0.2	34.2	4.9	7.7	14.4	25	26
1998	113	0.2	51.5	4.2	9.6	15.0	35	53
1999	99	0.4	57.9	4.3	10.2	16.8	25	45
2000	119	0.4	57.6	3.5	9.8	15.0	40	57
2001	109	0.5	65.7	3.5	9.6	15.5	33	52

greater than the background-threshold concentration of 3 mg/L and in which nitrate (as nitrogen) concentrations exceed 10 mg/L. As shown in figure 7, nitrate (as nitrogen) concentrations in most of the study area exceed the background threshold of 3 mg/L, and many—particularly in the central to southeastern part of the study area between Highways 285, 17, and 112, and an area north and east of the town of Center—exceed the USEPA drinking-water standard of 10 mg/L.

Nitrate (as nitrogen) concentrations were less than 3 mg/L in only about 25 mi^2 or about 7 percent of the study area and generally occurred near the western upgradient edge of the study area, not too distant from the proximal edge of the basin-fill deposits. Nitrate (as nitrogen) concentrations were greater than 3 and less than 10 mg/L in about 180 mi^2 or about 50 percent of the study area. Nitrate (as nitrogen) concentrations greater than 10 mg/L and less than 20 mg/L were distributed over an area of about 130 mi^2 or about 34 percent of the study area. Nitrate (as nitrogen) concentrations greater than 20 mg/L were distributed over an area of about 35 mi^2 or about 10 percent of the study area.

Data density may have influenced the computed spatial distribution of nitrate (as nitrogen). A larger spacing of wells sampled along the eastern extent of the lines of equal concentration for nitrate (as nitrogen) concentrations greater than 10 mg/L in figure 7 may have resulted in more error in the distribution of nitrate (as nitrogen) in this area, because nitrate (as nitrogen) concentrations greater than 20 mg/L in samples from two wells had a large influence on the computed distribution of nitrate (as nitrogen) in this area. Permission to sample additional wells in this area was not granted; therefore, fewer wells were sampled in this area than in other areas.

Temporal Variability in Nitrate (as Nitrogen) Concentrations

Temporal variability in nitrate (as nitrogen) concentrations was evaluated for seasonal variations during the annual multi-sampling periods (May through August) and for annual variations during the mass-sampling periods (June 1997–2001).

Seasonal Variability

Variability of nitrate (as nitrogen) concentrations during the growing season was evaluated based on the difference between the maximum and minimum nitrate (as nitrogen) concentrations in samples that were collected during the growing season during each year. Ninety-two evaluations of variability in concentration of nitrate (as nitrogen) during the growing season (May through August) were made during 1997–2001. The difference between minimum and maximum sample concentrations of nitrate (as nitrogen) during the growing season for a particular year generally were less than 2.5 mg/L for 61 of 92 comparisons (66 percent) (fig. 8). Wells with the largest variability in concentration in nitrate (as nitrogen) generally were located in the southeastern part of the study area (fig. 8). However, wells with small variability in concentration of nitrate (as nitrogen) usually were close to wells with larger variability in concentration of nitrate (as nitrogen), which indicates that variability in concentration of nitrate (as nitrogen) was more a function of local rather than regional factors.

Evaluating reasons for seasonal variability in concentration of nitrate (as nitrogen) was beyond the scope of this investigation, but preliminary investigations indicate that timing of sampling and diversion of surface water and proximity of well to diversion structures may, in part, explain the seasonal variability in concentration of nitrate (as nitrogen).

Variability during mass-sampling period

Samples were collected in early and late June (mass-sampling period) at selected wells during 1997–2001 to determine short-term (10–30 day) variation in nitrate (as nitrogen) concentrations. Sixty evaluations were made of variability in concentration of nitrate (as nitrogen) during the mass-sampling period were made. The median number of days between the collection of the initial sample and the last sample was 13 days. Differences between initial and final sample concentration of nitrate (as nitrogen) ranged from 0.0 to 33.2 mg/L (fig. 9). The median difference was 0.6 mg/L, and the average difference was 1.9 mg/L. Most differences (49 of 60 comparisons, 82 percent) were less than 2.5 mg/L.

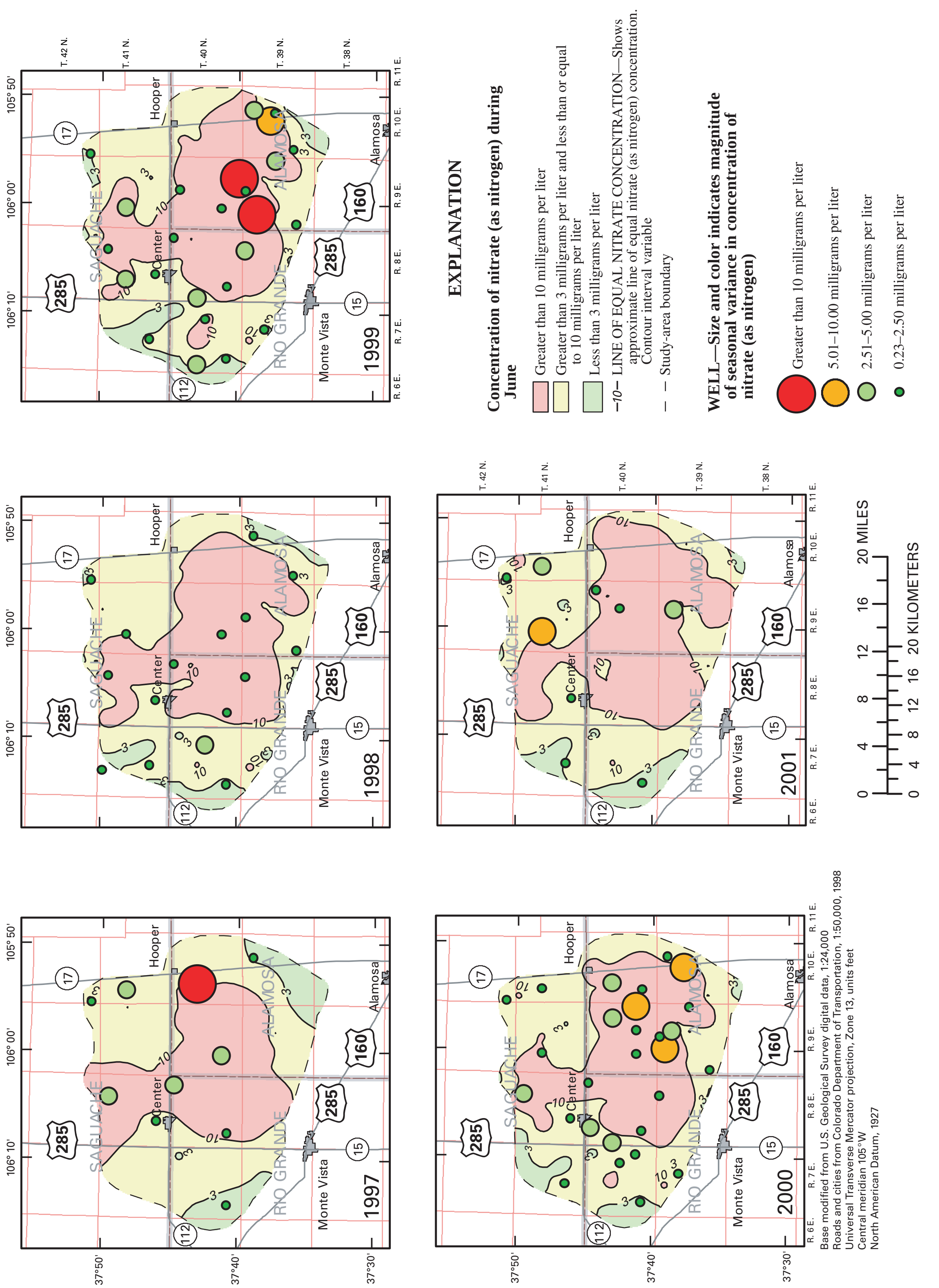


Figure 8. Distribution of nitrate (as nitrogen) and variation in concentration of nitrate (as nitrogen) in water-quality samples collected at multiple times during the growing season, May through August 1997–2001.

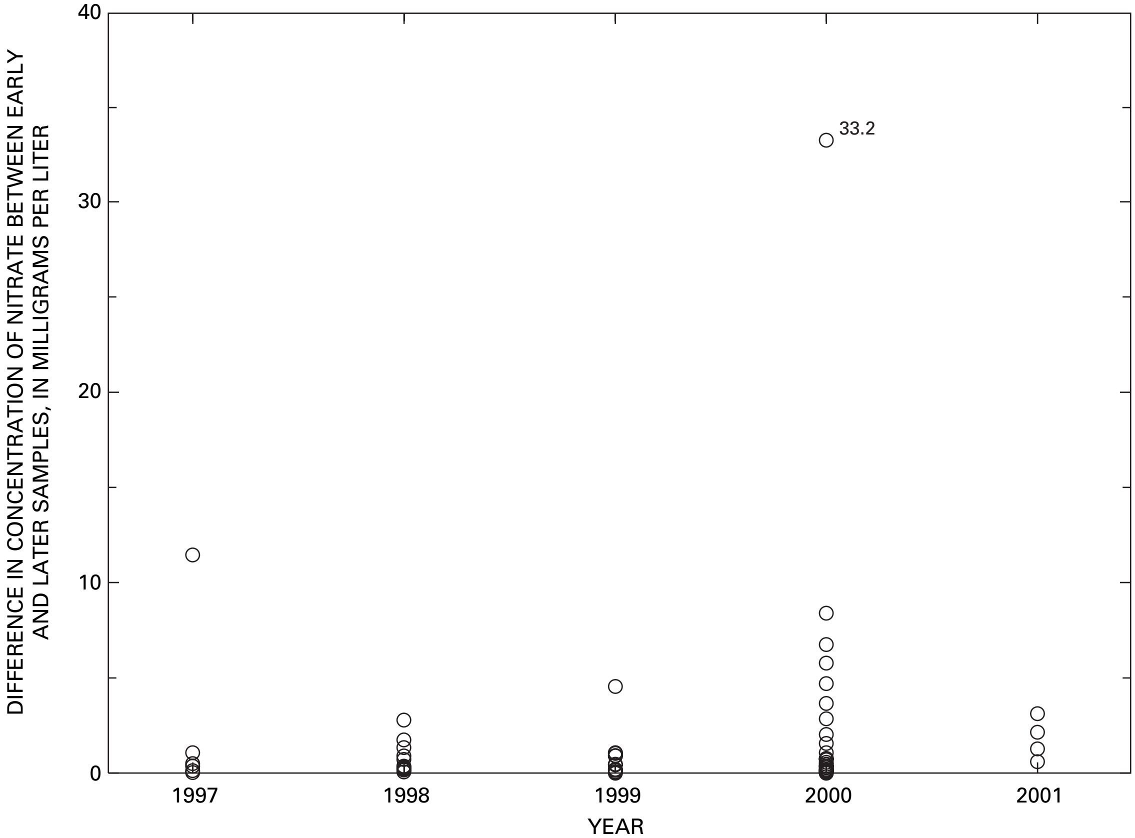


Figure 9. Variability in concentration of nitrate (as nitrogen) during mass-sampling period, June 1997–2001.

Annual Variability

Variability in nitrate (as nitrogen) concentrations between subsequent years at a particular well was evaluated by computing the difference between the concentration of nitrate (as nitrogen) in samples collected during sequential years and by using GIS to map the variability (fig. 10). In most of the study area, nitrate (as nitrogen) concentrations generally changed by less than 2.5 mg/L from 1 year to the next (fig. 10) indicating that nitrate (as nitrogen) concentrations were in a quasi-steady state during 1997–2001. Areas with variability greater than 2.5 mg/L generally seemed to be localized and were associated with one or a few wells.

Distribution of Nitrate (as Nitrogen) During 1968–69

Nitrate (as nitrogen) concentrations in ground-water samples collected from 83 wells in or near the study area during 1968–69 (Emery and others, 1972) ranged from less than 0.1 to 31.4 mg/L. The distribution of nitrate (as nitrogen) concentrations in ground-water samples collected from wells in or near the study area during 1968–69, however, may be biased because it includes data for samples collected from five shallow wells. The use of these data may result in overestimating the concentration of nitrate (as nitrogen) in the unconfined aquifer for 1968–69 at the location of the five wells because it is generally accepted that nitrate (as nitrogen) concentrations in shallow wells are greater than nitrate (as nitrogen) concentrations in deeper wells. Concentrations of nitrate (as nitrogen) were less than 3 mg/L in samples from two of these wells and between 3 and 10 mg/L in samples from three wells, and the corresponding nitrate (as nitrogen) concentrations in deeper ground-water samples likely would have been lower. Despite the potential bias of these data, the GIS methodology used in this study to contour concentrations of nitrate (as nitrogen) during 1968–69 (fig. 11) indicates smaller areas of nitrate (as nitrogen) concentrations greater than 3 mg/L than the original interpretation of the data reported in 1973 (Emery and others, 1973).

Using the GIS methods explained earlier in this report, analysis of the spatial distribution of nitrate (as nitrogen) concentrations measured during 1968–69 indicates the concentration of nitrate (as nitrogen) in the unconfined aquifer was less than 3 mg/L in an area of about 140 mi^2, or about 39 percent of the study area, and occurred primarily along the western, northern, and eastern boundary of the study area. Nitrate (as nitrogen) concentrations greater than 3 and less than 10 mg/L occurred in an area of about 210 mi^2, or about 58 percent of the study area, including the interior and southern boundary of the study area. Nitrate (as nitrogen) concentrations greater than 10 mg/L were distributed over an approximated area of about 12 mi^2, or about 3 percent of the study area. Areas with nitrate (as nitrogen) concentrations greater than 10 mg/L generally were small and localized and were identified by water-quality samples from one or two wells.

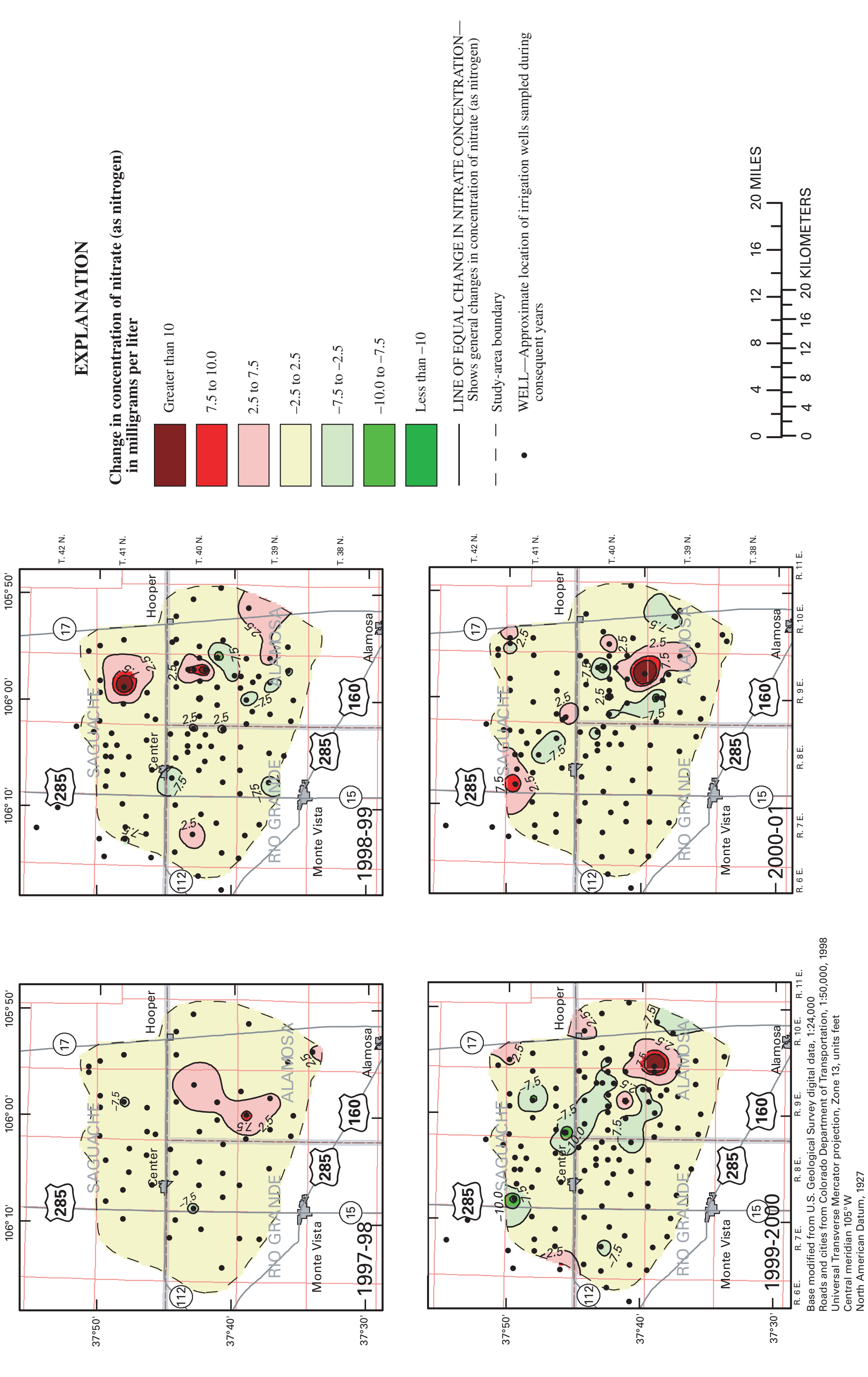
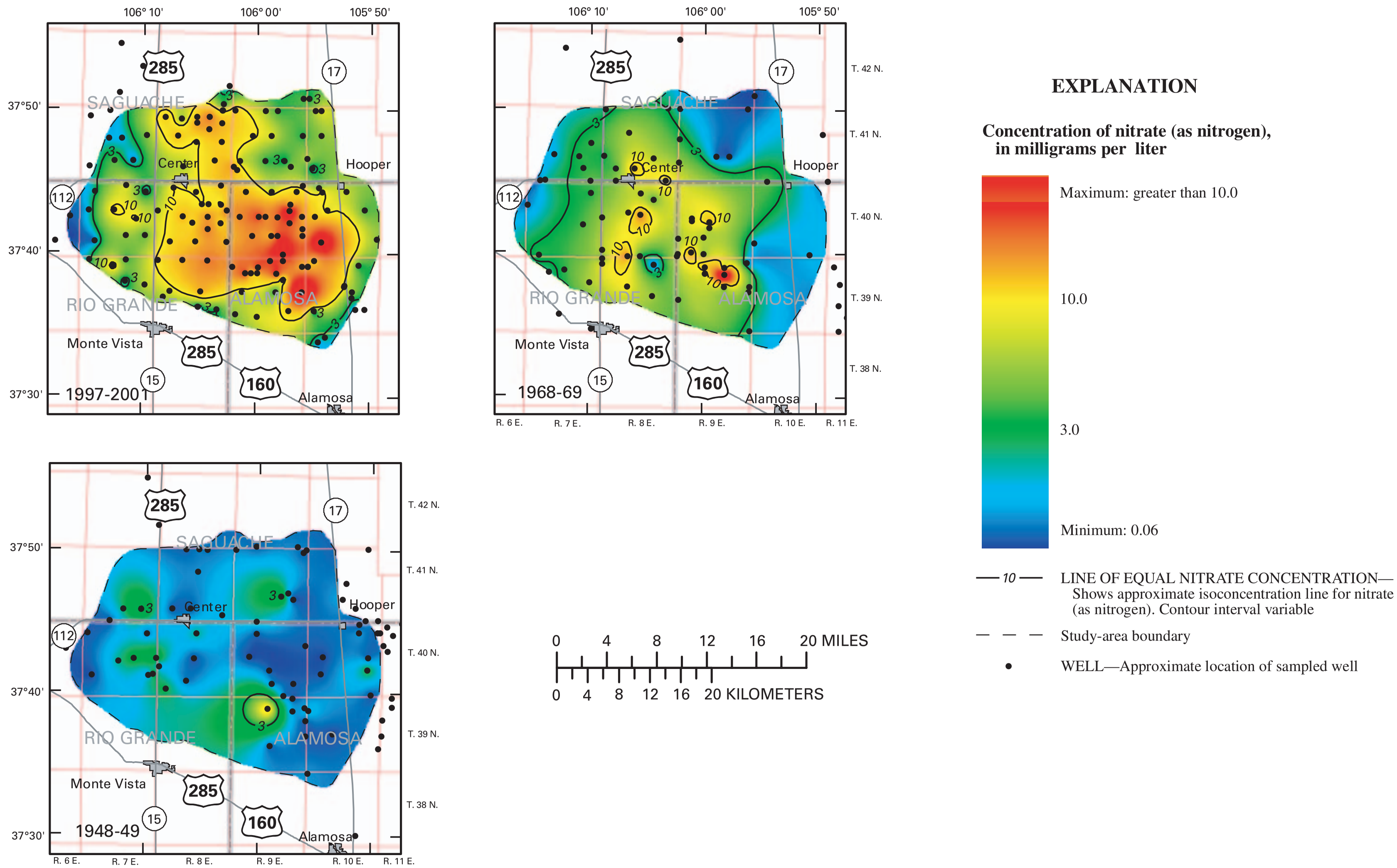


Figure 10. Estimated change in concentration of nitrate (as nitrogen), 1997 to 1998, 1998 to 1999, 1999 to 2000, and 2000 to 2001.



Base modified from U.S. Geological Survey digital data, 1:24,000
Roads and cities from Colorado Department of Transportation, 1:50,000, 1998
Universal Transverse Mercator projection, Zone 13, units feet
Central meridian 105°W
North American Datum, 1927

Figure 11. Estimated distribution of the concentration of nitrate (as nitrogen) in the unconfined aquifer during 1948–49, 1968–69, and 1997–2001.

Distribution of Nitrate (as Nitrogen) During 1948–49

The distribution of nitrate (as nitrogen) in the unconfined aquifer during 1948–49 (fig. 11), and prior to the widespread use of commercial fertilizers in the San Luis Valley, is based on identical GIS methodology used to evaluate the distribution of nitrate (as nitrogen) during 1997–2001 and 1968–69. During 1948–49, Scofield (1938) and Powell (1958) sampled 82 wells in and near the area for analysis of nitrate (as nitrogen) concentration. The distribution of the wells sampled was nonuniform with no samples in the south-central part of the study area; however, the distribution map presented represents an approximation based on available data.

During 1948–49, nitrate (as nitrogen) concentrations in the unconfined aquifer ranged from less than 0.1 to 11.4 mg/L and generally were less than 1 mg/L. The wells sampled generally were shallow, less than 40 ft in depth and likely did not fully penetrate the unconfined aquifer and, therefore, are more susceptible to being affected by transport of nitrate (as nitrogen) from the land surface.

Nitrate (as nitrogen) concentrations in ground-water samples from 65 wells were less than 1 mg/L; from 12 wells they were between 1 and 3 mg/L, and from 4 wells between 3 and 10 mg/L. Nitrate (as nitrogen) concentrations exceeded 10 mg/L (11.4 mg/L) in only one well, which was 9.7 ft deep. The four wells with ground-water samples in which nitrate (as nitrogen) concentrations were greater than 3 mg/L and less than 10 mg/L were less than 25 ft deep, isolated from other wells with elevated nitrate (as nitrogen) concentrations, and near other wells with nitrate (as nitrogen) concentrations less than 3 mg/L. Also, three of the five wells with nitrate (as nitrogen) concentrations greater than 3 mg/L, including the well from which the 11.4 mg/L sample was collected, were sampled numerous times during the 1940s, and at least one sample had a nitrate (as nitrogen) concentration less than 3 mg/L, indicating that samples with nitrate (as nitrogen) concentrations greater than 3 mg/L may have represented localized leaching of nitrate (as nitrogen). In 1948–49, the area in which wells would likely yield water with nitrate (as nitrogen) concentrations less than 3 mg/L was about 350 mi^2. Wells in the rest of the study area, about 20 mi^2, would likely yield water with nitrate (as nitrogen) concentrations greater than 3 mg/L but less than 10 mg/L.

Variations in the Distribution of Nitrate (as Nitrogen)

Variations in the distribution of nitrate (as nitrogen) during 1997 through 2001

The areas in which concentrations of nitrate (as nitrogen) were greater than 3 but less than 10 mg/L, and greater than 10 mg/L, respectively, generally were consistent from year to year during 1997–2001 (fig. 7) with minor changes in the location of lines of equal concentration. Some of these differences likely were the result of differences in the number and distribution of wells sampled during a given year. Analysis of variations in distribution of nitrate (as nitrogen) between sequential years based on similar well networks (fig. 10) reveals little change from 1 year to the next in most wells. Moderate to large variations generally were associated with one or a few wells in proximity to each other and near other wells with little change in concentration of nitrate (as nitrogen).

Variations in the distribution of nitrate (as nitrogen) during 1940s through 2001

Nitrate (as nitrogen) concentrations and their distribution changed considerably between 1948–49, 1968–69, and 1997–2001 (fig. 11). The cumulative area in which nitrate (as nitrogen) concentrations in ground water from the unconfined aquifer were less than 3 mg/L decreased from 350 mi^2 to 140 mi^2, between 1948–49 and 1968–69, and decreased from 140 mi^2 to 25 mi^2, between 1968–69 and 1997–2001. The cumulative area in which wells would likely yield water with nitrate (as nitrogen) concentrations greater than 3 but less than 10 mg/L increased from 20 mi^2 to 210 mi^2, between 1948–49 and 1968–69, and decreased slightly from 210 mi^2 to 180 mi^2, between 1968–69 and 1997–2001. The cumulative area in which wells would likely yield water with nitrate (as nitrogen) concentrations greater than 10 mg/L increased from 0 mi^2 in 1948–49 to 12 mi^2 in 1968–69 and 165 mi^2 in 1997–2001.

Mass of Nitrate (as Nitrogen) in the Unconfined Aquifer

Estimates of the mass of nitrate (as nitrogen) within the unconfined aquifer are a function of nitrate (as nitrogen) concentration, saturated thickness and effective porosity of the aquifer, and area. Areas with large concentrations of nitrate (as nitrogen), but relatively thin saturated thickness, may have less mass than areas with smaller concentrations but greater saturated thickness. Estimates of mass vary, not only with changes in concentrations of nitrate (as nitrogen), but also in response to changes in volume of water in the aquifer, which are indicated by changes in water levels.

The mass of nitrate (as nitrogen) in the unconfined aquifer was estimated for the current study period, 1997–2001, to evaluate short-term variations and trends, and for 1948–49 and 1968–69, to evaluate long-term variations in the mass of nitrate (as nitrogen) in the study area.

Estimation of Error

The error in the estimate of the mass of nitrate (as nitrogen) ranged from 51 to –42 percent (table 7); these errors result from errors in estimating the surface of the confining unit, the water-table surface, and the concentration of nitrate (as nitrogen) (table 8). Errors in estimating the surface of the confining unit, the water-table surface, and the concentration of nitrate (as nitrogen) (table 8) are a result of differences in point value and interpolated grid value. Errors in estimating the surface of the confining unit accounted for about one-half the total error.

Table 7. Range in estimates of mass of nitrate (as nitrogen) and percent error in estimates.

Year	Minimum estimated mass, in tons	Estimated mass, in tons	Maximum estimated mass, in tons	Percent error	
Estimated mass of nitrate (as nitrogen) and potential range in error when interpolation error of confining unit, water-table surface, and concentration of nitrate (as nitrogen) are included in computation					
1948	5,000	6,900	9,000	–27	31
1969	20,000	34,000	51,000	–42	51
1997	49,000	67,500	89,000	–27	31
1998	56,000	76,000	98,000	–26	30
1999	60,000	80,000	103,000	–25	29
2000	60,000	76,700	99,000	–26	29
2001	58,000	78,200	101,000	–25	29
Estimated mass of nitrate (as nitrogen) and potential range in error when interpolation error of water-table surface and concentration of nitrate (as nitrogen) are included and that of confining unit is not included in computation					
1948	5,600	6,900	8,100	–18	18
1969	22,000	34,000	46,000	–34	35
1997	56,000	67,500	79,000	–16	17
1998	65,000	76,000	87,000	–15	15
1999	69,000	80,000	91,000	–14	14
2000	66,000	76,700	88,000	–14	15
2001	67,000	78,200	89,000	–14	14

Mass of Nitrate (as Nitrogen) During 1997–2001

Estimates of mass of nitrate (as nitrogen) ranged from 67,500 tons in 1997 to 80,000 tons in 1999 and averaged about 76,000 tons during 1997–2001 (table 9). Based on estimates of error, the estimated mass of nitrate (as nitrogen) in the unconfined aquifer during 1997–2001 ranged from about 50,000 tons to about 100,000 tons, with an estimated average mass of 75,000 tons (fig. 12).

Influence of High Outliers

The possible influence of wells with large nitrate (as nitrogen) concentrations on the computation of total mass of nitrate (as nitrogen) in the unconfined aquifer was evaluated. Four wells (fig. 13) from which ground-water samples regularly had concentrations of nitrate (as nitrogen) greater than 30 mg/L were selectively deleted from the data set, and the mass of nitrate (as nitrogen) in the unconfined aquifer was recomputed. Additional wells were added to the network near two (L1 and L3) of the four wells early in the project to minimize individual influence on total-mass computations. Permission to sample additional wells near the remaining two wells (L2 and L4) with nitrate (as nitrogen) concentrations greater than 30 mg/L was not granted. The analysis revealed that the computation of mass of nitrate (as nitrogen) is influenced considerably by individual wells with large concentrations of nitrate (as nitrogen), when the density of monitored wells near the wells with large nitrate (as nitrogen) concentrations is sparse. Computation of mass generally varied by less than 1 percent as a result of deleting wells L1 and L3 from the network, because the influence of wells L1 and L3 were constrained by nearby wells. Wells L2 and L4 were not constrained by the values from nearby wells in the network, and annual-mass computations decreased by 3 to 8 percent when these wells were removed from the analysis. In the future, the addition of wells near L2 and L4 to the sampling network would improve estimates of the mass of nitrate (as nitrogen).

Estimated Mass of Nitrate (as Nitrogen) Pumped from the Unconfined Aquifer

Understanding the mass and distribution of nitrate (as nitrogen) in the unconfined aquifer is important to regional-resource managers; however, use of this information is limited without understanding the amount of water pumped and, consequently, the mass of nitrate (as nitrogen) removed from the aquifer on an annual basis. Additionally, an understanding of nitrate (as nitrogen) leached through the root zone and unsaturated zone to the water table is critical in evaluating the nitrogen budget. The volume of water pumped from the aquifer during the 1998 irrigation season was estimated to be about 220,000 acre-ft based on 1998 crop distribution (Ralph Curtis, Rio Grande Water Conservation District, written commun., 1999) and general crop-water requirements (Kirk Thompson, AGRO Engineering, oral commun., 1998). Assuming that crop distributions and water requirements were fairly constant from year to year during 1997–2001, an estimated 3,400 tons of

Table 8. Error in interpolation of grid-cell values.

[mg/L, milligrams per liter]

Year	Number of comparisons	Mean error (altitude, in feet; concentration, in mg/L)	Standard deviation	Number of occurrences of error within ±2 standard deviations	Percent of occurrences within standard ±2 deviations
		Water-Surface Altitude			
1948	292	–0.002	0.451	281	94
1969	64	0.027	0.448	60	94
1997	15	–0.035	0.188	14	93
1998	31	–0.046	0.244	30	97
1999	14	–0.020	0.211	13	93
2000	31	–0.043	0.263	30	97
2001	18	–0.060	0.383	17	94
		Confining-Unit Altitude			
	340	0.162	4.557	326	96
		Distribution of Concentration of Nitrate (as Nitrogen)			
1948	45	–0.007	0.070	42	93
1969	66	–0.091	0.682	65	98
1997	62	–0.018	0.232	58	94
1998	107	–0.053	0.823	100	93
1999	111	–0.044	0.751	106	95
2000	122	–0.020	0.723	113	93
2001	106	–0.003	0.743	99	93

nitrate (as nitrogen), or about 4 percent of the estimated nitrate (as nitrogen) mass in the unconfined aquifer, was removed annually through ground-water pumpage from the unconfined aquifer. During 1997–2001, the mass of nitrate (as nitrogen) in the unconfined aquifer seemed to be in a quasi-state of equilibrium, as indicated by the lack of substantial change in the total mass of nitrate (as nitrogen) even though the mass removed by pumping was about 4 percent of the total annual mass. The estimated cumulative mass removed between 1997–2001 was about 20 percent, and no substantial change occurred in estimated mass stored in the unconfined aquifer in the study area. Therefore, it can be postulated that an approximate equivalent mass of nitrate (as nitrogen) was transported through the unsaturated zone to the unconfined aquifer annually.

Hypothetical Effects of Nutrient Management

Timelines for measurable changes in water quality based on various rates of leaching of nitrate (as nitrogen) and reductions therein were evaluated (fig. 14). Assuming ground-water withdrawal does not change appreciably from 1 year to the next, decreases in mass of nitrate (as nitrogen) in the unconfined aquifer is likely to be achieved only by reducing the amount of nitrate (as nitrogen) that leaches through the unsaturated zone. Assuming small errors in estimated nitrate (as nitrogen) mass in the unconfined aquifer, no leaching of nitrate (as nitrogen) to the unconfined aquifer, and continued removal of about 4 percent of the total mass annually, measurable declines in the total mass of nitrate (as nitrogen) would occur within 3 to 5 years. Studies conducted by the SLVWQDP (Sharkoff and others, 1996) predicted net reductions in nitrate (as nitrogen) leaching of about 50 percent when nutrient- and water-management practices were incorporated into farm-management practices. Based on the predicted net rate of leaching of 50 percent, measurable declines in the total mass of nitrate (as nitrogen) would occur within 10 to 15 years.

Table 9. Summary of annual estimate of mass of nitrate (as nitrogen) in the unconfined aquifer.

Year	Number of wells included in sampling network	Estimated mass of nitrate (as nitrogen), in tons
1948–49	72	6,900
1968–69	83	34,000
1997	62	67,500
1998	116	76,000
1999	120	80,000
2000	132	76,700
2001	112	78,200

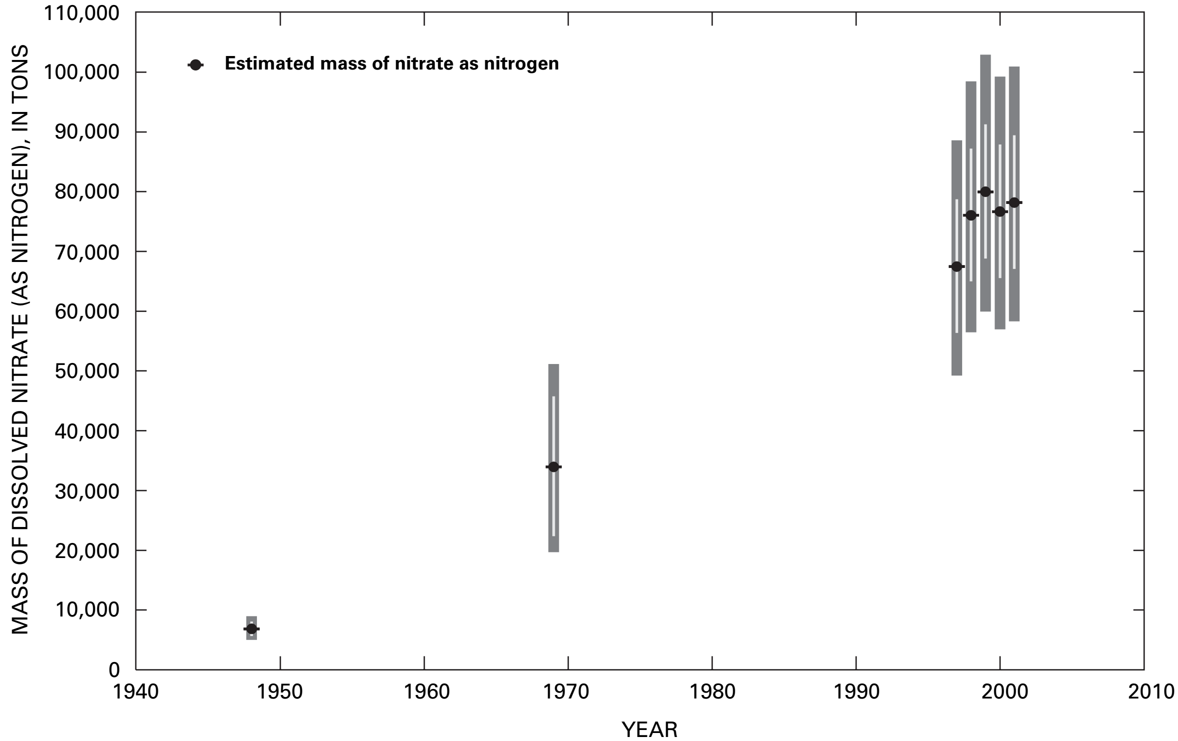


Figure 12. Annual estimates of mass of nitrate (as nitrogen) and potential range in estimates based on computed potential error in mass estimates including (dark bar) and excluding (white bar) errors associated with confining unit interpolation.

Net improvements in the water quality of the unconfined aquifer may be difficult to realize without widespread acceptance of irrigation management practices that limit the movement of nitrate (as nitrogen) in the unsaturated zone to the water table. An understanding of the mass of nitrate (as nitrogen) stored in the unsaturated zone and of the rates of nitrate (as nitrogen) leaching to the water table are needed to better predict reduction in mass of nitrate (as nitrogen) in the unconfined aquifer.

Mass of Nitrate (as Nitrogen) During 1968–69 and 1948–49

The mass of nitrate (as nitrogen) in the unconfined aquifer, based on nitrate (as nitrogen) concentrations in water-quality samples collected from wells during 1968–69 (Emery and others, 1972), was estimated to be about 34,000 tons. Based on estimates of error in the analysis of mass (+51 percent, –42 percent), the total mass during 1968–69 could have been as small as 20,000 tons or as large as 51,000 tons (table 7).

The mass of nitrate (as nitrogen) in the unconfined aquifer, based on nitrate (as nitrogen) concentrations in samples from wells sampled during 1948–49 (Powell, 1958), was estimated to be about 6,900 tons. Based on estimates of error in the analysis of mass (+31 percent, –27 percent), the total mass during 1948–49 could have been as small as 5,000 tons or as large as 9,000 tons (table 7). It should be noted that Powell (1958) did not collect ground-water samples in parts of the area that Emery and others (1973) identified as containing elevated nitrate (as nitrogen) concentrations. However, it is assumed that the distribution presented, based on available data, is a reasonable approximation of the distribution of nitrate (as nitrogen) concentrations that existed at the time.

Variations in the Mass of Nitrate (as Nitrogen)

Short- and long-term variations in the mass of nitrate (as nitrogen) in the unconfined aquifer were evaluated based on periodic estimates of mass.

Variations in the mass of nitrate (as nitrogen) during 1997 through 2001

The presence of trend in annual-mass estimates was evaluated for two periods—1997–2001 and 1998–2001. The 1997–2001 data set evaluated trends in the complete data set. The 1997 data set was omitted from the trend analysis for the 1998–2001 data set due to limitations in the number and distribution of wells sampled during 1997 and to remove any influence the apparent increase in mass of 8,500 tons between 1997 and 1998 may have had on the analysis. A Kendall trend test was used to evaluate temporal trends. The Kendall trend test is a nonparametric test used to evaluate the significance of a monotonic trend in a variable over time; a monotonic trend exists if variable *x* generally increases or decreases as variable

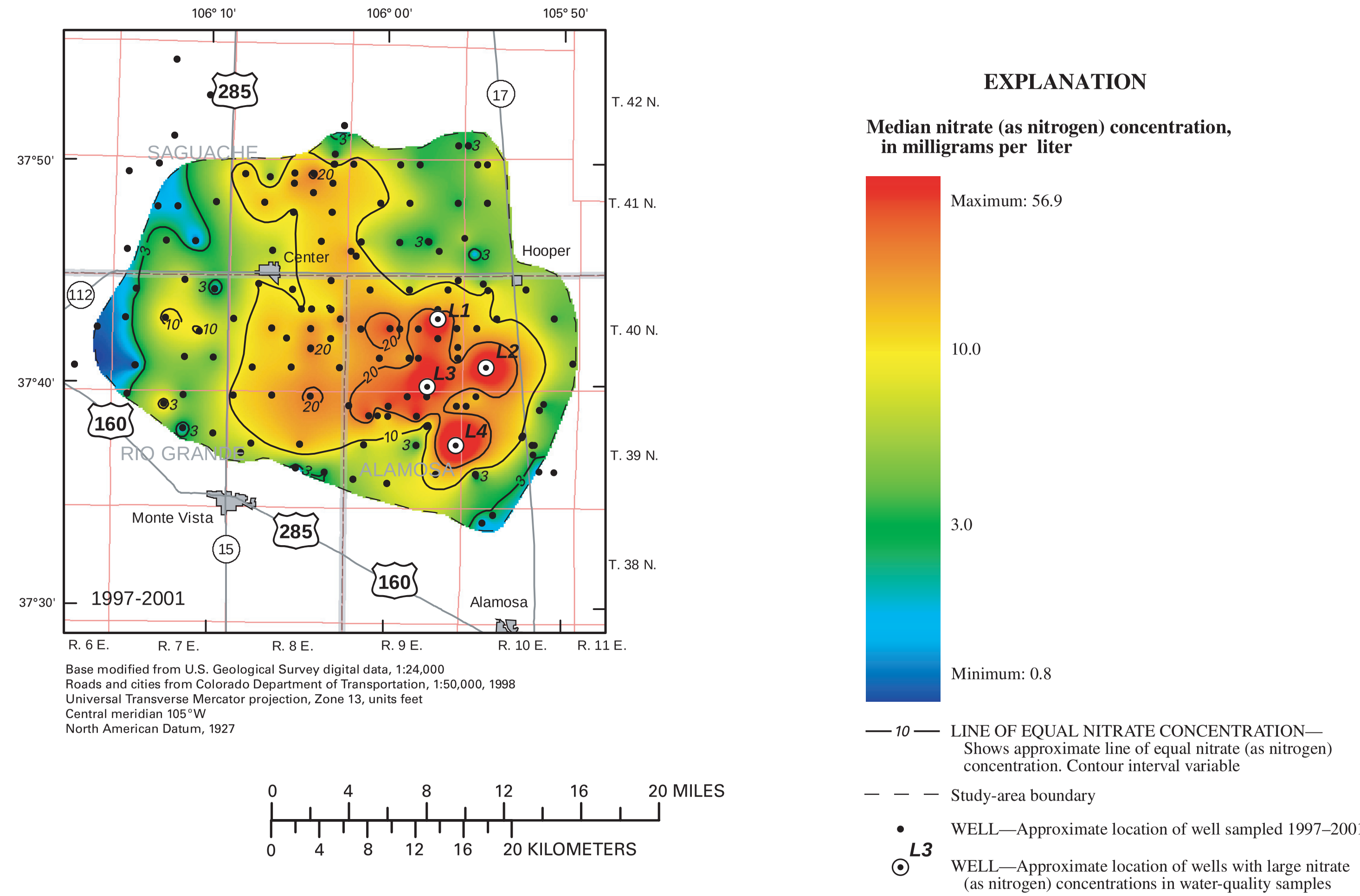


Figure 13. Median concentration of nitrate (as nitrogen) and location of wells with large concentration of nitrate (as nitrogen), 1997–2001.

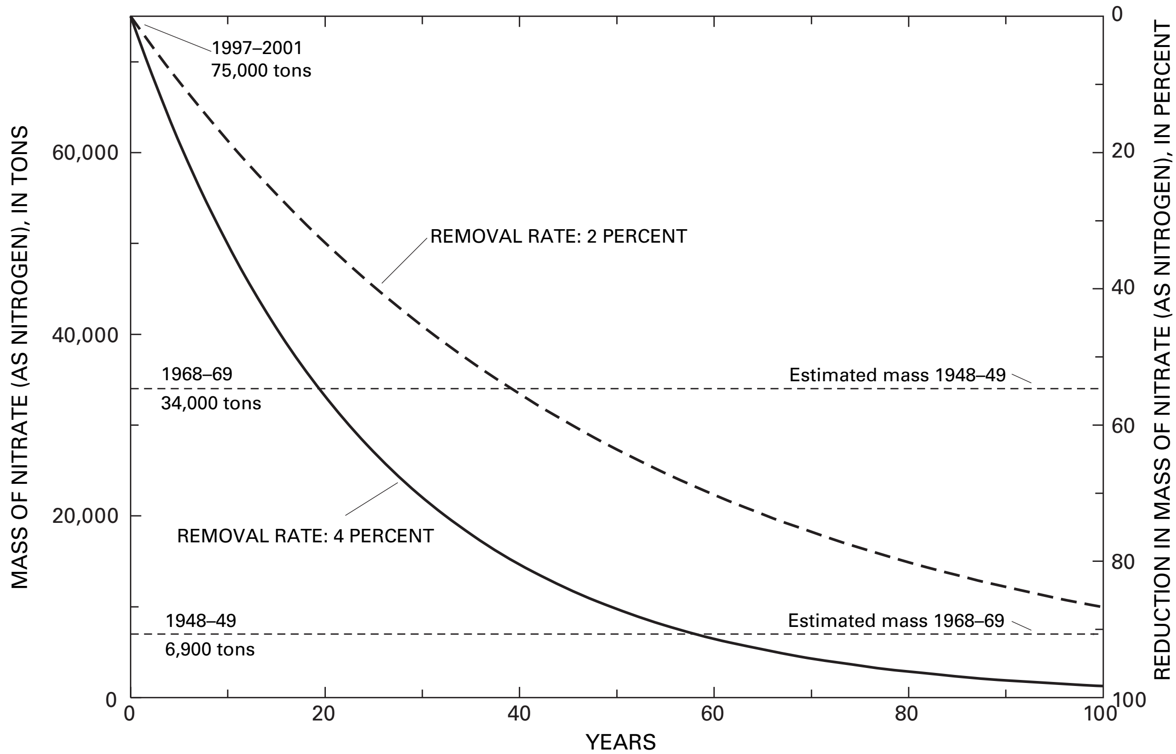


Figure 14. Estimation of the mass of nitrate (as nitrogen) in the unconfined aquifer given various annual rates of nitrate (as nitrogen) removal due to pumping ground water for irrigation.

y (time) increases (Helsel and Hirsch, 1995). Test results are expressed as *p*-values, the significance level attained by the data. For groups of nitrate (as nitrogen) data, *p*-values less than or equal to 0.05 indicate there is a 95-percent-or-greater confidence that a trend exists in the data. Significant trends, indicated by *p*-values less than or equal to 0.05, were not evident in the analysis for either period; *p*-values were 0.22 for 1997–2001 and 0.73 for 1998–2001. The absence of significant trends indicates that the system may be in a state of equilibrium; the mass of nitrate (as nitrogen) removed from the unconfined aquifer annually is being replaced by an equivalent mass of nitrate (as nitrogen) that leaches to the unconfined aquifer from the unsaturated zone.

The absence of significant short-term trends might indicate that nutrient and irrigation-management practices are helping to maintain nitrate (as nitrogen) concentrations of the ground-water resource. However, without an understanding of the degree of implementation of nutrient- and irrigation-management practices in the study area, an evaluation of their effectiveness in decreasing nitrate (as nitrogen) concentrations in ground water on a regional scale is not possible.

Variations in the mass of nitrate (as nitrogen) during 1940s through 2001

Estimates of the mass of nitrate (as nitrogen) in the unconfined aquifer varied considerably between 1948–49 and 2001 (table 9). Between 1948–49 and 1968–69, the estimated mass of nitrate (as nitrogen) in the unconfined aquifer increased by about 27,000 tons from an estimated 6,900 tons to an estimated 34,000 tons. Between 1968–69 and 1997–2001, the estimated mass of nitrate (as nitrogen) in the unconfined aquifer increased by about 41,000 tons from an estimated 34,000 tons to an estimated 75,000 tons. The average rate of increase in mass of nitrate (as nitrogen) during the two periods were similar—3.9 tons/mi^2/yr (12.2 lbs/acre/yr) during the 19-year period from 1950 to 1969 and 4.0 tons/mi^2/yr (12.5 lbs/acre/yr) during the 28-year period from 1969 to 1997.

Summary

Current (1997–2001) and historical (1948–49, 1968–69) nitrate (as nitrogen) concentrations in ground water were evaluated to determine the distribution and mass of nitrate (as nitrogen) in the unconfined aquifer and to evaluate short- and long-term trends in the distribution and mass of nitrate (as nitrogen.)

During 1997–2001, nitrate (as nitrogen) concentrations in ground-water samples collected from most sampled wells located in the intensively cultivated area north of the Rio Grande in the San Luis Valley in south-central Colorado exceeded the background concentration of 3 mg/L. Ground-water samples from some wells located near the boundary of the study area had concentrations less than 3 mg/L. Areas with nitrate (as nitrogen) concentrations in ground-water samples greater than 10 mg/L were primarily located in an area that is bounded by Highway 285 on the west, Highway 17 on the east, and Highway 112 to the north. A small area with nitrate (as nitrogen) concentrations greater than 10 mg/L also extended to the north and west of the town of Center across Highway 112. Nitrate (as nitrogen) concentrations in ground-water samples collected from individual wells generally showed little seasonal or annual variation during 1997–2001. As a result, the spatial extent of regions of the unconfined aquifer with elevated nitrate (as nitrogen) concentrations, defined as concentrations greater than 3 mg/L, did not appreciably change from 1997 through 2001. Observed variations generally were associated with minor changes in the distribution of sampled wells in the network.

Historically, from 1948–49 through 1997–2001, nitrate (as nitrogen) concentrations in water-quality samples collected from wells in the study area have increased. Regions with nitrate (as nitrogen) concentrations greater than 3 and less than 10 mg/L increased from 20 mi^2 to 180 mi^2, and regions with nitrate (as nitrogen) concentrations greater than 10 mg/L, increased from 0 mi^2 to 165 mi^2.

During 1997–2001, estimates of the mass of nitrate (as nitrogen) ranged from 67,500 to 80,000 tons, and averaged about 75,000 tons. The influence of wells with large nitrate (as nitrogen) concentrations on the mass computations was evaluated. Four wells were identified as having large concentrations of nitrate (as nitrogen). The influences of the large nitrate (as nitrogen) concentrations at two of the four wells were closely constrained by the addition of neighboring wells to the sampling network. Permission to sample neighboring wells at the other two wells with large nitrate (as nitrogen) concentrations was not granted and, subsequently, the influence of the large nitrate (as nitrogen) concentrations at these two wells was not further constrained. Sensitivity analysis of the influence of wells with large nitrate (as nitrogen) concentrations on the estimate of mass of nitrate (as nitrogen) revealed that the computed mass estimates varied by less than 1 to 2 percent if the constrained wells with large nitrate (as nitrogen) concentrations were deleted from the sampling network and decreased by 3 to 8 percent if the unconstrained wells with large nitrate (as nitrogen) concentrations were deleted from the network. The lack of neighboring wells near L2 and L4, and the relatively large concentrations of nitrate (as nitrogen) from these two wells, may result in overestimation of nitrate (as nitrogen) concentrations in this area. The addition of wells to the sampling network in this area would constrain the individual influence of the wells with large nitrate (as nitrogen) concentrations and likely improve estimates of the mass of nitrate (as nitrogen). Network design is an important component for consideration for future ground-water, water-quality projects with similar project objectives in areas of variable nitrate (as nitrogen) concentrations.

The mass of nitrate (as nitrogen) removed from the unconfined aquifer, as a result of irrigating with water from the unconfined aquifer during 1998, was estimated based on crop-type distributions and water requirements. During 1997–2001, an estimated 3,400 tons of nitrate (as nitrogen) was removed annually from the unconfined aquifer. Given the apparent lack of variation in estimates of the mass of nitrate (as nitrogen) during 1997–2001, an equal amount of nitrate (as nitrogen) also is being leached from the unsaturated zone annually to the unconfined aquifer. Based on field-scale studies, leaching of nitrate (as nitrogen) to the unconfined aquifer may be reduced by as much as 50 percent when nutrient- and water-management practices are implemented. Net improvements in the water quality of the unconfined aquifer may be difficult to realize without an understanding of the mass of nitrate (as nitrogen) in the unsaturated zone and widespread acceptance of nutrient and irrigation management practices, which may limit the movement of the nitrate (as nitrogen) in the unsaturated zone to the water table.

Trend analysis revealed no significant temporal trends in estimates of mass of nitrate (as nitrogen) in the unconfined aquifer during 1997–2001. Comparison of estimates of the mass of nitrate (as nitrogen), based on this and previous studies, indicate substantial increases in the mass of nitrate (as nitrogen) in the unconfined aquifer between 1948–49 and 1997–2001. The mass of nitrate (as nitrogen) more than quadrupled from about 6,900 tons in 1948–49 to about 34,000 tons in 1968–69, and more than doubled from 34,000 tons in 1968–69 to about 75,000 tons during 1997–2001. The estimated average annual rate of change in mass of nitrate (as nitrogen) for the periods 1948–49 to 1968–69 (3.9 tons/mi^2/yr) and 1968–69 to 1997–2001 (4.0 tons/mi^2/yr) were similar.

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Appendixes

Table 1. Concentration of nitrate (as nitrogen) in wells sampled during 1936–50.

[IndexNo, index number, refer to Scofield (1938) and Powell (1958); mm/dd/yr, month, day, year; mg/L, milligrams per liter; N, nitrogen]

Index no	Well location	Sampling date (mm/dd/yr)	Well depth (feet below land surface)	Nitrate (as nitrogen) (mg/L as N)
35 38 10	T38N R10E S35 Q160 NW Q40 NW	11/11/1936		0.14
38 10 06 bb	T38N R10E S06 Q160 NW Q40 NW	11/1/1949	40.00	0.55
38 10 06 bb	T38N R10E S06 Q160 NW Q40 NW	11/3/1949	40.00	0.55
39 09 01 dd	T39N R09E S01 Q160 SE Q40 SE	4/5/1949	9.40	0.64
39 09 11 aa	T39N R09E S11 Q160 NE Q40 NE	4/5/1949	5.60	0.52
39 09 11 aa	T39N R09E S11 Q160 NE Q40 NE	5/12/1948	5.60	0.52
39 09 12 dd	T39N R09E S12 Q160 SE Q40 SE	11/15/1948	9.90	0.05
39 09 02 aa	T39N R09E S02 Q160 NE Q40 NE	3/12/1948	9.30	0.11
39 09 22 cc	T39N R09E S22 Q160 SW Q40 SW	3/12/1948	9.90	0.10
39 09 22 cc	T39N R09E S22 Q160 SW Q40 SW	11/15/1948	9.90	0.10
39 09 24 aa	T39N R09E S24 Q160 NE Q40 NE	10/31/1949	40.00	0.05
39 09 04 dd	T39N R09E S04 Q160 SE Q40 SE	4/5/1949	9.70	7.28
39 09 04 dd	T39N R09E S04 Q160 SE Q40 SE	11/15/1948	9.70	7.28
39 09 04 dd	T39N R09E S04 Q160 SE Q40 SE	11/16/1936	9.70	7.28
16 39 10	T39N R10E S16 Q160 SW Q40 SW	11/17/1936		0.00
39 10 25 aa	T39N R10E S25 Q160 NE Q40 NE	2/13/1950	9.90	0.60
39 10 25 aa	T39N R10E S25 Q160 NE Q40 NE	1/20/1949	9.90	0.60
39 10 07 bb	T39N R10E S07 Q160 NW Q40 NW	10/21/1949	40.00	1.14
39 11 19 aa	T39N R11E S19 Q160 NE Q40 NE	3/11/1948	9.50	0.09
39 11 04 cc	T39N R11E S04 Q160 SW Q40 SW	6/21/1946	9.50	0.27
39 11 06 aa	T39N R11E S06 Q160 NE Q40 NE	3/28/1946	7.90	0.23
39 11 06 dd	T39N R11E S06 Q160 SE Q40 SE	12/1/1948	9.90	1.30
39 11 06 dd	T39N R11E S06 Q160 SE Q40 SE	3/8/1949	9.90	1.30
39 11 07 cc	T39N R11E S07 Q160 SW Q40 SW	1/20/1949	10.00	0.54
39 11 07 cc	T39N R11E S07 Q160 SW Q40 SW	4/14/1949	10.00	0.54
39 11 07 cc	T39N R11E S07 Q160 SW Q40 SW	3/17/1950	10.00	0.54
39 11 07 cc	T39N R11E S07 Q160 SW Q40 SW	2/17/1950	10.00	0.54
39 11 09 aa	T39N R11E S09 Q160 NE Q40 NE	6/21/1946	9.50	0.25
14 40 6	T40N R06E S14 Q160 NE Q40 NW	10/12/1936	40.00	0.14
40 06 02 dd	T40N R06E S02 Q160 SE Q40 SE	11/16/1948	27.30	0.16
40 07 01 cc	T40N R07E S01 Q160 SW Q40 SW	8/26/1949	104.00	0.23
40 07 01 cc	T40N R07E S01 Q160 SW Q40 SW	11/16/1948	104.00	0.23
40 07 13 dd	T40N R07E S13 Q160 SE Q40 SE	4/4/1949	20.30	2.83
40 07 13 dd	T40N R07E S13 Q160 SE Q40 SE	8/29/1949	20.30	2.83
40 07 14 cc	T40N R07E S14 Q160 SW Q40 SW	4/5/1949	72.00	2.20
40 07 21 aa	T40N R07E S21 Q160 NE Q40 NE	11/4/1947	17.20	1.45
40 07 25 ab	T40N R07E S25 Q160 NE Q40 NW	11/22/1949	24.00	2.50
25 40 7	T40N R07E S25 Q160 NW Q40	8/24/1936	54.00	0.14
30 40 7	T40N R07E S30 Q160 NE Q40	8/24/1936		0.00

Table 1. Concentration of nitrate (as nitrogen) in wells sampled during 1936–50.—Continued

[IndexNo, index number, refer to Scofield (1938) and Powell (1958); mm/dd/yr, month, day, year; mg/L, milligrams per liter; N, nitrogen]

Index no	Well location	Sampling date (mm/dd/yr)	Well depth (feet below land surface)	Nitrate (as nitrogen) (mg/L as N)
40 07 06 cd	T40N R07E S06 Q160 SW Q40 SE	4/4/1949	20.00	0.16
16 40 8	T40N R08E S16 Q160 SE Q40 SE	11/17/1936		0.00
40 08 19 cb	T40N R08E S19 Q160 SW Q40 NW	5/1/1940	31.20	0.45
28 40 8	T40N R08E S28 Q160 SW Q40	8/24/1936	32.00	0.28
40 08 03 cc	T40N R08E S03 Q160 SW Q40 SW	11/16/1948	69.90	1.44
40 08 03 cc	T40N R08E S03 Q160 SW Q40 SW	4/5/1949	69.90	1.44
40 08 31 ac	T40N R08E S31 Q160 NE Q40 SW	5/1/1940	83.00	1.89
40 09 12 dd2	T40N R09E S12 Q160 SE Q40 SE	11/15/1948	9.90	0.19
40 09 12 dd2	T40N R09E S12 Q160 SE Q40 SE	8/29/1949	9.90	0.19
17 40 9	T40N R09E S17 Q160 SW Q40	8/24/1936	30.00	0.00
40 09 21 dd	T40N R09E S21 Q160 SE Q40 SE	3/13/1948	9.90	0.11
40 09 26 dd	T40N R09E S26 Q160 SE Q40 SE	11/16/1949	9.60	0.16
40 09 27 cc	T40N R09E S27 Q160 SW Q40 SW	3/15/1948	8.80	0.39
40 09 27 cc	T40N R09E S27 Q160 SW Q40 SW	4/5/1949	8.80	0.39
40 09 35 cc3	T40N R09E S35 Q160 SW Q40 SW	5/12/1948	9.30	0.30
40 09 05 dd	T40N R09E S05 Q160 SE Q40 SE	11/15/1948	8.20	0.15
40 10 01 dd	T40N R10E S01 Q160 SE Q40 SE	4/3/1946	6.80	0.93
40 10 01 dc	T40N R10E S01 Q160 SE Q40 SW	2/21/1941	5.70	0.05
40 10 14 dd	T40N R10E S14 Q160 SE Q40 SE	4/16/1946	10.00	0.14
17 40 10	T40N R10E S17 Q160 SW Q40	8/24/1936	35.00	0.00
2 40 10	T40N R10E S02 Q160 NW Q40 NW	11/14/1936		0.00
40 10 02 cc	T40N R10E S02 Q160 SW Q40 SW		32.00	0.58
40 10 02 cc	T40N R10E S02 Q160 SW Q40 SW	4/5/1946	32.00	0.58
40 10 02 cc	T40N R10E S02 Q160 SW Q40 SW	4/12/1946	32.00	0.58
40 10 23 dd	T40N R10E S23 Q160 SE Q40 SE	4/16/1946	9.60	2.02
40 10 29 bb	T40N R10E S29 Q160 NW Q40 NW	4/6/1949	9.90	0.09
36 40 10	T40N R10E S36 Q160 SW Q40 SW	11/13/1936		0.00
40 11 18 bd	T40N R11E S18 Q160 NW Q40 SE	4/8/1946	9.00	0.50
40 11 33 cc	T40N R11E S33 Q160 SW Q40 SW	3/17/1950	6.00	0.74
40 11 33 cc	T40N R11E S33 Q160 SW Q40 SW	2/17/1950	6.00	0.74
40 11 33 cc	T40N R11E S33 Q160 SW Q40 SW	4/14/1949	6.00	0.74
40 11 33 cc	T40N R11E S33 Q160 SW Q40 SW	11/13/1936	6.00	0.74
40 11 05 ab	T40N R11E S05 Q160 NE Q40 NW	4/3/1946	5.40	3.18
40 11 06 bd	T40N R11E S06 Q160 NW Q40 SE	4/4/1946	8.10	0.50
40 11 07 aa	T40N R11E S07 Q160 NE Q40 NE	4/3/1946	9.40	0.25
40 11 07 cc	T40N R11E S07 Q160 SW Q40 SW	3/5/1941	10.00	0.09
41 07 26 dc	T41N R07E S26 Q160 SE Q40 SW	11/17/1948	22.70	3.30
41 07 26 dc	T41N R07E S26 Q160 SE Q40 SW	4/4/1949	22.70	3.30
41 07 27 cc	T41N R07E S27 Q160 SW Q40 SW	11/17/1948	42.20	1.57

Table 1. Concentration of nitrate (as nitrogen) in wells sampled during 1936–50.—Continued

[IndexNo, index number, refer to Scofield (1938) and Powell (1958); mm/dd/yr, month, day, year; mg/L, milligrams per liter; N, nitrogen]

Index no	Well location	Sampling date (mm/dd/yr)	Well depth (feet below land surface)	Nitrate (as nitrogen) (mg/L as N)
33 41 7	T41N R07E S33 Q160 SW Q40 SW	11/16/1936	11.50	0.00
41 08 10 cc	T41N R08E S10 Q160 SW Q40 SW	8/12/1948	80.00	0.47
41 08 10 cc	T41N R08E S10 Q160 SW Q40 SW	8/10/1948	80.00	0.47
41 08 28 dc	T41N R08E S28 Q160 SE Q40 SW	11/17/1948	33.10	0.14
41 08 29 cc2	T41N R08E S29 Q160 SW Q40 SW	11/17/1948	71.80	0.07
41 08 03 aa	T41N R08E S03 Q160 NE Q40 NE	11/17/1948	10.00	0.30
41 08 03 bb	T41N R08E S03 Q160 NW Q40 NW	11/17/1948	8.60	0.39
41 08 36 bc	T41N R08E S36 Q160 NW Q40 SW	11/17/1948	34.20	1.02
41 08 04 bb	T41N R08E S04 Q160 NW Q40 NW	4/4/1949	10.00	0.14
41 09 01 aa	T41N R09E S01 Q160 NE Q40 NE	11/17/1948	10.00	0.43
41 09 01 ac	T41N R09E S01 Q160 NE Q40 SW	10/26/1948	110.00	0.14
41 09 22 dd	T41N R09E S22 Q160 SE Q40 SE	11/18/1948	9.90	3.41
41 09 23 ca	T41N R09E S23 Q160 SW Q40 NE	10/11/1948	29.60	0.66
26 41 9	T41N R09E S26 Q160 NE Q40 NE	11/18/1936		0.00
41 09 32 dd	T41N R09E S32 Q160 SE Q40 SE	11/18/1948	9.90	1.31
41 09 32 dd	T41N R09E S32 Q160 SE Q40 SE	3/13/1948	9.90	1.31
41 09 06 bb	T41N R09E S06 Q160 NW Q40 NW	11/17/1948	9.80	0.48
41 10 15 cc	T41N R10E S15 Q160 SW Q40 SW	2/21/1941	8.30	0.43
2 41 10	T41N R10E S02 Q160 NE Q40 NE	11/19/1936		0.00
41 10 27 dd	T41N R10E S27 Q160 SE Q40 SE	11/18/1948	11.40	0.24
41 10 27 dd	T41N R10E S27 Q160 SE Q40 SE	4/4/1949	11.40	0.24
41 10 28 aa	T41N R10E S28 Q160 NE Q40 NE	11/23/1949	9.90	0.75
41 10 35 dc	T41N R10E S35 Q160 SE Q40 SW	4/28/1946	8.80	0.57
41 10 36 dc	T41N R10E S36 Q160 SE Q40 SW	3/28/1946	9.90	0.23
42 07 02 ad	T42N R07E S02 Q160 NE Q40 SE	6/21/1948	91.40	0.18
25 42 7	T42N R07E S25 Q160 NE Q40 NE	11/13/1936		0.00
42 09 32 dd	T42N R09E S32 Q160 SE Q40 SE	11/17/1948	10.00	0.17
42 09 32 dd	T42N R09E S32 Q160 SE Q40 SE	11/23/1949	10.00	0.17
42 09 36 cc	T42N R09E S36 Q160 SW Q40 SW	11/18/1949	9.90	0.41

Table 2. Concentration of nitrate (as nitrogen) in wells sampled during 1968-69.

[mm/dd/yr, month, day, year; mg/L, milligrams per liter; N, nitrogen; see Emery and others (1972) for well location]

Well location	Sample date mm/dd/yr	Well depth (feet below land surface)	Nitrate (as nitrogen) (mg/L as N)
NA 39 07 08 ADD	7/19/68	80	2.1
NA 39 07 10 BBB1		100	3.6
NA 39 07 13 BBB	6/28/68	40	6.8
NA 39 07 28 DA	8/26/68	80	1.3
NA 39 07 36 CAB	9/9/68	47	1.5
NA 39 08 02 CBB3	10/31/68	70	0.0
NA 39 08 06 BBB	9/6/68	14	5.2
NA 39 08 06 CBB2	5/27/69	80	8.6
NA 39 08 16 BCB	5/27/69	75	9.8
NA 39 08 23 BBB	5/27/69	55	6.4
NA 39 09 01 ACC	7/18/68	100	0.8
NA 39 09 03 DDD	9/6/68	10	3.6
NA 39 09 04 CBD	5/27/69	75	11.8
NA 39 09 09 BAA	6/3/69	61	8.0
NA 39 09 10 ABB	6/3/69	63	31.4
NA 39 09 13 ACC	6/3/69	113	4.1
NA 39 09 13 DAC		110	4.3
NA 39 09 15 AAC	6/3/69	116	4.1
NA 39 09 19 BCB	5/27/69	70	4.5
NA 39 09 23 DCA	6/3/69	0	2.5
NA 39 09 36 DDD	9/9/68	17	2.2
NA 39 11 02 ABB1	11/21/68	20	0.3
NA 39 11 06 DCB	6/3/69	50	1.5
NA 39 11 16 AAA	8/6/68	16	0.4
NA 39 11 17 BBB	8/6/68	16	0.9
NA 39 11 20 AAA	8/7/68	22	0.0
NA 39 11 20 CCC	8/7/68	21	0.0
NA 39 11 25 AAA	8/8/68	20	0.8
NA 39 11 29 DCD	8/7/68	21	0.6
NA 39 11 32 CCC	8/7/68	21	0.0
NA 39 11 34 ABB	8/9/68	21	0.3
NA 40 07 01 CCC3	6/11/68	104	3.4
NA 40 07 07 CCC	6/2/69	60	0.5
NA 40 07 23 ACC	6/2/69	100	4.1
NA 40 07 32 CCB	5/27/69	112	3.6
NA 40 08 03 CCC	6/26/68	102	7.0
NA 40 08 11 BCC	5/7/68	90	4.1

Table 2. Concentration of nitrate (as nitrogen) in wells sampled during 1968-69.—Continued

[mm/dd/yr, month, day, year; mg/L, milligrams per liter; N, nitrogen; see Emery and others (1972) for well location]

Well location	Sample date mm/dd/yr	Well depth (feet below land surface)	Nitrate (as nitrogen) (mg/L as N)
NA 40 08 15 CBB	6/2/69	110	14.8
NA 40 08 16 BCC2	6/2/69	99	8.0
NA 40 08 18 CCB	6/2/69	90	5.9
NA 40 08 31 BCC1	7/19/68	87	7.0
NA 40 08 33 CCC	5/27/69	80	14.1
NA 40 08 34 CCD	9/6/68	13	3.2
NA 40 09 17 CCC3	6/26/68	54	8.2
NA 40 09 20 BBB	6/2/69	83	9.5
NA 40 09 21 ABC	6/2/69	85	12.5
NA 40 09 21 ACC	6/2/69	85	6.8
NA 40 09 28 BCC	6/3/69	74	6.8
NA 40 09 30 CBB2	6/2/69	40	6.4
NA 40 09 31 CBC	5/27/69	75	6.8
NA 40 09 31 CCC	8/19/68	84	8.0
NA 40 09 32 CBB2	6/20/68	45	13.2
NA 40 09 33 CBD		87	5.5
NA 40 10 30 CCC	8/19/68	75	1.1
NA 40 10 35 DCC	5/14/69	98	1.2
NA 40 11 35 ABA	8/6/68	16	3.2
NA 41 07 13 CCC1	5/29/69	124	3.9
NA 41 07 21 CCC3	5/29/69	86	1.4
NA 41 07 23 CDD	5/29/69	95	3.6
NA 41 07 26 DCC2	6/11/68	80	3.6
NA 41 07 32 CCC	7/29/68	205	0.3
NA 41 07 32 CD	8/11/68	55	2.2
NA 41 07 36 CCC2	5/29/69	94	4.5
NA 41 08 01 BCC2	5/29/69	109	3.0
NA 41 08 06 CCC	5/29/69	85	2.3
NA 41 08 16 CCC2	6/2/69	50	6.8
NA 41 08 19 CCC2	5/29/69	103	3.2
NA 41 08 26 CCC1	6/2/69	81	7.0
NA 41 08 28 DCC1	4/10/68	70	12.0
NA 41 08 29 CCC2	6/28/68	105	4.1
NA 41 08 32 CCC1	5/29/69	100	5.5
NA 41 08 36 BCC2	5/3/68	95	11.4
NA 41 09 01 ACB	6/11/68	105	0.2
NA 41 09 06 BCC2	7/11/68	100	1.6
NA 41 09 18 BCC	6/2/69	113	3.6

Table 2. Concentration of nitrate (as nitrogen) in wells sampled during 1968-69.—Continued

[mm/dd/yr, month, day, year; mg/L, milligrams per liter; N, nitrogen; see Emery and others (1972) for well location]

Well location	Sample date mm/dd/yr	Well depth (feet below land surface)	Nitrate (as nitrogen) (mg/L as N)
NA 41 09 22 CCC	6/2/69	102	0.3
NA 41 09 23 CCC	6/3/69	94	0.2
NA 41 09 30 BCC2	6/2/69	104	5.9
NA 41 10 13 ABD	9/6/68	9	2.3
NA 41 10 32 CCC	7/11/68	127	4.5
NA 41 10 36 DDD	9/6/68	12	0.1
NA 42 07 09 ACD	7/11/68	170	0.3
NA 42 08 01 ADD	9/6/68	15	0.2
NA 42 08 10 CCC	9/6/68	0	0.1
NA 42 10 31 BBB	9/6/68	10	0.1

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
38N10E05NE	373411	1055353	6/12/97	0.2	*N*
38N10E05NE	373411	1055353	6/10/98	3.0	*N*
38N10E05NE	373411	1055353	6/17/00	3.6	*N*
38N10E05NE	373411	1055353	6/6/01	2.7	*N*
38N10E05SW	373350	1055429	6/1/99	1.2	*N*
38N10E05SW	373350	1055429	5/31/00	1.4	*N*
38N10E05SW	373350	1055429	6/6/01	1.7	*N*
39N07E02NW	373928	1061126	6/23/97	4.0	*N*
39N07E02NW	373928	1061126	6/23/97	3.8	*Q*
39N07E02NW	373928	1061126	6/17/98	4.2	*N*
39N07E02NW	373928	1061126	6/27/00	3.1	*N*
39N07E02NW	373928	1061126	6/25/01	3.3	*N*
39N07E04SE	373903	1061232	6/10/98	12.5	*N*
39N07E04SE	373903	1061232	6/21/99	11.6	*N*
39N07E04SE	373903	1061232	6/10/00	12.0	*N*
39N07E06NE	373929	1061439	6/23/98	2.7	*N*
39N07E06NE	373929	1061439	6/10/99	2.5	*N*
39N07E06NE	373929	1061439	6/1/00	2.3	*N*
39N07E06NE	373929	1061439	6/7/01	2.4	*N*
39N07E13NW	373745	1060945	6/24/97	7.0	*N*
39N07E13NW	373745	1060945	7/30/99	7.4	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
39N07E13NW	373745	1060945	6/29/00	8.2	*N*
39N07E15NE	373759	1061128	6/19/97	1.5	*N*
39N07E15NE	373759	1061128	6/22/98	1.5	*N*
39N07E15NE	373759	1061128	5/13/99	1.4	*N*
39N07E15NE	373759	1061128	6/2/99	1.4	*N*
39N07E15NE	373759	1061128	6/21/99	1.5	*N*
39N07E15NE	373759	1061128	6/14/00	2.9	*N*
39N07E15NE	373759	1061128	6/27/00	2.2	*N*
39N07E15NE	373759	1061128	8/28/01	2.0	*N*
39N08E02NW	373928	1060415	5/12/98	4.2	*N*
39N08E02NW	373928	1060415	6/2/98	22.9	*N*
39N08E02NW	373928	1060415	6/15/98	23.1	*N*
39N08E02NW	373928	1060415	7/30/98	22.4	*N*
39N08E02NW	373928	1060415	6/29/99	19.3	*N*
39N08E02NW	373928	1060415	7/25/99	21.9	*N*
39N08E02NW	373928	1060415	5/9/00	21.9	*N*
39N08E02NW	373928	1060415	6/1/00	21.8	*N*
39N08E02NW	373928	1060415	6/28/00	21.4	*N*
39N08E02NW	373928	1060415	6/11/01	23.7	*N*
39N08E04NW	373929	1060627	6/24/97	16.1	*N*
39N08E04NW	373929	1060627	6/3/98	15.4	*N*
39N08E04NW	373929	1060627	6/9/99	16.8	*N*
39N08E04NW	373929	1060627	6/13/00	15.3	*N*
39N08E04NW	373929	1060627	6/11/01	15.9	*N*
39N08E06NW	373928	1060838	6/8/98	9.8	*N*
39N08E06NW	373928	1060838	6/22/99	9.1	*N*
39N08E06NW	373928	1060838	6/14/00	11.6	*N*
39N08E06NW	373928	1060838	6/11/01	13.0	*N*
39N08E15SE	373718	1060450	6/13/97	14.4	*N*
39N08E15SE	373718	1060450	6/15/98	15.9	*Q*
39N08E15SE	373718	1060450	6/15/98	16.0	*N*
39N08E15SE	373718	1060450	6/18/99	17.2	*N*
39N08E15SE	373718	1060450	6/1/00	16.6	*N*
39N08E15SE	373718	1060450	6/28/01	16.5	*N*
39N08E17SW	373719	1060734	6/8/98	12.3	*N*
39N08E17SW	373719	1060734	6/21/99	8.4	*N*
39N08E17SW	373719	1060734	6/1/00	7.0	*N*
39N08E19NE	373653	1060808	6/17/97	5.3	*N*
39N08E19NE	373653	1060808	6/22/99	6.7	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
39N08E19NE	373653	1060808	6/11/01	8.1	*N*
39N08E25NW	373603	1060325	6/5/98	2.9	*N*
39N08E25NW	373603	1060325	6/27/00	3.1	*N*
39N08E25NW	373603	1060325	6/25/01	2.8	*N*
39N08E27NE	373613	1060503	6/11/98	0.2	*N*
39N08E27NE	373613	1060503	7/26/99	0.8	*N*
39N08E27NE	373613	1060503	6/12/00	0.9	*N*
39N09E01SE	373905	1055559	6/6/98	14.9	*N*
39N09E01SE	373905	1055559	7/21/99	13.8	*N*
39N09E01SE	373905	1055559	6/10/00	18.8	*N*
39N09E02NW	373929	1055739	8/25/97	26.3	*N*
39N09E02NW	373929	1055739	6/6/98	23.3	*N*
39N09E02NW	373929	1055739	6/16/99	48.9	*N*
39N09E02NW	373929	1055739	7/14/99	22.3	*N*
39N09E02NW	373929	1055739	5/31/00	21.4	*N*
39N09E03NW	373929	1055846	6/3/98	25.3	*N*
39N09E03NW	373929	1055846	6/21/98	26.0	*N*
39N09E03NW	373929	1055846	5/13/99	27.4	*N*
39N09E03NW	373929	1055846	6/8/99	26.8	*N*
39N09E03NW	373929	1055846	6/21/99	26.4	*N*
39N09E03NW	373929	1055846	7/21/99	13.3	*N*
39N09E03NW	373929	1055846	6/12/00	23.9	*N*
39N09E03NW	373929	1055846	6/21/00	24.5	*N*
39N09E04SW	373902	1055951	6/12/97	26.9	*N*
39N09E04SW	373902	1055951	6/6/98	36.5	*N*
39N09E04SW	373902	1055951	6/4/99	31.5	*N*
39N09E04SW	373902	1055951	5/8/00	23.1	*N*
39N09E04SW	373902	1055951	6/12/00	31.6	*N*
39N09E04SW	373902	1055951	6/21/00	24.8	*N*
39N09E04SW	373902	1055951	6/11/01	15.5	*N*
39N09E06SW	373903	1060204	6/24/97	17.8	*N*
39N09E06SW	373903	1060204	6/3/98	19.5	*N*
39N09E06SW	373903	1060204	6/22/99	19.3	*N*
39N09E06SW	373903	1060204	5/31/00	19.6	*N*
39N09E06SW	373903	1060204	6/6/01	18.6	*N*
39N09E08NE	373836	1060027	6/11/01	10.9	*N*
39N09E08NW	373836	1060056	6/3/98	28.1	*N*
39N09E08NW	373836	1060056	6/10/99	13.5	*N*
39N09E08NW	373836	1060056	7/15/99	28.2	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
39N09E08NW	373836	1060056	5/31/00	30.6	*N*
39N09E09NW	373836	1055952	6/9/99	25.9	*N*
39N09E09NW	373836	1055952	5/31/00	13.1	*N*
39N09E09NW	373836	1055952	6/6/01	11.1	*N*
39N09E10NE	373836	1055813	6/3/98	32.4	*N*
39N09E10NE	373836	1055813	6/16/99	31.0	*N*
39N09E10NE	373836	1055813	5/8/00	27.5	*N*
39N09E10NE	373836	1055813	5/31/00	29.7	*N*
39N09E10NE	373836	1055813	6/21/00	31.7	*N*
39N09E10NE	373836	1055813	6/12/01	30.1	*N*
39N09E10NE	373836	1055813	9/4/01	33.4	*N*
39N09E11SW	373809	1055739	6/6/98	3.9	*N*
39N09E11SW	373809	1055739	7/2/99	4.9	*N*
39N09E11SW	373809	1055739	5/31/00	4.7	*N*
39N09E11SW	373809	1055739	6/11/01	4.8	*N*
39N09E13SE	373719	1055559	6/12/97	11.4	*N*
39N09E13SE	373719	1055559	6/10/98	51.5	*N*
39N09E13SE	373719	1055559	6/3/99	57.9	*N*
39N09E13SE	373719	1055559	7/21/99	54.7	*N*
39N09E13SE	373719	1055559	6/13/00	57.6	*N*
39N09E13SE	373719	1055559	6/21/00	58.4	*N*
39N09E13SE	373719	1055559	6/7/01	65.7	*N*
39N09E15SE	373718	1055815	6/17/97	2.6	*N*
39N09E15SE	373718	1055815	6/3/98	5.7	*N*
39N09E15SE	373718	1055815	6/3/99	1.9	*N*
39N09E15SE	373718	1055815	6/12/00	2.2	*N*
39N09E15SE	373718	1055815	6/12/01	2.1	*N*
39N09E17SW	373717	1060112	6/19/97	7.4	*N*
39N09E17SW	373717	1060112	6/10/98	7.5	*N*
39N09E17SW	373717	1060112	6/4/99	7.6	*N*
39N09E17SW	373717	1060112	6/8/00	6.6	*N*
39N09E17SW	373717	1060112	6/11/01	7.3	*N*
39N09E26NE	373559	1055707	6/27/97	6.7	*N*
39N09E26NE	373559	1055707	6/3/98	15.0	*N*
39N09E26NE	373559	1055707	6/10/99	12.1	*N*
39N09E26NE	373559	1055707	5/31/00	12.7	*N*
39N09E28SW	373534	1055952	6/12/97	5.5	*N*
39N09E28SW	373534	1055952	6/3/98	7.7	*N*
39N09E28SW	373534	1055952	6/7/99	8.4	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
39N09E28SW	373534	1055952	6/12/00	9.5	*N*
39N09E28SW	373534	1055952	6/6/01	9.9	*N*
39N09E30SE	373544	1060147	6/19/97	7.4	*N*
39N09E30SE	373544	1060147	6/10/98	6.2	*N*
39N09E30SE	373544	1060147	6/16/98	6.3	*N*
39N09E30SE	373544	1060147	6/7/99	7.1	*N*
39N09E30SE	373544	1060147	6/23/99	6.2	*N*
39N09E30SE	373544	1060147	7/23/99	4.7	*N*
39N09E30SE	373544	1060147	5/8/00	5.0	*N*
39N09E30SE	373544	1060147	5/31/00	5.8	*N*
39N09E30SE	373544	1060147	6/22/00	5.8	*N*
39N09E30SE	373544	1060147	6/6/01	5.4	*N*
39N10E02SW	373855	1055117	6/23/97	2.3	*Q*
39N10E02SW	373855	1055117	6/23/97	2.1	*N*
39N10E02SW	373855	1055117	7/29/97	1.9	*N*
39N10E02SW	373855	1055117	8/25/97	2.2	*N*
39N10E02SW	373855	1055117	5/12/98	1.6	*N*
39N10E02SW	373855	1055117	6/11/98	1.8	*N*
39N10E02SW	373911	1055102	6/10/99	15.3	*N*
39N10E02SW	373855	1055117	6/23/99	6.4	*N*
39N10E02SW	373911	1055102	6/23/99	15.1	*N*
39N10E02SW	373855	1055117	7/21/99	3.3	*N*
39N10E02SW	373911	1055102	7/21/99	16.4	*N*
39N10E02SW	373855	1055117	6/15/00	3.1	*N*
39N10E02SW	373855	1055117	6/24/00	3.5	*N*
39N10E06NE	373931	1055453	6/6/01	12.5	*N*
39N10E06SW	373905	1055526	7/1/99	16.1	*N*
39N10E06SW	373905	1055526	6/10/00	39.5	*N*
39N10E09SE	373742	1055217	6/1/99	11.6	*N*
39N10E09SE	373742	1055217	7/14/99	17.8	*N*
39N10E09SE	373742	1055217	8/4/99	17.4	*N*
39N10E09SE	373742	1055217	5/8/00	10.5	*N*
39N10E09SE	373742	1055217	6/13/00	8.7	*N*
39N10E09SE	373742	1055217	6/21/00	17.1	*N*
39N10E09SE	373742	1055217	6/18/01	8.2	*N*
39N10E15NW	373746	1055212	6/8/99	0.1	*N*
39N10E15NW	373746	1055212	6/12/00	14.4	*N*
39N10E15NW	373746	1055212	6/4/01	1.1	*N*
39N10E15SE	373721	1055141	6/12/98	1.1	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
39N10E15SE	373721	1055141	6/1/99	6.3	*N*
39N10E15SE	373721	1055141	7/14/99	5.3	*N*
39N10E15SE	373721	1055141	6/12/00	6.8	*N*
39N10E15SE	373721	1055141	6/6/01	10.2	*N*
39N10E22NE	373655	1055137	6/18/01	3.5	*N*
39N10E26NE	373608	1055027	6/13/00	2.0	*N*
39N10E26NW	373608	1055117	6/10/99	0.8	*N*
39N10E30NE	373560	1055453	6/24/97	1.5	*N*
39N10E30NE	373560	1055453	5/7/98	1.4	*N*
39N10E30NE	373560	1055453	6/6/98	1.6	*N*
39N10E30NE	373560	1055453	5/12/99	1.6	*N*
39N10E30NE	373560	1055453	6/1/99	1.8	*N*
39N10E30NE	373560	1055453	6/23/99	1.8	*N*
39N10E30NE	373560	1055453	7/23/99	1.0	*N*
39N10E30NE	373560	1055453	6/22/00	2.1	*N*
39N10E30NE	373560	1055453	6/12/01	2.9	*N*
40N06E02SE	374413	1061657	6/1/98	1.1	*N*
40N06E02SE	374413	1061657	6/8/99	1.0	*N*
40N06E02SE	374413	1061657	6/16/99	0.8	*N*
40N06E02SE	374413	1061657	6/30/00	1.8	*N*
40N06E02SE	374413	1061657	6/22/01	0.7	*N*
40N06E13SW	374230	1061622	6/16/98	1.0	*N*
40N06E13SW	374230	1061622	7/23/99	1.1	*N*
40N06E13SW	374230	1061622	6/1/00	0.9	*N*
40N06E13SW	374230	1061622	6/7/01	0.8	*N*
40N06E26SW	374046	1061737	6/5/98	0.6	*N*
40N06E26SW	374046	1061737	6/14/99	0.6	*N*
40N06E26SW	374046	1061737	6/1/00	0.7	*N*
40N06E26SW	374046	1061737	6/7/01	0.6	*N*
40N07E01SW	374414	1060945	6/24/97	1.6	*N*
40N07E01SW	374414	1060945	6/15/98	1.4	*N*
40N07E01SW	374414	1060945	6/9/99	42.8	*N*
40N07E01SW	374414	1060945	7/22/99	1.1	*N*
40N07E01SW	374414	1060945	6/12/00	1.3	*N*
40N07E01SW	374414	1060945	6/19/01	0.9	*N*
40N07E03NE	374440	1061126	6/12/97	8.5	*N*
40N07E03NE	374440	1061126	6/11/98	9.1	*N*
40N07E03NE	374440	1061126	6/25/99	31.4	*N*
40N07E03NE	374440	1061126	6/27/00	8.8	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
40N07E03NE	374440	1061126	6/13/01	9.7	*N*
40N07E05SW	374414	1061411	6/10/98	2.4	*N*
40N07E05SW	374414	1061411	6/8/99	2.4	*N*
40N07E05SW	374414	1061411	6/12/00	3.2	*N*
40N07E14SE	374220	1061035	6/19/97	9.1	*N*
40N07E14SE	374220	1061035	6/8/98	11.6	*N*
40N07E14SE	374220	1061035	6/23/98	8.8	*N*
40N07E14SE	374220	1061035	5/11/99	10.9	*N*
40N07E14SE	374220	1061035	6/11/99	11.7	*N*
40N07E14SE	374220	1061035	6/24/99	12.1	*N*
40N07E14SE	374220	1061035	5/12/00	45.0	*N*
40N07E14SE	374220	1061035	6/1/00	10.5	*N*
40N07E14SE	374220	1061035	6/13/00	10.1	*N*
40N07E14SE	374220	1061035	6/27/00	10.1	*N*
40N07E14SE	374220	1061035	6/8/01	9.5	*N*
40N07E16NE	374256	1061230	6/2/98	10.6	*N*
40N07E16NE	374256	1061230	6/8/99	15.8	*N*
40N07E16NE	374256	1061230	6/20/00	12.4	*N*
40N07E16NE	374256	1061230	6/25/01	10.6	*N*
40N07E18NE	374256	1061445	6/17/97	1.8	*N*
40N07E18NE	374256	1061445	6/8/99	6.2	*N*
40N07E18NE	374256	1061445	7/22/99	1.6	*N*
40N07E18NE	374256	1061445	6/1/00	1.6	*N*
40N07E18NE	374256	1061445	6/25/01	1.5	*N*
40N07E25NW	374111	1060945	6/25/97	4.3	*N*
40N07E25NW	374111	1060945	6/25/99	32.3	*N*
40N07E25NW	374111	1060945	6/12/00	3.8	*N*
40N07E25NW	374111	1060945	6/27/00	4.5	*N*
40N07E25NW	374111	1060945	6/7/01	4.0	*N*
40N07E27NE	374111	1061125	6/20/98	7.1	*N*
40N07E27NE	374111	1061125	6/10/99	7.0	*N*
40N07E27NE	374111	1061125	6/8/00	5.2	*N*
40N07E27NE	374111	1061125	6/7/01	5.4	*N*
40N07E29SW	374046	1061411	6/19/97	1.0	*N*
40N07E29SW	374046	1061411	6/25/97	0.9	*N*
40N07E29SW	374046	1061411	7/24/97	0.8	*N*
40N07E29SW	374046	1061411	5/13/98	0.7	*N*
40N07E29SW	374046	1061411	6/5/98	0.8	*N*
40N07E29SW	374046	1061411	6/22/98	0.8	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
40N07E29SW	374046	1061411	6/29/99	0.6	*N*
40N07E29SW	374046	1061411	7/29/99	1.0	*N*
40N07E29SW	374046	1061411	5/8/00	0.8	*N*
40N07E29SW	374046	1061411	6/1/00	0.8	*N*
40N07E29SW	374046	1061411	6/27/00	0.8	*N*
40N07E29SW	374046	1061411	6/19/01	0.8	*N*
40N07E29SW	374046	1061411	8/28/01	0.9	*N*
40N08E01NW	374441	1060308	6/13/97	14.2	*N*
40N08E01NW	374441	1060308	6/18/97	15.0	*N*
40N08E01NW	374441	1060308	6/25/97	14.7	*N*
40N08E01NW	374441	1060308	7/28/97	10.3	*N*
40N08E01NW	374441	1060308	6/8/98	12.1	*N*
40N08E01NW	374441	1060308	6/22/98	13.8	*N*
40N08E01NW	374441	1060308	8/3/98	14.2	*N*
40N08E01NW	374441	1060308	5/12/99	15.6	*N*
40N08E01NW	374441	1060308	6/24/99	13.8	*N*
40N08E01NW	374441	1060308	7/29/99	24.7	*N*
40N08E01NW	374441	1060308	6/12/00	13.2	*N*
40N08E01NW	374441	1060308	6/15/00	13.0	*N*
40N08E01NW	374441	1060308	6/28/00	13.0	*N*
40N08E01NW	374441	1060308	6/9/01	12.6	*N*
40N08E03SW	374415	1060520	6/23/97	11.5	*N*
40N08E03SW	374415	1060520	6/8/98	9.7	*N*
40N08E03SW	374415	1060520	6/23/99	9.5	*N*
40N08E03SW	374415	1060520	6/5/00	9.3	*N*
40N08E03SW	374415	1060520	6/11/01	11.9	*N*
40N08E05NE	374431	1060716	6/1/98	16.0	*N*
40N08E05NE	374431	1060716	7/23/99	8.3	*N*
40N08E05NE	374431	1060716	6/15/00	10.2	*N*
40N08E05NE	374431	1060716	6/28/00	6.6	*N*
40N08E05NE	374431	1060716	6/25/01	10.5	*N*
40N08E10SE	374323	1060448	6/10/98	9.2	*N*
40N08E10SE	374323	1060448	6/10/99	12.1	*N*
40N08E10SE	374323	1060448	6/28/00	9.8	*N*
40N08E10SE	374323	1060448	6/9/01	10.0	*N*
40N08E11SW	374323	1060414	6/15/98	11.4	*N*
40N08E11SW	374323	1060414	6/10/99	10.7	*N*
40N08E11SW	374323	1060414	6/28/00	11.0	*N*
40N08E11SW	374323	1060414	6/12/01	9.6	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
40N08E12SW	374323	1060308	6/8/98	9.1	*N*
40N08E12SW	374323	1060308	6/7/99	9.7	*N*
40N08E12SW	374323	1060308	6/28/00	10.8	*N*
40N08E12SW	374323	1060308	6/18/01	5.8	*N*
40N08E13NE	374257	1060236	6/10/98	17.1	*N*
40N08E13NE	374257	1060236	6/22/99	20.6	*N*
40N08E13NE	374257	1060236	6/14/00	19.5	*N*
40N08E13NE	374257	1060236	6/11/01	21.6	*N*
40N08E14SW	374231	1060415	6/19/97	21.2	*N*
40N08E14SW	374231	1060415	6/1/98	19.7	*N*
40N08E14SW	374231	1060415	6/9/99	19.0	*N*
40N08E14SW	374231	1060415	6/13/00	18.8	*N*
40N08E14SW	374231	1060415	6/12/01	20.9	*N*
40N08E16SW	374230	1060628	6/17/97	14.6	*N*
40N08E16SW	374230	1060628	6/3/98	15.3	*N*
40N08E16SW	374230	1060628	6/24/99	17.0	*N*
40N08E16SW	374230	1060628	6/12/00	15.5	*N*
40N08E16SW	374230	1060628	6/11/01	17.6	*N*
40N08E18NW	374255	1060839	6/11/97	8.4	*N*
40N08E18NW	374255	1060839	6/2/98	4.9	*N*
40N08E18NW	374255	1060839	6/14/99	8.8	*N*
40N08E18NW	374255	1060839	6/28/99	4.2	*N*
40N08E18NW	374255	1060839	6/1/00	5.6	*N*
40N08E18NW	374255	1060839	6/9/00	10.3	*N*
40N08E18NW	374255	1060839	6/11/01	7.5	*N*
40N08E22NW	374204	1060537	6/8/98	11.3	*N*
40N08E22NW	374204	1060537	6/22/99	13.7	*N*
40N08E22NW	374204	1060537	6/27/00	11.4	*N*
40N08E23SW	374138	1060415	6/24/98	22.3	*N*
40N08E23SW	374138	1060415	6/15/99	20.7	*N*
40N08E23SW	374138	1060415	6/12/00	21.0	*N*
40N08E23SW	374138	1060415	6/11/01	19.9	*N*
40N08E24NW	374204	1060308	6/5/98	10.7	*N*
40N08E24NW	374204	1060308	6/15/99	12.0	*N*
40N08E24NW	374204	1060308	6/12/00	11.3	*N*
40N08E24NW	374204	1060308	6/13/01	13.9	*N*
40N08E25SE	374046	1060237	6/23/97	16.8	*N*
40N08E25SE	374046	1060237	6/3/98	15.2	*N*
40N08E25SE	374046	1060237	6/17/99	18.4	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
40N08E25SE	374046	1060237	6/12/00	12.0	*N*
40N08E25SE	374046	1060237	6/13/01	10.9	*N*
40N08E27SW	374046	1060521	6/25/97	15.0	*N*
40N08E27SW	374046	1060521	6/18/98	13.8	*N*
40N08E27SW	374046	1060521	6/21/99	13.4	*N*
40N08E27SW	374046	1060521	6/5/00	13.8	*N*
40N08E27SW	374046	1060521	6/19/01	0.0	*N*
40N08E29SW	374045	1060733	6/11/97	12.9	*N*
40N08E29SW	374045	1060733	6/18/97	12.7	*N*
40N08E29SW	374045	1060733	6/23/97	11.8	*N*
40N08E29SW	374045	1060733	7/23/97	11.0	*N*
40N08E29SW	374045	1060733	6/10/98	12.2	*N*
40N08E29SW	374045	1060733	6/22/98	11.3	*N*
40N08E29SW	374045	1060733	7/27/98	10.5	*N*
40N08E29SW	374045	1060733	6/8/99	0.1	*N*
40N08E29SW	374045	1060733	6/14/99	11.9	*N*
40N08E29SW	374045	1060733	6/23/99	13.0	*N*
40N08E29SW	374045	1060733	7/22/99	11.1	*N*
40N08E29SW	374045	1060733	6/1/00	11.9	*N*
40N08E29SW	374045	1060733	6/28/00	11.6	*N*
40N08E29SW	374045	1060733	6/13/01	13.1	*N*
40N09E01NE	374444	1055557	6/24/97	7.4	*N*
40N09E01NE	374444	1055557	6/7/99	8.9	*N*
40N09E01NE	374444	1055557	6/10/00	9.9	*N*
40N09E01NE	374444	1055557	6/4/01	8.9	*N*
40N09E01SW	374418	1055631	6/11/98	12.7	*N*
40N09E01SW	374418	1055631	6/28/99	12.1	*N*
40N09E01SW	374418	1055631	6/10/00	11.9	*N*
40N09E01SW	374418	1055631	6/4/01	11.9	*N*
40N09E01SW	374418	1055631	6/13/01	14.1	*N*
40N09E03SW	374417	1055842	6/12/97	6.0	*N*
40N09E03SW	374417	1055842	6/15/98	7.6	*N*
40N09E03SW	374417	1055842	6/8/99	8.4	*N*
40N09E03SW	374417	1055842	6/21/99	9.3	*N*
40N09E03SW	374417	1055842	6/8/00	5.4	*N*
40N09E03SW	374417	1055842	6/4/01	7.1	*N*
40N09E05SW	374416	1060055	6/23/97	14.1	*Q*
40N09E05SW	374416	1060055	6/23/97	13.8	*N*
40N09E05SW	374416	1060055	6/7/99	17.6	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
40N09E05SW	374416	1060055	6/8/00	13.3	*N*
40N09E05SW	374416	1060055	6/4/01	14.9	*N*
40N09E11SW	374325	1055704	6/10/98	8.3	*N*
40N09E11SW	374325	1055704	6/7/99	17.3	*N*
40N09E11SW	374325	1055704	6/8/00	14.9	*N*
40N09E11SW	374325	1055704	6/4/01	7.5	*N*
40N09E13SE	374234	1055559	6/10/98	16.0	*N*
40N09E13SE	374234	1055559	7/1/99	17.1	*N*
40N09E13SE	374234	1055559	6/8/00	15.2	*N*
40N09E13SE	374234	1055559	6/6/01	16.4	*N*
40N09E14NE	374259	1055704	6/23/97	34.2	*N*
40N09E14NE	374259	1055704	6/23/97	35.4	*Q*
40N09E14NE	374259	1055704	6/11/98	42.1	*N*
40N09E14NE	374259	1055704	6/30/99	50.5	*N*
40N09E14NE	374259	1055704	6/8/00	45.1	*N*
40N09E14NE	374259	1055704	6/21/00	42.3	*N*
40N09E14NE	374259	1055704	6/4/01	31.2	*N*
40N09E15SE	374232	1055810	6/11/98	23.2	*N*
40N09E15SE	374232	1055810	7/1/99	23.2	*N*
40N09E15SE	374232	1055810	6/8/00	22.3	*N*
40N09E15SE	374232	1055810	6/4/01	21.7	*N*
40N09E15SE	374232	1055810	6/18/01	21.1	*N*
40N09E16SE	374232	1055914	6/8/99	19.0	*N*
40N09E16SE	374232	1055914	7/21/99	27.6	*N*
40N09E16SE	374232	1055914	6/10/00	18.2	*N*
40N09E16SE	374232	1055914	6/11/01	18.8	*N*
40N09E16SW	374233	1055948	6/21/98	24.4	*N*
40N09E16SW	374233	1055948	7/21/99	27.3	*N*
40N09E16SW	374233	1055948	6/12/00	27.0	*N*
40N09E16SW	374233	1055948	6/11/01	30.9	*N*
40N09E18SE	374231	1060127	6/27/97	19.3	*N*
40N09E18SE	374231	1060127	6/11/98	19.8	*N*
40N09E18SE	374231	1060127	6/8/99	19.4	*N*
40N09E18SE	374231	1060127	6/12/00	18.7	*N*
40N09E18SE	374231	1060127	6/13/01	14.6	*N*
40N09E23NE	374206	1055704	6/11/98	13.1	*N*
40N09E23NE	374206	1055704	6/25/99	28.0	*N*
40N09E23NE	374206	1055704	6/12/00	22.7	*N*
40N09E23NE	374206	1055704	6/13/01	26.2	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
40N09E24SE	374143	1055556	6/10/98	17.4	*N*
40N09E24SE	374143	1055556	6/12/00	16.5	*N*
40N09E25NE	374114	1055557	6/10/98	24.4	*N*
40N09E25NE	374114	1055557	7/9/99	12.7	*N*
40N09E25NE	374114	1055557	6/8/00	13.7	*N*
40N09E25NE	374114	1055557	6/21/00	19.5	*N*
40N09E25NE	374114	1055557	6/7/01	17.1	*N*
40N09E27NE	374114	1055809	6/12/00	24.9	*N*
40N09E27NE	374114	1055809	6/21/00	26.0	*N*
40N09E27NE	374114	1055809	6/18/01	28.4	*N*
40N09E27NW	374113	1055842	6/10/97	11.2	*N*
40N09E27NW	374113	1055842	7/30/98	16.9	*N*
40N09E27NW	374113	1055842	7/30/98	12.7	*N*
40N09E27NW	374113	1055842	6/8/99	14.9	*N*
40N09E27NW	374113	1055842	6/12/00	25.0	*N*
40N09E29NE	374113	1060022	6/24/97	19.4	*N*
40N09E29NE	374113	1060022	7/29/97	19.0	*N*
40N09E29NE	374113	1060022	8/25/97	16.1	*N*
40N09E29NE	374113	1060022	6/11/98	19.7	*N*
40N09E29NE	374113	1060022	6/22/98	19.4	*N*
40N09E29NE	374113	1060022	6/30/99	19.9	*N*
40N09E29NE	374113	1060022	7/19/99	20.7	*N*
40N09E29NE	374113	1060022	6/12/00	17.2	*N*
40N09E29NE	374113	1060022	6/22/00	15.2	*N*
40N09E29NE	374113	1060022	6/13/01	13.1	*N*
40N09E35SW	373956	1055738	6/6/98	39.9	*N*
40N09E35SW	373956	1055738	6/16/99	22.9	*N*
40N09E35SW	373956	1055738	7/14/99	47.2	*N*
40N09E35SW	373956	1055738	5/10/00	39.1	*N*
40N09E35SW	373956	1055738	5/31/00	13.0	*N*
40N09E35SW	373956	1055738	6/10/00	4.2	*N*
40N09E35SW	373956	1055738	6/21/00	46.2	*N*
40N09E35SW	373956	1055738	6/6/01	49.4	*N*
40N10E03SW	374420	1055206	6/18/97	6.2	*N*
40N10E03SW	374420	1055206	6/15/98	7.5	*N*
40N10E03SW	374420	1055206	6/8/99	7.8	*N*
40N10E03SW	374420	1055206	5/31/00	12.5	*N*
40N10E03SW	374420	1055206	6/4/01	10.5	*N*
40N10E05NW	374436	1055432	6/21/98	4.8	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
40N10E05NW	374436	1055432	6/9/99	4.8	*N*
40N10E05NW	374436	1055432	6/13/01	3.8	*N*
40N10E05SW	374418	1055416	6/18/97	11.0	*N*
40N10E05SW	374418	1055416	6/10/98	10.4	*N*
40N10E05SW	374418	1055416	6/9/99	12.1	*N*
40N10E05SW	374418	1055416	6/15/00	9.9	*N*
40N10E14NE	374303	1055029	6/27/97	6.8	*N*
40N10E14NE	374303	1055029	6/18/98	4.5	*N*
40N10E14NE	374303	1055029	6/21/99	3.6	*N*
40N10E14NE	374303	1055029	5/31/00	3.2	*N*
40N10E17NE	374301	1055345	6/24/97	14.4	*N*
40N10E17NE	374301	1055345	6/27/97	2.9	*N*
40N10E17NE	374301	1055345	7/29/97	3.6	*N*
40N10E17NE	374301	1055345	8/25/97	2.9	*N*
40N10E17NE	374301	1055345	6/18/98	48.1	*N*
40N10E17NE	374301	1055345	7/2/99	8.1	*N*
40N10E17NE	374301	1055345	7/19/99	0.5	*N*
40N10E17NE	374301	1055345	5/8/00	8.8	*N*
40N10E17NE	374301	1055345	6/13/00	45.7	*N*
40N10E17NE	374301	1055345	6/21/00	12.3	*N*
40N10E17NE	374301	1055345	6/13/01	12.3	*N*
40N10E18SE	374235	1055453	6/10/98	12.2	*N*
40N10E18SE	374235	1055453	6/8/99	13.8	*N*
40N10E18SE	374235	1055453	6/8/00	10.3	*N*
40N10E18SE	374235	1055453	6/13/01	15.8	*N*
40N10E25SE	374101	1054925	6/12/98	6.0	*N*
40N10E25SE	374101	1054925	6/8/99	4.9	*N*
40N10E25SE	374101	1054925	5/31/00	6.9	*N*
40N10E25SE	374101	1054925	7/2/01	6.0	*N*
40N10E29SW	374049	1055419	6/12/98	44.8	*N*
40N10E29SW	374049	1055419	6/16/99	3.3	*N*
40N10E29SW	374049	1055419	7/14/99	43.2	*N*
40N10E29SW	374049	1055419	6/17/00	45.2	*N*
40N10E29SW	374049	1055419	6/22/00	43.7	*N*
40N10E29SW	374049	1055419	6/6/01	41.6	*N*
41N07E04NW	374953	1061257	6/24/98	0.3	*N*
41N07E04NW	374953	1061257	8/3/98	0.3	*N*
41N07E04NW	374953	1061257	6/29/99	0.4	*N*
41N07E04NW	374953	1061257	6/8/00	0.4	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
41N07E04NW	374953	1061257	6/27/01	1.8	*N*
41N07E06SE	374930	1061439	6/1/98	1.8	*N*
41N07E06SE	374930	1061439	6/3/99	1.7	*N*
41N07E06SE	374930	1061439	6/8/00	1.9	*N*
41N07E13NW	374810	1060942	6/19/97	5.1	*N*
41N07E13NW	374810	1060942	6/23/98	5.2	*N*
41N07E13NW	374810	1060942	6/7/99	6.4	*N*
41N07E13NW	374810	1060942	6/14/00	5.3	*N*
41N07E13NW	374810	1060942	6/19/01	6.9	*N*
41N07E15NW	374757	1061153	6/17/98	1.3	*N*
41N07E15NW	374757	1061153	6/4/99	1.7	*N*
41N07E15NW	374757	1061153	6/8/00	2.5	*N*
41N07E15NW	374757	1061153	6/26/01	1.7	*N*
41N07E16SW	374757	1061260	6/1/98	4.7	*N*
41N07E16SW	374757	1061260	6/14/99	1.4	*N*
41N07E16SW	374757	1061260	6/8/00	2.0	*N*
41N07E16SW	374757	1061260	6/15/01	1.6	*N*
41N07E26NW	374624	1061051	6/23/98	1.1	*N*
41N07E26NW	374624	1061051	6/7/99	0.8	*N*
41N07E26NW	374624	1061051	6/14/00	1.0	*N*
41N07E26NW	374624	1061051	6/15/01	0.8	*N*
41N07E28NE	374624	1061229	6/5/98	4.5	*N*
41N07E28NE	374624	1061229	6/20/98	4.5	*N*
41N07E28NE	374624	1061229	7/31/98	4.4	*N*
41N07E28NE	374624	1061229	6/9/99	4.2	*N*
41N07E28NE	374624	1061229	6/21/99	4.2	*N*
41N07E28NE	374624	1061229	6/2/00	5.1	*N*
41N07E28NE	374624	1061229	6/22/00	5.1	*N*
41N07E28NE	374624	1061229	6/26/01	4.4	*N*
41N07E28NE	374624	1061229	9/1/01	2.2	*N*
41N07E30SE	374560	1061442	6/2/98	1.1	*N*
41N07E30SE	374560	1061442	6/8/99	1.1	*N*
41N07E30SE	374560	1061442	6/8/00	12.5	*N*
41N08E01NE	374955	1060304	6/4/99	9.0	*N*
41N08E01NW	374955	1060301	6/2/98	9.6	*N*
41N08E01NW	374955	1060301	6/21/00	9.6	*N*
41N08E01NW	374955	1060301	6/21/01	9.5	*N*
41N08E02SW	374929	1060412	6/25/97	21.3	*N*
41N08E02SW	374929	1060412	6/30/97	21.3	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
41N08E02SW	374929	1060412	8/22/97	17.6	*N*
41N08E02SW	374929	1060412	6/2/98	22.0	*N*
41N08E02SW	374929	1060412	6/15/98	22.4	*N*
41N08E02SW	374929	1060412	7/30/98	22.3	*N*
41N08E02SW	374929	1060412	5/17/99	22.9	*N*
41N08E02SW	374929	1060412	6/2/99	22.1	*N*
41N08E02SW	374929	1060412	6/21/99	23.1	*N*
41N08E02SW	374929	1060412	7/29/99	23.5	*N*
41N08E02SW	374929	1060412	5/10/00	21.5	*N*
41N08E02SW	374929	1060412	6/2/00	5.1	*N*
41N08E02SW	374929	1060412	6/21/00	24.3	*N*
41N08E03SW	374929	1060517	6/8/98	11.5	*N*
41N08E03SW	374929	1060517	6/7/99	12.1	*N*
41N08E03SW	374929	1060517	6/8/00	13.9	*N*
41N08E03SW	374929	1060517	6/21/01	17.3	*N*
41N08E04SW	374920	1060639	6/1/98	5.8	*N*
41N08E04SW	374920	1060639	6/24/99	4.2	*N*
41N08E04SW	374920	1060639	6/5/00	5.2	*N*
41N08E04SW	374920	1060639	6/15/01	11.4	*N*
41N08E06SE	374927	1060803	6/12/97	16.6	*N*
41N08E06SE	374927	1060803	6/2/98	14.9	*N*
41N08E06SE	374927	1060803	6/3/99	13.4	*N*
41N08E06SE	374927	1060803	6/8/00	1.0	*N*
41N08E06SE	374927	1060803	6/27/01	11.5	*N*
41N08E10NW	374903	1060518	6/2/98	19.5	*N*
41N08E10NW	374903	1060518	6/25/99	18.4	*N*
41N08E10NW	374903	1060518	6/8/00	17.8	*N*
41N08E10NW	374903	1060518	6/21/01	17.7	*N*
41N08E11SW	374837	1060413	6/8/98	15.0	*N*
41N08E11SW	374837	1060413	6/22/99	16.7	*N*
41N08E11SW	374837	1060413	6/14/00	16.9	*N*
41N08E11SW	374837	1060413	6/15/01	16.9	*N*
41N08E12NW	374903	1060306	6/12/98	15.0	*N*
41N08E12NW	374903	1060306	6/14/99	14.6	*N*
41N08E12NW	374903	1060306	6/12/00	15.3	*N*
41N08E12NW	374903	1060306	6/13/01	17.1	*N*
41N08E13SW	374745	1060307	6/17/97	15.6	*N*
41N08E13SW	374745	1060307	6/15/98	14.0	*N*
41N08E13SW	374745	1060307	6/15/00	12.8	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
41N08E13SW	374745	1060307	6/15/01	12.7	*N*
41N08E15SW	374744	1060519	6/12/97	10.6	*N*
41N08E15SW	374744	1060519	6/2/98	9.4	*N*
41N08E15SW	374744	1060519	6/7/99	9.2	*N*
41N08E15SW	374744	1060519	6/15/00	9.0	*N*
41N08E15SW	374744	1060519	6/15/01	3.9	*N*
41N08E17NE	374810	1060658	6/12/97	13.6	*N*
41N08E17NE	374810	1060658	6/15/98	14.6	*N*
41N08E17NE	374810	1060658	6/10/99	14.4	*N*
41N08E17NE	374810	1060658	7/29/99	10.6	*N*
41N08E17NE	374810	1060658	6/14/00	15.2	*N*
41N08E17NE	374810	1060658	6/22/01	15.6	*N*
41N08E26NE	374626	1060342	6/12/97	15.1	*N*
41N08E26NE	374626	1060342	6/5/98	12.8	*N*
41N08E26NE	374626	1060342	6/18/99	14.1	*N*
41N08E26NE	374626	1060342	6/15/00	13.0	*N*
41N08E26NE	374626	1060342	6/15/01	6.9	*N*
41N08E28SW	374560	1060628	6/12/97	7.6	*N*
41N08E28SW	374560	1060628	6/18/97	7.2	*N*
41N08E28SW	374560	1060628	6/25/97	7.2	*N*
41N08E28SW	374560	1060628	7/23/97	7.1	*N*
41N08E28SW	374560	1060628	6/15/98	5.2	*N*
41N08E28SW	374560	1060628	6/23/98	6.5	*N*
41N08E28SW	374560	1060628	5/13/99	7.1	*N*
41N08E28SW	374560	1060628	6/4/99	7.2	*N*
41N08E28SW	374560	1060628	6/5/00	5.4	*N*
41N08E28SW	374560	1060628	6/21/00	5.2	*N*
41N08E28SW	374560	1060628	6/22/01	6.2	*N*
41N08E28SW	374560	1060628	9/1/01	5.8	*N*
41N09E02NE	374956	1055811	6/23/97	4.2	*Q*
41N09E02NE	374956	1055811	6/23/97	4.3	*N*
41N09E02NE	374956	1055811	6/15/98	2.9	*N*
41N09E02NE	374956	1055811	7/8/99	3.1	*N*
41N09E02NE	374956	1055811	6/22/00	3.5	*N*
41N09E02NE	374956	1055811	6/21/01	4.1	*N*
41N09E04NE	374956	1055917	6/19/97	5.4	*N*
41N09E04NE	374956	1055917	6/15/98	6.9	*N*
41N09E04NE	374956	1055917	7/8/99	6.9	*N*
41N09E04NE	374956	1055917	6/16/00	6.6	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
41N09E04NE	374956	1055917	6/27/01	7.2	*N*
41N09E06NW	374956	1060157	6/23/97	11.6	*N*
41N09E06NW	374956	1060157	6/23/97	11.4	*Q*
41N09E06NW	374956	1060157	6/21/98	12.6	*N*
41N09E06NW	374956	1060157	7/9/99	14.9	*N*
41N09E06NW	374956	1060157	6/15/00	13.9	*N*
41N09E13NE	374812	1055559	6/19/97	3.0	*N*
41N09E13NE	374812	1055559	7/8/99	4.0	*N*
41N09E13NE	374812	1055559	6/16/00	3.8	*N*
41N09E13NE	374812	1055559	6/15/01	3.0	*N*
41N09E15NW	374811	1055844	6/18/97	6.5	*N*
41N09E15NW	374811	1055844	6/22/98	3.3	*N*
41N09E15NW	374811	1055844	7/8/99	20.1	*N*
41N09E15NW	374811	1055844	6/21/00	11.1	*N*
41N09E17NE	374811	1060022	5/4/98	10.5	*N*
41N09E17NE	374811	1060022	6/18/98	9.6	*N*
41N09E17NE	374811	1060022	5/10/99	12.8	*N*
41N09E17NE	374811	1060022	7/7/99	9.6	*N*
41N09E17NE	374811	1060022	6/14/00	10.9	*N*
41N09E17NE	374811	1060022	6/29/00	10.9	*N*
41N09E17NE	374811	1060022	6/8/01	5.8	*N*
41N09E17NE	374811	1060022	6/29/01	12.0	*N*
41N09E17NE	374811	1060022	9/1/01	10.9	*N*
41N09E26NW	374627	1055737	7/8/99	2.6	*N*
41N09E26NW	374627	1055737	6/21/00	2.6	*N*
41N09E26NW	374627	1055737	6/22/01	2.1	*N*
41N09E26SE	374602	1055703	6/13/97	3.2	*N*
41N09E26SE	374602	1055703	6/15/01	7.8	*N*
41N09E28NE	374626	1055917	6/10/97	3.6	*N*
41N09E28NE	374626	1055917	6/11/98	3.5	*N*
41N09E28NE	374626	1055917	7/7/99	3.1	*N*
41N09E28NE	374626	1055917	6/16/00	3.3	*N*
41N09E28NE	374626	1055917	6/15/01	2.9	*N*
41N09E30NE	374626	1060128	6/13/97	7.8	*N*
41N09E30NE	374626	1060128	6/11/98	8.2	*N*
41N09E30NE	374626	1060128	7/8/99	6.8	*N*
41N09E30NE	374626	1060128	6/14/00	6.9	*N*
41N09E30NE	374626	1060128	6/15/01	7.3	*N*
41N09E30SE	374548	1060145	6/17/97	12.3	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
41N09E30SE	374548	1060145	6/18/98	14.0	*N*
41N09E30SE	374548	1060145	7/9/99	15.4	*N*
41N09E30SE	374548	1060145	6/22/00	3.2	*N*
41N09E30SE	374548	1060145	6/22/01	13.3	*N*
41N09E30SW	374600	1060201	6/22/00	18.6	*N*
41N09E30SW	374600	1060201	6/15/01	19.4	*N*
41N10E05NW	374958	1055421	6/10/98	5.0	*N*
41N10E05NW	374958	1055421	7/7/99	40.1	*N*
41N10E05NW	374958	1055421	6/16/00	3.3	*N*
41N10E05NW	374958	1055421	6/15/01	12.9	*N*
41N10E06NE	374958	1055454	6/13/97	5.1	*N*
41N10E06NE	374958	1055454	6/10/98	6.7	*N*
41N10E06NE	374958	1055454	7/7/99	8.6	*N*
41N10E06NE	374958	1055454	6/16/00	12.3	*N*
41N10E06NE	374958	1055454	6/22/01	4.6	*N*
41N10E17NW	374813	1055420	6/18/97	3.3	*N*
41N10E17NW	374813	1055420	7/29/97	6.5	*N*
41N10E17NW	374813	1055420	6/15/98	6.7	*N*
41N10E17NW	374813	1055420	7/9/99	5.9	*N*
41N10E17NW	374813	1055420	6/10/00	6.2	*N*
41N10E17NW	374813	1055420	6/22/00	6.1	*N*
41N10E17NW	374813	1055420	6/8/01	2.7	*N*
41N10E17NW	374813	1055420	6/12/01	5.8	*N*
41N10E17NW	374813	1055420	9/1/01	5.2	*N*
41N10E31NW	374638	1055536	6/27/00	7.0	*N*
42N07E03SW	375433	1061202	7/2/98	0.6	*N*
42N07E03SW	375433	1061202	6/3/99	0.6	*N*
42N07E03SW	375433	1061202	6/26/00	0.6	*N*
42N07E03SW	375433	1061202	6/27/01	0.6	*N*
42N07E14SE	375259	1061006	6/8/98	1.8	*N*
42N07E14SE	375259	1061006	6/3/99	1.9	*N*
42N07E14SE	375259	1061006	6/13/00	2.0	*N*
42N07E27SW	375108	1061207	6/16/98	0.9	*N*
42N07E27SW	375108	1061207	6/10/99	0.1	*N*
42N07E27SW	375108	1061207	6/15/00	1.4	*N*
42N07E27SW	375108	1061207	6/19/01	1.5	*N*
42N08E25NE	375139	1060228	6/22/98	1.8	*N*
42N08E25NE	375139	1060228	6/3/99	0.6	*N*
42N08E25NE	375139	1060228	6/8/00	1.0	*N*

Table 3. Concentration of nitrate (as nitrogen) in wells sampled during 1997–2001.—Continued

[ID, identifier; ddmmss, degrees, minutes, seconds; mm/dd/yr, month, day; mg/L, milligrams per liter; N, nitrogen; *N*, normal; *Q*, duplicate]

Site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Sampling date (mm/dd/yr)	Nitrate (as nitrogen) (mg/L as N)	Sample type
42N08E25NE	375139	1060228	6/19/01	0.5	*N*
42N08E36SW	375022	1060300	6/16/98	2.4	*N*
42N08E36SW	375022	1060300	6/3/99	2.4	*N*
42N08E36SW	375022	1060300	6/8/00	3.5	*N*
42N08E36SW	375022	1060300	6/19/01	4.7	*N*
42N09E36NE	375049	1055559	6/19/97	5.6	*N*
42N09E36NE	375049	1055559	6/10/98	4.3	*N*
42N09E36NE	375049	1055559	6/16/00	4.2	*N*
42N09E36NE	375049	1055559	6/15/01	3.1	*N*
42N10E31NW	375049	1055527	6/18/97	1.4	*N*
42N10E31NW	375049	1055527	7/31/97	2.7	*N*
42N10E31NW	375049	1055527	8/27/97	2.8	*N*
42N10E31NW	375049	1055527	5/4/98	0.6	*N*
42N10E31NW	375049	1055527	6/22/98	2.9	*N*
42N10E31NW	375049	1055527	7/8/99	3.0	*N*
42N10E31NW	375049	1055527	7/21/99	1.9	*N*
42N10E31NW	375049	1055527	6/8/00	3.5	*N*
42N10E31NW	375049	1055527	6/22/00	3.7	*N*
42N10E31NW	375049	1055527	6/8/01	2.8	*N*
42N10E31NW	375049	1055527	6/14/01	1.5	*N*

Table 5. Depth to the water table during June 1997–2001.

[USGS, U.S. Geological Survey; ID, identifier; ddmmss, degrees minutes seconds; NGVD29, National Geodetic Vertical Datum of 1929]

USGS site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Well depth (feet below land surface)	Altitude of land surface (feet above NGVD 29)	Date of water-level measurement	Depth to water table (feet below land surface)
370325105575201	370325	1055752	30	7,815	6/20/97	9.36
370325105575201	370325	1055752	30	7,815	6/4/98	15.36
370325105575201	370325	1055752	30	7,815	6/9/99	6.61
370325105575201	370325	1055752	30	7,815	6/7/00	20.46
370758105564401	370758	1055644	14	7,740	6/20/97	1.32
370758105564401	370758	1055644	14	7,740	6/4/98	1.23
370758105564401	370758	1055644	14	7,740	6/9/99	1.12
370758105564401	370758	1055644	14	7,740	6/7/00	0.95
370758105564401	370758	1055644	14	7,740	6/12/01	1.2
370815106011201	370815	1060112	65	7,828	6/6/97	23.34
370815106011201	370815	1060112	65	7,828	6/4/98	23.8
370815106011201	370815	1060112	65	7,828	6/9/99	21.13
370815106011201	370815	1060112	65	7,828	6/7/00	22.67
370815106011201	370815	1060112	65	7,828	6/12/01	23.43
371330106002101	371330	1060021	31.6	7,655	6/6/97	2.4
371330106002101	371330	1060021	31.6	7,655	6/4/98	2.62
371330106002101	371330	1060021	31.6	7,655	6/9/99	3.29
371330106002101	371330	1060021	31.6	7,655	6/7/00	4.54
371330106002101	371330	1060021	31.6	7,655	6/12/01	3.56
371333105555001	371333	1055550	30	7,625	6/6/97	3.38
371333105555001	371333	1055550	30	7,625	6/4/98	4.04
371333105555001	371333	1055550	30	7,625	6/9/99	1.31
371333105555001	371333	1055550	30	7,625	6/7/00	4.08
371333105555001	371333	1055550	30	7,625	6/12/01	3.79
371757105543601	371757	1055436	35	7,574	6/6/97	2.56
371757105543601	371757	1055436	35	7,574	6/4/98	2.44
371757105543601	371757	1055436	35	7,574	6/9/99	2.44
371757105543601	371757	1055436	35	7,574	6/7/00	2.55
371847106010901	371847	1060109	28	7,641	6/6/97	0.88
371847106010901	371847	1060109	28	7,641	6/4/98	0.8
371847106010901	371847	1060109	28	7,641	6/7/00	3.16
371850105491301	371850	1054913	30	7,532	6/6/97	1.78
371850105491301	371850	1054913	30	7,532	6/4/98	2.41
371850105491301	371850	1054913	30	7,532	6/9/99	1.13
371850105491301	371850	1054913	30	7,532	6/7/00	2.65
371850105491301	371850	1054913	30	7,532	6/7/01	1.9
372326107491501	372326	1074915	30	7,525	6/6/97	6.01
372326107491501	372326	1074915	30	7,525	6/4/98	5.22
372326107491501	372326	1074915	30	7,525	6/9/99	3.98
372326107491501	372326	1074915	30	7,525	6/7/00	3.9
372326107491501	372326	1074915	30	7,525	6/7/01	5.14
372403106022401	372403	1060224	27	7,615	6/6/97	5.53
372403106022401	372403	1060224	27	7,615	6/2/98	5.13

Table 5. Depth to the water table during June 1997–2001.—Continued

[USGS, U.S. Geological Survey; ID, identifier; ddmmss, degrees minutes seconds; NGVD29, National Geodetic Vertical Datum of 1929]

USGS site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Well depth (feet below land surface)	Altitude of land surface (feet above NGVD 29)	Date of water-level measurement	Depth to water table (feet below land surface)
372403106022401	372403	1060224	27	7,615	6/10/99	2.88
372403106022401	372403	1060224	27	7,615	6/8/00	5.18
372403106022401	372403	1060224	27	7,615	6/4/01	5.44
372453105553901	372453	1055539	10.2	7,549	6/12/97	3.32
372453105553901	372453	1055539	10.2	7,549	6/2/98	2.87
372453105553901	372453	1055539	10.2	7,549	6/10/99	3.04
372453105553901	372453	1055539	10.2	7,549	6/8/00	3.3
372453105553901	372453	1055539	10.2	7,549	6/4/01	3.83
372537105523001	372537	1055230	25.9	7,530	6/13/97	1.88
372537105523001	372537	1055230	25.9	7,530	6/3/98	1.79
372537105523001	372537	1055230	25.9	7,530	6/7/99	1.51
372537105523001	372537	1055230	25.9	7,530	6/8/00	1.66
372537105523001	372537	1055230	25.9	7,530	6/13/01	2.33
372549105434401	372549	1054344	47.4	7,558	6/13/97	9.65
372549105434401	372549	1054344	47.4	7,558	6/3/98	9.71
372549105434401	372549	1054344	47.4	7,558	6/7/99	9.81
372549105434401	372549	1054344	47.4	7,558	6/6/00	9.93
372549105434401	372549	1054344	47.4	7,558	6/4/01	10.07
372549105434401	372549	1054344	47.4	7,558	6/28/01	10.23
372914105555201	372914	1055552	33.3	7,557	6/13/97	3.64
372914105555201	372914	1055552	33.3	7,557	6/9/98	3.64
372914105555201	372914	1055552	33.3	7,557	6/7/99	2.96
372914105555201	372914	1055552	33.3	7,557	6/6/00	3.33
372914105555201	372914	1055552	33.3	7,557	6/4/01	3.28
372916106085801	372916	1060858	55	7,657	6/6/97	1.47
372916106085801	372916	1060858	55	7,657	6/2/98	2.4
372916106085801	372916	1060858	55	7,657	6/10/99	1.41
372916106085801	372916	1060858	55	7,657	6/8/00	2.5
372916106085801	372916	1060858	55	7,657	6/4/01	2.28
372918105471101	372918	1054711	26	7,526	6/4/97	2.93
372918105471101	372918	1054711	26	7,526	6/8/98	3.92
372918105471101	372918	1054711	26	7,526	6/8/99	3.3
372918105471101	372918	1054711	26	7,526	6/8/00	3.67
372918105471101	372918	1054711	26	7,526	6/4/01	4.82
372918105471101	372918	1054711	26	7,526	6/28/01	4.27
372919105421201	372919	1054212	29	7,544	6/4/97	8.98
372919105421201	372919	1054212	29	7,544	6/3/98	9.45
372919105421201	372919	1054212	29	7,544	6/8/99	10.04
372919105421201	372919	1054212	29	7,544	6/5/00	10.62
372919105421201	372919	1054212	29	7,544	6/6/01	10.99
372919105421201	372919	1054212	29	7,544	6/28/01	11.21
372923105383501	372923	1053835	50	7,598	6/4/97	28.4
372923105383501	372923	1053835	50	7,598	6/3/98	28.8

Table 5. Depth to the water table during June 1997–2001.—Continued

[USGS, U.S. Geological Survey; ID, identifier; ddmmss, degrees minutes seconds; NGVD29, National Geodetic Vertical Datum of 1929]

USGS site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Well depth (feet below land surface)	Altitude of land surface (feet above NGVD 29)	Date of water-level measurement	Depth to water table (feet below land surface)
372923105383501	372923	1053835	50	7,598	6/8/99	29.27
372923105383501	372923	1053835	50	7,598	6/5/00	29.66
372923105383501	372923	1053835	50	7,598	6/6/01	30.07
372923105383501	372923	1053835	50	7,598	6/28/01	30.09
372930106022201	372930	1060222	17	7,591	6/5/97	2.51
372930106022201	372930	1060222	17	7,591	6/2/98	2.4
372930106022201	372930	1060222	17	7,591	6/10/99	2.2
372930106022201	372930	1060222	17	7,591	6/6/00	2.47
372930106022201	372930	1060222	17	7,591	6/4/01	2.63
373358105371301	373358	1053713	53.5	7,605	6/4/97	8.33
373358105371301	373358	1053713	53.5	7,605	6/9/98	7.92
373358105371301	373358	1053713	53.5	7,605	6/8/99	7.99
373358105371301	373358	1053713	53.5	7,605	6/5/00	8.19
373358105371301	373358	1053713	53.5	7,605	6/6/01	8.57
373358105371301	373358	1053713	53.5	7,605	6/28/01	8.83
373424105445202	373424	1054452	45.5	7,521	6/12/97	8.66
373424105445202	373424	1054452	45.5	7,521	6/8/98	8.6
373424105445202	373424	1054452	45.5	7,521	6/7/99	8.47
373424105445202	373424	1054452	45.5	7,521	6/6/00	8.48
373424105445202	373424	1054452	45.5	7,521	6/4/01	8.45
373428106073401	373428	1060734	30.5	7,648	6/5/97	5.69
373428106073401	373428	1060734	30.5	7,648	6/2/98	5.71
373428106073401	373428	1060734	30.5	7,648	6/10/99	5.16
373428106073401	373428	1060734	30.5	7,648	6/6/00	4.3
373428106073401	373428	1060734	30.5	7,648	6/4/01	4.38
373429105554001	373429	1055540	25	7,568	6/4/97	14.37
373429105554001	373429	1055540	25	7,568	6/8/98	11.22
373429105554001	373429	1055540	25	7,568	6/7/99	12.05
373429105554001	373429	1055540	25	7,568	6/6/00	10.45
373429105554001	373429	1055540	25	7,568	6/4/01	9.23
373433105513201	373433	1055132	30	7,547	6/12/97	4.82
373433105513201	373433	1055132	30	7,547	6/8/98	4.96
373433105513201	373433	1055132	30	7,547	6/7/99	4.76
373433105513201	373433	1055132	30	7,547	6/1/00	4.01
373433105513201	373433	1055132	30	7,547	6/4/01	4.54
373438106022101	373438	1060221	27	7,596	6/4/97	1.64
373438106022101	373438	1060221	27	7,596	6/2/98	2.8
373438106022101	373438	1060221	27	7,596	6/10/99	2.05
373438106022101	373438	1060221	27	7,596	6/8/00	4.94
373438106022101	373438	1060221	27	7,596	6/4/01	2.65
373704105593401	373704	1055934	32.5	7,590	6/4/97	8.46
373704105593401	373704	1055934	32.5	7,590	6/8/98	6.54
373704105593401	373704	1055934	32.5	7,590	6/7/99	3.71

Table 5. Depth to the water table during June 1997–2001.—Continued

[USGS, U.S. Geological Survey; ID, identifier; ddmmss, degrees minutes seconds; NGVD29, National Geodetic Vertical Datum of 1929]

USGS site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Well depth (feet below land surface)	Altitude of land surface (feet above NGVD 29)	Date of water-level measurement	Depth to water table (feet below land surface)
373704105593401	373704	1055934	32.5	7,590	6/6/00	3.78
373704105593401	373704	1055934	32.5	7,590	6/5/01	5.73
373705106051701	373705	1060517	30	7,633	6/5/97	4.29
373705106051701	373705	1060517	30	7,633	6/9/98	4.26
373705106051701	373705	1060517	30	7,633	6/7/99	3.62
373705106051701	373705	1060517	30	7,633	6/6/00	3.51
373705106051701	373705	1060517	30	7,633	6/5/01	4.05
373754105575201	373754	1055752	19.7	7,582	6/10/98	9.06
373754105575201	373754	1055752	19.7	7,582	6/19/00	8.83
373849106074301	373849	1060743	24.8	7,663	6/10/98	11.72
373849106074301	373849	1060743	24.8	7,663	6/19/00	10.35
373916106021701	373916	1060217	19.7	7,613	6/10/98	6.57
373916106021701	373916	1060217	19.7	7,613	6/19/00	5.22
373924106082501	373924	1060825	37	7,680	6/5/97	19.21
373924106082501	373924	1060825	37	7,680	6/2/98	18.06
373924106082501	373924	1060825	37	7,680	6/10/99	17.02
373924106082501	373924	1060825	37	7,680	6/8/00	16.18
373924106082501	373924	1060825	37	7,680	6/11/01	22.39
373944105553701	373944	1055537	28	7,568	6/12/97	11.15
373944105553701	373944	1055537	28	7,568	6/3/98	10.99
373944105553701	373944	1055537	28	7,568	6/8/99	10.26
373944105553701	373944	1055537	28	7,568	6/5/00	10
373944105553701	373944	1055537	28	7,568	6/6/01	9.79
373944105553701	373944	1055537	28	7,568	6/28/01	10.5
373944106022001	373944	1060220	28	7,612	6/4/97	5.79
373944106022001	373944	1060220	28	7,612	6/2/98	4.72
373944106022001	373944	1060220	28	7,612	6/10/99	4.39
373944106022001	373944	1060220	28	7,612	6/8/00	4.48
373944106022001	373944	1060220	28	7,612	6/11/01	5.03
373947105490701	373947	1054907	27	7,540	6/4/97	2.72
373947105490701	373947	1054907	27	7,540	6/3/98	2.63
373947105490701	373947	1054907	27	7,540	6/8/99	2.6
373947105490701	373947	1054907	27	7,540	6/5/00	2.18
373947105490701	373947	1054907	27	7,540	6/6/01	2.39
373947105490701	373947	1054907	27	7,540	6/28/01	4.07
374012105410401	374012	1054104	30	7,535	6/4/97	4.57
374012105410401	374012	1054104	30	7,535	6/3/98	4.73
374012105410401	374012	1054104	30	7,535	6/8/99	3.84
374012105410401	374012	1054104	30	7,535	6/5/00	4.75
374012105410401	374012	1054104	30	7,535	6/6/01	4.72
374012105410401	374012	1054104	30	7,535	6/28/01	4.83
374033105582801	374033	1055828	24.8	7,587	6/10/98	16.26
374033105582801	374033	1055828	24.8	7,587	6/19/00	14.98

Table 5. Depth to the water table during June 1997–2001.—Continued

[USGS, U.S. Geological Survey; ID, identifier; ddmmss, degrees minutes seconds; NGVD29, National Geodetic Vertical Datum of 1929]

USGS site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Well depth (feet below land surface)	Altitude of land surface (feet above NGVD 29)	Date of water-level measurement	Depth to water table (feet below land surface)
374046106163801	374046	1061638	48	7,807	6/5/97	14.4
374046106163801	374046	1061638	48	7,807	6/2/98	18.31
374046106163801	374046	1061638	48	7,807	6/10/99	14.33
374046106163801	374046	1061638	48	7,807	6/8/00	21.4
374046106163801	374046	1061638	48	7,807	6/11/01	17.66
374101106035601	374101	1060356	19.36	7,625	6/10/98	7.95
374101106035601	374101	1060356	19.36	7,625	6/19/00	6.03
374210106053001	374210	1060530	100	7,640	6/5/97	10.19
374210106053001	374210	1060530	100	7,640	6/9/98	8.4
374210106053001	374210	1060530	100	7,640	6/7/99	6.5
374210106053001	374210	1060530	100	7,640	6/6/00	5.72
374210106053001	374210	1060530	100	7,640	6/5/01	6.09
374217106082501	374217	1060825	24.75	7,671	6/10/98	13.71
374217106082501	374217	1060825	24.75	7,671	6/19/00	10.56
374220105585801	374220	1055858	29.2	7,585	6/5/97	13.46
374220105585801	374220	1055858	29.2	7,585	6/8/98	13.28
374220105585801	374220	1055858	29.2	7,585	6/7/99	13.7
374220105585801	374220	1055858	29.2	7,585	6/6/00	11.54
374220105585801	374220	1055858	29.2	7,585	6/5/01	14.73
374223105511401	374223	1055114	19.8	7,548	6/10/98	8.59
374223105511401	374223	1055114	19.8	7,548	6/19/00	8.56
374225105533101	374225	1055331	20	7,557	6/10/98	14.54
374225105533101	374225	1055331	20	7,557	6/19/00	11.87
374310106032401	374310	1060324	14.9	7,617	6/10/98	3.72
374310106032401	374310	1060324	14.9	7,617	6/19/00	3.3
374359106085501	374359	1060855	24.2	7,670	6/10/98	12.38
374359106085501	374359	1060855	24.2	7,670	6/19/00	12.29
374423106042801	374423	1060428	15.89	7,624	6/10/98	7.58
374423106042801	374423	1060428	15.89	7,624	6/19/00	6.22
374431106000701	374431	1060007	17	7,587	6/10/98	6.11
374431106000701	374431	1060007	17	7,587	6/19/00	5.85
374446106022001	374446	1060220	25	7,604	6/5/97	4.47
374446106022001	374446	1060220	25	7,604	6/2/98	3.46
374446106022001	374446	1060220	25	7,604	6/10/99	5.5
374446106022001	374446	1060220	25	7,604	6/8/00	3.43
374446106022001	374446	1060220	25	7,604	6/11/01	5.49
374454106145801	374454	1061458	136	7,751	6/5/97	38.53
374455106085501	374455	1060855	73	7,668	6/5/97	10.8
374455106085501	374455	1060855	73	7,668	6/2/98	10.66
374455106085501	374455	1060855	73	7,668	6/10/99	12.04
374455106085501	374455	1060855	73	7,668	6/8/00	8.85
374455106085501	374455	1060855	73	7,668	6/11/01	9.94
374505105554001	374505	1055540	53	7,571	6/3/97	18.02

Table 5. Depth to the water table during June 1997–2001.—Continued

[USGS, U.S. Geological Survey; ID, identifier; ddmmss, degrees minutes seconds; NGVD29, National Geodetic Vertical Datum of 1929]

USGS site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Well depth (feet below land surface)	Altitude of land surface (feet above NGVD 29)	Date of water-level measurement	Depth to water table (feet below land surface)
374505105554001	374505	1055540	53	7,571	6/3/98	15.52
374505105554001	374505	1055540	53	7,571	6/5/00	16.08
374505105554001	374505	1055540	53	7,571	6/6/01	18.32
374505105554001	374505	1055540	53	7,571	6/28/01	17.4
374614106000701	374614	1060007	18.37	7,584	6/10/98	5.13
374614106000701	374614	1060007	18.37	7,584	6/19/00	5.88
374704105590002	374704	1055900	32	7,574	6/3/97	9.21
374704105590002	374704	1055900	32	7,574	6/8/98	9.1
374704105590002	374704	1055900	32	7,574	6/7/99	10.67
374704105590002	374704	1055900	32	7,574	6/6/00	10.17
374704105590002	374704	1055900	32	7,574	6/5/01	10.06
374734105533001	374734	1055330	22.8	7,546	6/10/98	12.51
374734105533001	374734	1055330	22.8	7,546	6/19/00	13.4
374736106053404	374736	1060534	30.3	7,617	6/3/97	7.9
374736106053404	374736	1060534	30.3	7,617	6/8/98	6.39
374736106053404	374736	1060534	30.3	7,617	6/7/99	8.07
374736106053404	374736	1060534	30.3	7,617	6/6/00	6.83
374736106053404	374736	1060534	30.3	7,617	6/5/01	9.2
374757106085301	374757	1060853	17.6	7,643	6/10/98	6.1
374757106085301	374757	1060853	17.6	7,643	6/19/00	4.92
374825106021301	374825	1060213	19.7	7,587	6/10/98	8.14
374825106021301	374825	1060213	19.7	7,587	6/19/00	9.39
375005106092501	375005	1060925	30	7,633	6/11/97	0.92
375005106092501	375005	1060925	30	7,633	6/2/98	2.34
375005106092501	375005	1060925	30	7,633	6/10/99	0.66
375005106092501	375005	1060925	30	7,633	6/8/00	3.3
375005106092501	375005	1060925	30	7,633	6/11/01	1.7
375009105503001	375009	1055030	34.3	7,530	6/3/97	11.89
375009105503001	375009	1055030	34.3	7,530	6/3/98	13.6
375009105503001	375009	1055030	34.3	7,530	6/8/99	14.14
375009105503001	375009	1055030	34.3	7,530	6/1/00	13.65
375009105503001	375009	1055030	34.3	7,530	6/6/01	13.8
375009105503001	375009	1055030	34.3	7,530	6/28/01	3.7
375010105554302	375010	1055543	56	7,549	6/3/97	24.78
375010105554302	375010	1055543	56	7,549	6/3/98	25.72
375010105554302	375010	1055543	56	7,549	6/8/99	27.13
375010105554302	375010	1055543	56	7,549	6/5/00	26.7
375010105554302	375010	1055543	56	7,549	6/6/01	29.09
375010105554302	375010	1055543	56	7,549	6/28/01	30.39
375016106021201	375016	1060212	27	7,578	6/11/97	5.02
375016106021201	375016	1060212	27	7,578	6/2/98	5.85
375016106021201	375016	1060212	27	7,578	6/10/99	4.92
375016106021201	375016	1060212	27	7,578	6/8/00	5.79

Table 5. Depth to the water table during June 1997–2001.—Continued

[USGS, U.S. Geological Survey; ID, identifier; ddmmss, degrees minutes seconds; NGVD29, National Geodetic Vertical Datum of 1929]

USGS site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Well depth (feet below land surface)	Altitude of land surface (feet above NGVD 29)	Date of water-level measurement	Depth to water table (feet below land surface)
375016106021201	375016	1060212	27	7,578	6/11/01	6.71
375324105553301	375324	1055533	57	7,539	6/3/97	14.08
375324105553301	375324	1055533	57	7,539	6/3/98	13.27
375324105553301	375324	1055533	57	7,539	6/8/99	14.38
375324105553301	375324	1055533	57	7,539	6/5/00	12.43
375324105553301	375324	1055533	57	7,539	6/6/01	12.13
375324105553301	375324	1055533	57	7,539	6/28/01	12.48
375520106081201	375520	1060812	40	7,590	6/11/97	2.14
375520106081201	375520	1060812	40	7,590	6/2/98	2.39
375520106081201	375520	1060812	40	7,590	6/10/99	2.1
375520106081201	375520	1060812	40	7,590	6/8/00	2.37
375520106081201	375520	1060812	40	7,590	6/11/01	2.16
375524106020501	375524	1060205	30	7,559	6/11/97	6.29
375524106020501	375524	1060205	30	7,559	6/2/98	6.33
375524106020501	375524	1060205	30	7,559	6/10/99	6.07
375524106020501	375524	1060205	30	7,559	6/8/00	6.53
375524106020501	375524	1060205	30	7,559	6/11/01	6.54
375745105553001	375745	1055530	25	7,552	6/3/97	8.18
375745105553001	375745	1055530	25	7,552	6/3/98	7.32
375745105553001	375745	1055530	25	7,552	6/8/99	8.72
375745105553001	375745	1055530	25	7,552	6/5/00	7.5
375745105553001	375745	1055530	25	7,552	6/6/01	8.29
375745105553001	375745	1055530	25	7,552	6/28/01	8.73
375938106015901	375938	1060159	27	7,581	6/11/97	4.42
375938106015901	375938	1060159	27	7,581	6/2/98	4.33
375938106015901	375938	1060159	27	7,581	6/10/99	4.43
375938106015901	375938	1060159	27	7,581	6/8/00	4.29
375938106015901	375938	1060159	27	7,581	6/11/01	4.46
380023105551901	380023	1055519	35	7,565	6/16/97	4.06
380023105551901	380023	1055519	35	7,565	6/3/98	3.7
380023105551901	380023	1055519	35	7,565	6/8/99	4.2
380023105551901	380023	1055519	35	7,565	6/5/00	4.45
380023105551901	380023	1055519	35	7,565	6/6/01	4.33
380023105551901	380023	1055519	35	7,565	6/28/01	4.8
380128105484401	380128	1054844	27	7,612	6/18/97	3.6
380128105484401	380128	1054844	27	7,612	6/3/98	3.3
380128105484401	380128	1054844	27	7,612	6/8/99	3.29
380128105484401	380128	1054844	27	7,612	6/5/00	3.5
380128105484401	380128	1054844	27	7,612	6/6/01	3.46
380128105484401	380128	1054844	27	7,612	6/28/01	3.87
380421106033001	380421	1060330	63.3	7,625	6/16/97	4.57
380421106033001	380421	1060330	63.3	7,625	6/2/98	3.08
380421106033001	380421	1060330	63.3	7,625	6/10/99	3.73

Table 5. Depth to the water table during June 1997–2001.—Continued

[USGS, U.S. Geological Survey; ID, identifier; ddmmss, degrees minutes seconds; NGVD29, National Geodetic Vertical Datum of 1929]

USGS site ID	Latitude (in ddmmss)	Longitude (in ddmmss)	Well depth (feet below land surface)	Altitude of land surface (feet above NGVD 29)	Date of water-level measurement	Depth to water table (feet below land surface)
380421106033001	380421	1060330	63.3	7,625	6/8/00	5.03
380421106033001	380421	1060330	63.3	7,625	6/11/01	4.17
380512106004901	380512	1060049	86	7,628	6/16/97	23.09
380512106004901	380512	1060049	86	7,628	6/2/98	22.96
380512106004901	380512	1060049	86	7,628	6/10/99	22.84
380512106004901	380512	1060049	86	7,628	6/8/00	22.73
380512106004901	380512	1060049	86	7,628	6/11/01	23.52
380601105505201	380601	1055052	52	7,670	6/18/97	19.14
380601105505201	380601	1055052	52	7,670	6/3/98	18.76
380601105505201	380601	1055052	52	7,670	6/8/99	20.59
380601105505201	380601	1055052	52	7,670	6/5/00	20.24
380601105505201	380601	1055052	52	7,670	6/6/01	22.22
380601105505201	380601	1055052	52	7,670	6/28/01	22.28
380602105551501	380602	1055515	27	7,629	6/16/97	11.69
380602105551501	380602	1055515	27	7,629	6/3/98	11
380602105551501	380602	1055515	27	7,629	6/8/99	12.19
380602105551501	380602	1055515	27	7,629	6/5/00	12.36
381742105571801	381742	1055718	99	7,980	6/3/98	2.39
381742105571801	381742	1055718	99	7,980	6/8/99	2.5
381742105571801	381742	1055718	99	7,980	6/1/00	4.37
381742105571801	381742	1055718	99	7,980	6/6/01	2.53
381742105571801	381742	1055718	99	7,980	6/28/01	4.29