SUMMARY OF GROUND-WATER DATA AND EVALUATION OF GROUND-WATER MONITORING NETWORKS FOR EASTERN MERCED COUNTY, CALIFORNIA

By Scott N. Hamlin

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Conversion Factors

Multiply	By	To obtain
acre	0.4047	square hectometer
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year
foot (ft)	0.3048	meter
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Vertical Datum

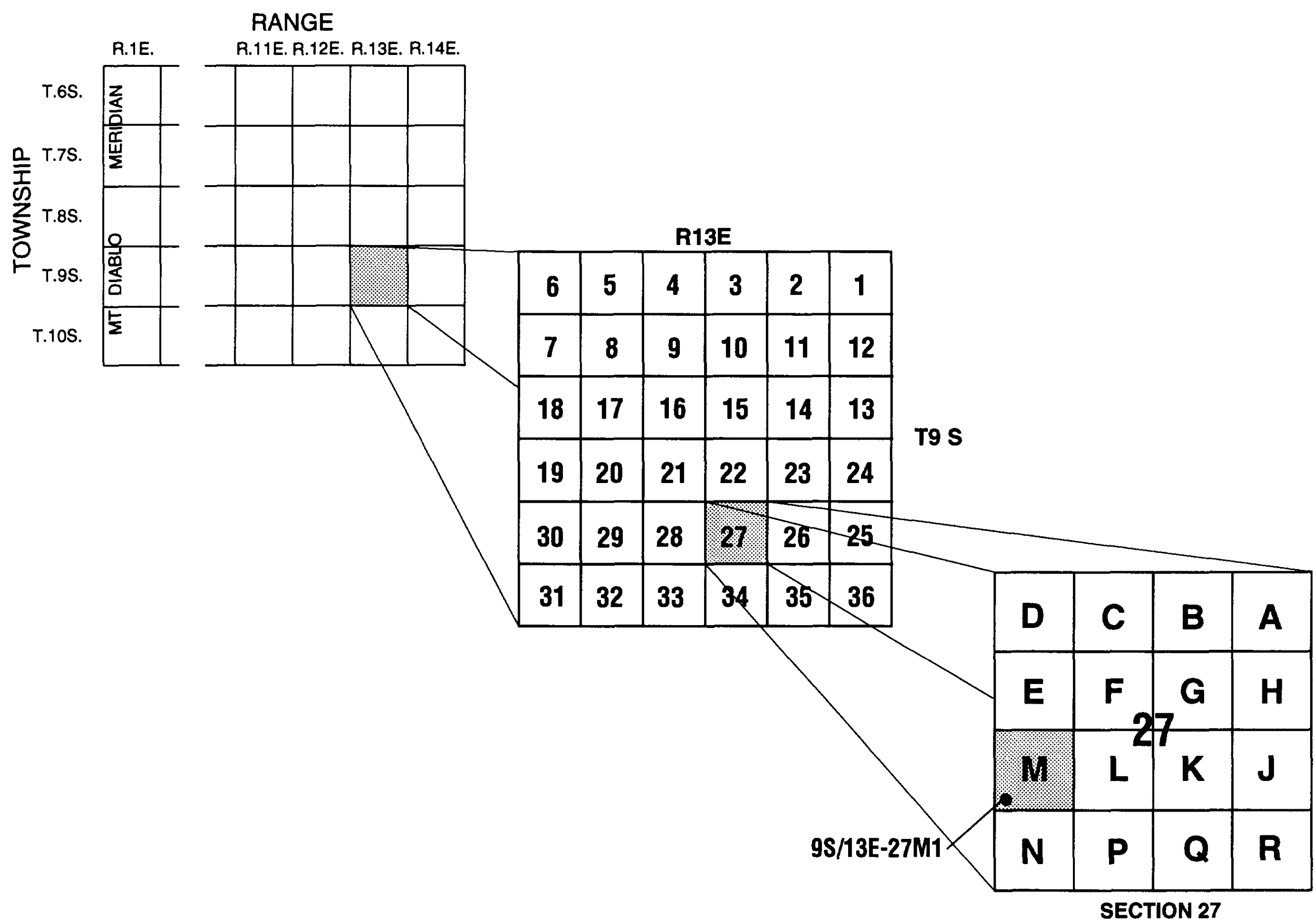
Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Water-Quality Information

Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams and micrograms per liter are units expressing the weight of the solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. Micrograms per liter is equivalent to "parts per billion."

Well-Numbering System

Wells are numbered according to their location in the rectangular system for subdivision of public land. For example, in well number 009S013E27M01M, the identification number consists of the township number, north or south; the range number, east or west; and the section number. Each section is further divided into sixteen 40-acre tracts lettered consecutively (except I and O), beginning with A in the northeast corner of the section and progressing in a sinusoidal manner to R in the southeast corner. Within each 40-acre tract, wells are sequentially numbered in the order that they are inventoried. The final letter refers to the base line and meridian. In California, there are three base lines and meridians; Humboldt (H), Mount Diablo (M), and San Bernardino (S). Because all wells in the study area are referenced to the Mount Diablo base line and meridian (M), the final letter will be omitted. Commonly, and in this report, well numbers are abbreviated and written 9S/13E-27M1. Wells in the same township and range may be referred to only by their section designation, 27M1.



SUMMARY OF GROUND-WATER DATA AND EVALUATION OF GROUND-WATER MONITORING NETWORKS FOR EASTERN MERCED COUNTY, CALIFORNIA

By Scott N. Hamlin

Abstract

The city of Merced relies exclusively on ground water for its water supply. Development near Merced has increased demand for water while introducing factors that may reduce the quantity of available potable water. These factors include irrigation-return flow and infiltration of sewage, which introduce nitrate to ground water.

Potable ground water in the Merced area generally occurs to a depth of about 1,200 feet. Regional flow is to the southwest with pumping depressions near Turlock, Atwater, and El Nido. The current drought and ground-water pumping combined to produce water-level declines of 10 to 20 feet between 1982 and 1990.

The quality of water from 135 wells was evaluated. Of the sampled constituents, only nitrate-nitrogen exceeded the U.S. Environmental Protection Agency's (EPA) maximum contaminant level (12 wells). In addition, water from several wells exceeded the U.S. Environmental Protection Agency's secondary maximum contaminant levels for chloride (two wells), iron (seven wells), and manganese (six wells).

The networks used to monitor ground-water levels and water quality were revised on the basis of an evaluation of available data. The water-level network consists of 53 irrigation wells that are screened in the primary production zone. These wells will be used to monitor changes in water levels caused by climatic variations and pumping. The water-quality network consists of 24 domestic wells equipped with submersible pumps. These wells will be used to evaluate spatial and temporal changes in water quality.

INTRODUCTION

The city of Merced (fig. 1) derives its water supply solely from ground water. Continuing development in the area has increased the demand on this resource and has introduced factors, such as irrigation-return flow and infiltration of sewage, that may reduce the quantity of potable ground water. To gain a better understanding of the local ground-water system, the U.S. Geological Survey began a cooperative study with the city of Merced in 1975. As part of the study, wells have been monitored to detect any adverse changes in water levels and water quality. Preliminary findings of the study were presented in a report by Page (1977). The area of this preliminary study is contained within the current study area shown in figure 1. Page (1977) presented baseline information necessary for long-term management of the water supply for the city of Merced. Collection of data that describe the occurrence and quality of ground water in the Merced area has continued to the present (1992). Elliott (1984) described ground-water conditions in the eastern half of Merced County for 1977-82. D.H. Wilson (U.S. Geological Survey, written commun., 1991) defined the water table in the northeastern part of the county where water-level data are sparse.

PURPOSE AND SCOPE

The primary objectives of this report are to summarize ground-water data collected as part of the cooperative program in eastern Merced County (fig.

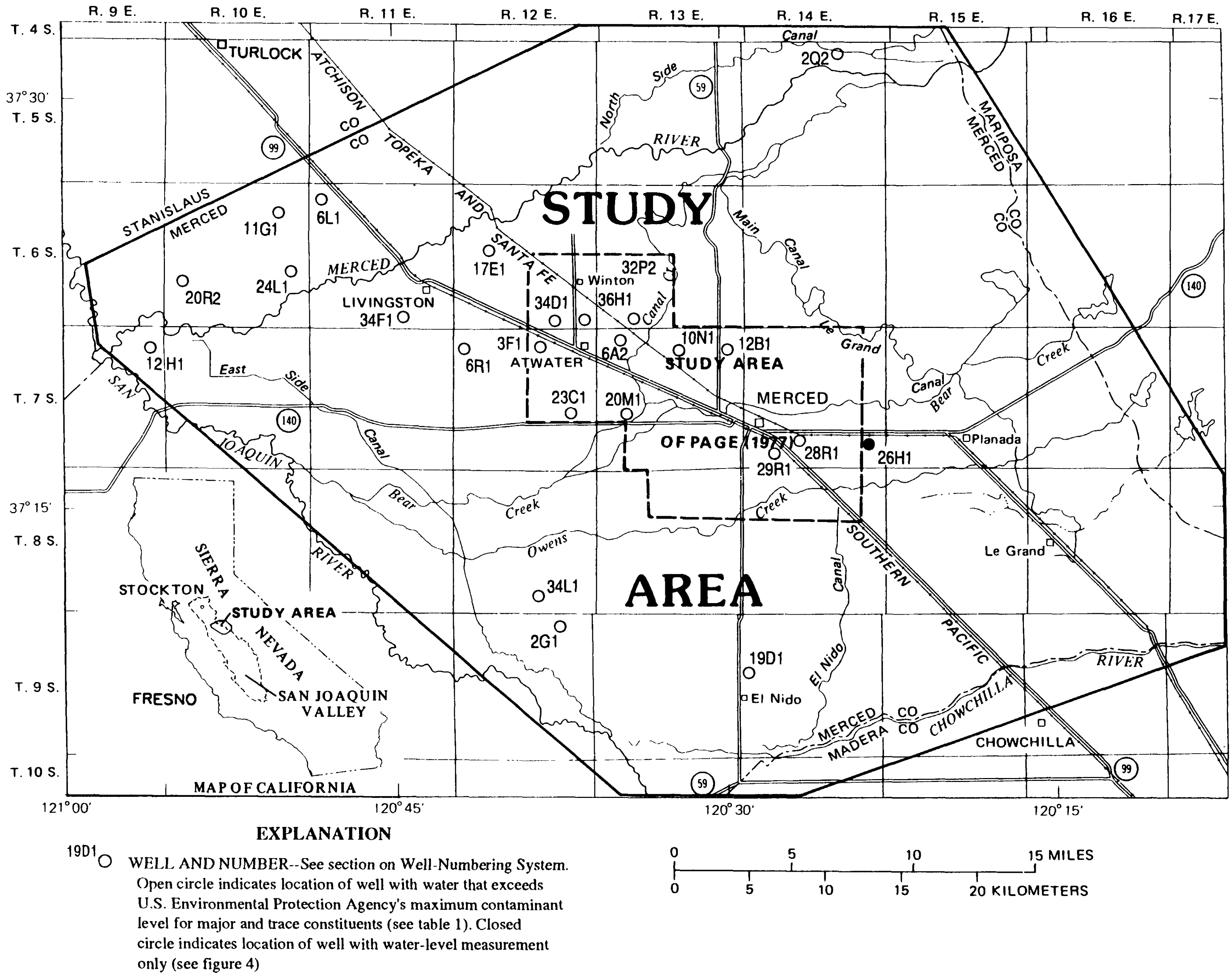


Figure 1. Location of past (1977) and current study areas and selected wells.

1), to evaluate the previous monitoring well network, and to describe revised networks that can be used to monitor the effects of increased development and ground-water pumping in the area. The purposes of the networks are to document variations in water levels and to detect any changes in the distribution and quality of ground water that would affect the development and use of this resource.

All ground-water data collected from 1975 to 1991, as part of the cooperative study with the city of Merced, were evaluated. Water-level and quality data were available for 135 wells. Additionally, data from about 1,400 wells were reviewed to determine suitability of individual wells for monitoring purposes based on location, availability of construction data, pump type, use of well, and depth of perforated interval. Ground-water and surface-water quality data are described using graphical methods that classify water types and indicate flow relations. Trends in water-level data were evaluated in the context of ground-water pumpage and rainfall distribution.

PHYSICAL SETTING

Eastern Merced County comprises about 1,129 mi^2 in the northeastern part of the San Joaquin Valley (fig. 1). The Merced area lies mostly within the "Great Valley of California" defined by Jenkins (1943). Alluvial plains and fans are the dominant geomorphic features.

Primary land-use activities in the area are agriculture and residential development. Because agriculture is a primary business in the area, a number of food packaging and processing plants are in the city of Merced.

The average annual rainfall measured at the city of Merced is 12.6 in. (Page, 1977), and most rain falls between October and May. Rainfall can vary greatly from year to year in the area. This variability has a significant effect on streamflow and the quantity of available surface water (Davis and others, 1959).

DESCRIPTION OF THE GROUND-WATER SYSTEM

The aquifer system in the Merced area is composed of unconsolidated sediments (Page, 1977, and Elliott, 1984). Ground water primarily is in the Mehrten Formation of Tertiary age, a confined aquifer, an intermediate aquifer, and a shallow aquifer (fig. 2).

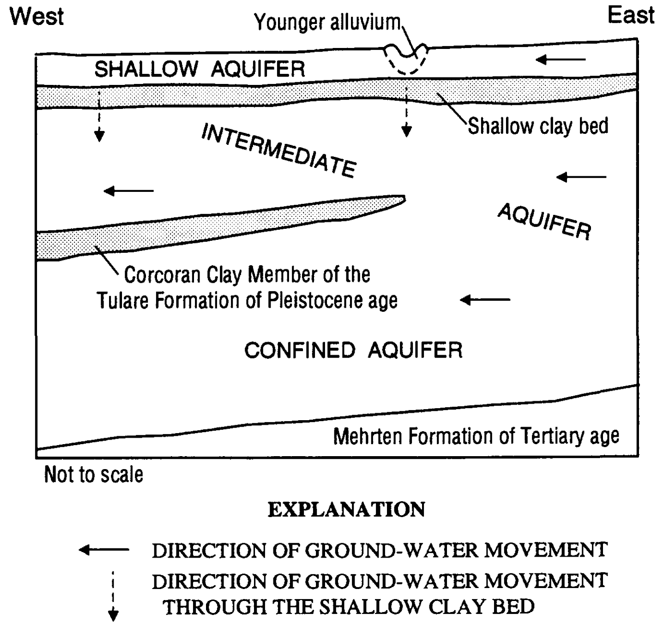


Figure 2. Diagrammatic section across the central part of the Merced area showing occurrence and movement of ground water (from Page, 1977).

The Mehrten Formation is 200 to 500 ft below land surface in the Merced area and probably is more than 700 ft thick (Page and Balding, 1973). Most wells that tap it are in the eastern part of the area. Because the base of the Mehrten Formation is poorly defined, the saturated thickness of fresh water in this unit is not accurately known. However, southwest of the city of Merced, the saturated thickness of fresh water in the Mehrten Formation is at least 600 ft (Page and Balding, 1973). The confined aquifer is in deposits that underlie the Corcoran Clay Member of the Tulare Formation of Pleistocene age (fig. 2). The confined aquifer directly overlies the Mehrten Formation. In the Merced area, fresh water probably occupies the entire thickness of the confined aquifer (Page, 1977). The intermediate aquifer is in deposits that underlie the shallow clay bed and overlie or are east of the Corcoran Clay Member. In the eastern part of the area, where the Corcoran Clay Member is absent, the intermediate aquifer extends to the Mehrten Formation. Most wells tapping the intermediate aquifer are in the eastern area. Available data indicate fresh water between 10 and 305 ft (Page, 1977). The shallow aquifer is in deposits that overlie the shallow clay bed. The saturated thickness of this aquifer ranges from less than 10 to 35 ft. Fresh water in the shallow aquifer ranges from 0 to 35 ft.

SUMMARY OF GROUND-WATER DATA

WATER LEVELS

Elliott (1984) prepared potentiometric contour maps for the major aquifers in the Merced area. The contour map of the water table in the intermediate aquifer for winter 1982 shows the general flow direction from northeast to southwest (fig. 3). Superimposed on this regional gradient are pumping depressions near Turlock, Atwater, and El Nido. Water-level data for winter 1990 indicate the same general configuration of the water table, although insufficient data were available to produce a complete contour map of the area. The best data coverage is near the city of Merced, where water levels for 1990 are 10 to 20 ft lower than in 1982. Many wells in the area show declines in water levels related to current drought conditions--less recharge as a result of below-average rainfall and increased pumping. The effects of the 1976-77 drought and the current drought are shown by the water-level hydrograph for 7S/14E-26H1 (fig. 4). This Merced Irrigation District well is about 5 mi southeast of the city of Merced (fig. 1). Pumping for irrigation produces seasonal variations in water levels. Minimum water levels correspond to the irrigation season, particularly in the summer and autumn. The annual data show the lowest water levels during periods of drought and highest water levels during the intervening periods of average rainfall.

PUMPAGE

Most ground water pumped from the Merced area is used for irrigation, with smaller quantities used for domestic and industrial purposes. The Merced Irrigation District is the largest user of ground water in the area. Other irrigation districts that pump ground water include those in Turlock, El Nido, and Chowchilla. The city of Merced also pumps ground water for potable use. During 1973-80, the city of Merced pumped about 15 to 30 percent of the amount of ground water used for irrigation, exclusive of the drought years 1976 and 1977 (Elliott, 1984). During that drought, pumping for irrigation increased substantially and pumping by the city of Merced for municipal supply remained relatively constant. This observation illustrates the importance of surface-water use in an evaluation of the ground-water budget. The Merced Irrigation District normally derives more than 80 percent of its water supply from the Merced River. During periods of decreased surface-water availability, such as the current drought, the deficit is balanced with increased ground-water pumpage. The correlation between total ground-water pumpage (irrigation and municipal) and rainfall is shown in figure 5. The highest annual pumpage values (almost 200,000 acre-ft/yr) were associated with the lowest annual rainfall (less than 10 in.) during the drought years of 1976 and 1977.

WATER QUALITY

SAMPLE COLLECTION AND ANALYSIS

Ground-water samples currently are collected from irrigation and domestic wells. The samples generally are obtained from a petcock at the well head or from a discharge pipe. Prior to sample collection, wells were purged of stagnant water in the casing as determined by stabilization of electrical conduction and pH of the discharged water. Treatment and preservation of the water samples followed procedures outlined by Wood (1976). Temperature, pH, specific conductance, and alkalinity were measured in the field according to techniques described by Marc Sylvester (U.S. Geological Survey, written commun., 1990). Samples for organic analyses were collected in glass bottles to prevent contamination from the sample container.

Major ions, trace elements, and organic compounds currently are determined in samples of ground water. The major ions include calcium, magnesium, sodium, potassium, sulfate, chloride, fluoride, silica, nitrogen species, and orthophosphate. The trace elements consist of aluminum, arsenic, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, strontium, vanadium, and zinc. The organic compounds, chiefly pesticides, include aldrin, chlordane, dibromochloropropane (DBCP), 1,1-dichloro-2,2-bis (4-chlorophenyl) ethane (DDD), 1,1-dichloro-2,2-bis (4-chlorophenyl) ethylene (DDE), 1,1,1-trichloro-2,2-bis (4-chlorophenyl) ethane (DDT), S,S,S,-tributylphosphorotrithioate (DEF), diazinon, dieldrin, disulfoton, ethylenedibromide (EDB), endosulfan, endrin, ethion, ethyl-trithion, heptachlor, heptachlorepoxide, lindane, malathion, methoxychlor, methyl parathion, methyl trithion, mirex, parathion, polychlorinated biphenyls (PCB), polychlorinated napthalenes (PCN), perthane, phorate, and toxaphene.

WATER TYPES

The proportion of major ions in ground water in eastern Merced County is similar to that of water from the Merced River, indicating interflow between

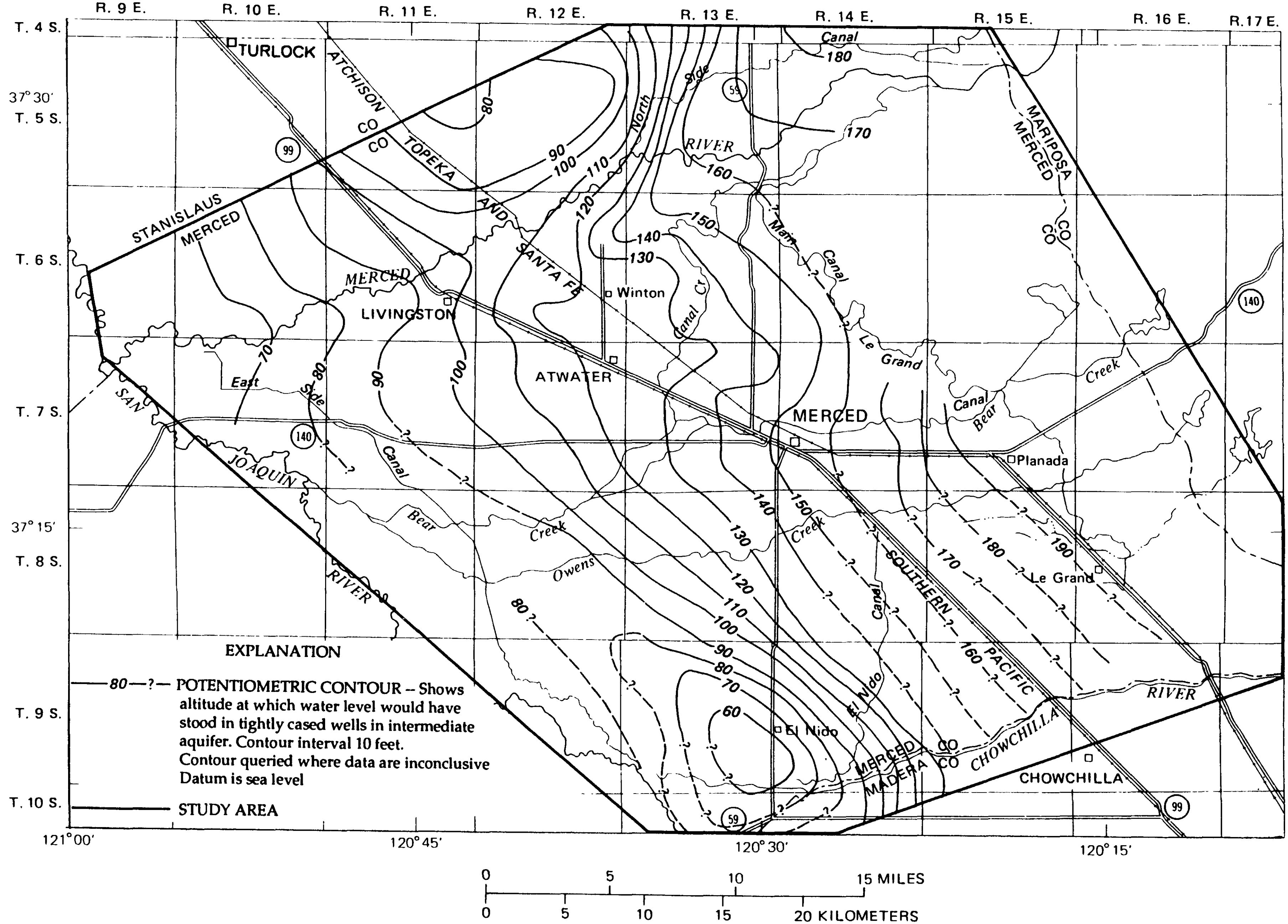


Figure 3. Altitude of potentiometric surface in the intermediate aquifer, January and February 1982 (from Elliott, 1984).

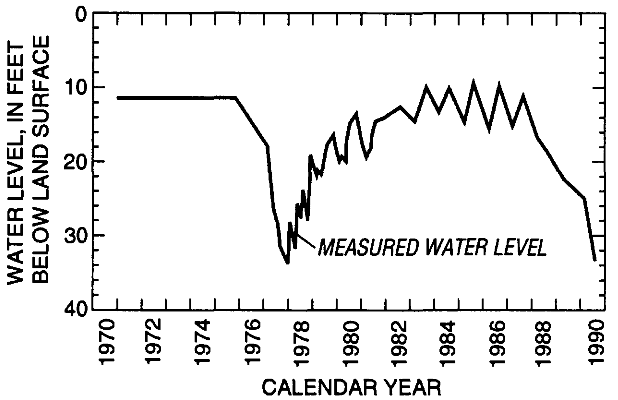


Figure 4. Water-level response to seasonal variations in pumping and droughts in well 7S/14E-26H1 between 1970 and 1990.

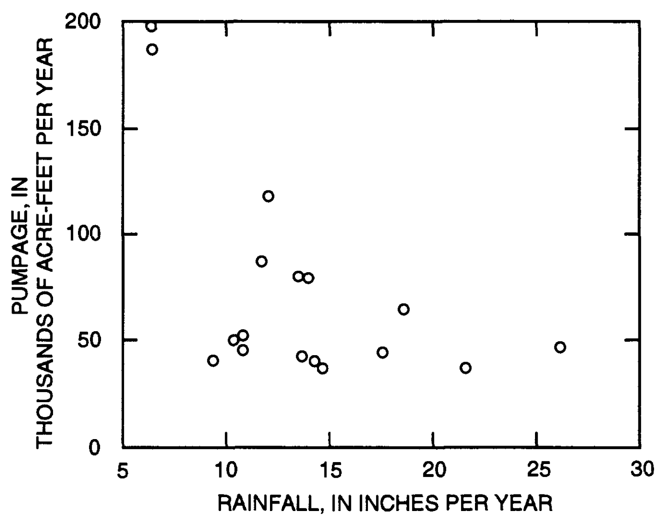


Figure 5. Relation between annual ground-water pumpage and rainfall, 1973-89. Pumpage values are the sums of municipal and irrigation production figures.

ground water and surface water. This relation can be seen by comparing trilinear diagrams showing compositions of samples of Merced River water and local ground water (figs. 6*A* and 6*B*). These trilinear diagrams show the chemical composition of a water sample independent of the concentration of dissolved constituents. Mixing different water types without chemical reaction will produce intermediate compositions. Both diagrams show that most samples fall within the field of similar proportions of major cations (calcium, magnesium, and sodium plus potassium). Most anion compositions fall within the bicarbonate field. Therefore, both surface water and ground water are classified as mixed cation, bicarbonate types.

Most wells in the Merced area yield water that meets the drinking water standards recommended by the U.S. Environmental Protection Agency (1986) for the constituents determined. Ground water to a depth of about 1,200 ft is potable (Page, 1977). Ground water at depths greater than 1,200 ft probably is nonpotable and is characterized as a sodium-chloride-type water (Page and Balding, 1973). Most wells in the Merced area are shallower than 1,200 ft.

PRIMARY MAXIMUM CONTAMINANT LEVELS

The U.S. Environmental Protection Agency has established primary maximum contaminant levels (MCL's) for chemical constituents in drinking water. Primary MCL's were developed for constituents that are potentially harmful to human health. The only constituent that exceeded a primary MCL was nitrate-nitrogen. Samples from 12 wells in the Merced area exceeded the 10 mg/L MCL for nitrate-nitrogen (table 1). Nitrate-nitrogen concentrations greater than 10 mg/L may cause methemoglobinemia (blue-baby disease) when consumed by infants.

SOURCES OF NITRATE

According to Schmidt (1972), natural concentrations of nitrate are low in most ground water in the eastern part of the San Joaquin Valley. Elevated concentrations of nitrate in ground water commonly are associated with leachate from septic-tank systems, percolation from sewage-effluent ponds, discharge of industrial waste waters, and irrigation-return flow containing fertilizers. Predominant sources of nitrate in the Merced area probably are sewage and fertilizers. In addition to the risk of methemoglobinemia in infants previously mentioned, nitrate from sewage may be associated with the presence of pathogenic bacteria.

The distribution of nitrate derived from anthropogenic activities is related to depth. High concentrations of nitrate tend to be in shallow ground water near the nitrate source. The highest concentrations of nitrate in the Merced area generally are in wells less than 300 ft deep (fig. 7). Schmidt (1972) found that nitrate was stratified in the aquifer beneath unsewered metropolitan areas with highest concentrations present in the upper 50 to 60 ft. In areas served by septic tanks, an inverse relation was observed between nitrate concentration and permeability of the aquifer. Hardpan layers acted as barriers to downward movement of shallow, high-nitrate water. Water from the

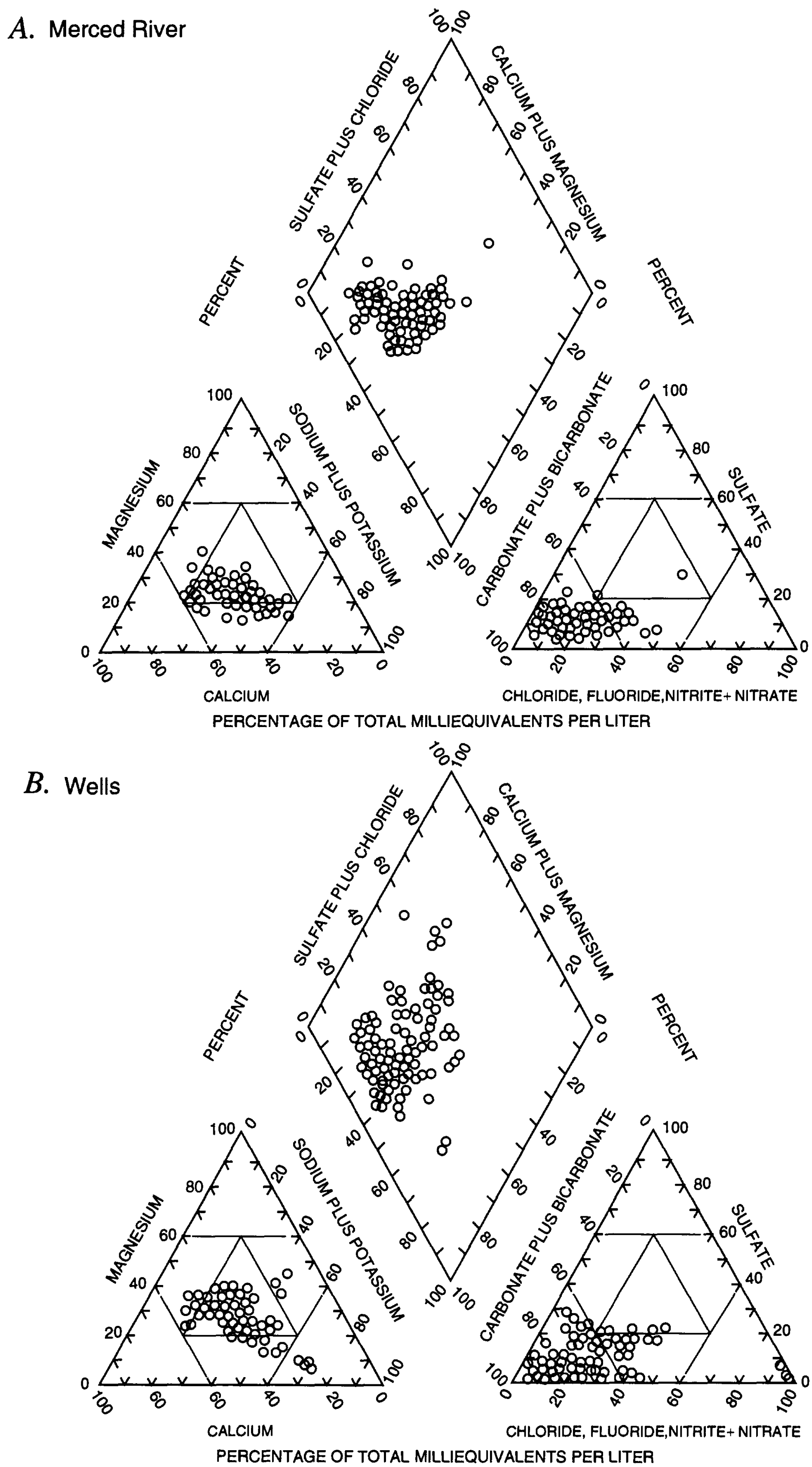


Figure 6. Chemical composition of water samples from the Merced River and from wells in eastern Merced County.

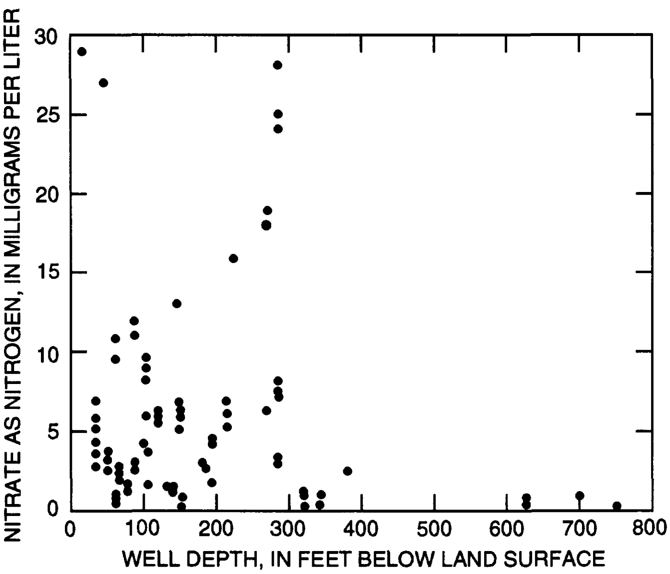


Figure 7. Variation of nitrate-nitrogen in ground water with well depth in the Merced area.

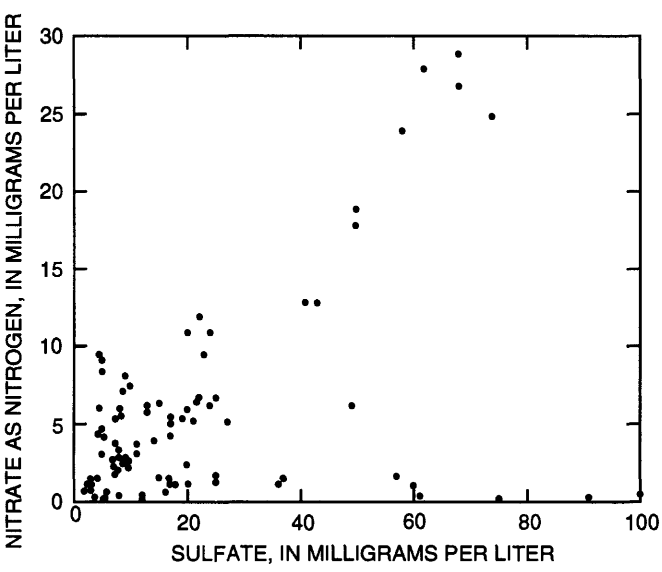


Figure 8. Concentrations of nitrate-nitrogen and sulfate in ground water from the Merced area.

aquifers underlying these hardpan layers generally contained low concentrations of nitrate. Additionally, heavy pumping during summer months produced high concentrations of nitrate in the deep aquifer as a result of induced downward migration of nitrate from shallow zones.

The relation between nitrate-nitrogen and sulfate in ground water from the Merced area shows two trends (fig. 8). One trend shows a positive correlation between these two constituents and probably represents the effects of sewage and (or) fertilizer in ground water. The second trend shows a correlation of high sulfate to low nitr; te concentration. This trend indicates that sulfate has been derived from a natural source, such as gypsum, or that nitrate has been selectively removed from solution. Reduction of nitrate to ammonia (and subsequent loss from solution) occurs prior to a similar reduction of sulfate to hydrogen sulfide. Sulfate commonly is applied in agricultural operations (Denver, 1989), but it is also present in sewage. As a consequence, irrigation-return flow and disposal of sewage may cause sulfate to enter the shallow ground-water system.

The association of nitrate with chloride in ground water may indicate the presence of sewage. Schmidt (1972) observed similar nitrate and chloride distributions with depth for 16 of 19 wells in ground water underlying areas serviced by septic tanks in the Fresno area. This similarity was attributed to the mobility of these anions and their common derivation from septic-tank effluent. Many samples of ground water in the Merced area, which has a similar geographic environment, show a positive correlation between nitrate and chloride concentrations. Barber and others (1988) determined the extent of sewage contamination in ground water using the distributions of boron, detergents, organochlorine compounds, and chloride. Boron was the best indicator of contamination because it was unique to the sewage source and was chemically inert during transport, showing a similar distribution to the conservative chloride ion.

SECONDARY MAXIMUM CONTAMINANT LEVELS

The U.S. Environmental Protection Agency has established secondary MCL's for chemical constituents that affect the esthetic quality in drinking water, although considerably higher concentrations may have health implications. Several constituents in ground water from the Merced area exceeded these secondary MCL's, including chloride, iron, and manganese (table 1). Samples from two wells exceeded the 250 mg/L secondary MCL for chloride, giving the water a salty taste. High concentrations of either iron or manganese may cause objectionable tastes and stains on laundry or porcelain. Samples from seven wells exceeded the secondary MCL of 300 μg/L of iron and samples from six wells exceeded the 50 μg/L secondary MCL for manganese. Iron and manganese commonly are precipitated as oxide coatings in streambed deposits (Hem, 1985). These coatings may be dissolved under reducing conditions, which are present in deeper parts of ground-water systems.

Table 1. Wells with major and trace constituents that exceed U.S. Environmental Protection Agency's maximum contaminant levels

[Location of wells in figure 1. mg/L, milligram per liter; μg/L, microgram per liter]

State well No.	Date	Concentration
Chloride concentrations greater than 250 mg/L[1]		
6S/10E- 20R2	7-27-83	2,000
	6-19-84	2,100
	6-27-85	2,300
24L1	8-15-56	280
Nitrate-nitrogen concentrations greater than 10 mg/L[2]		
6S/10E- 11G1	7-27-83	17
	6-19-84	21
6S/11E- 6L1	7-27-83	24
	6-19-84	28
	6-27-85	25
34F1	7-25-83	13
	6-25-85	13
6S/12E- 17E1	5-13-87	12
34D1	7-25-83	27
	6-28-84	29
36H1	7-26-83	11
	6-28-84	11
	6-25-85	12
7S/12E- 3F1	6-28-84	11
	6-25-85	11
6R1	7-25-83	19
	6-25-85	18
23C1	7-25-83	16
	6-26-84	18
	6-25-85	15
7S/13E- 10N1	7-25-83	12
	6-28-84	12
	6-25-85	11
12B1	8-09-79	11
7S/14E- 28R1	6-30-84	11

State well No.	Date	Concentration
Iron concentrations greater than 300 μg/L[1]		
6S/10E- 20R2	7-27-83	400
	6-19-84	600
6S/13E- 32P2	1-14-70	470
7S/9E- 12H1	7-28-83	390
	6-19-84	540
7S/12E- 6R1	7-25-83	310
7S/13E- 6A2	3-11-69	480
20M1	1-14-70	830
7S/14E- 29R1	7-21-53	500
Manganese concentrations greater than 50 μg/L[1]		
5S/14E- 2Q2	7-25-89	60
6S/10E- 20R2	7-27-83	300
	6-19-84	260
	6-27-85	330
7S/9E- 12H1	7-28-83	400
	6-19-84	450
8S/12E- 34L1	6-18-84	140
	6-24-85	140
9S/12E- 2G1	7-25-83	70
	6-18-84	80
	6-24-85	85
9S/14E- 19D1	6-26-85	180

[1]Secondary standard, threshold at which the esthetic quality of water is affected.
[2]Primary standard, related to threshold of adverse health effects.

HARDNESS

The water from many wells in the Merced area can be considered to be hard. Although not a health problem, excessive hardness reduces the effectiveness of soap and can be considered to represent the soap-consuming capacity of a water (Hem, 1985). Water hardness is attributed to calcium and magnesium and commonly is reported in terms of equivalent concentrations of calcium carbonate ($CaCO_3$). Hem (1985) presents the following classification for degree of hardness:

Hardness range (mg/L $CaCO_3$)	Description
0-60	Soft
61-120	Moderately hard
121-180	Hard
Greater than 180	Very hard

Using this classification, hardness data for 106 wells were evaluated. The percentages of wells falling within each range were 13 percent (soft), 54 percent (moderately hard), 25 percent (hard), and 8 percent (very hard). Hardness showed no relation to depth in the sampled wells.

EVALUATION OF GROUND-WATER MONITORING NETWORKS

Ground water is the sole water supply for the city of Merced. Ground-water data have been collected since 1975 to describe and facilitate management of this resource. Monitoring networks were established to define general conditions and to detect changes in water levels and water quality.

Data collected from the water-level monitoring network indicate direction of ground-water flow, show depressions caused by pumping, and can be used to estimate changes in storage. During the period of study, increased pumping and intermittent droughts have generally resulted in declining water levels.

Data collected from the water-quality monitoring network define the chemical character of ground water, show variations in chemical composition, and indicate possible areas of degradation or contamination. The most common contaminant found in local ground water is nitrate-nitrogen.

ORIGINAL NETWORKS

The original monitoring networks in eastern Merced County consisted of two overlapping groups of wells, one for measurement of water levels and one for collection of water-quality samples. The wells were selected to serve as indicators of potential adverse changes in water levels and water quality. Water levels were measured in 55 wells on a semiannual basis, generally during February and July. These months represent periods when the water table is highest and lowest, respectively, due to variations in pumpage and recharge from rainfall. Water samples were collected from 16 wells on an annual basis.

Water samples were analyzed for several groups of water-quality constituents. Major ions were determined, including the plant nutrients nitrogen and phosphorus. In addition, the following trace elements were determined: aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, strontium, vanadium, and zinc. Analysis for organic compounds included common pesticides, dibromochloropropane (DBCP) and ethylenedibromide (EDB).

A comprehensive review of the water-level and water-quality data began in 1990. On the basis of this review, proposals were made regarding future data collection. Revisions to the original monitoring networks began in 1991.

The coverage of wells used to monitor water levels did not allow detailed evaluation of depressions caused by ground-water pumping. Additionally, an insufficient number of wells in the northeastern part of Merced County resulted in a gap in the network. Irrigation and domestic wells screened over a wide range of depths make correlation of water-level data difficult. These deficiencies in the original network are corrected in the revised network.

The original water-quality network also had a gap in the northeastern part of Merced County. Most wells sampled were deep irrigation wells that might not intercept contamination originating in the shallow ground-water zone. Although the only primary pollutant detected in this network was nitrate-nitrogen, contamination may exist and be undetected in shallow ground water. These deficiencies in the original network are corrected in the revised network.

REVISED NETWORKS

Ground-water data in eastern Merced County have been collected using separate well networks for water-level and water-quality data. Because of the availability and coverage, some wells are included in both networks. Additionally, water levels are measured in conjunction with water-quality sampling. Water levels are measured twice annually in order to define the range in variation between winter highs and summer lows. Water-quality samples are collected during the summer irrigation season, which has the greatest potential for ground-water degradation.

The revised network to monitor ground-water levels (table 2) uses irrigation wells that are screened in the most commonly pumped zones, which comprise the intermediate and confined aquifers (fig. 2). The fact that these wells generally are not pumped during winter months allows collection of water-level data representing static conditions. Data collected during the irrigation season describe the minimum level of the water table and define the effects of localized pumping. The network was designed in order to monitor general changes in ground-water levels caused by climatic variations and ground-water pumping. Data collected from this network can be used to establish spatial and temporal trends in water

Table 2. Revised ground-water monitoring networks for water levels and water quality

[Perforated interval in feet below land surface; Water use: H, domestic; I, irrigation; N, industrial; O, observation; S, stock. Pump: S, submersible]

Revised water-level network

State well No.	Perforated interval	State well No.	Perforated interval	State well No.	Perforated interval
5S/11E- 22B2	226-398	6S/14E- 17H1	130-140	8S/13E- 24L1	90-300
29R1	140-410	32A1	145-165	32K1	107-240
5S/12E- 2G2	124-368	7S/11E- 8P1	72-168	8S/14E- 11A1	83-269
19M1	155-194	13R1	160-180	16M1	168-438
34J1	166-181			31A1	180-485
		7S/12E- 11G1	150-220		
5S/13E- 7C1	[1]312-600	20Q1	90-202	8S/15E- 7J1	116-225
32K1	[1]112-660			16J1	200-280
		7S/13E- 6L1	160-259		
5S/14E- 9B2	[2]64	9B3	130-250	9S/13E- 5M1	110-290
29K1	[1]80-410	21K1	108-188	11K1	[1]80-310
		33K1	165-378	27M1	[1]178-350
6S/11E- 1M1	155-163				
6L1	202-286	7S/14E- 26K1	290-570	9S/14E- 1B1	[1]225-340
35B1	130-150	27R1	50-108	13J1	[1]161-290
		31M1	72-178	24G1	190-288
6S/12E- 13P1	120-160	35B1	155-268	27R1	[1]160-260
20E1	120-200				
25D2	170-265	7S/15E- 28M1	84-196	9S/15E- 15A1	200-440
		30E1	80-188	21R1	[1]150-440
6S/13E- 5P1	122-158			29F1	150-339
18F1	123-168	8S/12E- 13R1	76-150		
28A1	168-312	15A1	125-240		

Revised water-quality network

State well No.	Water use	Pump	Perforated interval	State well No.	Water use	Pump	Perforated interval
5S/14E- 2Q2	H	S	[2]100	7S/13E- 22Q1	H	S	222-242
9B2	H	S	[2]64	7S/14E- 5A1	H	S	[2]109
18K1	H	S	42-100	16L1	H	S	[2]264
5S/15E- 5P1	I	Unknown	[2]20	25G1	H	S	[2]92
6S/13E- 4Q1	H	S	108-128	29P1	N	S	[2]71
25M1	H	S	192-202	7S/15E- 28K1	H	S	44-56
6S/14E- 17H1	O	None	130-140	32R1	H	S	[2]170
29R1	H	S	137-152	35A2	H	S	80-120
32A1	H	S	145-165	35F1	S	S	[2]68
32B1	H	S	[2]126	35P1	H	S	[2]76
6S/15E- 4F1	S	Unknown	[2]232	8S/14E- 18D1	S	S	76-86
7S/13E- 22P1	H	S	80-100	19E1	H	S	84-94

[1]Approximated from well depth.
[2]Actual well depth.

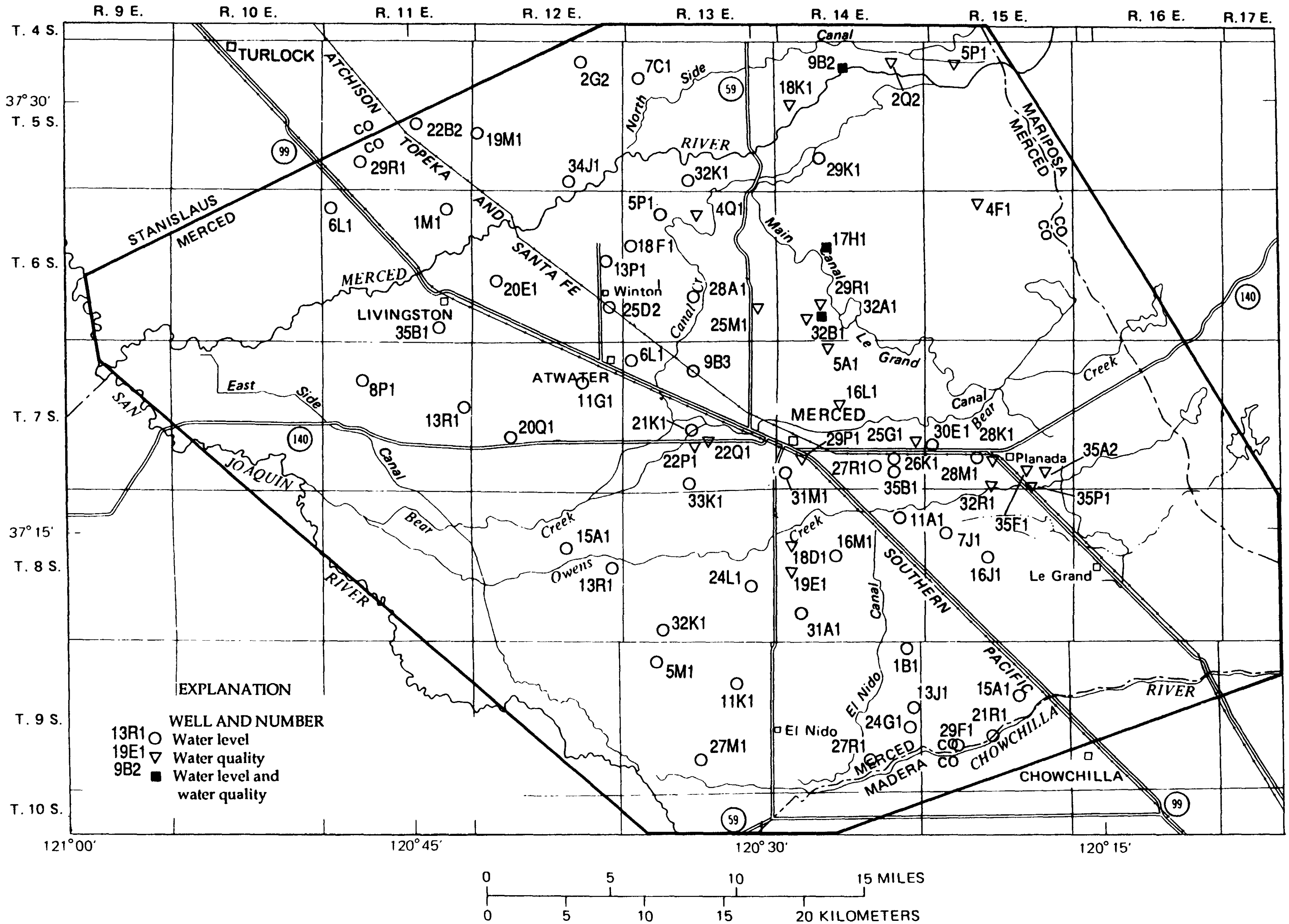


Figure 9. Revised well network to monitor water levels and water quality.

levels, as well as to monitor changes in areas of ground-water pumping. Specific objectives of this network are to (1) provide uniform coverage in eastern Merced County, and (2) define depressions in the ground-water table caused by pumping. Fifty-three wells will be measured twice per year. These wells are shown in table 2 and figure 9.

The revised network to monitor ground-water quality (table 2) primarily uses domestic wells equipped with submersible pumps. Irrigation wells are more likely to show point-source, or local, contamination as opposed to areal water-quality conditions caused by use of pesticides and fertilizers. Also, because most contamination is at the water table, shallow domestic wells are more likely to have contamination than deep irrigation wells. Specific objectives of this network are to (1) determine and describe spatial and temporal variations in water quality, and (2) identify sources and areas of ground-water contamination. Twenty-four wells will be sampled once every 3 years on a rotating basis. Hence, 8 of 24 wells would be sampled each year during the 3-year cycle. These wells are shown in table 2 and figure 9.

SUMMARY

Ground water is the sole source of water supply for the city of Merced. Continued development in the area has increased the demand for this resource while introducing factors that may impair the quality of potable water available. These factors include irrigation-return flow, infiltration of sewage, and discharge of industrial wastewater. The land-use activities associated with these factors are agriculture, residential developments, and food processing.

In the Merced area, fresh ground water occurs in several zones to a depth of about 1,200 ft. The general flow direction for ground water is from northeast to southwest. Depressions in the water table caused by pumping occur near Turlock, Atwater, and El Nido.

The current and past droughts have a two-fold effect on the ground-water system. Irrigation accounts for the largest quantity of ground-water pumpage in the Merced area. During periods of average rainfall, most of the irrigation demand is supplied by surface water. However, during periods of drought, the deficit is balanced with increased ground-water pumpage. Hence, ground-water levels decline in response to decreased recharge and increased pumping. A review of wells in eastern Merced County shows that ground-water levels near Merced have declined 10 to 20 ft between 1982 and 1990.

The general quality of ground water is similar to that of Merced River water. Ground water in the area is recharged by surface water and both are classified as mixed cation, bicarbonate types. Water from 12 wells exceeded the U.S. Environmental Protection Agency's maximum contaminant level for nitrate-nitrogen. Water from several wells exceeded the U.S. Environmental Protection Agency's secondary maximum contaminant levels for chloride (two wells), iron (seven wells), and manganese (six wells).

Background concentrations of nitrate are low in most ground water in the eastern part of San Joaquin Valley. The primary sources of high nitrate concentrations in the Merced area probably are sewage and fertilizers. The highest concentrations of nitrate in ground water were in wells less than 300 ft deep, indicating a shallow source of contamination. The positive correlation of nitrate to sulfate and chloride probably results from the sewage and (or) fertilizers in ground water.

An evaluation was made of the well networks used to monitor ground-water levels and quality. The original water-level network provided good areal coverage, but did not emphasize pumping depressions and utilized a variety of wells screened at varying depths. The revised water-level network uses irrigation wells that are screened in the most commonly pumped zones. This network was designed to monitor changes in ground-water levels in response to climatic variations and pumping. The original water-quality network had sparse coverage in the northeastern part of Merced County. Also, most samples were from deep irrigation wells. The chief sources of contamination, sewage and fertilizers, primarily affect shallow ground water. The revised water-quality network uses shallow domestic wells equipped with submersible pumps. This network was designed to evaluate spatial and temporal changes in water quality. Network coverage also has been increased to fill in gaps from the original network. Information from these networks can be used to more efficiently manage the local ground-water resource.

References Cited

Barber, L.B., Thurman, E.M., Schroeder, M.P., and LeBlanc, D.R., 1988, Long-term fate of organic micropollutants in sewage-contaminated groundwater: Environmental Science and Technology, v. 22, p. 205-211.

Davis, G.H., Green, J.H., Olmsted, F.H., and Brown, D.W., 1959, Ground-water conditions and storage capacity in the San Joaquin Valley, California: U.S. Geological Survey Water-Supply Paper 1469, 287 p.

Denver, J.M., 1989, Effects of agricultural practices and septic-system effluent on the quality of water in the unconfined aquifer in parts of eastern Sussex County, Delaware: Delaware Geological Survey, Reports of Investigations No. 45, 66 p.

Elliott, A.L., 1984, Ground-water conditions and shallow test-well information in the eastern half of Merced County, California, 1977-82: U.S. Geological Survey Water-Resources Investigations Report 83-4081, 56 p.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Jenkins, O.P., 1943, Geomorphic provinces of California *in* Geologic formations and economic development of the oil and gas fields of California: California Division of Mines Bulletin 118, p. 83-88.

Page, R.W., 1977, Appraisal of ground-water conditions in Merced, California, and vicinity: U.S. Geological Survey Open-File Report 77-454, 43 p.

Page, R.W., and Balding, G.O., 1973, Geology and quality of water in the Modesto-Merced area, San Joaquin Valley, California, *with a brief section on* Hydrology: U.S. Geological Survey Water-Resources Investigations Report 6-73, 85 p.

Schmidt, K.D., 1972, Nitrate in ground water of the Fresno-Clovis Metropolitan area, California: Ground Water, v. 10, no. 1, p. 50-64.

U.S. Environmental Protection Agency, 1986, Quality criteria for water: U.S. Environmental Protection Agency 440/5-86-001, (May 1, 1986), 453 p.

Wood, W.W., 1976, Guidelines for collection and field analysis of ground-water samples for selected unstable constituents: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 1, Chapter D2, 24 p.

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