

CHAPTER 2 - MESILLA BASIN GROUNDWATER AQUIFER SYSTEM

This section will describe three groundwater aquifers within the Mesilla basin groundwater aquifer system. These are the Mesilla Bolson, the Rio Grande Floodplain Alluvium, and the Jornada del Muerto Bolson. These are shown in the western edge of the study area in Figure 1.2. These three groundwater aquifers are connected hydrologically, however the connections are restricted by aquitards and/or faults and therefore are considered and described as separate aquifers. The discussion of these groundwater systems (Mesilla basin aquifers) first includes general information of location, extent of the aquifers, climate, development, and use of the resource followed by sections specific to each of the aquifers such as regional structure, depositional history, geology, water bearing characteristics, quality, recharge and discharge.

Location and Extent

The Mesilla basin aquifer system is an extensive intermontane aquifer system which extends from southern New Mexico to northern Mexico. It is surrounded by mountains which form the boundaries of the aquifers. The eastern boundary consists of the San Andres Mountains, San Augustin Mountains, Organ Mountains, Bishop Cap and the Franklin Mountains. The East and West Potrillo Mountains, Aden Hills and Sleeping Lady Hills are on the west. On the north, there are Robledo Mountains and Doña Ana Mountains. On the southeast are the Sierra de Cristo Rey at the international boundary and the Sierra de Juarez just north of the international boundary. The Rio Grande enters the basin through Seldon Canyon between the Robledo Mountains and Doña Ana Mountains. From Seldon Canyon the river traverses the Mesilla basin diagonally for approximately 60 miles until it exits into the Hueco Bolson through the El Paso narrows between the Franklin Mountains and the Sierra de Cristo Rey. The Rio Grande floodplain and

lands adjacent to the floodplain define the Mesilla Valley which is a low gradient, narrow, alluvial valley ranging in width from a few hundred feet to about 5 miles near Las Cruces. Altitude of the valley varies from 3,980 feet at Leasburg Dam in Seldon Canyon to 3,729 feet at the El Paso narrows.

Steep bluffs rise up from the Mesilla Valley floor, and form the walls of the valley. To the west of the Valley the bluffs immediately level off and form the broad piedmont slope that extends for over 20 miles until it intersects the mountain fronts. This broad mesa is known as the West Mesa, and it encompasses approximately 750 square miles. The Jornada del Muerto is another broad mesa on the east side of the Mesilla Valley that extends 100 miles north from Las Cruces to San Marcial. To the east and south of the Valley, the bluffs level off slightly and quickly meet the base of the San Andres Mountains, Organ and Franklin Mountains. The Mesilla Valley is located on the eastern side of the Mesilla basin and is characterized by a broad erosional surface of low topographic relief produced by the meandering Rio Grande. An extensive remnant of an earlier basin-floor surface, the "West Mesa" of recent water resource publications (Wilson and others, 1981; Myers and Orr, 1985), that predates river-valley incision is preserved between the Mesilla Valley and the East Potrillo and Robledo mountain uplifts to the west.

The surface water system is comprised of the Rio Grande and its tributaries and a network of canals, laterals and drainage ditches that discharge to the river. The Rio Grande, which is the main surface-water feature associated with the Mesilla Valley, is the primary source of irrigation water in the Mesilla Valley. The Rio Grande is a highly regulated stream with reservoir storage and channel stabilization throughout the area. The operation of the river is controlled by an irrigation project (Rio Grande Project), interstate compact, and international treaty. Operation of the Rio Grande is based on discharge at upstream index stations and storage in upstream reservoirs (Nickerson and Myers, 1993). The water is administered by the Elephant Butte

Irrigation District (EBID) and El Paso County Water Improvement District #1 (EPCWID). To control water flow, surface water for the area is stored in two large reservoirs, Caballo Reservoir and Elephant Butte Reservoir. Elephant Butte Reservoir is about 75 miles upstream from Leasburg Dam, and Caballo Reservoir is about 45 miles upstream from Leasburg Dam. The discharge of the Rio Grande in the Mesilla Valley is regulated by releases from these two reservoirs and diverted into an extensive network of canals. An extensive network of drains carries return flows back to the river. Percha Dam, Leasburg Dam, and Mesilla Dam are diversion dams along the Rio Grande that divert water into irrigation canals. Percha Dam diverts water for the Rincon Valley, Leasburg Dam diverts water for the northern portion of the Mesilla Valley, and Mesilla Dam diverts water for the southern portion.

Streamflow in the river and the amount of water diverted for irrigation may vary greatly from year to year. Surface water is supplemented by groundwater primarily in years when surface supplies are insufficient for crop requirements. Groundwater is used for all domestic water needs both public and private.

Several arroyos flow into the Rio Grande mainly from the mountains on the east side of the basin. Flow in some of the large arroyos is blocked by retention dams near Las Cruces and El Paso. Flow in other arroyos reaches the valley, but probably does not contribute much flow to the discharge of the Rio Grande.

The two principal mechanisms for recharge in the Mesilla basin is seepage from the Rio Grande and from deep percolation of applied irrigation water. The convergence of the surface flow from time to time into arroyos where it can rapidly infiltrate deep into the alluvial sediments may provide a secondary mechanism for natural recharge of groundwater. This type of recharge is referred to as mountain front recharge or slope front recharge (Frenzel and Kaehler, 1990). Mountain and slope front recharge comprise only a

very small portion of total recharge to the Mesilla basin aquifers.

History of Groundwater Development

In the Mesilla Valley, agriculture is a major activity. Agriculture in the valley is irrigated by surface water from the Rio Grande Project, which consists of Elephant Butte and Caballo reservoirs. Discharge from the reservoirs has been highly variable over time, due to variances in the hydrologic cycle and differing operational parameters. The flow into Elephant Butte Reservoir has averaged about 904,000 acre-feet per year (1895-1985) and past the Elephant Butte gaging station about 872,000 acre-feet per year (1915-1992).

Historically, irrigators have used irrigation practices that effectively use the groundwater system as a reservoir in a combined stream-aquifer system. During years of plentiful surface water, irrigators divert most of the irrigation water from the Rio Grande. According to Blaney and Hanson (1965) about two thirds of the applied irrigation water may replenish the groundwater system. However more recent studies in the Mesilla Valley (Sammis 1996, personal communication) has shown that only about one third of the applied irrigation water seeps into the groundwater system. Some groundwater seeps into drains that discharge to the Rio Grande. During years of inadequate surface water supply, the shortfall is made up from groundwater causing lower than usual groundwater levels and diminished drain discharge. Groundwater levels generally recover after a normal irrigation season. Studies conducted in the wells installed by the Bureau of Reclamation have shown that the water table in the Mesilla Valley fluctuates about four feet between the irrigation and nonirrigation season.

Groundwater Investigations

Groundwater investigations have been conducted in the Mesilla basin since the early 1900. Slichter (1905) was one of the first to report on the groundwater conditions of the Mesilla Valley. His report included infor-

mation about well occurrence, pumping rates, and depth to water table. Lee (1907) provided a more detailed record of the geology, depth to water, hydraulic gradients and water quality for the shallow aquifer (Rio Grande Alluvium) of the Mesilla basin during pre-development years.

The earliest comprehensive reports of hydrology of the area are in U.S. Geological Survey Water Supply Papers by Sayre and Livingston (1945), Conover (1954), Knowles and Kennedy (1958) and Leggat, Lowry and Hood (1962). King and others (1971) discussed both the geology and groundwater resources of the Las Cruces area. This report was followed by a more comprehensive work on the hydrogeology of the region by Wilson and others (1981). Wilson and White (1984) presented aquifer test data for the central Mesilla Valley, and Myers and Orr (1985) presented aquifer test data for the northern West Mesa area. A report by Hernandez and others (1987) included estimates of municipal water use for 1984. Nickerson (1989) reported aquifer test data based on the stage changes in the Rio Grande. Hawley and Lozinsky (1992) reviewed electric logs, identifying upper, middle, and lower hydrostratigraphic units of the Santa Fe Group. Groundwater flow model studies include Gates and others (1984), Peterson and others (1984), Frenzel and Kaehler (1990), Frenzel (1992) and Hamilton and Maddock (1993).

Geologic/Geohydrologic Setting

Regional structure

The Mesilla basin aquifers (Figures 1.2 and 2.1) are defined geologically and hydrologically by structural boundaries. They are bounded by uplifted blocks of bedrock or by relatively impermeable volcanic rocks and are filled with alluvial sediment from surrounding mountains and with fluvial sediment carried in by the ancestral Rio Grande. The Mesilla basin is at the southern end of a north-trending series of structural basins and flanking mountain uplifts that comprise the Rio Grande rift (Chapin and Seager, 1975; Seager and

Morgan, 1979; Chapin, 1988). The rift extends through New Mexico from the San Luis Basin of south-central Colorado to the Hueco Bolson and Bolson de los Muertos area of western Texas and northern Chihuahua, Mexico (Hawley, 1978).

The area's geology (Figure 2.2) includes numerous mountain ranges and outcrops forming impermeable and semi-impermeable boundaries for the intermontane bolsons and the valley of the Rio Grande. For the most part, the mountains in the region consist of fault-block uplifts with a general north-south trend (Kottowski, 1958).

The Robledo Mountains consist of a tilted fault-block uplift that has the form of a wedge-shaped horst. They are bound on the east and west by faults and tilt toward the south. The peaks and high ridges are mostly underlain by thick-bedded carbonate rocks of Paleozoic age. The western portion of the Mesilla basin commonly is called the West Mesa. The West Mesa is approximately 300 feet above the present valley floor. The West Potrillo Mountains reflect the primary form of the basaltic volcanic cones and flows that underlie the West Mesa. The Aden Hills, the Sleeping Lady Hills, and the Rough and Ready Hills are comprised of a belt of small peaks, ridges, buttes, and elongated mesas underlain by Tertiary volcanic rocks. The Sierra de Cristo Rey and the Sierra de Juarez are in Mexico. To the east, Goat Mountain is similar in composition to that of San Diego Mountain. Small fault-block uplifts form Tortugas Mountain and Bishop Cap Mountain. The San Andres, San Augustin, Organ and the Franklin Mountains are similar in composition to the Caballo Mountains (King and others, 1971).

Productive aquifers in the Mesilla basin occur in both late Pleistocene to Holocene-Rio Grande alluvium deposits and the upper Tertiary and Quaternary unconsolidated sedimentary deposits of the Santa Fe Group. Generally, the groundwater system of the Mesilla basin is divided into three zones based on lithology, borehole geophysical logs, chemical quality of water and the dif-

ferences in water levels under stress. The shallow zone is referred to as floodplain alluvium deposits and basin fill deposits within the Mesilla Valley and consists of a mixture of gravel and coarse sand. The formation below the floodplain alluvium, Santa Fe Group deposits, refers to alternate layers of fine to coarse-grained sand, silty clay, and some gravel. Lenticular deposits of silty clay occur throughout the sand deposits which have predominantly medium to fine grain sizes. The deep zone of the Santa Fe Group aquifer consists of a more uniform fine to medium grain size with some silt and clay (Nickerson, 1989). Frenzel (1992) divided the system into the Rio Grande Alluvium deposits and three hydrostratigraphic units within the Santa Fe group.

The surface drainage of the Mesilla basin covers approximately 11,000 square miles. The Rio Grande enters the basin through Selden Canyon, between the Robledo Mountains and the Doña Ana Mountains, and exits through the El Paso narrows, between the Franklin Mountains and the Sierra de Cristo Rey. The Mesilla Valley, created by the latest incision of the Rio Grande, extends from Leasburg to northwest El Paso along the eastern portion of the Mesilla basin. The altitude of the valley ranges from 3,980 feet at Leasburg Dam to 3,729 feet at the El Paso narrows. The Mesilla Valley is about 50 miles long and is about 5 miles across at its widest section. The Mesilla Valley covers an area of approximately 110,000 acres (Frenzel and Kaehler, 1990).

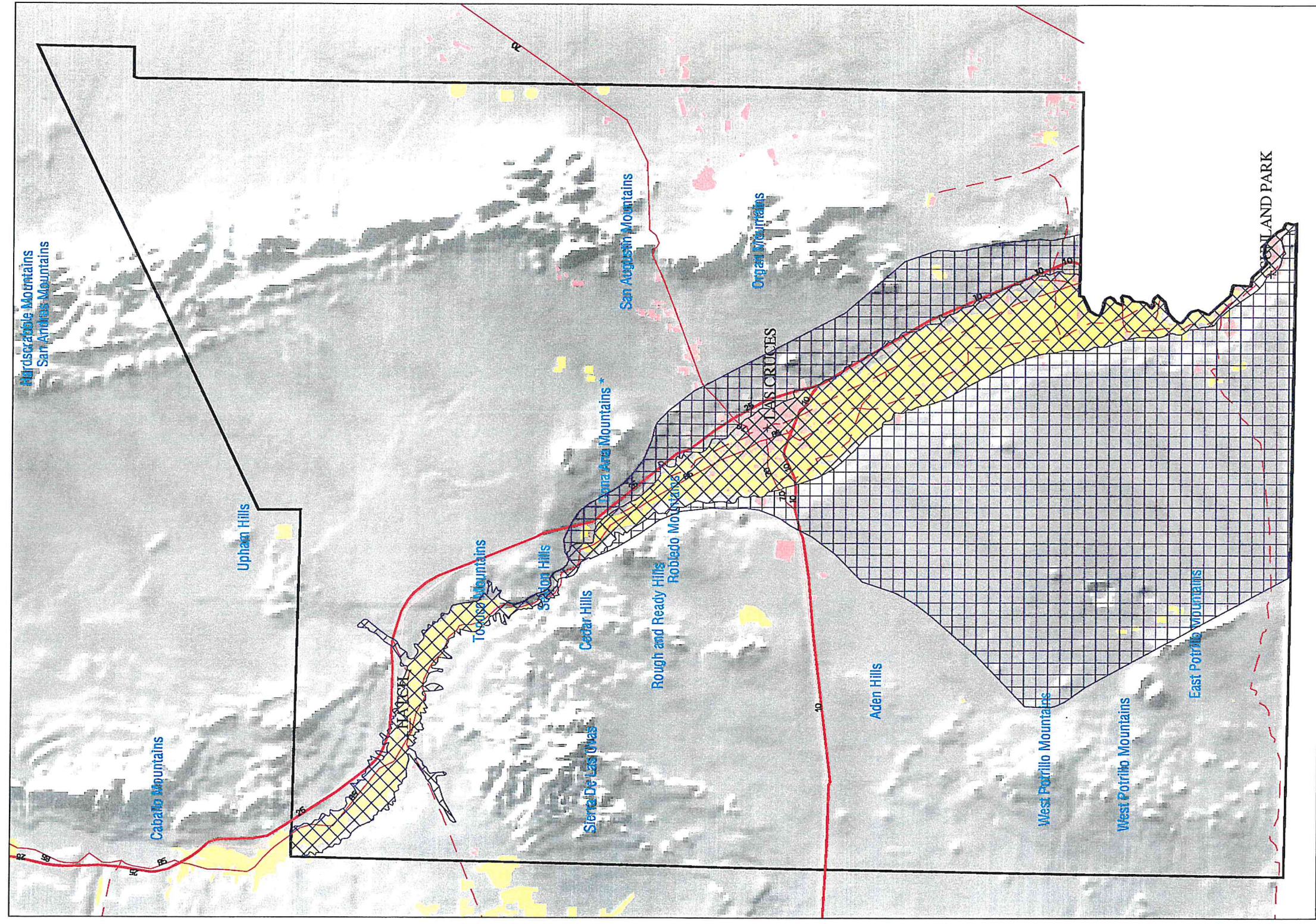
Depositional history

The bolsons within the study area contain groundwater systems primarily consisting of basin-fill aquifers composed of unconsolidated alluvial deposits. The aquifer system may be divided into two main geologic units: the Rio Grande floodplain alluvium and the Santa Fe Group (King and others, 1971). It was deposited by the latest incision of the Rio Grande from the late Pleistocene to the Holocene age. Beneath the Rio Grande floodplain alluvium is the Santa Fe Group. The Santa Fe Group is an intermontane basin-fill unit

composed of alluvial deposits of Miocene to middle Pleistocene age (Wilson and others, 1981). The Santa Fe Group can further be broken down into three facies:

- alluvial-fan facies, composed of various size sediments ranging from gravel to clay, which is formed by the erosion of the nearby hills and mountains.
- clay facies, possibly produced by the continued erosion of alluvial-fan facies, deposited in ancient lake and playa deposits, and by deposition of overbank deposits due to seasonal flooding; and
- fluvial facies, consisting of well-sorted sand and gravel deposited axially by the Rio Grande and its major arroyos (King and others, 1971). Because the layers were directly deposited by the Rio Grande, the horizontal permeability greatly exceeds the vertical permeability, usually by several orders of magnitude (Wilson and others, 1981).

Within the Mesilla basin the Santa Fe Group is laterally divided by Pleistocene age normal faults called the Jornada fault zone. These faults split the Mesilla Bolson from the Jornada del Muerto Bolson along a transect north to south from the Doña Ana Mountains, through Tortugas Mountain, to Bishop Cap Mountain. A hydrologic connection between the aquifers exists along this fault zone. Frenzel (1992) estimated that the inflow to the Mesilla was equal to the discharge from the Jornada. Shoemaker (1996) estimated the discharge from the Jornada to the Mesilla along the common boundary to be equal to about 2,860 acre-feet per year.



LAND USE SOURCE: U.S. Geological Survey, 1990, EPA Land Use and Land Cover Digital, Data from 1:250,000- and 1:100,000-Scale Maps — Data Users Guide 4, 1:250,000 QUAD LAND USE, 1982. Contract: Ed Partington at EPA, Phone (703) 235-5395.

SHADED RELIEF: Shaded relief based on USGS DEM files for the state of New Mexico. Processed by Earth Data Analysis Center, Albuquerque, NM, USA.

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Explanation

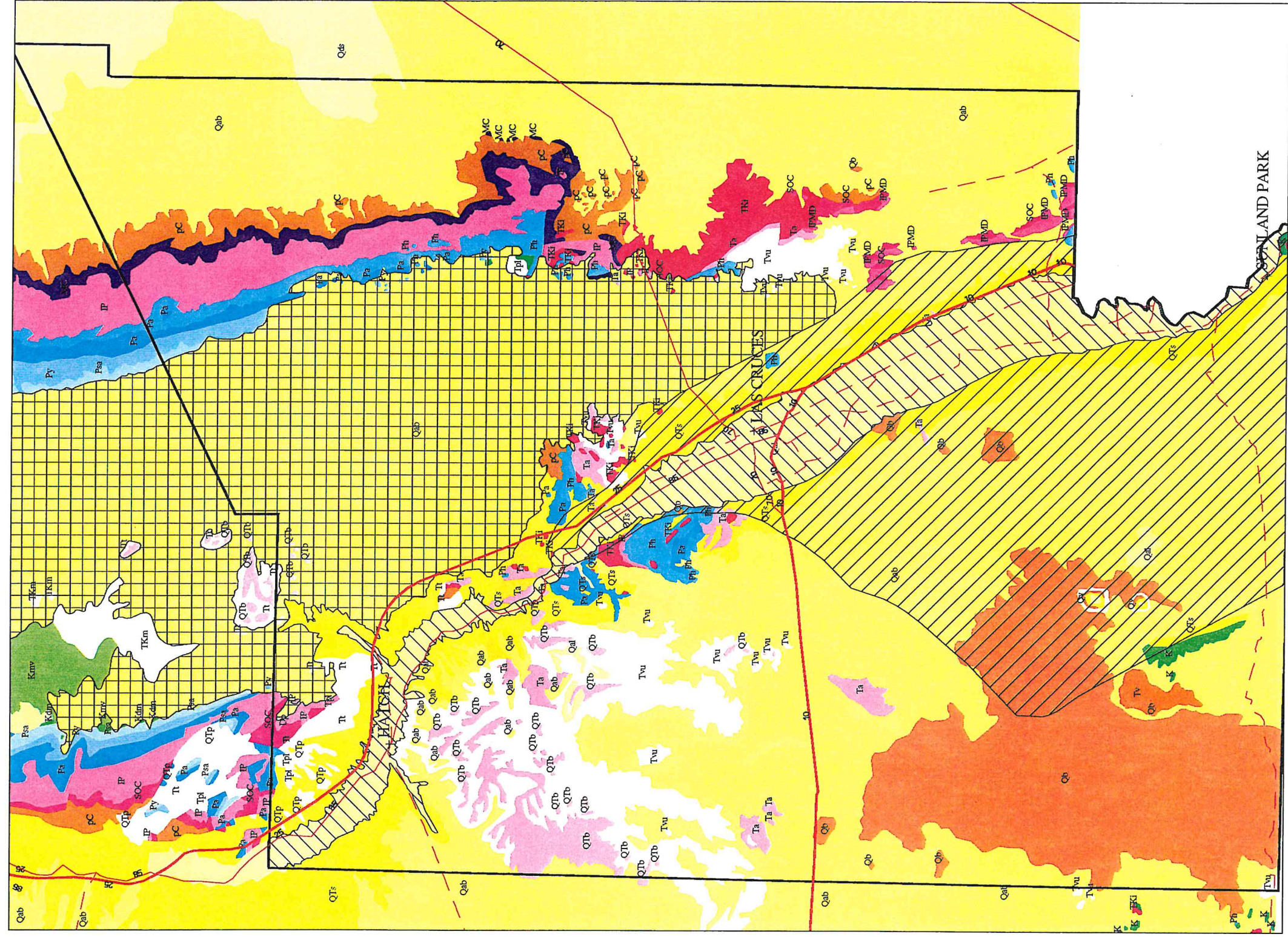
	Interstate
	US Highway
	State Highway
	Urban or Built-Up Land
	Agricultural Land
	Mesilla Bolson
	Rio Grande Alluvium

SCALE 1:500000

0 5 10 MILES



Figure 2.1. Shaded Relief Map with Urban and Agricultural Land Use



SOURCE: Dane and Bachman 1965, Geology of New Mexico, 1:500,000 map. USGS in cooperation with New Mexico Tech, New Mexico Bureau of Mines & Mineral Resources, and UNM, Geology Dept., (digital file scanned and georeference corrected by USGS/WRD).

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Explanation

- Interstate
- US Highway
- State Highway
- Mesilla Bolson
- Rio Grande Alluvium
- Jornada del Muerto



Figure 2.2. Surface Geology of Dona Ana County, New Mexico

RIO GRANDE FLOODPLAIN ALLUVIUM

The Rio Grande Floodplain Alluvium is not a confined aquifer and consists of alternating and interfingering layers of clay and fluvial facies. The alluvium generally runs the width of the valley and is approximately 80 feet deep. Alluvial deposits extend laterally for hundreds of feet beyond the valley slopes (Wilson and others, 1981). The floodplain alluvium has a basal gravel layer about 30 to 40 feet thick. The water table in the valley is approximately 10 to 25 feet below the land surface. Groundwater within the alluvium is generally unconfined and typically moves southeastward down the valley at an average gradient of about 4 to 6 feet per mile; however, the direction is somewhat influenced by nearby hydraulic structures such as the river, drains, canals, well pumpage and heavily irrigated fields (Wilson and White, 1984).

The majority of discharge from the floodplain alluvium occurs through evapotranspiration of irrigated crops, flow to drain system, irrigation pumpage, municipal pumping, and industrial pumping. A small amount of river underflow exits at El Paso narrows (Slichter 1905). According to Wilson and others (1981), transmissivity values range from 10,000 to 30,000 ft²/day. This transmissivity values translates into hydraulic conductivity of 100 to 350 ft/day. Frenzel (1992) estimated a specific yield value of 0.2.

Recharge

The majority of recharge to the floodplain alluvium is through applied irrigation water and seepage from the Rio Grande and its tributaries. A small amount of underflow probably recharges the alluvium at Selden Canyon (Frenzel, 1992). This possible underflow recharge at Selden Canyon was also confirmed by Avalos (1994). An example of this recharge occurred on January 15, 1986, when an abrupt rise in Rio Grande stage due to a scheduled upstream release caused a rapid rise of groundwater levels. This rapid response of groundwater levels to a rise of flow in the Rio Grande

indicates a strong hydraulic connection between the river and the floodplain alluvium. Records of mean daily water levels in monitoring wells maintained by the USGS and mean daily river stage clearly indicate that the water levels in the wells in the floodplain alluvium follow the trends of the river stage throughout the year. Recharge from precipitation is considered minor. The net recharge to the aquifer is directly related to Rio Grande streamflow and the volume of river water used for irrigation (Nickerson and Myers, 1993). The Rio Grande acts both as a gaining as well as a losing stream along its 60 mile length from Leasburg Dam to El Paso narrows (Hamilton and Maddock 1993).

Discharge

Most groundwater discharge from the Alluvium takes place in the vicinity of the valley-margin and floodplain surfaces (Nickerson and Myers, 1993). This discharge occurs in several different ways:

- flow to agricultural drains
- seepage to the Rio Grande in the gaining reaches of the stream
- well discharge
- evapotranspiration
- discharge from interbasin groundwater outflow is considered minor (Wilson and others, 1981)

When the water table in the floodplain alluvium aquifer intersects a drain channel, discharge to the channel occurs. Some drains flow all year, while others flow periodically, varying with water levels in the shallow aquifer. Much of the irrigation water that infiltrates to the water table is thus returned by drains to the river (Nickerson and Myers, 1993).

Discharge to the Rio Grande in the gaining reaches of the river occurs when the potentiometric surface of the aquifer rises above the river stage. Seepage investiga-

tions show that the Rio Grande is usually a losing stream through most of the Mesilla Valley. Gains, however have been reported between Leasburg Dam and Las Cruces (Wilson and others, 1981) and immediately upstream from the El Paso narrows in the southern end of the Mesilla Valley.

Hydrologic Characteristics

The specific capacities ranges from 10 to 217 gpm/foot drawdown with an average of 69 gpm/foot drawdown. Based on these specific capacities of shallow irrigation wells that perforated the floodplain alluvium south of Las Cruces, the transmissivity was estimated to range from 10,000 ft²/day to 20,000 ft²/day (Wilson and White, 1984).

Water Quality

An attempt was made to evaluate if water quality degradation had occurred over time by plotting conductivity and nitrates vs time over an extended period. This was less informative than hoped because there were no shallow wells with a complete long term record.

MESILLA BOLSON

The major source of the fresh groundwater within the Mesilla Bolson is from the Quaternary-to-Tertiary age Santa Fe Group. The extent of the aquifer system within the Santa Fe Group is controlled by the surrounding faults which create an effective barrier to groundwater flow, although a small amount of flow may enter or leave the bolson at low barrier points.

Saturated Thickness

The Santa Fe Group has thick sequences of clay and silt facies that interfinger with fluvial facies, which create confined/leaky aquifer conditions in the basin fill. The largest amounts of freshwater can be found in the fluvial facies. This facies varies in depth, due to the volcanic activity within the region, from 280 feet in the northern part of the bolson to over 2,000 feet near the

center of the bolson. In some areas of the northern West Mesa, the fluvial facies extends to depths close to 2,500 feet below the surface. In the southern section of the bolson, well fields near Canutillo, Texas withdraw a substantial amount of water from depths up to 1,100 feet below the surface. The southeastern sections of the bolson contains a thick clay facies. At the El Paso narrows, a bedrock high prevents much of the groundwater from leaving the valley.

Hydrologic Characteristics

The Santa Fe Group hydrological characteristics vary from place to place due to heterogeneity of its lacustrine, playon, fluvial and alluvial deposits. Hawley and Lozinsky (1992) defined the Santa Fe Group as consisting of three hydrostratigraphic units which are referred to as upper unit, middle unit and deep unit. The upper unit is generally only saturated in the northern third of the bolson and consists of gravels with lenticular deposits of clay. This unit may be the most permeable based on larger grain sizes and less cementation. The middle hydrostratigraphic unit is less permeable than the upper unit due to a greater degree of cementation. This unit also consists of gravel and lenticular deposits of clay. The lower unit consists of a uniform fine sand and averages approximately 600 feet in thickness. In general, the basin fill deposits of the Santa Fe Group are deep under the Mesilla Valley and generally thin toward the basin edges. The maximum thickness of Santa Fe Group deposits is estimated as approximately 2,500 feet. The lower hydrostratigraphic group rests on a bedrock of limestone conglomerate which is generally considered impermeable. Frenzel (1992) estimated hydraulic conductivity's ranging from 2 - 68 ft/day, 1 - 100 ft/day, and 1 - 34 ft/day for upper, middle and lower hydrostratigraphic units respectively. The median hydraulic conductivity estimates fall at 25 ft/day for the upper unit, between 13 - 14 ft/day for middle unit and between 11 - 14 ft/day for the lower unit.

Other authors (Nickerson, 1989; Myers and Orr, 1985; Alvarez and Buckner, 1980) have provided esti-

mates of transmissivity based on pump tests. Nickerson (1989) reports transmissivity of 2,600 ft²/day and less than or equal to 4,700 ft²/day for the upper intermediate and deep zones and storage coefficient of 0.00043 for the Santa Fe Group aquifer at Canutillo. Myers and Orr (1985) studied aquifer properties in the West Mesa area and calculated transmissivity of 5,900 ft²/day for a well screened at selected intervals between 710 to 1,210 feet below surface. The authors concluded that this was probably conservative and that transmissivity may be as great as 6,800 ft²/day. Spiegel (1972) estimated transmissivity of 10,000 ft²/day and a storage coefficient of 0.00002 for a well in the northern section of West Mesa. Gates and others (1984) reported a storage coefficient of 0.0007 for the medium-depth and deep aquifers under the floodplain within the Mesilla Valley. Avalos (1994) calculated transmissivity values ranging from 800 ft²/day to 6000 ft²/day for the City of Las Cruces Well Field. Based on aquifer tests, the transmissivity ranged from 10,900 ft²/day to 40,000 ft²/day throughout the bolson. The average horizontal hydraulic conductivity was 67 ft/day. These tests also provided evidence that the horizontal hydraulic conductivity apparently decreases with depth (Wilson and White, 1984). Vertical hydraulic conductivity values were found to range from 0.21 ft/day to 3.0 ft/day for the entire thickness of the confining layer.

Recharge

The majority of recharge to the Santa Fe Group aquifer occurs through mountain front recharge along the Franklin, Organ, Robledo, West Potrillo and East Potrillo mountains, and the Aden-Sleeping Lady, Rough and Ready Hills complex and through vertical flow of groundwater from the floodplain alluvium in the Mesilla Valley region. Recharge into the Santa Fe Group from the groundwater in the floodplain alluvium moves down through layers of sand and around clay layers. Cones of depression also influence the movement of groundwater into the Santa Fe Group.

Discharge

The majority of the discharge from the Santa Fe Group aquifer system occurs as municipal and industrial pumping in the Mesilla Valley. It is clear from plotting of USGS water-level data that the municipal cones of depression from Las Cruces and Canutillo have a significant regional impact on the direction of groundwater flow (Figure 2.3). The potential impact of this change in the local groundwater flow direction was further investigated in the particle tracking work by Hanson and Samani (1995).

Water Quality

The general water quality in the Mesilla basin aquifers is shown by the use of stiff diagrams in Plate 1. The reader is cautioned that the stiff diagrams do not provide information on the depth of the water sample which can strongly influence the quality. There is an overall general trend of decreasing dissolved solids concentration with depth. This may be attributed, in part to the effects of surface irrigation practices and evapotranspiration (Frenzel and others, 1990). As part of the applied water evaporates or is transpired, the dissolved solids in the water are concentrated. This water is recharged to the shallow groundwater system. Frenzel and others (1990) described the factors in the valley which will have a major impact on water quality in the Mesilla Bolson. From their analysis the current irrigation practices allow the soils in the valley to be kept flushed of salts. Most of the flushing water tends to be captured by the drain system and returned to the river. Some may move into the shallow groundwater.

This shallow groundwater can be mixed into the deeper high quality groundwater through pumping activity. The cone of depression formed by the pump may act as a mixing zone. Wilson and White (1984) reported on pumping tests for five EBID wells during the 1976 - 78 irrigation seasons. Four of the five wells showed no change in water quality from pumping. The fifth well showed a reduction in water quality. It appeared that the wells that did not show a reduction

in water quality were constructed in a manner that prevented poorer quality shallow water from moving down into the screened zone. It was noted that irrigation wells constructed with cement casing or blank casings set in a thick clay layer at approximately 200 feet or more below the land surface produce the water with the smallest specific conductance. Thus it appears that good construction practices can minimize the impact of localized vertical mixing.

Volume with TDS less than 10,000 mg/L

Wilson and others (1981) estimated the thickness of the saturated sediments in the Mesilla Bolson containing freshwater (<300 mg/L TDS) from Less than 400 feet near the edges to more than 2,400 feet near the center of the Mesilla Valley. He estimated the volume of the freshwater in storage beneath the Mesilla Valley, with the thickest zone generally following the present course of the Rio Grande, to be about 66 million acre-feet and an additional 34 million acre-feet beneath the West Mesa (Wilson, et al., 1981).

Avalos (1994) estimated the freshwater zone of the mesilla Bolson to be limited to the top two layers of the aquifer, with an average thickness of 700 feet and a surface extent of about 612 thousand acres. With a specific yield of 0.2 (Frenzel and Kaehler, 1990) then the volume of freshwater would be about 85.7 million acre-feet.

JORNADA DEL MUERTO BOLSON

Location and Extent

The Jornada del Muerto Bolson is east of the Rio Grande Valley. It is bordered by the Caballo Mountains and Point of Rocks to the west, the Doña Ana Mountains, San Diego Mountain, and Tortugas Mountain to the southwest, and the Organ Mountains and the San Andres Mountains to the east. The Point of Rocks appears to be the remnant of a former cover of andesites, basalts, rhyolite tuffs, and associated sedimentary rocks, that have been disrupted by a combina-

tion of erosion, faulting, and warping. The Doña Ana Mountains are domal uplifts composed mainly of Tertiary igneous rocks. San Diego Mountain appears to be a peak formed by the erosional remnant of Tertiary igneous intrusive rock. Tortugas Mountain is a small fault-block uplift. The Organ Mountains and the San Andres Mountains are similar in composition to the Caballo Mountains (King and others, 1971).

The Jornada del Muerto Bolson covers approximately 3,344 square miles and is approximately 12 miles across at its widest section. It does not have a noticeable boundary with the Mesilla Bolson. The two bolsons are separated by a subsurface Tertiary volcanic rock high bounded by normal faults that extend from the Doña Ana Mountains to Tortugas Mountain, to Fillmore Pass. There is no evidence that the Rio Grande ever flowed through the Jornada del Muerto Bolson (King and others, 1971). The latest incision of the Rio Grande was restricted from entering the Jornada del Muerto Bolson by the Caballo Mountains (King and others, 1971).

Hydrologic Characteristics

The Santa Fe Group in the Jornada del Muerto Bolson is composed of a fluvial facies, a clay facies, and an alluvial-fan facies. Throughout the bolson, the fluvial facies is usually above the water table. The portion of the bolson that is south of the Point of Rocks and north of the Doña Ana Mountains has a fluvial facies layer that is more than 325 feet deep. It is possible that the lowest portions of this facies dips below the water table. The zone of saturation is most likely in older alluvial-fan deposits or in the fine-grained units of the clay facies. The clay facies is the predominant facies in the zone of saturation in the northern and extreme southern sections of the Jornada del Muerto Bolson. Water production is mainly in the southern region of the Jornada del Muerto on the lower slopes of the large alluvial-fan facies north of Highway 70 and south of the Point of Rocks. The depth to the water table is between 300 to 575 feet and the thickness of the satu-

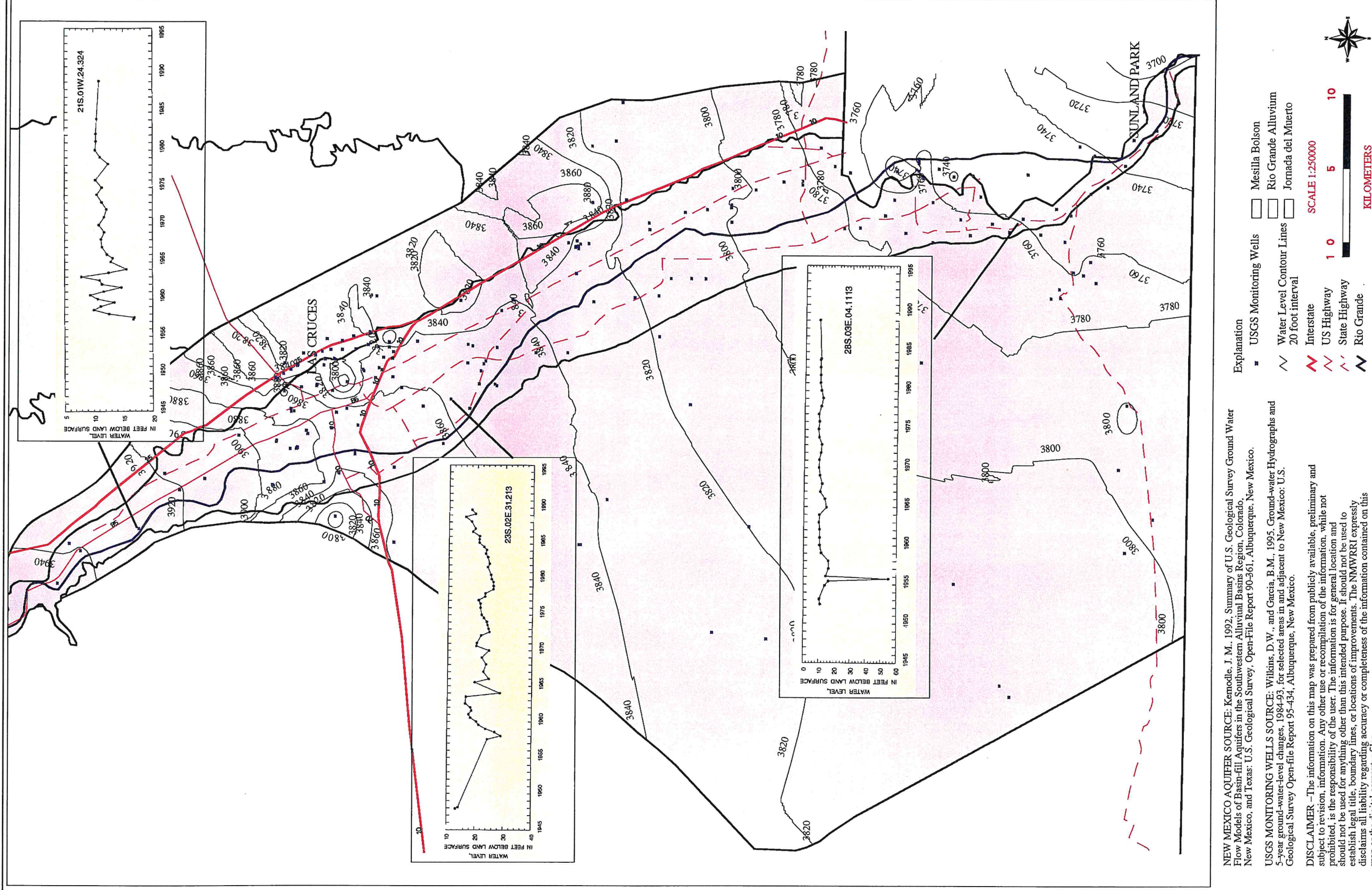


Figure 2.3. Water Level Contours and Selected Hydrographs for the Mesilla Bolson and Rio Grande Alluvium Aquifers

rated sediment is between 400 to 500 feet. Four wells drilled into the large alluvial-fan of the southern San Andres Mountains have penetrated more than 1,000 feet of alluvial sediment and pump a substantial amount of water (King and others, 1971). The City of Las Cruces currently is in the process of establishing a well field in the southern portion of the Jornada del Muerto Bolson. Shoemaker and Finch (1996) in a report prepared for the City of Las Cruces estimated that the ultimate rate of annual withdrawal from the aquifer could be about 9,000 acre-feet per year.

Groundwater Movement

Groundwater movement in this bolson varies greatly. The groundwater in the northern part of the bolson moves south down the valley and west toward the Rio Grande into the Rincon Valley at an average gradient of 150 feet per mile. Groundwater from the southern part of the bolson moves north and west into the Rincon Valley at an average gradient of 10 feet per mile. There is some evidence that groundwater in the southern section may move west across the subsurface igneous boundary into the Mesilla Bolson through subsurface channels that have been eroded through the boundary. It has been speculated that large amounts of fresh water could be pumped from one of these channels (Wilson and others, 1981). Shoemaker and Finch (1996) estimated that subsurface groundwater flow across the boundary from the Jornada del Muerto into the Mesilla Bolson amounted to about 2,860 acre-feet per year. Frenzel's (1992) model estimated about 3,790 acre-feet of flow per year from the Jornada into the Mesilla across their common boundary. The specific capacities for wells in the southern section of the Jornada del Muerto Bolson is about 5 gpm/foot drawdown. Estimated transmissivity values in this area range from 5,000 ft²/day to 15,000 ft²/day (Wilson and others, 1981).

Recharge

Recharge into the Jornada del Muerto Bolson occurs primarily from precipitation and infiltration of moun-

tain front runoff through major arroyos (Frenzel and Kaehler, 1990).

Water Quality

Groundwater in the southern section of the Jornada del Muerto Bolson is classified as fresh. The hardness of the water ranges from 24 to 320 mg/l. Water in the northern section of the bolson is classified as slightly saline. In the Rincon Valley, where most of the groundwater is discharged, dissolved-solids concentrations taken from depths of 130 ft to 150 ft, and 250 ft to 280 ft were 1,800 and 2,820 mg/L respectively. Both Shoemaker and Finch (1996) and Icerman and Lohse (1983) reported that some water enters the aquifer in the form of geothermal water moving upward, presumably along a fault zone or zones, in the area east of Las Cruces. Shoemaker and Finch (1996) estimated the volume to be about 59 acre-feet per year.

WATER USE

Total water use, both surface water and groundwater, is summarized by category in Tables 2.1 through 2.4 for Doña Ana County, New Mexico for the years 1990, 1985, 1980, and 1975, respectively. The groundwater withdrawals numbers are not separated by aquifer source (Alluvium, Mesilla Bolson, or Jornada Bolson) and include withdrawals from each. In 1990 the total water withdrawals for all categories was 513,841 acre-feet of which 145,663 was from groundwater sources (Wilson, 1992). Depletions were 246,279 acre-feet of which 96,895 was from groundwater. Of the 96,895 acre-feet of groundwater depleted in 1990, 73% (70,900 acre-feet) was used by irrigated agriculture, 19% (18,797 acre-feet) was used by public and private domestic water uses (Table 2.1). Water use by irrigated agriculture varies from year to year and depends upon the quantity of surface water available with groundwater use providing a supplemental supply. All public and private domestic needs rely on groundwater. In 1990 there were 32 public water supply systems in the county that pumped 28,956 acre-feet (most of which were measured) with depletions estimated to be 17,410 acre-

feet (Table 2.1). These water systems are shown on Figure 2.4.

In 1975 the groundwater depletions in the county were 60,740 acre-feet for all uses, 53,710 acre-feet in 1980, and 50,958 in 1985 (Figure 2.5 and Table 2.5). The irrigated agriculture uses dominate and vary from year to year depending upon the availability of surface water. Excluding irrigated agriculture, the remaining groundwater depletions were 10,980 acre-feet in 1975, 15,380 acre-feet in 1980, 17,509 acre-feet in 1985, and 25,995 acre-feet in 1990 (Sorensen, 1977; Sorensen, 1982; Wilson, 1986; and Wilson, 1992) (Figure 2.6).

SUSCEPTIBILITY TO CONTAMINATION

Land Ownership and Land Use

The federal government is the largest landholder with 1,782,350 acres or 73% of the land in Doña Ana County. Of this total, the Bureau of Land Management (BLM) administers 63% (1,123,833 acres), and the military controls 31% (547,808 acres). The State of New Mexico holds a total of 11% of the land in Doña Ana County, and 16% of the land is privately owned. The largest percentage of private agricultural land in the county lies under the jurisdiction of the Elephant Butte Irrigation District, which administers the delivery of surface water to about 90,730 acres of cropland.

Land use in Doña Ana County is regulated by zoning and subdivision laws adopted by the county under state statutes. Residential developments and business permits are reviewed by state and local agencies. Two zoning authorities administer policy and regulations in the unincorporated portions of Doña Ana County. The Extraterritorial Zoning Commission (ETZ) has jurisdiction within five miles of Las Cruces, and the Doña Ana County Planning and Zoning Commission (PZC) reviews zoning and subdivisions outside of the ETZ and in the unincorporated areas of the county. Sunland Park, Las Cruces, Hatch, and Mesilla are incorporated

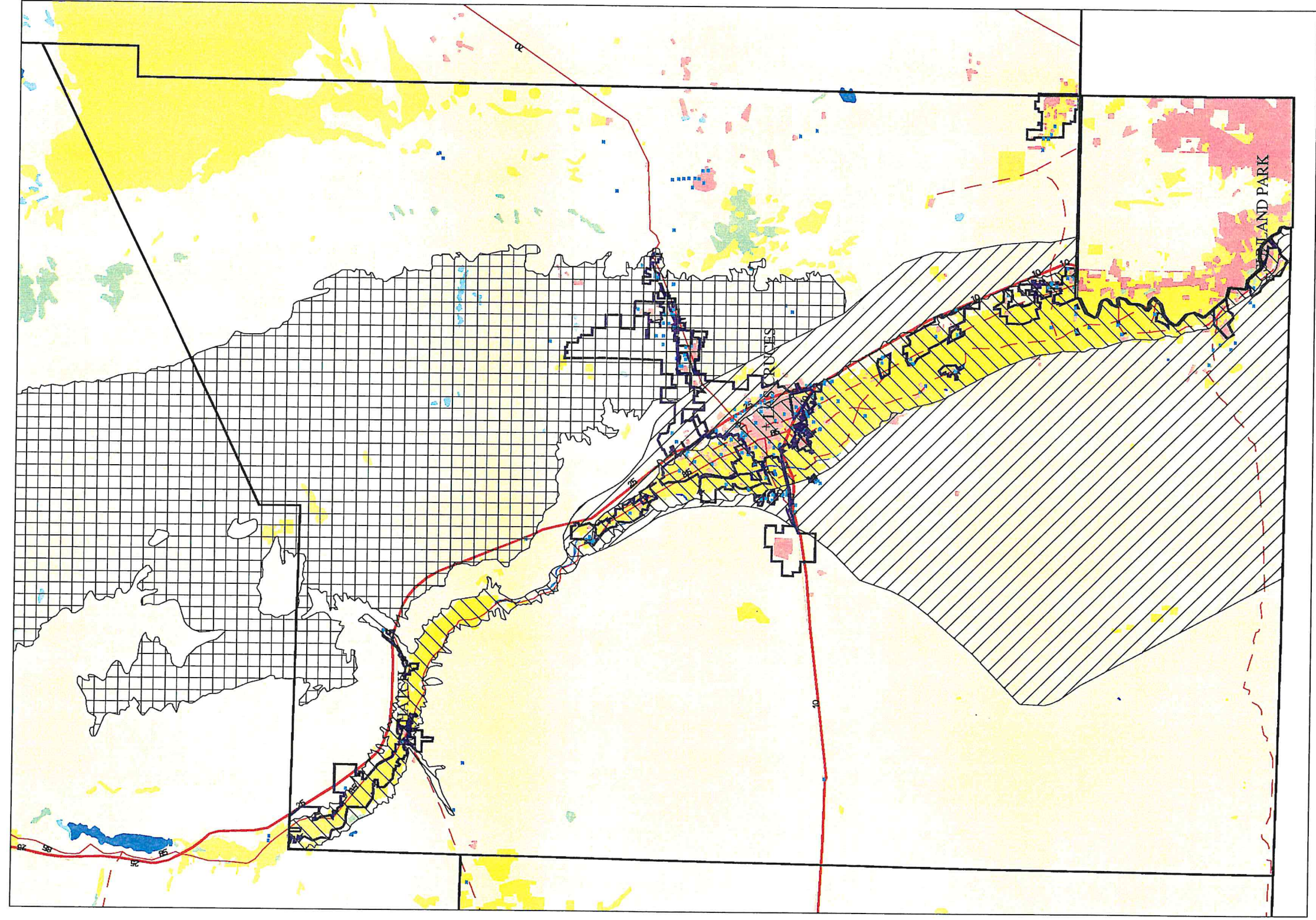
municipalities, and each has its own zoning and subdivision regulations.

Land-use statistics were reported for two categories of land: vacant lands (undeveloped tracts of federal, state, and private land holdings) and non-vacant lands. This classification was used to show the effects that undeveloped land has on the county's land statistics. The largest category of land use is agricultural (69.9%) followed by residential (16.4%). These percentages are much lower when vacant lands are included. Land use is shown on Figure 2.4. The land use shown on this map is 1982 data. If the agricultural area shown on this map is compared to the public water supply systems also shown on the map, it is apparent that a significant amount of agricultural land has been converted to residential use over the past 14 years. The land use information is of interest if the surface use has a potential impact on groundwater quality. Any activity that produces a soluble contaminant and which provides a transport mechanism (water) is a potential groundwater contamination source. The residential areas with septic tanks, and agricultural areas which perform flood or furrow irrigation are both potential pollution sources.

Special-use permits

Until 1993, zoning in Doña Ana County was carried out through the approval of special-use permits. Each permit application was considered by the PZC, and permits were approved or denied based on review by county staff, state and local agency comments and recommendations, and public comment. Most applications were approved with certain conditions.

In 1993, Doña Ana County adopted a new interim zoning ordinance which prohibits some industrial and commercial land uses until a new comprehensive plan is adopted. The largest non-residential land-use category in Doña Ana County is commercial at 42% with industrial second at 37%. Public (7%) and residential (6%) land uses lie within the miscellaneous category. Interestingly, multi-family residential special-use-permit approvals make up a small percentage of the overall



LAND USE SOURCE: U.S. Geological Survey, 1990. EPA Land Use and Land Cover Digital, Data from 1:250,000- and 1:100,000-Scale Maps -Data Users Guide 4, 1:250,000 QUAD LAND USE, 1982. Contact: Ed Partington at EPA, Phone (703) 235-5595.

WATER SYSTEM SOURCE: Dona Ana County Planning Department, GIS Division, 1996.

DRINKING WATER WELLS SOURCE: New Mexico Environmental Drinking Water Bureau, 1996.

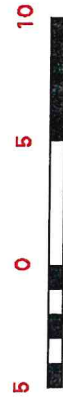
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Explanation

- Public Drinking Water wells
- Interstate
- US Highway
- State Highway
- Public Water Distribution System Boundaries
- Urban or Built-Up Land
- Agricultural Land
- Rangeland
- Forest Land
- Water
- Wetland
- Barren Land
- Mesilla Bolson
- Rio Grande Alluvium
- Jornada del Muerto

SCALE 1:500000



MILES

Figure 2.4. Public Water Wells, Water Distribution Systems, and Land Use in Dona Ana County, New Mexico

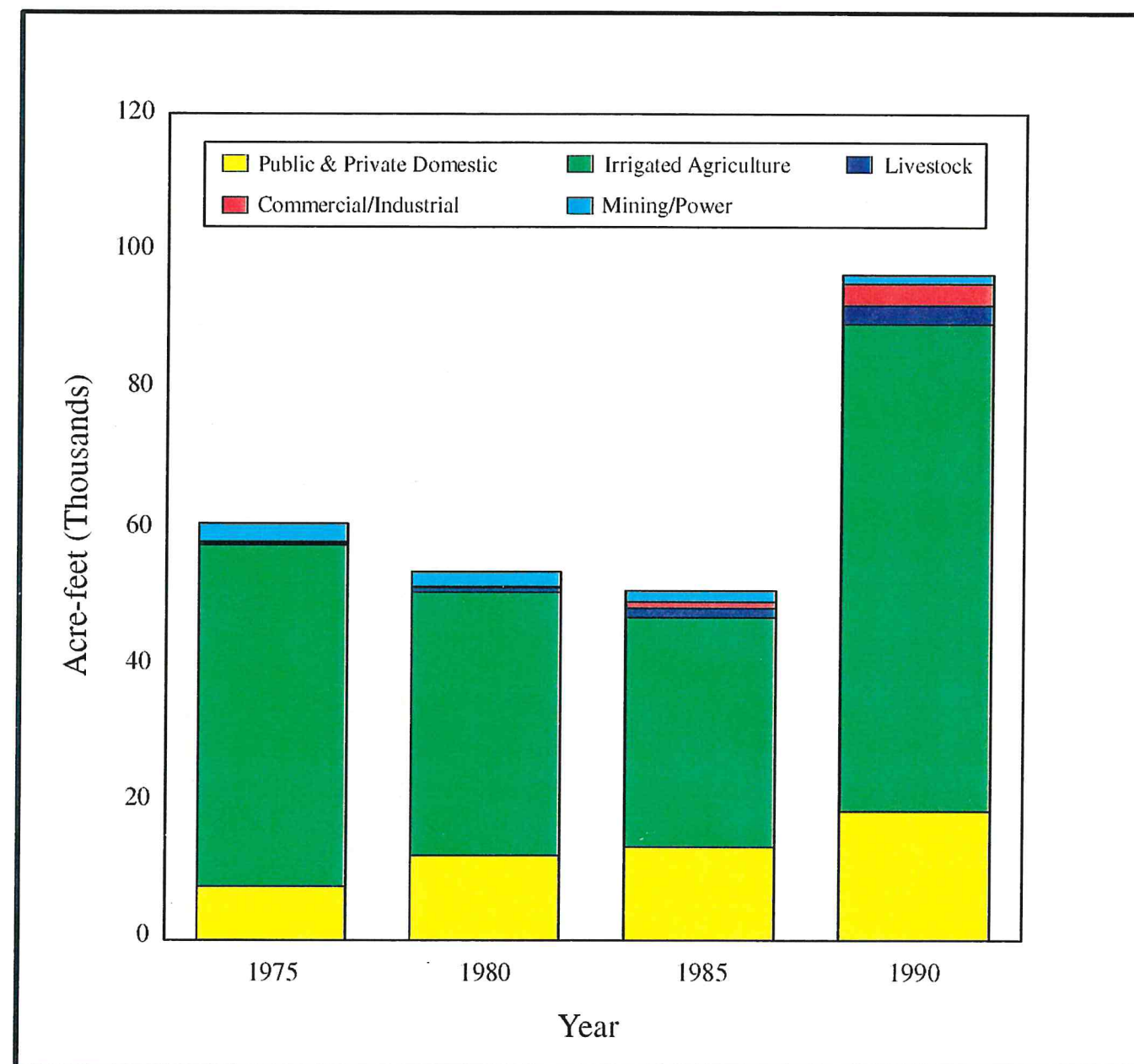


Figure 2.5. Groundwater depletions by category in Doña Ana County, New Mexico for 1980, 1985, and 1990 (source of data, Sorensen, E.F., 1977; Sorensen, E.F., 1982; Wilson, B.C., 1986; Wilson, B.C., 1992).

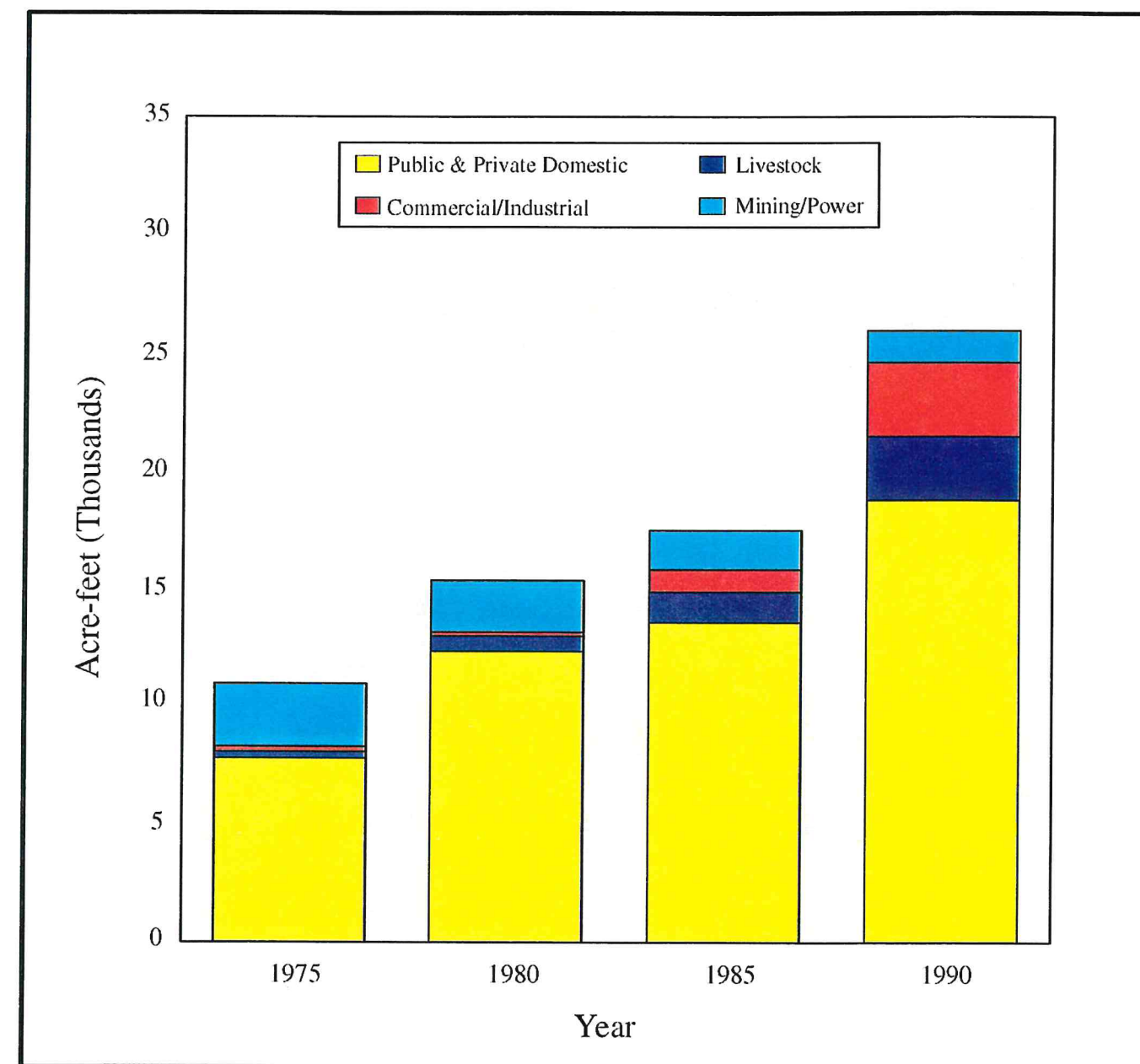


Figure 2.6. Groundwater depletions by category excluding irrigated agriculture in Doña Ana County, New Mexico for 1980, 1985, and 1990 (source of data, Sorensen, E.F., 1977; Sorensen, E.F., 1982; Wilson, B.C., 1986; Wilson, B.C., 1992).

Table 2.1. Water Use by category in Doña Ana County, New Mexico in 1990 in acre-feet.

	WSW	WGW	TW	DSW	DGW	TD	RFSW	RFGS	TRF
Public Water Supply *	0.00	28955.98	28955.98	0.00	17409.69	17409.69	0.00	11546.29	11546.29
Domestic (self-supplied) *	0.00	2311.64	2311.64	0.00	1386.98	1386.98	0.00	924.66	924.66
Irrigated Agriculture	368042.00	104989.00	473031.00	149254.00	70900.00	220154.00	218788.00	34089.00	252877.00
Livestock (self-supplied)	48.04	2977.30	3025.34	48.04	2708.47	2756.51	0.00	268.83	268.83
Commercial (self-supplied)	88.80	4547.25	4636.05	81.70	3077.55	3159.25	7.10	1469.70	1476.80
Industrial (self-supplied)	0.00	129.49	129.49	0.00	69.54	69.54	0.00	59.95	59.95
Mining (self-supplied)	0.00	44.80	44.80	0.00	11.15	11.15	0.00	33.65	33.65
Power (self-supplied)	0.00	1707.09	1707.09	0.00	1331.53	1331.53	0.00	375.56	375.56
Reservoir Evaporation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	368178.84	145662.55	513841.39	149383.74	96894.91	246278.65	218795.10	48767.64	267562.74

Column definitions: WSW= Withdrawals Surface Water, WGW=Withdrawals Ground Water, TW=Total Withdrawals, DSW=Depletions Surface Water, DGW=Depletions Ground Water, TD=Total Depletions, RFSW=Return Flows Surface Water, RFGW=Return Flows Ground Water, TRF= Total Return Flows.

* Detail below list withdrawals and calculated depletions for Public Water Supply and Domestic (self-supplied).

	Measured	WGW	DGW(calculated)
Anthony Water Works	Y	542.60	347.26
Berino Water Users Assn.	Y	196.00	98.00
Butterfield Park MDWCA	Y	84.88	42.44
Chaparral Water System	Y	879.64	439.82
Delara Estates MDWCA	Y	88.33	44.17
Desert Sands MDWCA	Y	77.54	38.77
Doña Ana MDWCA	Y	1,063.06	531.53
Ft. Seldon Subdivision	Y	88.10	44.05
Garfield MDWCA	Y	202.15	101.08
Green Valley MHP	Y	19.00	9.50
Hacienda Acres Water System	Y	286.51	143.26
Hatch Water Supply System	Y	285.44	182.68
Holly Gardens MHP	Y	24.59	12.30
Las Alturas Estates	Y	173.51	86.76
Las Cruces Municipal System	Y	16,904.92	10,142.95
Mesa Development Ctr., Inc.	Y	89.00	44.50
Mesilla Park Manor Water	Y	202.27	101.14
Mesilla Water System	Y	209.46	104.73
Mesquite MDWCA	Y	513.15	256.58
Moongate Water System	Y	563.00	281.50
Mountain View MDWCA	Y	83.69	41.85
Picacho Hills Water System	N	557.98	457.54
Raasaf Hills Water System	Y	16.32	8.16
Rincon Water Consumers Co-op	N	47.77	23.89
Rural self-supplied homes	N	2,311.64	1,386.98
San Andres Estates Water System	Y	127.61	63.81
Santa Teresa Water System	Y	2,356.80	1,932.58
Skoshi Mobile Home Park	Y	18.38	9.19
Sunland Park Water System	Y	870.92	435.46
Talavera Water Co-op1	Y	8.95	4.48
University Estates	Y	424.13	212.07
Vista Real MHP	Y	25.28	12.64
White Sands Missile Range	Y	1,925.00	1,155.00
Total		31,267.62	18,796.62

Source: Wilson, B.C., (1992)

Table 2.2. Water Use by category in Doña Ana County, New Mexico in 1985 in acre-feet

	WSW	WGW	TW	DSW	DGW	TD
Urban *	0	16021	16021	0	8012	8012
Rural *	0	5399	5399	0	2701	2701
Irrigated Agriculture	376465	58183	434648	139150	33449	172599
Livestock	136	1576	1712	136	1309	1445
Stockpond Evaporation	340	0	340	340	0	340
Commercial	0	1792	1792	0	930	930
Industrial	0	57	57	0	32	32
Minerals	0	181	181	0	60	60
Military	0	2058	2058	0	1235	1235
Power	0	1601	1601	0	1601	1601
Fish and Wildlife	0	0	0	0	0	0
Recreation	160	2485	2645	160	1629	1789
Reservoir Evaporation	0	0	0	0	0	0
Total	377101	89353	466454	139786	50958	190744

Column definitions: WSW=Withdrawals Surface Water, WGW=Wighdrawals Ground Water, TW=Total Withdrawals, DSW=Depletions Surface Water, DGW=Depletions Ground Water, TD=Total Depletions.

Detail below list withdrawals for Urban, Rural and Military.

	Urban/Rural	WGW
Anthony	U	374
Chaparral	U	439
Doña Ana	U	427
Las Cruces	U	14781
White Sands Missile Base	M	2048
Butterfield Park	R	84
Hacienda Acres MHP	R	121
Hatch	R	214
Mesilla	R	188
Mesilla Park	R	158
Pecan Valley Estates	R	36
Rincon	R	43
San Andres Estates	R	113
University Estates	R	138
Other Rural	R	4653
Total		23817

Source: Wilson, B.C., (1986).

Table 2.3. Water Use by category in Doña Ana County, New Mexico in 1980 in acre-feet

	WSW	WGW	TW	DSW	DGW	TD
Urban *	0	14179	14179	0	7089	7089
Rural *	0	4878	4878	0	2439	2439
Irrigated Agriculture	395860	58110	453970	166640	38330	204970
Livestock	257	738	995	257	642	899
Stockpond Evaporation	340	0	340	340	0	340
Commercial	0	234	234	0	141	141
Industrial	0	51	51	0	31	31
Minerals	0	181	181	0	59	59
Military	0	2010	2010	0	1209	1209
Power	0	2150	2150	0	2150	2150
Fish and Wildlife	0	0	0	0	0	0
Recreation (land based only)	255	3030	3285	255	1620	1875
Reservoir Evaporation	0	0	0	0	0	0
Total	396712	85561	482273	167492	53710	221202

Column definitions: WSW=Withdrawals Surface Water, WGW=Wighdrawals Ground Water, TW=Total Withdrawals, DSW=Depletions Surface Water, DGW=Depletions Ground Water, TD=Total Depletions.

Detail below list withdrawals for Urban, Rural and Military.

	Urban/Rural	WGW	DGW(calculated)
Anthony	U	220	110
Chaparral	U	—	—
Doña Ana	U	336	168
Las Cruces	U	12070	6035
White Sands Missile Base	M	—	—
Berino	R	20	10
Butterfield Park	R	26	13
Hacienda Acres MHP	R	111	56
Hatch	R	108	54
Mesilla	R	180	90
Mesilla Park	R	117	58
Mesquite	R	68	34
Organ	R	110	55
Pecan Valley Estates	R	31	16
Rincon	R	25	12
San Andres Estates	R	68	34
University Estates	R	170	85
Other Rural	R	3844	1922
New Mexico State Univesity	U	1553	776
Total		19057	9528

Source: Sorensen, E. F., (1982).

Table 2.4. Water Use by category in Doña Ana County, New Mexico in 1975 in acre-feet

	WSW	WGW	TW	DSW	DGW	TD
Urban	0	9705	9705	0	4852	4852
Rural	0	3508	3508	0	1754	1754
Irrigated Agriculture	412270	72930	485200	153600	49760	203360
Livestock	268	269	537	268	269	537
Stockpond Evaporation	180	0	180	180	0	180
Manufacturing	0	365	365	0	219	219
Minerals	0	181	181	0	59	59
Military	0	2000	2000	0	1200	1200
Power	0	3503	3503	0	2627	2627
Fish and Wildlife	250	0	250	250	0	250
Recreation (land based only)	0	0	0	0	0	0
Reservoir Evaporation	255	0	0	0	0	0
Playa Lake Evaporation	3200	0	3200	3200	0	3200
Total	416423	92461	508629	157498	60740	218238

Column definitions: WSW=Withdrawals Surface Water, WGW=Wighdrawals Ground Water, TW=Total Withdrawals, DSW=Depletions Surface Water, DGW=Depletions Ground Water, TD=Total Depletions.

Source: Sorensen, E. F., (1975).

Table 2.5. Summary of groundwater depletions by category for Doña Ana County, New Mexico, 1975, 1980, 1985, 1990.

	1975	1980	1985	1990
Public & Private Domestic	7806	12357	13577	18796.67
Irrigated Agriculture	49760	38330	33449	70900.00
Livestock	269	642	1309	2708.47
Commercial/Industrial	219	172	962	3147.09
Mining/Power	2686	2209	1661	1342.68
Total	60740.00	53710.00	50958.00	96894.91

Sources: Sorensen, E.F., (1977), Sorensen, E.F., (1982), Wilson, B.C., (1986), Wilson, B.C., (1992).

land uses permitted in Doña Ana County. Single family residential and agricultural uses are permitted by right and no special-use-permit is required.

Colonias in Doña Ana County

According to the US Government Accounting Office, a colonia is defined as follows:

- an unincorporated community situated within 100 kilometers of the US/Mexico border
- designated by the county or state in which it is located
- lacking adequate potable water, adequate sewage systems, and safe, sanitary housing
- was in existence before November 1990

By this definition, Doña Ana County has designated thirty-four communities as colonias. Most of these communities are located within the service areas of public water utilities, privately owned water utilities, and water associations. However, due to economic limitations, new residents often have no access to these utilities. The cost of extending water lines is prohibitive, and in many cases, water utilities do not have the capacity to accept new connections. Drilling a domestic water well in the area costs between \$5,000 and \$8,000. Many residents may dig or drive their own shallow wells and haul in potable water due to the poor water quality in the Rio Grande Floodplain Alluvium aquifer. This wide spread use of shallow wells makes water quality information on the alluvium aquifer of great interest. Unfortunately there appears to be very little water quality data available on the aquifer.

Under the State of New Mexico's 1973 Land Subdivision Act, (Section 47-6-1, et seq., NMSA, 1978) four parcels of land may be divided within three years before subdivision plat approval is required. Therefore, lots may be split without providing access to utilities such as water and sewage disposal. Developers of these marginal subdivisions argue that they provide

property ownership opportunities for low-income families. However, the cost of developing utilities becomes a heavy burden on buyers of these undeveloped lots. In some cases, the water table is less than four feet below ground surface, requiring a modified septic tank drain-field. Many homes are built in flood zones without adequate drainage. Families often must haul potable water when local water associations cannot economically extend water lines to these developments.

During the years from 1991 to 1993, the number of building permits issued for mobile homes and site-built homes in the unincorporated areas of the county averaged 1,016, a 4.5% increase in households, per year. This growth was concentrated in the Las Cruces Five Mile-Extraterritorial Zone and the South Valley of the county. This trend was continuing in 1994.

In 1993 the county was ranked as the twelfth poorest in New Mexico in per capita personal income. In many areas, the low income levels have contributed to poor infrastructure development for basic utilities, including drinking water and wastewater treatment. Figure 2.4 shows the location of public water supplies and wells in the Mesilla basin aquifers. Figure 2.7 shows the location of septic tanks in this same region.

From 1980 to 1990, the median income of Doña Ana County residents rose faster than inflation in the county. However, at the same time, the percentage of county residents below the poverty level rose from 22.7% to 26.5% (South Central Council of Governments 1994).

From 1988 to 1993, the labor force in Doña Ana County increased by 7.0% with declining increases each year. In this period, the number of employed persons in the county increased by 5.3%, and the number of unemployed persons increased by 26.9%. Unemployment in each year was lowest in January and highest in June, following the same trend as the size of the labor force.

Agriculture

Most of the region's farming activities are restricted to the valley (Figures 2.1 and 2.4) where the land surface is fairly level and the mean depth to the water table is about 180 cm. The main field crops grown in the area are cotton (22,850 acres), orchards (18,605), alfalfa (15,700), chile (6,000), corn (4,000), and onions (3,900) (Lansford and others, 1996). Crop production is extensively supported by irrigation. Most irrigation is done using flood irrigation systems, with little or no tail-end water.

Historical irrigation practices have used the groundwater system effectively as a reservoir in a combined stream-aquifer system. During years of sufficient surface water, most of the water needed for irrigation is diverted from the Rio Grande. Water levels in shallow observation wells located near the Rio Grande vary with river stage. Water levels in observation wells near the river increase and decline in response to the amount of infiltration of applied irrigation water (Nickerson and Myers, 1993). A portion of the shallow groundwater seeps into irrigation drains that discharge to the Rio Grande. During years of inadequate surface-water supply, groundwater is used as a supplemental water supply. This causes abnormally low groundwater levels resulting in less water being discharged to the drains. Groundwater levels generally return to normal after an irrigation season when surface water is plentiful.

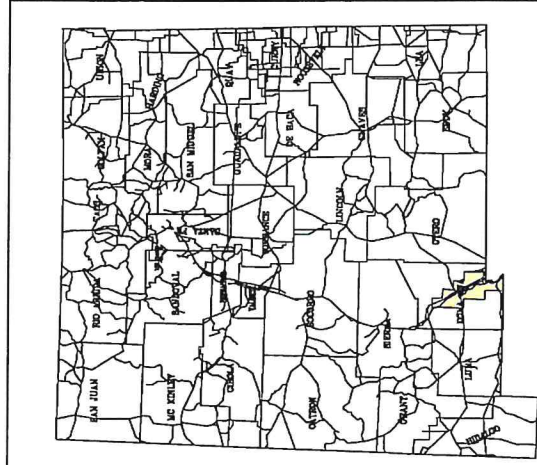
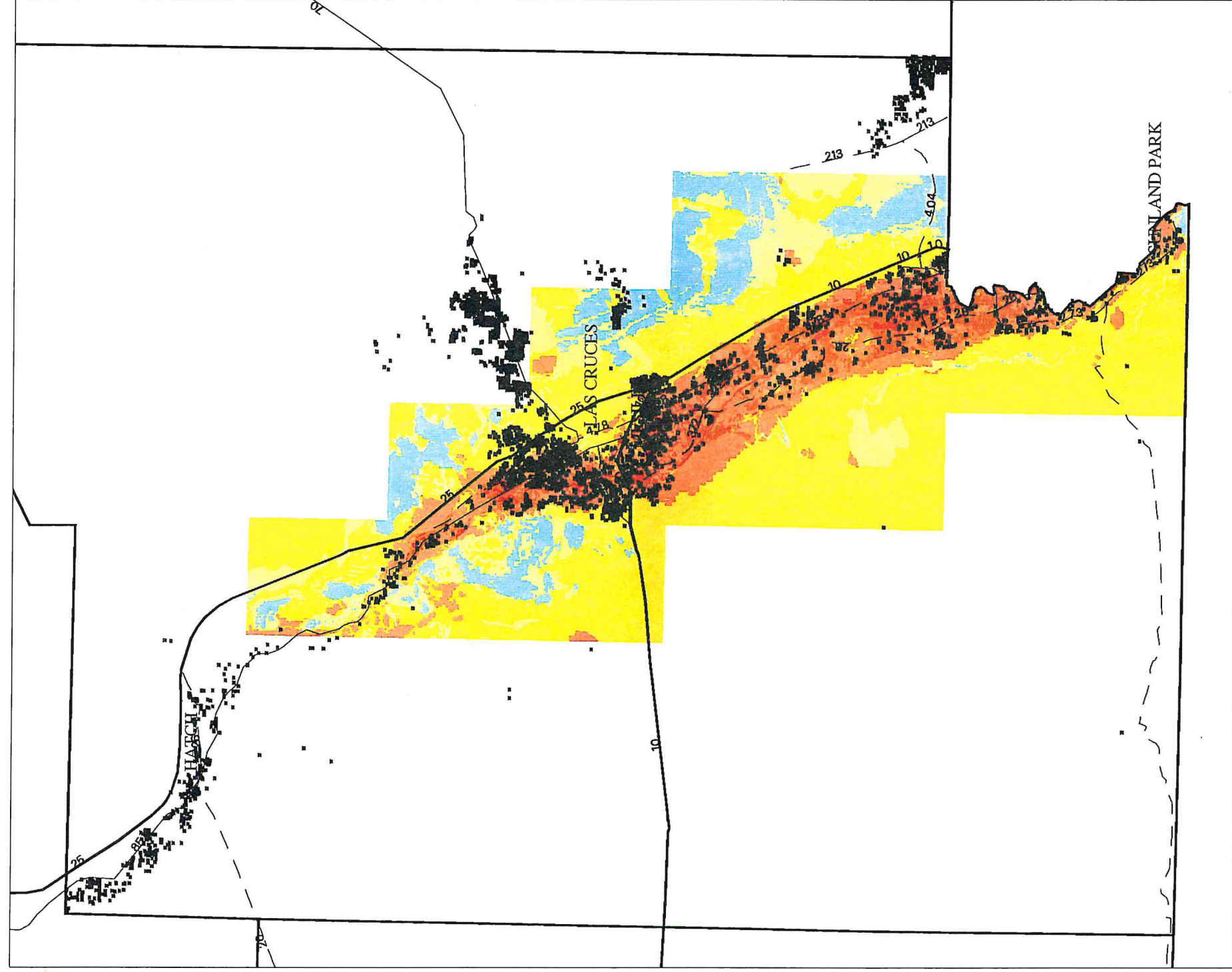
Sources of Contamination

There are two major potential sources of groundwater contamination in the Rio Grande Valley which might impact the Mesilla Bolson: agricultural activity and high density residential septic tanks. The agricultural activity can again be broadly sub-divided into two major impact categories: cropping and dairies.

Aquifer sensitivity assessment

A study has been completed to assess the natural sensitivity of the groundwater aquifers in the Mesilla Valley of southern New Mexico and to assess, using a model, the potential impact that farmers' and selected irrigation scheduling practices may have on selected pesticides leaching and concentrations below the root zone (Creel and others, 1997).

This assessment of the natural sensitivity of the groundwater aquifers employed a regional Geographic Information System (GIS) to determine and map the relative sensitivity of aquifers to contamination sources. The DRASTIC model was used to assess aquifer sensitivity by combining data sets that describe the depth-to-groundwater, recharge rates, aquifer material, soils composition, land slope, vadose zone materials, and saturated hydraulic conductivity. The study evaluated the data requirements and techniques necessary to employ the DRASTIC model so that it could be utilized in other regions of New Mexico. GIS coverages were developed for each of the DRASTIC parameters and combined into a natural sensitivity coverage for the study area. The resulting natural sensitivity values were grouped into six categories: very slight - indicating that the groundwater aquifer is very well protected and risk of contamination from nonpoint sources is very low; slight - the groundwater aquifer is reasonably well protected, but because one or more of the hydrologic parameters are conducive to contaminate transport, there is a higher level of risk of nonpoint pollution; low - the groundwater aquifer is somewhat protected, but more than one of the parameters are conducive; moderate - the groundwater aquifer is susceptible to contamination because few natural protections exist; severe - the groundwater aquifer is much more susceptible to contamination due to several hydrologic conditions; and extreme - all hydrologic parameters are conducive to the rapid transport of contamination to the groundwater aquifer. Results indicated that of the 2,282 km² included in the study area less than one percent was classified as extreme, slightly over 10 percent as severe,



Explanation

- Septic Tanks
- Interstate
- US Highway
- State Highway
- County Line
- VERY SLIGHT - groundwater aquifers are very well protected and risk of contamination from non point sources is very low (overall DRASTIC index less than 86).
- SLIGHT - groundwater aquifers are reasonably well protected, but because one or more of the hydrologic parameters are conducive to contaminant transport, there is a higher level of risk of non point pollution (overall DRASTIC index from 87 to 112).
- LOW - groundwater aquifers are somewhat protected, but more than one of the parameters are conducive to contaminant transport (overall DRASTIC index from 113 to 139).
- MODERATE - groundwater aquifers are somewhat susceptible to contamination because few natural protections exist (overall DRASTIC index from 140 to 175).
- SEVERE - groundwater aquifers are much more susceptible to contamination due to several hydrologic conditions (overall DRASTIC index from 176 to 200).
- EXTREME - all hydrologic parameters are conducive to the rapid transport of contamination to the groundwater aquifers (overall DRASTIC index greater than 200).

SOURCE: Creel, B., Sammis, T., Kennedy, J.F., Sitze, D.O., Asare, D., Monger, H. C., and Samani, Z. A., Groundwater Aquifer Sensitivity Assessment and Management Practices Evaluation for Pesticides in the Mesilla Valley of New Mexico: New Mexico Water Resources Research Institute, New Mexico State University, Las Cruces, New Mexico (in press).

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SCALE 1:500000



KILOMETERS



Figure 2.7. Septic Tanks and Natural Sensitivity of the Mesilla Valley
Dona Ana County, New Mexico

almost 19 percent as moderate, almost 43 percent as low, almost 16 percent as slight, and over 12 percent as very slight.

Cropping activity

The cropping activities which may have a negative impact on the groundwater are: fertilization practices, pesticide and herbicide use, and irrigation practices. Some examples will be used to demonstrate the magnitude of the problem. Nitrate concentrations of 10 - 40 mg/L have been reported in the shallow groundwater just below onion fields (Gallego, 1994). Fertilization in excess of plant use may move down past the root zone and go to the groundwater if it is not intercepted by a drain.

The other major inorganic agricultural contaminant of concern, besides nitrate, in both surface and groundwater is salinity. The TDS of the river water progressively increases as the Rio Grande flows toward the south (Wierenga, 1979). The increased salinity of the groundwater is due to irrigation return flow from about 400 miles of open drains installed along the agricultural fields in the Mesilla Valley and the influx of treated wastewater from municipalities. The drain ditches intercept the water table in the valley and drains the incoming seepage from agricultural fields into the Rio Grande. The drains play an important role in the quality of the groundwater by intercepting and draining the seepage water from the farms. However, drains do not intercept the entire seepage water, thus some of the seepage water replenishes the aquifer in the areas where pumping is taking place. The recharge of the aquifer by seepage water contributes to salinization of the groundwater through lateral and vertical migration of the salt. It is speculated that if the current practice of furrow irrigation was switched to drip irrigation, the quantity and quality of water seeping into the aquifer would be drastically reduced. However, there is so little baseline data available, it is difficult to quantify the magnitude of the existing flux. It is equally difficult to predict the impact of changing irrigation and fertilization practices

without first having an accurate understanding of the existing situation.

Dairies

The number of milk cows in Doña Ana County in 1994 was estimated to be 31,000 (USDA, 1994). The dairy activity is largely concentrated south of Las Cruces along the eastern border of the Mesilla Bolson. There are ten dairies along an eight mile stretch between Mesquite and Vado (Figure 2.8). In terms of waste production, each cow can be viewed as the waste equivalent of 15 - 20 people. This is roughly equivalent to the waste load of 465,000 people. The wastewater from these dairies are either stored in lagoons or applied to the agricultural fields through sprinkler or conventional flood irrigation. The seepage from lagoons, corrals and agricultural fields which cover several hundred acres, all contribute to increased groundwater salinity and nitrate contamination in the area. Figures 2.9 thru 2.11 are a detailed site map, groundwater contour map, and a contamination map, respectively. It is seen that the water directly under the dairies contains nitrate concentrations in the 100 to 150 mg/L range. Jacquez and Samani (1992) measured groundwater nitrate contamination ranging from 20 to 200 ppm and salinity of more than 1,500 ppm in the groundwater under the dairies. At this time the nitrate is not moving significantly in the groundwater. The dairies production wells are containing the majority of the plume. However, in the event the dairies cease pumping water or new production wells are developed in the vicinity, the plume would be free to move downgradient and could do significant damage to adjacent groundwater. The potential mobility is illustrated by the nitrate in the Figure 2.11 which has already started to move. The nitrate that is moving to the south is nitrate associated with the treated dairy wastewater applied to irrigated fields outside of the cone of depression formed by the dairy production wells.

Septic tanks

Although the nitrate levels associated with the groundwater under the dairies are significantly higher than those expected in septic tank effluent (150 mg/L vs 45 mg/L), and the volume of septic tank effluent is less than the volume of wastewater produced by the dairies. The waste produced is still very significant. It is estimated, based on figures from the 305(b) report, that the volume of waste water discharged to the groundwater may be as high as 2.2 MGD from septic tanks over the Mesilla Bolson. This represents approximately 825 lb/day of nitrogen being discharged into the subsurface environment from septic tanks over the Mesilla Bolson. Septic tanks are considered the single largest non-point source of groundwater contamination in the state of New Mexico. According to Water Quality and Water Pollution Control In New Mexico 1994, the Clean Water Act 305(b) report, more than 50 percent of the identified cases of groundwater contamination in the state of New Mexico are attributed to non-point (diffuse) sources. Most of these cases involve large numbers of small, household septic tanks and cesspools distributed over rapidly developing areas in unsewered subdivisions and un-incorporated rural areas. It is estimated that there are over 170,000 septic tanks and cesspools in the State with a subsurface discharge of 51,000,000 gallons of waste water every day (NMWQCC, 1994).

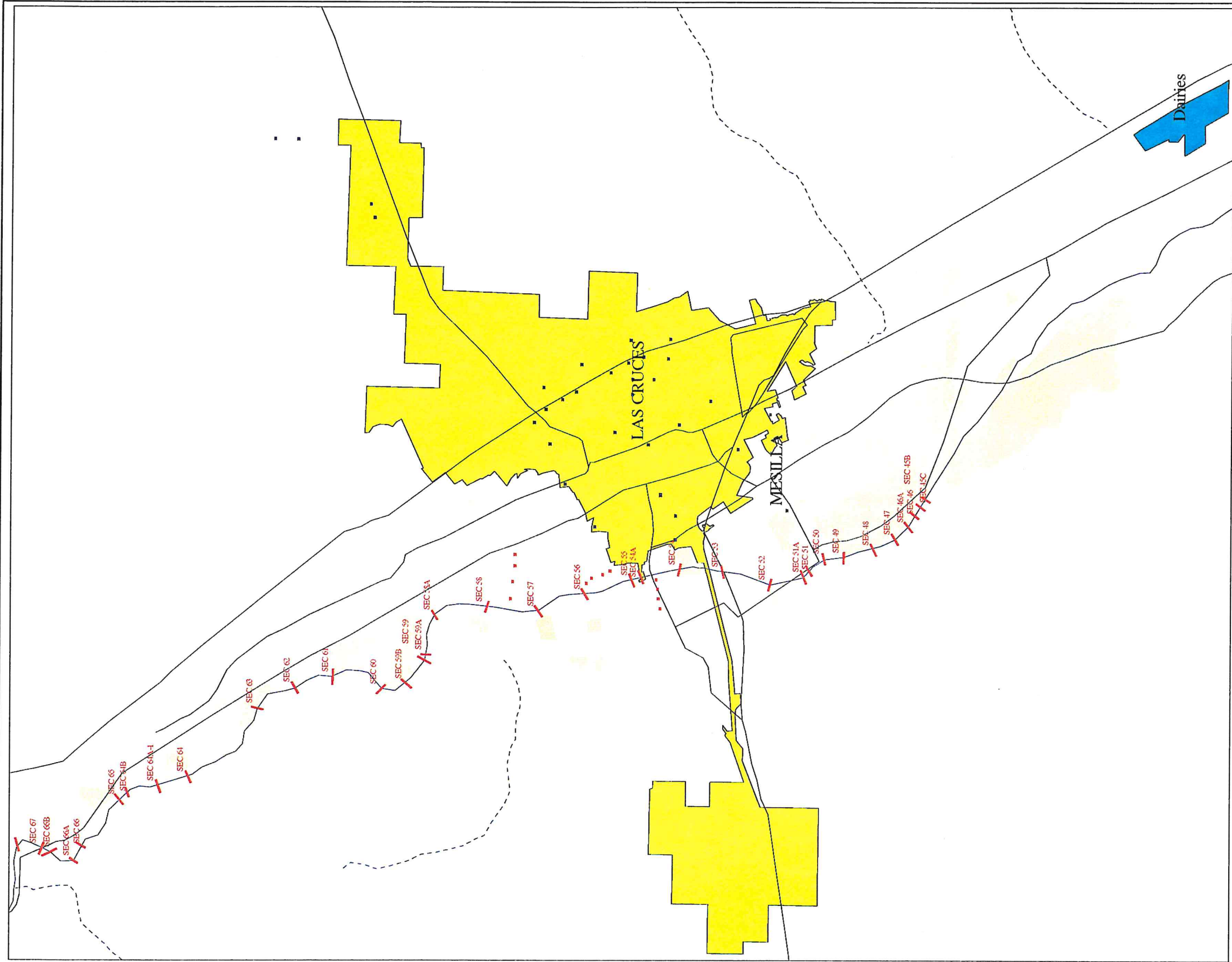
While these septic tank discharges and their impact on groundwater is a State wide problem, the areas of greatest concern are the regions associated with the Colonias, many of which are over the Mesilla Bolson. The 305(b) report (NMWQCC, 1994) referred to Colonias as one of the more serious environmental concerns facing New Mexico along its southern border. The report notes that "Congestion, uncontrolled urban development, and lack of basic environmental health and sanitation facilities have become significant problems in many communities on both sides of the border" (NMWQCC, 1994). Of the estimated 200,000 residents in El Paso County, Texas and over 40,000 residents of southern Doña Ana County, New Mexico,

fewer than 7% are on sewerred wastewater systems. The majority use on-site waste treatment systems.

The majority of the current Colonia residents are first and second generation, low income, migratory families of Mexican descent. In New Mexico the vast majority of the Colonias with their overwhelming concentrations of people and concurrent health and environmental concerns occur along the 44 mile stretch of the Rio Grande Valley from Las Cruces to the El Paso/Ciudad Juarez Metro area. In Doña Ana County alone, 43 percent of all dwellings in the un-incorporated areas were mobile homes according to 1990 data. Of these residents (about 40,000 people), only 20% are connected to public water supplies. This leads to serious environmental and public health concerns because the groundwater is very sensitive to environmental damage from non-point sources like septic tanks and their associated liquid disposal systems (drainfields).

This is illustrated by combining the natural sensitivity information map with the location of on-site liquid waste facilities (septic tanks) in Doña Ana County (Figure 2.7). The septic tank data was developed in 1994 by the Doña Ana County Planning Department by use of county land parcel database. Parcels that have had building permits issued or had mobile home utility connections, that were not served by a liquid waste treatment system were assumed to have on-site liquid waste facilities (septic or cesspool). The location of the on-site facility was calculated as the centroid of the parcel polygon. This database is shown as dots on the natural sensitivity map. It is seen that most of these septic tanks between Las Cruces and the Texas/Mexico Border are located in the naturally sensitive portion of Mesilla Valley.

The potential groundwater problems associated with dense septic tank development are well documented. Because of the reliance on groundwater in the arid southwest, this area is particularly vulnerable to damage. Very few of the individuals building homes in the Colonias and similar developments can afford the luxu-



ORCHARD LOCATION SOURCE: U.S. Geological Survey, 1990, EPA Land Use and Land Cover Digital, Data from 1:250,000—and 1:100,000—Scale Maps —Data Users Guide 4, 1:250,000 QUAD LAND USE, 1982. Contact: Ed Partington at EPA, Phone (703) 235-5595.

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- | Explanation | |
|--|---|
| Cities | • |
| Las Cruces Water Wells | • |
| Simulated Particle Path (modified from Hanson and Samani 1995) | • |
| Roads | — |
| County Line | — |
| Perennial Streams | — |
| Intermittent Streams | — |
| Canals | — |
| Sections (modified from Hanson and Samani 1995) | — |
-
- | | |
|---|---|
| City limits of Las Cruces | ■ |
| Location of Dairies | ■ |
| Orchards, Groves, Vineyards, Nurseries and Ornamental Horticultural Areas | ■ |



Figure 2.8. Dairies, Particle Tracking Sections, and Orchard Location

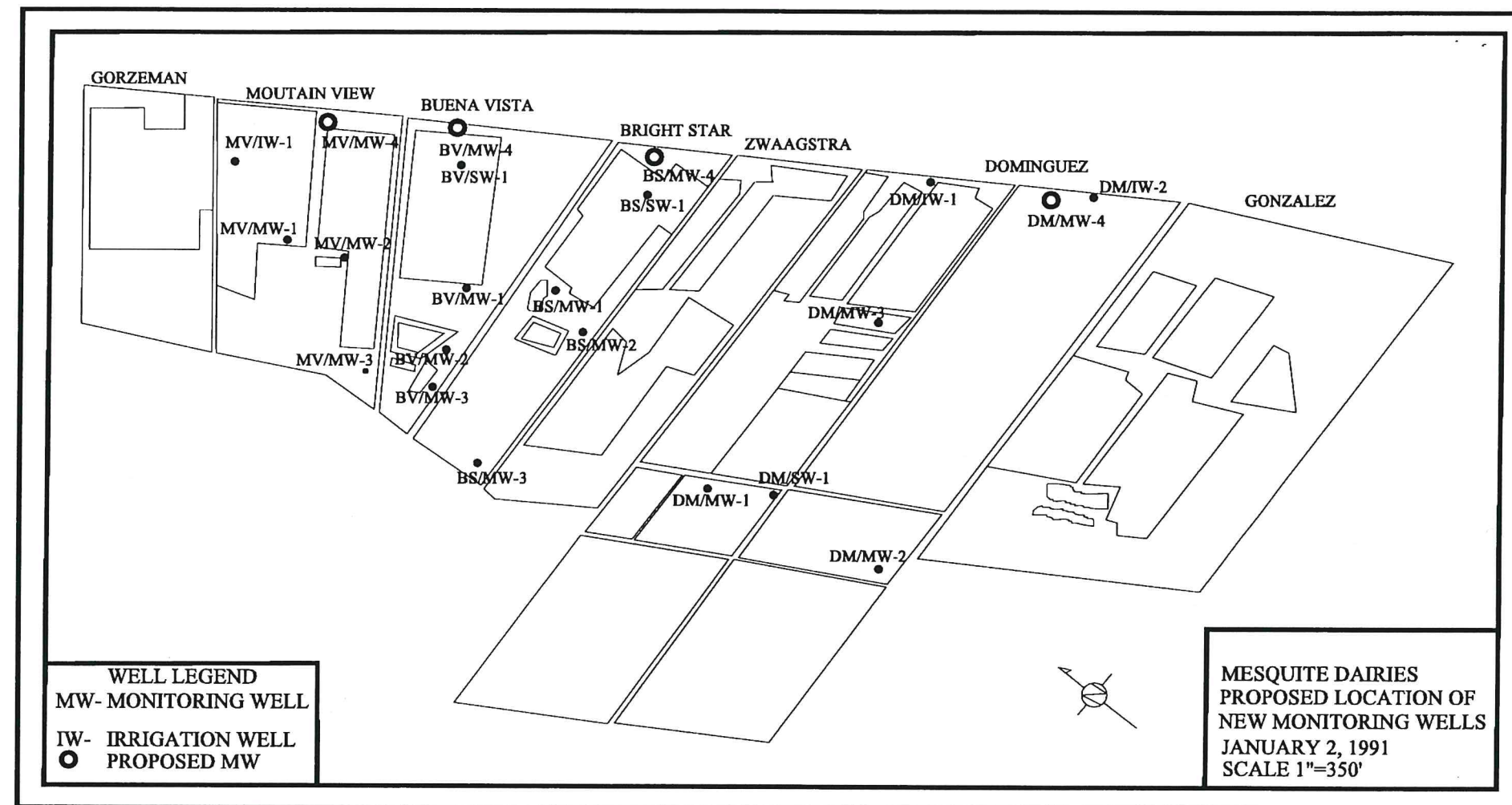


Figure 2.9. Dairy site map detail.

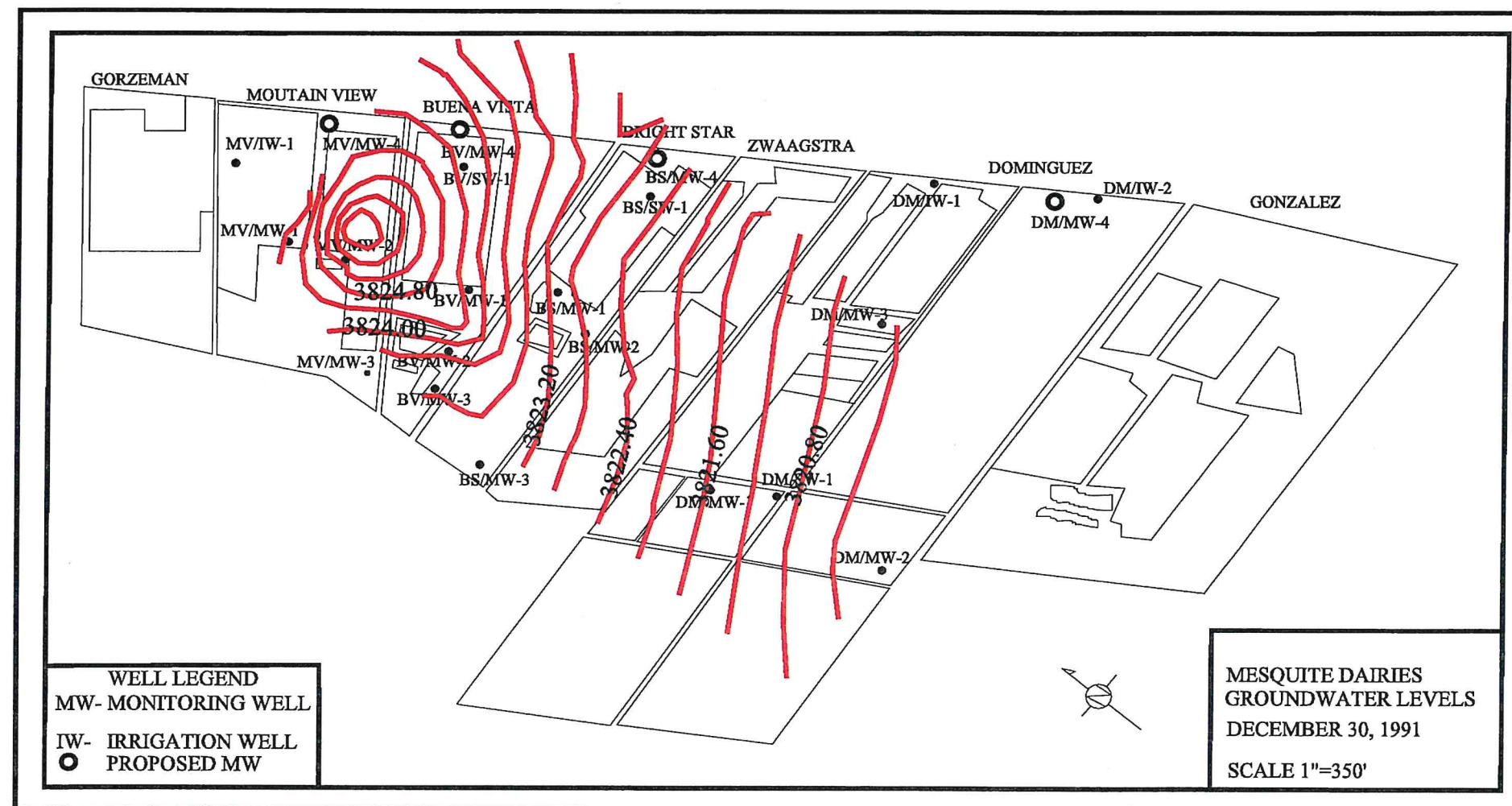


Figure 2.10. Dairy groundwater levels.

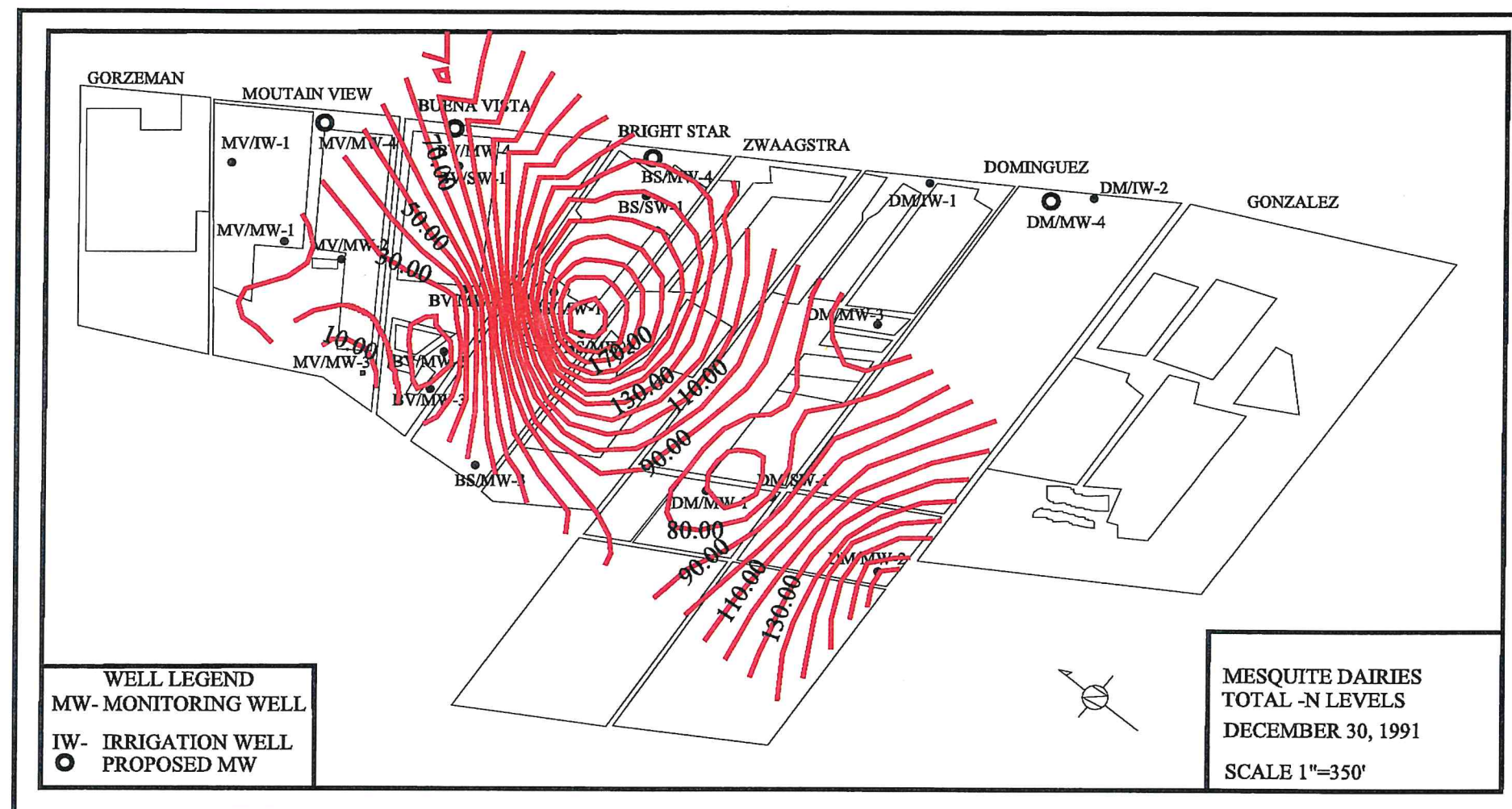


Figure 2.11. Dairy groundwater nitrate levels.

ry of hiring a contractor to install their septic tank and drainfield system. Many of the residents of Doña Ana County and El Paso Counties are extremely poor with the average annual incomes less than \$9,500. While the average incomes remain low, growth is very rapid exceeding 15 percent per year in the region. The development scenario just described has caused concern among County Planning Staffs and state environmental professionals, and represents a severe threat to groundwater in the Mesilla basin aquifers. Regardless of the nitrogen form when it is discharged from the septic tank, it will eventually be converted to nitrate. There is little possibility of the nitrate being removed from the groundwater, so it will build up over time. This will become a critical problem when the groundwater levels of nitrate approach 10 mg/L, which is the Safe Drinking Water Act (SDWA) Maximum Contaminant Level (MCL) for nitrate.

Particle tracking

One means of estimating the impact of a pollution source on the aquifer is to use a particle tracking model. Particle tracking simulations have been performed in the Mesilla Bolson near Las Cruces, NM (Hanson and Samani, 1995) to evaluate the potential for contaminate migration from the Rio Grande into the adjacent aquifer. The river reach near Las Cruces was selected since the large cone of depression associated with the City well field is a worst case condition. For the Hanson and Samani (1995) study, simulated particles were released at different stations, located at the midpoint of a cross-section, from the bottom of the Rio Grande stream bed and then tracked for a period of 50 years. An overview of the cross-sections modeled is shown in Figure 2.8.

The rate and direction of particle transport from the river to the adjacent groundwater was directly related to hydraulic gradient. The simulation showed that between sections 57 and 58, which were under strong influence of the cone of depression created by the Las Cruces City Well Field, the particles moved east toward

the cone of depression at a rate of 160 feet per year. Between sections 55 and 56, which were not affected by the cone of depression, the movement of the particles were parallel to the river channel. At sections 55 and 54, which were outside of the zone of municipal well field influence but were influenced by irrigation wells on the west side of the river, the simulated particles moved toward the west at a rate of 60 feet per year. It is clear from Figure 2.3 that the cone of depression for the municipal well field may have an impact on the transport of contaminants in the aquifer. The quality of the river water can have significant impact on the adjacent groundwater especially since some of the municipal wells are located less than 4,000 feet from the river.

There is evidence from water quality data collected by the City of Las Cruces that the cone of depression formed by the City's well field facilitates the vertical and lateral transport of contaminants from the agricultural area on the west side of the river, under the river and into the City well field. Particle tracking simulations were conducted by the City of Las Cruces (Gallego, 1994) to evaluate the potential for contamination of City's public water supply wells outside of the irrigated areas due to chemical application within the irrigated areas in the valley. The simulation showed that nitrate contamination in the groundwater below the agricultural fields can apparently reach and contaminate City's wells which are several miles outside of the agricultural areas along the interstate I-10. The results of this simulation were confirmed by actual measurement of elevated nitrate levels within the modeled wells.

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