STUDY AREA DESCRIPTION

The Mesilla Valley is located in Doña Ana County, New Mexico and El Paso County, Texas (Fig. 1). The study was restricted to the portion within New Mexico. Agriculture is a major activity, and irrigation is the chief use of water in the area. The Rio Grande is the primary source of irrigation water, which is administered by the Elephant Butte Irrigation District (EBID) in the New Mexico part of the Mesilla Valley. The Rio Grande is the primary surface-water feature. Rio Grande water is stored in Elephant Butte Reservoir, about 75 miles upstream from Leasburg Dam, and in Caballo Reservoir, about 45 miles upstream from Leasburg Dam, and in a number of reservoirs farther upstream. 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. Surface water is supplemented by ground water primarily in years when surface supplies are insufficient for crop requirements. Ground water is used for all domestic water needs both public and private.

CLIMATE

The region's climate is arid, but becomes semiarid in high mountainous areas within the region. The average annual precipitation, mostly in the form of rain, is just over 20 cm. About half the annual rainfall results from thunderstorms during July through September. Figure 2 summarizes the area's precipitation for the period 1960-1992. Temperatures average about 60 degrees Fahrenheit, but often range over a span of 30 degrees Fahrenheit during 24-hour periods in the summer.

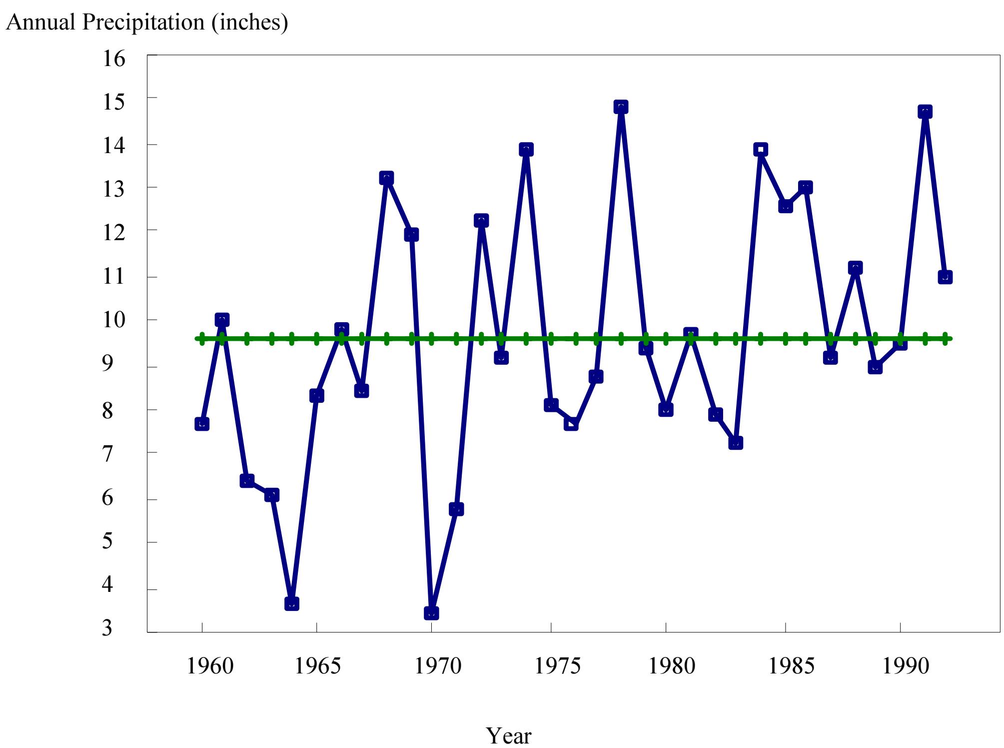
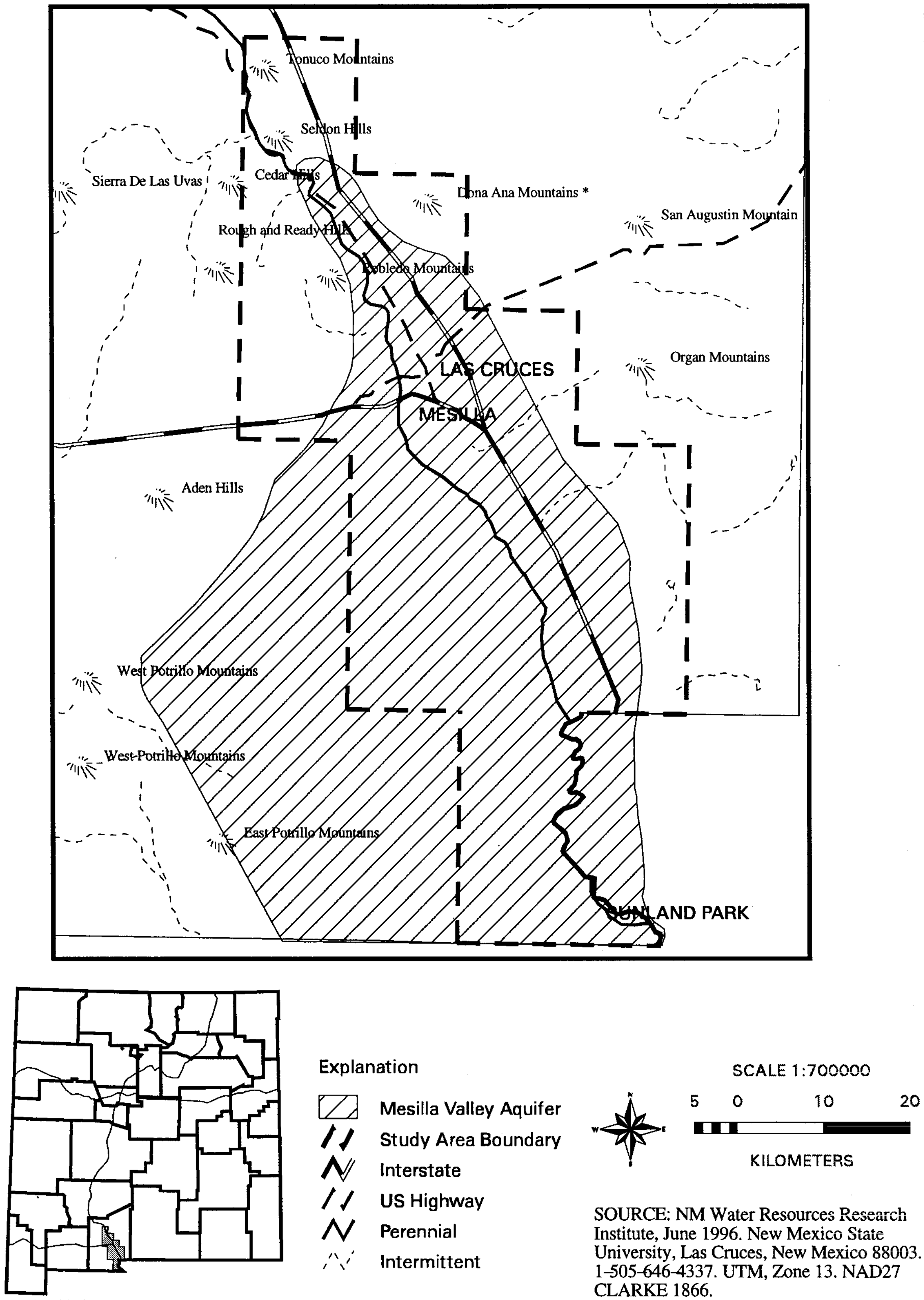


Figure 2. Annual precipitation 1960-1992, New Mexico State University, Las Cruces, New Mexico.

Figure 1. Study Area Location Map



SOURCE: NM Water Resources Research Institute, June 1996. New Mexico State University, Las Cruces, New Mexico 88003. 1-505-646-4337. UTM, Zone 13. NAD27 CLARKE 1866.

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GEOLOGY

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 (Fig. 3) 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 (Kottlowski 1958).

The Mesilla Bolson is encompassed completely by mountains. The Robledo Mountains and the Doña Ana Mountains form the northern boundary; the East and West Potrillo Mountains, the Aden Hills, the Sleeping Lady Hills, and the Rough and Ready Hills form the western boundary; the Sierra de Cristo Rey and the Sierra de Juarez form the southern boundary; and Goat Mountain, Tortugas Mountain, the Organ Mountains, Bishop Cap Mountain, and the Franklin Mountains form the eastern boundary (Fig. 1).

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 Bolson 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. Both the Organ Mountains and the Franklin Mountains are similar in composition to the Caballo Mountains (King et al. 1971).

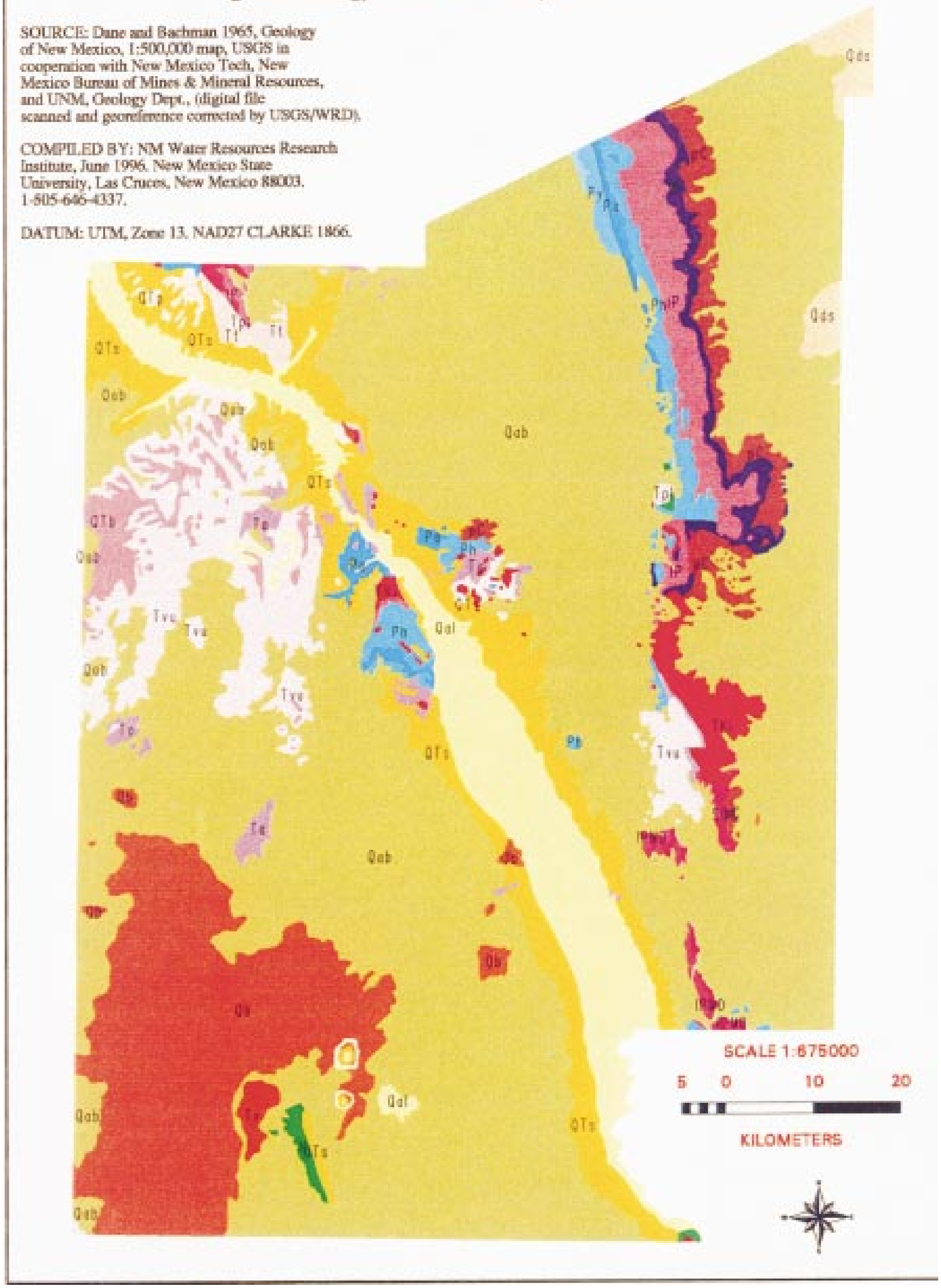
The Mesilla Bolson covers approximately 11,000 square miles. The Rio Grande enters the bolson through Selden Canyon, between the Robledo Mountains and the Doña Ana Mountains, and exits through the El Paso Narrows, between the Franklin Mountains and the Sierra de Cristo Rey. The Mesilla Valley, created by the latest incision of the Rio Grande, extends from Leasburg to northwest El Paso along the eastern portion of the Mesilla Bolson. 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).

HYDROGEOLOGY

The bolsons within the study area contain ground-water 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 et al. 1971). The Rio Grande floodplain alluvium is the upper aquifer. 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 et al. 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;

Figure 3. Geology –Dona Ana County, New Mexico



- clay facies, possibly produced by the continued erosion of alluvial-fan facies or by ancient lake and playa deposits; and
- fluvial facies, consisting of well-sorted sand and gravel deposited axially by the Rio Grande and its major arroyos (King et al. 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 et al. 1981).

The Mesilla Bolson contains most of the available water in the region. The floodplain alluvium has a basal gravel layer about 30 to 40 feet thick that is covered by sand, gravel, and clay lenses. Alluvial deposits continue hundreds of feet under the valley slopes, which have been continually building up on the floodplain ever since the Pleistocene age (Wilson et al. 1981). The water table is approximately 10 to 25 feet below the surface. Ground water within this alluvium 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 Rio Grande, drains, canals, well pumpage and heavily irrigated fields (Wilson and White 1984).

Recharge into the floodplain alluvium is due primarily to seepage from the river and canals along with infiltration of irrigation water. 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 ground-water levels. This rapid response of ground-water 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 and interbasin ground-water inflow are 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 specific capacities ranged 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 ft^2/day to 20,000 ft^2/day (Wilson and White 1984).

Most ground-water discharge from the Mesilla Bolson 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 ground-water outflow is considered minor (Wilson et al. 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 water table. 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 investigations show that the Rio Grande is usually a losing stream through most of the Mesilla Valley. Portions of the river, however, are gaining. Gains have been reported between Leasburg Dam and Las Cruces (Wilson et al. 1981) and immediately upstream from the El Paso Narrows in the southern end of the Mesilla Valley.

The Santa Fe Group is a leaky-confined aquifer. 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 Cañutillo, Texas withdraw a substantial amount of water from depths up to 1,100 feet below the surface. The southeastern sections of the basin contains a thick clay facies. At the El Paso Narrows, a bedrock high prevents much of the ground water from leaving the valley.

Recharge into the Santa Fe Group comes from the ground water in the floodplain alluvium. The water moves down through layers of sand and around clay layers. Cones of depression also permit the ground water to enter the Santa Fe Group. Based on aquifer tests, the transmissivity ranged from 10,900 ft^2/day to 40,000 ft^2/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.

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 et al. 1981; Myers and Orr 1986), that predates river-valley incision is preserved between the Mesilla Valley and the East Potrillo and Robledo mountain uplifts to the west. The Mesilla Basin (Fig. 1) is defined geologically and hydrologically by structural boundaries. The ground-water basin is bounded by uplifted blocks of bedrock or by relatively impermeable volcanic rocks and is filled with alluvial sediment from surrounding mountains and with fluvial sediment carried in by the ancestral Rio Grande.

SURFACE-WATER SYSTEM

The surface-water system in the Mesilla Valley is part of an intricate connection with the ground-water system. For more detailed discussion of the hydrologic systems of the Mesilla Valley and Mesilla Basin, and the interaction between the two systems see Wilson and others (1981), Peterson and others (1984), Frenzel (1992), and Nickerson and Myers (1993). The Rio Grande is a highly regulated stream with reservoir storage and channel stabilization throughout the area. The regulation 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). Streamflow in the river and the amount of water diverted for irrigation may vary greatly from year to year. During the irrigation season, March through September, water is released from the storage reservoirs, diverted from the river by diversion dams, and distributed through numerous canals, laterals, and ditches. Excess diversions and return flow from irrigation is returned through a network of drains. To control water flow, surface water for the area is stored in two large reservoirs, Caballo Reservoir and Elephant Butte Reservoir. 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.

The surface water available for release to the Rio Grande Project from Elephant Butte and Caballo reservoirs has been highly variable over time. This is 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).

Most of the region's farming activities are restricted to the valley (Fig. 1) 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 valley are alfalfa, chile, corn, cotton, and onions (New Mexico Department of Agricultural 1993). Crop production is extensively supported by irrigation. Most irrigation is done using furrow irrigation systems, with little or no tail-end water.

Historical irrigation practices have used the ground-water 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. Blaney and Hanson (1965) estimated that about one-third of applied irrigation water may replenish the ground-water system. Peterson, Khaleel, and Hawley (1984) in their quantification of components of a Mesilla Bolson hydrologic budget reported that the two most important sources of subsurface water in the Mesilla Bolson was applied irrigation water (62.2%) and seepage losses from surface waterways (30.0%). They further qualified their numbers "*the reader is cautioned not to interpret the average annual volume attributed to irrigation sources in Table 1 as being recharge to the water table. Instead, a very large portion of the applied irrigation water is probably lost to evapotranspiration before infiltrating water reaches saturated depths. As a consequence, it is possible that more net recharge to the saturated subsurface regime is actually contributed by stream losses than from irrigation water.*" (Peterson, Khaleel, and Hawley 1984, p 108).

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). Some ground water seeps into drains that discharge to the Rio Grande. During years of inadequate surface-water supply, ground water is used as a supplemental water supply. This causes abnormally low ground-water levels resulting in less water being discharged to the drains. Ground-water levels generally return to normal after an irrigation season when surface water is plentiful.

WATER QUALITY

Throughout the Mesilla Valley there is a layer or zone of slightly saline ground water near the land surface that occupies the flood-plain alluvium aquifer and the upper part of the Santa Fe Group (Wilson and White 1984). This zone is mostly a result of evapotranspiration and the resulting concentration of salts being flushed down to the water table. Water in this zone may exceed a dissolved-solids concentration of 2,000 milligrams per liter with sulfate being the predominant anion (Wilson and White 1984). Below the slightly saline zone is a much thicker zone of freshwater. There is a thin transition zone of freshwater having a dissolved-solids concentration of 500 to 1,000 milligrams per liter below the slightly saline water zone. Below the transition zone is a zone of freshwater generally less than 500 milligrams per liter dissolved solids that extents to a depth of 1,500 feet, and from this depth to about 2,500 feet, the aquifer contains freshwater having a dissolved-solids concentration of 500 to 1,000 milligrams per liter (Wilson and White 1984).

During 1990 sampling for agricultural chemicals was conducted for 20 wells in Doña Ana County by the New Mexico Environment Department (NMED) and analyzed for volatile organic compounds (VOCs) and carbamate pesticides. Two sites had detectable levels of VOCs but the levels were below state or federal standards. During the summer of 1992 the NMED, Surface Water Quality Bureau, conducted a water quality survey of ground-water wells and surface water drains located in Doña Ana County to analyze the water quality of irrigation wells and surface water drains for organochlorine pesticides, organophosphate pesticides, chlorophenoxy acid herbicides, VOCs, and carbamate pesticides (Richards 1993). Six surface water drains and one ground-water well were sampled. Analysis revealed no detectable levels of any of the constituents.

The U.S. Geological Survey National Water-Quality Assessment Program conducted a two-phase synoptic study of the occurrence and distribution of pesticides and nutrients in the surface water of the Mesilla Valley. Phase one, conducted in April-May 1994 during the high-flow irrigation season, consisted of a 6-week time-series sampling event during which 17 water-column samples were collected at 3 main-stem sites on the Rio Grande and a synoptic irrigation-run sampling event during which 19 water-column samples were collected at

7 main-stem sites, 10 drain sites, and 2 sites at the discharges of wastewater-treatment plants. Phase two, conducted in January 1995 during the low-flow non-irrigation season, consisted of a non-irrigation synoptic sampling event during which 18 water-column samples were collected at seven main-stem sites, nine drain sites, and two sites at the discharges of wastewater-treatment plants (Healy 1996). The 51 water-column samples were analyzed for 78 pesticides and metabolites and 8 nutrients along with other constituents. A total of 100 detections of 17 different pesticides were detected in 44 of the water-column samples. None of the concentrations exceeded U.S. EPA’s drinking-water standards or any other federal or state criteria. As many as 38 percent of these detections may be attributed to pesticide use upstream from the valley or to nonagricultural pesticide use within the valley (Healy 1996). The highest concentration of any pesticide was 0.75 microgram per liter (µg/L) of carbofuran.