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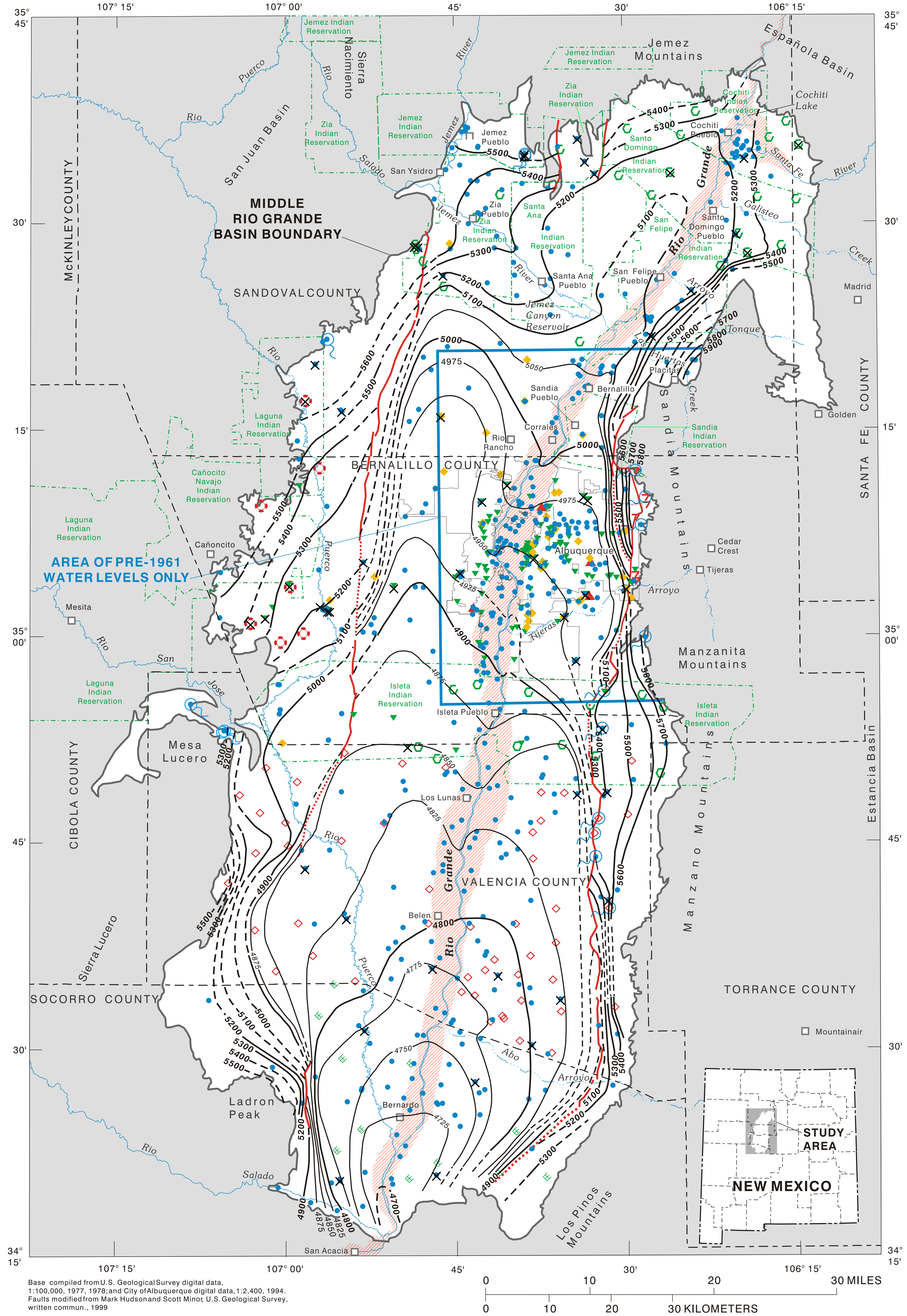
Predevelopment Water-Level Map of the Santa Fe Group Aquifer System in the
Middle Rio Grande Basin between Cochiti Lake and San Acacia, New Mexico



EXPLANATION

INNER VALLEY

WATER-LEVEL CONTOUR--Interval, in feet, is variable. Dashed where inferred. Datum is sea level

MAJOR FAULT LOCATED IN THE VICINITY OF A LARGE HYDRAULIC DISCONTINUITY

AREA OF APPARENT HYDRAULIC DISCONTINUITY, NOT LOCATED NEAR A KNOWN FAULT

DATA SOURCE:
- National Water Information System
- Meeks (1949)
- Ugrinic (1950)
- Caprio (1960)
- Bjorklund and Maxwell (1961)
- Titus (1963)
- Spiegel (1955)
- Kernodle (1998; written commun., 1996)
- Risser and Lyford (1983)

SPRING DATA

DATA DEVIATING FROM CONTOURED VALUE BY MORE THAN 50 FEET

Predevelopment Water-Level Map of the Santa Fe Group Aquifer System in the Middle Rio Grande Basin between Cochiti Lake and San Acacia, New Mexico

By Laura M. Bexfield and Scott K. Anderholm

INTRODUCTION

Because of its increasing population and limited water resources, the Middle Rio Grande Basin between Cochiti Lake and San Acacia, New Mexico, has recently become the subject of intense study. In particular, the U.S. Geological Survey (USGS) in cooperation with the City of Albuquerque has constructed a series of ground-water-flow models of the Tertiary and Quaternary basin-fill deposits of the Santa Fe Group aquifer system (Kernodle and Scott, 1986; Kernodle and others, 1987; Kernodle and others, 1995; Kernodle, 1998; Tiedeman and others, 1998). The ground-water-flow system also has been the focus of hydrochemical studies and other efforts intended largely to help develop an improved flow model. Among the information critical to a thorough understanding of the ground-water-flow system are water-level data that indicate the directions of ground-water flow and the magnitudes of hydraulic gradients in the aquifer prior to perturbation by substantial ground-water withdrawals (under predevelopment conditions).

Although maps of water-level elevations in the basin have been previously published, these maps focused on particular subsections of the basin and (or) included water levels that may have been affected substantially by ground-water pumpage. This report, prepared in cooperation with the City of Albuquerque Public Works Department, provides a water-level map representing general predevelopment conditions throughout the Middle Rio Grande Basin between Cochiti Lake and San Acacia, primarily in about the upper 300 feet of the saturated zone.

Completion of this map would not have been possible without the efforts of Lauren Todd of the USGS, who diligently entered data from older ground-water studies into computer files and transferred information onto maps to obtain well locations and land-surface elevations. The authors also thank Doug McAda and Ward Sanford of the USGS for their technical advice.

DATA SOURCES AND COMPILATION

The water-level data used to complete this map were obtained from a variety of sources, including the USGS National Water Information System (NWIS) database, reports published by Federal and State agencies, and unpublished master's theses from the University of New Mexico. In general, well or spring information from any of the sources discussed in this report was included in the data set used to produce the map if the location and land-surface elevation of the well or spring could be determined reasonably accurately and if the reported water level could be expected to broadly represent predevelopment conditions (as discussed below). Additional investigations that show water-level contours (but generally not individual data points) for parts of the region are included in the list of references at the end of this report.

The NWIS database contains water-level information for the entire Middle Rio Grande Basin from as early as the 1930's to the present. The database includes well locations by latitude and longitude, land-surface elevations, water levels and the associated dates of measurement, and other ancillary data available for some wells, such as well depth, source of water-level data, and pumping status of the well at the time of measurement. Locations and land-surface elevations of springs also are included. Many of the data included in the database have previously been published in reports by the USGS or others.

Several studies prior to the mid-1960's compiled water-level data specifically for Bernalillo and (or) Sandoval Counties in the vicinity of Albuquerque. These studies include Meeks (1949), Ugrinic (1950), Caprio (1960), and Bjorklund and Maxwell (1961). Most data for wells and springs included in these studies had not been entered into the NWIS database. These studies do not include site locations by latitude and longitude or State plane coordinates; instead, locations are listed in tables by township, range, and section, which do not provide unique positions. Consequently, wells and springs that had not previously been entered into the NWIS database were plotted on USGS 7.5-minute quadrangle maps (scale 1:24,000) based on maps of site locations included in the original reports, in addition to detailed location descriptions when available (such as provided by Bjorklund and Maxwell, 1961). Unique locations were then determined from the 7.5-minute quadrangles, along with the land-surface elevations that were used in calculations of water-level elevations. Because the process of transferring data points to 7.5-minute quadrangles may increase the amount of error associated with any particular data point, water-level elevations likely are accurate only to within a few feet. However, this error is negligible because of the scale and contour intervals used for the predevelopment water-level map. Meeks (1949), Ugrinic (1950), and Caprio (1960) do not provide dates when water levels were measured; measurements were assumed to have been made within a few years of the date of the report. Although Bjorklund and Maxwell (1961) do not provide dates for all water-level measurements, most of the dates listed range between 1956 and 1958.

Spiegel (1955) and Titus (1963) compiled early water-level data for the southern part of the Middle Rio Grande Basin. The water-level measurements compiled by Spiegel (1955) are for Socorro County and were collected during 1949-50. Titus (1963) compiled water-level measurements for Valencia County, most of which were collected during 1956-57. Most of the data collected for these studies had not been entered into the NWIS database. Similar to early studies in the vicinity of Albuquerque, these studies list well and spring locations only by township, range, and section. Therefore, each data point not already in the NWIS database was transferred from the investigator's study-area map to a 7.5-minute quadrangle to obtain latitude, longitude, and land-surface elevation.

Investigations of water resources have been conducted on several Indian Pueblos within the basin. Risser and Lyford (1983) compiled water-level data for wells and springs in the vicinity of the Pueblo of Laguna, near the western edge of the Middle Rio Grande Basin. Each data point in their report included latitude and longitude, land-surface elevation, water level and date of measurement (generally 1973-74), principal water-bearing unit, and other ancillary data. Most data points in their report had been entered into the NWIS database, but the points that had not were added to the data set used to construct the predevelopment water-level map. Craigg (1992) compiled water-level data on Jemez, Zia, and Santa Ana Pueblos. Because all data from his investigation were previously entered into the NWIS database, Craigg's report is not listed as a separate data source on the map.

Kernodle (1998; and written commun., 1996) compiled water-level data for 35 wells that had not previously been entered into the NWIS database, all of which have been included in the data set for the predevelopment water-level map. Twenty-three of these wells are concentrated in the northern part of the basin. Information available for the 35 wells includes State plane coordinates, land-surface elevations, water levels, dates of water-level measurement (generally 1993-94), and ancillary information.

To eliminate duplicate data, individual data points that had been included in more than one of the data sources previously discussed were identified, when possible. If more than one water level was available for a particular data point, the oldest water level was included in the data set used for the map. Exceptions were wells in which the oldest water level was measured while a well was being pumped or the water level appeared erroneous in comparison to data for nearby wells.

In addition to water-level data for wells and springs compiled from the sources previously discussed, riverbed elevations were included in the data set used to construct the predevelopment water-level map. Elevations of the riverbeds of the Rio Grande and the Jemez River were used because both rivers probably are in fairly good hydraulic connection with the Santa Fe Group aquifer system (Craigg, 1992; McAda, 1996). Elevations of the Rio Grande were digitized from 7.5-minute quadrangles; those of the Jemez River were obtained from USGS 30-meter digital elevation models.

SELECTION OF PREDEVELOPMENT DATA

In most areas of the basin, development is sparse and ground-water withdrawals were assumed to be small enough to have only minimal effects on water levels. Consequently, water levels measured in most areas during any year were assumed to be reasonably representative of predevelopment conditions and were included in the data set used to construct the water-level map.

In the vicinity of Albuquerque, only data determined to be representative of predevelopment conditions were used. Ground-water withdrawals are known to have affected water levels over large areas (Thorn and others, 1993). Although the extents of these areas and the temporal changes in their boundaries have not been clearly defined, they can be approximated using municipal-supply well locations, estimates of ground-water withdrawals, and long-term water-level data available for selected wells in the basin (Rankin, 1996). Prior to 1955, most City of Albuquerque municipal-supply wells were located in the inner valley of the Rio Grande and annual ground-water withdrawals were fairly small (generally less than about 25,000 acre-feet), even though withdrawals had begun to increase in the late 1940's because of population growth (Thorn and others, 1993). Therefore, effects of development on regional water levels until about 1955 probably were fairly limited. During the 1960's and 1970's, many additional municipal-supply wells were installed outside the inner valley and annual ground-water withdrawals increased to as much as 90,000 acre-feet, probably resulting in greater effects on water levels across a much wider area. Consistent with this pattern of ground-water development, the longest water-level records of Rankin (1996) indicate that substantial declines (more than 2 feet per year) in some areas, particularly near pumping centers, may have begun as early as the mid-1950's. To minimize the amount of water-level data affected by ground-water withdrawals while still retaining enough data to create a reasonably accurate picture of regional conditions, a region was defined around Albuquerque within which only data collected prior to 1961 were included in the overall data set (see map).

Water levels throughout the inner valley of the Rio Grande have historically been affected on a short (seasonal) time scale by natural and human-induced processes; thus, a detailed characterization of this area was not attempted. Water levels in the inner valley have been affected not only by ground-water withdrawals in the vicinity of Albuquerque and locally near smaller communities, but also by long-term irrigation throughout the basin. Surface water from the Rio Grande is diverted into canals (many of which are unlined) that carry water to fields in the inner valley. Interior and riverside drains constructed in the 1920's and 1930's prevent ground-water levels from rising within a few feet of land surface and damaging crops. Interactions among the Rio Grande, the irrigation system, and the ground-water system are complex and transient (probably changing at least seasonally), so a detailed characterization of their effects on water levels is beyond the scope of this report. Therefore, although the data shown on the map include inner-valley water levels that were readily available from the NWIS database, and although some consideration in contouring was given to data shown in the inner valley by previously published reports (Theis, 1938; Spiegel, 1955; Titus, 1963), no effort was made to compile additional data for this area. Because seasonal water-level changes likely are about 5 feet or less, the contours shown on the map probably represent a reasonable approximation of typical water levels in the inner valley after development for irrigation but prior to extensive ground-water development. For detailed pre-1940 water-level maps of parts of the Middle Rio Grande Basin inner valley, the reader is referred to Theis (1938).

METHODS OF CONTOURING

Contouring of water levels for the map was done by hand (rather than by use of computer software), taking into consideration all water-level and riverbed-elevation data. However, not every data point was ultimately included in contouring. This water-level map is intended to represent predevelopment conditions in the upper few hundred feet of the saturated zone of the Santa Fe Group aquifer system, which (as previously defined in Thorn and others, 1993) includes Quaternary alluvium along the Rio Grande. Therefore, preference in contouring was given to wells known to be completed in sediment of the Santa Fe Group aquifer system (as opposed to older geologic units present near basin margins) and to shallower rather than deeper wells. Preference also was given to wells with static (as opposed to pumping) water-level measurements and to wells with the oldest water-level measurements and (or) measurements that were assumed to be the least affected by regional ground-water withdrawals.

Because error is inherent in determining well locations and land-surface elevations and potentially is particularly large for data points transferred from smaller to larger scale maps, the smallest contour interval used was 25 feet. Data points with water-level elevations deviating more than 50 feet from values that would be inferred from the contours are indicated on the map. Contour segments believed to have the largest potential for error are dashed, typically in areas where few data points were available or where the available data conflicted. However, segments also are dashed in areas of Albuquerque where many of the data available were believed to have been affected by early ground-water withdrawals. These areas coincide with the locations of several of the oldest (pre-1960) well fields of the City of Albuquerque (Thorn and others, 1993).

Along limited sections of the Rio Grande and the Jemez River, the density of predevelopment water-level data was sufficient to indicate the configuration of water-level contours in close proximity to the river. The configuration of water-level contours in these areas can be used to infer whether ground water generally has flowed toward the surface-water drainage (upgradient flexures in contours at the river channel) or whether water generally has flowed outward from the surface-water drainage into the aquifer (downgradient flexures in contours). However, the density of water-level data was not sufficient to determine the configuration of water-level contours across most sections of most surface-water drainages in the basin. Because interactions between the ground-water and surface-water systems are complex and generally not well characterized over large areas, no attempt was made in areas of limited data to draw water-level contours in such a manner as to infer a particular type of interaction. Therefore, the lack of flexures in water-level contours across most surface-water drainages is not intended to indicate that no interaction exists between the ground-water and surface-water systems in those areas; instead, the lack of flexures indicates the lack of sufficient data to fully characterize any interactions that may exist.

Hydraulic discontinuities, or large differences in water levels over short lateral distances, appear to occur in several areas. The discontinuities typically are located in the proximity of major faults near the basin margins and appear on the map as closely spaced or truncated contour lines. Faults shown near the discontinuities were extracted from a digital compilation of major faults for the basin (Mark Hudson and Scott Minor, U.S. Geological Survey, written commun., 1999). Information for the fault compilation was derived from geologic mapping, gravity data, and high-resolution aeromagnetic data (Hudson and others, 1999). Areas where hydraulic discontinuities appear to occur but no faults have been mapped also are shown on the map. The apparent discontinuities across major faults likely are associated with large contrasts in hydraulic-conductivity values between fault-juxtaposed geologic materials. Some investigators, however, have suggested that ground-water flow near a fault could possibly be affected by decreased permeability caused by cementation or clay minerals in the fault zone or by preferential flow along the fault (Minor and Shock, 1998; Heynekamp and others, 1999).

Outside the major faults near the east and west sides of the Middle Rio Grande Basin, geologic units older than those of the Santa Fe Group aquifer system are known to exist within the basin close to land surface (Kelley, 1977). These units include rocks of Cretaceous and Jurassic age on the west side of the basin and rocks of Permian and Pennsylvanian age on the east side. The geologic units with which wells and springs in these areas are in hydraulic connection are not always known. Also, any differences in water-level elevations between these older geologic units and Santa Fe Group aquifer materials have not been clearly established. Therefore, although an attempt was made to contour water levels in these areas, the contours need to be regarded with caution because they may not be representative of water levels in the Santa Fe Group aquifer system or in any other single aquifer system. Instead, along different sections of its length, a contour could be representing water levels from different geologic materials that are not in hydraulic connection.

Discussion of the implications of this water-level map for predevelopment directions of ground-water flow and magnitudes of hydraulic gradients is beyond the scope of this report. Such detailed interpretation is left to subsequent investigations.

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