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# HISTORY OF WATER USE IN THE GREATER ALBUQUERQUE AREA

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## INTRODUCTION

The greater Albuquerque, New Mexico area is one of the oldest continuously occupied areas in the country. The early settlers of Albuquerque, founded in 1706, dug shallow wells in unconsolidated river alluvium in order to obtain a water supply more dependable than the Rio Grande, which periodically flooded or was very low and muddy. Subsequently, the municipal water system evolved from relatively shallow dug wells to wells drilled to depths of about 550 m (1,800 ft).

Early growth of the city was slow. Albuquerque had a population of only about 15,000 people in 1920. There were approximately 34,000 in the Albuquerque area when the first hydrologic evaluation of this region was made in 1936. It has been estimated that there were fewer than 50,000 residents at the end of World War II, but subsequent growth has been significant. The metropolitan area had a population of 331,767 in 1980, and projections by Bonem and others (1977) for the year 2000 show population estimates of 548,300 to 813,500.

The water resources of the Rio Grande Valley were first studied by Lee (1907), but the first comprehensive evaluation was conducted by the National Resources Committee for the purpose of regional planning of the Rio Grande basin (Theis, 1938). Both of these early studies emphasized the availability of water in the inner valley which, at that time, was the only area of development.

Bjorklund and Maxwell (1961) made the first thorough ground-water study of the Albuquerque area; Reeder and others (1967) presented a quantitative study which emphasized long-range projections for the same area. Additional municipal water-supply data were collected by Dinwiddie and others (1966); the fresh- and saline-water resources of the area were described by Kelly (1974). Lambert (1968), Kelley and Northrop (1975), and Kelley (1977) conducted detailed studies of the geology in the vicinity of Albuquerque. This paper is based on a comprehensive study made by Geohydrology Associates, Inc. as part of a report prepared by the Corps of Engineers (1979).

## GEOLOGIC SETTING

There are two geologically distinct provinces in the Albuquerque area. The eastern part of the region consists of the Sandia and Manzano mountains of Precambrian granite which rise 1,220 to 1,830 m (4,000 to 6,00 ft) above the Rio Grande Valley floor. The steep, rugged western face of the mountains is an eroded fault scarp. The eastern face of the mountains is gently sloping and relatively undissected. The granite is capped unconformably by a layer of late Paleozoic and Mesozoic marine sedimentary rocks approximtely 457 m (1,500 ft) thick.

The mountain province is important to the Albuquerque area as a contributor of both ground water and surface water. As much as 762 mm (30 in) of annual precpitation falls on the crest of the Sandia Mountains. This area is drained by Tijeras Arroyo, which joins the Rio Grande at the southern edge of the city. Very little surface water reaches the Rio Grande through this large arroyo (U.S. Geological Survey, 1977). Much of the surface runoff enters the permeable deposits; these act as major recharge areas to the underlying aquifers. Recently (*Albuquerque Journal,* April 7, 1982), Tijeras Arroyo has also been suspected as the source of major pollutants entering the Albuquerque ground-water system.

Most of the Albuquerque area is within the Rio Grande Valley. The Rio Grande originates in southwestern Colorado and flows southward through a series of north-south trending grabens. An aggrading stream for much of its history, the river has filled the grabens with as much as 6,100 m (20,000 ft) of sediment in southern Colorado (Kelly, 1974); up to 3,050 m (10,000 ft) of sediment is present in the vicinity of Albuquerque (Lambert, 1968). The sediments within the Rio Grande trough generally are divided into two separate geologic units: Santa Fe Group and recent alluvium. The Santa Fe Group consists of older, more consolidated sediments which accumulated in the Rio Grande Valley during Miocene (?) and Pliocene time. Through the normal erosional and depositional processes, coarse-grained sediments were deposited close to the foot of the Sandia and Manzano mountains; finer grained sediments were carried farther out into the valley. West of Albuquerque, the Santa Fe deposits generally are fine grained. Most of the material was derived from erosion of the fine grained Cretaceous sedimentary rocks of the San Juan Basin. This is interbedded with volcanic deposits and flows which originated along the western margin of the Albuquerque basin.

Following deposition of the Santa Fe Group, central New Mexico underwent a period of erosion. A series of coalescing alluvial fans of Quaternary age were deposited unconformably on the Santa Fe Group deposits. These fan deposits extend westward from the base of the mountains onto the floodplain of the Rio Grande. The sediments include both poorly sorted mudflow material and well-sorted stream gravel and may be up to 60 m (200 ft) thick. The contact of the alluvium with the underlying Santa Fe Group is not readily evident from well logs. However, the contact may be recognized by a change in lithologic character and degree of consolidation; this change generally occurs between 24 and 37 m (80 and 120 ft) below the land surface (Reeder and others, 1967).

## HYDROLOGIC SETTING

### Well Field Development

The first well field of the City of Albuquerque was constructed near the present intersection of Tijeras Avenue and Broadway (Bjorklund and Maxwell, 1961). Nine wells were hand dug, and each well reportedly had a yield of about 63 Us (1,000 gpm). One of these wells was 5 m (16 ft) in diameter and 10 m (32 ft) deep! These wells were gradually replaced by drilled wells in the Main Plant well field (fig. 1) which ultimately contained 23 wells ranging in depth from less than 61 m (200 ft) to more than 152 m (500 ft).

Four wells ranging in depth from 88 to 176 m (288 to 578 ft) were drilled in 1948 to offset the decline of the Main Plant field. These four wells comprise the Candelaria and Broadway. Significant expansion of the municipal system began about 1949 with the simultaneous development of the Duranes field along Rio Grande Boulevard (presently north of 1-40) and the San Jose field in the South Broadway area. West of the Rio Grande the Atrisco field was developed in the Five Points areas. Wells in all three fields are still in operation; however, many of the older wells have been abandoned and replaced. The City's first 305 m (1,000-ft) well was completed in the Duranes field and reportedly produced 177 Ps (2,800 gpm) (Bjorklund and Maxwell, 1961).

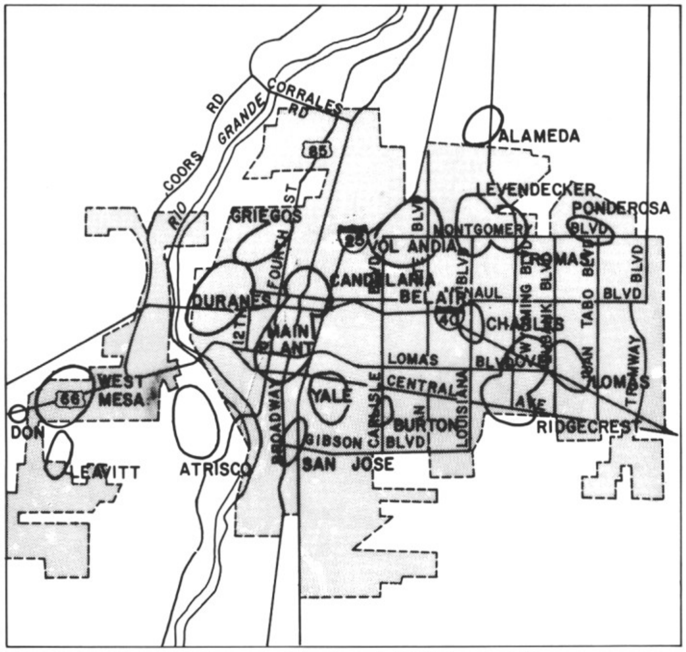


*Figure 1. Map showing municipal well fields in the Albuquerque area.*

During the later 1940's and early 1950's, a number of wells were drilled by private industry within and near Albuquerque. Three wells were constructed in the Bel Air subdivision, and these were subsequently incorporated into the municipal system. The old Hilton Hotel and all major hospitals drilled their own wells. The military expanded its water-supply system at Kirtland Air Force Base, and the Public Service Company drilled wells near Rio Bravo and South Broadway.

The five-well Griegos field was developed between 1955 and 1958 in the north valley east of the river. All of these wells were about 274 m (900 ft) deep. Three slightly deeper wells comprise the Burton field; these were drilled in 1954-1962.

Major expansion of the municipal water system began in 1959 with the development of several new well fields. West Mesa No. I was drilled to a depth of 360 m (1,180 ft) and produced water having a temperature of 32°C (90°F) at the land surface. Four wells ultimately were completed in this field. The Leyendecker and Thomas fields were the first development in the area now known as the Northeast Heights. Each field contains four wells, all of which are highly productive.

The Love field is comprised of five wells having an average depth of about 381 m (1,250 ft). This field, which is centered near Lomas and Wyoming, is characterized by a wide range in production capacities.

The Vol Andia field wells were started in 1960, and to date, six wells have been completed. This field is located midway between the old Candelaria field and the Leyendecker field. During the same time, Paradise Hills subdivision was started on the West Mesa and two wells were completed; the Ponderosa field near the intersection of Juan Tabo and Montgomery also went on line at this time.

The first Lomas field well was completed in about 1962. This field, which is located near the foot of the Sandia Mountains on Lomas Boulevard, had very low production rates.

The three wells in the Yale field south of the University of New Mexico were constructed beginning in 1964 as some of the older wells in the Southeast Heights went out of production. The Don No. 1, which is located on the far West Mesa, was drilled in 1961 and was found to have the greatest production capacity of any wells west of the Rio Grande. Construction of the four-well Charles field began in 1968. These wells penetrated a highly productive section of the aquifer midway between the Leyendecker and Love fields. Ridgecrest No. I was drilled in 1964.

The Volcano Cliffs subdivision on the West Mesa began production from two wells in 1974. Additional expansion has continued to the present with the most recent drilling activity in the Alameda field. There are now 84 wells in the Albuquerque municipal water system.

## Aquifer Characteristics

During the early development of the Albuquerque water system, all of the wells tapped the unconsolidated alluvium of the river valley. Subsequently, the wells were drilled through the alluvium and into the underlying Santa Fe Group deposits. At the present time, virtually all of the municipal wells are completed in Santa Fe with the upper portion of the hole, including the alluvium, being cased off. However, in the inner valley areas of the metropolitan area, numerous wells which tap the alluvium are drilled for private uses.

A number of aquifer tests have been conducted on the various municipal and industrial wells in the Albuquerque area (Table 1). The highest transmissivity values were measured in wells located in the middle part of the East Mesa, where well-sorted deposits are penetrated by wells tapping the Santa Fe aquifer. In this area, most transmissivity values exceed 1,236 $m^2$/day (13,300 $ft^2$/day); however, there is considerable variation within short distances and in individual well fields. These variations probably are due to changes in lithology of the aquifer and possibly can be credited to the ancestral arroyos that drained the western flank of the Sandia Mountains. The location of high transmissivity values in the Charles Wells, Thomas, and Leyendecker fields are closely aligned with Embudo Arroyo and Arroyo del Oso.

Poor sorting of aquifer sediments near the mountain front is reflected in the relative low values for transmissivity in the Lomas and Ponderosa well fields. Bjorklund and Maxwell (1961) reported the lowest transmissivity values in a well near the Four Hills area and very close to the mountain front. This well reportedly penetrated a thick sequence

*Table 1. Transmissivity values for selected well fields of the Albuquerque area; see Figure 1 for locations of fields.*

| | Transmissivity ($ft^2$/day) | | |
|---|---|---|---|
| **Field Name** | **Minimum** | **Maximum** | **Average** |
| Atrisco | 60,000 | | 60,000 (a) |
| Burton | 60,000 | 68,000 | 64,000 (b) |
| Chas. Wells | 107,000 | 210,000 | 184,000 |
| Don | 75,000 | | 75,000 (a) |
| Duranes | 6,500 | 62,000 | 32,900 |
| Griegos | 21,000 | 55,000 | 31,400 |
| Leavitt | 19,100 | 27,000 | 23,000 (b) |
| Leyendecker | 150,000 | 600,000 | 450,000 |
| Lomas | 3,000 | 60,000 | 31,500 (b) |
| Love | 5,000 | 150,000 | 58,000 |
| Ponderosa | 5,000 | 40,000 | 22,500 (b) |
| Ridgecrest | 35,000 | 114,000 | 87,000 |
| San Jose | 34,000 | 50,000 | 40,000 |
| Santa Barbara | 112,000 | | 112,000 (a) |
| Thomas | 100,000 | 400,000 | 245,000 |
| Tracy | 78,000 | | 78,000 (a) |
| Vol Andia | 102,000 | 300,000 | 173,400 |
| Volcano | 49,000 | | 49,000 (a) |
| West Mesa | 27,000 | 50,000 | 37,200 |
| Yale | 28,000 | 70,000 | 52,000 |

a = only one test.
b = only two tests.

of poorly sorted sediments, including a significant quantity of clay Similar conditions have been found in the Lomas and Ponderosa fields.

The effect of sorting on fan deposits in south-central New Mexicc was described by Kelly and Hearne (1976). In general, more coarse-grained, poorly-sorted sediments are found near the mountain front Several kilometers away from the source area, these deposits frequentl) retain their coarse-grained characteristics but the degree of sorting hay been increased by stream action. Fine-grained sediments predominate at more distant areas. Thus, the most permeable sediments and highes producing wells are located midway between the mountain front anc the inner valley or river; areas of lower permeability are present alorq the mountain front and in the inner valley.

Intermediate values of 437 to about 1,236 $m^2$/day (4,700 to about 13,300 $ft^2$/day) were determined for wells in the Ridgecrest and Griegem fields. Low values of transmissivity predominate in the San Jose anc Duranes fields on the east side of the Rio Grande and all of the wel fields west of the river. Several wells tested in the vicinity of the Ric Puerco have very low-yield capabilities which reflect fine-grained sediments derived from fine-grained sandstones and shales which crop out along the western boundary of the Rio Grande trough.

## Ground-Water Development

### *Water table prior to 1936*

The earliest known water-table map of the Albuquerque area wa! produced by Theis (1938) during October, 1936. There was a genera slope on the water table from northeast to southwest, roughly paralle to the orientation of the inner valley and channel of the Rio Grand( (fig. 2). The only deviation from this regional trend was produced 1:1, the various drains and canals which contributed recharge to the allu vium. In 1936, the city was drawing slightly less than 126 Vs (2,00( gpm) from the original dug wells and the shallow drilled wells in the Main Plant field. Since the water loss to the channel of the Rio Grand( greatly exceeds this amount, it is not surprising that the impact of th( city well fields was not apparent on the water table in 1936.

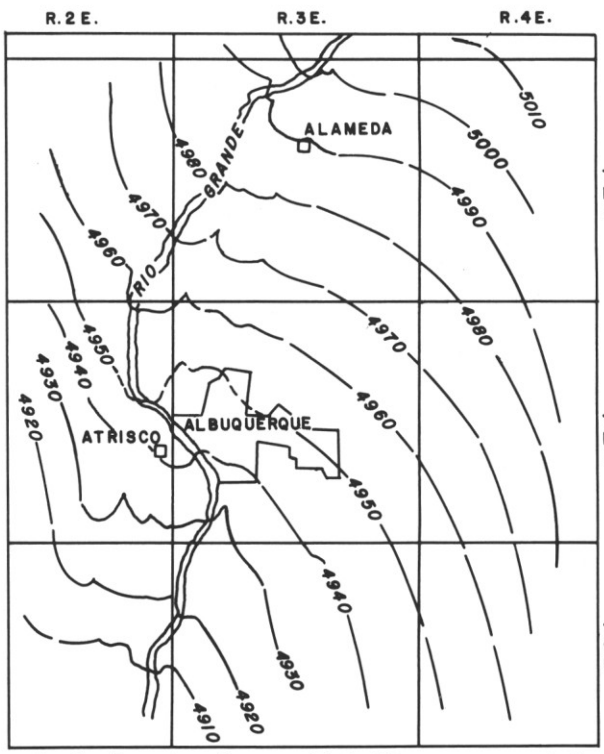


*Figure 2. Configuration of water table in Albuquerque area in October, 1936. Elevation contours in feet.*

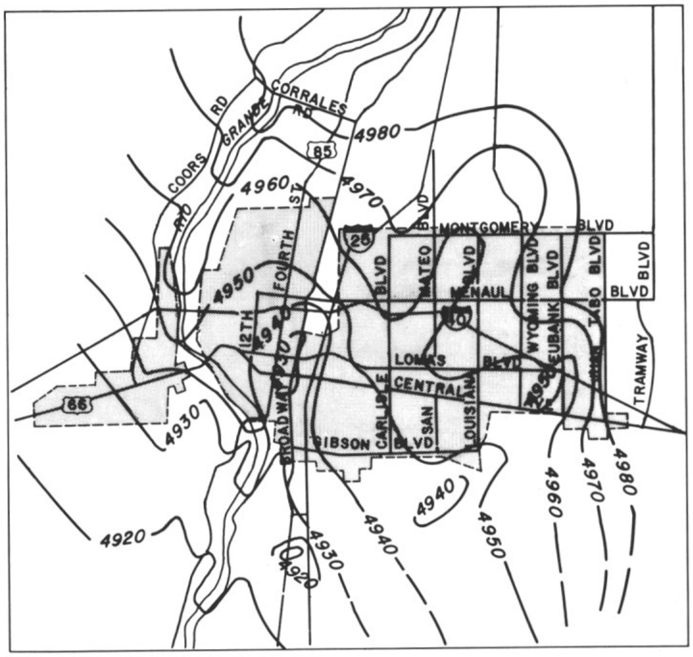


*Figure 3. Configuration of water table in Albuquerque area in 1960. Elevation contours in feet.*

### *Water table in 1960*

Water-table contours based on 1960 data (Bjorklund and Maxwell, 1961) clearly show the impact of ground-water development in the Albuquerque area (fig. 3). Although the regional trend of ground-water flow remained from northeast to southwest, the effect of the Atrisco, Main Plant, Candelaria, Duranes, and Love fields were all apparent in 1960.

The 1936 to 1960 impacts of pumping reflect the growth of the well fields, although by 1960 the effects on the aquifer were minimal. A relatively isolated depression surrounded the Atrisco field west of the Rio Grande (fig. 4). The maximum field drawdown was about 3 m (10 ft); this impact was confined to a relatively small area near the river. The water table beneath much of the Northeast Heights had declined 1.5 m (5 ft) or more below the 1936 static levels. Local areas of 3 m (10 ft) or more of drawdown were present beneath the Main Plant, Candelaria, and Duranes fields; the greatest drawdowns were created by pumping from the Love field and the Public Service Company wells, where 6.1 m (20 ft) of drawdown was measured.

### *Water table in 1978*

The 1978 water-table contour map of the Albuquerque area shows the results of major growth of the city toward the east (fig. 5). A pronounced cone of depression existed between the Lomas and Love fields in an area of heavy production and low transmissivity, and there was a general lowering throughout the Northeast Heights. West of the river production from the Atrisco field created additional lowering. Conversely, the area formerly impacted by the Main Plant and Candelaria fields showed nearly complete recovery as a result of the fields being abandoned.

A pronounced ridge in the water table extended along the general axis of Embudo Arroyo from the mountain front to the middle of the city. This indicates that the arroyo may have been a major recharge area before it was lined with concrete in 1979.

Water-level changes produced between 1960 and 1978 are shown in Figure 6. There was very little change in the water table west of the Rio Grande, other than minor changes produced by construction of

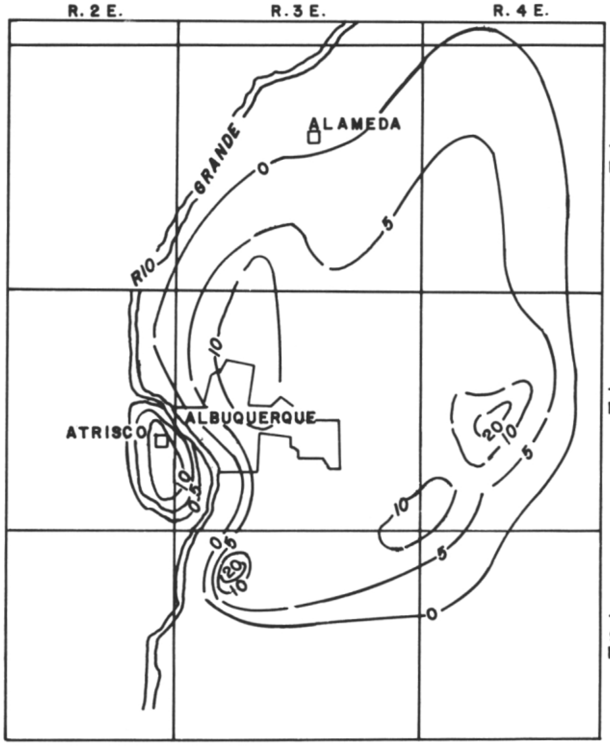


*Figure 4. Water level change in Albuquerque area for period of 1936 to 1960. Contours in feet.*

wells in the West Mesa and Leavitt fields. In the eastern part of the city, continued production from the Duranes field resulted in a small area of drawdown which locally exceeded 6.1 m (20 ft). A total of 15 m (50 ft) or more of drawdown occurred in the vicinity of the Leyendecker and Charles Wells fields; this is an area of approximately 21 $km^2$ (8 $mi^2$).

The most noteworthy feature of the 1960-1978 map was the deep cone of depression created by production from the Lomas and Love fields. Locally more than 40 m (130 ft) of drawdown was recorded. This pronounced feature was the result of excessive pumping from wells with low transmissivity values and a limited area of recharge adjacent to the Sandia Mountains.

The early maps by Theis (1938) illustrate that production of water in the Albuquerque area had only minimal effect on the water table prior to 1936. However, the study by Bjorklund and Maxwell (1961) determined that mining of ground water had spread throughout the Northeast Heights of the city. Based on the map of water-level changes (fig. 6) for the period 1960 through 1978, approximately 3.06 billion m' (4 billion yd') of aquifer had been dewatered. Assuming a specific yield of 15 percent, this represents slightly less than 0.46 billion m' (370,000 acre-feet) of ground water mined from the Albuquerque aquifer between 1960 and 1978.

### *Projected water table decline to year 2000*

Projected water-level declines are based on a variety of assumptions, many of which were made originally by Reeder and others (1967). Certain geohydrologic conditions must be assumed, as well as population projections and consumption rates (Corps of Engineers, 1979).

By the year 2000, the water table will have undergone very minor changes in the West Mesa area, but considerable spreading and decline will occur east of the Rio Grande (fig. 7). Local areas of water-table decline, probably not exceeding 3 m (10 ft), will occur in isolated

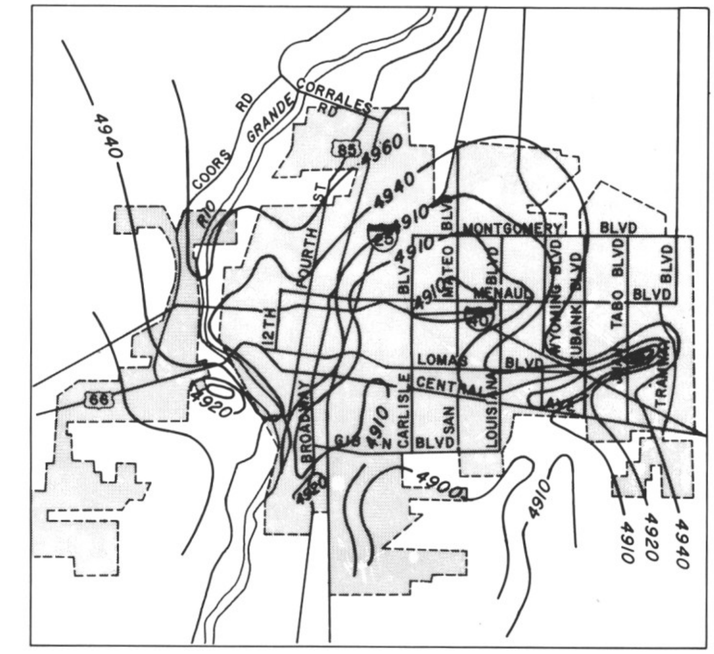


*Figure 5. Configuation of water table in Albuquerque area in 1978. Elevation contours in feet.*

population centers on the West Mesa. Greatest expansion of the cone of depression should develop in the southwestern area, where the West Mesa and Atrisco fields will expand their area of influence.

## CONCLUSIONS

The first 300 years of Albuquerque's history will have a relatively minor impact of the aquifer system tapped by the municipal system. No impact was noted for the period of 1706 to 1936, and regional decline of about 1.5 m (5 ft) occurred between 1936 and 1960. An additional 12 m (40 ft) of decline occurred throughout most of the

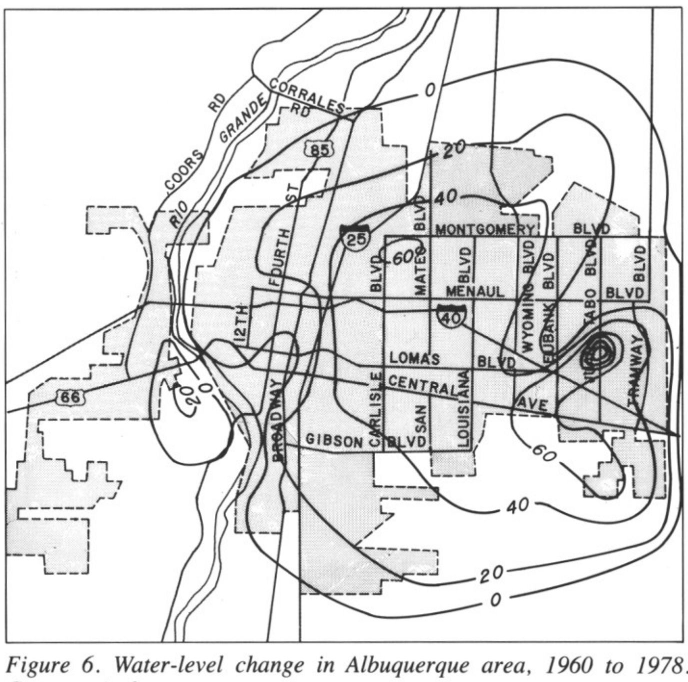


*Figure 6. Water-level change in Albuquerque area, 1960 to 1978. Contours in feet.*

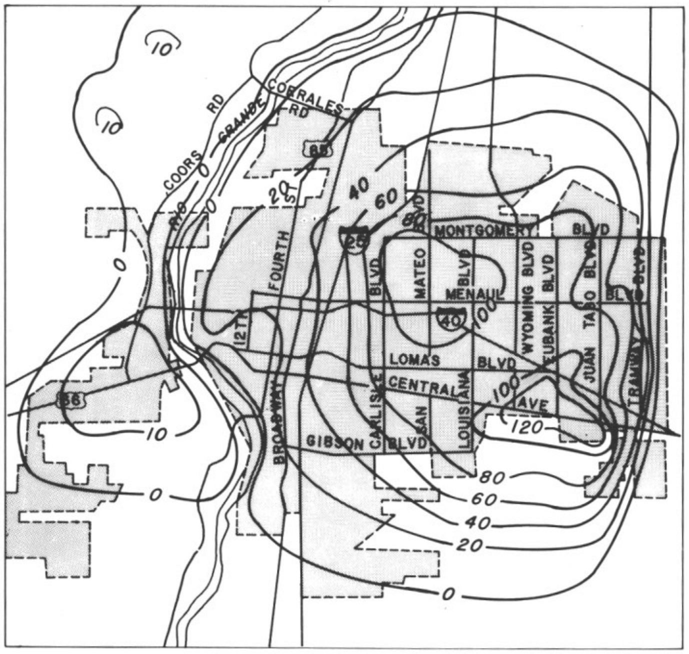


*Figure 7. Projected drawdown from time of no development to year 2000, Albuquerque area. Contours in feet.*

aquifer during the years 1961 through 1978. Total decline by the year 2000 will probably not exceed 37 m (120 ft). According to Kelly (1974), there is approximately 914 m (3,000 ft) of fresh-water saturation in the aquifer of the Albuquerque area.

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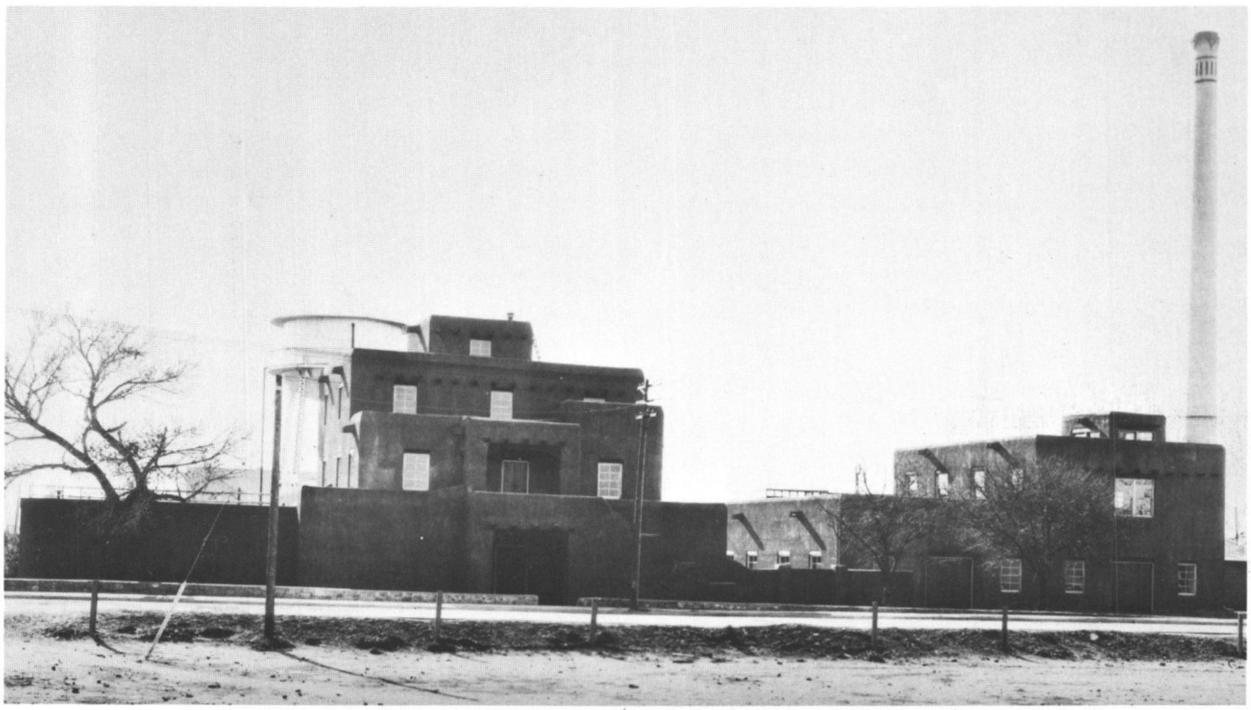

*Main ground-water pumping plant at Tijeras Blvd and Broadway was first major well field for City of Albuquerque. Courtesy of Albuquerque Museum Photoarchives.*

*Rio Grande from Atrisco Bluffs (J. F. Callender photo).*