U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
NEW MEXICO OFFICE OF THE STATE ENGINEER

SCIENTIFIC INVESTIGATIONS MAP 3038

Introduction

The Southern High Plains aquifer extends across parts of southeast New Mexico and northwest Texas and is part of the larger High Plains aquifer that extends from South Dakota to Texas (Hart and McAda, 1985). The Curry County, Portales, and Causey Lingo Underground Water Basins, as designated by the New Mexico Office of the State Engineer (www.ose.state.nm.us), encompass all of Curry County, most of Roosevelt County, and small parts of Quay and Chaves Counties in east-central New Mexico.

The Southern High Plains in New Mexico is defined by a plateau, bounded on the north by the Canadian River Valley and on the east and west by prominent escarpments rising 300 feet (ft) or more above the lower lands. The area has been described as having gently sloping plains, fertile soil, abundant sunshine, few streams, and frequent winds (McGuire and others, 2000). The physiography of the plains includes numerous shallow depressions, playa lakes, sand dunes, and small stream valleys. One of the largest topographic variations on the plains is Portales Valley, which extends from the west-northwest to the east-southeast for tens of miles though the area of Portales, N.M. The surface of the plateau generally slopes east-southeast at rates ranging from about 8 to 20 ft per mile (Cronin, 1969). The climate of the Southern High Plains area in New Mexico is semiarid, with low average annual precipitation (16.9 inches [in.] in Portales, 17.9 in. in Clovis, Western Region Climate Center, 2008), low relative humidity, high rate of evaporation (110 in./year), warm to hot summers, and moderate winters.

The unconfined Southern High Plains aquifer is composed primarily of the Ogallala Formation of late Tertiary age and alluvial sediments of Quaternary age (Langman and others, 2004). The Ogallala Formation consists of valley-fill deposits of clay, silt, fine to coarse-grained sand, gravel, and caliche, the distributions of which vary both vertically and horizontally. The formation is mostly unconsolidated although locally the sediments are cemented with calcium carbonate near the top. The formation ranges in thickness from zero to as much as 500 ft in east-central Curry County. The valley fill of the Portales Valley consists of sand, silt, and some gravel in the lower 1 to 10 ft of the deposit (Cronin, 1969).

The ground-water reservoir in the Ogallala Formation is continuous throughout most of the Southern High Plains. The aquifer is typically underlain by impermeable clays and shales although in some places the underlying geologic units of Cretaceous age are hydraulically connected to the aquifer. The principal source of recharge to the aquifer is infiltration of precipitation on the land surface. An unknown amount of water pumped from the formation for irrigation percolates back into the aquifer and constitutes some reduction in net discharge. Annual recharge estimates range from 0.5 to 1 inch (Cronin, 1969).

Irrigation from wells in the Portales Valley part of the Southern High Plains started as early as 1910, but it was not until the 1930s that development began on a substantial scale (Cronin, 1969). By the 1940s, irrigation using ground water from the Southern High Plains aquifer was extensive (McGuire, 2007). Irrigation expanded during the following years, especially during the drought years of the early 1950s. Irrigated acres have increased from initial development through the early 1990s in Curry and Roosevelt Counties (table 1; fig. 1). Recent decreases in irrigated acreages may be due in part to the increased cost of pumping water from the declining water table.

Table 1. Acres of irrigated cropland, including idle, fallow, and diverted acreage.

[From New Mexico Office of the State Engineer, technical reports on water use by categories in New Mexico counties and river basins, and irrigated acreage (Sorensen, 1997; Wilson, 1992; Wilson and Lucero, 1997, Wilson and others, 2003)]

County	1940	1950	1960	1970	1975	1990	1999
Curry	--	3,000	87,000	192,000	198,630	222,200	145,420
Roosevelt	11,300	30,000	62,000	103,700	135,000	143,670	87,342

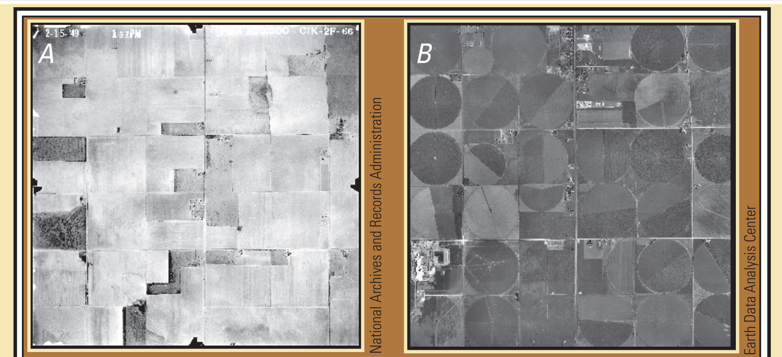

Figure 1. Aerial photographs from an area halfway between the cities of Portales and Clovis taken in 1949 (*A*) and 2005 (*B*) showing development of pivot irrigation.

Ground-water withdrawals in the New Mexico part of the High Plains aquifer had already greatly exceeded ground-water recharge by 1953; therefore, water levels had already declined and would continue to decline (McGuire, 2007). A study of ground-water levels completed in 1978 (Hart and McAda, 1985) indicated that levels had declined from 20 ft to more than 100 ft below land surface since predevelopment (pre-1940) years. By 2005, the estimated change in water storage in the New Mexico part of the High Plains aquifer since predevelopment was -9.7 million acre-ft, and declines were continuing (McGuire and others, 2000).

The Southern High Plains aquifer is the principal aquifer in Curry and Roosevelt Counties and, because of the large areal extent of the aquifer and the large yields of water to wells completed in the aquifer, is the primary source of water in southeastern New Mexico (Hart and McAda, 1985). Successful water-supply planning for New Mexico's Southern High Plains requires knowledge of the current aquifer conditions and a context to estimate future trends given current aquifer-management policy. At a time when water planners and the wider water-resources community in New Mexico are looking for alternatives to help slow the depletion of the High Plains Aquifer, this report provides a summary of the current (2007) water-level status of the Southern High Plains aquifer in New Mexico, including a basis for estimating future trends by comparison with historical conditions.

This report includes estimates of the extent of ground-water level declines in the Curry County, Portales, and Causey-Lingo Ground-water Management Area parts of the High Plains Aquifer in eastern New Mexico since predevelopment (fig. 2). Maps representing 2007 water levels, water-level declines, aquifer saturated thickness, and depth to water accompanied by hydrographs from representative wells for the Southern High Plains aquifer in the Curry County, Portales, and Causey Lingo Underground Water Basins were prepared in cooperation with the New Mexico Office of the State Engineer. The predevelopment water-levels on the maps correspond to predevelopment water levels created for the entire aquifer at a larger scale by Cederstrand and Becker (1999).

Methods of Map Generation

Maps of water levels in the study area in predevelopment (1931-54) and current (2004-07) time periods were constructed from 722 water-level measurements. Measurements were compiled from a USGS ground-water site-inventory database (*waterdata.usgs.gov/nwis*) containing information on historical and current ground-water levels throughout the State. Measurements were collected as part of a Federal, State, and local cooperative observation-well program in New Mexico (Allen, 1994).

Ground-water levels were recorded in feet below land surface. Water levels were converted to elevation by using the elevation documented for the well from a USGS topographic 7.5-minute quadrangle map. Because of the shallow terrain in the area, the maximum topographic interval encountered on topographic maps used was 10 ft. The uncertainty was calculated as one-half the topographic interval giving an uncertainty of 5 ft in the elevation estimates.

Water-level measurements collected during winter or early spring were selected for this study to avoid having data affected by pumping-drawdown caused by irrigation withdrawals; however, ground-water levels measured early in the irrigation season (April) were used from six predevelopment wells because they were the earliest ground-water levels available at those locations. In all six of these instances, the measurements used represent the highest water level recorded for the period of record in these wells. Therefore, despite being measured during the irrigation season, the author considers the measurements used to be the best estimate of predevelopment water levels.

Data from two predevelopment and two current wells whose water levels were not representative of aquifer conditions were removed from the datasets. Data from these four wells were considered to be unrepresentative of aquifer conditions because they may have been in perched water tables tens of feet above the ground-water levels of the aquifer. The predevelopment water-level measurements removed were 3 mi east and 5.5 mi southeast of Clovis. The current water-level measurements removed were west of Portales, near the edge of the aquifer, and 19 mi due north of Clovis.

Water-level measurements from 507 wells were used to generate the predevelopment water-level map. All measurements obtained were between February 1931 and December 1954, with preference given to the earliest measurement on record. Two hundred and thirteen measurements were made prior to 1940, and 294 measurements were from 1940 through 1955. Because ground-water development for irrigation began during the 1940s, these water-level measurements represent the predevelopment to early development period.

The expanded time period for water-level measurements for the predevelopment water-level map was necessary because of the lack in geographic extent of historical data for the predevelopment time period. Well measurements prior to 1945 occurred only near the town of Portales and in the surrounding Portales Valley. To increase the coverage area in the northwest part of this map around the communities of House and Forrest, water-level measurements from 1945 to 1950 were added. Finally, inclusion of water-level measurements from 1950 to 1955 greatly expanded the geographic extent to include areas around Clovis, Melrose, and along the Texas-New Mexico State line.

Predevelopment water levels in areas between geographic clusters of data were interpolated on the basis of the nearest data points. Because of the irregular geographical distribution of predevelopment data points, interpolation for predevelopment water levels occasionally had to be extended across distances as much as 25 miles. Confidence in ground-water estimates is therefore lower in the interpolated areas and higher closer to the data clusters. The dates of the earliest water-level measurements in a particular area are indicative of the time period in which that area was developed.

The development of irrigation in the study area from 1940 through 1955 was fairly rapid and caused an average decline in water level of 13 ft and a median decline of 9 ft across the three regions (Portales Valley, area near House and Forrest, and area near Clovis and Melrose) during that 15-year time period.

Water-level measurements from 215 wells were used to generate the current ground-water-level map. All measurements obtained were made between January 2004 and February 2007, with preference given to the most recent measurement. The current ground-water data are broadly distributed throughout the study area with the exception of some data gaps in the northwest corner. The water-level change throughout the area from 2004 to 2007 ranged from -7 to 13 ft with an average decline of 3.7 ft and a median decline of 4 ft.

To create the water-level contour maps, the ground-water-level data were plotted by using a geographic information system (GIS). A triangular irregular network (TIN) was generated representing the water-level data points, and potentiometric contours were generated in GIS by linear interpolation from the TIN. The interpolated contour lines calculated by GIS were smoothed by hand to remove contour irregularities unsupported by data and checked for inconsistencies with base of aquifer and topographic contours.

The water-level declines were established by subtracting water-level changes at all locations where current and predevelopment data points overlap and by subtraction of GIS points from a surface for the remaining areas. The sum of the topographic and period of record water-level uncertainties discussed previously and associated with the water-level decline map is +/- 23 ft. The saturated-thickness map was developed by subtracting the base of the aquifer elevations of Hart and McAda (1985) from the current water table (fig. 3) at each contour GIS node. The uncertainties associated with the base of aquifer are not documented in Hart and McAda (1985). The contour interval, however, is 50 ft so the assumed uncertainty is +/- 25 ft. The sum of the base of aquifer elevation uncertainties (+/- 25 ft) and the current water-level uncertainties (+/- 9 ft) associated with the saturated thickness map is +/- 34 ft. The depth-to-water map was developed by subtracting the current ground-water levels established for this project from the USGS surface elevation 30-meter (m) digital elevation model. In some instances the base of aquifer elevations (Hart and McAda, 1985) were found to be in conflict with surface elevations derived from USGS 30-m digital elevation models. In these situations, data from the surrounding area were used to interpolate across the area in conflict.

The method used to develop the water-level decline, water-table, saturated thickness, and depth-to-water maps has inherent inaccuracy. Accuracy decreases with distance from common points as interpolation algorithms in the GIS produce surfaces with less influence from the known data. The results were checked at 10 wells, where both predevelopment and current water-level measurements were available. The differences between water levels at these points were found to be in agreement (within 1 ft) with the estimates of water-level change, saturated thickness, and depth to water created with GIS.

Ground Water in the High Plains Aquifer

The configuration of the water table in the Curry County, Portales, and Causey Lingo Underground Water Basins is shown in figures 2-4. The water table ranges in elevation from 3,820 ft in the east-central part of the aquifer near the Texas State line to an estimated 5,080 ft in the northwestern-most extent of the aquifer (fig. 3). As a result, the water table has a general east-southeast slope towards the Texas state line (Gutentag and others, 1984; Hart and McAda, 1985) and ground water generally flows in this direction. Depth to ground water varies with surface elevation but generally increases from east to west with the minimum depth occurring along the eastern edges of the study area and a maximum depth of over 450 ft occurring in a narrow band approximately 10 mi long, roughly parallel with the Portales Valley, 13 mi north of the Town of Clovis (fig. 4).

As depicted on the map, the aquifer is not saturated in some areas, or the saturation is laterally discontinuous with the principal water body (Gutentag and others, 1984). A few wells in these areas are drilled in areas delineated as having little or no saturated thickness and likely will not yield water unless they penetrate sediment in buried channels or sinks in the bedrock.

The current saturated thickness ranges from 0 ft in many areas to 116 ft east of Portales, New Mexico, near the Texas State line. The areas of maximum saturated thickness coincide with areas of maximum water-level decline. The water-level declined as much as 175 ft (fig. 2). Hydrographs of wells with continuous records from predevelopment to 2006 indicate rates of water-level declines from about 0.4 ft/yr at wells 341852103291801 and 341002103303001 west and northwest of Portales to 1.76 ft/yr at well 340842103123101 southeast of Portales.

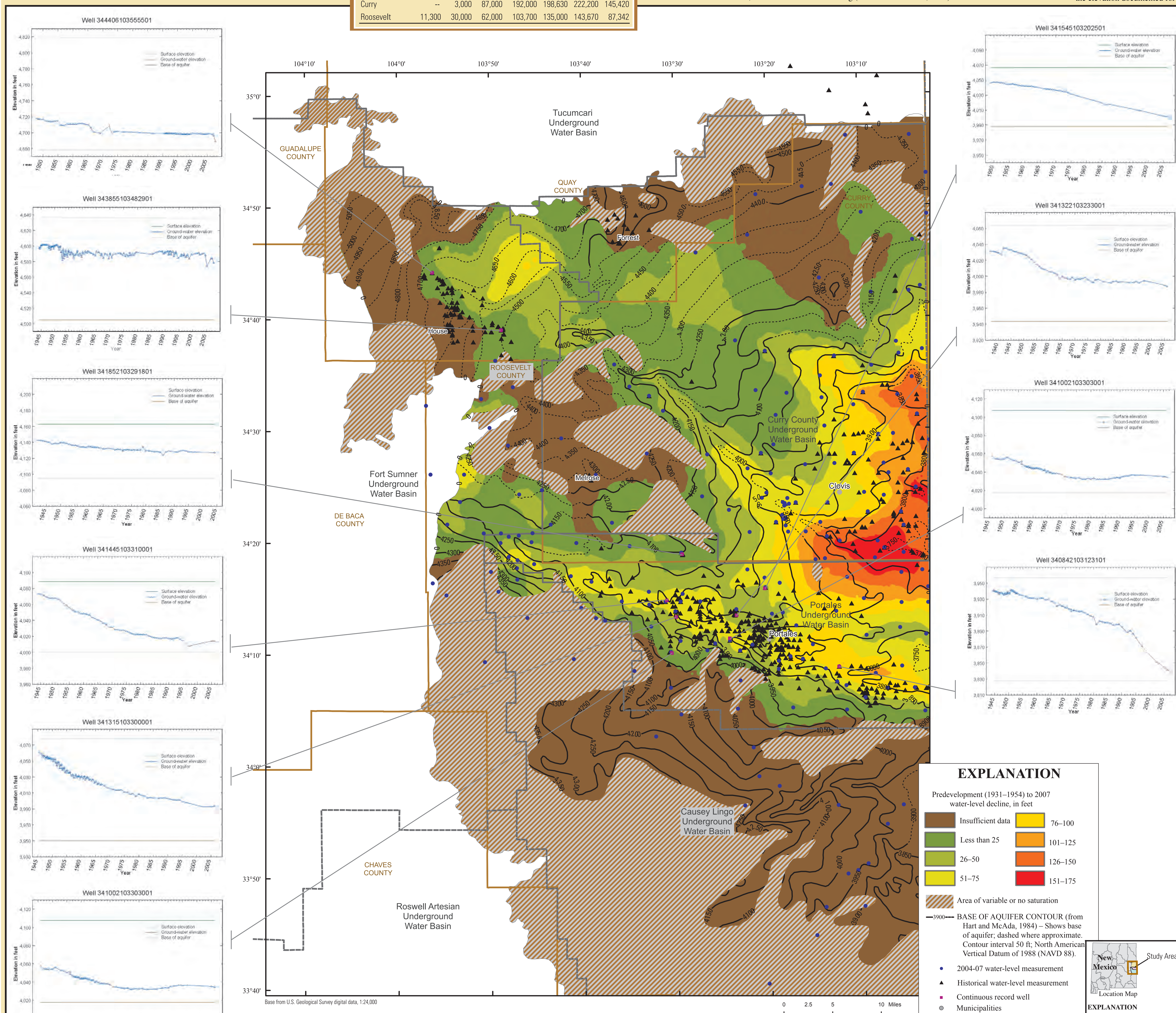

Figure 2. Water-level decline in Curry County, Portales, and Causey Lingo Underground Water Basins.

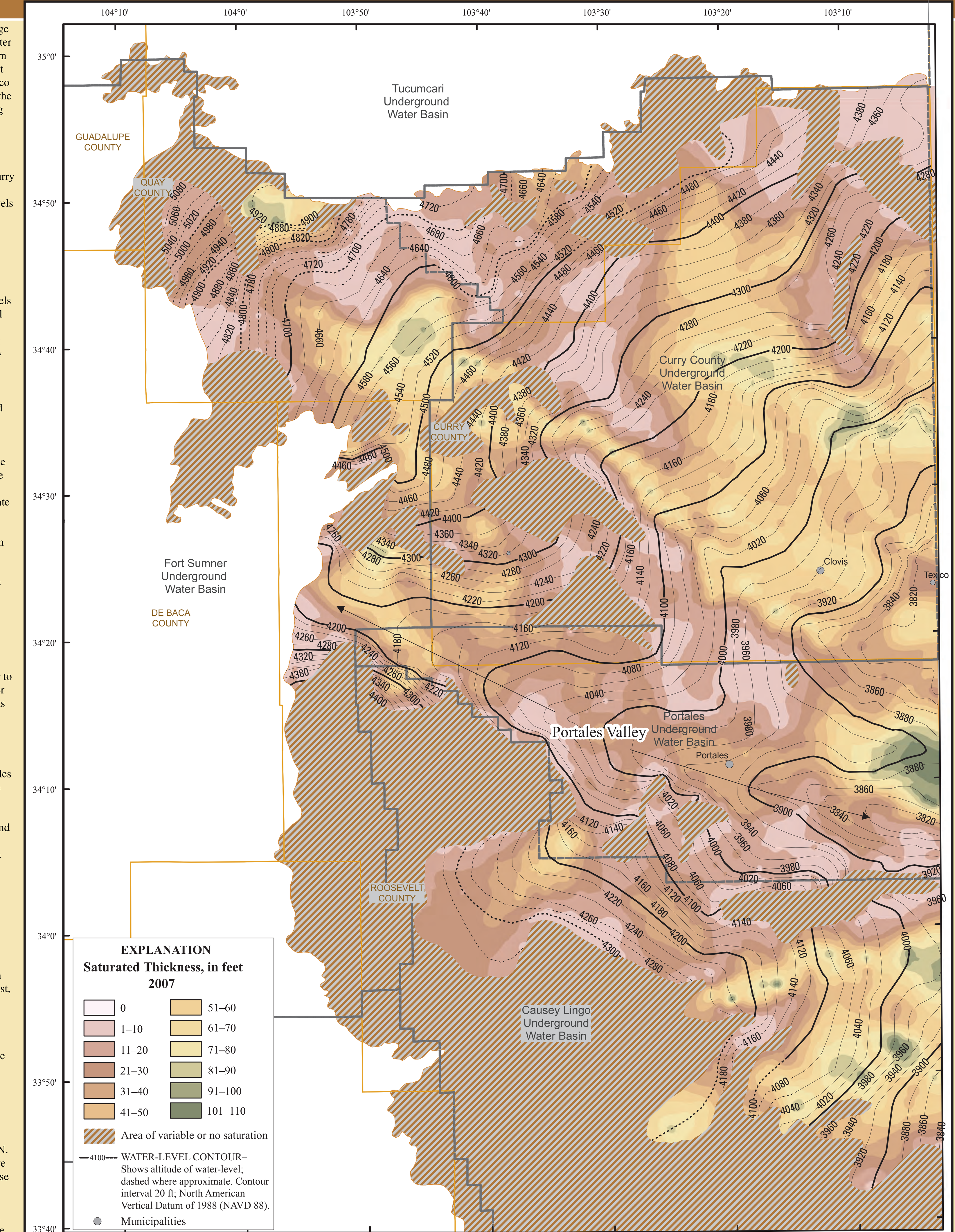

Figure 3. 2007 ground-water levels and aquifer-saturated thickness in Curry County, Portales, and Causey Lingo Underground Water Basins.

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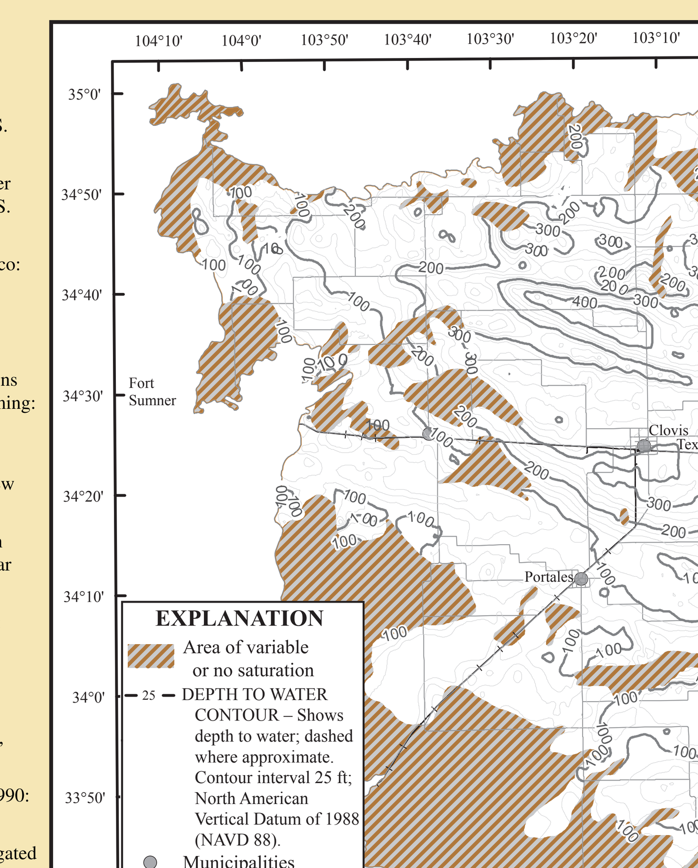

Figure 4. Depth-to-water map.

Current (2004-07) Conditions and Changes in Ground-Water Levels from Predevelopment to 2007, Southern High Plains Aquifer, East-Central New Mexico—Curry County, Portales, and Causey Lingo Underground Water Basins

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