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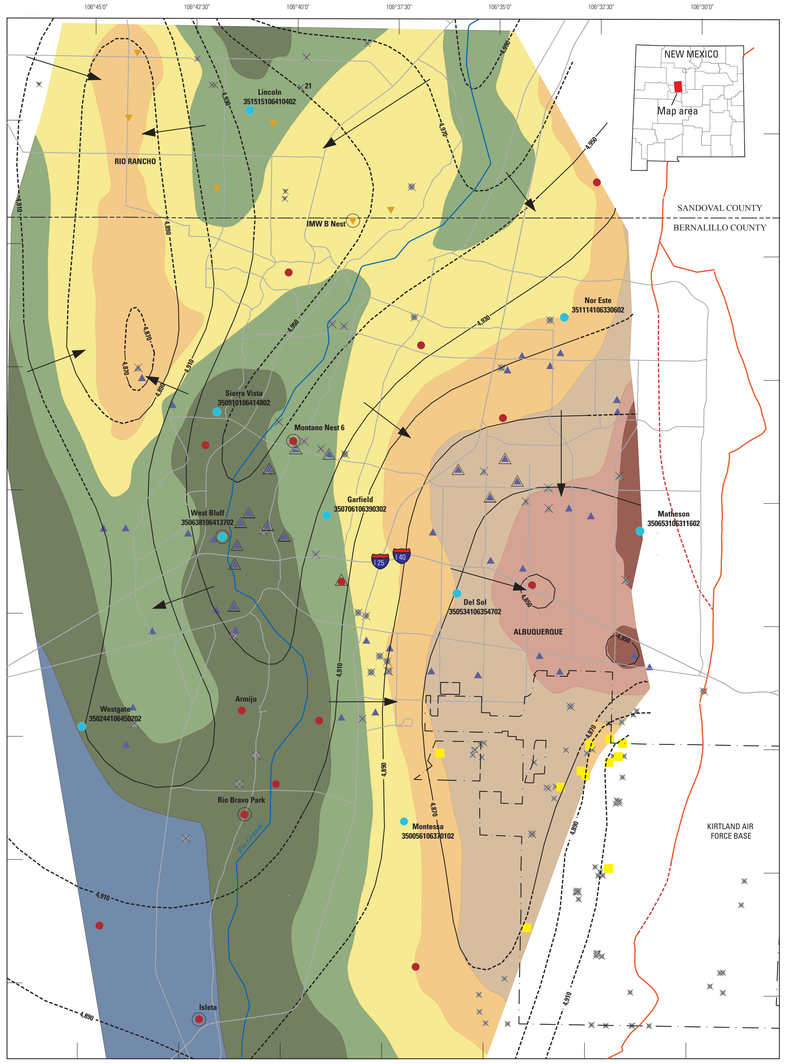
Prepared in cooperation with the
Albuquerque Bernalillo County Water Utility Authority

Scientific Investigations Map 3301



Base from ESRI Data and Maps, 2008 World, Europe, United States, Canada, and Mexico (2008). Redlands, Calif., ESRI, digital data, 1:50,000
Faults modified from Mark Hudson and Scott Minor, U.S. Geological Survey, written commun., 1999
Streams, military base, and Indian reservation boundaries from the U.S. Department of Commerce, Bureau of the Census, various years, TIGER/Line files, digital data, 1:100,000
Universal Transverse Mercator Zone 13N projection
North American Datum of 1983 and North American Vertical Datum of 1988

0 3 6 MILES
0 3 6 KILOMETERS

EXPLANATION

Estimated drawdown, in feet, predevelopment to 2012—Areas underlying dashed contour are approximate

- No drawdown
- 0 to 20
- 21 to 40
- 41 to 60
- 61 to 80
- 81 to 100
- 101 to 120
- More than 120

4,850 **Potentiometric contour, 2012**—Shows altitude at which water level would have stood in tightly cased wells, estimated 2012, interval 20 feet. Dashed where inferred. Datum is the North American Vertical Datum of 1988 (NAVD 88)

Area of apparent hydraulic discontinuity, not near a known fault, as identified by Bexfield and Anderholm (2000)

Basin-bounding fault in the area of a large hydraulic discontinuity, as identified by Bexfield and Anderholm (2000)

Approximate direction of groundwater flow

Well used to verify the groundwater-level change

Piezometer used to determine the difference in water level between the shallow aquifer and the production zone along the Rio Grande

U.S. Geological Survey (USGS) water-level measurement (by steel tape or electric tape) in USGS piezometer, 2011–12

351515106410402 **Piezometer for which hydrograph is shown for period of record and USGS site identifier**

USGS water-level measurement (by steel tape or electric tape) in USGS piezometer—Not used in constructing the potentiometric surface

USGS water-level measurement (by steel tape or electric tape) in Albuquerque Bernalillo County Water Utility Authority supply well, 2011–12

USGS water-level measurement (by steel tape or electric tape) in Albuquerque Bernalillo County Water Utility Authority supply well—Not used in constructing the potentiometric surface

City of Rio Rancho water-level measurement (by airline) in City of Rio Rancho supply well, 2010–12

City of Rio Rancho water-level measurement (by airline) in City of Rio Rancho supply well—Not used in constructing the potentiometric surface

Sandia National Laboratories (SNL) or Kirtland Air Force Base (KAFB) water-level measurement (by steel tape or electric tape) in SNL and KAFB piezometer, 2011–13

SNL or KAFB water-level measurement (by steel tape or electric tape) in SNL and KAFB piezometer—Not used in constructing the potentiometric surface

Figure 1. Estimated 2012 potentiometric surface and drawdown, predevelopment to 2012, Albuquerque metropolitan area, central New Mexico.

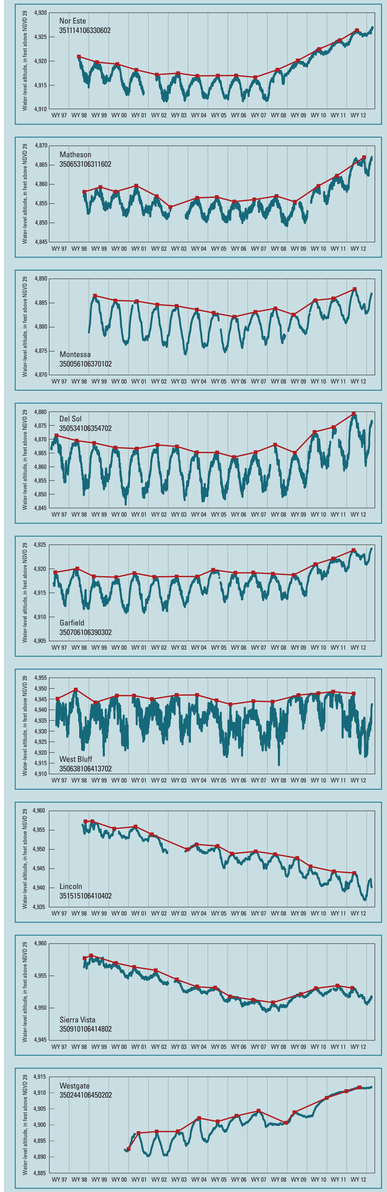


Figure 2. Hydrographs from selected piezometers in wells in the Albuquerque metropolitan area, central New Mexico (locations shown on fig. 1), for the period of record.

Estimated 2012 Groundwater Potentiometric Surface and Drawdown from Predevelopment to 2012 in the Santa Fe Group Aquifer System in the Albuquerque Metropolitan Area, Central New Mexico

By
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Abstract

Historically, the water-supply requirements of the Albuquerque metropolitan area of central New Mexico were met almost exclusively by groundwater withdrawal from the Santa Fe Group aquifer system. In response to water-level declines, the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) began diverting water from the San Juan-Chama Drinking Water Project in December 2008 to reduce the use of groundwater to meet municipal demand. Modifications in the demand for water and the source of the supply of water for the Albuquerque metropolitan area have resulted in a variable response in the potentiometric surface of the production zone (the interval of the aquifer, from within about 200 feet below the water table to 900 feet or more, in which supply wells generally are screened) of the Santa Fe Group aquifer system. Analysis of the magnitude and spatial distribution of water-level change can help improve the understanding of how the groundwater system responds to withdrawals and variations in the management of the water supply and can support water-management agencies' efforts to minimize future water-level declines and improve sustainability. The U.S. Geological Survey (USGS), in cooperation with the ABCWUA, has developed an estimate of the 2012 potentiometric surface of the production zone of the Santa Fe Group aquifer system in the Albuquerque metropolitan area. This potentiometric surface is the latest in a series of reports depicting the potentiometric surface of the area.

This report presents the estimated potentiometric surface during winter (from December to March) of water year 2012 and the estimated changes in potentiometric surface between predevelopment (pre-1961) and water year 2012 for the production zone of the Santa Fe Group aquifer system in the Albuquerque metropolitan area. Hydrographs from selected piezometers are included to provide details of historical water-level changes.

In general, water-level measurements used for this report were collected in small-diameter observation wells screened over short intervals near the middle of the production zone and were considered to best represent the potentiometric head in the production zone. The water-level measurements were collected by various local and Federal agencies. The water year 2012 potentiometric surface map was created in a geographic information system, and the change in water-level altitude from predevelopment to water year 2012 was calculated. The 2012 potentiometric surface indicates that the general direction of groundwater flow is from the Rio Grande towards clusters of supply wells in the east, north, and west. Water-level changes from predevelopment to 2012 were variable across the Albuquerque metropolitan area. Estimated drawdown from 2008 was spatially variable across the Albuquerque metropolitan area. Hydrographs from piezometers on the east side of the river indicate an increase in the annual highest water-level measurement from 2008 to 2012. Hydrographs from piezometers in the northwest part of the study area indicate either steady decline of the water-level altitude over the period of record or recently variable trends in which water-level altitudes increased for a number of years but have declined since water year 2012.

Introduction

In the past, groundwater withdrawal from the Santa Fe Group aquifer system was the principal water supply for the Albuquerque metropolitan area of central New Mexico. The large quantity of groundwater withdrawal relative to recharge has resulted in drawdown in the aquifer system throughout the metropolitan area (Bexfield and Anderholm, 2002a). Additionally, increased demand for water in the area has been driven by population growth of approximately 22 percent from 2000 to 2010 (Rice and others, 2014). In response to the drawdown, the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) has implemented a strategy to obtain and develop sustainable sources of water for municipal use (ABCWUA, 2007). The principal components of this strategy include use of renewable surface-water allocations as the primary municipal supply, establishment of a groundwater reserve for times of drought, increased use of water-conservation measures to reduce water consumption, and regional water-resource planning and management. The ABCWUA began diverting water from the San Juan-Chama Drinking Water Project in December 2008 to meet municipal demand. Groundwater withdrawals will be gradually reduced as the distribution of treated water from the San Juan-Chama Drinking Water Project is increased to provide 90 percent of the municipal supply (ABCWUA, 2009). Additionally, the ABCWUA initiated development of a groundwater reserve by testing the injection of treated water in the northeast part of the metropolitan area at the Webster Well Field in May 2013 (Fleck, 2013). The ABCWUA's efforts at encouraging consumers to reduce consumption through various conservation efforts have resulted in "* * * lowering [the] per capita usage from more than 250 gallons per day in the mid-1990s to less than 150 gpcd [gallons per capita daily] today" (ABCWUA, 2013).

Changes in the demand for water and in the source of the primary water supply for the Albuquerque metropolitan area have resulted in a variable response in the potentiometric surface of the production zone (the interval of the aquifer, from within about 200 feet (ft) below the water table to 900 ft or more, in which supply wells generally are screened) of the Santa Fe Group aquifer system (Bexfield and Anderholm, 2002b; Falk and others, 2011). Analysis of the magnitude and spatial distribution of water-level change can help improve the understanding of how the groundwater system responds to withdrawals and variations in the management of the water supply and can support water-management agencies' efforts to minimize future water-level declines and improve sustainability. The U.S. Geological Survey (USGS), in cooperation with the ABCWUA, has developed an estimate of the 2012 potentiometric surface of the production zone of the Santa Fe Group aquifer system for the Albuquerque metropolitan area. This potentiometric surface is the latest in a series of reports depicting the potentiometric surface of the area (Bexfield and Anderholm, 2002b; Falk and others, 2011).

Purpose and Scope

This report presents the estimated groundwater potentiometric surface for water year 2012 (hereafter, a stated year refers to the water year [period from October 1 through September 30 designated by the calendar year in which it ends]) and the estimated changes in water-level altitudes between predevelopment and 2012 for the production zone of the Santa Fe Group aquifer system. The study area includes Albuquerque and the surrounding metropolitan area including the federally owned property associated with Kirtland Air Force Base (KAFB). Water-level altitudes used to construct the 2012 potentiometric-surface map were measured during winter (December to March) of 2012. Hydrographs from selected piezometers are included to provide details of historical water-level changes.

Data Sources

The accuracy of water-level altitudes used in this report is related to the methods used to determine the altitude of land surface and to measure the depth to water in the well. Water-level altitudes were calculated as the difference between the land-surface altitude and the measured depth to water. Land-surface altitudes were determined by the USGS by estimating from 7.5-minute topographic quadrangle maps or Global Positioning System methods or were determined by the agency reporting the water-level altitude. All land-surface altitudes were assumed to be accurate to within plus or minus 5 ft, the accuracy of the likely least accurate method (estimation from 7.5-minute topographic quadrangle maps with 10-ft land-surface-altitude contour intervals).

Depths to water in wells were measured by using a steel tape, an electric tape, or an airline. The standard USGS procedure for water-level measurement is done by using a steel tape (Cunningham and Schalk, 2011), which is generally considered accurate to within plus or minus 0.01 ft (Sweet and others, 1990; Dalton and others, 1991). Electric-tape measurements of shallow water-level altitudes conducted with a well-maintained probe are accurate to within plus or minus 0.02 ft (Dalton and others, 1991). Airline measurements of water-level altitude by determination of the pressure required to displace the water from a known length of submerged tubing are accurate to within plus or minus 0.25 ft (Garber and Koopman, 1968; Dalton and others, 1991). For this report, steel-tape and electric-tape measurements were considered accurate to within 1 ft. Airline measurements were considered accurate to within 5 ft and were used only when other data were not available, when water-level altitudes were comparable to data for nearby wells, and when water-level altitudes from a well did not show erratic variation over the period of record. Water-level altitudes were reported in the USGS National Water Information System (NWIS) in the National Geodetic Vertical Datum of 1929 (NGVD 29), which was then converted to the North American Vertical Datum of 1988 (NAVD 88) to use for the creation of the potentiometric surface.

Water-level altitudes from wells and piezometers screened in the middle of the production zone were considered to best represent the potentiometric head in the production zone (the potentiometric head is the altitude at which water stands in a tightly cased well). The water-level altitudes measured at the water table can differ by 25 ft or more from the water-level altitudes measured in deeper parts of the aquifer; generally the potentiometric-head gradient is downward in the central and west parts of Albuquerque metropolitan area and upward in the east part of Albuquerque metropolitan area (Bexfield and Anderholm, 2002a). In general, piezometers used for this report were small-diameter observation wells screened over short intervals (5–20 ft) near the middle of the production zone (except for piezometers located at KAFB, described later in this section).

Water-level measurements were not collected from numerous sites during water year 2012; therefore, measurements from 2010 to 2013 were used to increase the data density. Water-level measurements collected from 2010 to 2013 were determined to be comparable and within the uncertainty of the analysis because the variations in water-level measurements collected during this time period are similar to the variations in water-level measurements collected during a year in wells screened over a long interval. Bexfield and Anderholm (2002b) noted that water-level altitudes varied by 10 ft or more between nested piezometers that span the length of the screened interval in nearby supply wells. Additionally, water-level measurements in piezometers in the production zone generally vary 1–2 ft annually.

Water-level measurements for ABCWUA supply wells were collected by USGS personnel as part of a program to monitor near-static water-level altitudes during times of low water demand for each well. Measurements were collected in winter, which is generally the interval of maximum seasonal recovery of the aquifer from pumping stresses, and after the well had not been pumped for at least 2 weeks and the water-level altitude in the well had stabilized. A minimal number of measurements were collected in October, November, or April with a steel or electric tape. The most recently available winter water-level altitude for each well, either 2011 or 2012, was used in this report.

Water-level measurements for the City of Rio Rancho supply wells were collected by City of Rio Rancho personnel and were provided to the USGS by the City of Rio Rancho Department of Public Works Utilities Operation Division (Mick Jakymiw and Steve Gallegos, City of Rio Rancho, written commun., 2013). Measurements in Rio Rancho supply wells were collected monthly after the well pump had been shut off for several hours and in some cases for days to months. Water-level measurements were collected with either an airline or an electric tape. City of Rio Rancho water-level-altitude data used in this report were selected from measurements collected primarily in February or March during 2010, 2011, or 2012. Water-level measurements from this time period collected with an electric tape and water-level measurements collected after the well had not been pumped for at least 1 week were considered to be more accurate and representative of aquifer conditions and were given preference in the water-level-data selection process for this report. Water-level measurements for selected Rio Rancho wells (including well 21, which was previously used to document substantial drawdown [Falk and others, 2011]) were not available for this report.

Water-level measurements for 26 piezometer nests (4 nests are outside the area shown on the map; fig. 1), part of a water-level network maintained by the USGS in cooperation with the ABCWUA, were collected by USGS personnel with an electric or steel tape. The piezometer nests generally are located at least 1 mile (mi) from supply wells to reduce the short-term effects of pumping on measured water-level altitudes. The piezometers are installed as nested wells, usually three piezometers per nest, and in most cases the screen lengths are 5–10 ft. Typically, one piezometer is near the water table, one is near the middle of the production zone, and one is near the bottom of or below the production zone. Data used in this report were from piezometers screened near the middle of the production zone and were selected from measurements collected in winter during 2011 or 2012.

Continuous water-level-altitude data were collected by using pressure transducers at piezometer nests as part of the Albuquerque Basin monitoring network (Beman, 2013). Continuous water-level-altitude data for the period of record through 2012 (Beman, 2013) were used to evaluate trends in water-level altitudes. The data were collected hourly by using pressure transducers and dataloggers following USGS guidelines described in Freeman and others (2004; Joseph Beman, oral commun., 2010). The piezometer nests were visited every 4–8 weeks, at which times water-level-altitude data were downloaded from the dataloggers and measurements of water-level altitude were obtained (Joseph Beman, written commun., 2010).

Water-level measurements for 11 piezometers located on KAFB were collected by KAFB or Sandia National Laboratories (SNL) personnel (the SNL facility in New Mexico is located on KAFB) and were provided to the USGS by SNL (Michael Skelly and Sherry Ricketson, SNL, written commun., 2013). The piezometers, installed by SNL, generally are screened near the water table in the upper part of the aquifer. Water-level altitudes were usually measured 3 or 4 times a year and were measured with an electric or steel tape. For this report, water-level-altitude data were selected from measurements collected in winter during 2011, 2012, or 2013 with a preference given to measurements collected in 2012.

Water-level measurements for supply wells located on KAFB were collected by KAFB personnel and were provided to the USGS (Mark Dalzell, KAFB, written commun., 2012); however, the data did not meet the criteria to be included in this report.

For areas near the Rio Grande, few water-level measurements were available in the production zone; therefore, riverbed altitudes and water-level differences at five nested piezometer sites located near the river (Isleta, Rio Bravo Park, West Bluff, Montano Nest 6, and IMW B Nest; fig. 1) were used to estimate water-level altitudes in the production zone. Water-level measurements from a piezometer screened across the shallow aquifer and another screened across the production zone were compared to estimate the difference in potentiometric head between the shallow aquifer and the production zone. The potentiometric-head difference between the shallow aquifer and the production zone was then linearly interpolated along the length of the river at 1-mi intervals. Potentiometric heads in the shallow aquifer were 6 ft to more than 25 ft higher than potentiometric heads in the production zone (Beman, 2013). Presuming that the river and the shallow aquifer are hydraulically connected and that the altitude of the riverbed is representative of the potentiometric head in the shallow aquifer, an estimated water-level altitude in the production zone was calculated as the difference between the riverbed altitude and the production-zone potentiometric head along the river.

Methods for Estimating Potentiometric Surface Contours and Drawdown

The 2012 potentiometric-surface map (fig. 1) was created by using a geographic information system (GIS). Well locations were plotted, and the water-level-altitude data were hand contoured on the basis of the water-level-altitude gradients between the wells in the GIS. Water-level-altitude contours were converted to a gridded surface by using a spline interpolation technique that requires the surface to exactly match the water-level altitude along the contour and to have minimum curvature; the technique was modified to better constrain the surface to the sample data range (Environmental Systems Research Institute, Inc., 2009). Water-level altitudes from the 2012 estimated potentiometric surface and the predevelopment (pre-1961) potentiometric surface of Bexfield and Anderholm (2000) were interpolated onto a grid of points spaced at 1,640-ft intervals. Comparison of observed water-level altitudes with calculated water-level altitudes from the gridded surface for all wells located within the contoured area (two wells were used to constrain the contours of water-level altitudes but were located outside the area contoured) had a root mean square error value of 2.8 ft and a coefficient of determination (R-squared) value of 0.979. The drawdown in the potentiometric surface from predevelopment to 2012 was then calculated for each grid point. A surface of the calculated drawdown was generated from the gridded points by using the spline interpolation technique. Paired predevelopment and 2012 water-level measurements from 15 wells were used to verify the calculated drawdown. Comparison of the observed drawdown for the 15 wells had a root mean square error value of 5.9 ft and an R-squared value of 0.994. The extent of the potentiometric surface and the estimated drawdown shown on the map (fig. 1) were selected to focus on areas where the most data were available, and in general, the boundary was selected to exclude areas where water-level measurements were sparse. The east edge of the contoured area was selected with the intent of excluding the area east of where Bexfield and Anderholm (2000) indicated the existence of hydraulic discontinuities, probably associated with major faults, where water-level altitudes would not be representative of the production zone.

Estimated 2012 Groundwater Potentiometric Surface and Drawdown from Predevelopment to 2012

The areas of water-level change presented in figure 1 are intended to provide only reasonable estimates of the general magnitude, extent, and spatial distribution of drawdown in the production zone of the Santa Fe Group aquifer system. Because of the degree of variability and accuracy of the data and the uncertainty introduced by the comparison of interpolated values on a discrete grid, the boundaries shown between intervals of drawdown are not precisely located. Areas of increased uncertainty are shown on figure 1 by dashed lines. It is not appropriate to use this map to estimate the exact drawdown at an individual location.

Hydrographs

Hydrographs from selected piezometers for the period of record (fig. 2) were examined visually for trends in water-level altitudes. Water-level altitudes are reported as referenced to the NGVD 29, as reported in the USGS NWIS. The altitudes of the annual highest water levels (AHWLs) are highlighted on the hydrographs to indicate the maximum amount of recovery of the aquifer from pumping stresses during the year. Hydrographs from the selected piezometers indicate seasonal variation in water levels that is related to withdrawals from nearby supply wells; in general, water-level altitudes decline during summer, when withdrawals are larger, and increase during winter, when withdrawals are smaller.

Trends in water-level altitudes shown in the hydrographs vary spatially across the Albuquerque metropolitan area. In general, similar trends are indicated by hydrographs from piezometers in the northeast, southeast, northwest, and southwest parts of the study area as defined by Interstate Highway 40 and the Rio Grande (fig. 1). Hydrographs from piezometers in the northeast and southeast areas (Del Sol, Garfield, Matheson, Montessa, and Nor Este) indicate a recent increase in the AHWL. The hydrographs from the Del Sol, Montessa, and Nor Este piezometers generally indicate a steady decline in the AHWL over the period of record until a low was reached in 2007 for Nor Este and in 2009 for Montessa and Del Sol, after which time the AHWL has been increasing. In general, the hydrographs from the Garfield and Matheson piezometers indicate no consistent trend in the AHWL through the period of record until 2009, after which time the AHWL has been increasing.

Hydrographs from piezometers in the northwest area (Lincoln, Sierra Vista, and West Bluff) indicate spatial variability in water-level-altitude trends. The hydrograph from the Lincoln piezometer, the northernmost piezometer, shows a steady decline in the AHWL for the period of record through 2012. The hydrograph from the Sierra Vista piezometer indicates a steady decline in the AHWL through the period of record until 2008, when the AHWL started to increase. The hydrograph from the West Bluff piezometer indicated no consistent trend in the AHWL through the period of record until approximately 2008, when the AHWL started to increase. The hydrographs from Sierra Vista and West Bluff piezometers indicate a recent maximum AHWL in 2011 with a decline in the AHWL starting in 2012. The hydrograph from the Westgate piezometer, located in the southwest part of the study area, indicates an increase in the AHWL for the period of record except for 2005 and 2008.

Groundwater Flow and Drawdown

The 2012 potentiometric surface indicates that the general direction of groundwater flow is from the Rio Grande towards clusters of supply wells in the east, north, and west (fig. 1). Prior to development, groundwater in the mapped area generally flowed from north-northeast to south-southwest (Bexfield and Anderholm, 2000).

Drawdown from predevelopment to 2012 is variable across the Albuquerque metropolitan area (fig. 1). Drawdown is smallest in the southwest part of the study area, where groundwater withdrawals are minimal, and along the Rio Grande, where recharge from the river is occurring. Drawdown is largest along the east margin of the study area (decline of more than 120 ft) and in the northwest (decline of more than 60 ft). Drawdown along the east margin of the study area is likely amplified by the proximity of clusters of supply wells to basin-bounding faults that are the boundary between the large thickness of the basin-fill sediments (which are higher permeability) and the reduced thickness of the sediments overlying bedrock along the margin of the basin (Connell, 2006). Drawdown along the river north of the Sierra Vista piezometer likely results from groundwater withdrawals in the north and propagation of drawdown outward from clusters of supply wells. Drawdown in the west and northwest parts of the basin is likely a result of pumping stresses; however, faulting and the resulting juxtaposition of lithologic units with different hydrologic properties likely increase the drawdown as a result of withdrawals (Heywood and others, 2002; McAda and Barroll, 2002). The estimated potentiometric surface northeast of the Lincoln piezometer likely represents the maximum altitude of the potentiometric surface for 2012 because water-level measurements were not available for Rio Rancho well 21 in this area, for which substantial drawdown had been previously estimated (Falk and others, 2011). The current estimated drawdown likely represents a minimum amount of drawdown in this area for 2012.

Estimated drawdown from 2008 (Falk and others, 2011) to 2012 was spatially variable across the Albuquerque metropolitan area. The potentiometric surface in the east part of the Albuquerque metropolitan area has increased compared to the 2008 potentiometric surface (fig. 1 and Falk and others, 2011), which is in accord with hydrographs from piezometers located near this area (Del Sol, Matheson, Montessa, and Nor Este; fig. 2). The potentiometric surface in the northwest part of the Albuquerque metropolitan area west of the Rio Grande, which is coincident with clusters of supply wells, continued to decline from 2008 to 2012 (fig. 1 and Falk and others, 2011), which is in accord with the hydrographs from the piezometers located in the area (Lincoln; fig. 2). Water-level altitudes northeast of the Lincoln piezometer likely have increased since 2008 as the result of decreased pumping from Rio Rancho well 21 (supply well data obtained from the State of New Mexico Water Rights Reporting System database at http://nmwrrs.ose.state.nm.us/index.html); however, the amount of change in the water-level altitudes is uncertain because of the lack of data. The potentiometric surface along the Rio Grande south of Sierra Vista indicates small declines from 2008 to 2012 (fig. 1 and Falk and others, 2011); however, water-level altitudes along the Rio Grande north of Sierra Vista indicate continued declines from 2008 to 2012 (Lincoln; fig. 2). Some of the differences in mapped groundwater conditions from 2008 (Falk and others, 2011) to 2012 (fig. 1) may be the result of mapping techniques and changes in the availability of water-level-altitude data.

Acknowledgments

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The authors thank Joseph Beman of the USGS for collecting measurements of water-level altitudes in the ABCWUA supply wells and the USGS piezometers.

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