Mashburn, S.L. and Magers, Jessica, 2011, Potentiometric surface in the Central Oklahoma (Garber-Wellington) aquifer, Oklahoma, 2009

Introduction

A study of the hydrogeology of the Central Oklahoma aquifer was started in 2008 to provide the Oklahoma Water Resources Board (OWRB) hydrogeologic data and a groundwater flow model that can be used as a tool to help manage the aquifer. The 1973 Oklahoma water law requires the OWRB to do hydrologic investigations of Oklahoma's aquifers (termed "groundwater basins") and to determine amounts of water that may be withdrawn by permitted water users. "Maximum annual yield" is a term used by OWRB to describe the total amount of water that can be withdrawn from a specific aquifer in any year while allowing a minimum 20-year life of the basin (Oklahoma Water Resources Board, 2010). Currently (2010), the maximum annual yield has not been determined for the Central Oklahoma aquifer. Until the maximum annual yield determination is made, water users are issued a temporary permit by the OWRB for 2 acre-feet/acre per year. The objective of the study, in cooperation with the Oklahoma Water Resources Board, was to study the hydrogeology of the Central Oklahoma aquifer to provide information that will enable the OWRB to determine the maximum annual yield of the aquifer based on different proposed management plans. Groundwater flow models are typically used by the OWRB as a tool to help determine the maximum annual yield.

This report presents the potentiometric surface of the Central Oklahoma aquifer based on water-level data collected in 2009 as part of the current (2010) hydrologic study. The U.S. Geological Survey (USGS) Hydrologic Investigations Atlas HA-724 by Christenson and others (1992) presents the 1986-87 potentiometric-surface map. This 1986-87 potentiometric-surface map was made as part of the USGS National Water-Quality Assessment pilot project for the Central Oklahoma aquifer that examined the geochemical and hydrogeological processes operating in the aquifer. An attempt was made to obtain water-level measurements for the 2009 potentiometric-surface map from the wells used for the 1986-87 potentiometric-surface map. Well symbols with circles on the 2009 potentiometric-surface map (fig. 1) indicate wells that were used for the 1986-87 potentiometric-surface map.

Description of Aquifer

The Central Oklahoma aquifer underlies about 3,000 square miles in central Oklahoma, where the aquifer is used for municipal, industrial, commercial, agricultural, and domestic water supplies. Estimated daily water withdrawals from the Central Oklahoma aquifer for 2005 were 40 million gallons per day, with 66 percent of total withdrawal being for public supply (Tortorelli, 2009). The Central Oklahoma aquifer consists of consolidated Permian-age Garber Sandstone and Wellington Formation and Chase, Council Grove, and Admire Groups that dip to the west at about 50 feet per mile. The Garber Sandstone and Wellington Formation have similar lithologies and consist of lenticular beds of fine-grained, cross-bedded sandstone interbedded with siltstone and mudstone. The Chase, Council Grove, and Admire Groups consist of fine-grained, cross-bedded sandstone, shale, and thin limestone (Christenson and others, 1992). Overlying these bedrock units are Quaternary-age unconsolidated alluvial and terrace deposits along streams in the study area. The Hennessey Group is Permian-age shale and mudstone that acts as a confining unit overlying the western one-third of the study area (fig. 1 and table 1). The Quaternary-age alluvial and terrace deposits along the streams are in contact with the Central Oklahoma aquifer except where the Hennessey Group overlies the aquifer in the western part of the study area.

Table 1. Stratigraphic column of geologic and hydrogeologic units in central Oklahoma (shaded hydrogeologic units are included in the Central Oklahoma aquifer) (modified from Parkhurst and others, 1989).

ERATHEM	SYSTEM	GEOLOGIC UNIT	HYDROGEOLOGIC UNIT	THICKNESS, IN FEET
Cenozoic	Quaternary	Alluvium	Alluvial and Terrace Deposits	[a]0–100
		Terrace Deposits		[a]0–100
Paleozoic	Permian	El Reno Group	El Reno	[b]200
		Hennessey Group	Hennessey	[b]700
		Garber Sandstone	Garber-Wellington	[a]1,165–1,600
		Wellington Formation		
		Chase Group	Chase, Council Grove, and Admire Groups	[a]570–940
		Council Grove Group		
		Admire Group		
	Pennsylvanian	Vanoss Formation	Vanoss	[c]250–490

[a]Christenson and others, 1992
[b]Wood and Burton, 1968
[c]Bingham and Moore, 1975

Yields in the Garber Sandstone and Wellington Formation generally range from 50 to 300 gallons per minute (Bingham and Moore, 1975). Chase, Council Grove, and Admire Groups typically yield 25 to 50 gallons per minute. Yields from the alluvial and terrace deposits are typically higher than the bedrock units and are commonly greater than 300 gallons per minute. The Central Oklahoma aquifer also is commonly referred to as the "Garber-Wellington aquifer" because most deep wells in central Oklahoma are completed in the Garber Sandstone and Wellington Formations. For this report, the aquifer will be referred to as the Central Oklahoma aquifer to be consistent with previous USGS publications describing the aquifer.

2009 Potentiometric Surface

A potentiometric surface is defined as the level to which water will rise in tightly cased wells. An aquifer with substantial vertical flow can have multiple potentiometric surfaces. The potentiometric surface in this report approximates only the upper zone of saturation in the Central Oklahoma aquifer, sometimes referred to as the "water table". Water levels from land surface were measured by using an electric tape from February 17 to March 13, 2009 in 280 shallow wells (depth from land surface less than 300 feet). One hundred sixty-six of these water-level measurements (59 percent) were from wells measured for the 1986-87 potentiometric-surface map published in USGS Hydrologic Investigations Atlas HA-724 by Christenson and others (1992). Most of these wells are used for domestic supply and are completed in the different geologic units in the Central Oklahoma aquifer including the alluvial and terrace deposits (table 1). Well depths and completion information can be found at the USGS National Water Information System website, http://nwis.waterdata.usgs.gov/ok/nwis/gwlevels. The potentiometric-surface altitude was calculated by subtracting depth to water from land-surface altitude. The land-surface altitude used for the 2009 potentiometric-surface map was determined by using a Global Positioning System, which is accurate to the nearest 1 foot and referenced to the North American Vertical Datum of 1988 (NAVD 88). Stream and lake elevations, which were obtained from a USGS 10-meter (3.3-foot) digital elevation model (DEM; http://ned.usgs.gov/), were included when contouring the potentiometric surface, except for the western part of the aquifer that is confined by the overlying Hennessey Group where the Central Oklahoma aquifer is not hydraulically connected to the alluvial and terrace deposits above the Hennessey Group (fig. 1). The potentiometric-surface contours were generated in a geographic information system (GIS) by using stream and lake elevation data from the DEM and the potentiometric-surface altitudes determined at wells. The contours were adjusted manually based on professional judgment to address inconsistencies, especially near streams and lakes.

The highest water-level altitudes are in the western part of the aquifer and the lowest water-level altitudes are where the Cimarron River flows beyond the extent of the aquifer. The general slope of the potentiometric surface is west-to-east. Groundwater flows perpendicular to potentiometric contour lines from high potentiometric altitude to low potentiometric altitude. The west-to-east slope of the potentiometric surface indicates that the regional trend in shallow groundwater flow is from west to east. The potentiometric surface slopes steeply toward the Deep Fork River in Oklahoma County, with the potentiometric contour lines forming approximate "V" patterns that point upstream along the Deep Fork River, indicating the Deep Fork River acts as a drain for the groundwater-flow system. The potentiometric contour lines show a similar pattern along the North Canadian River, but only in the eastern part of the study area. The lack of "V" patterns on the western part of the North Canadian River is an artifact of not using stream elevations as control points in the confined (western) part of the aquifer. The 2009 potentiometric-surface map shows that no streams on the aquifer are major sources of water to the groundwater-flow system, for example, few streams demonstrate the "V" pattern pointing downstream that indicates the stream could be a major source of water to the groundwater-flow system.

Acknowledgments

The authors appreciate the willingness of landowners to provide access to their wells for obtaining water-level measurements. The authors also thank the Oklahoma Water Resources Board for providing assistance in obtaining water-level measurements. Appreciation also is extended to Jason Masoner and Aaron Pugh for providing thorough reviews of this report.

Selected References

Bingham, R.H., and Moore, R.L., 1975, Reconnaissance of the water resources of the Oklahoma City quadrangle central Oklahoma: Oklahoma Geological Survey Hydrologic Atlas 4, 4 sheets, scale 1:250,000.

Christenson, S.C., Morton, R.B., and Mesander, B.A., 1992, Hydrogeologic maps of the Central Oklahoma aquifer, Oklahoma: U.S. Geological Survey Hydrologic Investigations Atlas HA-724, 3 sheets, scale 1:250,000.

Havens, J.S., 1989, Geohydrology of the alluvial and terrace deposits of the North Canadian River from Oklahoma City to Eufaula Lake, central Oklahoma: U.S. Geological Survey Water-Resources Investigations Report 88-4234, 32 p, 12 pls.

Oklahoma Water Resources Board, 2010, Fact Sheet on determination of maximum annual yield: available online at http://www.owrb.ok.gov/studies/reports/reports_pdf/DetermineMAY.pdf.

Parkhurst, D.L., Christenson, S.C., and Breit, G.N, 1996, Ground-water-quality assessment of the Central Oklahoma aquifer, Oklahoma—Geochemical and geohydrologic investigations: U.S. Geological Survey Water-Supply Paper 2357-C, 101 p.

Parkhurst, D.L., Christenson, S.C., and Schlottmann, J.L., 1989, Ground-water quality assessment of the Central Oklahoma aquifer, Oklahoma—Analysis of available water-quality data through 1987: U.S. Geological Survey Water-Supply Paper 2357-B, 74 p.

Tortorelli, R.L., 2009, Water use in Oklahoma 1950–2005: U.S. Geological Survey Scientific Investigations Report 2009-5212, 49 p.

Wood, P.R. and Burton, L.C., 1968, Ground-water resources in Cleveland and Oklahoma Counties, Oklahoma: Oklahoma Geological Survey Circular 71, 75 p.

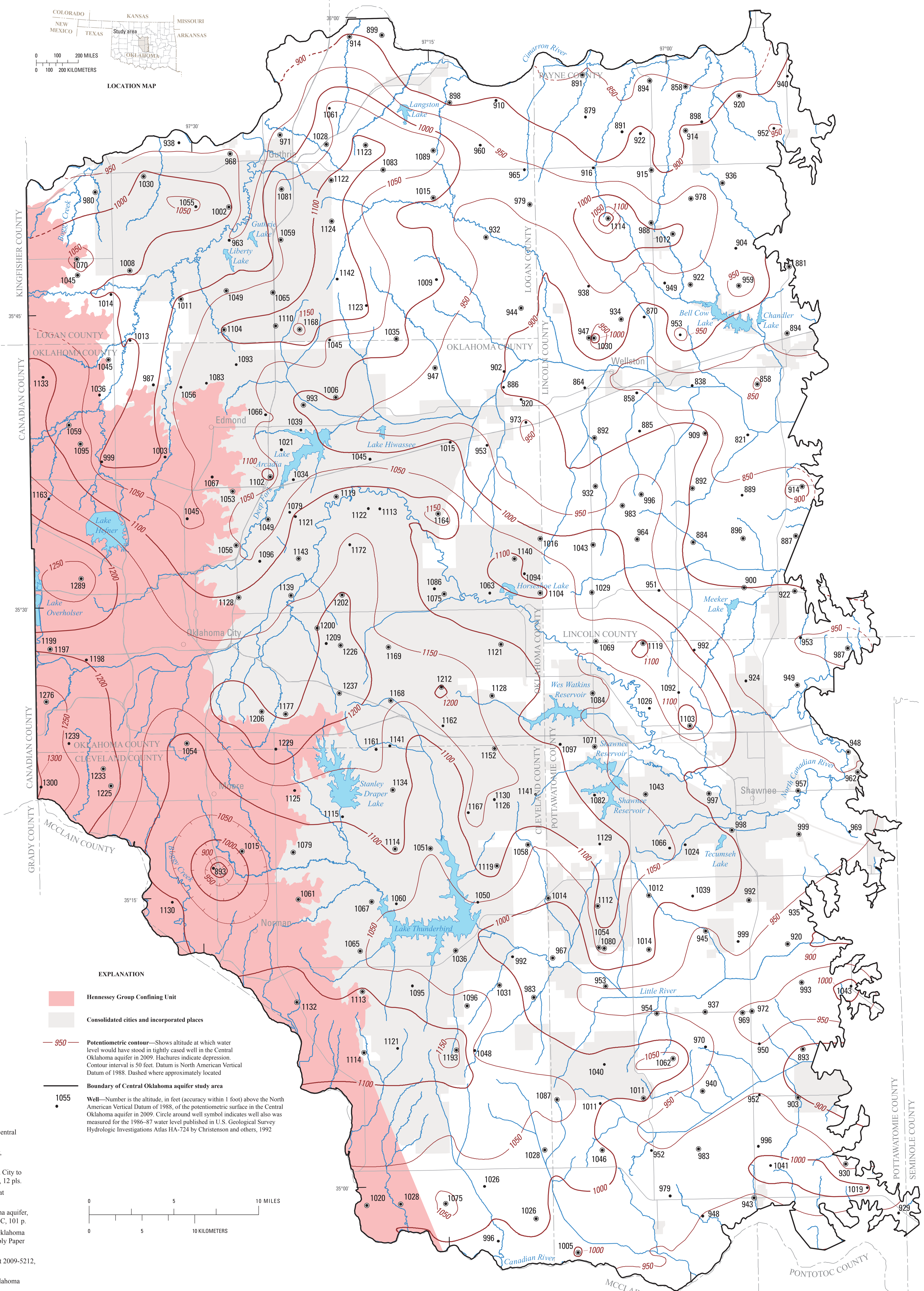

Figure 1. Potentiometric surface in the Central Oklahoma aquifer, 2009.

Base from U.S. Geological Survey digital data, 1:24,000
Universal Transverse Mercator projection, Zone 14
North American Datum of 1983

POTENTIOMETRIC SURFACE IN THE CENTRAL OKLAHOMA (GARBER-WELLINGTON) AQUIFER, OKLAHOMA, 2009

By
Shana L. Mashburn and Jessica Magers
2011

For additional information contact:
Director
U.S. Geological Survey
202 NW 66th Street, Building 7
Oklahoma City, OK 73116
http://ok.water.usgs.gov/

Publishing support provided by
Lafayette Publishing Service Center