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Water-Level Changes in the High Plains Aquifer, Republican River Basin in Colorado, Kansas, and Nebraska, 2002 to 2015

Pamphlet to accompany
Scientific Investigations Map 3373
Version 1.2, March 2017

U.S. Department of the Interior
U.S. Geological Survey

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
square foot (ft^2)	0.09290	square meter (m^2)
section (640 acres or 1 square mile)	259.0	square hectometer (hm^2)
square mile (mi^2)*	2.590	square kilometer (km^2)

Supplemental Information

*There are 640 acres in a square mile (mi^2); there are 0.64 million acres in 1,000 mi^2.

Water year is the 12-month period from October 1 through September 30 and is designated by the calendar year in which it ends.

Datums

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Water-Level Changes in the High Plains Aquifer, Republican River Basin in Colorado, Kansas, and Nebraska, 2002 to 2015

By V.L. McGuire

Abstract

The High Plains aquifer underlies 111.8 million acres (about 175,000 square miles) in parts of eight States—Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. More than 95 percent of the water withdrawn from the High Plains aquifer is used for irrigation. Water-level declines began in parts of the High Plains aquifer soon after the beginning of substantial irrigation with groundwater in the aquifer area (about 1950). The Republican River Basin is 15.9 million acres (about 25,000 square miles) and is located in northeast Colorado, northern Kansas, and southwest Nebraska. The Republican River Basin overlies the High Plains aquifer for 87 percent of the basin area. Water-level declines had begun in parts of the High Plains aquifer within the Republican River Basin by 1964. In 2002, management practices were enacted in the Middle Republican Natural Resources District in Nebraska to comply with the Republican River Compact Final Settlement. The U.S. Geological Survey, in cooperation with the Middle Republican Natural Resources District, completed a study of water-level changes in the High Plains aquifer within the Republican River Basin from 2002 to 2015 to enable the Middle Republican Natural Resources District to assess the effect of the management practices, which were specified by the Republican River Compact Final Settlement. Water-level changes determined from this study are presented in this report.

Water-level changes from 2002 to 2015 in the High Plains aquifer within the Republican River Basin, by well, ranged from a rise of 9.4 feet to a decline of 43.2 feet. The area-weighted, average water-level change from 2002 to 2015 in this part of the aquifer was a decline of 4.5 feet.

Introduction

The High Plains aquifer underlies 111.8 million acres (about 175,000 square miles) in parts of eight States—Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming (fig. 1, inset map; Qi, 2010). More than 95 percent of the water withdrawn from the High Plains aquifer is used for irrigation (Maupin and Barber, 2005). The Republican River Basin is about 15.9 million acres (about 25,000 square miles) and is located in northeast Colorado, northern Kansas, and southwest Nebraska. The Republican River Basin overlies the High Plains aquifer in 87 percent of the basin area.

In the High Plains aquifer overall, including in the Republican River Basin, groundwater generally is under unconfined conditions, and the water body, from a regional perspective, has a water table at which the water pressure is atmospheric (Weeks and Gutentag, 1981). The saturated thickness of the aquifer, which is the distance from the water table to the base of the aquifer, ranges from less than 50 feet (ft) to about 1,200 ft for the aquifer overall and ranges from less than 50 ft to about 500 ft for the aquifer within the Republican River Basin (McGuire and others, 2012). Gutentag and others (1984) reported that, in a few parts of the aquifer area, the water table is discontinuous; these areas, which total about 6.0 million acres in the aquifer overall and about 0.3 million acres in the part of the Republican River Basin that overlies the High Plains aquifer, are labeled in figure 1 as "area of little or no saturated thickness." Wells drilled in areas of little or no saturated thickness (sheet 1, https://doi.org/10.3133/sim3373) likely will not yield water unless the wells penetrated saturated sediment in buried channels or depressions in the bedrock surface (Gutentag and others, 1984; Cederstrand and Becker, 1999).

The area overlying the High Plains aquifer is one of the primary agricultural regions in the Nation; in parts of the area, farmers and ranchers began extensive use of groundwater for irrigation in the 1930s and 1940s. Estimated irrigated acreage in the High Plains aquifer area was 2.1 million acres in 1949, 13.7 million acres in 1980, 14.7 million acres in 2002, 15.8 million acres in 2007, and 14.7 million acres in 2012 (Heimes and Luckey, 1982; Thelin and Heimes, 1987; U.S. Geological Survey, 2015a, 2015b, 2015c). In the Republican River Basin overall, irrigated acres were about 1.9 million acres in 2002, 2.0 million acres in 2007, and 1.9 million acres in 2012; in the Republican River Basin area that overlies the High Plains aquifer, irrigated acres were about 1.8 million acres in 2002, 1.9 million acres in 2007, and 1.8 million acres in 2012 (table 1; U.S. Geological Survey 2015a, 2015b,

Table 1. Irrigated acres, 2002, 2007, and 2012, by State and in total in the Republican River Basin and in the area of the Republican River Basin overlying the High Plains aquifer (U.S. Geological Survey, 2015a, 2015b, 2015c).

State	Irrigated acres in Republican River Basin			Irrigated acres in Republican River Basin area overlying High Plains aquifer, not including area of little or no saturated thickness		
	2002	2007	2012	2002	2007	2012
Colorado	538,740	495,800	477,530	538,040	495,370	477,100
Kansas	288,770	312,900	297,080	210,440	230,720	200,510
Nebraska	1,089,750	1,221,690	1,135,930	1,088,070	1,217,970	1,134,040
Total	**1,917,260**	**2,030,390**	**1,910,540**	**1,836,550**	**1,944,060**	**1,811,650**

2015c). The distribution of irrigated acres in the Republican River Valley in 2012 is shown on figure 1.

Water-level declines began in parts of the High Plains aquifer soon after the onset of substantial irrigation using groundwater in the area (about 1950; Gutentag and others, 1984). By 2002, water levels in the High Plains aquifer in parts of Texas and southwestern Kansas had declined more than 150 ft and, in the Republican River Basin, had declined more than 50 ft (McGuire, 2004).

Changes in the static water level of an aquifer result from an imbalance between discharge and recharge. The static water level in a well is the water level after the well has recovered from pumping in the measured well or in nearby wells (that is, during nonpumping conditions). Discharge from the High Plains aquifer primarily consists of groundwater withdrawals for irrigation but also includes groundwater withdrawals for public water supply and other uses; evapotranspiration where the water table is near land surface; and seepage to streams, springs, and other surface-water bodies where the water table intersects the land surface (Maupin and Barber, 2005). Recharge to the aquifer primarily is from precipitation, but other sources of recharge include irrigation return flows and seepage from streams, canals, and reservoirs (Luckey and Becker, 1999). Water-level declines may result in increased costs to pump groundwater because of increased pumping lift and decreased well yields (Taylor and Alley, 2001); water-level declines also can affect groundwater availability, surface-water flow, and near-stream (riparian) habitat areas (Alley and others, 1999).

In 2002, management practices were enacted by the Middle Republican Natural Resources District in Nebraska to comply with the Republican River Compact Final Settlement (Republican River Compact Settlement Negotiation Team, 2002). The U.S. Geological Survey, in cooperation with the Middle Republican Natural Resources District, completed a study of water-level changes in the High Plains aquifer within the Republican River Basin from 2002 to 2015 to enable the Middle Republican Natural Resources District to assess the effect of the management practices, which were specified by the Republican River Compact Final Settlement. For this study, water-level changes from 2002 to 2015 were assessed using water levels from 1,523 wells that are screened in the High Plains aquifer and measured after the wells had recovered from the previous year's irrigation season and before pumping started for the 2002 or 2015 irrigation season. The 2002 water levels were measured from September 13, 2001 to June 5, 2002; the 2015 water levels were measured from September 16, 2014 to June 11, 2015. Water-level changes were primarily mapped using the 977 wells that are located in the Republican River Basin (sheet 1 [https://doi.org/10.3133/sim3373], table 2); water-level changes at the Republican River Basin boundary were mapped using the 546 wells located in the 20-mile buffer area surrounding the Republican River Basin (table 2). The purposes of this report are (1) to present water-level changes in the High Plains aquifer within the Republican River Basin from pre-irrigation season 2002 to pre-irrigation season 2015, and (2) to publish the raster dataset of those water-level changes.

Data and Methods

Area-weighted, average water-level changes from 2002 to 2015 were calculated for this report using geospatial data organized as a series of raster datasets (each dataset hereafter referred to as a "raster"). The methods used for this calculation are the same as the methods used in McGuire (2014) and will provide a final raster of water-level changes from 2002 to 2015 for other uses.

Characteristics of Raster Datasets

In this report, a raster was generated of water-level changes in the study area from 2002 to 2015. The raster was generated using two versions of a geographic information system (GIS): Esri® ArcInfo™ Workstation, version 9.3; and Esri® ArcMap, version 10.3.1 (Esri, 1992, 2010, 2016). The raster is georeferenced to geographic coordinates on an Albers equal-area conic projection using the North American Datum of 1983 (NAD 83). The cell size for the raster is 500 meters (m) by 500 m, or about 62 acres. Water-level-change values

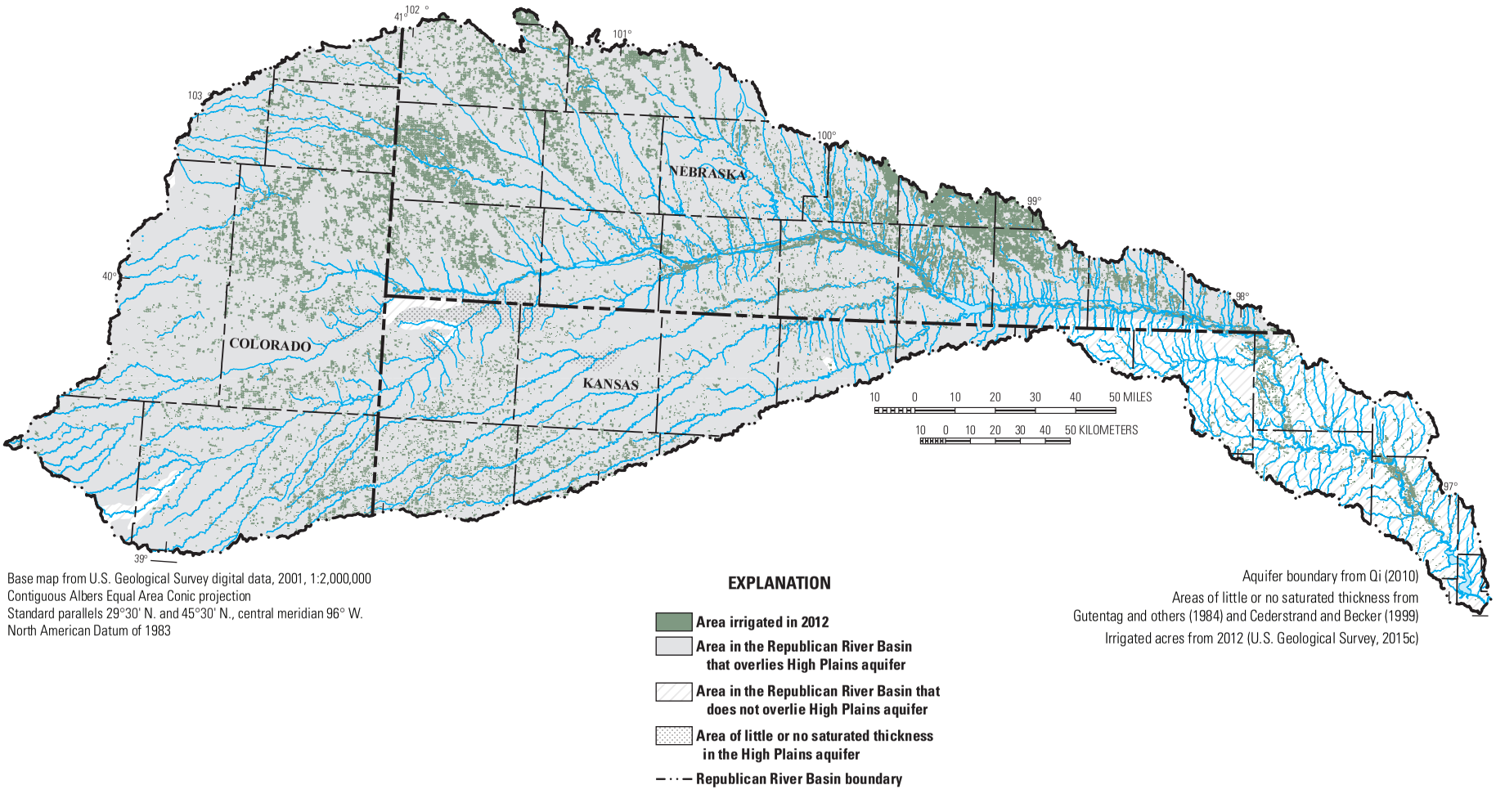

Figure 1. Irrigated acres during 2012 in the Republican River Basin.

Table 2. Number of wells screened in the High Plains aquifer that were used in this report for 2002 and 2015 water levels, and for the water-level comparison period 2002 to 2015, by State and in total for the High Plains aquifer within the Republican River Basin and for a 20-mile area surrounding the Republican River Basin.

State	Number of wells measured				Number of wells used in water-level comparison	
	Within the Republican River Basin		In the 20-mile area surrounding the Republican River Basin		Within the Republican River Basin	In the 20-mile area surrounding the Republican River Basin
	2002	2015	2002	2015	2002 to 2015	2002 to 2015
Colorado	464	389	51	44	361	41
Kansas	158	181	82	97	131	70
Nebraska	540	505	627	465	485	435
Total	**1,162**	**1,075**	**760**	**606**	**977**	**546**

were stored in units of feet. The raster of water-level changes, 2002 to 2015, is available for download in two formats (McGuire, 2016).

The interpolation process, which was used to generate the raster, estimates the water-level change value for each cell. For cells, which are colocated with a measured well, the cell values are generally similar to, but commonly not exactly equal to, the measured water-level-change value.

Characteristics of Water-Level Data

Water-level data used in this report generally were from wells measured with an electric or steel tape using methods similar to those described by Cunningham and Schalk (2011). The wells were measured by numerous State, local, and Federal water-resources agencies, and the measurement results were loaded into the U.S. Geological Survey (USGS) National Water Information System (NWIS) (U.S. Geological Survey, 2016).

Most of the wells were measured manually one to two times per water year. A water year is the 12-month period from October 1 through September 30 and is designated by the calendar year in which it ends. Generally, if a well was measured one time per water year, the well was measured in the mid to late winter or spring (water year 2002 or 2015); if a well was measured two times per water year, the well was measured in mid to late winter or spring (water year 2002 or 2015) and in fall or early winter (if before October 1, water year 2001 or 2014; if after September 30, water year 2002 or 2015). Some wells were measured nearly continuously using instrumentation (data recorders with sensors or floats) installed in the well that recorded the water level periodically (generally every 15 to 60 minutes) (Cunningham and Schalk, 2011).

Water-level data used to map water-level changes were compiled for the period before the irrigation season (September to mid-June), which could span two water years; therefore, the water year of the winter or spring measurement was used to designate the specified calendar years for comparison, 2002 or 2015 (U.S. Geological Survey, 2016). One of the wells for 2002 was measured in water year 2001; the remaining wells for 2002 were measured in water year 2002. One of the wells for 2015 was measured in water year 2014; the remaining wells for 2015 were measured in water year 2015. Available water-level data for each well were reviewed to select a water level that (1) represented the static water level for each applicable calendar year and (2) was consistent with water levels in nearby wells. If a static water level was not available for a given well for the specified calendar year, the water-level data for that well for the specified calendar year were not used in this report.

Most of the measured wells supply water for irrigation; water-level precision and accuracy in irrigation wells can be adversely affected by excess oil used to lubricate the well's pump. The thickness of the excess oil and the depth to the oil-water interface can be measured with specialized water-level tapes or can be estimated using a method described in Cunningham and Schalk (2011). The specialized tapes often cannot be used in irrigation wells because the opening(s) in the well casing for the tape generally are too small for the specialized tape. In this report, it is assumed that, if there is not oil in the well, the precision of the water-level measurements is 0.01 ft; if there is oil on the surface of the water, the precision of the water-level measurement likely is greater than 0.01 ft. The accuracy of the water-level measurement can be affected by many factors (Cunningham and Schalk, 2011); if there is oil on the surface of the water, the error in the water-level measurement could be as much as 5 ft, depending on the depth of the oil and whether the methods described in Cunningham and Schalk (2011) are used to correct the water-level measurement. For this study, methods were not used to assess the amount of oil on the surface of the water; therefore, the effect on the water-level accuracy that should be attributed to oil on the water surface cannot be assessed.

In the three States underlain by the High Plains aquifer within the Republican River Basin, water-level changes from 2002 to 2015 were determined using wells with a measured static water level for 2002 and 2015 (table 2 and the comma-delimited (csv) or Microsoft Excel® formatted file [https://doi.org/10.3133/sim3373] in the appendix). Estimated water levels were not used to map 2002 to 2015 water-level changes.

Characterizing Water-Level Changes, 2002 to 2015

The raster of water-level changes, 2002 to 2015, was generated using the GIS command "topogrid," which is the same method used in McGuire (2014) for the raster of water-level changes from 2011 to 2013. The mapped areas between a decline of less than 3 ft and a rise of less than 3 ft were termed "areas of no substantial change" and were assigned a value of zero water-level change rather than using the GIS interpolation of water-level change values in these areas. The calculation of area-weighted, average water-level changes for 2002 to 2015 did not include the areas of "little or no saturated thickness", which is the same methods used in McGuire (2014) to calculate area-weighted, average water-level changes for 2011 to 2013.

Water-Level Data

Water-level data used in this report were provided by the following State, local, and Federal entities through data files or downloads from Web sites and loaded into the USGS NWIS (U.S. Geological Survey, 2016):

- Colorado—Division of Water Resources (also known as the Office of the State Engineer) (http://water.state.co.us/Home/Pages/default.aspx);
- Kansas—Department of Agriculture, Division of Water Resources and the Kansas Geological Survey (Kansas Geological Survey, 2016);
- Nebraska—Central Nebraska Public Power and Irrigation District (http://www.cnppid.com/) and the Lower Republican (http://www.lrnrd.org/), Middle Republican (http://www.mrnrd.org/), Tri-Basin (http://www.tribasinnrd.org/), Twin Platte (http://www.tpnrd.org/), and Upper Republican Natural Resources Districts (http://www.urnrd.org/); and
- Federal—USGS offices in Colorado, Kansas, and Nebraska and U.S. Bureau of Reclamation (https://www.usbr.gov/gp/nkao/).

The data used in this report were retrieved from the USGS NWIS (U.S. Geological Survey, 2016) and are listed in the csv and Microsoft Excel® formatted files in the appendix.

Water-Level Changes, 2002 to 2015

Water levels were measured in 977 wells, which were screened in the High Plains aquifer within the Republican River Basin, and measured for 2002, after the irrigation season in 2001 and before the irrigation season in 2002, and, for 2015, after the irrigation season in 2014 and before the irrigation season in 2015 (table 2). The water levels for 2002 were measured from September 13, 2001 to June 5, 2002; the water levels for 2015 were measured from September 16, 2014 to June 11, 2015. The number of wells measured one time was 663 for 2002 and 668 for 2015, or about 68 percent for each year. The number of wells measured two times was 278 for 2002 and 269 for 2015, or about 28 percent for each year. The number of wells measured more than two times was 36 for 2002 and 40 for 2015, or about 4 percent for each year. Continuous water-level data were available for 4 wells in 2002 and 10 wells in 2015. Water-level changes in the measured wells ranged from (1) a rise of 9.4 ft in a well in Kit Carson County, Colorado, to a decline of 43.2 ft in another well in Yuma County, Colo.; (2) between a rise of 3 ft and a decline of 3 ft in 29 percent of the wells; and (3) between a rise of 1 ft and a decline of 1 ft in 12 percent of the wells.

Water levels declined 3 ft or more in 68 percent of the measured wells and declined 5 ft or more in 60 percent of the measured wells. Water levels rose 3 ft or more in 3 percent of measured wells and rose 5 ft or more in 1 percent of measured wells. Area-weighted, average water-level changes, 2002 to 2015, by State ranged from a 3.2-ft decline in Nebraska to a 6.1-ft decline in Colorado (table 3). The area-weighted, average water-level change for the High Plains aquifer within the Republican River Basin for the period 2002 to 2015 was a decline of 4.5 ft (sheet 1 [https://doi.org/10.3133/sim3373]; table 3; McGuire, 2016).

Table 3. Area-weighted, average water-level changes in the High Plains aquifer within the Republican River Basin, not including areas of little or no saturated thickness, 2002 to 2015, by State and as an overall total.

[Negative values for water-level declines]

State	Area-weighted, average water-level change, in feet
Colorado	-6.1
Kansas	-4.6
Nebraska	-3.2
Total	**-4.5**

Summary

The High Plains aquifer underlies 111.8 million acres (about 175,000 square miles) in parts of eight States—Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. More than 95 percent of the water withdrawn from the High Plains aquifer is used for irrigation. The Republican River Basin is 15.9 million acres (about 25,000 square miles) and is located in northeast Colorado, northern Kansas, and southwest Nebraska. The Republican River Basin overlies the High Plains aquifer in 87 percent of the basin area.

Water-level declines began in parts of the High Plains aquifer soon after the onset of substantial irrigation using groundwater in the area (about 1950). By 2002, water levels in the High Plains aquifer in parts of Texas and southwestern Kansas had declined more than 150 feet and, in the Republican River Basin, had declined more than 50 feet.

In 2002, management practices were enacted in the Middle Republican Natural Resources District in Nebraska to comply with the Republican River Compact Final Settlement. The U.S. Geological Survey, in cooperation with the Middle Republican Natural Resources District, completed a study of water-level changes in the High Plains aquifer within the Republican River Basin from 2002 to 2015 to enable the Middle Republican Natural Resources District to assess the effect of the management practices, which were specified by the Republican River Compact Final Settlement. For this study, water-level changes from 2002 to 2015 were assessed using water levels from 1,523 wells that are screened in the High Plains aquifer and measured before the irrigation season in 2002 and 2015. Water-level changes were primarily mapped using the 977 wells that are located in the Republican River Basin; water-level changes at the Republican River Basin boundary were mapped using the 546 wells located in the 20-mile buffer area surrounding the Republican River Basin. The purposes of this report are (1) to present water-level changes in the High Plains aquifer within the Republican River Basin from 2002 to 2015 and (2) to publish the raster dataset of those water-level changes. Water-level changes from 2002 to 2015, in individual wells located in the Republican River Basin, ranged from a rise of 9.4 feet to a decline of 43.2 feet. The area-weighted, average water-level change from 2002 to 2015 for the High Plains aquifer within the Republican River Basin was a decline of 4.5 ft.

Acknowledgments

Most of the water-level data used in this report were provided by the following State and local entities: Colorado—Division of Water Resources (also known as the Office of the State Engineer); Kansas—Department of Agriculture, Division of Water Resources and the Kansas Geological Survey; and Nebraska—Central Nebraska Public Power and Irrigation District and the Lower Republican, Middle Republican, Tri-Basin, Twin Platte, and Upper Republican Natural Resources Districts. The author thanks the above entities for providing the water-level data and for their responsiveness regarding questions about the data.

References Cited

Alley, W.M., Reilly, T.E., and Franke, O.L., 1999, Sustainability of ground-water resources: U.S. Geological Survey Circular 1186, 79 p. [Also available at http://pubs.usgs.gov/circ/circ1186/.]

Cederstrand, J.R., and Becker, M.F., 1999, Digital map of areas of little or no saturated thickness for the High Plains Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Open-File Report 99–266, accessed August 2011 at http://water.usgs.gov/GIS/metadata/usgswrd/XML/ofr99-266.xml.

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods, book 1, chap. A1, 151 p., accessed October 2014 at http://pubs.usgs.gov/tm/1a1/.

Esri, 1992, Understanding GIS—The Arc/Info method: Redlands, Calif., Esri, 450 p.

Esri, 2010, ArcDoc version 9.3: Redlands, Calif., Esri software documentation [online documentation and instructions included with GIS software].

Esri, 2016, ArcMap version 10.3.1: Redlands, Calif., Esri software documentation [online documentation and instructions included with GIS software].

Gutentag, E.D., Heimes, F.J., Krothe, N.C., Luckey, R.R., and Weeks, J.B., 1984, Geohydrology of the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Professional Paper 1400–B, 63 p. [Also available at http://pubs.usgs.gov/pp/1400b/report.pdf.]

Heimes, F.J., and Luckey, R.R., 1982, Method for estimating historical irrigation requirements from ground water in the High Plains in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Water-Resources Investigations Report 82–40, 64 p.

Kansas Geological Survey, 2016, Wizard water well levels database: Lawrence, Kansas Geological Survey digital data, accessed June 2016 at http://www.kgs.ku.edu/Magellan/WaterLevels/index.html.

Luckey, R.R., and Becker, M.F., 1999, Hydrogeology, water use, and simulation of flow in the High Plains aquifer in northwestern Oklahoma, southeastern Colorado, southwestern Kansas, northeastern New Mexico, and northwestern Texas: U.S. Geological Survey Water-Resources Investigations Report 99–4104, 68 p. [Also available at http://pubs.usgs.gov/wri/wri994104/.]

Maupin, M.A., and Barber, N.L., 2005, Estimated withdrawals from principal aquifers in the United States, 2000: U.S. Geological Survey Circular 1279, 46 p. [Also available at http://pubs.usgs.gov/circ/2005/1279/.]

McGuire, V.L., 2004, Water-level changes in the High Plains aquifer, predevelopment to 2002, 1980 to 2002, and 2001 to 2002: U.S. Geological Survey Fact Sheet 2004–3026, 4 p. [Also available at http://pubs.usgs.gov/fs/2004/3026/.]

McGuire, V.L., 2014, Water-level changes and change in water in storage in the High Plains aquifer, predevelopment to 2013 and 2011–13: U.S. Geological Survey Scientific Investigations Report 2014–5218, 14 p. [Also available at http://dx.doi.org/10.3133/sir20145218.]

McGuire, V.L., 2016, Data from map of water-level changes in the High Plains Aquifer, Republican River Basin in Colorado, Kansas, and Nebraska, 2002 to 2015: U.S. Geological Survey data release, accessed December, 2016 at https://doi.org/10.5066/F7X34VKH.

McGuire, V.L., Lund, K.D., and Densmore, B.K., 2012, Saturated thickness and water in storage in the High Plains aquifer, 2009, and water-level changes and changes in water in storage in the High Plains aquifer, 1980 to 1995, 1995 to 2000, 2000 to 2005, and 2005 to 2009: U.S. Geological Survey Scientific Investigations Report 2012–5177, 28 p. [Also available at http://pubs.usgs.gov/sir/2012/5177/.]

Qi, S.L., 2010, Digital map of aquifer boundary for the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Data Series 543. [Also available at http://pubs.usgs.gov/ds/543/.]

Republican River Compact Settlement Negotiation Team, 2002, Final Settlement Stipulation on December 15, 2002, Kansas v. Nebraska & Colorado: Republican River Compact Administration, accessed September 2016 at http://www.dnr.nebraska.gov/media/iwm/Republican/FinalSettlement3.pdf.

Taylor, C.J., and Alley, W.M., 2001, Ground-water-level monitoring and the importance of long-term water-level data: U.S. Geological Survey Circular 1217, 68 p. [Also available at http://pubs.usgs.gov/circ/circ1217/.]

Thelin, G.P., and Heimes, F.J., 1987, Mapping irrigated cropland from Landsat data for determination of water use from the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Professional Paper 1400–C, 38 p. [Also available at http://pubs.usgs.gov/pp/1400c/report.pdf.]

U.S. Geological Survey, 2015a, The 2002 Moderate Resolution Imaging Spectroradiometer (MODIS) Irrigated Agriculture 250-Meter Dataset for the Conterminous United States (MIrAD-US): U.S. Geological Survey spatial data, accessed July 2016 at http://earlywarning.usgs.gov/USirrigation/.

U.S. Geological Survey, 2015b, The 2007 Moderate Resolution Imaging Spectroradiometer (MODIS) Irrigated Agriculture 250-Meter Dataset for the Conterminous United States (MIrAD-US): U.S. Geological Survey spatial data accessed July 2016 at http://earlywarning.usgs.gov/USirrigation/.

U.S. Geological Survey, 2015c, The 2012 Moderate Resolution Imaging Spectroradiometer (MODIS) Irrigated Agriculture 250-Meter Dataset for the Conterminous United States (MIrAD-US): U.S. Geological Survey spatial data accessed July 2016 at http://earlywarning.usgs.gov/USirrigation/.

U.S. Geological Survey, 2016, USGS water data for the Nation: U.S. Geological Survey digital data, accessed July 2016 at http://dx.doi.org/10.5066/F7P55KJN.

Weeks, J.B., and Gutentag, E.D., 1981, Bedrock geology, altitude of base, and 1980 saturated thickness of the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas HA–648, 2 sheets, scale 1:2,500,000. [Also available at http://pubs.er.usgs.gov/publication/ha648.]

Appendix

Report Datasets

Water-level change data from 2002 to 2015 and selected other data for the 1,523 wells are presented in both a linked csv and Microsoft Excel® formatted files (https://doi.org/10.3133/sim3373). These wells are screened in the High Plains aquifer, measured in both 2002 and 2015, and located in the Republican River Basin or in the 20-mile buffer area surrounding the Republican River Basin.

The column names in the csv file are listed with some additional information in the first lines of the csv file; the first character of these comment lines is "#." The content of the comment lines includes the column name for each field, with no spaces or punctuation in the column name; 2 hyphens; a longer, generally more descriptive column name; information on format, units, or column values; and, if relevant, information for importing the column in the csv file into Excel®. The agency code (Agency-Code) and site identification number (SiteID) in the csv file, formatted as a number or as text with no decimal places, can be used to access water-level data for the wells in the U.S. Geological Survey National Water Information System database (U.S. Geological Survey, 2016).

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