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Winter 2019–2020 Water-Level Elevation Map for the Albuquerque Metropolitan Area

Prepared for Albuquerque Bernalillo County Water Utility Authority

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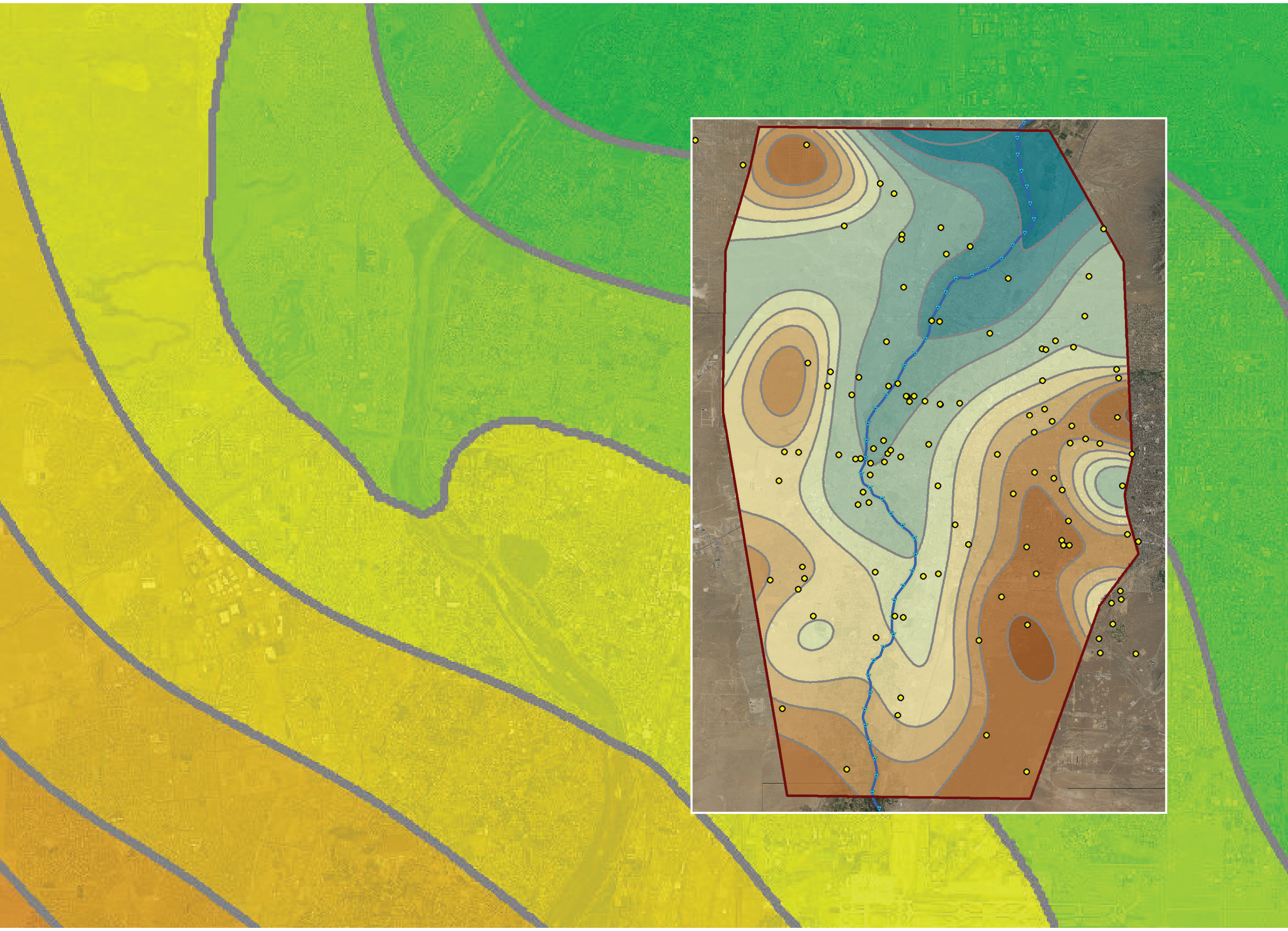

OPEN-FILE REPORT

Open-File Report 622—Winter 2019–2020 Water-Level Elevation Map for the Albuquerque Metropolitan Area

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WINTER 2019–2020 WATER-LEVEL ELEVATION MAP FOR THE ALBUQUERQUE METROPOLITAN AREA

Geoffrey Rawling, New Mexico Bureau of Geology and Mineral Resources

INTRODUCTION

Residents of the Albuquerque metropolitan area rely in part on groundwater for domestic, municipal, and industrial use. An understanding of changes in groundwater levels and groundwater storage changes in the aquifer is necessary to achieve groundwater management goals set by the Albuquerque Bernalillo County Water Utility Authority (2016), henceforth the Water Authority. Periodic and continuous water-level measurements in wells and maps of the water-level elevation surface, or water table, derived from these data are essential tools for understanding the groundwater resources of the region.

This report describes the preparation and interpretation of a water-table map for the Albuquerque area for the winter of 2019–2020. Water-level changes and changes in the amount of groundwater in storage in the aquifer since the predevelopment time period are presented. Predevelopment is defined by the map of Bexfield and Anderholm (2000; Fig. 1) and represents conditions prior to 1961. The present study also recasts recent water-level surface and changes since predevelopment in terms of water-level management criteria defined by the Water Authority (2016), shown in the block diagram in Figure 2. Referring to this diagram, the range of water-level elevations from 50 ft of drawdown to 250 ft of drawdown relative to predevelopment conditions is defined as the working reserve. The fuel gauge on the diagram pertains to the water level relative to the base of the working reserve, the 250-ft drawdown level. The 50 ft of aquifer below the working reserve is referred to as the safety reserve. The base of the safety reserve, at 300 ft of drawdown relative to predevelopment, is a conservative estimate of when irreversible compaction effects will start to be felt in the aquifer. The diagram also shows the management level of 110 ft of drawdown, which is a target average value drawdown for wells used by the Water Authority.

METHODS

Periodic manual measurements and continuous water-level data recorded in wells were used to map the winter 2019–2020 water-level surface within the producing zone of the Upper Santa Fe Group aquifer in the Albuquerque region. Winter was defined as November through February (inclusive). Standard methods, as described in Falk et al. (2011) and Galanter and Curry (2019), were used to acquire these data in the field.

All available data from January 1, 2015, to September 1, 2020, were accumulated and reviewed. The data were collected by the U.S. Geological Survey (USGS), the New Mexico Bureau of Geology and Mineral Resources (NMBGMR), Bernalillo County, and the U.S Department of Energy; the data were retrieved from USGS and NMBGMR databases. A total of 312 wells in the Albuquerque area that had water-level measurements from 2015 to 2020 were examined. These wells are located across an area larger than the extent of the boundaries of the maps shown in the accompanying figures. Calculations and interpolations were performed across this larger area, and the results were clipped to the extent shown, which is the extent of previous water-level maps prepared by Falk et al. (2011) and Galanter and Curry (2019). This process reduces the

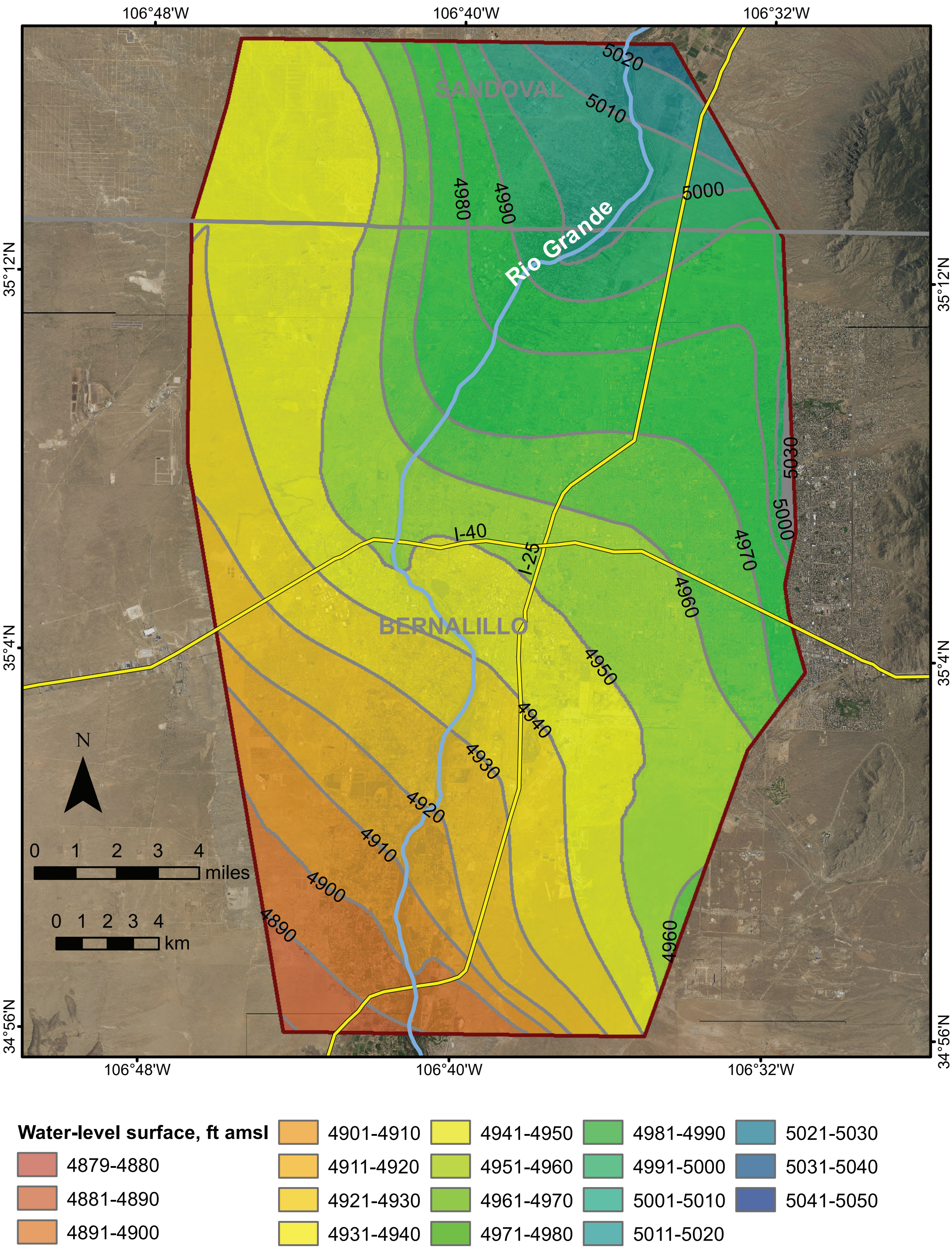

Figure 1. Predevelopment water-level elevation contours from Bexfield and Anderholm (2000) and interpolated surface (color shading). The study area boundary in this and the subsequent maps is from Galanter and Curry (2019).

influence of artifacts caused by edge effects in the interpolations and produces maps spatially consistent with previous work.

To produce a water-table map of the production zone of the aquifer, described by Falk et al. (2011) as "the interval of the aquifer, about 300 feet below land surface to 1,100 feet or more below land surface, in which production wells generally are screened," all single isolated wells were considered. Grouped wells (well nests) are also present, with two to six wells in each nest. The deeper well of a nested pair (two wells) was selected, and the second deepest well was selected from nests with three to six wells.

Water levels with a USGS pumping flag were removed. Hydrographs of water levels at each well were reviewed interactively to identify any outlier measurements, which differed noticeably, usually by several feet, from other measurements in the hydrograph trend. Two measurements were removed in this way. The highest water level for the winter time period for each well was retained. The final dataset contained 131 water levels at 131 wells, and all data were from November 1, 2019, through March 1, 2020.

An important methodological difference of this study from the earlier work of Bexfield and Anderholm (2000), Falk et al. (2011), and Galanter and Curry (2019) is the treatment of water-level elevation in the production zone of the aquifer along the course of the Rio Grande, which transects the study area and is hydrologically connected to the shallow aquifer system. Bexfield and Anderholm (2000) characterized the groundwater elevation at the river by using the elevation of the riverbed digitized from topographic maps. The riverbed elevation points are limited to the resolution of

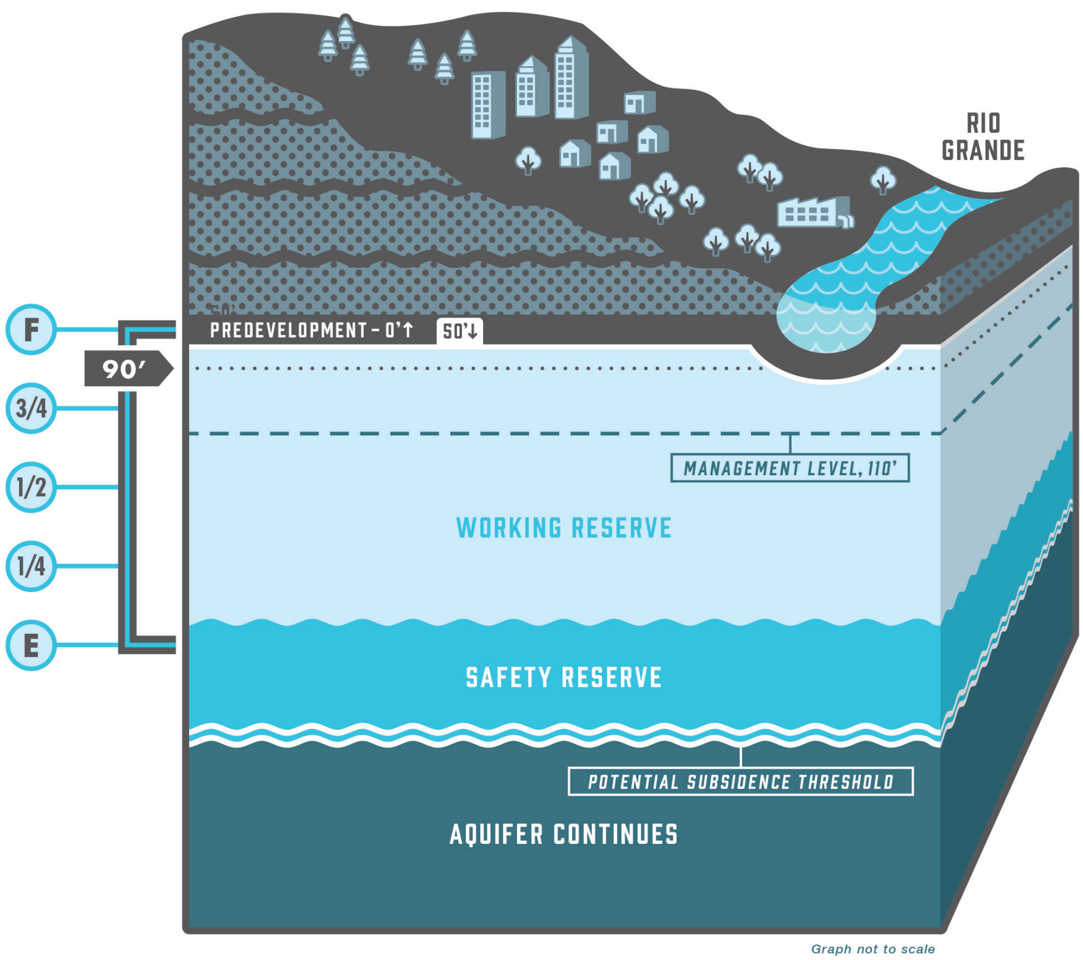

Figure 2. Block diagram illustrating water management criteria for the City of Albuquerque (Water Authority, 2016). See text for definitions and elevation thresholds.

the contour interval at the river (10 ft) and change over time as the channel morphology changes; in addition, riverside drains below the river level cause the groundwater levels to be beneath the riverbed. Falk et al. (2011) and Galanter and Curry (2019) calculated the head difference between shallow and deeper wells at five piezometer nests near the river and linearly interpolated this difference along the course of the river. The difference in groundwater levels between the shallow, river-connected aquifer and the deeper production zone at the five wells varied from 1 ft to 38 ft from south to north (Galanter and Curry, 2019), with the deeper well always having the lower level. This approach was not viable for the current study, as only three well nests had data for the winter 2019–2020 period, and this method produced an unreasonable trend of estimated water-level elevations when interpolated along the length of the river.

The method used in this study involved selecting wells within 500 m of the centerline of the Rio Grande and assigning water levels at those 12 wells to adjacent points along the river centerline (Alex Rinehart, personal communication, 2021). Water levels along the river reach were then modeled with an exponential curve fit at 500-m intervals along the river from south to north. This produced a smooth variation in water-level elevations derived from groundwater measurements and was not dependent on uncertain land- and/or river-surface elevations or the details of the surface water—shallow groundwater interactions between the river and riverside drains.

The standard geostatistical method of regression kriging (Hengl et al., 2007) was implemented with the *gstat* package in R (R Core Team, 2019) to interpolate water levels between the water-level measurement points. The regional water-level elevation trend was modeled with third-order polynomial fit to the easting and northing coordinates of the wells and river points. The spatial covariance structure of the residuals from this surface was modeled with a variogram and then interpolated using spatial kriging. Interpolated residuals were then added to the polynomial trend surface, resulting in the 2019–2020 water-level surface (Fig. 3).

It must be noted in Figure 3 and the subsequent maps that are derived from it that the accuracy of the interpolated surface is dependent on the locations of the data (i.e., wells shown in Fig. 3 and interpolation points along the Rio Grande). This is quantified by the kriging variance shown in Figure 4. Results are most reliable where data are abundant (low variance) and least reliable where data are scarce (high variance). This is particularly important when considering water-level changes. The same is also true of the original predevelopment water-level contours of Bexfield and Anderholm (2000), even though their contours were hand drawn rather than generated using geostatistical methods. The map of water-level change is based on interpolation of predevelopment water-level contours to raster surfaces using the Topo to Raster tool in ArcGIS 10.7.1 (Esri, 2019), followed by raster math operations.

RESULTS

The predevelopment water-level surface is shown in Figure 1. The colored raster surface accurately reflects the geometry of the water-level contours. See Bexfield and Anderholm (2000) for a discussion of the hydrogeology. Figures 3 and 4 show the interpolated winter 2019–2020 water-level surface and the kriging variance of the interpolation. Red colors in the kriging variance map are less reliable results in areas of sparse data.

Figure 5 shows the predicted depth to water in color shading. Areas in South Valley shown in purple have negative predicted depth to water, i.e., water above the ground surface. The most negative value is only a few feet. Both the water table and the land surface are very flat here, and data other than the interpolated river points are sparse. In reality, the water table is very shallow, probably less than 10 ft depth to water, and the negative values are due to uncertainty in the surface due to sparse data.

Figure 6 shows the water-level changes since predevelopment (pre-1961). The areas of largest change are associated with pumping wells in Rio Rancho and Albuquerque, north and south of I-40. Figure 7 shows the recent water-level surface (as contours) and its elevation with respect to the 110-ft management level. The management level is the surface defined by 110 ft of drawdown from the predevelopment water-level surface (Fig. 2). Blue shading shows areas where recent water levels are above the management level, and red shows areas where recent water levels are below it.

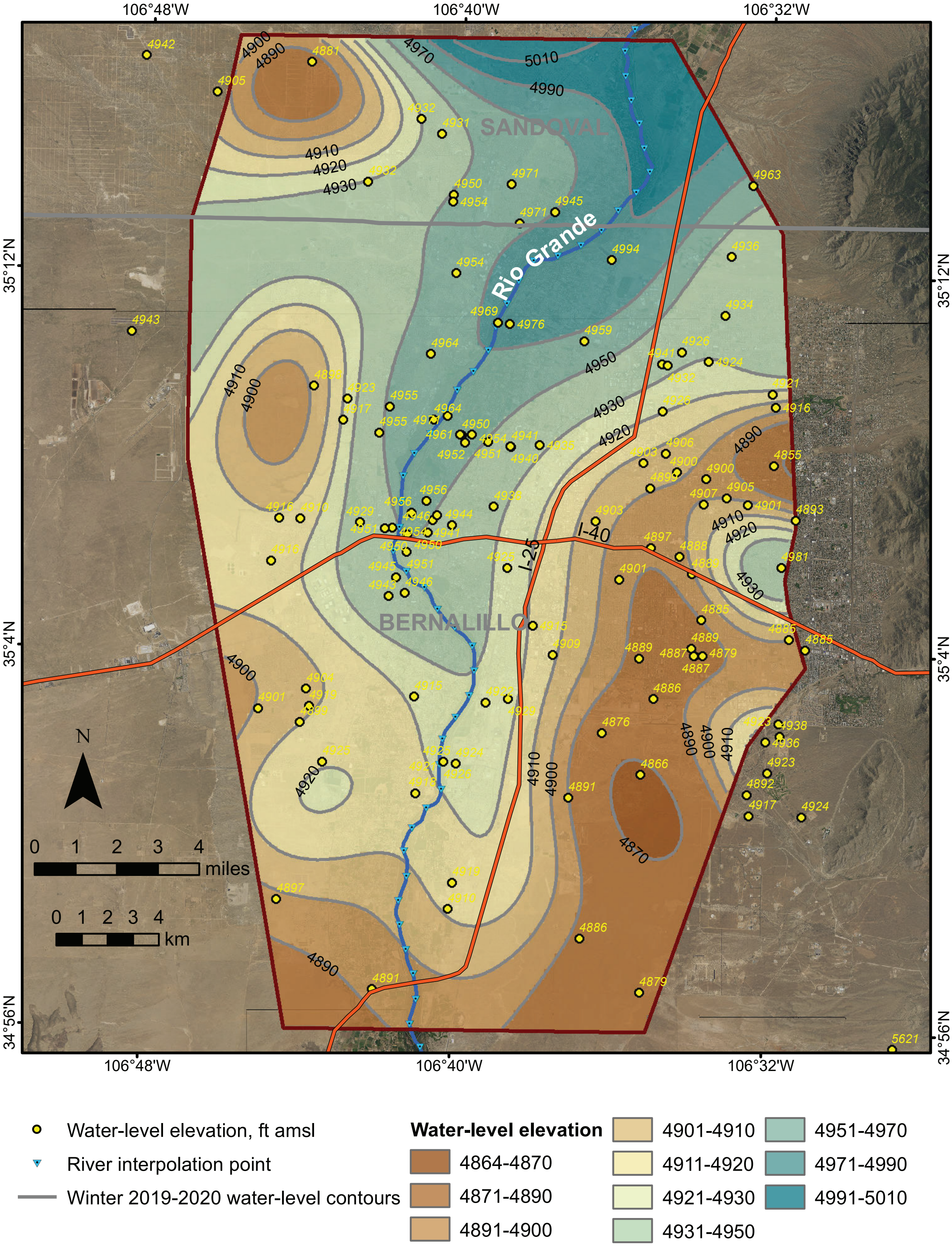

Figure 3. Winter 2019–2020 water-level elevation surface. Wells with measurements used in the geostatistical interpolation to create the surface are shown in yellow.

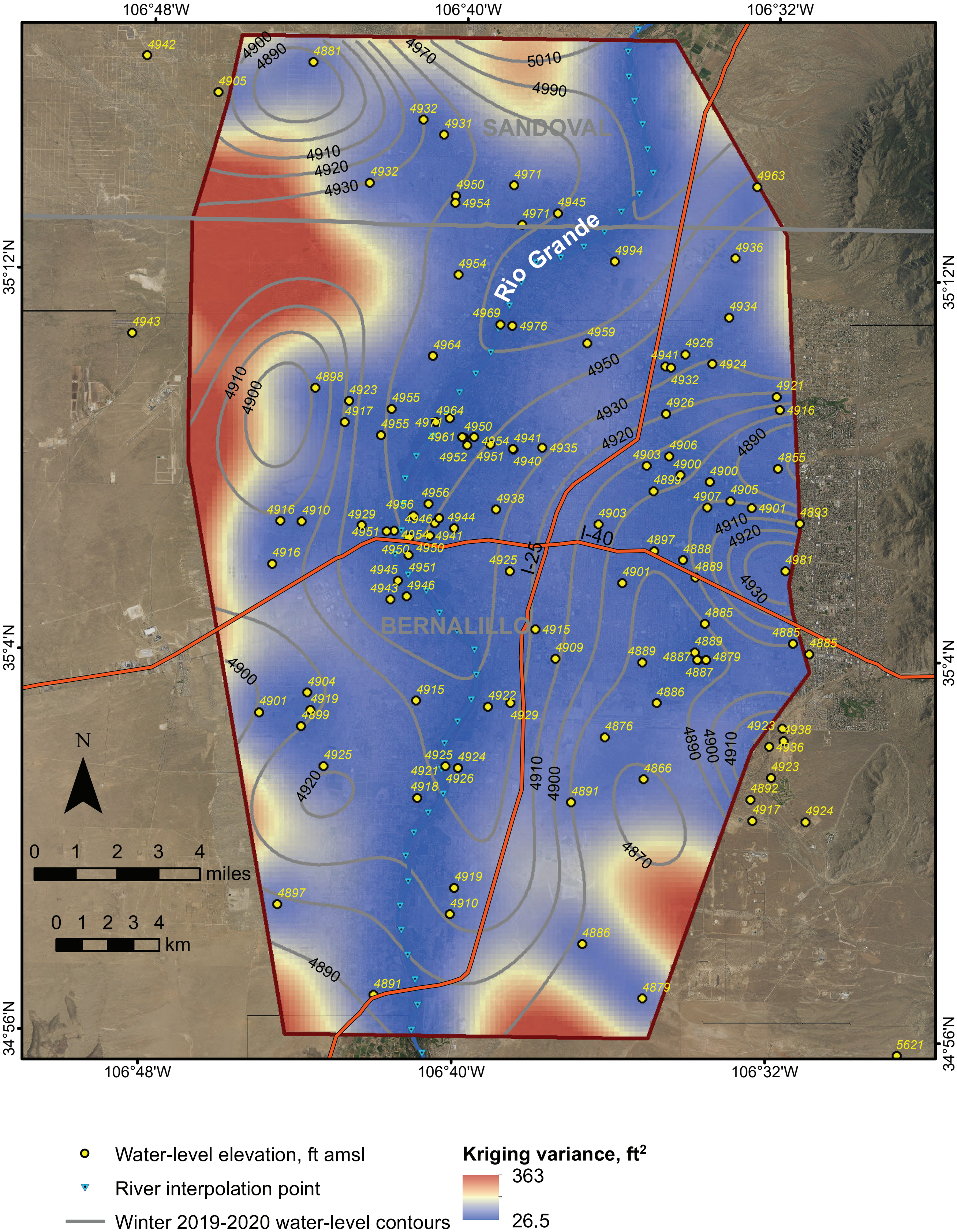

Figure 4. Kriging variance of the recent (2019–2020) water-level elevation surface. Lower variance corresponds to more reliable results. Wells with measurements used in the geostatistical interpolation to create the surface are shown in yellow.

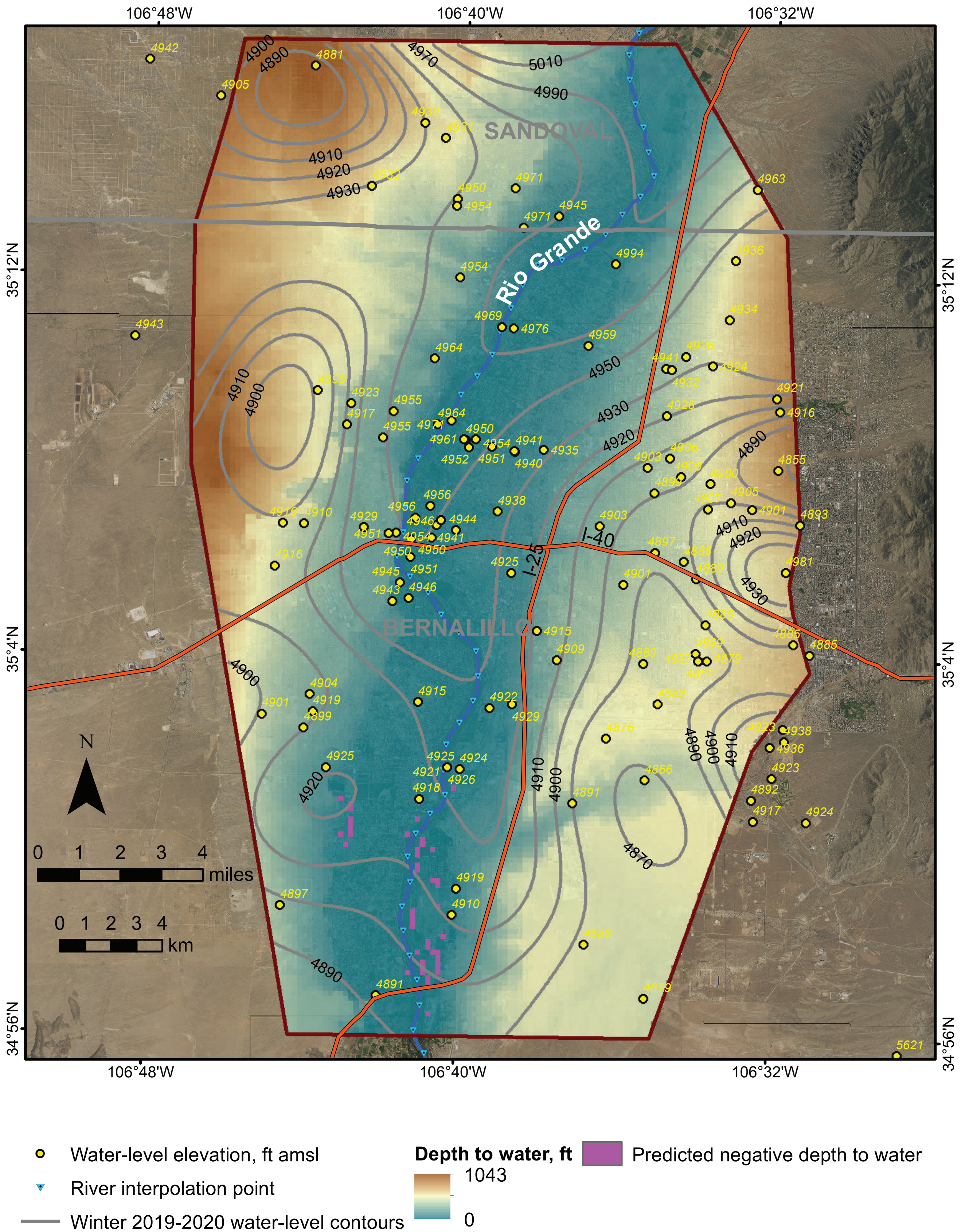

Figure 5. Depth to water based on the winter 2019–2020 water-level surface. Areas where the water level is predicted to be at or above the ground surface are shown in purple. See text for discussion.

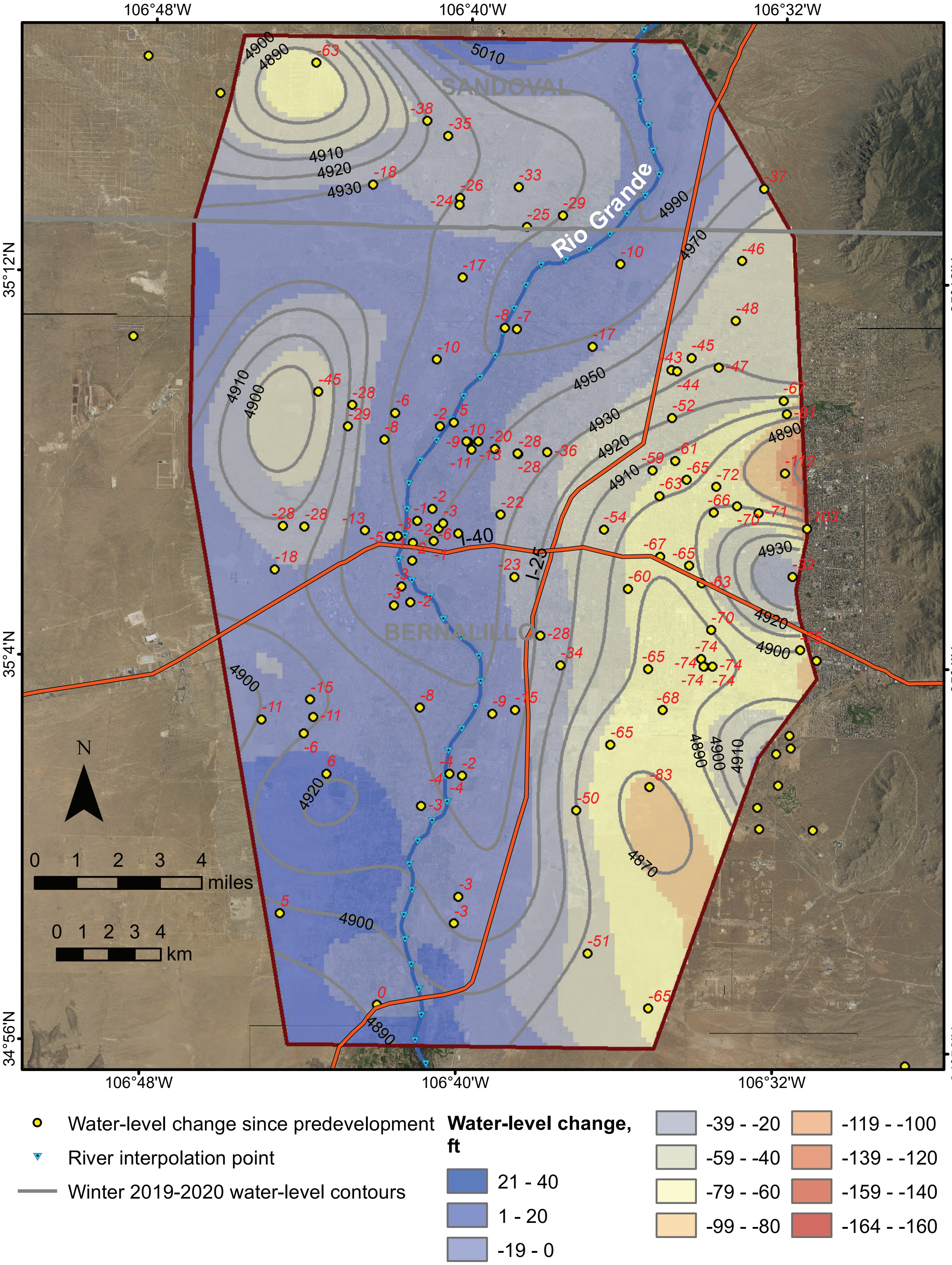

Figure 6. Change in water levels from predevelopment (pre-1961). Rises (positive) are in shades of blue and declines (negative) are in shades of gray, yellow, and red.

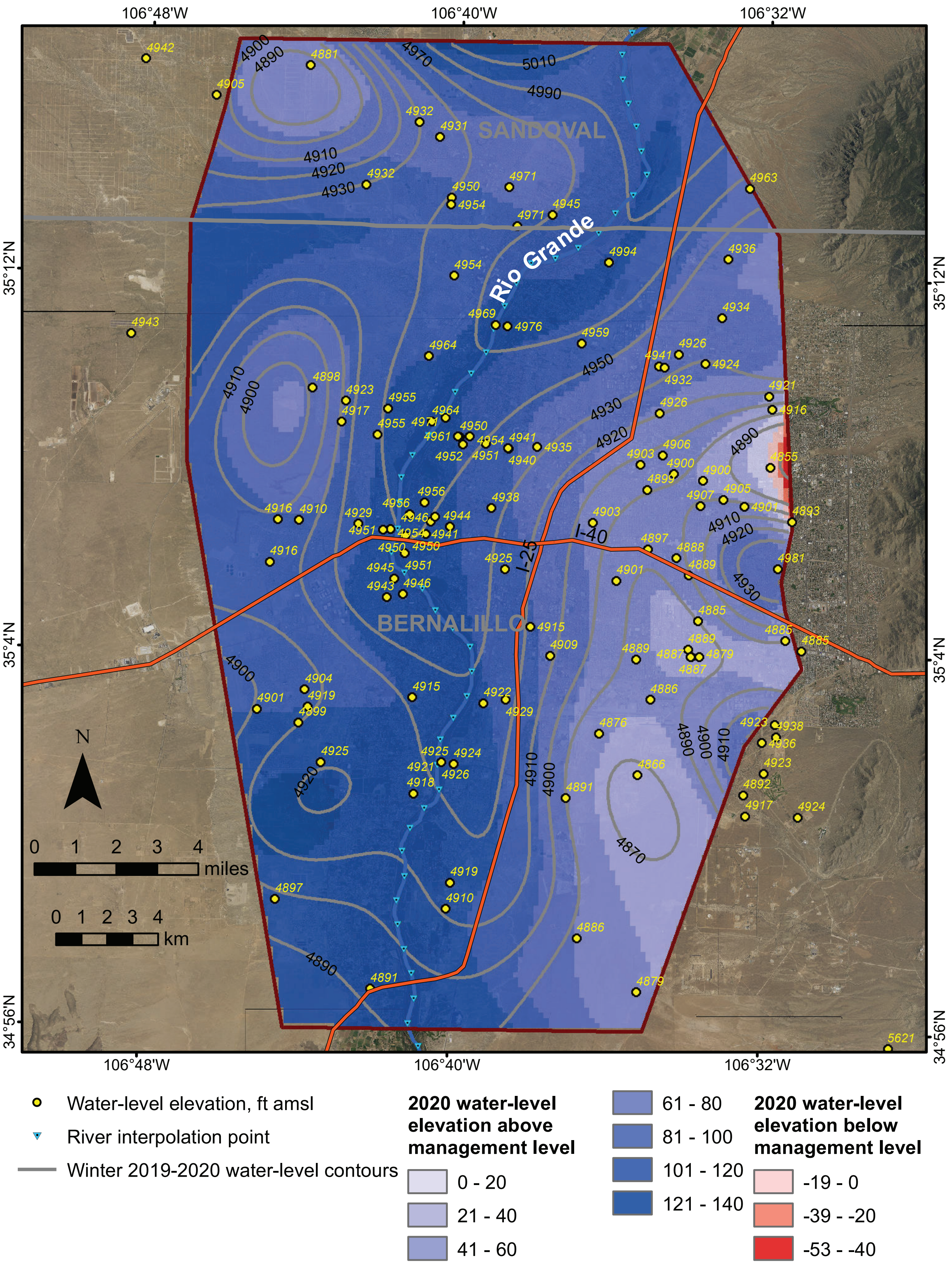

Figure 7. Winter 2019–2020 water-level surface with respect to the 110-ft drawdown management level. Water levels above the management level are in shades of blue; those below are in shades of red.

The map of water-level changes can be used to estimate the storage change in the aquifer since predevelopment. This is a straightforward calculation of the net volume change from the water-level changes multiplied by the specific yield. It must be viewed with caution because the result is highly dependent on the value for specific yield, which must be assumed in this case. A value of 0.2 was chosen for this study, consistent with previous work (McAda and Barroll, 2002; Rinehart et al., 2016). It is likely that the specific yield varies in space, with depth, and with lithology (e.g., Cederstrand and Becker, 1998). The calculation is also dependent on the accuracy of the predicted water-level changes, which are themselves dependent on the spatial density of the data as revealed by the kriging variance map (Fig. 4). From predevelopment to winter 2019–2020, the estimate of storage change is a net loss of 1,125,000 acre-ft of water from the aquifer. This estimate could be improved by mapping the specific yield across the Albuquerque Basin, and this is the subject of current research by the USGS.

SUMMARY

The maps presented here interpret the winter 2019–2020 water-level surface in the Albuquerque metropolitan area. Comparing this surface to water-level management criteria set by the Water Authority provides a clear picture of the current groundwater conditions. Changes in water levels and an estimate of the change in storage since predevelopment are also presented. It is estimated that approximately 1,125,000 acre-ft of water have been lost from storage due to groundwater pumping since predevelopment.

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