United States Department of the Interior

U. S. GEOLOGICAL SURVEY

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November 5, 2010

MEMORANDUM

To: Devin Galloway, Ground-Water Specialist, Western Region, USGS

From: Keith J. Halford, Ground-Water Specialist, Nevada WSC, USGS

Subject: AQUIFER TEST—Analysis of BS-NW, single-well aquifer test of basin-fill aquifer, southwestern Snake Valley, HA195, near Great Basin National Park, NV

A single-well aquifer test was conducted by the U.S. Geological Survey (USGS) in southwestern Snake Valley, HA195, near Great Basin National Park to estimate the transmissivity of the basin-fill aquifer (BS-NW; Figure 1). Well BS-NW was pumped for 42 hours at 260 gpm between 12:19 October 4, 2010 and 06:35 October 6, 2010, and discharge was measured with a totalizing flowmeter. Transmissivity from the well BS-NW aquifer test will help characterize flow to Big Springs, southern Snake Valley, Nevada.

Site and Geology

The aquifer test occurred in southwestern Snake Valley where groundwater development has been proposed (Welch and others, 2007). Basin-fill deposits were encountered from land surface to 460 ft below land surface. The basin fill comprised well-sorted sands, gravels, and cobbles with very little clay. The basin-fill aquifer could be interpreted as homogeneous because the sediments were distributed uniformly over the length of the borehole. Depth to water was about 230 ft below land surface. Saturated thickness of the basin fill was 400 ft, where total thickness was estimated from gravity data (Sweetkind and others, 2007, plate 1).

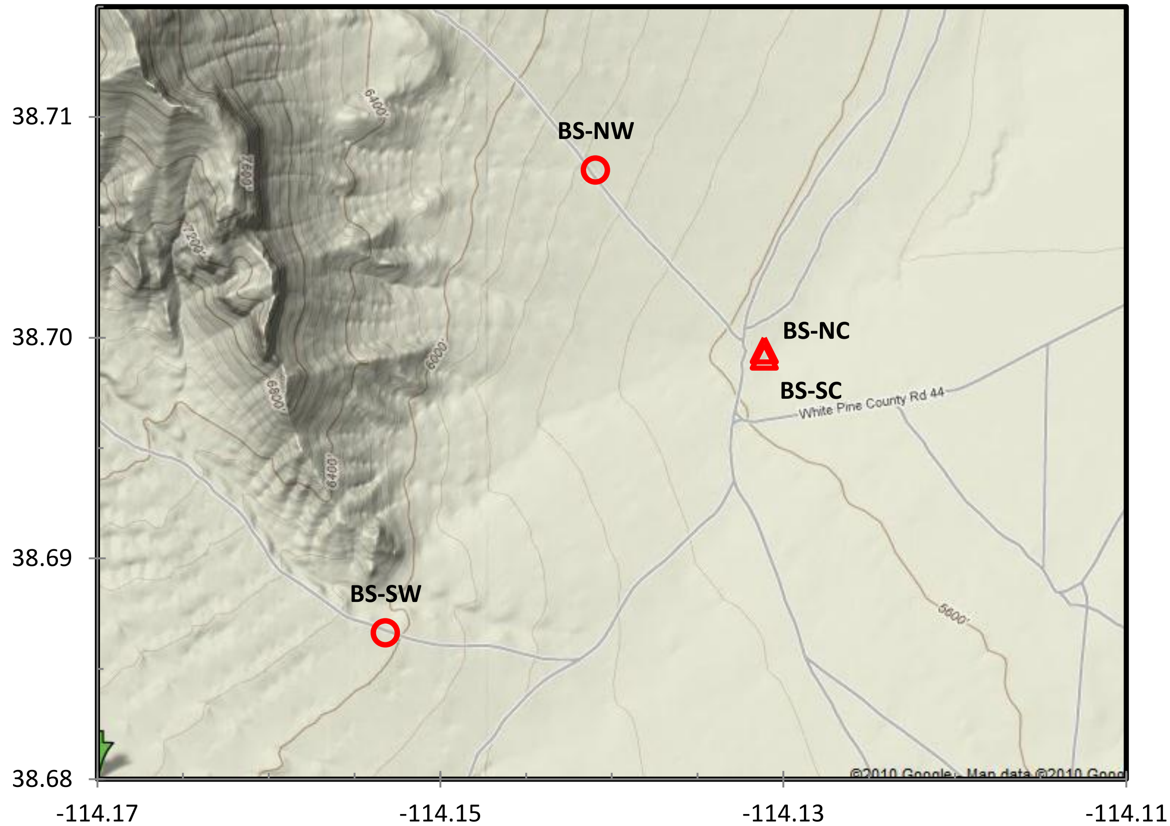

Figure 1.—Location of wells BS-NW and BS-SW and Big Springs gages, BS-NC and BS-SC, in Snake Valley, Nevada as referenced to North American Datum of 1983 (NAD 83).

Table 1.—Well location and construction data for wells near Big Springs, southwestern Snake Valley, Nevada.

[Latitude and longitude are in degrees, minutes, and seconds and referenced to North American Datum of 1983 (NAD 83); ft amsl, feet above North American Vertical Datum of 1988 (NAVD 88); ft bgs, feet below ground surface; na, not available.]

Map Identifier	SITE IDENTIFIER	Latitude	Longitude	Ground surface elevation, ft amsl	Depth to Static Water Level, ft bgs	Diameter Screen, in inches	Top Screen, ft bgs	Bottom Screen, ft bgs
BS-NW	384227114082701	38°42'27"	114°08'27"	5,815	228	8	300	460
BS-SW	384112114091101	38°41'12"	114°09'11"	6,020	355	8	500	700
BS-NC	102432241	38°41'58"	114°07'52"	5,571	na	na	na	na
BS-SC	10243224	38°41'57"	114°07'52"	5,571	na	na	na	na

Water Levels and Drawdowns

Water levels were measured in wells BS-NW and BS-SW (Figure 2). Water levels in wells BS-NW and BS-SW were 228 and 355 feet below land surface, respectively, prior to pumping. Water levels were monitored a couple of weeks prior to the BS-NW aquifer test and a few of weeks after pumping ceased. The monitoring period exceeded a month so pumping effects could be differentiated from barometric changes, tidal fluctuations, and seasonal declines.

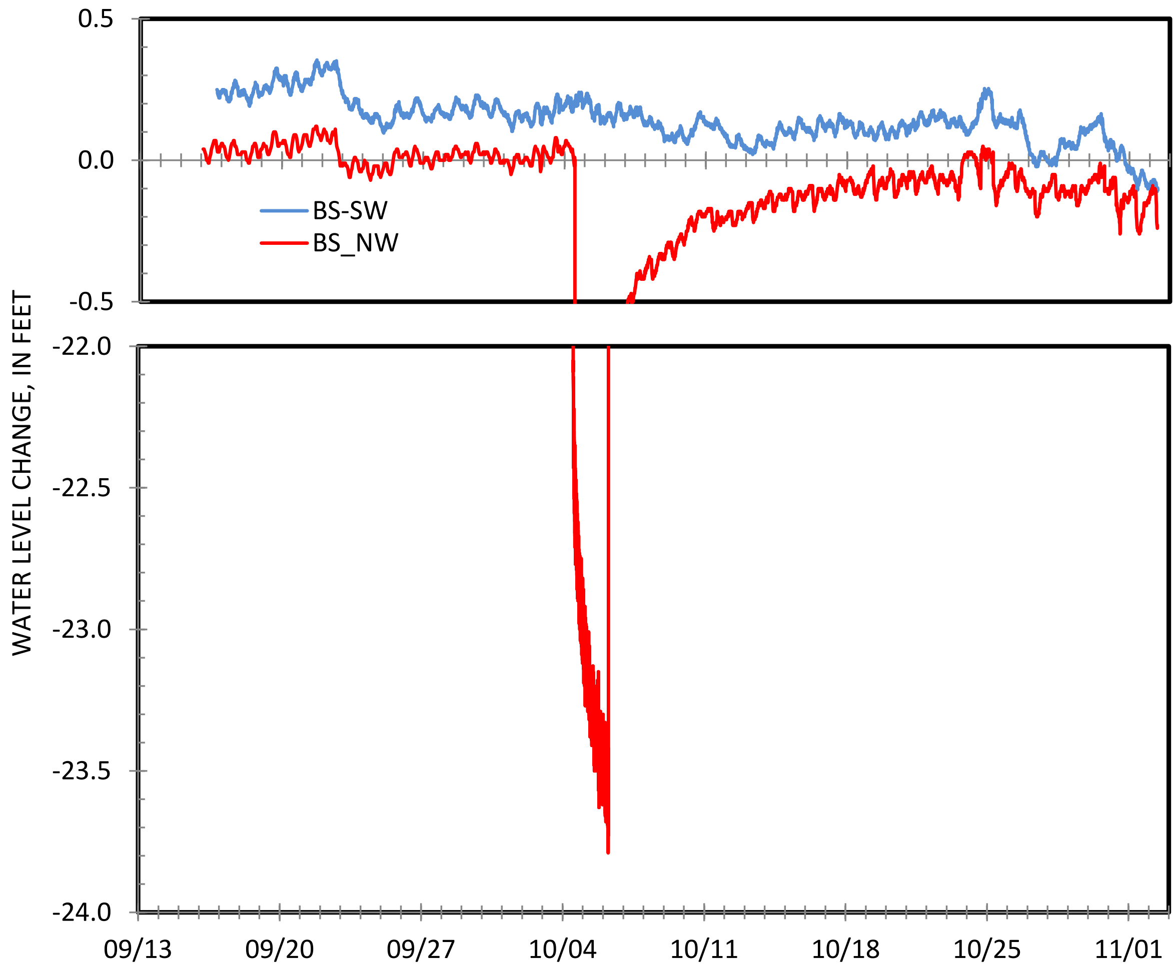

Figure 2.—Water-level changes in wells BS-NW and BS-SW between September 16, 2010 and November 2, 2010.

Drawdowns from pumping of well BS-NW were estimated by modeling water levels in the pumping and observation wells. This approach was necessary because environmental (naturally occurring) water-level fluctuations of more than 0.2 ft exceeded potential drawdowns in well BS-SW. Drawdowns were differentiated from environmental fluctuations by modeling synthetic water levels that simulated environmental water-level fluctuations and pumping effects. Environmental water-level fluctuations were simulated by summing individual time-series of barometric pressure, tidal potential, and background water levels (Halford, 2006). Pumping responses were simulated by superposition of Theis solutions.

Environmental water-level fluctuations were simulated with time series of barometric pressure, earth tides, gravity tides, and a linear trend. The linear trend approximated seasonal water-level declines during the fall. Seasonal water-level declines averaged 0.003 and 0.004 ft/d in wells BS-NW and BS-SW, respectively (Figure 2).

Pumping responses from well BS-NW were modeled with a superposition Theis model, where multiple pumping periods were simulated by superimposing multiple Theis (1935) solutions. Superposition Theis models served as simple transform functions, where step-wise pumping records were translated into approximate water-level responses. Numerical experiments have confirmed that superposition Theis models closely approximate water-level responses through hydrogeologically complex aquifers. This approach will herein be discussed as the superposition Theis model.

Synthetic water levels, which simulate environmental fluctuations and pumping effects, were fit to measured water levels by minimizing a sum-of-squares objective function (Halford, 2006). Amplitude and phase were adjusted in each time series that simulated environmental water-level fluctuations. Transmissivity and storage coefficient were adjusted if the superposition Theis model was used. Inclusion of a superposition Theis model extends the duration of fitting periods, which minimizes drift during the drawdown estimation period. Estimated values of transmissivity and storage coefficient generally were not valid estimates of aquifer properties because the assumptions of the underlying Theis solution were violated.

Drawdowns in well BS-NW were measured water levels minus synthetic water levels without the superposition Theis component during the period of pumping (Figure 3). Synthetic water levels fit measured water levels prior to pumping with a root-meansquare (RMS) error of 0.006 ft. Water-level modeling removed diurnal fluctuations of about 0.1 ft from the drawdown estimates.

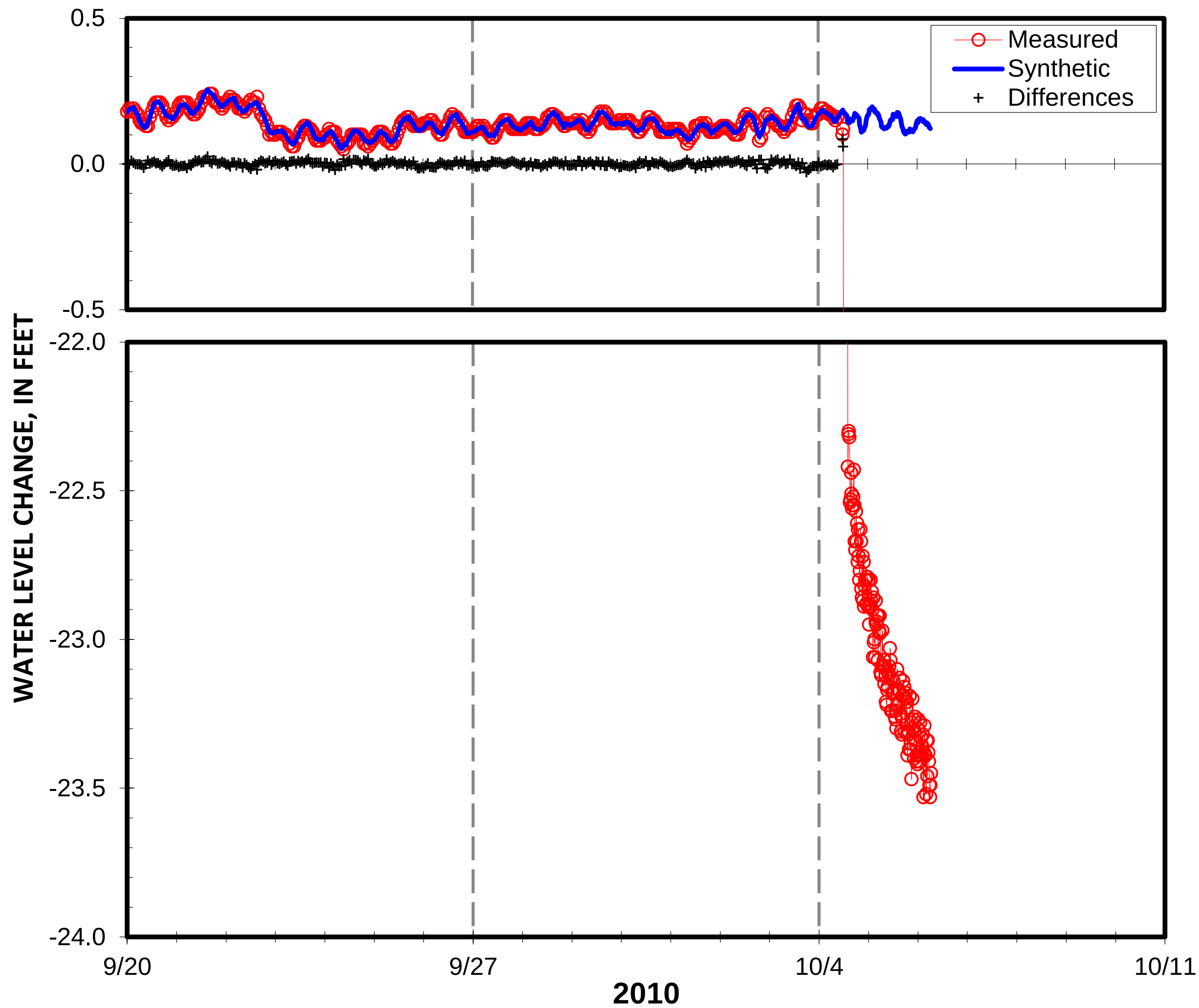

Figure 3.—Measured water-level change, synthetic water-level change, and differences between synthetic and measured water-level changes in well BS-NW between September 20, 2010 and October 6, 2010.

Drawdowns in well BS-SW were not detected during pumping or recovery through October 31, 2010 (Figure 4). Synthetic and measured water levels in well BS-SW could be matched with a RMS error of 0.009 ft without simulating pumping from well BS-NW, which was 8,100 ft from well BS-SW. Drawdowns from pumping well BS-NW at 260 gpm could be simulated with the superposition Theis model. Simulated drawdowns did not affect the synthetic water level if the hydraulic diffusivity was less than 200,000 ft^2/d.

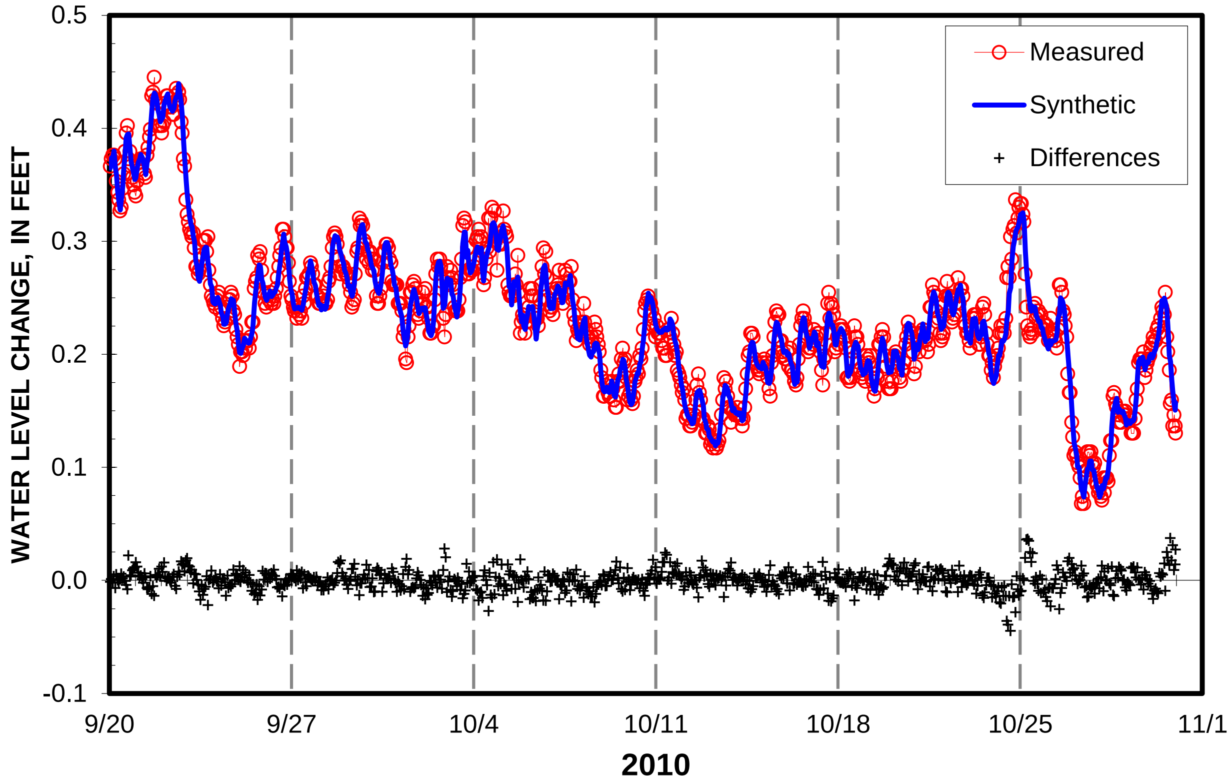

Figure 4.—Measured water-level change, synthetic water-level change, and differences between synthetic and measured water-level changes in well BS-SW between September 20, 2010 and October 31, 2010.

Analysis

The estimated transmissivity of the basin-fill aquifer was 10,000 ft^2/d (Figure 5). Drawdowns in well BS-NW were interpreted with the Cooper-Jacob method (Cooper and Jacob, 1946) as implemented by Halford and Kuniansky (2002). Drawdowns exhibited an unconfined response, which is evident in the transition to drainage, between hours 1 and 10 after pumping started. Analysis was limited to Cooper-Jacob because unconfined analysis of a single-well aquifer test has been demonstrated to be not useful (Halford and others, 2006). Because simulated drawdowns did not affect the synthetic water level if the hydraulic diffusivity was less than 200,000 ft^2/d, suggests that the storage coefficient governing hydraulic diffusivity between wells BS-NW and BS-SW is greater than 0.05 for the estimated governing transmissivity of 10,000 ft^2/d.

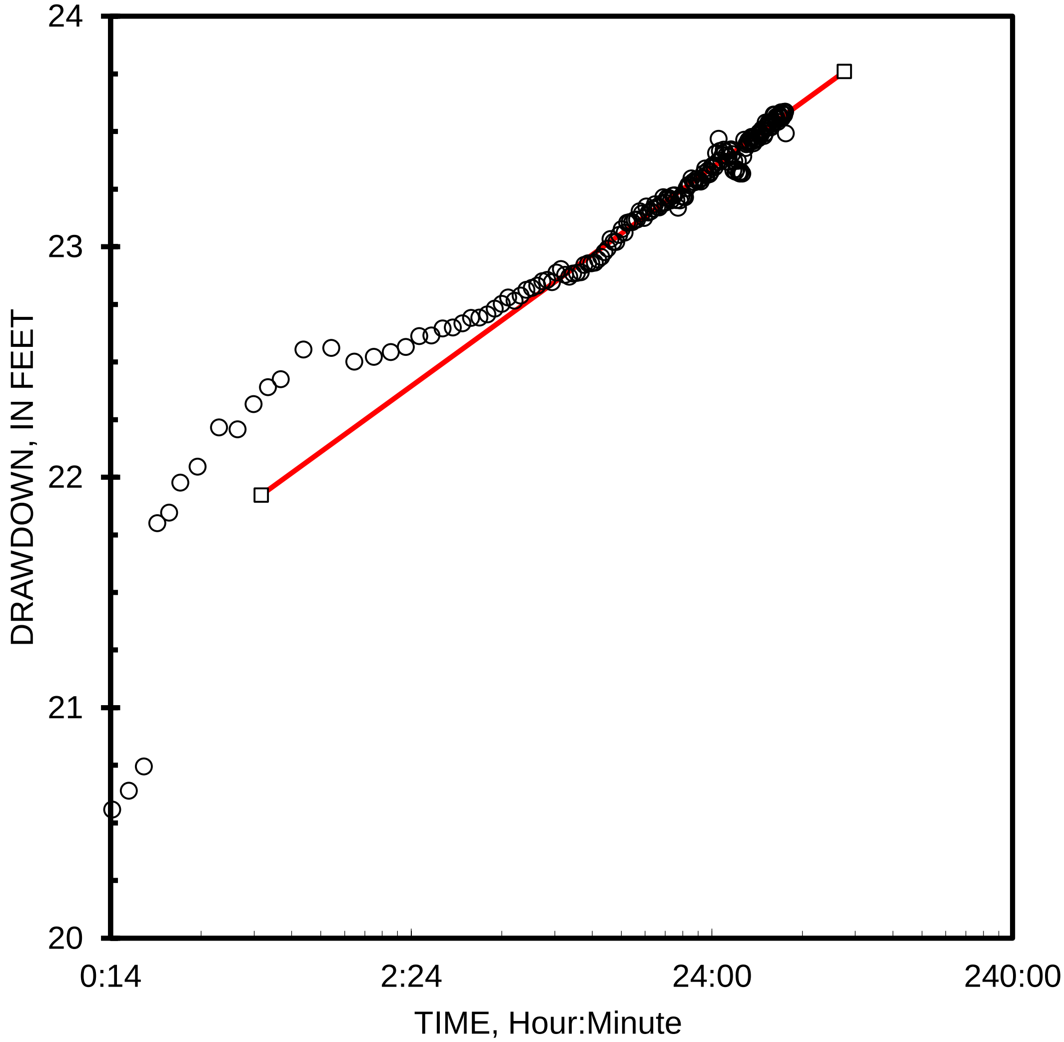

Figure 5.—Drawdowns and straight-line approximation in well BS-NW during 42-hour aquifer test.

References

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