United States Department of the Interior

U. S. GEOLOGICAL SURVEY

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MEMORANDUM

July 27, 2015

To: Devin Galloway, WSFT–Groundwater Specialist, USGS, Sacramento

Through: Kip K. Allander, Ground Water Specialist, USGS Nevada Water Science Center

From: Nancy L. Alvarez, Hydrologist, USGS Nevada Water Science Center
Michael Potts, formerly with USGS Nevada Water Science Center

Subject: SLUG TESTS--Analysis of slug tests in shallow wells adjacent to East Fork Carson River, Carson Valley Hydrographic Area (HA 105), Nevada

Slug tests were conducted in 10 drive-point wells in and near the East Fork Carson River near Minden, Nevada (figures 1 and 2) in the Carson Valley Hydrographic Area 105. The tests were conducted to estimate the hydraulic conductivity of the streambed and floodplain sediments. The first set of slug tests were conducted on one well on November 16 and 18, 2010. The second set of slug tests were conducted on 9 wells on November 29 and December 1, 2012. Results from these slug tests will be used in flow-net analysis to estimate groundwater discharge to the East Fork Carson River along the study reach.

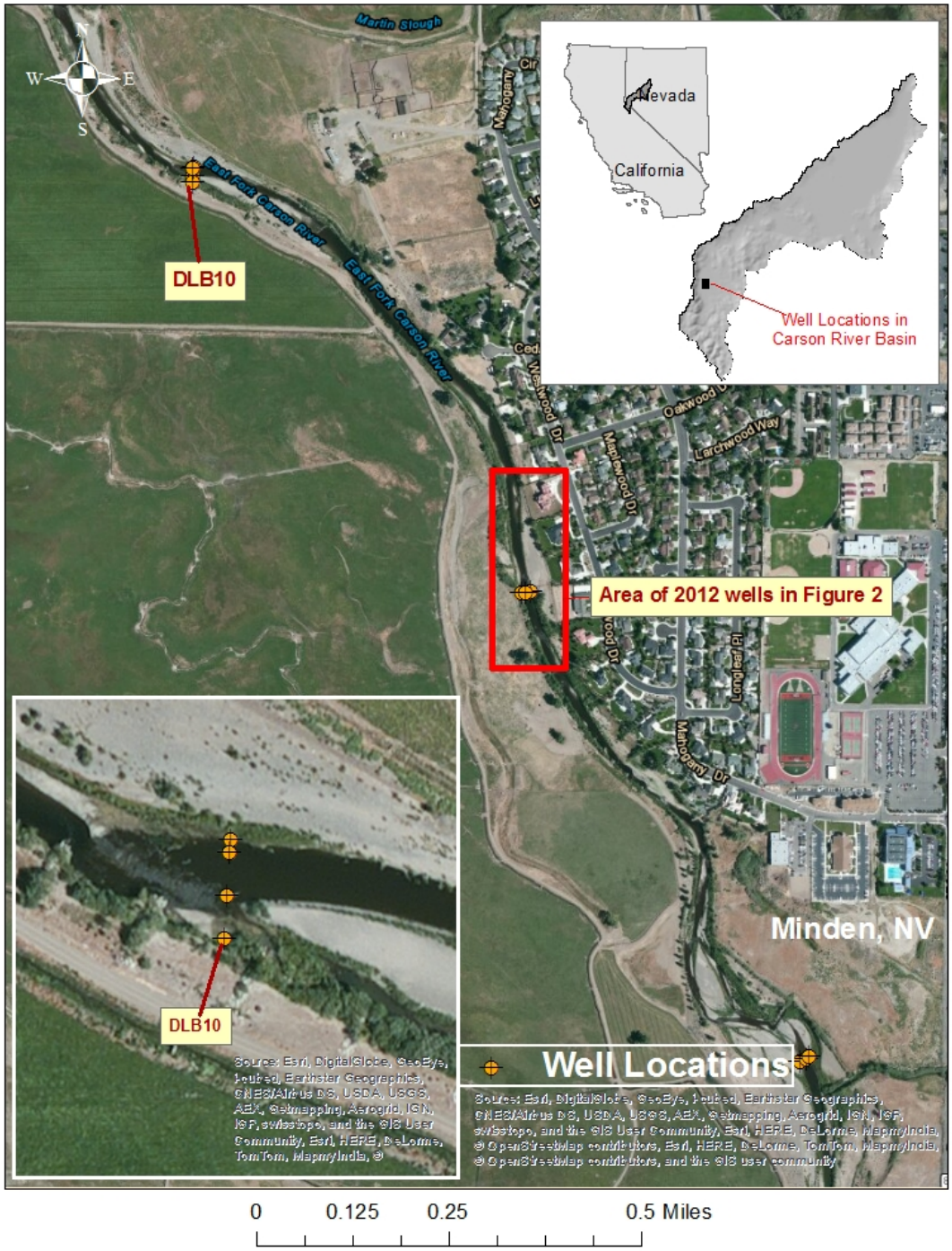

Figure 1. Location of drive-point well DLB10 used for slug tests along the East Fork Carson River in Carson Valley near Minden, NV in 2010.

Figure 2. Location and local names of drive-point wells used for slug tests along the East Fork Carson River in Carson Valley near Minden, NV in 2012.

SITE

The slug tests were conducted in drive-point wells that were completed in medium sand and cobble riverbed sediments (table 1). For the 2010 slug tests, the one drive point well was located on the left bank of the East Fork Carson River (figure 1). For the 2012 slug tests, one drive point well was located in the middle of the stream channel, four were located on the right bank within 5 feet of the river and four were located approximately 30 to 105 feet away from the right edge of the stream in the floodplain (figure 2). All wells were 1.63 inch diameter galvanized steel drive points. The screen lengths were approximately 1.1 to 1.25 feet in length and top of the screen ranged from 2.0 to 5.7 feet below land surface.

Table 1. Location and construction information for 2010 and 2012 wells used in slug tests. [Latitude and longitude coordinates are referenced to North American datum of 1983, Altitude is in North American Vertical Datum of 1988]

Site Number	Well local name	Latitude	Longitude	Land surface altitude, in feet above NAVD88	Well depth, in feet	Depth to top of screen, in feet	Depth to bottom of screen, in feet
2010							
385755119473705	DLB10	38°57'54.24"	119°47'37.12"	4,684.00	3.9	2.0	3.1
2012							
385731119471402	UMS3	38°57'30.95"	119°47'13.77"	4688.54	3.6	2.0	3.25
385731119471403	URB4	38°57'31.05"	119°47'13.45"	4688.73	3.6	2.0	3.25
385731119471404	URBFS5	38°57'31.31"	119°47'12.70"	4694.04	6.9	5.3	6.55
385733119471505	MLB7	38°57'32.91"	119°47'14.96"	4688.71	3.5	2.0	3.25
385733119471507	MRB9	38°57'33.03"	119°47'14.36"	4688.88	3.5	2.0	3.25
385733119471508	MRBMFS10	38°57'33.11"	119°47'13.98"	4691.62	4.9	3.4	4.65
385733119471510	MRBFFS12	38°57'33.29"	119°47'13.09"	4694.03	7.1	5.6	6.85
385735119471503	DRB16	38°57'34.90"	119°47'14.80"	4688.02	3.6	2.0	3.25
385735119471506	DRBFS20	38°57'35.05"	119°47'13.83"	4693.72	7.2	5.7	6.95

PROCEDURES

Water-levels were displaced by either a 1, 0.5, or 0.35-liter slug of water that took approximately 5 seconds to pour in 2010 and 10 to 16 seconds to pour in 2012. In two of the wells during the slug tests in 2012 there was not enough space from the water level to the top of casing to pour 1 liter of water in the well; therefore, in UMS3 well 0.5 liter was used and in URB4 well 0.35 liter was used. Water levels were measured with an unvented Schlumberger Mini-Diver™ pressure transducer at 0.5 second intervals to a resolution of 0.0066 feet. A Schlumberger Baro-Diver measuring atmospheric pressure and air temperature (installed in one of the wells above the water level) was used with the Diver™ software to perform barometric compensation on the

raw water level data. The data was processed with the Diver™ software. The continuous water level data in the spreadsheets are reported with respect to the top of casing. Water levels in all the wells were above the screened interval prior to the slug tests.

Three to four slug tests were performed per test for each well, however due to problems with either the datalogger, the process of pouring the water into the well, or the excel spreadsheet used to analyze the data, between 2 and 4 slug responses per test were analyzed per well. The recovery time ranged from 10 seconds to 2 minutes 20 seconds, although 10 well responses were less than 45 seconds. The water-level responses were well characterized by the 0.5 second sampling frequency of the pressure transducer.

ANALYSIS

Slug tests were analyzed using analytical solutions coded in spreadsheet software (Halford and Kuniansky, 2002). Slugs test responses from two wells (DLB10 and URB4) were analyzed using the Bouwer and Rice (1976) method (figure 3 and 4). Slug test responses from the other 8 wells were analyzed using methods presented by Butler, Garnett, and Healey (2003) (figure 5). Results from the slug tests are summarized in table 2.

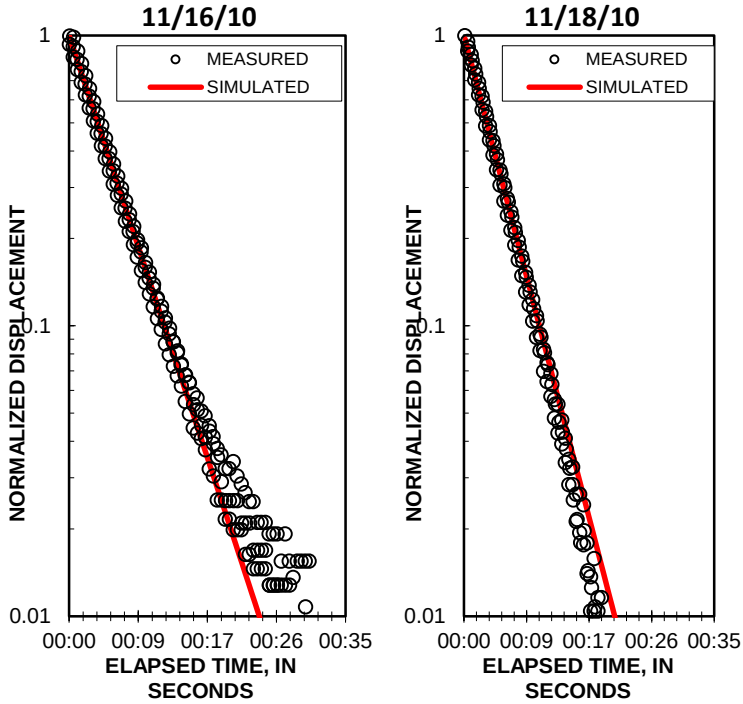

Figure 3. Normalized water-level recovery in well DLB10 for two separate slug tests in 2010 that were analyzed using methods by Bower and Rice (1976).

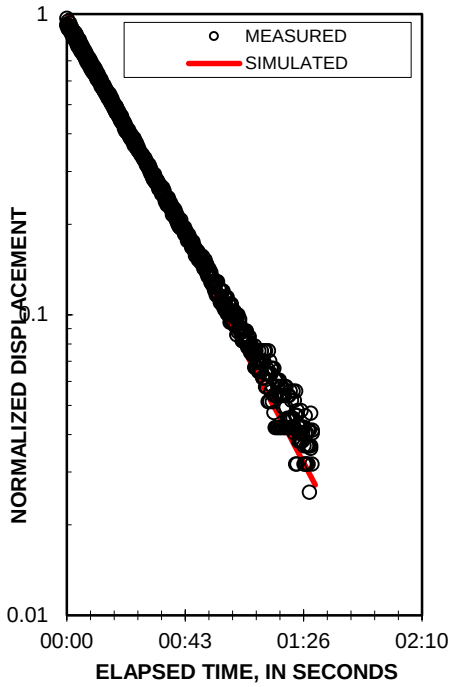

Figure 4. Normalized water-level recovery in well URB4 in 2012 that was analyzed using methods by Bower and Rice (1976).

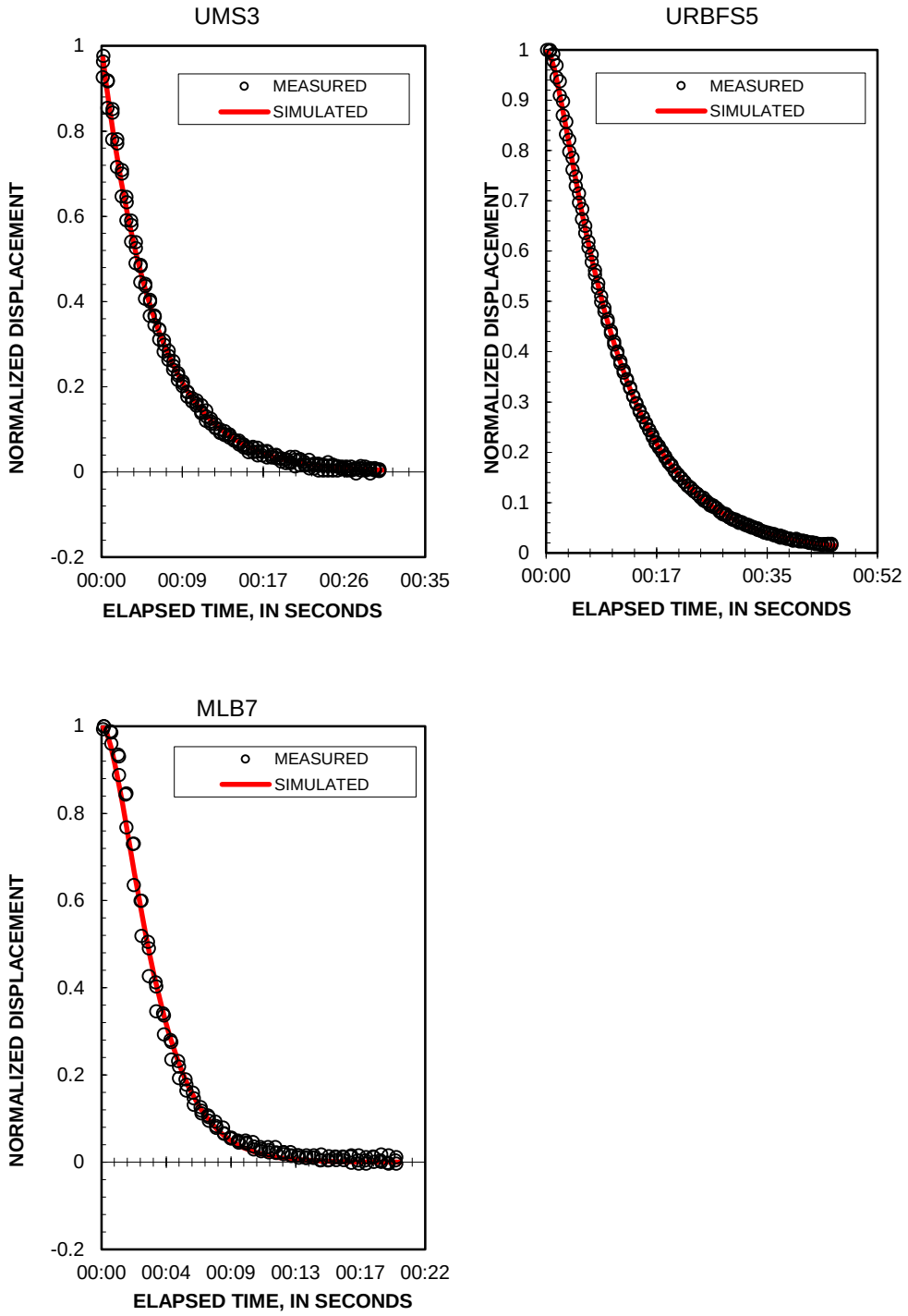

Figure 5. Normalized water-level recoveries in wells in 2012 that were analyzed using methods by Butler, Garnett and Healey (2003).

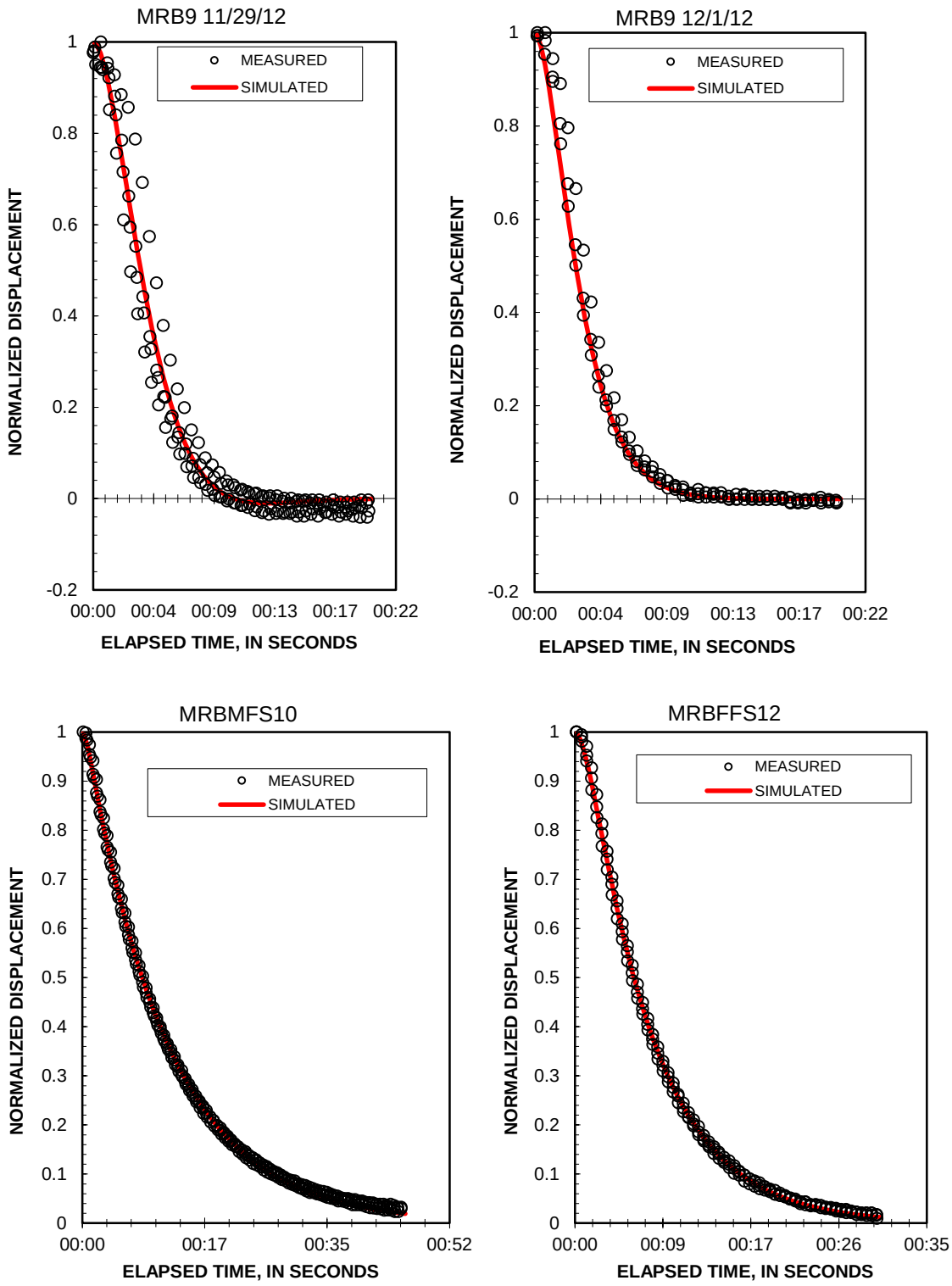

Figure 5. Normalized water-level recoveries in wells in 2012 that were analyzed using methods by Butler, Garnett and Healey (2003) - continued.

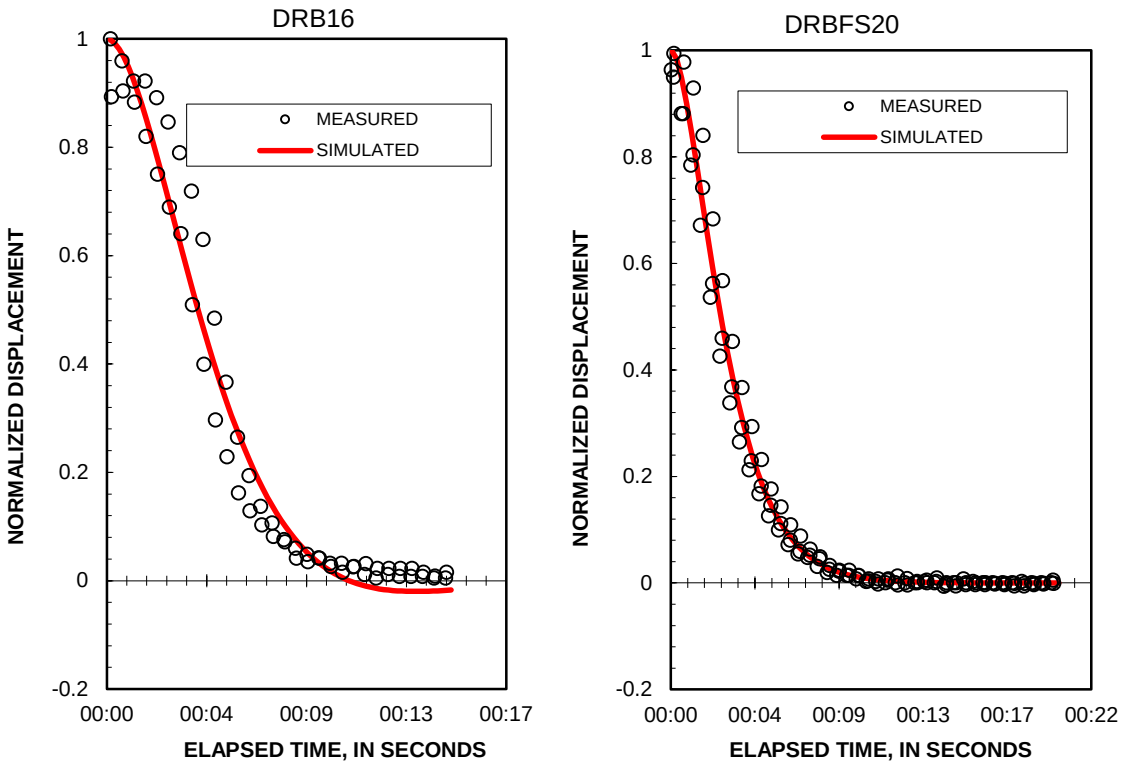

Figure 5. Normalized water-level recoveries in wells in 2012 that were analyzed using methods by Butler, Garnett and Healey (2003) - continued.

Table 2. Hydraulic conductivity estimates in wells in the Carson Valley near Minden, NV. [Abbreviations: NM, not measured; BR, Bower and Rice (1976); BGH, Butler, Garnett and Healey (2003)]

Site Number	Well local name	Depth to water from land surface, feet	Date of test	Lithology	Number of slug tests analyzed	Slug test analytical method	Hydraulic conduc-tivity, feet per day
2010							
385755119473705	DLB10	-1.44	11/16/2010	medium sand and cobble	3	BR	48
385755119473705	DLB10	-1.39	11/18/2010	medium sand and cobble	3	BR	54
2012							
385731119471402	UMS3	-1.57	12/1/2012	sand and cobble	3	BGH	60
385731119471403	URB4	-1.36	12/1/2012	sand and cobble	3	BR	10
385731119471404	URBFS5	NM	11/29/2012	sand and cobble	2	BGH	28
385733119471505	MLB7	-1.17	12/1/2012	sand and cobble	3	BGH	91
385733119471507	MRB9	NM	11/29/2012	sand and cobble	4	BGH	90
385733119471507	MRB9	-1.00	12/1/2012	sand and cobble	4	BGH	100
385733119471508	MRBMFS10	NM	11/29/2012	sand and cobble	3	BGH	28
385733119471510	MRBFFS12	NM	11/29/2012	sand and cobble	3	BGH	43
385735119471503	DRB16	NM	11/29/2012	sand and cobble	2	BGH	80
385735119471506	DRBFS20	NM	11/29/2012	sand and cobble	3	BGH	110

HYDRAULIC PROPERTY ESTIMATES

Hydraulic conductivity estimates ranged between 10 and 110 feet per day (table 2). The average of the slugs tests completed on DLB10 well in 2010 was 51 feet per day and the average of slug tests completed on 9 wells in 2010 was 60 feet per day. The average hydraulic conductivity from all of the wells tested was 60 feet per day.

REFERENCES

Bouwer, H., and Rice, R.C., 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells: Water Resources Research 12(3), p. 423-428.

Butler, J.J., Garnett, E.J., and Healey, J.M., 2003, Analysis of slug tests in formations of high hydraulic conductivity: Ground Water 41(5), p. 620-630.

Halford, K.J., and Kuniansky, E.L., 2002, Spreadsheets for the analysis of aquifer-test and slug-test data, version 1.1: U.S. Geological Survey Open-File Report 02-197, 51 51 p. (accessed at http://pubs.usgs.gov/of/2002/ofr02197/)