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Geologic, Hydrologic, and Chemical Data from the C Aquifer near Leupp, Arizona

Scientific Investigations Report 2005–5280

Prepared in cooperation with the BUREAU OF RECLAMATION

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By J.P. Hoffmann, D.J. Bills, J.V. Phillips, *and* K.J. Halford

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Conversion Factors

Multiply	By	To obtain
	Length	
inch (in)	2.54	centimeter (cm)
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)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	0.003785	cubic meter (m^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Specific capacity	
gallon per minute per foot (gal/min)/ft	0.2070	liter per second per meter (L/s)/m
	Hydraulic conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)
	Transmissivity*	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8x°C)+32$$

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

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

Altitude, as used in this report, refers to distance above the vertical datum.

*Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness [(ft^3/d)/ft^2]ft. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Geologic, Hydrologic, and Chemical Data from the C Aquifer near Leupp, Arizona

By J.P. Hoffmann, D.J. Bills, J.V. Phillips, *and* K. J. Halford

Abstract

As the most productive aquifer in northern Arizona, the C aquifer provides industry, land owners, businesses, and municipalities with a dependable supply of water. Because additional development is proposed, the U.S. Geological Survey, in cooperation with the Bureau of Reclamation, conducted an investigation of the C aquifer that included the collection of geologic, hydrologic, and water-chemistry data near Leupp, Arizona. The investigation included a program to drill test wells at three sites and use the wells to collect geologic and geophysical logs, collect and analyze aquifer-test data, and collect water samples for water-chemistry analyses. Rock units penetrated during drilling were, in descending order, the Moenkopi, Kaibab, and Toroweap Formations, the Coconino Sandstone, the Schnebly Hill Formation, and the Upper Supai Formation. The water table generally was within the Coconino Sandstone and ranged from about 226 to 615 feet below land surface. Constant-rate aquifer tests were simulated by using numerical models to estimate aquifer properties. Estimated transmissivity of the C aquifer near Leupp, Arizona, ranges from about 5,400 to 7,000 feet squared per day. The Coconino Sandstone is the most conductive unit of the aquifer.

Water quality, determined from samples collected during the constant-rate aquifer tests, is generally good for intended uses. Field specific-conductance values ranged from 837 to 1,230 microsiemens per centimeter and correlate with concentrations of dissolved chloride and sodium. Concentrations of arsenic and other trace metals, as well as concentrations of nutrients, were low. Concentrations of sulfate exceeded the U.S. Environmental Protection Agency Secondary Maximum Contaminant Level of 250 milligrams per liter at all sites and were highest at site 1 (about 385 milligrams per liter). Gross alpha and gross beta activity in ground water provide evidence the water had been exposed to radioactive material, such as uranium. Oxygen and hydrogen isotopic ratios in the ground water indicate the water was recharged at altitudes of about 6,700 to 7,600 feet.

Introduction

The C aquifer underlies much of northern Arizona, parts of northwestern New Mexico, and southeastern Utah, and is an important source of water for many users (fig. 1). Named for its primary water-bearing rock unit, the Coconino Sandstone, the C aquifer has an areal extent of more than 27,000 mi^2. It is the most productive aquifer in the Little Colorado River Basin. Industry (primarily powerplants and wood processing), individual homeowners, businesses, agriculture, and the municipalities of Flagstaff, Holbrook, Show Low, and Winslow, Arizona, depend upon water from the aquifer. The Department of the Interior (DOI) has important interests and trust responsibilities connected to the aquifer. The USGS, in cooperation with the Bureau of Reclamation (BOR) has been tasked with the collection of geologic, hydrogeologic, and water-chemistry data to determine viability of increased use of water from the aquifer. Base flow of numerous streams, such as Chevelon and Clear Creeks and the Little Colorado River, are sustained by discharge from the aquifer. Parts of these streams support threatened and (or) endangered fish species. The aquifer also represents an important source of water for the Navajo Nation and Hopi Tribe. Water from the aquifer is being considered as an alternate supply to relieve pumping from the N aquifer—the current source of water for a coal mine and coal slurry pipeline used to transport coal mined from Black Mesa near Keyenta, Arizona, to the Mohave Power Generation Station at Laughlin, Nevada. The Navajo Nation, the Hopi Tribe, and the city of Flagstaff are considering expanding withdrawals from the C aquifer to meet increasing water needs.

Purpose and Scope

This report presents data and analyses from a study in support of a Federal effort to evaluate the C aquifer. The Federal effort is a cooperative effort among the U.S. the Bureau of Reclamation (BOR), the U.S. Geological Survey (USGS), the U.S. Fish and Wildlife Service, the Office of Surface Mining, the Navajo Nation, and the Hopi Tribe.

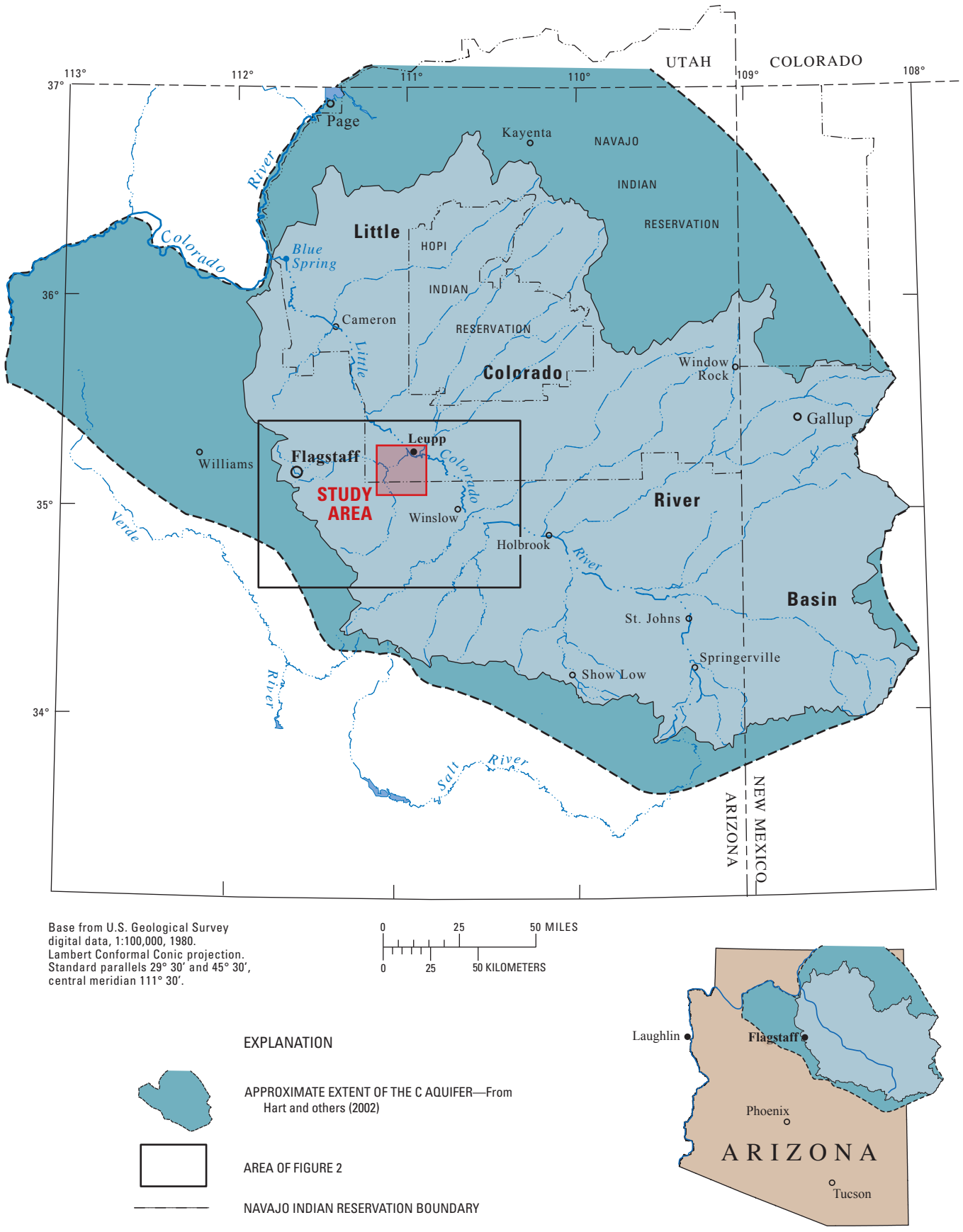

Figure 1. Approximate extent of the C aquifer and location of the study area, northeastern Arizona.

Data collected for this investigation and presented in this report pertain to well construction, geology, aquifer tests, and water chemistry at three sites within the study area. The study area is roughly a 40 mi^2 area south of Leupp, Arizona, on the Coconino Plateau (fig. 1). This report contains graphical and tabular data for water-level drawdown and recovery during the aquifer tests. Well-drilling and well-construction information, combined with pumping rates and drawdown, provide the basic information needed for aquifer-test analyses.

Previous Investigations

Portions of the C aquifer have been investigated to evaluate water availability for local needs. Studies by Cooley and others (1969), Mann (1976), Mann and Nemecek (1983), and McGavock and others (1986) have provided a basic hydrologic characterization of the C aquifer for general water use in the Little Colorado River Basin. Two recent studies have attempted to characterize the aquifer on a regional scale to determine the potential of the hydrologic system to meet regional water demands. An investigation of the aquifer in the area of Flagstaff, Arizona, by Bills and others (2000) included extensive structural mapping, geophysical surveying, determination of hydraulic properties, and chemical and isotopic analyses of ground water. A ground-water budget and a generalized geohydrologic characterization of the entire aquifer were developed by Hart and others (2002). Southwest Ground-water Consultants, Inc., constructed a local ground-water flow model of the aquifer in Leupp, Arizona, area ("Groundwater modeling support for the I-40 and Canyon Diablo wellfields", unpublished report to the Bureau of Reclamation, 2004). The model corresponds to a rectangular 2,400-mi^2 part of the aquifer that encompasses East Clear and Chevelon Creeks south and west of Leupp and was used to estimate changes in ground-water levels near proposed well fields and at other existing and proposed demand centers, and changes in base flow of East Clear and Chevelon Creeks. Additional models of the aquifer have been constructed to address Federal, tribal, and industrial interests. The aquifer is an important component of the available water resources in the Little Colorado River Basin. As such, these waters are part of long-standing negotiations to settle water-rights claims in the Little Colorado River Basin. With this backdrop of litigation, the data derived and ground-water flow models developed from these investigations typically are held in confidence and therefore not available in the public domain.

Acknowledgments

Bradley Prudhom, Mike Miller, and Paris Atherton of the BOR were on-site geologists and directed the drilling activities and helped to coordinate the aquifer tests. Steve Crawford and Art Clark (USGS) supervised the USGS well-drilling crews. Rodgers and Company, Incorporated, of Albuquerque, New Mexico, drilled selected production and observations wells and conducted the aquifer tests.

Drilling, Well Construction, and Static Water-Level Information

Test wells were drilled at three sites on the Navajo Indian Reservation to provide information for characterizing hydrogeologic properties of the C aquifer (fig. 2). The wells were drilled by the USGS Western Region Research and Central Region Research Drilling Units, and Rodgers and Company, Inc., between January and April 2005, and were constructed for use as withdrawal wells or observation wells for aquifer tests. The three sites are near a proposed site of a C aquifer well field and are 10 mi or less apart from each other. Detailed notes related to drilling, construction, development, and completion were compiled by the BOR (Bradley Prudhom, geologist, Bureau of Reclamation, written commun., 2005).

Site 1

Three wells (PW-1, PW-1A, and OW-1) were drilled during January-February 2005 at site 1 (fig. 2 and table 1). The wells were drilled by the USGS Western Region Research Drilling Unit using a top-head (TH) drive air rotary rig with hammer bit and water and foam. Test well PW-1 was drilled to a depth of 1,035 ft, but was abandoned because caving resulted in loss of a hammer assembly at about 600 ft. The drill stem was recovered and the hole was filled with bentonite and cement. Test well PW-1A was drilled at the location of PW-1 to a depth of 1,134 ft and completed with 10-inch inside-diameter (ID) steel casing and 10-inch ID continuous-slotted (0.040-inch openings, also referred to as "40 slot") steel screen. The well is screened from 837 to 1,077 ft below land surface and was constructed for use as the withdrawal well in the constant-rate aquifer test. Static depth to water in the well is about 614 ft. Test well OW-1 was drilled to 1,179 ft and was constructed as an observation well with 6-inch ID steel casing and 6-inch ID continuous-slotted (40 slot) steel screen. It is screened from 686 to 1,086 ft and has a static depth to water of about 615 ft. Windmill well 5T-533, which was completed to a depth of 802 ft in 1977, also was used as an observation well during the aquifer test. It also has a static water level of about 615 ft. Few construction details are available; however, records indicate that the well was completed to a depth of 802 ft with 6-5/8-inch steel casing that is torch slotted from 597 to 792 ft.

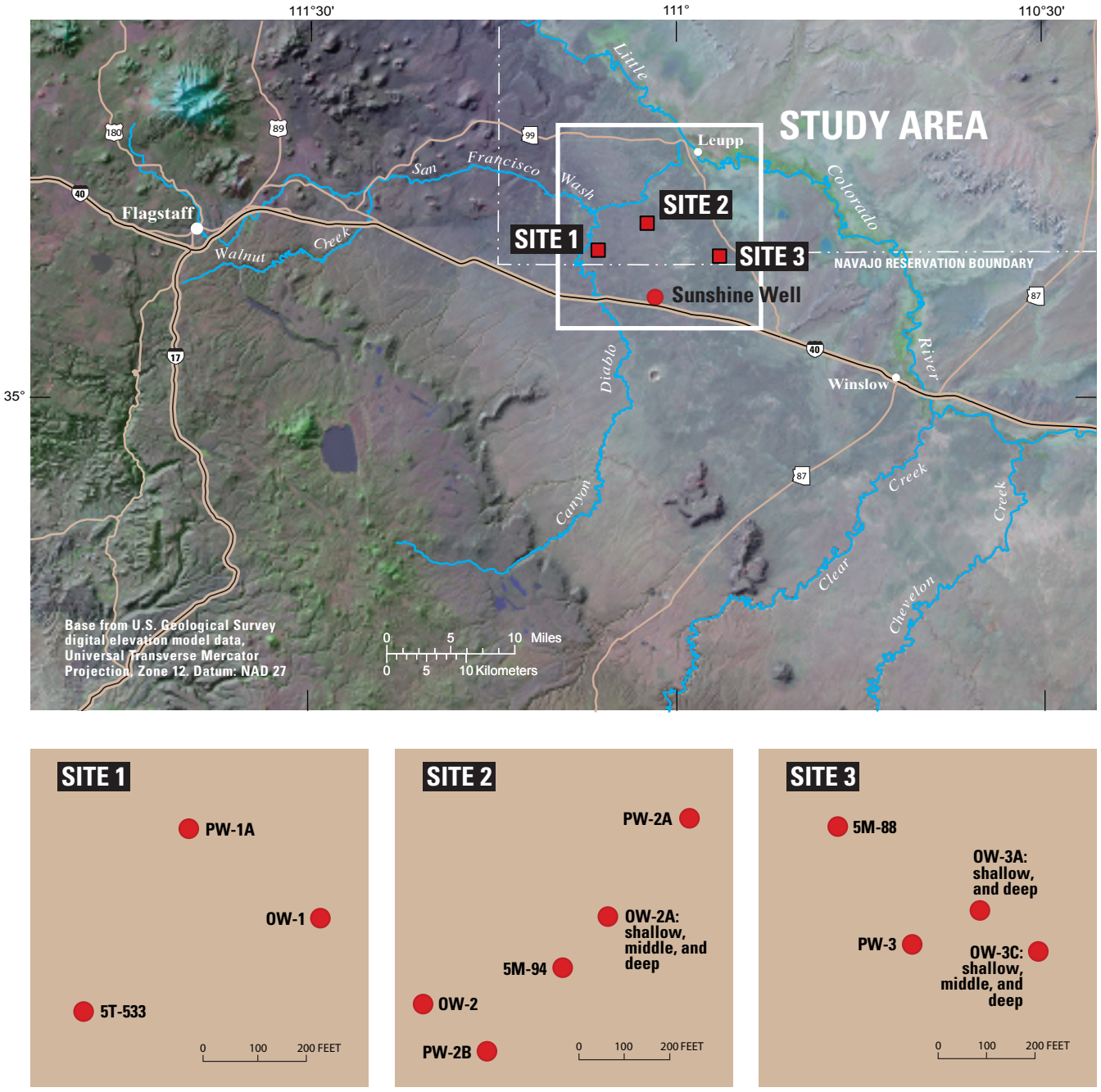

Figure 2. Location of drill sites, test wells, and windmill wells near Leupp, Arizona.

Table 1. Well locations and selected construction data for the wells at sites 1, 2 and 3, and the Sunshine well near Leupp, Arizona

[Latitude and longitude are in degrees, minutes, and seconds and referenced to NAD 83; ft, feet; ft bls, feet below land surface; NA, information not available]

Bureau of Reclamation well designation	Station number	Latitude	Longitude	Distance from pumping well (ft)	Land-surface altitude (ft above NAVD 88)	Hole depth (ft bls)	Static water level (ft bls)	Date	Preforations	
									Top (ft bls)	Bottom (ft bls)
				Site 1						
PW-1A	351023111062002	35°10'24.31"	111°06'23.26"	0	5,379.39	1,134	611.42	02/17/2005	837	1,077
OW-1	351022111061801	35°10'21.75"	111°06'21.63"	290	5,381.57	1,179	614.82	02/10/2005	686	1,086
5T-533		35°10'21.97"	111°06'27.76"	415	5,385.3	802	615.2	02/17/2005	597	792
				Site 2						
PW-2A		35° 12' 18.48"	111° 02' 17.05"	687	5,021.49	1,096	321.55	03/08/2005		
PW-2B	351213111022101	35° 12' 13.32"	111° 02' 22.45"	0	5,030.13	1,096	330.95	04/20/2005	576.5	996.5
OW-2A (deep)		35° 12' 16.33"	111° 02' 19.32"	402	4,985.28	1,140	323.16	02/11/2005	1,100	1,120
OW-2A (middle)		35° 12' 16.33"	111° 02' 19.32"	402	4,985.28	1,140	323.24	02/11/2005	661	681
OW-2A (shallow)		35° 12' 16.33"	111° 02' 19.32"	402	4,985.28	1,140	323.25	02/11/2005	400	420
OW-2	351214111022101	35° 12' 14.38"	111° 02' 24.11"	178	5,029.13	1,068	328.33	04/18/2005	698	998
5M-94	351215111021701	35° 12' 15.18"	111° 02' 20.35"	251	5,027.45	388	327.82	01/29/2005	Open from 163 to 388	
				Site 3						
PW-3	350958110562201	35°09'55.84"	110°56'25.55"	0	4,909.27	1,128	225.5	02/09/2005	696	1,076
OW-3A (deep)	350959110562302	35°09'57.2"	110°56'22.54"	248	4,882.25	755	225.98	02/04/2005	694	714
OW-3A (shallow)	350959110562303	35°09'57.2"	110°56'22.54"	248	4,882.25	755	225.68	02/04/2005	250	270
OW-3C (deep)		35°09'57.59"	110°56'19.91"	474	4,880.57	1,180	226.64	02/17/2005	1,150	1,170
OW-3C (middle)		35°09'57.59"	110°56'19.91"	474	4,880.57	1,180	226.45	02/17/2005	680	700
OW-3C (shallow)		35°09'57.59"	110°56'19.91"	474	4,880.57	1,180	226.38	02/17/2005	240	260
5M-88	351001110562601	35°10'0.59"	110°56'28.61"	547	4,903.74	425	222.63	02/11/2005	Open from 388 to 425	
Sunshine	350706111014701	35007'05.52"	111001'49.15"	NA	5,351.94	1,155	562.04	02/26/2005	NA	

Site 2

Four wells were drilled between February and April 2005 (fig. 2 and table 1). Test well PW-2A, which was drilled to a depth of 1,096 ft and reamed to 684 ft, was abandoned owing to the loss of the reaming drill bit. The well has a surface casing to 55 ft, beyond which the well is open to about 500 ft. It was used as an observation well during the aquifer test at site 2. Test well PW-2B was drilled to a depth of 1,096 ft and was constructed after the abandonment of PW-2A as the withdrawal well for the constant-rate aquifer test. The well has 10-inch ID continuous-slotted (40 slot) steel screen from 576.5 to 996.5 ft below land surface. Static depth to water at this well is about 328 ft. Observation wells at this site, OW-2A and OW-2, were drilled to depths of 1,140 ft and 1,068 ft, respectively. Well OW-2A was completed with a vertical nest of three piezometers. Each piezometer was completed with 20 ft of 2-inch diameter schedule 80 polyvinyl chloride (PVC) screen (400–420 ft, 661–681 ft, and 1,100–1,120 ft). No vertical water-level gradients were measured at this site, as the static water level in each of the piezometers is about 323 ft below land surface. Well OW-2 was completed with 6-inch ID steel casing to a depth of 698 ft and has 6-inch ID continuous-slotted (40 slot) steel screen from 698 to 998 ft. Static water level in the well is about 328.5 ft below land surface. An existing windmill well (5M-94) also was used as an observation well during the aquifer test. This well was completed in 1924 to a depth of 388 ft and has 6-inch steel casing to 163 ft. Perforation data are not available for this well; therefore, for the purpose of aquifer-test analysis, it was assumed that the hole is open from 163 to 388 ft. Static water level in well 5M-94 is about 324.5 ft below land surface. With the exception of OW-2, wells at site 2 were drilled by the USGS drilling crews using a TH drive rig predominantly with water and foam. Well OW-2 was drilled by Rodgers and Company Inc. with water and bentonite mud.

Site 3

Three test wells were drilled during January–February 2005 (fig. 2 and table 1). Test well PW-3 was constructed for use as a withdrawal well during the aquifer test. It was drilled to a depth of 1,128 ft and constructed with 10-inch ID continuous-slot (40 slot) steel screen from 696 to 1,076 ft. The static water level in PW-3 is 225.5 ft below land surface. The main observation wells, OW-3A and OW-3C, were drilled to depths of 755 and 1,180 ft, respectively, and were completed with vertical nests of piezometers. Each of the piezometers has 20 ft of 2-inch diameter schedule 80 PVC screen. In OW-3A, the shallow piezometer is screened from 250 to 270 ft and the deep piezometer is screened from 694 to 714 ft. Well OW-3C has three piezometers—the shallow piezometer is screened from 240 to 260 ft, the middle piezometer is screened from 680 to 700 ft, and the deep piezometer is screened from 1,150 to 1,170 ft. Windmill well 5M-88, which was completed in 1924 to a depth of 425 ft. Available construction information for the well is incomplete; however, records indicate that the well was constructed with 6-inch steel casing to a depth of 388 ft and is open below that depth.

Geologic Logs

Drill-cutting samples were collected at 10-ft intervals in each test well when conditions permitted. A suite of geophysical logs, including gamma, temperature, caliper, self potential, resistivity, electromagnetic, acoustic, and optical, also were collected in selected wells (tables 2–4). Rock units identified in the cuttings are, in descending order, the Moenkopi, Kaibab, and Toroweap Formations, the Coconino Sandstone, the Schnebly Hill Formation, and the Upper Supai Formation (tables 2–4). The Moenkopi Formation is a red to dark-red to reddish brown siltstone, silty sandstone, fine- to very fine grained sandstone, mudstone, and gypsum of Triassic age (McKee, 1954). The formation occurs as a continuous erosional remnant at land surface in the eastern half of the study area and generally does not exceed 50 ft in thickness. The Kaibab Formation, which is Late Permian in age, is primarily a limestone, sand to silty limestone, and dolomitic limestone that is as much as 650 ft thick (Sorauf and Billingsley, 1991). The Kaibab Formation is exposed at land surface in the western part of the study area and is generally less than 200 ft thick. The Toroweap Formation, which underlies the Kaibab Formation, is Late Permian in age (Sorauf and Billingsley, 1991) and comprises carbonate sandstone, red beds, silty sandstone, siltstone, limestone, and thin layers of gypsum. The formation thins to extinction in the eastern part of the study area. The Coconino Sandstone is Permian in age and is a white to tan to light brown, crossbedded, eolian, fine-grained quartz sandstone (Blakey, 1990). The Coconino Sandstone thins eastward in the study area from 1,100 ft to 300 ft, and can be extensively fractured where faulted. These fractured zones are likely areas of high permeability and yield the most water to the wells. Where saturated, the Coconino Sandstone is the primary water-bearing unit of the C aquifer. The Permian Schnebly Hill Formation both interfingers with and underlies the Coconino Sandstone. It comprises a sequence of reddish-brown to reddish-orange very fine to silty sandstone, mudstone, limestone, and dolomite (Blakey, 1990). Thickness of the formation ranges from a few feet north of the study area to as much as 800 ft south of the study area. Within the study area, the formation is predominantly interfingered with the Coconino Sandstone (Hart and others, 2002; Bills and Flynn, 2002; and Bills and others, in press), and is in hydraulic connection with the Coconino Sandstone where it is saturated. McKee (1982) divided the Supai Group into three formations—the upper, middle, and lower—along the Mogollon Rim and at the southern end of the Colorado Plateau. The Upper Supai Formation is a complex series of

horizontally bedded reddish to brown sedimentary units that are mostly fine-grained sandstone, siltstone, and mudstone. The Middle Supai Formation is a grayish-orange calcareous very fine grained sandstone to siltstone with interbeds of evaporites. The Lower Supai Formation is a red to purple sandstone and siltstone, and gray limestone and dolomite. The Supai Group generally is 1,600 to 2,400 ft thick in the study area. The Upper Supai Formation is the most permeable unit in the group. Drilling during this study did not fully penetrate the Upper Supai Formation.

Site 1

Geologic units identified in cuttings collected at site 1 include the Kaibab and Toroweap Formations, the Coconino Sandstone, and the Schnebly Hill and Upper Supai Formations. The Kaibab Formation is exposed at land surface at site 1. Thickness of the Kaibab Formation in the test wells is about 192 to 202 ft on the basis of geologic logs from PW-1A and OW-1 (table 2). The Toroweap Formation underlies the Kaibab Formation and ranges from 20 to 40 ft in thickness. Its silt and carbonate content and yellow-orange color are used to distinguish the Toroweap from the underlying Coconino Sandstone; however, the formations are difficult to distinguish in many places. The Coconino Sandstone underlies the Toroweap Formation and, combined with the Schnebly Hill Formation, is the primary water-bearing unit of the C aquifer. The Coconino Sandstone extends from 222 to 774 ft below land surface in PW-1A and from 232 to 684 ft in OW-1 (table 2). Beyond these depths, the Coconino Sandstone interfingers with the Schnebly Hill Formation. The layer of interfingered Coconino Sandstone and Schnebly Hill Formation extends to 1,120 ft below land surface in PW-1A and to 1,130 ft below land surface in OW-1, and is underlain by the Upper Supai Formation. Maximum drilling depth at site 1 was 1,179 ft, and drilling did not fully penetrate the Upper Supai Formation.

Site 2

Geologic units identified in cuttings collected at site 2 include the Moenkopi, Kaibab, and Toroweap Formations, the Coconino Sandstone, and the Schnebly Hill and Upper Supai Formations. A shallow north-northwest trending graben was identified near site 2 on the basis of field observations made during the study. The Moenkopi Formation is exposed at land surface and ranges from 15 to 52 ft in thickness in the test wells (table 3). The Kaibab Formation underlies the Moenkopi Formation and ranges from 178 to 180 ft in thickness. A 20-ft-thick section (230 to 250 ft below land surface) of Toroweap Formation was identified in PW-2 beneath the Kaibab Formation.

Table 2. Summary of geologic logs and available geophysical logs from test wells at site 1

[Formation breaks are based on descriptions by U.S. Geological Survey personnel. Formation breaks also were selected by Bureau of Reclamation personnel (Bradley Prudhom, geologist, Bureau of Reclamation, personal commun., 2005) and commonly differed slightly from those selected by U.S. Geological Survey personnel]

Test well PW-1A		Test well OW-1	
Depth below land surface (feet)	Formation	Depth below land surface (feet)	Formation
0–202	Kaibab Formation	0–192	Kaibab Formation
202–222	Toroweap Formation	192–232	Toroweap Formation
222–774	Coconino Sandstone	232–684	Coconino Sandstone
774–1,120	Layer of interfingered Coconino Sandstone and Schnebly Hill Formation	684–1,130	Layer of interfingered Coconino Sandstone and Schnebly Hill Formation
1,120–1,134	Upper Supai Formation	1,130–1,179	Upper Supai Formation
Geophysical logs available		Geophysical logs available	
Self potential (SP), single point resistance, 16-inch and 64-inch normal resistivity, natural gamma, fluid resistivity and temperature, caliper, acoustic televiewer, and optical televiewer		Self potential (SP), single point resistance, 16-inch and 64-inch normal resistivity, natural gamma, fluid resistivity and temperature, electromagnetic induction, caliper, and optical televiewer	

Table 3. Summary of geologic logs and available geophysical logs from test wells at site 2

[Formation breaks for test wells PW-2A and OW-2 are based on descriptions by U.S. Geological Survey personnel. Formation breaks for test wells PW-2B and OW-2A are based on descriptions by Bureau of Reclamation personnel. Formation breaks for test wells PW-2A and OW-2 also were selected by Bureau of Reclamation personnel (Bradley Prudhom, geologist, Bureau of Reclamation, personal commun., 2005) and commonly differed slightly from those selected by U.S. Geological Survey personnel]

Test well PW-2A	
Depth below land surface (feet)	**Formation**
0–52	Moenkopi Formation
52–230	Kaibab Formation
230–250	Toroweap Formation
250–792	Coconino Sandstone
792–1,096	Layer of interfingered Coconino Sandstone and Schnebly Hill Formation
Geophysical logs available	
Self potential (SP), single point resistance, 16-inch and 64-inch normal resistivity, natural gamma, fluid resistivity and temperature, induction electromagnetic, and caliper	

Test well PW-2B	
Depth below land surface (feet)	**Formation**
0–23	Moenkopi Formation
23–205	Kaibab Formation
205–755	Coconino Sandstone
755–1,057	Layer of interfingered Coconino Sandstone and Schnebly Hill Formation
1,057–1,096	Upper Supai Formation
Geophysical logs available	
Self potential (SP), single point resistance, 16-inch and 64-inch normal resistivity, natural gamma, fluid resistivity and temperature, induction electromagnetic, and caliper	

Test well OW-2A	
Depth below land surface (feet)	**Formation**
0–30	Moenkopi Formation
30–210	Kaibab Formation
210–740	Coconino Sandstone
740–1,057	Layer of interfingered Coconino Sandstone and Schnebly Hill Formation
1,057–1,068	Upper Supai Formation
Geophysical logs available	
None	

Test well OW-2	
Depth below land surface (feet)	**Formation**
0–15	Moenkopi Formation
15–325	Mix cuttings
325–1,050	Coconino Sandstone
1,050–1,080	Layer of interfingered Coconino Sandstone and Schnebly Hill Formation
1,080–1,140	Upper Supai Formation
Geophysical logs available	
None	

Underlying the Toroweap at PW-2, and the Moenkopi at the other test wells, is a layer of Coconino Sandstone and a layer of interfingered Coconino Sandstone and Schnebly Hill Formation. The layer of Coconino Sandstone generally ranges from 530 to 550 ft in thickness; at OW-2 it is 725-ft thick. The layer of Coconino Sandstone extends to a maximum depth of 1,050 ft below land surface at site 2. Below the layer of Coconino Sandstone, the layer of interfingered Coconino Sandstone and Schnebly Hill Formation ranges from about 260 to 320 ft in thickness at three of the four test wells and extends to a maximum depth of 1,096 ft below land surface.

The Coconino Sandstone and Schnebly Hill Formation could also interfinger in the fourth test well (OW-2), but the relation could not be determined from the drill cuttings. The Upper Supai Formation was identified beneath the layer of interfingered Coconino Sandstone-Schnebly Hill Formation in OW-2, and OW-2A, where drilling extended 10 to 60 ft in the Upper Supai.

Site 3

The Moenkopi Formation is exposed at land surface at site 3 and generally ranges from 50 to 80 ft in thickness in the test wells (table 4). The underlying Kaibab Formation ranges from 110 to 193 ft in thickness. The Toroweap Formation was identified only at one of the three test wells, PW-3, where it is 20-ft thick. At PW-3, the Coconino Sandstone extends from 200 ft to 680 ft below land surface, beneath which it interfingers with the Schnebly Hill Formation to a depth of 1,100 ft. Flowing sand in OW-3A resulted in loss of drilling-fluid circulation and prevented the identification of units below 245 ft. A layer of interfingered Coconino Sandstone and Schnebly Hill Formation was not identified in OW-3C; however, it is possible that the layer is present. Drilling extended 10 ft into the Upper Supai Formation in OW-3C and 28 ft into the formation in PW-3.

Table 4. Summary of geologic logs and available geophysical logs from test wells at site 3

[Formation breaks are based on descriptions by U.S. Geological Survey personnel. Formation breaks also were selected by Bureau of Reclamation personnel (Bradley Prudhom, geologist, Bureau of Reclamation, personal commun., 2005) and commonly differed slightly from those selected by U.S. Geological Survey personnel]

Test well PW-3		Test well OW-3A		Test well OW-3C	
Depth below land surface (feet)	Formation	Depth below land surface (feet)	Formation	Depth below land surface (feet)	Formation
0–70	Moenkopi Formation	0–50	Moenkopi Formation	0–80	Moenkopi Formation
70–180	Kaibab Formation	52–245	Kaibab Formation	80–210	Kaibab Formation
180–200	Toroweap Formation	245–745	Coconino Sandstone	210–1,170	Coconino Formation
200–680	Coconino Sandstone		Flowing sand, could not complete hole to Upper Supai Formation	1,170–1,180	Upper Supai Formation
680–1,100	Layer of interfingered Coconino Sandstone and Schnebly Hill Formation				
1,100–1,128	Upper Supai Formation				
Geophysical logs available		Geophysical logs available		Geophysical logs available	
Self potential (SP), single point resistance, 16-inch and 64-inch normal resistivity, natural gamma, fluid resistivity and temperature, electromagnetic induction, and caliper		Self potential (SP), single point resistance, 16-inch and 64-inch normal resistivity, natural gamma, fluid resistivity and temperature, electromagnetic induction, and caliper		Self potential (SP), single point resistance, 16-inch and 64-inch normal resistivity, natural gamma, fluid resistivity and temperature, electromagnetic induction, caliper, and acoustic televiewer	

Aquifer-Test Analyses

Multiple-well aquifer tests were conducted at the three sites to estimate hydraulic properties of the C aquifer. One withdrawal well and a minimum of two observation wells were used for the tests at each site. Wells were pumped for a minimum of 14 days, and water levels were allowed to recover for a minimum of 14 days. Pumping rates ranged from about 400 to 800 gal/min. Generally, each well was instrumented with a pressure transducer (miniTROLL, In-Situ Inc.) that measured water level and temperature at least once every hour. Measurements were made more frequently near the beginning of the pumping period and at the start of the recovery period. When possible, the water level in each well was manually measured several times during the few weeks before pumping began. Manual check measurements were made during the aquifer tests by using electric tapes. Pumping rates for the aquifer tests were determined by conducting step tests at each site before the constant-rate tests. Pumping rates were measured by using an in-line flowmeter or an acoustic flowmeter. A anometer and pressure transducers at the end of the discharge line were used for back-up measurements. A few manual discharge measurements were made by using a pygmy current meter.

Drawdown in each well was estimated by subtracting the water level measured before pumping began from subsequent water levels. When possible, barometric, earth-tide, and regional effects were removed from measured water levels before drawdowns were estimated. The raw water-level data are archived on a BOR FTP site (Bradley Prudhom, geologist, Bureau of Reclamation, written commun., 2005). The data provided in this report are the reduced drawdown values used in the aquifer-test analyses.

The transmissivity, specific yield, specific storage, and vertical anisotropy of the C aquifer were estimated at each site by using a numerical model. The model was used in the analyses because, unlike analytical solutions, a model can account for heterogeneity caused by layering and can provide estimates of vertical anisotropy. Initial analytical-solution results from use of the Moench solution for unconfined aquifers (Barlow and Moench, 1999) yielded reasonable property estimates that were used as starting values in the numerical models. The numerical models were solved with MODFLOW (McDonald and Harbaugh, 1988; and Harbaugh and McDonald, 1996) and calibrated with MODOPTIM (Halford, 1992). All hydraulic properties were estimated by minimizing the weighted sum-of-squares differences between simulated and measured drawdowns.

In the process of drilling, the permeability of the aquifer in the immediate vicinity of the borehole is reduced. This is referred to as "skin effect." At the onset of pumping, the water level can fluctuate significantly in response to the changes in local permeability. These large fluctuations create considerable noise in the water-level record and typically are difficult to interpret. In addition, well-bore storage in the withdrawal well affects water levels at the beginning of the aquifer test. Thus, water-level values from the withdrawal wells were weighted less than values from the observation wells. Simulated and measured drawdowns in the withdrawal wells were compared after 1 to 2 hours of pumping to minimize the effects of well construction on calibration results.

Simulated drawdowns from the model simulations at sites 1 and 3 are similar to measured drawdowns at the sites; therefore, estimates of aquifer properties derived from the simulations are assumed to be more representative of the regional-scale aquifer properties than model simulations at site 2. Simulated drawdown from the model simulations at site 2 did not always agree with measured drawdown; therefore, estimates of aquifer properties derived from both the analytical methods and the numerical model are presented in this report.

Site 1

Withdrawal well PW-1A was pumped between March 3 and March 17, 2005, at a rate of about 386 to 412 gal/min for a total discharge of about 8.1×10^6 gal during the test. The pumping rate was selected on the basis of results from step-drawdown tests in February 2005. In those tests, pumping rates were increased by steps of 50 gal; a rate of 450 gal/min caused the water level to decline below the top of the well screen. Water was discharged into Canyon Diablo, about 2,300 ft from well PW-1A, and flowed away from the site. Given the distance from the pumping well, the local geology, and the depth to water, there is a small likelihood that the discharged water would have recharged the aquifer during the test. The aquifer test was simulated with four stress periods: three periods in which well PW-1A was pumped at a rate of 386 to 412 gal/min, and one recovery period.

Well OW-1 and windmill well 5T-533 were used as observation wells during the aquifer test. Drawdowns in each of the three wells (PW-1A, OW-1, and 5T-533) for the pumping and recovery period of the test are shown in figure 3. The specific capacity of PW-1A was about 2 (gal/min)/ft, on the basis of a maximum drawdown of 204.5 ft and a pumping rate of 400 gal/min (table 5).

The aquifer system was simulated with a radial model that incorporated the withdrawal well and observation wells OW-1 and 5T-533. The geology was generalized into three units on the basis of geologic logs: the Coconino Sandstone, the layer of interfingered Coconino Sandstone and Schnebly Hill Formation, and the Upper Supai Formation. Homogeneous hydraulic conductivity was assumed for each unit. Vertical anisotropy (a ratio of the vertical to horizontal hydraulic conductivity other than 1) also was assumed.

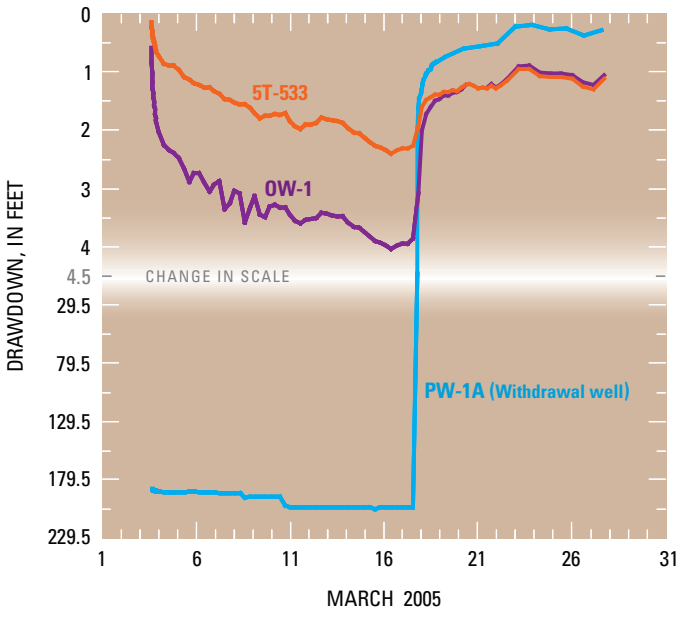

Figure 3. Filtered water-level drawdown and recovery at site 1 during aquifer test near Leupp, Arizona.

The model was discretized into 84 rows and 69 columns and extended laterally 200,000 ft from PW-1A. The vertical extent of the model was from 615 to 1,500 ft below land surface. The upper boundary of the model was the water table. The bottom boundary of the model was 885 ft below the water table and was represented as the bottom of the Upper Supai Formation. Column widths were 0.2 ft near well PW-1A and increased in width by a factor of 1.2 to the edge of the model. Row thicknesses were 1 ft adjacent to changes in lithology and increased by a factor of 1.5 to the midpoint of each unit. All external boundaries were no-flow. Changes in the wetted thickness of the aquifer were not simulated because, except near the withdrawal well, the drawdown near the water table was small relative to the thickness of the aquifer.

Initial simulations with a uniform hydraulic conductivity were not successful in matching simulated drawdowns with measured drawdowns. Consequently, hydraulic properties then were allowed to vary for each of the primary lithologic units (Coconino Sandstone and the layer of interfingered Coconino Sandstone and Schnebly Hill Formation). The hydraulic conductivity value for the Upper Supai Formation and the vertical anisotropy values were held constant and were estimated on the basis of aquifer-test results from site 3.

Table 5. Estimated hydraulic properties from numerical-model simulations at test-well sites 1, 2, and 3 near Leupp, Arizona

[(gal/min)/ft, gallons per minute per foot of drawdown; ft^2/d, foot squared per day; ft/d, foot per day; NC, not calculated; ft-1, per foot. Specific-capacity values were determined during constant-rate aquifer test]

Hydraulic property	Site 1	Site 2	Site 3
Specific capacity, (gal/min)/ft	2	7.5	2.4
Transmissivity, ft^2/d	7,000	18,000	5,400
Hydraulic conductivity of Coconino Sandstone, ft/d	28	42	11
Hydraulic conductivity of Schnebly Hill Formation, ft/d	NC	.5	.2
Hydraulic conductivity of interfingered of the Coconino Sandstone/Schnebly Hill Formation, ft/d	8	.04	.9
Hydraulic conductivity of Upper Supai Formation, ft/d	[1].1	NC	.2
Specific yield, dimensionless	.06	.08	.05
Specific storage, ft-1	$2x10^{-6}$	$2x10^{-6}$	$2x10^{-6}$
Vertical-to-horizontal anisotropy, dimensionless	.5	[1].2	.17

[1]Estimated on the basis of results from site 3.

Measured drawdown and recovery in PW-1A, OW-1, and 5T-533 were compared with simulated drawdowns and recovery from the numerical model (fig. 4). Simulated water levels matched measured water levels with a root-mean-square (RMS) error of 0.3 ft for the observation wells.

Estimated hydraulic conductivity was about 28 ft/d for the Coconino Sandstone and about 8 ft/d for the layer of interfingered Coconino Sandstone and Schnebly Hill Formation (table 5); hydraulic conductivity of the Upper Supai Formation was set at 0.1 ft/d in the model on the basis of estimates from aquifer tests at site 3 (there was no piezometer screened in the Upper Supai Formation at site 1). Estimated specific storage was 2×10^{-6} ft^{-1}, and estimated specific yield was 0.06. The hydraulic conductivity of the three units corresponds to a transmissivity of 7,000 ft²/d; most of the transmissivity can be attributed to the Coconino Sandstone. The vertical-to-lateral anisotropy of the aquifer system was set to 0.5 in the model.

Site 2

Withdrawal well PW-2B was pumped from April 26 through May 10, 2005, at a rate of about 745 gal/min. The rate was selected on the basis of results from step-drawdown tests in April 2005. In those tests, rates were increased by steps of 200 gal/min; a rate of 800 gal/min resulted in a drawdown of about 139 ft. A total discharge of about 13.8×10^6 gal was pumped during the constant-rate aquifer test. The water discharged to a dry channel about 750 ft from well PW-2B and then flowed to a stock tank about 7,000 ft north of the site. Pumping rates were measured by using a combination of an in-line flowmeter, a manometer, a pygmy current meter, and an acoustic flowmeter.

One withdrawal well (PW-2B), a nest of three piezometers (OW-2A), and three observation wells (PW-2A, OW-2, and 5M-94) were used for the aquifer test (table 1 and fig. 2). Most wells were instrumented with a pressure transducer, although manual water-level measurements were made at PW-2A and 5M-94. These data were collected by Rodgers and Company, Inc., and provided to the BOR. The specific capacity of PW-2B was about 7.5 (gal/min)/ft on the basis of a drawdown of 100 ft and a pumping rate of 745 gal/min (table 5).

Drawdowns at site 2 did not respond as expected, given the responses measured at sites 1 and 3. For example, drawdowns in OW-2A were virtually the same at each of the three piezometers. On the basis of aquifer-test results from site 3 and the short distance between the withdrawal well and OW-2A, it was expected that drawdown would be greatest in the deep piezometer (an indication of confined aquifer conditions) and smallest in the shallow piezometer (an indication of a water-table response). Maximum drawdown in the piezometers was about 0.6 ft (fig. 5). Although the screened intervals in the piezometers are separated by more than 100 ft of bentonite seal, it is possible that they are not hydraulically isolated. Drawdown in PW-2A was measured manually with an electric tape. The drawdown in this well, which is almost 300 ft farther from the withdrawal well than the piezometers at OW-2A, was slightly greater than the drawdown in the piezometers. The water-level in PW-2A never fully recovered during the measurement period. At well 5M-94, both the manual tape-down measurements and the pressure-transducer data were considered in the analysis owing to a partial failure of the pressure transducer.

The transmissivity, specific yield, specific storage, and vertical anisotropy of the C aquifer at site 2 were estimated with straight-line analytical methods (Cooper and Jacob, 1946) and a numerical model. The confidence in these estimates is less than that for estimates at sites 1 and 3 because (1) the analytical estimates produced inconsistent results (fig. 6) and (2) the simulated drawdown from the numerical model does not adequately match the measured drawdown. The inconsistent results likely are due to uncertainties in the drawdown data. Estimates of aquifer properties at site 2 derived from analytical and numerical methods are provided to indicate a range of possible values.

The straight-line method of drawdown versus distance from pumping yielded an estimated transmissivity of 7,500 ft²/d and a storage value of 0.2. The straight-line method of drawdown versus time yielded an estimated transmissivity of 52,600 ft²/d (fig. 6). These values are considered rough estimates for many of the same reasons described in the following discussion about the numerical model results.

The aquifer system at site 2 was simulated with a three-dimensional model. The geology was generalized into two units on the basis of geologic logs. Hydraulic conductivity was assumed homogeneous and vertically anisotropic within each unit. Model simulations produced hydraulic-conductivity estimates that ranged from 0.04 to 42 ft/d and a specific yield of 0.08 (table 5). The hydraulic conductivity of the combined units corresponds to a transmissivity of 18,000 ft²/d; most of the transmissivity can be attributed to the Coconino Sandstone. The model-estimated vertical-to-horizontal anisotropy of the aquifer system was about 0.2 (table 5).

Although estimated aquifer properties were obtained from the numerical model simulations, the confidence in these estimates is less than that for estimates at sites 1 and 3. The lower confidence is attributed to the uncertainty of measured data, the poor fit of simulated to measured drawdown values, and the nonuniqueness of the model domain. For the estimate of drawdown in well 5M-94, the water level was assumed to have fully recovered by the end of the test. Water levels in PW-2A are questionable because construction details could not be verified owing to the loss of the drill bit and stem. Water levels in the piezometers behaved similarly, which indicates the possibility that the piezometers were not hydraulically isolated during well construction. Simulated drawdown did not match well with measured drawdown in monitor wells OW-2 or PW-2B (fig. 7A). Although measured drawdown in some wells was approximated by simulations (fig. 7B), the properties of the model domain had to be varied beyond values that can be justified on the basis of field data. For example, in order to obtain the simulated results for this site, a zone of low permeability close to the water table was applied, and the fault zone was represented by a zone of low permeability.

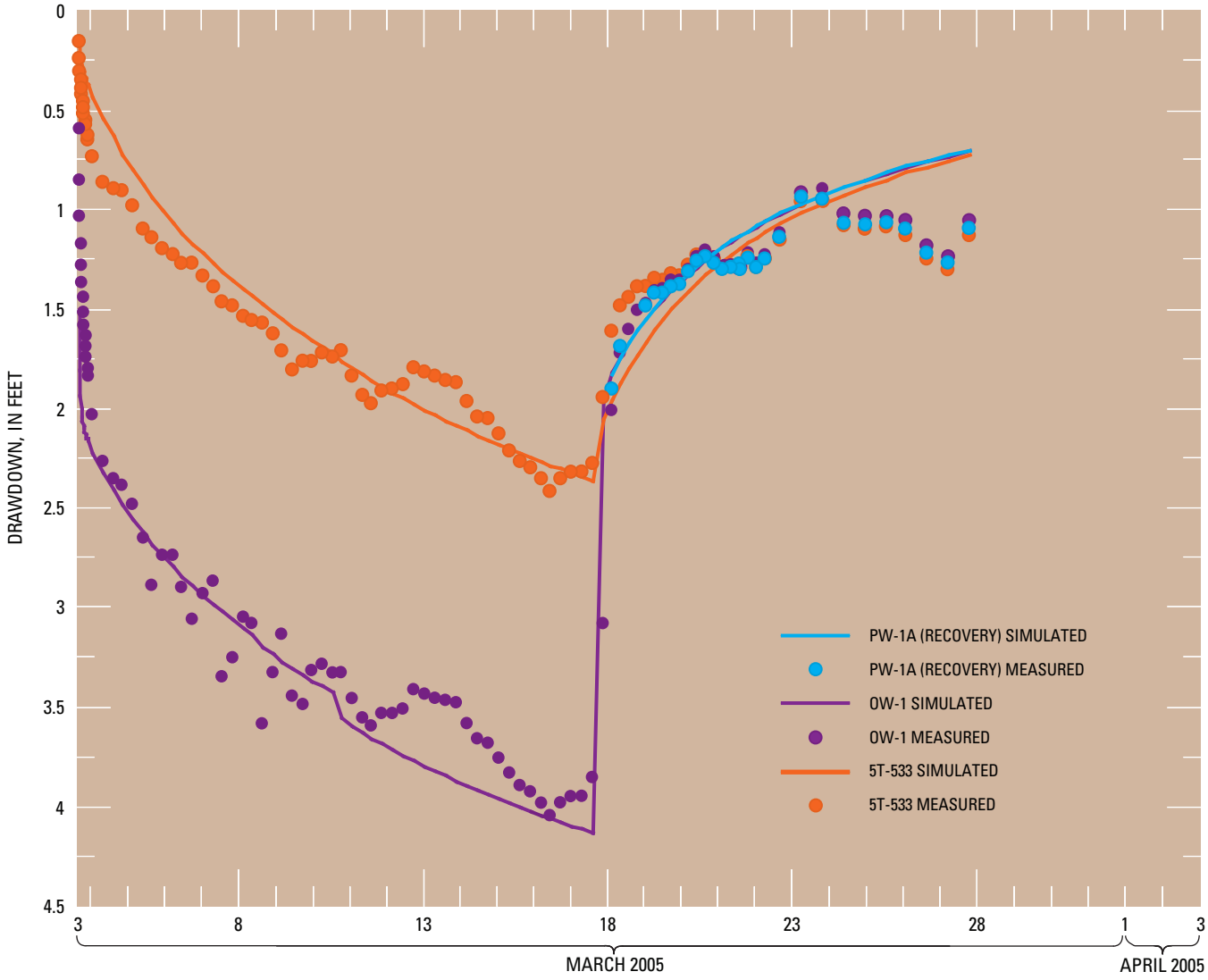

Figure 4. Simulated and measured water-level drawdown in PW-1A, OW-1, and windmill well 5T-533 near Leupp, Arizona.

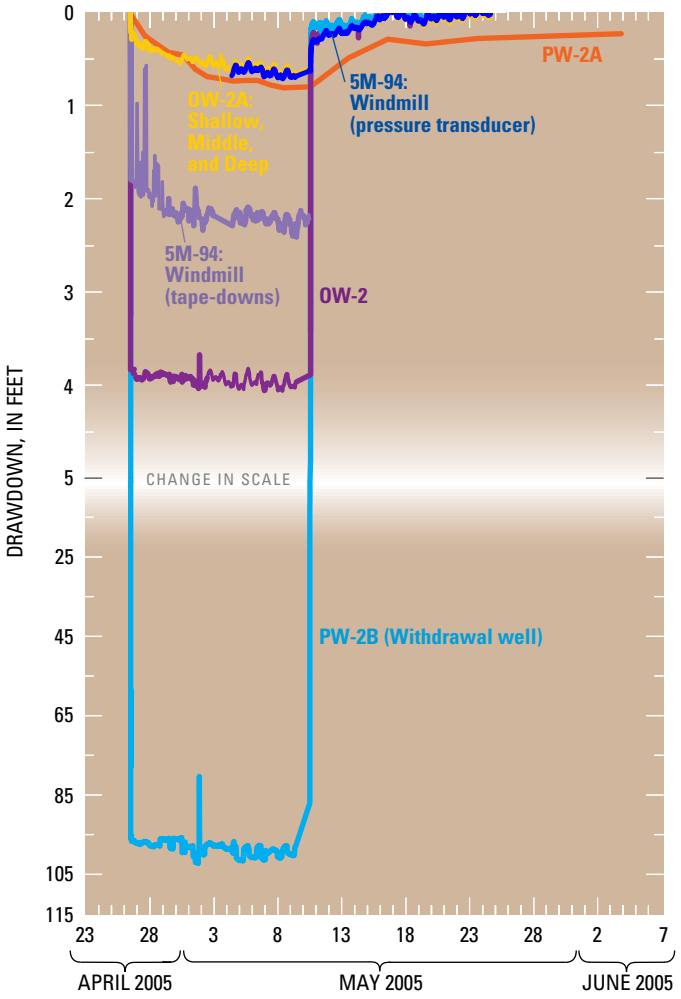

Figure 5. Water-level drawdown during aquifer test at site 2 near Leupp, Arizona.

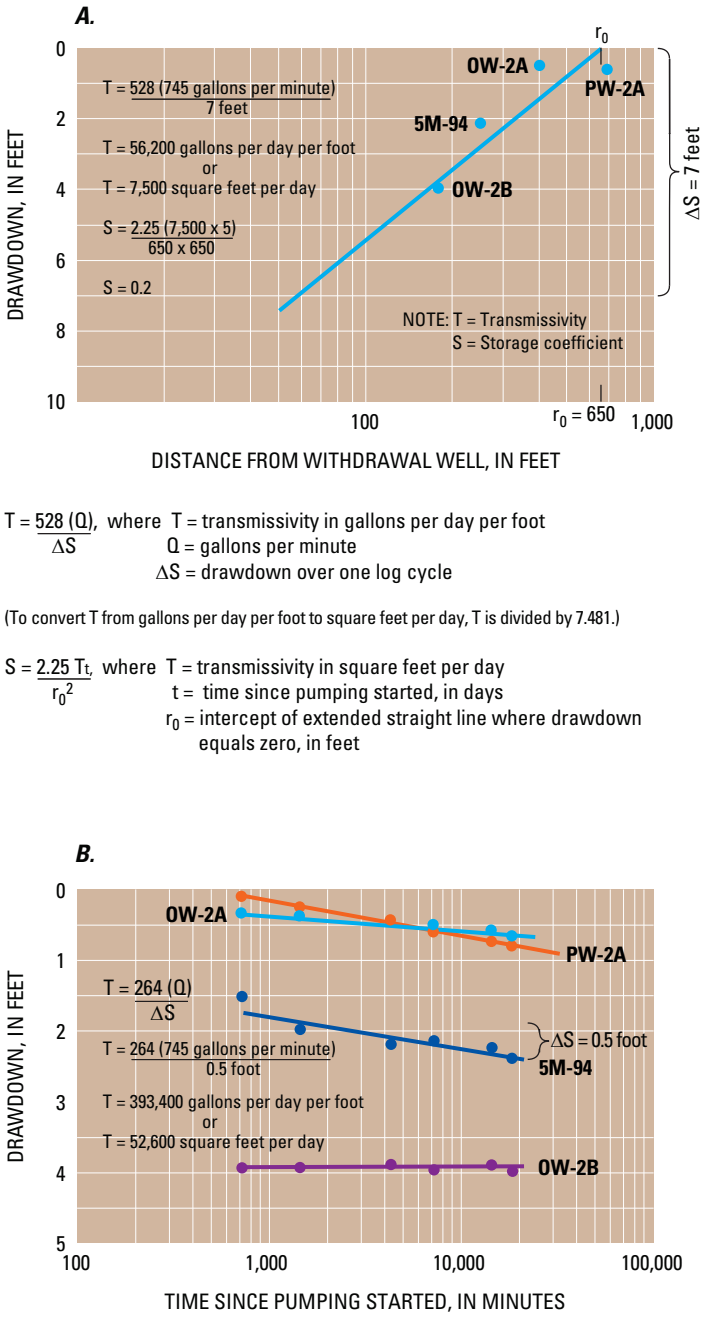

Figure 6. Straight-line methods to estimate transmissivity and storage coefficient at site 2 near Leupp, Arizona. *A*, Distance drawdown; *B*, Time drawdown.

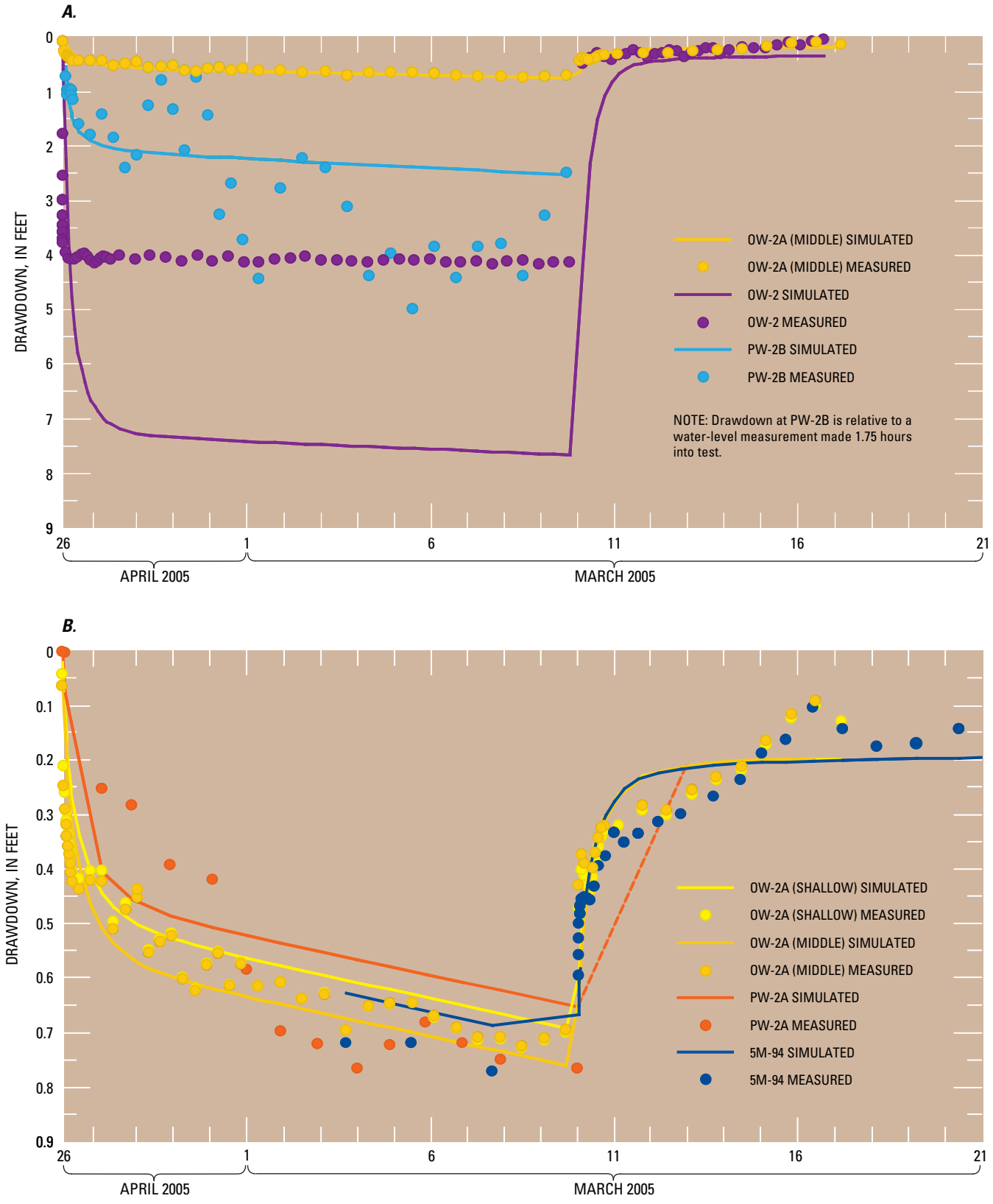

Figure 7. Simulated and measured water-level drawdown at site 2 near Leupp, Arizona. *A*, OW-2A (middle), OW-2, and PW-2B; *B*, OW-2A (shallow), OW-2A (middle), PW-2A, and 5M-94.

Site 3

Aquifer-test results from site 3 are deemed more reliable than those from sites 1 and 2 owing to the duration of the aquifer test and the distribution of the water-level measurements. The aquifer test at site 3 included two pumping periods and two recovery periods. The first pumping period extended from February 26 through March 5, 2005, during which the pumping rate was about 795 gal/min. The second period extended from March 11 to March 25, 2005, during which the pumping rate was 775 gal/min. Recovery was measured between the two pumping periods and after the second pumping period until April 8, 2005. The pumping rate was selected on the basis of results from step-drawdown tests in February 2005. In those tests, pumping rates were increased by steps of 100 to 250 gal/min; a rate of 750 gal/min resulted in a drawdown of about 306 ft. Total discharge was about 24.5×10^6 gal during the test. Water discharged into a dry channel about 500 ft from well PW-3 and flowed away from the test site. Pumping rates were measured using an in-line flowmeter. A manometer at the end of the discharge line was used for back-up measurements. One withdrawal well, five piezometers, and one observation well were used for the aquifer test (table 1 and fig. 2). Water levels were measured in the wells throughout the pumping and recovery periods (fig. 8). The specific capacity of PW-3 was about 2.4 (gal/min)/ft on the basis of a drawdown of 325 ft and a pumping rate of 775 gal/min (table 5).

The aquifer system at site 3 was simulated with a radial model that incorporated the piezometers in wells OW-3A and OW-3C, and windmill well 5M-88. The geology at site 3 was generalized into four units on the basis of geologic logs. Hydraulic conductivity was assumed to be homogeneous and vertically anisotropic within each unit.

The model domain was discretized into 78 rows and 69 columns, and extended laterally 200,000 ft from PW-3. The vertical extent of the model was from 227 to 1,500 ft below land surface. The upper boundary of the model was the water table and was represented by the uppermost row at a depth of 227 ft. The bottom of the model was 1,273 ft below the water table and was represented as the bottom of the Upper Supai Formation. Column widths were 0.2 ft near well PW-3 and increased in width by a factor of 1.2 to the edge of the model. Row widths were 1 ft adjacent to changes in lithology and increased by a factor of 1.5 to the midpoint of each unit. All external boundaries were no-flow. Changes in the wetted thickness of the aquifer were not simulated because, except near the withdrawal well, the drawdown near the water table was small relative to the thickness of the aquifer. The aquifer test was simulated with four stress periods that represent two pumping periods and two recovery periods.

Initial simulations with a uniform hydraulic conductivity were not successful in matching simulated drawdowns with measured drawdowns. Consequently, the hydraulic conductivity was allowed to vary by unit. Measured drawdowns in piezometers at OW-3A and OW-3C, and in 5M-88 were compared with simulated drawdowns from the numerical model (fig. 9). Simulated drawdowns matched measured drawdowns with an RMS error of 1.2 ft.

Estimated hydraulic conductivity of the four units ranged from 0.2 to 11 ft/d; estimated specific storage was 2×10^{-6} ft^{-1}; and estimated specific yield was 0.05 (table 5). The hydraulic conductivity of the four units corresponds to a transmissivity of 5,400 ft^2/d; most of the transmissivity can be attributed to the Coconino Sandstone. The model-estimated vertical-to-horizontal anisotropy of the aquifer system was 0.17 (table 5).

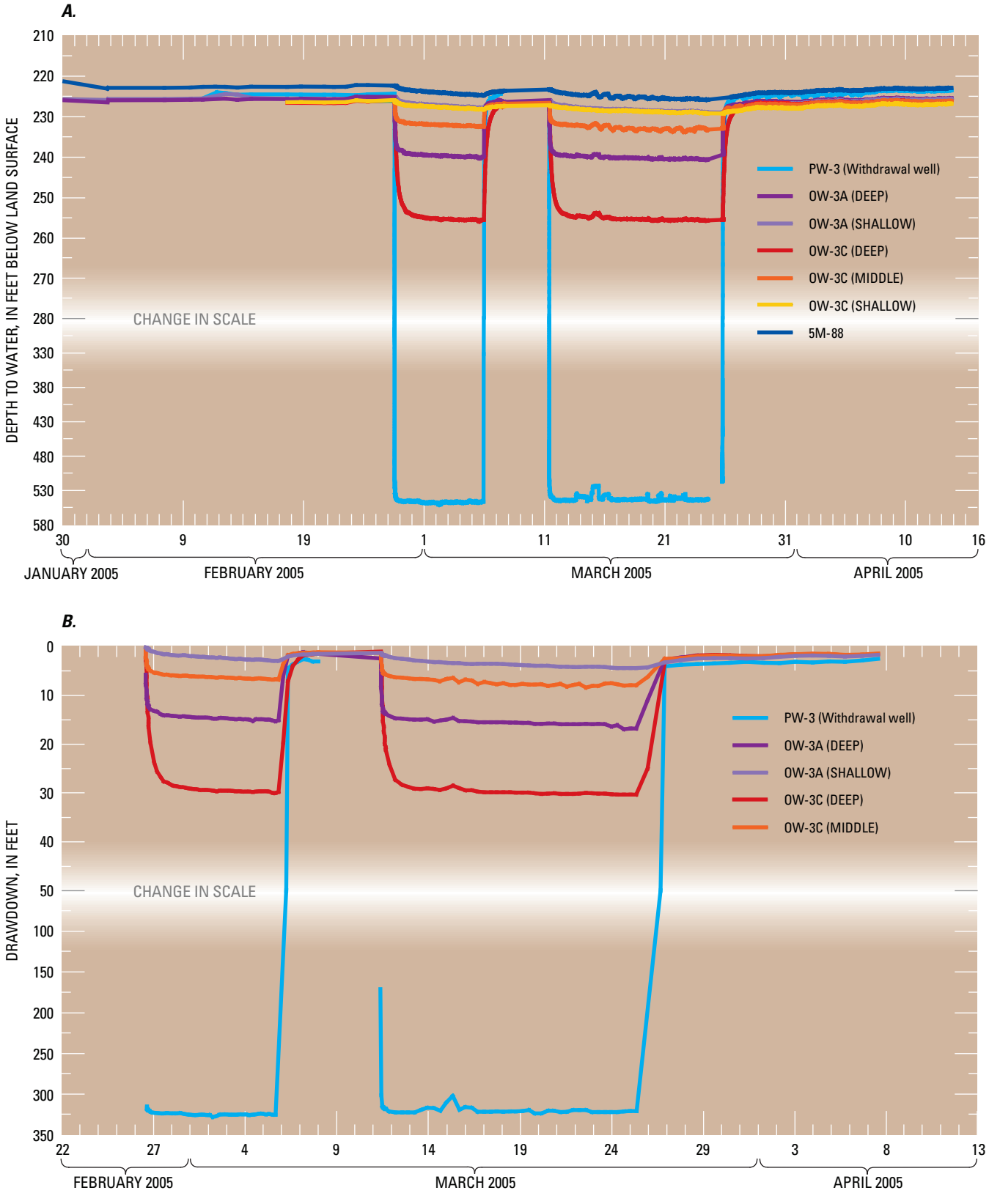

Figure 8. Water-level record at site 3 near Leupp, Arizona. *A*, Depth to water; *B*, Water-level drawdown.

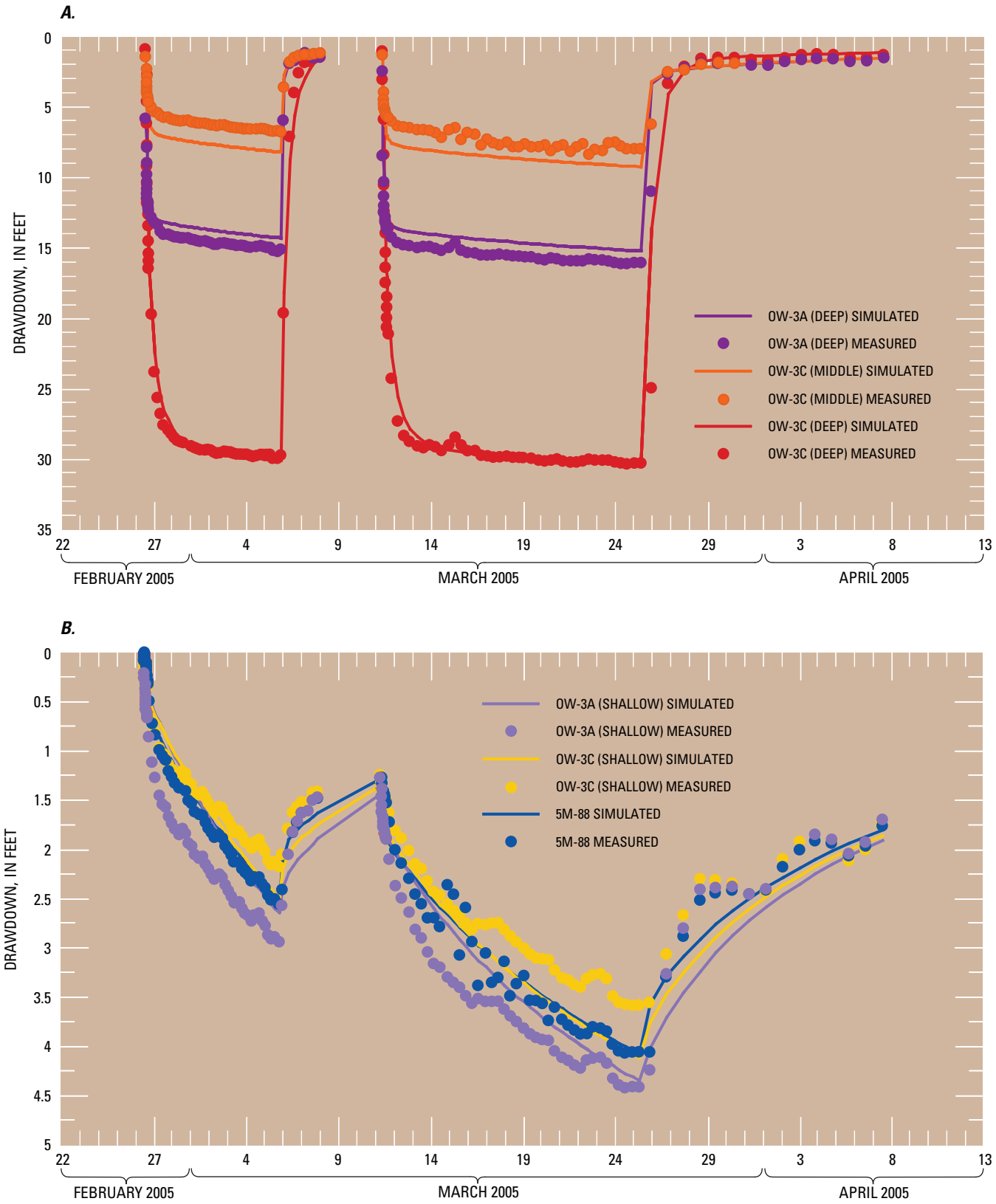

Figure 9. Water-level record at site 3 for period prior to pumping and during pumping and recovery periods of aquifer tests, near Leupp, Arizona. The first pumping period extended from February 26 through March 5, 2005 and the second period was between March 11 and March 25, 2005. Recovery was measured between pumping periods and until April 7, 2005. A. Depth to water for period prior to pumping, and during pumping and recovery periods of constant-rate aquifer tests. B. Drawdown in wells during constant-rate aquifer tests.

Water Chemistry

Ground-water sample collection during this investigation followed protocols described in the National Field Manual for the Collection of Water Quality Data (U.S. Geological Survey Techniques of Water Resources Investigations, chapter 9A, variously dated). The samples were analyzed by the USGS National Water Quality Laboratory in Denver, Colorado, for major ions, nutrients, trace elements, stable isotopes, and radioisotopes. Selected water properties and constituents were measured on-site during sample collection. Samples collected for major-ion and trace-element analyses were filtered through a 0.45-micrometer capsule filter into acid-rinsed bottles and preserved with nitric acid.

Samples were acquired under one of the following conditions: well development, step-test, or constant-rate aquifer test. Pumping rate, water level, pH, specific conductance, water temperature, dissolved-oxygen concentration, alkalinity, and chloride concentration were monitored during well development and pumping. Samples were collected only after confirming that successive measurements of these properties and constituents showed negligible change. Water samples were collected from the well head during development and from the discharge line for the step and constant-rate tests. Sample collection during the constant-rate aquifer tests occurred near the end of each test. Eighteen water samples were collected at the three drill sites from February 9, 2005, to May 9, 2005 (table 6). In addition, two samples were collected from a nearby inactive windmill well that is occasionally used for livestock watering (Sunshine well; fig. 2 and table 6). The Sunshine well is south of the three test sites and is owned by the Hopi Tribe. Available construction information for the well is incomplete; however, a sounding of the well indicated a depth of about 736 ft (Bradley Prudhom, geologist, Bureau of Reclamation, written commun., 2005), and records for this well in the USGS Ground-Water Site-Inventory database indicate a depth of 1,155 ft.

On-site measurements of water properties and constituents for all sampling conditions were similar among the sites. Specific conductance was lowest at site 2 (837 to 850 µS/cm; table 6) and highest at site 3 (1,160 to 1,230 µS/cm). Specific conductance and chloride increased slightly near the end of the constant-rate test at site 3. At the three test sites and the Sunshine well, values of pH ranged from 7.2 to 8.3 and water temperature ranged from 16 to 18.7°C.

Water chemistry varied among the sites; however, the variations were minimal. Similar to the on-site measurements, concentrations of major ions from laboratory analyses were highest at site 3; chloride concentrations at the site ranged from 121 to 129 mg/L, and sodium concentrations ranged from 72.9 to 115 mg/L. Concentrations of chloride and sodium were lowest at site 2, where they ranged from 20.6 to 21.7 and 26.2 to 27.8 mg/L, respectively. Concentrations of chloride and sodium at the Sunshine well were similar to those at site 2. Nutrient concentrations (ammonia, nitrite, nitrate, orthophosphate, and phosphorous) at all sites were less than U.S. Environmental Protection Agency's (USEPA) Maximum Contaminant Levels (MCLs). Concentrations of arsenic and other trace metals also were less than USEPA MCLs at all sites, and concentrations of many trace metals were less than or near laboratory detection limits. With the exception of sulfate concentrations, constituent concentrations did not exceed USEPA Secondary Maximum Contaminant Levels (SMCLs). Sulfate concentrations exceeded the SMCL of 250 mg/L at all sites and were highest at site 1 (about 385 mg/L)—the average concentration at the other sites, including the Sunshine well, was about 255 mg/L. Gross alpha and gross beta radioactivity at the sites ranged from about 4.2 to 11.6 and 1.1 to 4.1 pCi/L, respectively. These counts indicate the likelihood that ground water has interacted with radioactive material, such as uranium, which is a component of some geologic units in the area.

A water sample collected from each site during the constant-rate aquifer tests was analyzed for stable isotopes of oxygen and hydrogen by the USGS Isotope Fractionation Project Laboratory in Reston, Virginia. Stable-isotope ratios determined in this study are reported relative to Vienna Standard Mean Ocean Water (VSMOW). Differences from the standard are expressed by delta notation (δ) in per mil (‰):

$$\partial = \left(\frac{Rx - Rstd}{Rstd} \right) 1,000, \quad (1)$$

where

Rx = ratio of isotopes measured in sample, and

Rstd = ratio of same isotopes in the standard (VSMOW).

Stable-isotope values for the three samples were similar: $\delta^{18}O$ ranged from -11.34 to -11.07, and $\delta^{2}H$ ranged from -82 to -77.9. The ratios of $\delta^{18}O$ to $\delta^{2}H$ are similar to those of global meteoric water, indicating no effect from evaporation (Craig, 1961). On the basis of a local stable-isotope/altitude relation (Blasch and others, in press), these values indicate the ground water has received recharge from precipitation occurring at altitudes of about 6,700 to 7,600 ft.

The presence of tritium (0.02 to 0.18 tritium units, table 6) in water samples indicates the likelihood that ground water at the sites has received at least a small component of recharge since the early 1950s. These data, combined with data and interpretation from future studies, could yield information on ground-water age and flow paths.

Table 6. Field parameters and chemical constituents of water collected from test wells at sites 1, 2, 3 and from the Sunshine well near Leupp, Arizona

[ft, feet; bls, below land surface; gal/min, gallons/minute; mm Hg, millimeters of mercury; ---, no data; >, greater than; mg/L, milligrams per liter; µS/cm, microsiemen per centimeter; °C, degrees Celsius; <, less than; E, estimated; µg/L, micrograms per liter; M, presence verified but not quantified; pCi/L, picocuries per liter]

Well name	Station number	Date	Time	Sample conditions	Agency collecting sample (code)	Agency analyzing sample (code)	Depth of well (ft bls)	Depth to water level (ft bls)	Land-surface altitude (ft above NAVD 88)	Flow rate, instantaneous (gal/min)	Pump or flow period prior to sampling (minutes)	Sampling depth (ft below NAD 83)	Sampling method (code)	Barometric pressure (mm Hg)
Site 1														
PW-1A	351023111062002	02/13/2005	19:00	Development	1028	80020	1,134	---	5,378	150	---	---	---	631
		02/19/2005	12:30	Step-test	1028	80020	1,134	---	5,378	150	---	---	70	631
		02/19/2005	17:00	Step-test	1028	80020	1,134	---	5,378	300	---	---	70	626
		03/15/2005	13:00	Constant-rate test	---	80020	1,134	---	5,378	---	---	---	---	---
OW-1	351022111061801	02/21/2005	23:30	Development	1028	80020	1,179	---	5,378	---	---	---	70	629
		02/25/2005	12:00	Step-test	1028	80020	1,179	---	5,378	150	---	---	---	627
		02/25/2005	15:30	Step-test	1028	80020	1,179	---	5,378	232	---	---	---	626
Site 2														
PW-2B	351213111022101	04/12/2005	19:10	Development	1028	80020	1,096	---	5,030	1,800	300	---	---	635
		04/20/2005	15:30	Step-test	1028	80020	1,096	330.95	5,030	600	340	430	8030	634
		04/20/2005	20:25	Step-test	1028	80020	1,096	330.95	5,030	>1,000	635	497	8030	636
		05/09/2005	10:00	Constant-rate test	---	80020	1,096	---	5,030	---	---	---	---	---
OW-2	351214111022101	04/22/2005	12:15	Step-test	1028	80020	1,068	329.21	5,030	150	255	381	8030	638
		04/22/2005	15:30	Step-test	1028	80020	1,068	329.31	5,030	350	450	415	8030	637
Site 3														
PW-3	350957110562601	02/09/2005	20:30	Development	1028	80020	1,128	---	4,903	102	---	---	70	834
		02/24/2005	12:45	Step-test	1028	80020	1,128	226.89	4,903	300	285	350	---	639
		02/24/2005	17:30	Step-test	1028	80020	1,128	226.89	4,903	500	570	432	---	638
		03/23/2005	13:00	Constant-rate test	---	80020	1,128	---	4,903	---	---	---	---	---
OW-3C	350958110562201	02/09/2005	16:25	Development	1028	80020	1,180	---	4,903	50	---	---	70	834
Sunshine well														
Sunshine well	350706111014701	02/28/2005	10:30	Step-test	1028	80020	1,155	---	5,349	150	2	---	---	631
		02/28/2005	12:45	Step-test	1028	80020	1,155	---	5,349	222	---	---	---	630

Table 6. Field parameters and chemical constituents of water collected from test wells at sites 1, 2, 3 and from the Sunshine well near Leupp, Arizona—Continued

Well name	Station number	Date	Time	Sample conditions	Carbon dioxide, water, unfiltered (mg/L)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent of saturation)	pH, water, unfltrd field (std units)	pH, water, unfiltered lab (std units)	Specific conductance, water, unfiltered lab (µS/cm 25°C)	Specific conductance, water, unfiltered (µS/cm 25°C)	Temperature, air (°C)	Temperature, water (°C)	Hardness, water (mg/L as CaCO3)
Site 1														
PW-1A	351023111062002	02/13/2005	19:00	Development	2.6	6.3	81	8	8	1,160	1,170	9	17.6	490
		02/19/2005	12:30	Step-test	7	5.0	66	7.6	7.8	1,150	1,160	8.6	18.7	550
		02/19/2005	17:00	Step-test	6.8	4.3	55	7.6	7.7	1,160	1,170	7.5	18.2	550
		03/15/2005	13:00	Constant-rate test	---	---	---	---	7.7	1,120	---	---	---	560
OW-1	351022111061801	02/21/2005	23:30	Development	2.3	6.4	83	8.1	7.9	1,160	1,180	5.6	17.8	540
		02/25/2005	12:00	Step-test	7.5	4.9	64	7.6	7.7	1,150	1,180	7.8	18.2	560
		02/25/2005	15:30	Step-test	7.5	7.0	91	7.6	7.6	1,160	1,190	7.6	18.0	560
Site 2														
PW-2B	351213111022101	04/12/2005	19:10	Development	6.1	7.7	94	7.8	8	808	837	---	16.2	400
		04/20/2005	15:30	Step-test	16	6.0	75	7.3	7.8	819	849	---	17.5	410
		04/20/2005	20:25	Step-test	19	6.5	80	7.2	7.8	812	850	---	16.8	420
		05/09/2005	10:00	Constant-rate test	---	---	---	---	7.5	802	---	---	---	430
OW-2	351214111022101	04/22/2005	12:15	Step-test	12	4.7	60	7.4	7.6	823	841	---	18.1	420
		04/22/2005	15:30	Step-test	13	5.2	65	7.4	7.6	825	842	---	17.5	430
Site 3														
PW-3	350957110562601	02/09/2005	20:30	Development	1.9	10.0	93	8.3	8.2	1,160	1,230	---	16.0	400
		02/24/2005	12:45	Step-test	4.2	4.8	60	7.9	7.5	1,150	1,160	---	18.4	470
		02/24/2005	17:30	Step-test	5.3	4.9	59	7.8	7.7	1,150	1,160	4	16.4	480
		03/23/2005	13:00	Constant-rate test	---	---	---	---	7.8	1,140	---	---	---	490
OW-3C	350958110562201	02/09/2005	16:25	Development	7.9	8.4	80	7.7	7.6	1,140	1,200	---	17.4	480
Sunshine Well														
Sunshine Well	350706111014701	02/28/2005	10:30	Step-test	10	6.0	75	7.5	7.6	843	860	---	16.8	450
		02/28/2005	12:45	Step-test	11	5.9	75	7.5	7.6	840	856	---	17.0	450

Table 6. Field parameters and chemical constituents of water collected from test wells at sites 1, 2, 3 and from the Sunshine well near Leupp, Arizona—Continued

Well name	Station number	Date	Time	Sample conditions	Noncarb hardness, water filtered, field (mg/L as CaCO3)	Calcium water, filtered (mg/L)	Magnesium, water, filtered (mg/L)	Potassium, water, filtered (mg/L)	Sodium adsorption ratio	Sodium, water, filtered (mg/L)	Sodium, percent	ANC, water unfiltered, fixed end point, lab (mg/L as CaCO3)	Alkalinity, water filtered, inc tit field (mg/L as CaCO3)	Bicarbonate, water filtered, incrm. titr., field (mg/L)
						Site 1								
PW-1A	351023111062002	02/13/2005	19:00	Development	330	110	51.6	2.13	1	54.9	20	147	159	193
		02/19/2005	12:30	Step-test	400	124	57.8	2.27	1	58.4	19	149	142	172
		02/19/2005	17:00	Step-test	400	124	58.1	2.16	1	57.9	19	151	145	176
		03/15/2005	13:00	Constant-rate test	---	127	59.2	2.21	1	57.4	18	---	---	---
OW-1	351022111061801	02/21/2005	23:30	Development	380	122	56.7	2.21	1	56.6	19	145	161	194
		02/25/2005	12:00	Step-test	400	125	59.2	2.5	1	59.1	19	150	153	186
		02/25/2005	15:30	Step-test	410	127	59.5	2.4	1	59.1	19	154	155	188
						Site 2								
PW-2B	351213111022101	04/12/2005	19:10	Development	220	91.9	42	1.87	.6	27.3	13	187	184	223
		04/20/2005	15:30	Step-test	250	97	41.3	1.97	.6	27.8	13	160	163	198
		04/20/2005	20:25	Step-test	260	99.6	41.9	1.98	.6	27.7	12	162	160	195
		05/09/2005	10:00	Constant-rate test	---	98.7	45	1.81	.5	26.2	12	---	---	---
OW-2	351214111022101	04/22/2005	12:15	Step-test	260	98.3	42.6	1.81	.6	27.6	12	161	165	200
		04/22/2005	15:30	Step-test	260	100	43.5	1.82	.6	27.5	12	163	165	201
						Site 3								
PW-3	350957110562601	02/09/2005	20:30	Development	220	88.6	43.5	5.15	3	115	38	187	178	217
		02/24/2005	12:45	Step-test	280	102	52.8	2.23	2	75.3	26	187	192	232
		02/24/2005	17:30	Step-test	300	104	53.5	2.47	2	77.4	26	187	182	220
		03/23/2005	13:00	Constant-rate test	---	106	55	2.18	1	72.9	24	---	---	---
OW-3C	350958110562201	02/09/2005	16:25	Development	300	107	50.7	2.5	2	80.1	27	184	178	216
						Sunshine Well								
Sunshine Well	350706111014701	02/28/2005	10:30	Step-test	280	107	45.5	1.74	.5	26.1	11	173	178	217
		02/28/2005	12:45	Step-test	280	106	44.9	1.68	.5	26.1	11	173	170	207

Table 6. Field parameters and chemical constituents of water collected from test wells at sites 1, 2, 3 and from the Sunshine well near Leupp, Arizona—Continued

Well name	Station number	Date	Time	Sample conditions	Carbonate, water filtered, incremental titr., field (mg/L)	Hydroxide, water filtered incremental titr., field (mg/L)	Chloride, water, filtered (mg/L)	Fluoride, water, filtered (mg/L)	Silica, water, filtered (mg/L)	Sulfate water, filtered, (mg/L)	Residue water, filtered, sum of constituents (mg/L)	Residue water, filtered (tons/acre-ft)	Residue on evap. at 180°C water filtered (mg/L)	Ammonia + org-N, water, unfiltered (mg/L as N)
						Site 1								
PW-1A	351023111062002	02/13/2005	19:00	Development	0	0	65.2	0.2	14.1	385	779	1.16	855	<.10
		02/19/2005	12:30	Step-test	0	0	66.1	.2	14	384	793	1.13	832	<.10
		02/19/2005	17:00	Step-test	0	0	62.7	.2	14.1	383	789	1.12	824	<.10
		03/15/2005	13:00	Constant-rate test	---	---	64.6	.2	14.6	379	---	---	---	---
OW-1	351022111061801	02/21/2005	23:30	Development	1	0	64.9	.2	12.6	385	797	1.14	837	<.10
		02/25/2005	12:00	Step-test	0	0	65.4	.2	13.1	386	803	1.13	832	E.06
		02/25/2005	15:30	Step-test	0	0	65.4	.2	13.6	386	808	1.15	846	<.10
						Site 2								
PW-2B	351213111022101	04/12/2005	19:10	Development	0	0	21.0	.3	13.6	257	565	0.81	597	<.10
		04/20/2005	15:30	Step-test	0	0	20.8	.3	14.1	257	558	0.80	589	<.10
		04/20/2005	20:25	Step-test	0	0	20.8	.3	14.2	257	560	0.81	597	<.10
		05/09/2005	10:00	Constant-rate test	---	---	20.6	.2	13.6	254	---	---	---	---
OW-2	351214111022101	04/22/2005	12:15	Step-test	0	0	21.6	.2	13.3	255	561	0.80	589	<.10
		04/22/2005	15:30	Step-test	0	0	21.7	.3	13.3	255	563	0.81	595	<.10
						Site 3								
PW-3	350957110562601	02/09/2005	20:30	Development	0	0	125	.3	15	267	767	1.06	778	0.12
		02/24/2005	12:45	Step-test	0	---	123	.2	13.3	250	734	1.04	768	<.10
		02/24/2005	17:30	Step-test	0	0	123	.3	13.6	251	734	1.04	763	<.10
		03/23/2005	13:00	Constant-rate test	---	---	121	.2	13.5	247	---	---	---	---
OW-3C	350958110562201	02/09/2005	16:25	Development	0	0	129	.2	13.1	253	742	1.05	773	<.10
						Sunshine Well								
Sunshine Well	350706111014701	02/28/2005	10:30	Step-test	0	0	21.7	.2	13.1	265	587	0.82	601	<.10
		02/28/2005	12:45	Step-test	0	0	21.6	.2	13	265	582	0.83	610	<.10

Table 6. Field parameters and chemical constituents of water collected from test wells at sites 1, 2, 3 and from the Sunshine well near Leupp, Arizona—Continued

Well name	Station number	Date	Time	Sample conditions	Ammonia water unfiltered (mg/L)	Ammonia water, unfiltered (mg/L as N)	Nitrite + nitrate water filtered (mg/L as N)	Nitrite + nitrate water unfiltered (mg/L as N)	Nitrite water, filtered (mg/L as N)	Organic nitrogen, water, unfiltered (mg/L)	Orthophosphate, water, filtered, (mg/L as P)	Phosphorus, water, unfiltered (mg/L)	Total nitrogen, water, unfiltered (mg/L)	Total nitrogen, water, unfiltered (mg/L as NO3)
							Site 1							
PW-1A	351023111062002	02/13/2005	19:00	Development	0.02	0.01	---	0.444	---	---	<.006	E.03	---	---
		02/19/2005	12:30	Step-test	.01	.01	---	.438	---	---	<.006	<.04	---	---
		02/19/2005	17:00	Step-test	---	E.01	---	.442	---	---	<.006	<.04	---	---
		03/15/2005	13:00	Constant-rate test	---	---	0.41	---	<.008	---	<.02	---	---	---
OW-1	351022111061801	02/21/2005	23:30	Development	.02	.01	---	.438	---	---	<.006	<.04	---	---
		02/25/2005	12:00	Step-test	.05	.04	---	.324	---	---	<.006	<.04	---	---
		02/25/2005	15:30	Step-test	.05	.04	---	.318	---	---	<.006	E.02	---	---
							Site 2							
PW-2B	351213111022101	04/12/2005	19:10	Development	.01	.01	---	.252	---	---	<.006	0.15	---	---
		04/20/2005	15:30	Step-test	---	E.01	---	.25	---	---	<.006	<.04	---	---
		04/20/2005	20:25	Step-test	---	E.01	---	.248	---	---	<.006	<.04	---	---
		05/09/2005	10:00	Constant-rate test	---	---	.25	---	<.008	---	<.02	---	---	---
OW-2	351214111022101	04/22/2005	12:15	Step-test	---	E.01	---	.246	---	---	<.006	<.04	---	---
		04/22/2005	15:30	Step-test	---	E.01	---	.244	---	---	<.006	<.04	---	---
							Site 3							
PW-3	350957110562601	02/09/2005	20:30	Development	.08	.06	---	.251	---	0.05	<.006	<.04	0.37	1.6
		02/24/2005	12:45	Step-test	.02	.01	---	.201	---	---	<.006	<.04	---	---
		02/24/2005	17:30	Step-test	.02	.02	---	.199	---	---	<.006	<.04	---	---
		03/23/2005	13:00	Constant-rate test	---	---	.18	---	<.008	---	<.02	---	---	---
OW-3C	350958110562201	02/09/2005	16:25	Development	---	E.01	---	.206	---	---	<.006	<.04	---	---
							Sunshine Well							
Sunshine Well	350706111014701	02/28/2005	10:30	Step-test	.03	.03	---	.209	---	---	<.006	<.04	---	---
		02/28/2005	12:45	Step-test	.02	.02	---	.207	---	---	<.006	<.04	---	---

Table 6. Field parameters and chemical constituents of water collected from test wells at sites 1, 2, 3 and from the Sunshine well near Leupp, Arizona—Continued

Well name	Station number	Date	Time	Sample conditions	Aluminum, water, filtered (µg/L)	Arsenic water, filtered (µg/L)	Barium, water, filtered (µg/L)	Beryllium, water, filtered (µg/L)	Boron, water, filtered (µg/L)	Cadmium water, filtered (µg/L)	Chromium, water, filtered (µg/L)	Cobalt water, filtered (µg/L)	Copper, water, filtered, (µg/L)	Iron, water, filtered (µg/L)
						Site 1								
PW-1A	351023111062002	02/13/2005	19:00	Development	---	0.2	19	---	85	---	---	---	3.1	<6
		02/19/2005	12:30	Step-test	---	.3	15	---	93	---	---	---	1.4	572
		02/19/2005	17:00	Step-test	---	.4	16	---	94	---	---	---	3	357
		03/15/2005	13:00	Constant-rate test	<2	<2	11.8	<.2	93	<2	9	<2	<2	65
OW-1	351022111061801	02/21/2005	23:30	Development	---	.2	14	---	91	---	---	---	1.6	80
		02/25/2005	12:00	Step-test	---	.5	16	---	102	---	---	---	1.5	794
		02/25/2005	15:30	Step-test	---	.6	15	---	102	---	---	---	1.8	287
						Site 2								
PW-2B	351213111022101	04/12/2005	19:10	Development	---	E.2	24	---	83	---	---	---	1.4	E5
		04/20/2005	15:30	Step-test	---	.7	22	---	93	---	---	---	1.7	50
		04/20/2005	20:25	Step-test	---	.6	20	---	91	---	---	---	1.6	34
		05/09/2005	10:00	Constant-rate test	<2	<2	14.5	<.2	81	<2	7	<2	<2	51
OW-2	351214111022101	04/22/2005	12:15	Step-test	---	E.2	16	---	82	---	---	---	1	512
		04/22/2005	15:30	Step-test	---	.2	15	---	84	---	---	---	1.1	391
						Site 3								
PW-3	350957110562601	02/09/2005	20:30	Development	---	1.3	25	---	87	---	---	---	2.5	434
		02/24/2005	12:45	Step-test	---	.4	17	---	87	---	---	---	1.3	176
		02/24/2005	17:30	Step-test	---	.5	19	---	86	---	---	---	1.1	268
		03/23/2005	13:00	Constant-rate test	M	<2	16.5	<.2	84	<2	5	<2	<2	92
OW-3C	350958110562201	02/09/2005	16:25	Development	---	1	15	---	83	---	---	---	2.4	9
						Sunshine Well								
Sunshine Well	350706111014701	02/28/2005	10:30	Step-test	---	.5	13	---	78	---	---	---	1.1	280
		02/28/2005	12:45	Step-test	---	.5	12	---	79	---	---	---	1	214

Table 6. Field parameters and chemical constituents of water collected from test wells at sites 1, 2, 3 and from the Sunshine well near Leupp, Arizona—Continued

Well name	Station number	Date	Time	Sample conditions	Lead, water, filtered (µg/L)	Lithium water, filtered (µg/L)	Manganese, water, filtered (µg/L)	Mercury water, filtered (µg/L)	Molybdenum, water, filtered (µg/L)	Nickel, water, filtered (µg/L)	Selenium, water, filtered (µg/L)	Silver, water, filtered (µg/L)	Strontium, water, filtered (µg/L)	Vanadium, water, filtered (µg/L)
							Site 1							
PW-1A	351023111062002	02/13/2005	19:00	Development	E.07	---	41.1	<.01	---	---	---	---	---	---
		02/19/2005	12:30	Step-test	E.05	---	17	<.01	---	---	---	---	---	---
		02/19/2005	17:00	Step-test	E.06	---	10	.01	---	---	---	---	---	---
		03/15/2005	13:00	Constant-rate test	0.18	33	1.2	---	6	M	E2	<3	1,320	2
OW-1	351022111061801	02/21/2005	23:30	Development	.11	---	31.8	<.01	---	---	---	---	---	---
		02/25/2005	12:00	Step-test	.35	---	38.7	<.01	---	---	---	---	---	---
		02/25/2005	15:30	Step-test	.66	---	20.3	<.01	---	---	---	---	---	---
							Site 2							
PW-2B	351213111022101	04/12/2005	19:10	Development	.49	---	20.6	<.01	---	---	---	---	---	---
		04/20/2005	15:30	Step-test	<.08	---	4	<.01	---	---	---	---	---	---
		04/20/2005	20:25	Step-test	<.08	---	3	<.01	---	---	---	---	---	---
		05/09/2005	10:00	Constant-rate test	.09	21	.8	---	7	M	<3	<3	1,220	<2
OW-2	351214111022101	04/22/2005	12:15	Step-test	E.06	---	13.2	E.01	---	---	---	---	---	---
		04/22/2005	15:30	Step-test	.13	---	6.8	E.01	---	---	---	---	---	---
							Site 3							
PW-3	350957110562601	02/09/2005	20:30	Development	.08	---	65.8	<.01	---	---	---	---	---	---
		02/24/2005	12:45	Step-test	E.04	---	9.5	<.01	---	---	---	---	---	---
		02/24/2005	17:30	Step-test	<.08	---	21.7	<.01	---	---	---	---	---	---
		03/23/2005	13:00	Constant-rate test	E.05	20	1.2	---	5	M	E2	<3	1,320	<2
OW-3C	350958110562201	02/09/2005	16:25	Development	.08	---	3.6	<.01	---	---	---	---	---	---
							Sunshine Well							
Sunshine Well	350706111014701	02/28/2005	10:30	Step-test	.1	---	10.4	<.01	---	---	---	---	---	---
		02/28/2005	12:45	Step-test	E.07	---	11.8	<.01	---	---	---	---	---	---

Table 6. Field parameters and chemical constituents of water collected from test wells at sites 1, 2, 3 and from the Sunshine well near Leupp, Arizona—Continued

Well name	Station number	Date	Time	Sample conditions	Zinc, water, filtered (µg/L)	C-13/C-12 ratio, water, unfiltered (per mil)	C-14 countng error, water, filtered (percent modern)	C-14, water, filtered (percent modern)	Deuterium/ protium ratio, water, unfiltered (per mil)	O-18/O-16 ratio, water, unfiltered (per mil)	Tritium water unfiltered (pCi/L)	Tritium units	Gross alpha (pCi/L)	Gross beta (pCi/L)
						Site 1								
PW-1A	351023111062002	02/13/2005	19:00	Development	8.6	---	---	---	---	---	---	---	---	---
		02/19/2005	12:30	Step-test	13.6	---	---	---	---	---	---	---	---	---
		02/19/2005	17:00	Step-test	16.2	---	---	---	---	---	---	---	---	---
		03/15/2005	13:00	Constant-rate test	E4	-8.31	0.12	30.48	-82	-11.34	0.06	E0.02	---	---
OW-1	351022111061801	02/21/2005	23:30	Development	1.6	---	---	---	---	---	---	---	---	---
		02/25/2005	12:00	Step-test	5.8	---	---	---	---	---	---	---	---	---
		02/25/2005	15:30	Step-test	4.7	---	---	---	---	---	---	---	---	---
						Site 2								
PW-2B	351213111022101	04/12/2005	19:10	Development	1.1	---	---	---	---	---	---	---	---	---
		04/20/2005	15:30	Step-test	2.9	---	---	---	---	---	---	---	---	---
		04/20/2005	20:25	Step-test	2.3	---	---	---	---	---	---	---	---	---
		05/09/2005	10:00	Constant-rate test	<6	-8.28	.14	29.9	-77.9	-11.07	.56	E.18	11.55	1.068
OW-2	351214111022101	04/22/2005	12:15	Step-test	4.1	---	---	---	---	---	---	---	---	---
		04/22/2005	15:30	Step-test	3.2	---	---	---	---	---	---	---	---	---
						Site 3								
PW-3	350957110562601	02/09/2005	20:30	Development	3.3	---	---	---	---	---	---	---	---	---
		02/24/2005	12:45	Step-test	7.1	---	---	---	---	---	---	---	---	---
		02/24/2005	17:30	Step-test	7.1	---	---	---	---	---	---	---	---	---
		03/23/2005	13:00	Constant-rate test	6	-7.21	.1	24.2	-79.8	-11.16	-.29	E0	4.236	4.11
OW-3C	350958110562201	02/09/2005	16:25	Development	37.8	---	---	---	---	---	---	---	---	---
						Sunshine Well								
Sunshine Well	350706111014701	02/28/2005	10:30	Step-test	15.7	---	---	---	---	---	---	---	---	---
		02/28/2005	12:45	Step-test	17	---	---	---	---	---	---	---	---	---

Table 6. Field parameters and chemical constituents of water collected from test wells at sites 1, 2, 3 and from the Sunshine well near Leupp, Arizona—Continued

Well name	Station number	Date	Time	Sample conditions	Uranium direct (pCi/L)	Thorium-228 (pCi/L)	Thorium-230 (pCi/L)	Thorium-232 (pCi/L)	Total alpha raduim (pCi/L)	Strontium (µg/L)	Strontium Sr-87 Sr-86 (per mil)
					Site 1						
PW-1A	351023111062002	02/13/2005	19:00	Development	---	---	---	---	---	---	---
		02/19/2005	12:30	Step-test	---	---	---	---	---	---	---
		02/19/2005	17:00	Step-test	---	---	---	---	---	---	---
		03/15/2005	13:00	Constant-rate test	---	---	---	---	---	1,385	0.70912
OW-1	351022111061801	02/21/2005	23:30	Development	---	---	---	---	---	---	---
		02/25/2005	12:00	Step-test	---	---	---	---	---	---	---
		02/25/2005	15:30	Step-test	---	---	---	---	---	---	---
					Site 2						
PW-2B	351213111022101	04/12/2005	19:10	Development	---	---	---	---	---	---	---
		04/20/2005	15:30	Step-test	---	---	---	---	---	---	---
		04/20/2005	20:25	Step-test	---	---	---	---	---	---	---
		05/09/2005	10:00	Constant-rate test	2.432	-0.00362	-0.00722	-0.00361	0.9853	1,306	.70887
OW-2	351214111022101	04/22/2005	12:15	Step-test	---	---	---	---	---	---	---
		04/22/2005	15:30	Step-test	---	---	---	---	---	---	---
					Site 3						
PW-3	350957110562601	02/09/2005	20:30	Development	---	---	---	---	---	---	---
		02/24/2005	12:45	Step-test	---	---	---	---	---	---	---
		02/24/2005	17:30	Step-test	---	---	---	---	---	---	---
		03/23/2005	13:00	Constant-rate test	1.683	.02285	-.03183	-.00606	.5127	1,320	.70858
OW-3C	350958110562201	02/09/2005	16:25	Development	---	---	---	---	---	---	---
					Sunshine Well						
Sunshine Well	350706111014701	02/28/2005	10:30	Step-test	---	---	---	---	---	---	---
		02/28/2005	12:45	Step-test	---	---	---	---	---	---	---

Summary

The C aquifer is the most productive aquifer in northern Arizona and provides industry, land owners, businesses, agriculture, and municipalities with a dependable water supply. The areal extent of the aquifer is more than 27,000 mi^2. Proposed new development of water resources in the area has led to an evaluation of the aquifer by a Federal team comprising personnel from the Bureau of Reclamation (BOR), the U.S. Geological Survey, (USGS), the U.S. Fish and Wildlife Service, the Office of Surface Mining, and Native American tribes. The USGS has been tasked with collection of geologic, hydrologic, and water-chemistry data on the aquifer to determine viability of the aquifer for increased use. The BOR and USGS, therefore, entered into a program to drill test wells at three sites near Leupp, Arizona. Activities included geologic logging of test wells, aquifer tests, and collection and analysis of water-chemistry samples. Rock units penetrated during drilling were, in descending order, the Moenkopi, Kaibab, and Toroweap Formations, the Coconino Sandstone, the Schnebly Hill Formation, and the Upper Supai Formation. Water levels ranged from 226 to 615 ft below land surface and were generally within the Coconino Sandstone. Estimated transmissivity of the aquifer was about 5,400 to 7,000 ft^2/d on the basis of numerical-model analyses of aquifer tests at two of the three sites. Estimated transmissivity at site 2, determined from analytical and numerical-model methods, ranges from 7,600 to 53,000 ft^2/d, but these values are less reliable than those from the other sites. Most of the transmissivity can be attributed to the Coconino Sandstone.

Water quality, based on the analysis of 18 water samples collected at the 3 sites and 2 samples from a nearby abandoned well, generally was good for intended uses. Specific conductance ranged from 837 to 1,230 µS/cm and was lowest at site 2 and highest at site 3. Concentrations of dissolved chloride and dissolved sodium correlated with specific conductance values and ranged from 20.6 to 129 mg/L and 26.2 to 115 mg/L, respectively. Trace-metal and nutrient concentrations were below USEPA MCLs at all sites. Sulfate concentrations exceeded the USEPA SMCL at all sites—concentrations were highest at site 3 (about 385 mg/L). Average sulfate concentrations at the other sites was about 255 mg/L. The radioactivity in the water indicates the water likely has interacted with radioactive material, such as uranium, which is a component of some geologic units in the area. Stable-isotope values are indicative of water that has received recharge from precipitation occurring at altitudes of about 6,700 to 7,600 ft.

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Appendix

Table A. Filtered drawdown data for wells during constant-rate aquifer test at site 1 near Leupp, Arizona

[Constant-rate aquifer test started at 14:00 on March 3, 2005. Pumping rate during the test ranged from 386 to 412 gallons per minute and averaged about 400 gallons per minute]

Well PW-1A (withdrawal well)			Well OW-1 (290 feet from PW-1A)			Well 5T-533 (415 feet from PW-1A)		
Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
03/03/2005	1511	187.08	03/03/2005	1442	0.585	03/03/2005	1442	0.15
03/03/2005	1539	187.617	03/03/2005	1511	.85	03/03/2005	1511	.24
03/03/2005	1608	188.039	03/03/2005	1539	1.033	03/03/2005	1539	.304
03/03/2005	1636	188.276	03/03/2005	1608	1.171	03/03/2005	1608	.348
03/03/2005	1705	188.259	03/03/2005	1636	1.279	03/03/2005	1636	.388
03/03/2005	1733	188.569	03/03/2005	1705	1.358	03/03/2005	1705	.423
03/03/2005	1802	188.664	03/03/2005	1733	1.438	03/03/2005	1733	.449
03/03/2005	1830	188.639	03/03/2005	1802	1.515	03/03/2005	1802	.484
03/03/2005	1859	188.702	03/03/2005	1830	1.579	03/03/2005	1830	.517
03/03/2005	1927	188.876	03/03/2005	1859	1.631	03/03/2005	1859	.544
03/03/2005	1956	189.082	03/03/2005	1927	1.685	03/03/2005	1927	.568
03/03/2005	2024	189.137	03/03/2005	1956	1.736	03/03/2005	1956	.592
03/03/2005	2053	189.125	03/03/2005	2024	1.785	03/03/2005	2024	.618
03/04/2005	0020	189.406	03/03/2005	2053	1.836	03/03/2005	2053	.644
03/04/2005	0647	189.79	03/04/2005	0020	2.021	03/04/2005	0020	.728
03/04/2005	1314	190.065	03/04/2005	0647	2.257	03/04/2005	0647	.854
03/04/2005	1941	190.371	03/04/2005	1314	2.342	03/04/2005	1314	.89
03/05/2005	0209	190.26	03/04/2005	1941	2.379	03/04/2005	1941	.898
03/05/2005	0836	190.052	03/05/2005	0209	2.48	03/05/2005	0209	.973
03/05/2005	1503	189.588	03/05/2005	0836	2.651	03/05/2005	0836	1.09
03/05/2005	2130	189.533	03/05/2005	1503	2.882	03/05/2005	1503	1.132
03/06/2005	0357	189.783	03/05/2005	2130	2.732	03/05/2005	2130	1.194
03/06/2005	1024	190.054	03/06/2005	0357	2.736	03/06/2005	0357	1.223
03/06/2005	1651	190.21	03/06/2005	1024	2.898	03/06/2005	1024	1.264
03/06/2005	2318	190.439	03/06/2005	1651	3.055	03/06/2005	1651	1.261
03/07/2005	0545	190.719	03/06/2005	2318	2.927	03/06/2005	2318	1.331
03/07/2005	1212	191.063	03/07/2005	0545	2.863	03/07/2005	0545	1.379
03/07/2005	1839	191.092	03/07/2005	1212	3.348	03/07/2005	1212	1.459
03/08/2005	0106	190.863	03/07/2005	1839	3.251	03/07/2005	1839	1.475
03/08/2005	0733	191.115	03/08/2005	0106	3.041	03/08/2005	0106	1.528
03/08/2005	1400	194.437	03/08/2005	0733	3.08	03/08/2005	0733	1.557
03/08/2005	2027	193.894	03/08/2005	1400	3.581	03/08/2005	1400	1.559
03/09/2005	0254	193.643	03/08/2005	2027	3.322	03/08/2005	2027	1.62
03/09/2005	0922	193.764	03/09/2005	0254	3.133	03/09/2005	0254	1.703
03/09/2005	1549	193.863	03/09/2005	0922	3.441	03/09/2005	0922	1.798
03/09/2005	2216	193.752	03/09/2005	1549	3.481	03/09/2005	1549	1.758

Table A. Filtered drawdown data for wells during constant-rate aquifer test at site 1, near Leupp, Arizona—Continued

Well PW-1A (withdrawal well)			Well OW-1 (290 feet from PW-1A)			Well 5T-533 (415 feet from PW-1A)		
Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
03/10/2005	0443	193.7	03/09/2005	2216	3.307	03/09/2005	2216	1.752
03/10/2005	1110	193.899	3/10/2005	0443	3.279	03/10/2005	0443	1.715
03/10/2005	1737	201.627	3/10/2005	1110	3.326	03/10/2005	1110	1.733
03/11/2005	0004	202.811	3/10/2005	1737	3.321	03/10/2005	1737	1.701
03/11/2005	0631	202.829	3/11/2005	0004	3.448	03/11/2005	0004	1.836
03/11/2005	1258	203.103	3/11/2005	0631	3.55	03/11/2005	0631	1.929
03/11/2005	1925	202.999	3/11/2005	1258	3.593	03/11/2005	1258	1.972
03/12/2005	0205	202.917	3/11/2005	1925	3.53	03/11/2005	1925	1.903
03/12/2005	0859	203.048	3/12/2005	0205	3.525	03/12/2005	0205	1.899
03/12/2005	1552	202.837	3/12/2005	0859	3.499	03/12/2005	0859	1.872
03/12/2005	2246	202.789	3/12/2005	1552	3.408	03/12/2005	1552	1.784
03/13/2005	0540	202.8	3/12/2005	2246	3.433	03/12/2005	2246	1.81
03/13/2005	1233	202.924	3/13/2005	0540	3.454	03/13/2005	0540	1.834
03/13/2005	1927	202.957	3/13/2005	1233	3.466	03/13/2005	1233	1.849
03/14/2005	0220	203.029	3/13/2005	1927	3.476	03/13/2005	1927	1.865
03/14/2005	0914	203.187	3/14/2005	0220	3.577	03/14/2005	0220	1.962
03/14/2005	1607	203.175	3/14/2005	0914	3.653	03/14/2005	0914	2.034
03/14/2005	2301	203.165	3/14/2005	1607	3.671	03/14/2005	1607	2.049
03/15/2005	0554	203.074	3/14/2005	2301	3.745	03/14/2005	2301	2.124
03/15/2005	1248	204.208	3/15/2005	0554	3.824	03/15/2005	0554	2.202
03/15/2005	1941	202.975	3/15/2005	1248	3.893	03/15/2005	1248	2.266
03/16/2005	0235	203.022	3/15/2005	1941	3.923	03/15/2005	1941	2.29
03/16/2005	0929	202.974	3/16/2005	0235	3.971	03/16/2005	0235	2.343
03/16/2005	1622	202.923	3/16/2005	0929	4.036	03/16/2005	0929	2.406
03/16/2005	2316	202.917	3/16/2005	1622	3.972	03/16/2005	1622	2.342
03/17/2005	0609	203.001	3/16/2005	2316	3.943	03/16/2005	2316	2.312
03/17/2005	1303	202.884	3/17/2005	0609	3.947	03/17/2005	0609	2.315
03/17/2005	1840	1.967	3/17/2005	1303	3.85	03/17/2005	1303	2.271
03/17/2005	2003	1.624	3/17/2005	1922	3.077	03/17/2005	1922	1.938
03/17/2005	2126	1.456	3/18/2005	0053	2.002	03/18/2005	0053	1.607
03/17/2005	2249	1.375	3/18/2005	0624	1.717	03/18/2005	0624	1.478
03/18/2005	0012	1.29	3/18/2005	1155	1.595	03/18/2005	1155	1.438
03/18/2005	0135	1.194	3/18/2005	1726	1.498	03/18/2005	1726	1.383
03/18/2005	0258	1.131	3/18/2005	2258	1.469	03/18/2005	2258	1.383
03/18/2005	0421	1.065	3/19/2005	0429	1.406	03/19/2005	0429	1.338
03/18/2005	0544	1.025	3/19/2005	1000	1.397	03/19/2005	1000	1.347
03/18/2005	0707	1.006	3/19/2005	1531	1.353	03/19/2005	1531	1.314
03/18/2005	0831	.986	3/19/2005	2102	1.349	03/19/2005	2102	1.325
03/18/2005	0954	.965	3/20/2005	0233	1.295	03/20/2005	0233	1.276
03/18/2005	1117	.945	3/20/2005	0804	1.227	03/20/2005	0804	1.222

Table A. Filtered drawdown data for wells during constant-rate aquifer test at site 1, near Leupp, Arizona—Continued

Well PW-1A (withdrawal well)			Well OW-1 (290 feet from PW-1A)			Well 5T-533 (415 feet from PW-1A)		
Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
03/18/2005	1240	0.911	03/20/2005	1335	1.204	03/20/2005	1335	1.211
03/18/2005	1403	.883	03/20/2005	1906	1.232	03/20/2005	1906	1.238
03/18/2005	1526	.86	03/21/2005	0037	1.272	03/21/2005	0037	1.283
03/18/2005	1649	.84	03/21/2005	0608	1.262	03/21/2005	0608	1.276
03/18/2005	1812	.825	03/21/2005	1139	1.262	03/21/2005	1139	1.283
03/18/2005	1935	.825	03/21/2005	1710	1.214	03/21/2005	1710	1.236
03/19/2005	0717	.744	03/21/2005	2241	1.266	03/21/2005	2241	1.287
03/20/2005	0517	.599	03/22/2005	0412	1.221	03/22/2005	0412	1.243
03/21/2005	0318	.566	03/22/2005	1349	1.113	03/22/2005	1349	1.143
03/22/2005	0118	.508	03/23/2005	0334	.906	03/23/2005	0334	.949
03/22/2005	2318	.229	03/23/2005	1718	.889	03/23/2005	1718	.951
03/23/2005	2119	.191	03/24/2005	0702	1.018	03/24/2005	0702	1.076
03/24/2005	1919	.275	03/24/2005	2047	1.029	03/24/2005	2047	1.091
03/25/2005	1719	.257	03/25/2005	1031	1.024	03/25/2005	1031	1.087
03/26/2005	1520	.379	03/26/2005	0015	1.054	03/26/2005	0015	1.124
03/27/2005	1320	.285	03/26/2005	1359	1.179	03/26/2005	1359	1.248
			03/27/2005	0344	1.229	03/27/2005	0344	1.294
			03/27/2005	1728	1.055	03/27/2005	1728	1.122

Table B. Filtered drawdown data for wells during constant-rate aquifer test at site 2, near Leupp, Arizona

[Constant-rate aquifer test started at 1200 on April 26, 2005. Pumping rate during the test averaged 745 gallons per minute]

Well OW-2A (deep) (402 ft from PW-2B)			Well OW-2A (middle) (402 ft from PW-2B)			Well OW-2A (shallow) (402 ft from PW-2B)		
Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
04/26/2005	1221	0.092	4/26/2005	1221	0.063	4/26/2005	1221	0.041
04/26/2005	1303	.248	4/26/2005	1303	0.245	4/26/2005	1303	.209
04/26/2005	1346	.259	4/26/2005	1346	0.288	4/26/2005	1346	.258
04/26/2005	1428	.266	4/26/2005	1428	0.318	4/26/2005	1428	.292
04/26/2005	1510	.249	4/26/2005	1510	0.339	4/26/2005	1510	.311
04/26/2005	1553	.246	4/26/2005	1553	0.357	4/26/2005	1553	.336
04/26/2005	1635	.247	4/26/2005	1635	0.371	4/26/2005	1635	.354
04/26/2005	1718	.256	4/26/2005	1718	0.389	4/26/2005	1718	.369
04/26/2005	1800	.276	4/26/2005	1800	0.405	4/26/2005	1800	.386
04/26/2005	1842	.304	4/26/2005	1842	0.421	4/26/2005	1842	.402
04/26/2005	2251	.398	4/26/2005	2251	0.435	4/26/2005	2251	.416
04/27/2005	627	.403	4/27/2005	0627	0.42	4/27/2005	627	.402
04/27/2005	1402	.414	4/27/2005	1402	0.421	4/27/2005	1402	.401
04/27/2005	2137	.443	4/27/2005	2137	0.509	4/27/2005	2137	.495
04/28/2005	0513	.444	4/28/2005	0513	0.473	4/28/2005	513	.46
04/28/2005	1248	.474	4/28/2005	1248	0.451	4/28/2005	1248	.436
04/28/2005	2023	.475	4/28/2005	2023	0.553	4/28/2005	2023	.547
04/29/2005	359	.503	4/29/2005	359	0.532	4/29/2005	359	.527
04/29/2005	1134	.546	4/29/2005	1134	0.522	4/29/2005	1134	.516
04/29/2005	1909	.535	4/29/2005	1909	0.601	4/29/2005	1909	.597
04/30/2005	245	.586	4/30/2005	245	0.623	4/30/2005	245	.619
04/30/2005	1020	.582	4/30/2005	1020	0.576	4/30/2005	1020	.572
04/30/2005	1755	.53	4/30/2005	1755	0.554	4/30/2005	1755	.551
05/01/2005	131	.557	5/1/2005	131	0.614	5/1/2005	131	.612
05/01/2005	906	.564	5/1/2005	906	0.573	5/1/2005	906	.571
05/01/2005	2004	.584	5/1/2005	2004	0.614	5/1/2005	2004	.612
05/02/2005	1024	.597	5/2/2005	1024	0.606	5/2/2005	1024	.606
05/03/2005	045	.606	5/3/2005	045	0.636	5/3/2005	045	.636
05/03/2005	1505	.618	5/3/2005	1505	0.63	5/3/2005	1505	.625
05/04/2005	525	.661	5/4/2005	0525	0.693	5/4/2005	525	.693
05/04/2005	1946	.615	5/4/2005	1946	0.649	5/4/2005	1946	.651
05/05/2005	1006	.616	5/5/2005	1006	0.644	5/5/2005	1006	.646
05/06/2005	027	.627	5/6/2005	027	0.643	5/6/2005	027	.644
05/06/2005	1447	.647	5/6/2005	1447	0.667	5/6/2005	1447	.67
05/07/2005	507	.685	5/7/2005	507	0.688	5/7/2005	507	.69
05/07/2005	1928	.661	5/7/2005	1928	0.706	5/7/2005	1928	.711
05/08/2005	948	.684	5/8/2005	0948	0.707	5/8/2005	948	.71
05/09/2005	009	0.69	5/9/2005	0009	0.722	5/9/2005	009	.726

Table B. Filtered drawdown data for wells during constant-rate aquifer test at site 2, near Leupp, Arizona—Continued

Well OW-2A (deep)—Continued (402 ft from PW-2B)			Well OW-2A (middle)—Continued (402 ft from PW-2B)			Well OW-2A (shallow)—Continued (402 ft from PW-2B)		
Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
05/09/2005	1429	0.76	05/09/2005	1429	0.708	05/09/2005	1429	0.712
05/10/2005	0449	.768	05/10/2005	0449	.692	05/10/2005	0449	.698
05/10/2005	1326	.422	05/10/2005	1326	.428	05/10/2005	1326	.47
05/10/2005	1513	.302	05/10/2005	1513	.372	05/10/2005	1513	.4
05/10/2005	1700	.276	05/10/2005	1700	.388	05/10/2005	1700	.41
05/10/2005	1848	.315	05/10/2005	1848	.405	05/10/2005	1848	.428
05/10/2005	2035	.361	05/10/2005	2035	.415	05/10/2005	2035	.44
05/10/2005	2222	.382	05/10/2005	2222	.396	05/10/2005	2222	.414
05/11/2005	0010	.36	05/11/2005	0010	.369	05/11/2005	0010	.383
05/11/2005	0157	.32	05/11/2005	0157	.34	05/11/2005	0157	.356
05/11/2005	0344	.28	05/11/2005	0344	.323	05/11/2005	0344	.339
05/11/2005	0532	.281	05/11/2005	0532	.319	05/11/2005	0532	.328
05/11/2005	1430	.285	05/11/2005	1430	.306	05/11/2005	1430	.319
05/12/2005	0640	.282	05/12/2005	0640	.282	05/12/2005	0640	.29
05/12/2005	2250	.245	05/12/2005	2250	.291	05/12/2005	2250	.3
05/13/2005	1500	.233	05/13/2005	1500	.253	05/13/2005	1500	.261
05/14/2005	2320	.172	05/14/2005	2320	.209	05/14/2005	2320	.217
05/15/2005	1530	.143	05/15/2005	1530	.164	05/15/2005	1530	.171
05/16/2005	0740	.101	05/16/2005	0740	.115	05/16/2005	0740	.122
05/16/2005	2350	.063	05/16/2005	2350	.09	05/16/2005	2350	.098
05/17/2005	1600	.098	05/17/2005	1600	.12	05/17/2005	1600	.127

Well PW-2B (withdrawal well)			Well 5M-94 (251 ft from PW-2B)			Well OW-2 (178 ft from PW-2B)		
Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
04/26/2005	1428	93.703	05/04/2005	0530	.718	04/26/2005	1203	1.767
04/26/2005	1510	93.612	05/06/2005	0014	.718	04/26/2005	1206	2.538
04/26/2005	1553	93.616	05/08/2005	0448	.77	04/26/2005	1209	2.97
04/26/2005	1635	93.6	05/10/2005	1236	.594	04/26/2005	1211	3.256
04/26/2005	1718	93.613	05/10/2005	1247	.556	04/26/2005	1214	3.437
04/26/2005	1800	93.703	05/10/2005	1301	.526	04/26/2005	1217	3.56
04/26/2005	1842	93.782	05/10/2005	1319	.498	04/26/2005	1219	3.688
04/26/2005	2251	94.236	05/10/2005	1343	.481	04/26/2005	1222	3.703
04/27/2005	0627	94.427	05/10/2005	1415	.466	04/26/2005	1224	3.755
04/27/2005	1402	94.057	05/10/2005	1455	.454	04/26/2005	1329	3.934
04/27/2005	2137	94.478	05/10/2005	1548	.451	04/26/2005	1535	4.048
04/28/2005	0513	95.035	05/10/2005	1656	.45	04/26/2005	1741	4.064
04/28/2005	1248	94.805	05/10/2005	1825	.452	04/26/2005	1947	4.071
04/28/2005	2023	93.889	05/10/2005	2021	.456	04/26/2005	2153	4.029

Table B. Filtered drawdown data for wells during constant-rate aquifer test at site 2, near Leupp, Arizona—Continued

Well OW-2 (178 ft from PW-2B)—Continued			Well OW-2 (178 ft from PW-2B)—Continued			Well OW-2 (178 ft from PW-2B)—Continued		
Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
04/26/2005	2359	3.97	05/03/2005	1246	4.081	05/12/2005	0017	.236
04/27/2005	0205	3.952	05/03/2005	2254	4.073	05/12/2005	0502	.283
04/27/2005	0411	4.005	05/04/2005	0902	4.096	05/12/2005	0947	.377
04/27/2005	0617	4.088	05/04/2005	1910	4.108	05/12/2005	1433	.302
04/27/2005	0823	4.127	05/05/2005	0518	4.089	05/12/2005	1918	.29
04/27/2005	1029	4.096	05/05/2005	1526	4.059	05/13/2005	0003	.236
04/27/2005	1236	4.042	05/06/2005	0135	4.073	05/13/2005	0448	.248
04/27/2005	1442	4.013	05/06/2005	1143	4.06	05/13/2005	0933	.359
04/27/2005	1648	4.035	05/06/2005	2151	4.121	05/13/2005	1419	.288
04/27/2005	1854	4.065	05/07/2005	0759	4.11	05/13/2005	1904	.258
04/28/2005	0101	3.991	05/07/2005	1807	4.091	05/13/2005	2349	.198
04/28/2005	1109	4.06	05/08/2005	0415	4.144	05/14/2005	0434	.196
04/28/2005	2117	3.998	05/08/2005	1423	4.099	05/14/2005	0919	.308
04/29/2005	0725	4.021	05/09/2005	0031	4.086	05/14/2005	1531	.237
04/29/2005	1733	4.093	05/09/2005	1039	4.16	05/14/2005	2309	.172
04/30/2005	0341	3.992	05/09/2005	2047	4.116	05/15/2005	0647	.196
04/30/2005	1349	4.1	05/10/2005	0655	4.116	05/15/2005	1424	.199
04/30/2005	2357	4.007	05/10/2005	1946	.378	05/15/2005	2202	.137
05/01/2005	1006	4.121	05/11/2005	0031	.294	05/16/2005	0540	.086
05/01/2005	2014	4.122	05/11/2005	0516	.348	05/16/2005	1318	.137
05/02/2005	0622	4.062	05/11/2005	1001	.407	05/16/2005	2056	.072
05/02/2005	1630	4.051	05/11/2005	1446	.324	05/17/2005	0434	.037
05/03/2005	0238	4.004	05/11/2005	1932	.305			

Table C. Filtered drawdown data for wells during constant-rate aquifer test at site 3, near Leupp, Arizona

[The aquifer test at site 3 included two pumping periods and two recovery periods. The first pumping period extended from 1300 hr on February 26 through March 5, 2005, at rate of about 795 gallons per minute. The second pumping period was between March 11 and March 25, 2005, at a rate of 775 gallons per minute. Recovery was measured between the two pumping periods and after the second pumping period]

Well PW-3 (withdrawal well)			Well OW-3A (deep) (248 feet from PW-3)			Well OW-3A (shallow) (248 feet from PW-3)			Well OW-3C (middle) (474 feet from PW-3)			Well OW-3C (deep) (474 feet from PW-3)		
Date	Time	Draw-down (feet)	Date	Time	Draw-down (feet)	Date	Time	Draw-down (feet)	Date	Time	Draw-down (feet)	Date	Time	Draw-down (feet)
02/26/2005	1443	315.23	02/26/2005	1328	5.775	02/26/2005	1309	0.032	02/26/2005	1309	0.174	02/26/2005	1328	0.91
02/26/2005	1501	316.452	02/26/2005	1346	7.795	02/26/2005	1328	.078	02/26/2005	1328	1.401	02/26/2005	1346	2.699
02/26/2005	1520	317.473	02/26/2005	1405	8.989	02/26/2005	1346	.143	02/26/2005	1346	2.283	02/26/2005	1405	4.58
02/26/2005	1539	318.286	02/26/2005	1424	9.749	02/26/2005	1405	.21	02/26/2005	1405	2.862	02/26/2005	1424	6.145
02/26/2005	1558	318.798	02/26/2005	1443	10.338	02/26/2005	1424	.261	02/26/2005	1424	3.236	02/26/2005	1443	7.717
02/26/2005	1616	319.137	02/26/2005	1501	10.79	02/26/2005	1443	.317	02/26/2005	1443	3.549	02/26/2005	1501	9.173
02/26/2005	1635	319.573	02/26/2005	1520	11.135	02/26/2005	1501	.363	02/26/2005	1501	3.795	02/26/2005	1520	10.461
02/26/2005	1654	319.964	02/26/2005	1539	11.453	02/26/2005	1520	.412	02/26/2005	1520	3.981	02/26/2005	1539	11.791
02/26/2005	1713	320.348	02/26/2005	1558	11.637	02/26/2005	1539	.467	02/26/2005	1539	4.16	02/26/2005	1558	12.608
02/26/2005	1731	320.564	02/26/2005	1616	11.81	02/26/2005	1558	.499	02/26/2005	1558	4.258	02/26/2005	1616	13.432
02/26/2005	1950	321.812	02/26/2005	1635	12.019	02/26/2005	1616	.529	02/26/2005	1616	4.349	02/26/2005	1635	14.53
02/27/2005	0009	322.895	02/26/2005	1654	12.171	02/26/2005	1635	.575	02/26/2005	1635	4.466	02/26/2005	1654	15.346
02/27/2005	0428	323.401	02/26/2005	1713	12.274	02/26/2005	1654	.612	02/26/2005	1654	4.548	02/26/2005	1713	15.888
02/27/2005	0847	323.759	02/26/2005	1731	12.372	02/26/2005	1713	.637	02/26/2005	1713	4.599	02/26/2005	1731	16.426
02/27/2005	1306	323.464	02/26/2005	1950	12.828	02/26/2005	1731	.665	02/26/2005	1731	4.652	02/26/2005	1950	19.707
02/27/2005	1725	323.142	02/27/2005	0009	13.196	02/26/2005	1950	.854	02/26/2005	1950	4.959	02/27/2005	0009	23.776
02/27/2005	2144	323.522	02/27/2005	0428	13.337	02/27/2005	0009	1.113	02/27/2005	0009	5.312	02/27/2005	0428	25.603
02/28/2005	0203	323.733	02/27/2005	0847	13.858	02/27/2005	0428	1.269	02/27/2005	0428	5.41	02/27/2005	0847	26.777
02/28/2005	0621	323.793	02/27/2005	1306	14.04	02/27/2005	0847	1.452	02/27/2005	0847	5.624	02/27/2005	1306	27.6
02/28/2005	1040	323.232	02/27/2005	1725	14.048	02/27/2005	1306	1.539	02/27/2005	1306	5.755	02/27/2005	1725	27.889
02/28/2005	1459	323.896	02/27/2005	2144	14.152	02/27/2005	1725	1.569	02/27/2005	1725	5.762	02/27/2005	2144	28.204
02/28/2005	1918	324.919	02/28/2005	0203	14.225	02/27/2005	2144	1.671	02/27/2005	2144	5.853	02/28/2005	0203	28.49
02/28/2005	2337	325.397	02/28/2005	0621	14.259	02/28/2005	0203	1.734	02/28/2005	0203	5.914	02/28/2005	0621	28.644
03/01/2005	0356	325.74	02/28/2005	1040	14.34	02/28/2005	0621	1.795	02/28/2005	0621	5.951	02/28/2005	1040	28.781
03/01/2005	0815	325.597	02/28/2005	1459	14.271	02/28/2005	1040	1.851	02/28/2005	1040	5.993	02/28/2005	1459	28.855
03/01/2005	1234	325.414	02/28/2005	1918	14.312	02/28/2005	1459	1.791	02/28/2005	1459	5.94	02/28/2005	1918	28.93
03/01/2005	1653	325.111	02/28/2005	2337	14.423	02/28/2005	1918	1.836	02/28/2005	1918	5.967	02/28/2005	2337	29.068
03/01/2005	2112	325.489	03/01/2005	0356	14.464	02/28/2005	2337	1.939	02/28/2005	2337	6.059	03/01/2005	0356	29.179
03/02/2005	0131	325.726	03/01/2005	0815	14.524	03/01/2005	0356	1.969	03/01/2005	0356	6.082	03/01/2005	0815	29.261
03/02/2005	0550	328.026	03/01/2005	1234	14.553	03/01/2005	0815	2.053	03/01/2005	0815	6.142	03/01/2005	1234	29.335
03/02/2005	1009	326.768	03/01/2005	1653	14.516	03/01/2005	1234	2.087	03/01/2005	1234	6.17	03/01/2005	1653	29.336
03/02/2005	1427	325.14	03/01/2005	2112	14.567	03/01/2005	1653	2.071	03/01/2005	1653	6.14	03/01/2005	2112	29.342
03/02/2005	1846	324.683	03/02/2005	0131	14.63	03/01/2005	2112	2.144	03/01/2005	2112	6.192	03/02/2005	0131	29.408
03/02/2005	2305	324.908	03/02/2005	0550	14.738	03/02/2005	0131	2.201	03/02/2005	0131	6.246	03/02/2005	0550	29.523
03/03/2005	0324	325.178	03/02/2005	1009	14.746	03/02/2005	0550	2.25	03/02/2005	0550	6.299	03/02/2005	1009	29.619
03/03/2005	0743	325.268	03/02/2005	1427	14.642	03/02/2005	1009	2.307	03/02/2005	1009	6.333	03/02/2005	1427	29.509
03/03/2005	1202	325.098	03/02/2005	1846	14.633	03/02/2005	1427	2.256	03/02/2005	1427	6.264	03/02/2005	1846	29.467
03/03/2005	1621	324.731	03/02/2005	2305	14.699	03/02/2005	1846	2.282	03/02/2005	1846	6.268	03/02/2005	2305	29.476

Table C. Filtered drawdown data for wells during constant-rate aquifer test at site 3, near Leupp, Arizona—Continued

Well PW-3 (withdrawal well)—Continued			Well OW-3A (deep)—Continued (248 feet from PW-3)			Well OW-3A (shallow)—Continued (248 feet from PW-3)			Well OW-3C (middle)—Continued (474 feet from PW-3)			Well OW-3C (deep)—Continued (474 feet from PW-3)		
Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
03/03/2005	2040	324.705	03/03/2005	0324	14.752	03/02/2005	2305	2.364	03/02/2005	2305	6.332	03/03/2005	324	29.525
03/04/2005	0059	324.975	03/03/2005	0743	14.798	03/03/2005	0324	2.414	03/03/2005	0324	6.375	03/03/2005	0743	29.577
03/04/2005	0518	325.473	03/03/2005	1202	14.854	03/03/2005	0743	2.475	03/03/2005	0743	6.42	03/03/2005	1202	29.644
03/04/2005	0937	325.421	03/03/2005	1621	14.827	03/03/2005	1202	2.541	03/03/2005	1202	6.477	03/03/2005	1621	29.65
03/04/2005	1356	324.852	03/03/2005	2040	14.869	03/03/2005	1621	2.529	03/03/2005	1621	6.456	03/03/2005	2040	29.669
03/04/2005	1815	323.869	03/04/2005	0059	14.912	03/03/2005	2040	2.598	03/03/2005	2040	6.509	03/04/2005	0059	29.673
03/04/2005	2233	324.218	03/04/2005	0518	14.958	03/04/2005	0059	2.646	03/04/2005	0059	6.547	03/04/2005	0518	29.713
03/05/2005	0252	324.846	03/04/2005	0937	15.2	03/04/2005	0518	2.671	03/04/2005	0518	6.574	03/04/2005	0937	29.78
03/05/2005	0711	324.556	03/04/2005	1356	14.915	03/04/2005	0937	2.728	03/04/2005	0937	6.621	03/04/2005	1356	29.715
03/05/2005	1130	325.095	03/04/2005	1815	14.857	03/04/2005	1356	2.668	03/04/2005	1356	6.549	03/04/2005	1815	29.662
03/05/2005	1549	325.034	03/04/2005	2233	14.916	03/04/2005	1815	2.65	03/04/2005	1815	6.514	03/04/2005	2233	29.662
03/06/2005	0807	4.484	03/05/2005	0252	14.963	03/04/2005	2233	2.728	03/04/2005	2233	6.572	03/05/2005	0252	29.663
03/06/2005	1440	3.624	03/05/2005	0711	14.952	03/05/2005	0252	2.778	03/05/2005	0252	6.614	03/05/2005	0711	29.695
03/06/2005	2112	3.018	03/05/2005	1130	15.187	03/05/2005	0711	2.869	03/05/2005	0711	6.693	03/05/2005	1130	29.957
03/07/2005	0345	2.582	03/05/2005	1549	15.264	03/05/2005	1130	2.912	03/05/2005	1130	6.737	03/05/2005	1549	29.947
03/07/2005	1018	2.694	03/05/2005	2008	15.076	03/05/2005	1549	2.887	03/05/2005	1549	6.709	03/05/2005	2008	29.767
03/07/2005	1651	3.02	03/06/2005	0134	5.925	03/05/2005	2008	2.936	03/05/2005	2008	6.748	03/06/2005	0134	19.648
03/07/2005	2324	3.039	03/06/2005	0807	1.857	03/06/2005	0134	2.574	03/06/2005	0134	3.582	03/06/2005	0807	7.077
03/11/2005	0929	170.977	03/06/2005	1440	1.68	03/06/2005	807	2.053	03/06/2005	0807	1.737	03/06/2005	1440	4.006
03/11/2005	0958	301.301	03/06/2005	2112	1.34	03/06/2005	1440	1.817	03/06/2005	1440	1.462	03/06/2005	2112	2.562
03/11/2005	1126	313.822	03/07/2005	0345	1.119	03/06/2005	2112	1.712	03/06/2005	2112	1.364	03/07/2005	0345	1.83
03/11/2005	1155	315.195	03/07/2005	1018	1.263	03/07/2005	0345	1.632	03/07/2005	0345	1.282	03/07/2005	1018	1.72
03/11/2005	1224	315.941	03/07/2005	1651	1.485	03/07/2005	1018	1.61	03/07/2005	1018	1.279	03/07/2005	1651	1.57
03/11/2005	1253	316.446	03/07/2005	2324	1.465	03/07/2005	1651	1.503	03/07/2005	1651	1.186	03/07/2005	2324	1.396
03/11/2005	1322	316.886	03/11/2005	0929	2.426	03/07/2005	2324	1.478	03/07/2005	2324	1.17	03/11/2005	0929	1.008
03/11/2005	1351	317.187	03/11/2005	0958	8.412	03/11/2005	0929	1.268	03/11/2005	0929	1.265	03/11/2005	0958	3.063
03/11/2005	1420	317.539	03/11/2005	1027	10.304	03/11/2005	0958	1.376	03/11/2005	0958	3.043	03/11/2005	1027	5.874
03/11/2005	1450	317.834	03/11/2005	1056	11.331	03/11/2005	1027	1.469	03/11/2005	1027	3.938	03/11/2005	1056	8.369
03/11/2005	1519	317.995	03/11/2005	1126	11.995	03/11/2005	1056	1.552	03/11/2005	1056	4.461	03/11/2005	1126	10.541
03/11/2005	1548	318.237	03/11/2005	1155	12.45	03/11/2005	1126	1.614	03/11/2005	1126	4.806	03/11/2005	1155	12.36
03/11/2005	1617	318.343	03/11/2005	1224	12.787	03/11/2005	1155	1.663	03/11/2005	1155	5.046	03/11/2005	1224	13.975
03/11/2005	2041	321.136	03/11/2005	1253	13.31	03/11/2005	1224	1.711	03/11/2005	1224	5.226	03/11/2005	1253	15.32
03/12/2005	0500	322.591	03/11/2005	1322	13.201	03/11/2005	1253	1.75	03/11/2005	1253	5.358	03/11/2005	1322	16.392
03/12/2005	1318	322.222	03/11/2005	1351	13.344	03/11/2005	1322	1.775	03/11/2005	1322	5.446	03/11/2005	1351	17.456
03/12/2005	2137	322.344	03/11/2005	1420	13.474	03/11/2005	1351	1.792	03/11/2005	1351	5.522	03/11/2005	1420	18.479
03/13/2005	0556	322.341	03/11/2005	1450	13.565	03/11/2005	1420	1.818	03/11/2005	1420	5.591	03/11/2005	1450	19.224
03/13/2005	1414	319.262	03/11/2005	1519	13.651	03/11/2005	1450	1.838	03/11/2005	1450	5.638	03/11/2005	1519	19.945
03/13/2005	2233	316.802	03/11/2005	1548	13.729	03/11/2005	1519	1.863	03/11/2005	1519	5.687	03/11/2005	1548	20.645
03/14/2005	0652	317.254	03/11/2005	1617	13.776	03/11/2005	1548	1.886	03/11/2005	1548	5.731	03/11/2005	1617	21.091
03/14/2005	1510	320.221	03/11/2005	2041	14.24	03/11/2005	1617	1.904	03/11/2005	1617	5.757	03/11/2005	2041	24.247

Table C. Filtered drawdown data for wells during constant-rate aquifer test at site 3, near Leupp, Arizona—Continued

Well PW-3 (withdrawal well)—Continued			Well OW-3A (deep)—Continued (248 feet from PW-3)			Well OW-3A (shallow)—Continued (248 feet from PW-3)			Well OW-3C (middle)—Continued (474 feet from PW-3)			Well OW-3C (deep)—Continued (474 feet from PW-3)		
Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
03/14/2005	2329	310.503	03/12/2005	0500	14.665	03/11/2005	2041	2.102	03/11/2005	2041	6.034	03/12/2005	0500	27.281
03/15/2005	0748	302.015	03/12/2005	1318	14.751	03/12/2005	0500	2.371	03/12/2005	500	6.316	03/12/2005	2137	28.724
03/15/2005	1607	319.225	03/12/2005	2137	14.852	03/12/2005	1318	2.493	03/12/2005	1318	6.393	03/13/2005	0556	29.075
03/16/2005	0025	315.865	03/13/2005	0556	14.979	03/12/2005	2137	2.641	03/12/2005	2137	6.492	03/13/2005	1414	29.173
03/16/2005	0844	316.776	03/13/2005	1414	14.924	03/13/2005	0556	2.81	03/13/2005	0556	6.609	03/13/2005	2233	28.994
03/16/2005	1703	321.442	03/13/2005	2233	14.909	03/13/2005	1414	2.899	03/13/2005	1414	6.63	03/14/2005	0652	29.14
03/17/2005	0121	321.766	03/14/2005	0652	15.38	03/13/2005	2233	3.043	03/13/2005	2233	6.693	03/14/2005	1510	29.387
03/17/2005	0940	321.513	03/14/2005	1510	15.185	03/14/2005	0652	3.157	03/14/2005	0652	6.822	03/14/2005	2329	29.004
03/17/2005	1759	321.372	03/14/2005	2329	14.972	03/14/2005	1510	3.203	03/14/2005	1510	7.116	03/15/2005	0748	28.458
03/18/2005	0217	321.549	03/15/2005	0748	14.622	03/14/2005	2329	3.293	03/14/2005	2329	6.604	03/15/2005	1607	28.969
03/18/2005	1036	321.166	03/15/2005	1607	15.192	03/15/2005	0748	3.353	03/15/2005	0748	6.448	03/16/2005	0025	29.417
03/18/2005	1855	320.981	03/16/2005	0025	15.291	03/15/2005	1607	3.401	03/15/2005	1607	7.315	03/16/2005	0844	29.426
03/19/2005	0314	320.812	03/16/2005	0844	15.358	03/16/2005	0025	3.485	03/16/2005	0025	6.797	03/16/2005	1703	29.714
03/19/2005	1132	319.531	03/16/2005	1703	15.479	03/16/2005	0844	3.561	03/16/2005	0844	6.974	03/17/2005	0121	29.823
03/19/2005	1951	323.599	03/17/2005	0121	15.523	03/16/2005	1703	3.512	03/16/2005	1703	7.676	03/17/2005	0940	29.848
03/20/2005	0410	323.584	03/17/2005	0940	15.499	03/17/2005	0121	3.541	03/17/2005	0121	7.254	03/17/2005	1759	29.816
03/20/2005	1228	320.239	03/17/2005	1759	15.47	03/17/2005	0940	3.546	03/17/2005	0940	7.52	03/18/2005	0217	29.836
03/20/2005	2047	320.276	03/18/2005	0217	15.524	03/17/2005	1759	3.548	03/17/2005	1759	7.684	03/18/2005	1036	29.868
03/21/2005	0506	321.877	03/18/2005	1036	15.557	03/18/2005	0217	3.618	03/18/2005	0217	7.482	03/18/2005	1855	29.894
03/21/2005	1324	321.511	03/18/2005	1855	15.59	03/18/2005	1036	3.686	03/18/2005	1036	7.815	03/19/2005	0314	29.91
03/21/2005	2143	319.731	03/19/2005	0314	15.641	03/18/2005	1855	3.748	03/18/2005	1855	7.821	03/19/2005	1132	29.923
03/22/2005	0602	319.606	03/19/2005	1132	15.631	03/19/2005	0314	3.812	03/19/2005	0314	7.622	03/19/2005	1951	30.05
03/22/2005	1421	319.379	03/19/2005	1951	15.809	03/19/2005	1132	3.871	03/19/2005	1132	7.802	03/20/2005	0410	30.172
03/22/2005	2239	321.942	03/20/2005	0410	15.839	03/19/2005	1951	3.915	03/19/2005	1951	7.814	03/20/2005	1228	30.076
03/23/2005	0658	322.114	03/20/2005	1228	15.735	03/20/2005	0410	3.928	03/20/2005	0410	7.713	03/20/2005	2047	30.021
03/23/2005	1517	321.913	03/20/2005	2047	15.788	03/20/2005	1228	3.943	03/20/2005	1228	8.085	03/21/2005	0506	30.177
03/23/2005	2335	321.897	03/21/2005	0506	15.925	03/20/2005	2047	4.047	03/20/2005	2047	7.823	03/21/2005	1324	30.185
03/24/2005	0754	321.826	03/21/2005	1324	15.914	03/21/2005	0506	4.117	03/21/2005	0506	7.679	03/21/2005	2143	30.181
03/24/2005	1613	321.113	03/21/2005	2143	15.916	03/21/2005	1324	4.139	03/21/2005	1324	8.18	03/22/2005	0602	30.117
03/25/2005	0031	320.888	03/22/2005	0602	15.924	03/21/2005	2143	4.187	03/21/2005	2143	7.856	03/22/2005	1421	30.005
03/25/2005	0850	320.888	03/22/2005	1421	15.808	03/22/2005	0602	4.224	03/22/2005	0602	7.613	03/22/2005	2239	30.07
03/26/2005	2120	4.028	03/22/2005	2239	15.878	03/22/2005	1421	4.145	03/22/2005	1421	8.368	03/23/2005	0658	30.084
03/27/2005	1854	3.739	03/23/2005	0658	15.856	03/22/2005	2239	4.12	03/22/2005	2239	8.047	03/23/2005	1517	30.101
03/28/2005	1627	3.579	03/23/2005	1517	15.883	03/23/2005	0658	4.116	03/23/2005	0658	8.068	03/23/2005	2335	30.24
03/29/2005	1401	3.448	03/23/2005	2335	16.38	03/23/2005	1517	4.175	03/23/2005	1517	7.581	03/24/2005	0754	30.302
03/30/2005	1134	3.34	03/24/2005	0754	16.101	03/23/2005	2335	4.329	03/23/2005	2335	7.495	03/24/2005	1613	30.332
03/31/2005	0908	3.089	03/24/2005	1613	16.92	03/24/2005	0754	4.397	03/24/2005	0754	7.734	03/25/2005	0031	30.298
04/01/2005	0641	3.309	03/25/2005	0031	16.78	03/24/2005	1613	4.42	03/24/2005	1613	7.967	03/25/2005	0850	30.298
04/02/2005	0415	3.39	03/25/2005	0850	16.78	03/25/2005	0031	4.41	03/25/2005	0031	7.943	03/25/2005	2346	24.97
04/03/2005	0149	3.099	03/25/2005	2346	10.984	03/25/2005	0850	4.41	03/25/2005	0850	7.943	03/26/2005	2120	3.329

Table C. Filtered drawdown data for wells during constant-rate aquifer test at site 3, near Leupp, Arizona—Continued

Well PW-3 (withdrawal well)—Continued			Well OW-3A (deep)—Continued (248 feet from PW-3)			Well OW-3A (shallow)—Continued (248 feet from PW-3)			Well OW-3C (middle)—Continued (474 feet from PW-3)			Well OW-3C (deep)—Continued (474 feet from PW-3)		
Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
04/03/2005	2322	3.241	03/26/2005	2120	2.635	03/25/2005	2346	4.241	03/25/2005	2346	6.234	03/27/2005	1854	2.079
04/04/2005	2056	3.075	03/27/2005	1854	2.22	03/26/2005	2120	3.263	03/26/2005	2120	2.487	03/28/2005	1627	1.529
04/05/2005	1829	3.102	03/28/2005	1627	1.855	03/27/2005	1854	2.803	03/27/2005	1854	2.381	03/29/2005	1401	1.451
04/06/2005	1603	2.856	03/29/2005	1401	1.858	03/28/2005	1627	2.412	03/28/2005	1627	1.94	03/30/2005	1134	1.495
04/07/2005	1337	2.51	03/30/2005	1134	1.891	03/29/2005	1401	2.391	03/29/2005	1401	1.834	03/31/2005	0908	1.646
			03/31/2005	0908	2.023	03/30/2005	1134	2.38	03/30/2005	1134	1.865	04/01/2005	0641	1.71
			04/01/2005	0641	2.031	03/31/2005	0908	2.452	03/31/2005	0908	1.986	04/02/2005	0415	1.483
			04/02/2005	0415	1.771	04/01/2005	0641	2.399	04/01/2005	0641	1.976	04/03/2005	0149	1.298
			04/03/2005	0149	1.593	04/02/2005	0415	2.102	04/02/2005	0415	1.71	04/03/2005	2322	1.226
			04/03/2005	2322	1.523	04/03/2005	0149	1.925	04/03/2005	0149	1.538	04/04/2005	2056	1.255
			04/04/2005	2056	1.562	04/03/2005	2322	1.845	04/03/2005	2322	1.471	04/05/2005	1829	1.505
			04/05/2005	1829	1.765	04/04/2005	2056	1.894	04/04/2005	2056	1.515	04/06/2005	1603	1.49
			04/06/2005	1603	1.69	04/05/2005	1829	2.045	04/05/2005	1829	1.708	04/07/2005	1337	1.268
			04/07/2005	1337	1.466	04/06/2005	1603	1.925	04/06/2005	1603	1.623			
						04/07/2005	1337	1.697	04/07/2005	1337	1.396			

Table C. Filtered drawdown data for wells during constant-rate aquifer test at site 3, near Leupp, Arizona—Continued

Well OW-3C (shallow) (474 feet from PW-3)											
Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
02/26/2005	1309	0.047	03/02/2005	1009	1.627	03/11/2005	1253	1.469	03/21/2005	0506	3.302
02/26/2005	1328	.073	03/02/2005	1427	1.566	03/11/2005	1322	1.474	03/21/2005	1324	3.321
02/26/2005	1346	.094	03/02/2005	1846	1.584	03/11/2005	1351	1.474	03/21/2005	2143	3.374
02/26/2005	1405	.123	03/02/2005	2305	1.659	03/11/2005	1420	1.479	03/22/2005	0602	3.404
02/26/2005	1424	.144	03/03/2005	0324	1.708	03/11/2005	1450	1.484	03/22/2005	1421	3.315
02/26/2005	1443	.172	03/03/2005	0743	1.766	03/11/2005	1519	1.493	03/22/2005	2239	3.279
02/26/2005	1501	.195	03/03/2005	1202	1.831	03/11/2005	1548	1.502	03/23/2005	0658	3.266
02/26/2005	1520	.217	03/03/2005	1621	1.812	03/11/2005	1617	1.509	03/23/2005	1517	3.318
02/26/2005	1539	.248	03/03/2005	2040	1.873	03/11/2005	2041	1.63	03/23/2005	2335	3.485
02/26/2005	1558	.266	03/04/2005	0059	1.923	03/12/2005	0500	1.807	03/24/2005	0754	3.557
02/26/2005	1616	.284	03/04/2005	0518	1.946	03/12/2005	1318	1.89	03/24/2005	1613	3.578
02/26/2005	1635	.308	03/04/2005	0937	1.998	03/12/2005	2137	2.017	03/25/2005	0031	3.58
02/26/2005	1654	.33	03/04/2005	1356	1.928	03/13/2005	0556	2.15	03/25/2005	0850	3.58
02/26/2005	1713	.344	03/04/2005	1815	1.904	03/13/2005	1414	2.2	03/25/2005	2346	3.551
02/26/2005	1731	.361	03/04/2005	2233	1.974	03/13/2005	2233	2.32	03/26/2005	2120	3.059
02/26/2005	1950	.492	03/05/2005	0252	2.023	03/14/2005	0652	2.423	03/27/2005	1854	2.667
02/27/2005	0009	.679	03/05/2005	0711	2.116	03/14/2005	1510	2.468	03/28/2005	1627	2.298
02/27/2005	0428	.806	03/05/2005	1130	2.158	03/14/2005	2329	2.557	03/29/2005	1401	2.316
02/27/2005	0847	.972	03/05/2005	1549	2.13	03/15/2005	0748	2.625	03/30/2005	1134	2.347
02/27/2005	1306	1.038	03/05/2005	2008	2.175	03/15/2005	1607	2.668	03/31/2005	0908	2.462
02/27/2005	1725	1.05	03/06/2005	0134	2.049	03/16/2005	0025	2.748	04/01/2005	0641	2.426
02/27/2005	2144	1.14	03/06/2005	0807	1.79	03/16/2005	0844	2.817	04/02/2005	0415	2.103
02/28/2005	0203	1.184	03/06/2005	1440	1.632	03/16/2005	1703	2.751	04/03/2005	0149	1.925
02/28/2005	0621	1.233	03/06/2005	2112	1.567	03/17/2005	0121	2.767	04/03/2005	2322	1.865
02/28/2005	1040	1.277	03/07/2005	0345	1.519	03/17/2005	0940	2.749	04/04/2005	2056	1.928
02/28/2005	1459	1.202	03/07/2005	1018	1.522	03/17/2005	1759	2.746	04/05/2005	1829	2.123
02/28/2005	1918	1.231	03/07/2005	1651	1.429	03/18/2005	0217	2.815	04/06/2005	1603	2
02/28/2005	2337	1.32	03/07/2005	2324	1.415	03/18/2005	1036	2.879	04/07/2005	1337	1.754
03/01/2005	0356	1.339	03/11/2005	0929	1.256	03/18/2005	1855	2.939			
03/01/2005	0815	1.417	03/11/2005	0958	1.319	03/19/2005	0314	3.01			
03/01/2005	1234	1.441	03/11/2005	1027	1.356	03/19/2005	1132	3.067			
03/01/2005	1653	1.416	03/11/2005	1056	1.392	03/19/2005	1951	3.105			
03/01/2005	2112	1.478	03/11/2005	1126	1.415	03/20/2005	0410	3.111			
03/02/2005	0131	1.532	03/11/2005	1155	1.436	03/20/2005	1228	3.125			
03/02/2005	0550	1.572	03/11/2005	1224	1.454	03/20/2005	2047	3.23			

Table C. Filtered drawdown data for wells during constant-rate aquifer test at site 3, near Leupp, Arizona—Continued

Well 5M-88 —Continued
(547 ft from PW3)

Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)	Date	Time	Drawdown (feet)
02/26/2005	1328	0.009	03/04/2005	09:37	2.319	03/16/2005	0844	2.936
02/26/2005	1346	.027	03/04/2005	1356	2.283	03/16/2005	1703	3.379
02/26/2005	1405	.047	03/04/2005	1815	2.284	03/17/2005	0121	3.05
02/26/2005	1424	.067	03/04/2005	2233	2.35	03/17/2005	0940	3.356
02/26/2005	1443	.095	03/05/2005	0252	2.394	03/17/2005	1759	3.304
02/26/2005	1501	.121	03/05/2005	0711	2.469	03/18/2005	0217	3.143
02/26/2005	1520	.147	03/05/2005	1130	2.51	03/18/2005	1036	3.484
02/26/2005	1539	.185	03/05/2005	1549	2.502	03/18/2005	1855	3.361
02/26/2005	1558	.208	03/05/2005	2008	2.549	03/19/2005	0314	3.286
02/26/2005	1616	.231	03/06/2005	0134	2.408	03/19/2005	1132	3.532
02/26/2005	1635	.264	03/06/2005	0807	2.054	03/19/2005	1951	3.539
02/26/2005	1654	.29	03/06/2005	1440	1.834	03/20/2005	0410	3.56
02/26/2005	1713	.311	03/06/2005	2112	1.724	03/20/2005	1228	3.739
02/26/2005	1731	.333	03/07/2005	0345	1.64	03/20/2005	2047	3.601
02/26/2005	1950	.5	03/07/2005	1018	1.605	03/21/2005	0506	3.731
02/27/2005	0009	.718	03/07/2005	1651	1.507	03/21/2005	1324	3.787
02/27/2005	0428	.84	03/07/2005	2324	1.487	03/21/2005	2143	3.838
02/27/2005	0847	.992	03/11/2005	0929	1.254	03/22/2005	0602	3.877
02/27/2005	1306	1.061	03/11/2005	0958	1.274	03/22/2005	1421	3.869
02/27/2005	1725	1.099	03/11/2005	1027	1.302	03/22/2005	2239	3.805
02/27/2005	2144	1.2	03/11/2005	1056	1.329	03/23/2005	0658	3.817
02/28/2005	0203	1.262	03/11/2005	1126	1.354	03/23/2005	1517	3.845
02/28/2005	0621	1.328	03/11/2005	1155	1.376	03/23/2005	2335	3.98
02/28/2005	1040	1.382	03/11/2005	1224	1.401	03/24/2005	0754	4.042
02/28/2005	1459	1.351	03/11/2005	1253	1.421	03/24/2005	1613	4.063
02/28/2005	1918	1.407	03/11/2005	1322	1.433	03/25/2005	0031	4.054
02/28/2005	2337	1.5	03/11/2005	1351	1.446	03/25/2005	0850	4.054
03/01/2005	0356	1.536	03/11/2005	1420	1.463	03/25/2005	2346	4.054
03/01/2005	0815	1.615	03/11/2005	1450	1.478	03/26/2005	2120	3.295
03/01/2005	1234	1.649	03/11/2005	1519	1.497	03/27/2005	1854	2.876
03/01/2005	1653	1.654	03/11/2005	1548	1.517	03/28/2005	1627	2.511
03/01/2005	2112	1.726	03/11/2005	1617	1.533	03/29/2005	1401	2.441
03/02/2005	0131	1.78	03/11/2005	2041	1.724	03/30/2005	1134	2.408
03/02/2005	0550	1.829	03/12/2005	0500	2.002	03/31/2005	0908	2.462
03/02/2005	1009	1.881	03/12/2005	1318	2.142	04/01/2005	0641	2.421
03/02/2005	1427	1.852	03/12/2005	2137	2.296	04/02/2005	0415	2.174
03/02/2005	1846	1.892	03/13/2005	0556	2.456	04/03/2005	0149	2.005
03/02/2005	2305	1.963	03/13/2005	1414	2.556	04/03/2005	2322	1.92
03/03/2005	0324	2.008	03/13/2005	2233	2.697	04/04/2005	2056	1.941
03/03/2005	0743	2.066	03/14/2005	0652	2.698	04/05/2005	1829	2.066
03/03/2005	1202	2.125	03/14/2005	1510	2.781	04/06/2005	1603	1.968
03/03/2005	1621	2.131	03/14/2005	2329	2.363	04/07/2005	1337	1.776
03/03/2005	2040	2.192	03/15/2005	0748	2.459			
03/04/2005	0059	2.236	03/15/2005	1607	3.073			
03/04/2005	0518	2.268	03/16/2005	0025	2.587			

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