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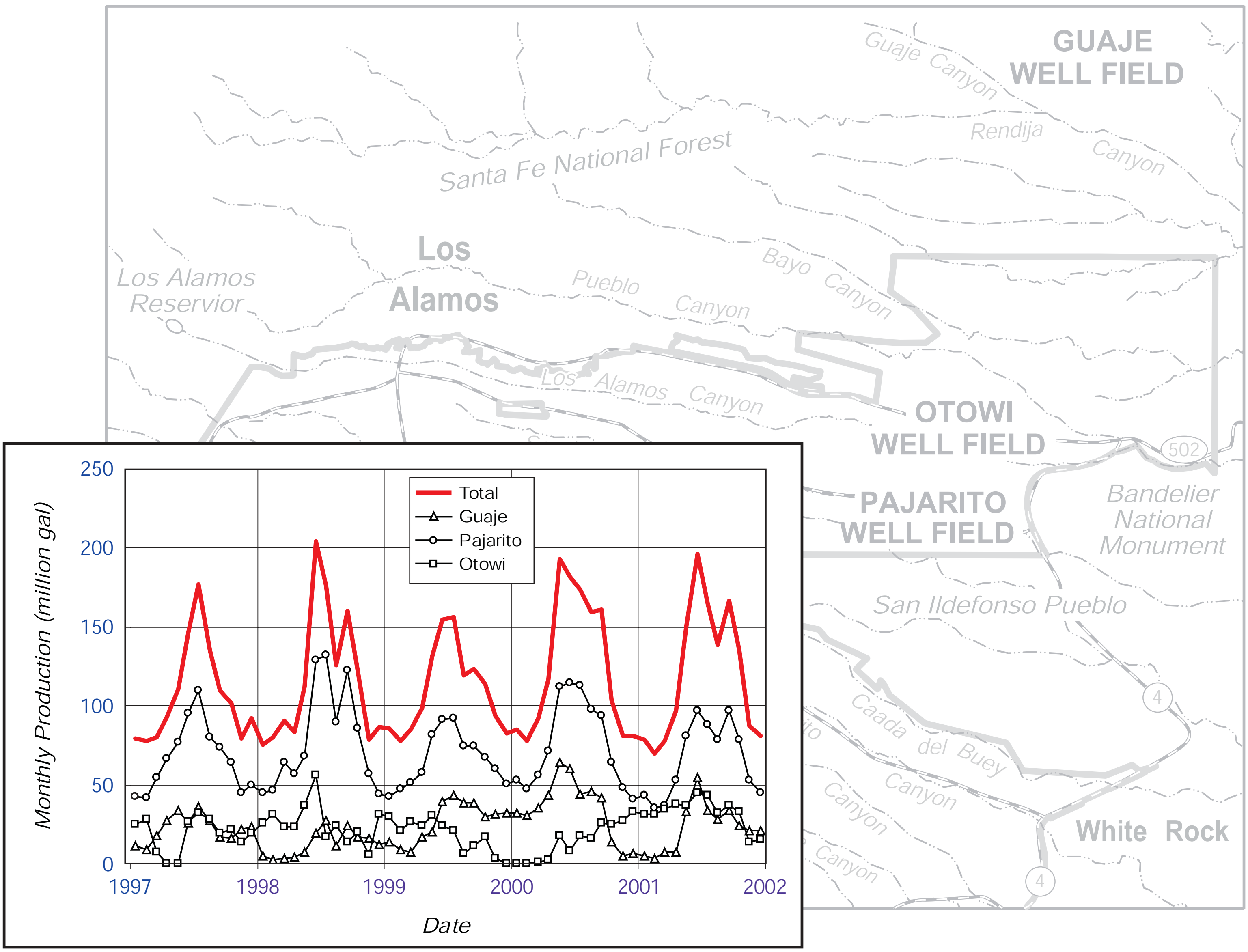
Water Supply at Los Alamos 1998–2001



Los Alamos
NATIONAL LABORATORY

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The chart on the cover shows the monthly groundwater production from each of the well fields at Los Alamos from 1997 through 2001 (Figure 4 of this report). The map (Figure 1 of this report) shows the locations of well fields at Los Alamos.

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Water Supply at Los Alamos, 1998-2001

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Los Alamos
NATIONAL LABORATORY

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WATER SUPPLY AT LOS ALAMOS, 1998 – 2001

by

Richard J. Koch and David B. Rogers

EXECUTIVE SUMMARY

For the period 1998 through 2001, the total water used at Los Alamos from all sources ranged from 1325 million gallons (Mg) in 1999 to 1515 Mg in 2000. Groundwater production ranged from 1323 Mg in 1999 to 1506 Mg in 2000 from the Guaje, Pajarito, and Otowi fields. Nonpotable surface water used from Los Alamos reservoir ranged from zero gallons in 2001 to 9.3 Mg in 2000. For years 1998 through 2001, over 99% of all water used at Los Alamos was groundwater.

Water use by Los Alamos National Laboratory (LANL) between 1998 and 2001 ranged from 379 Mg in 2000 to 461 Mg in 1998. The LANL water use in 2001 was 393 Mg or 27% of the total water use at Los Alamos. Water use by Los Alamos County ranged from 872 Mg in 1999 to 1137 Mg in 2000, and averaged 1006 Mg/yr.

Four new replacement wells in the Guaje field (G-2A, G-3A, G-4A, and G-5A) were drilled in 1998 and began production in 1999; with existing well G-1A, the Guaje field currently has five producing wells. Five of the old Guaje wells (G-1, G-2, G-4, G-5, and G-6) were plugged and abandoned in 1999, and one well (G-3) was abandoned but remains as an observation well for the Guaje field.

The long-term water level observations in production and observation (test) wells at Los Alamos are consistent with the formation of a cone of depression in response to water production. The water level decline is gradual and at most has been about 0.7 to 2 ft per year for production wells and from 0.4 to 0.9 ft/yr for observation (test) wells. The largest water level declines have been in the Guaje field where nonpumping water levels were about 91 ft lower in 2001 than in 1951. The initial water levels of the Guaje replacement wells were 32 to 57 ft lower than the initial water levels of adjacent original Guaje wells. When production wells are taken off-line for pump replacement or repair, water levels have returned to within about 25 ft of initial static levels within 6 to 12 months. Thus, the water-level trends suggest no adverse impacts by production on long-term water supply sustainability at Los Alamos.

1.0 INTRODUCTION

This report summarizes production data and aquifer conditions for water production and monitor wells in the Los Alamos, New Mexico, and Los Alamos National Laboratory (LANL) area (Figure 1). Water production wells are grouped within the Guaje, Pajarito, and Otowi fields, the locations of which are shown on Figure 1. Wells from these fields supply all the potable water used for municipal and most industrial purposes in Los Alamos County (LAC), at LANL, and at Bandelier National Monument.

This report has three primary objectives:

(1) Provide a continuing historical record of metered well production and overall water usage;

(2) Provide data to the Department of Energy (DOE) and LANL management, and Los Alamos County planners for operation of the water supply system and for long-range water resource planning; and

(3) Provide water-level data from regional aquifer production wells, test wells, and monitoring wells.

1.1 Transfer of the Water Supply System and Water Rights at Los Alamos

In September 1998, the DOE leased the Los Alamos water supply system to LAC and in September 2001 the ownership of the water supply system was officially conveyed to Los Alamos County. The water rights owned by DOE from all permitted sources (surface water and groundwater) in 1998 were 5541.3 acre-feet (ac-ft) per year or about 1805.6 million gallons per year (Mg/yr). In September 1998, these water rights were leased to Los Alamos County. In September 2001, 70% of the water rights (3878.91 ac-ft) were conveyed to Los Alamos County and 30% of the water rights (1662.39 ac-ft) were leased to Los Alamos County. DOE retained ownership of 30% of the water rights; this amount of water has been established as a maximum “target quantity” for water use by LANL (Beers et al. 2001). Transfer of ownership of the water supply system and water rights was completed on September 05, 2001.

Prior to September 1998, Johnson Controls Northern New Mexico (JCNNM), the support contractor to LANL and DOE at Los Alamos, maintained and operated the water supply system. At that time, DOE sold water to Los Alamos County for the communities of Los Alamos and White Rock and to the National Park Service for water supply at Bandelier National Monument. After September 8, 1998, the Los Alamos County Utilities Department assumed operation and maintenance of the water supply system, and LANL now purchases water from Los Alamos County. Water meters were installed at all delivery points to LANL, and water now provided to LANL is metered for documentation and billing purposes.

Since 1998, water production records and water-level data for the water supply wells have been collected and maintained by Los Alamos County personnel. These records were provided to personnel of the LANL Water Quality and Hydrology group (RRES-WQH) for compilation into this report. Personnel of the WQH group collect water-level data from test and observation wells. Therefore, this report incorporates contributions of the LANL WQH group and the LAC Utilities Department.

1.2 Guaje Replacement Wells and Abandonment of Old Guaje Wells

The original Guaje wells, G-1, G-2, G-3, G-4, and G-5, were constructed in 1950 and 1951. Well G-1A was added in 1954 and well G-6 was added in 1964 to supplement the original Guaje wells. Production from the well field declined during the early 1990s and the generally deteriorated condition of the original Guaje wells and a desire to improve production efficiency of the field prompted the decision to construct four new replacement wells and permanently abandon six of the seven existing Guaje wells, leaving only original Guaje well G-1A in production.

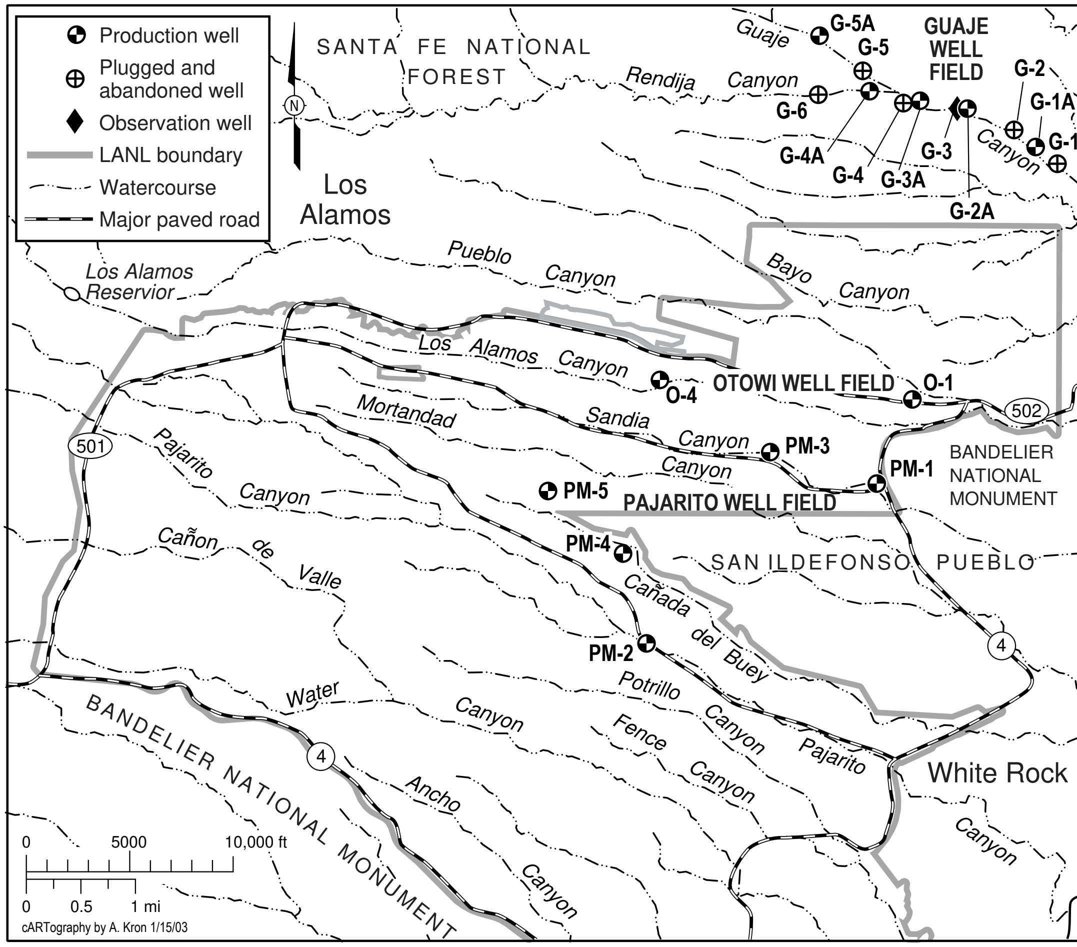

Figure 1. Location of water supply wells at Los Alamos

Four Guaje replacement wells, G-2A, G-3A, G-4A, and G-5A, were constructed between November 1997 and July 1998 but were not fully equipped and ready for service until June through September of 1999 (Shomaker & Associates 1999; Watson and Rappuhn 1999). When originally drilled, the replacement wells were named GR-1, GR-2, GR-3, and GR-4, but these wells were later renamed G-5A, G-2A, G-3A, and G-4A, respectively. The locations of the replacement wells are shown in Figure 1.

Wells G-1, G-2, G-4, G-5, and G-6 were abandoned and plugged between July and September 1999; well G-3 was abandoned (the pump and associated piping and facilities were removed) but remains as an observation well for the well field (Watson and Rappuhn 1999). Table 1 shows the dates of completion and first production of the replacement wells and the dates of last production from the abandoned wells.

1.3 Brief Description of the Regional Aquifer and the Los Alamos Water Supply System

The Guaje, Pajarito, and Otowi fields are located in the mesas and canyons of the Pajarito Plateau (Figure 1). The supply wells are all completed within the regional aquifer, located beneath the Pajarito Plateau, the only local aquifer capable of municipal and industrial water supply in the Los Alamos area. The piezometric surface of the regional aquifer ranges in depth from about 20 ft above ground level (artesian water conditions) in portions of lower Los Alamos Canyon near the confluence with Guaje Canyon, to about 750 ft below ground surface along the eastern edge of LANL property near PM-1, to more than 1230 ft below ground surface near the center of the Pajarito Plateau at well PM-5. Water in the regional aquifer generally moves eastward to southeastward beneath the plateau toward the Rio Grande, where at least a portion of the water is discharged into the river through seeps and springs (e.g., Purtymun 1984; Purtymun and Stoker 1988; Purtymun 1995; Nylander et al., 2001). Most of these seeps and springs are located adjacent to the western side of the Rio Grande between Otowi Bridge and Frijoles Canyon above Cochiti reservoir.

Potable groundwater is pumped from the wells into the distribution system. Booster pumps lift the water to terminal storage for distribution to LANL and the community. The entire water supply is disinfected with mixed-oxidant (MIOX) solution before it is distributed to Los Alamos, White Rock, Bandelier National Monument, and LANL areas. The potable water storage tanks at Los Alamos have a combined terminal storage of 35–40 million gallons (Mg). Under drought-like conditions, daily water production alone may not be sufficient to meet water demands, and the county relies upon the terminal storage supply to make up the difference (Beers et al. 2001). The firm rated capacity is the maximum amount of water that can be pumped immediately to meet peak demand. The firm rated capacity of the Los Alamos water production system is 7797 gallons per minute (gpm) or 11.22 Mg per day (Mgpd) (Beers et al. 2001).

The LAC Utilities Department (and before September 1998, JCNNM) maintains a record of the operation of each well along with records of daily and monthly water production using in-line flow meters at each well. Monthly averages of nonpumping and pumping water levels are computed from available daily air-line bubble-pressure measurements or pressure transducer data recorded at each well. These data are used to determine individual well pumping rates, drawdown, and other important well field performance information. The annual pumping and production information for all active water supply wells is tabulated in Appendix B. The production characteristics of each well and well field are summarized in Appendix C, and annual production characteristics for each well are tabulated in Appendix D.

Summary information about the wells, including location, depth, surface elevation, date of first (or last, if applicable) production, and initial water depth, is listed in Table 1. All wells are electric except well PM-4. The electric wells are usually operated at night or during the weekend, which are off-peak demand times for electricity. The electric-powered wells pump water as needed to generate an adequate supply for use by LANL and Los Alamos County and for storage. Well PM-4 is powered by a natural gas motor that is typically started in late spring and that operates 24 hours per day during the summer, except for periods when the well is shut down temporarily for maintenance and repairs.

Surface water has historically been collected from reservoirs in Guaje and Los Alamos Canyons, and from the Water Canyon spring gallery (e.g., McLin et al. 1998). However, surface water has not been used from Guaje reservoir since 1991 or from the Water Canyon gallery since 1995. Surface water from Los Alamos reservoir has been used to irrigate public parks and athletic fields in Los Alamos. Water use from Los Alamos reservoir was curtailed in 2000 after the Cerro Grande fire, when floodwaters filled the reservoir with ash and sediment and disabled the water collection system.

Table 1
Water Supply Wells at Los Alamos

Well Name	Status	Date Completed	Total Depth (Ft)	Depth Completed (Ft)	Date First Production	Date Last Production	Date Abandoned	X-Coord (Ft)	Y-Coord (Ft)	Surface Elev (Ft)	Initial Depth to Water (Ft)	Pump Depth (Ft)
G-1	Plugged and Abandoned	Jul-50	2023	2000	Mar-51	May-99	Sep-99	1,656,191	1,783,609	5973	192	NA
G-2	Plugged and Abandoned	Aug-51	2015	1980	Jun-51	Jul-99	Sep-99	1,654,211	1,785,123	6056	259	NA
G-3	Observation Well	Jul-51	2005	1800	Aug-51	Jul-86	NA	1,651,676	1,786,218	6139	280	NA
G-4	Plugged and Abandoned	May-51	2011	1940	Oct-51	Jan-98	Sep-99	1,648,949	1,786,452	6229	347	NA
G-5	Plugged and Abandoned	May-51	2004	1850	Nov-51	Nov-98	Sep-99	1,646,950	1,787,907	6306	411	NA
G-6	Plugged and Abandoned	Mar-64	2005	1530	Jun-64	Jun-99	Sep-99	1,644,825	1,786,851	6422	572	NA
G-1A	Production Well	Oct-54	2071	1519	Dec-54	NA	NA	1,655,241	1,784,353	6014	250	496
G-2A	Production Well	Mar-98	2000	1980	Jun-99	NA	NA	1,651,974	1,786,166	6140	318	540
G-3A	Production Well	May-98	2000	1980	Aug-99	NA	NA	1,649,662	1,786,585	6212	408	560
G-4A	Production Well	Apr-98	2000	1980	Jun-99	NA	NA	1,647,318	1,787,113	6299	452	630
G-5A	Production Well	Jun-98	2000	1980	Sep-99	NA	NA	1,644,877	1,789,636	6414	551	740
O-1	Production Well	Aug-90	2609	2497	Apr-98	NA	NA	1,649,396	1,772,232	6396	673	877
O-4	Production Well	Mar-90	2806	2595	Feb-93	NA	NA	1,637,337	1,772,995	6627	780	928
PM-1	Production Well	Feb-65	2501	2499	Jun-65	NA	NA	1,647,734	1,768,112	6520	722	901
PM-2	Production Well	Jul-65	2600	2300	Dec-66	NA	NA	1,636,698	1,760,406	6715	823	950
PM-3	Production Well	Nov-66	2552	2552	Feb-68	NA	NA	1,642,590	1,769,530	6610	740	830
PM-4	Production Well	Aug-81	2920	2874	Aug-82	NA	NA	1,635,623	1,764,740	6920	1060	1210
PM-5	Production Well	Sep-82	3110	3092	Jun-85	NA	NA	1,632,110	1,767,790	7095	1208	1384

Note: NA = Not Applicable. Completion dates from Shomaker & Associates (1999) and abandonment dates from Watson and Rappuhn (1999). Coordinate data from the RRES-WQH Group water-quality database (WQDB). The coordinate system is NM State Plane, North American Datum of 1983 (NAD-83).

1.4 Historical Water Supply Information

A summary hydrologic report for the Pajarito Plateau covered well production for the years from 1947 to 1971 (Purtymun and Herceg 1972). Since then, 27 annual reports containing the results of past water supply studies (these reports are listed in Appendix A) have been published for the years 1972 through 1997. An additional report summarized the hydrology of the regional aquifer and made recommendations for future development of groundwater supplies (Purtymun 1984). A 1988 report examining the status of wells and future water supply (Purtymun and Stoker 1988) and a 1995 report describing individual drilling logs from water supply and test wells (Purtymun 1995) were also published.

Annual historical water production data and aquifer characteristics data for the Los Alamos, Guaje, Pajarito, and Otowi fields are provided in Appendix C. Historical water production and aquifer characteristics data for the former Los Alamos well field was previously reported (McLin et al. 1997a); because production from the Los Alamos well field ceased in 1992, detailed information about this well field is not included in this report. Water-quality data for the regional aquifer are reported in the annual environmental surveillance reports (e.g., ESP 1999, ESP 2000, ESP 2001, ESP 2002). Water-quality data determining compliance of the water supply system with the Safe Drinking Water Act are collected and reported by LAC.

2.0 WATER USE SUMMARY

2.1 Water Use 1998 – 2001

For the period 1998 through 2001, the water used each year at Los Alamos is summarized in Table 2. Total water use from all sources (surface water and groundwater) at Los Alamos ranged from 1324.8 Mg in 1999 to 1515.4 Mg in 2000, with an average annual use of 1417 Mg.

Groundwater production during this period ranged from 1322.8 Mg in 1999 to 1506.1 Mg in 2000; the average annual groundwater production was 1417.0 Mg (see Section 2.4). The use of nonpotable surface water from Los Alamos reservoir ranged from zero in 2001 to 9.3 Mg in 2000, which represented 0.6% of the total water used at Los Alamos (See Section 2.6). For years 1998 through 2001, over 99% of all water used at Los Alamos was groundwater.

Table 2
Summary of Water Production at Los Alamos 1998–2001

Year	Potable Groundwater (10^6 gal.)	Los Alamos Reservoir (10^6 gal.)	Total Water Use (10^6 gal.)	Total Use Change from Previous Year (10^6 gal.)	Total Use as % of Water Rights
1998	1395.9	1.6	1397.5	109.2	77%
1999	1322.8	2.0	1324.8	-72.6	73%
2000	1506.1	9.3	1515.4	190.6	83%
2001	1443.4	0.0	1443.4	-72.1	79%
Average	1417.0	3.2	1420.3	—	78%

The total water use at Los Alamos, as a percent of the water rights (5541.3 ac-ft/yr or 1805.6 Mg/yr), from 1998 through 2001 is also shown in Table 2. The percent of the water right used ranged from 73% in 1999 to 83% in 2000, with an average of 78%.

2.2 Historical Water Use at Los Alamos

The total annual water use at Los Alamos from all sources (surface water and groundwater) is tabulated in Appendix Table B-1 and is shown in Figure 2. The years of highest annual water use were 1976, when 1736 Mg was used, representing 96% of the water rights, and in 1989 when 1717 Mg were used, representing 95% of the water rights. Since 1990, water use at Los Alamos has been less than 1600 Mg per year and use of the water rights has been less than 90%. Also shown in Figure 2 is the amount of surface water used annually. Since 1990, surface water use has been minimal, representing less than 1% of the total water use; most water used at Los Alamos comes from groundwater (see Section 2.4).

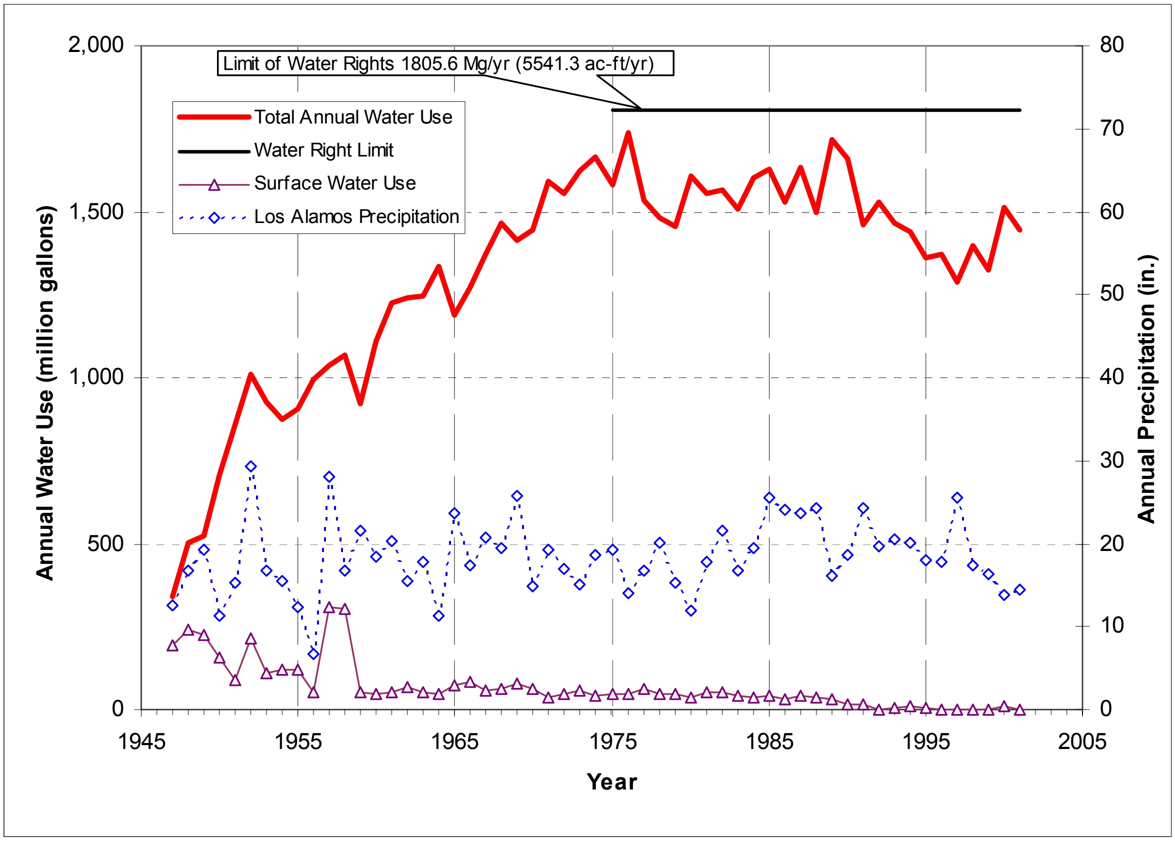

Figure 2. Total water use and surface water use from 1947 to 2001, with annual precipitation at Los Alamos

Some of the variation in annual water use at Los Alamos results from water use for landscape irrigation, the amount of which is partially governed by annual precipitation. The annual precipitation at Los Alamos (LANL 2002) is shown in Figure 2. In general, since about 1975, the change in annual total water use has generally been inversely related to the annual change in the precipitation at Los Alamos (R^2 = 0.3); that is, water use tends to be less during wet years and more during dry years (see Figure 2). The historical water-use pattern is shaped by other more critical water-use factors, such as population growth (1947 through 1975) (e.g., Purtymun and Herceg 1976), LANL water conservation measures (1990 through present) (Glasco 2002), etc.

2.3 LANL and Los Alamos County Water Consumption

The annual water use by LANL (calendar year and fiscal year) and by Los Alamos County from 1998 through 2001 is shown in Table 3. Previous water supply reports estimated LANL water consumption to be 30% of the total water production (McLin et al. 1998). Since the water supply system was transferred to LAC in September 1998, metered records are available to document LANL water consumption for part of 1998 and from 1999 through 2001. LANL water use varied from 379 Mg in 2000 (25% of total water use) to 461 Mg (33%) in 1998. The average LANL water consumption from 1998 through 2001 was approximately 422 Mg per calendar year. All water used by LANL since 1995, when the Water Canyon gallery was last used, is groundwater.

Los Alamos County water use (from all sources) ranged from 872 Mg in 1998 to 1139 Mg in 2000, for an average consumption (1998 through 2001) of 999 Mg per year.

Table 3
LANL and Los Alamos County Annual Water Consumption, 1998-2001

Year	Total Annual Water Use (Mg/yr)	LANL Water Use Calendar Year (Mg/yr)	LANL Water Use Fiscal Year (Mg/yr)	Los Alamos County Water Use (Mg/yr)
1998	1397	461	469	936
1999	1325	453	447	872
2000	1515	379	415	1137
2001	1443	393	371	1050

2.4 Groundwater Production

2.4.1 Historical Groundwater Production

The annual groundwater production from each well field at Los Alamos from 1947 through 2001 is shown in Figure 3 and the data are tabulated in Appendix Table B-1. Since 1968, most groundwater production has come from the Pajarito field. Production from the Otowi field began in 1993, which coincided with a decrease in production from the Guaje field.

2.4.2 Groundwater Production 1998 - 2001

The monthly groundwater production from each well field from 1997 through 2001 is shown in Figure 4. The bulk of the groundwater production was from the five wells in the Pajarito field, which produced 54% of the groundwater in 2001, and up to 68% of the groundwater in 1998. The Guaje field (5 wells) and the Otowi field (2 wells) each contribute about equal amounts of the remaining production. Production from the Guaje field ranged from 11% of the total in 1998 to 28% of the total in 2000, while production from the Otowi field ranged from 11% of the total in 2000 to 27% of the total production in 2001. The production from each field varies each year because of routine cyclical pumping operations and occasional shutdowns for pump maintenance and repair. The production characteristics of each well and field for the period 1997 through 2001 are summarized in Appendix Table C-1.

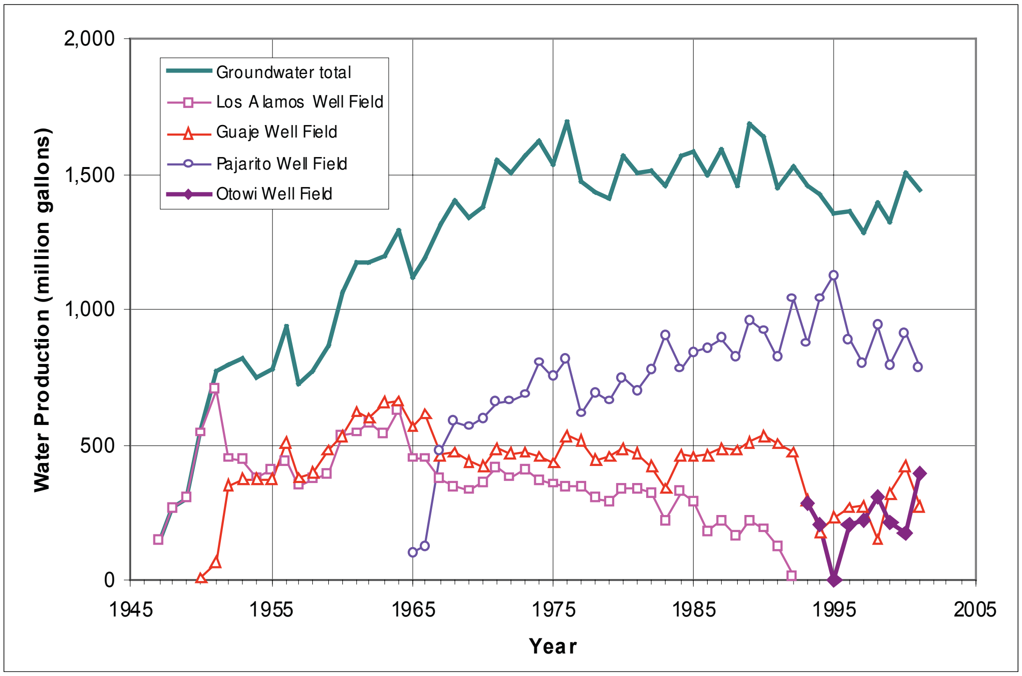

Figure 3. Groundwater production from each well field, 1947 to 2001

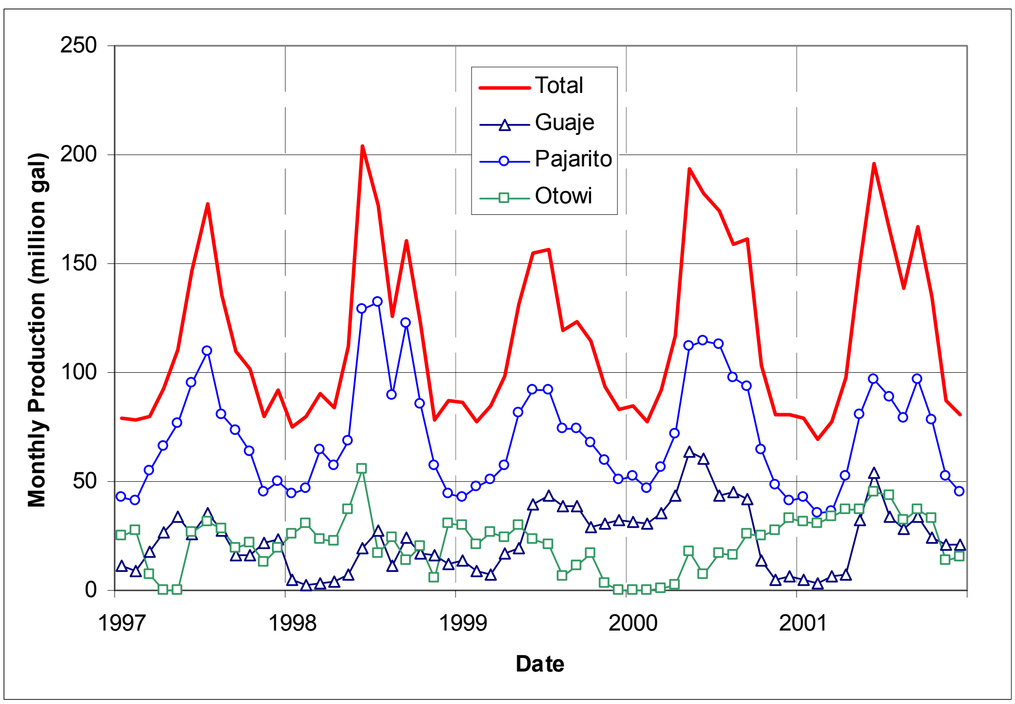

Figure 4. Monthly production from each well field, 1997 to 2001

Average annual pumping rates, drawdown, and specific capacity of production wells are summarized in Appendix Table C-2. Drawdown is the difference between the pumping and nonpumping water levels in each well when the well is operating (see Section 3.1 for detailed information). The average annual drawdown for each well is summarized in Appendix Table C-2 and is tabulated for each well in

Appendix D. From 1998 through 2001, wells in the Guaje and Pajarito fields had drawdown values ranging from about 25 ft to 80 ft, and in the Otowi field (data available for O-1 only) drawdown ranged from 100 to 140 ft.

The productivity of a well may be expressed in terms of specific capacity. The average specific capacity of each well was calculated by dividing the average annual pumping rate in gpm by the average annual drawdown in feet, to obtain the specific capacity in gpm/ft of drawdown (e.g., Freeze and Cherry 1979). In general, more productive wells have higher specific capacities, and specific capacities of wells tend to decrease over time as a result of factors such as well construction, water chemistry, corrosion, scale build-up, and aquifer properties. In 2000 and 2001, specific capacities of wells at Los Alamos ranged from 3.2 to 26.2 gpm/ft. Wells in the Guaje field averaged 11.3 gpm/ft, and wells in the Pajarito field averaged 22.5 gpm/ft. Tables in Appendix D list the annual production, pump time, pump rate, average pumping and nonpumping water levels, drawdown, and specific capacity for each currently active production well. For the period from 1998 through 2001, no significant changes occurred in the specific capacities of active production wells for which data were available.

2.4.3 Guaje Field

The annual production from the Guaje field from 1988 through 2001 ranged from 148.5 Mg in 1998 to 422 Mg in 2000 (Figure 3; Appendix Table B-1). During this period, the Guaje field produced an average of 20% of the groundwater at Los Alamos. Monthly water production from the Guaje field ranged from 2.6 Mg in February 1998 (during drilling of the replacement wells) to 63.8 Mg in May 2000, at the time of the Cerro Grande fire (Figure 4). Before the replacement wells began production in mid-1999, from January 1997 through June 1999, the Guaje field averaged 17.3 Mg per month. After the replacement wells were placed in service and the original wells were abandoned, from July 1999 through December 2001, the Guaje field averaged 30.1 Mg per month, an increase in production of about 74%. Recent production from the Guaje field, however, has been less than pre-1992 levels (see Figure 3).

The monthly production from each well in the Guaje field is shown in Figure 5. During drilling of the Guaje replacement wells, most production from nearby wells was curtailed; only well G-6, located in lower Rendija Canyon away from most of the replacement well drilling, was consistently pumped during drilling of the replacement wells.

Well G-2A has been the most productive new well in the Guaje field. Under normal operating conditions, this well typically produces 15 to 20 Mg per month and has produced as much as 30.7 Mg in a month. In 2001, well G-2A produced 55% of the water from the Guaje field and 10% of the total groundwater produced at Los Alamos (Appendix Table C-1). Wells G-4A and G-5A have been plagued by mechanical problems; these wells were operated intermittently in 2001.

Average pumping rates in the Guaje field in 2001 ranged from 400 gpm at well G-1A to 820 gpm at well G-2A, with a total field pumping rate of 2770 gpm (Appendix Table C-2). Recent drawdown in Guaje wells ranged from 31 ft in well G-1A (1997) to 126 ft in well G-5A (2000). Well G-2A, which produces most of the water from the field, had a maximum drawdown of 56 ft in 2000. Specific capacity in the Guaje field ranged from 3.2 gpm/ft at well G-5A in 2000 to 15 gpm/ft at wells G-1A and G-2A in 2000 (Appendix Table C-2).

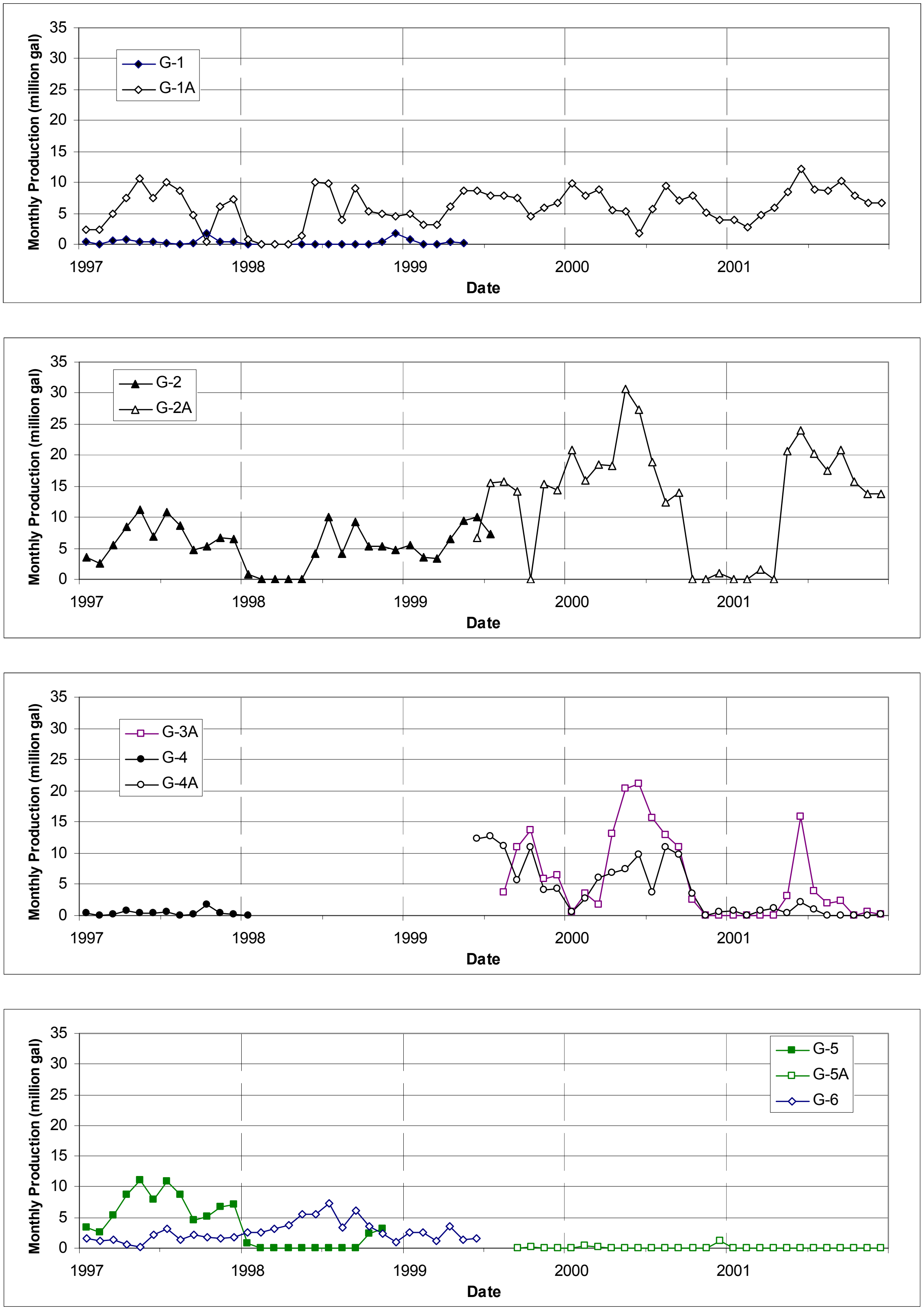

Figure 5. Monthly well production in the Guaje field, 1997 to 2001

2.4.4 Pajarito Field

The Pajarito field consists of five wells that were completed over an 18-year period, from 1965 through 1982; the wells range in depths from 2300 to 3092 ft (Table 1). Wells PM-1 and PM-3 are located in Sandia Canyon, well PM-2 is located in Pajarito Canyon, and wells PM-4 and PM-5 are located on mesas adjacent to Cañada del Buey (Figure 1). The depths to water are substantial, ranging from about 753 ft at PM-1 to more that 1250 ft at PM-5.

From 1998 through 2001, the production from the Pajarito field ranged from 785 Mg in 2001 to 940 Mg in 1998, for an average annual production of 857 Mg over four years. During this period, the Pajarito field produced an average of 61% of the water produced at Los Alamos (Appendix Table B-1). Production from the Pajarito field has declined slightly since 1995 but has been supplemented by production from the Otowi field (Figure 3).

The monthly production from each well in the Pajarito field for the years 1997 through 2001 is shown in Figure 6. Because well PM-4 usually operates continuously during the peak summer demand periods, this well typically has the highest monthly production of 50 to 60 Mg when operating. The pump in well PM-4 experienced problems in 1998 and was removed and replaced during the winter and spring of 1999. Well PM-2 typically produces 20 to 40 Mg per month. Wells PM-3 and PM-5 each produce about 10 to 30 Mg per month. Well PM-1 usually produces less than 10 Mg per month.

In 2001, the pumping rates of the Pajarito wells ranged from 586 gpm at PM-1 to 1400 gpm at PM-3 (Table C-2). Four of the wells (PM-2, PM-3, PM-4, and PM-5) are high-yield wells with pumping rates over 1000 gpm. The pumping rates from the individual wells varied only slightly from 1997 to 2001 with a total field pumping rate of 5766 gpm in 2001. Specific capacities of wells in the Pajarito field in 1998 ranged from 13.7 gpm/ft at PM-5 to 52 gpm/ft at PM-3. Where data are available, no significant changes occurred in the specific capacities of Pajarito field wells from 1998 through 2001.

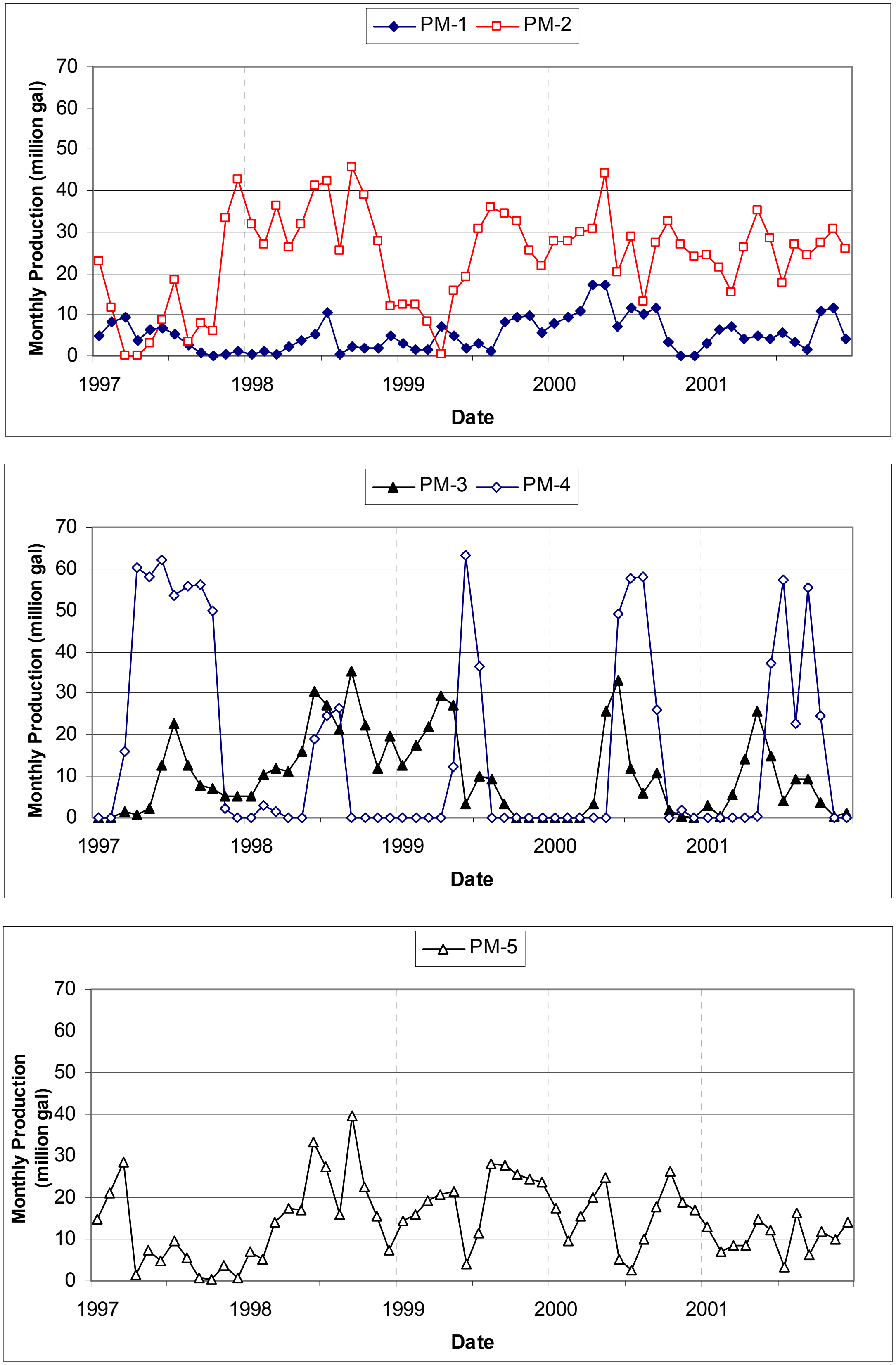

Figure 6. Monthly well production in the Pajarito field, 1997 to 2001

2.4.5 Otowi Field

The Otowi field consists of two wells that were completed in 1990. Well O-1 was completed to a depth of 2497 ft; the original depth to the regional aquifer was about 673 ft. Well O-4 was completed to a depth of 2595 ft, and the original depth to water was about 780 ft (Table 1). Well O-4 began production in February 1993 and well O-1 began production in April 1998.

From 1998 through 2001, the production from the Otowi field ranged from 172 Mg in 2000 to 389 Mg in 2001, for an average annual production of 270 Mg. Most production is from well O-4, which has produced from 69% to 94% of the total production from the field. During this period, the Otowi field produced an average of 19% of the water supply at Los Alamos (Appendix Table C-1). The highest monthly production from the Otowi field was in June 1998 when 55.8 Mg were produced (Figure 4). When operated, the field typically produces about 20 to 40 Mg per month; in 2001, peak monthly production from the field was 45 Mg.

The monthly production from each well in the Otowi field for the years 1997 through 2001 is shown in Figure 7. Well O-4 is a very high-producing well and produces most of the water from the Otowi field. Well O-4 typically produces 25 to 35 Mg per month when operated, and in June 2001 it produced 43.5 Mg. In 2001, well O-4 produced 25% of the total groundwater at Los Alamos (Appendix Table C-2).

Well O-1 produces at a rate of about 973 gpm, and well O-4 produces at a rate of about 1450 gpm. Water-level data, and therefore drawdown and specific capacity information, are not available for well O-4. The specific capacity of well O-1 declined from 9.7 gpm/ft in 1999 to 6.9 gpm/ft in 2001 (Appendix Table C-2).

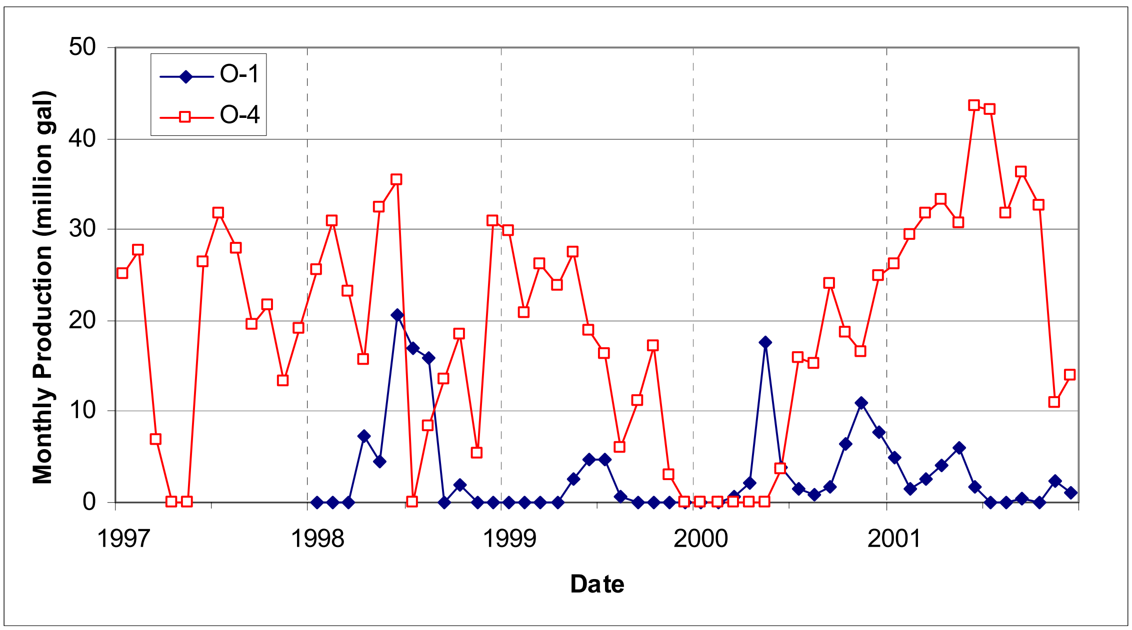

Figure 7. Monthly well production in the Otowi field, 1997 to 2001

2.4.6 Seasonal Groundwater Demand

Peak demand periods generally occur in the summer months between June and September. Low demand periods occur in the winter months from November through February. The monthly average daily well production from 1997 through 2001 is shown in Figure 8. Daily demand during the winter months averages about 2.7 Mgpd. Demand during the summer months is dependent on seasonal weather conditions, and is usually 5 to 7 Mgpd. Peak demand periods typically result from landscape irrigation during the dry spring and summer months. Municipal supply wells are operated during peak periods to meet demand and to keep storage tanks filled to capacity for local fire protection.

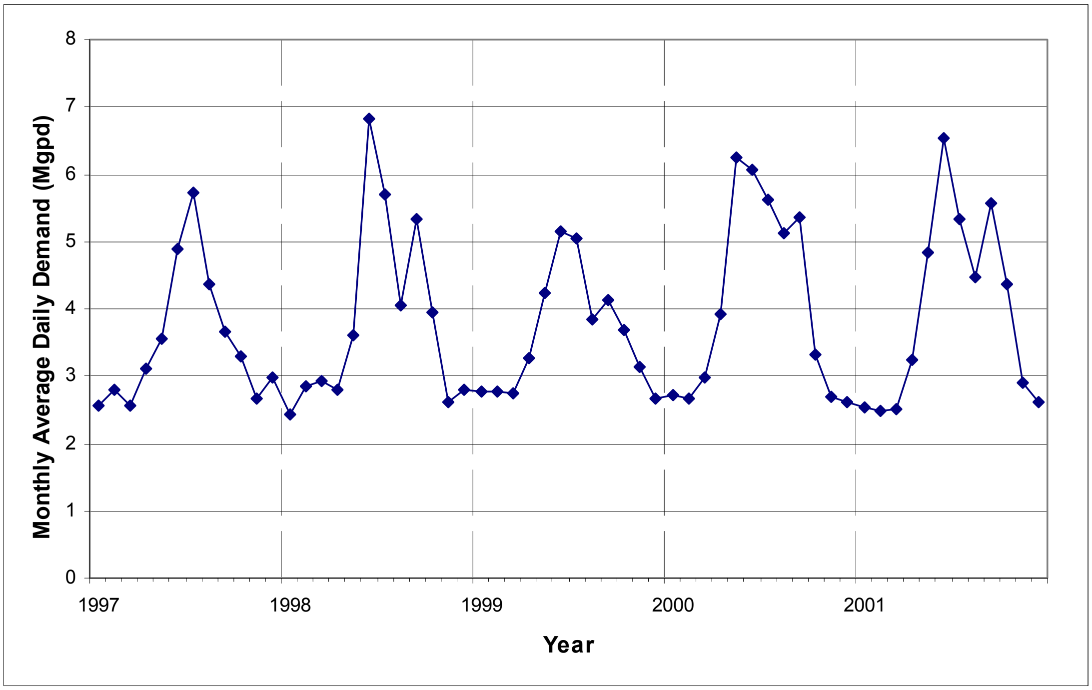

Figure 8. Monthly average daily well production at Los Alamos, 1997 to 2001

Table 4 summarizes the peak demand periods for years 1997 through 2001. Peak demand in 1998 occurred during the month of June when average daily demand was 6.8 Mgpd. The average daily demand from June through September in 1998 was 5.5 Mgpd.

In 1999, peak demand occurred in June and July. The highest daily production in 1999 was 9.4 Mg on July 4, which was 83% of the firm rated system capacity (see Section 1.3). Production of more than 6 Mgpd occurred on 22 days in 1999, extending intermittently from May 16 to July 30, and from August 29 to September 13. The average daily demand June through September was 4.5 Mgpd.

In 2000, peak demand occurred in May, during fighting of the Cerro Grande fire, when 193 Mg were produced during the month. During the fire, 48 Mg were produced from May 8 to May 14, 2000, averaging about 6.8 Mgpd. The peak daily production in 2000 was 10.2 Mg on June 18, which was 91% of the firm rated system capacity. Seasonal production of more than 6 Mgpd occurred on 61 days in 2000, extending from April 26 to September 23. The daily use from June through September averaged 5.5 Mgpd.

In 2001, peak demand occurred during June when 196 Mg were produced. The peak daily production in 2001 was 8.3 Mg on June 30, representing 74% of the firm rated system capacity. Seasonal production of more than 6 Mgpd occurred on 48 days, extending from May 23 to October 17, 2001. The average daily use from June through September was 5.5 Mgpd, similar to year 2000.

Table 4
Summary of Peak Demand Periods 1997 – 2001

Year	1997	1998	1999	2000	2001
Peak Month	July	June	June	May	June
Peak Month Production (Mg)	177	204	157	193	196
Monthly Avg. Daily Prod (Mg)	5.7	6.8	5.1	6.2	6.5
June–Sept Production (Mg)	569	667	554	676	667
Seasonal Avg. Daily Prod (Mg)	4.7	5.5	4.5	5.5	5.5
Date of Peak Production	7/1 to 7/21	7/1	7/4	6/18	6/30
Peak Daily Production (Mg)	6.7	9.5	9.4	10.2	8.3
Peak % of Rated Capacity	59%	85%	83%	90%	74%
Number of Production Days					
>10 Mgpd	0	0	0	1	0
>9 Mgpd	0	2	1	1	0
>8 Mgpd	0	10	3	5	1
>7 Mgpd	8	19	9	20	20
>6 Mgpd	13	36	22	61	48

2.5 Surface Water Production 1998 – 2001

The annual water production from Los Alamos reservoir is tabulated in Appendix Table B-1. Water use from Los Alamos reservoir was 1.6 Mg in 1998, 2.0 Mg in 1999, and 9.3 Mg in 2000. Surface water was used from Los Alamos reservoir until storm runoff after the Cerro Grande fire filled the reservoir with ash, muck, and sediment. The collection system was temporarily disconnected while the reservoir was dredged and the dam structure rebuilt. Storm runoff events in 2001 continued to fill the reservoir with debris resulting from the fire, temporarily preventing water use from the reservoir. Surface water use from Los Alamos reservoir is planned in the future or when conditions at the reservoir permit collecting water of adequate quality.

Water Canyon gallery was a source of potable spring water from the early days of the Manhattan Project until 1987. The use of the gallery as a potable water supply was discontinued in 1987; water from the gallery was used as a nonpotable supply for the steam plant at TA-16 from 1989 until 1995. The collection of water from the Water Canyon gallery ended in 1995 when a tree fell across a raised portion of the collection pipeline, causing significant damage to the pipeline and total loss of collected water to Water Canyon. In 2000, after the Cerro Grande fire, the water collection pipeline was removed from the gallery and from the tributary to upper Water Canyon. Additional information about the Water Canyon gallery was provided in earlier water supply reports (see Appendix A). The historical water production data from the Water Canyon gallery are provided by McLin et al. (1998).

Guaje and Los Alamos reservoirs are man-made reservoirs located on the eastern flanks of the Sierra de los Valles to the northwest and west of Los Alamos. These reservoirs are replenished by snowmelt and storm runoff and by baseflow from spring discharges in upper Guaje and Los Alamos Canyons. During the early days of the Manhattan Project, water from Guaje and Los Alamos reservoirs was used for municipal and industrial supply at Los Alamos. Use of the reservoirs for potable water supply was discontinued in 1958 because of intermittent periods of turbidity caused by summer thunderstorm runoff. Surface water from Guaje reservoir has not been used since 1991 (McLin et al. 1998).

3.0 WATER-LEVEL TRENDS

Water levels have been measured in wells tapping the regional aquifer at Los Alamos since the late 1940s, when the first exploratory wells were drilled by the US Geological Survey (USGS). These data have been documented in various reports over the years and are summarized in Appendices D and F. The annual summary data for each water supply well has been documented since 1971 in this series of water supply reports.

The annual water levels for all active water supply wells are tabulated in Appendix D, which contains one table for each of the wells used as a water supply well at Los Alamos from 1998 through 2001. The tables include annual average water-level data for both nonpumping and pumping conditions. Table 1 of this report provides information about the location and surface elevation and the water level at the time of completion of each well. Data for the now-abandoned Los Alamos well field were previously reported by McLin et al. (1997a).

Water-level data for supply wells are obtained by LAC personnel using pressure transducers, except for wells G-1A, PM-1 and PM-3, which are equipped with bubble pressure lines. For test wells, water levels are obtained using pressure transducers by WQH personnel. Recent water-level data for test wells are available from the RRES-WQH water-quality database (WQDB) on the Internet at the following website: http://wqdbworld.lanl.gov/. Website data are periodically updated; in addition, the website data can be downloaded in text or spreadsheet format. Historical water-level data for test wells are summarized in Appendix F.

When pressure transducers are installed, water-level measurements are usually obtained manually to calibrate the transducer readings. Occasionally the pressure transducers fail and must be removed or replaced during well maintenance activities. When transducers are replaced, the measurement datum may change by up to 1 to 2 ft; as a result, some water-level records might indicate false trends after replacement of transducers.

Most water supply wells at Los Alamos are electric and are operated daily during non-peak electrical demand times. Therefore, most wells are turned on and off each day, which does not allow sufficient time for static pumping or nonpumping water levels to be determined. Well PM-4 is usually operated continuously during summer peak demand periods and is usually not operated during winter months; thus, pumping and nonpumping water levels for this well may at times approach static conditions each year.

The pumping and nonpumping water-level data for the water supply wells were compiled for this report on approximately a weekly basis for each well and the average values for the year were determined (see Appendix C). Water levels in production wells are obtained by two methods: (1) some wells have chart recorders that continuously record water levels above the pump whether they are pumping or not pumping, and (2) some wells have digital readouts in the well house that display the water level above the pump. For wells with digital readouts, LAC employees manually record the water level, usually twice daily during routine inspections of the well equipment, and note whether the pump was operating at the time of recording the water level.

The pumping and nonpumping water levels of wells with chart recorders were determined each week by obtaining the highest water level when the well was not pumping and the lowest water level when the well was pumping. For wells with digital readouts, the daily well inspection and water-level records were reviewed and the highest nonpumping water levels and the lowest pumping water levels were documented for each week. This method attempts to obtain pumping and nonpumping water levels that approach static conditions and eliminates intermediate water levels obtained when the well was on or off for short periods of time. The weekly pumping and nonpumping water-level data were compiled for each well and entered into a database for storage and retrieval.

3.1 Short-Term Water-Level Trends

The short-term water-level trends of water supply wells typically show the water-level responses to the varying pumping demands placed on each well. The time series plots of pumping and nonpumping short-term water-level trends of active water supply wells are shown and discussed in Appendix E for each active well. The difference between the nonpumping and pumping water levels is the drawdown.

Prior to September 1998, pumping and nonpumping water-level data were compiled by JCNNM personnel on a monthly basis, and the average monthly drawdown was determined for each well. The monthly water-level and drawdown data were averaged over each year to determine the average annual pumping and nonpumping water levels and drawdown (Appendix D). After the operation of the water supply system was transferred to LAC Utilities Department, personnel began documenting water levels in production wells in January 2000. Therefore, no water-level data are available for production wells from about October 1998 through December 1999. Water-level data recorded by LAC were reviewed for quality and continuity and were compiled on approximately a weekly basis for this report.

The available short-term water-level data show that nonpumping and pumping water levels respond to the pumping stress placed on each well. The figures in Appendix E show the monthly production from each well where water levels were obtained and for nearby wells that appear to indicate water-level impacts. The short-term water-level data indicate that well G-2A may respond to pumping at well G-3A, wells PM-2 and PM-5 appear to respond to high-volume pumping at well PM-4, and well PM-4 appears to respond to pumping at well PM-2. Additional discussion about short-term water-level data is in Appendix E.

3.2 Long-Term Water-Level Trends

The average annual nonpumping water levels for each well (Appendix D) are used to evaluate the long-term water-level trends. The time-series of the average annual nonpumping water levels are plotted in the following charts to provide a graphical view of long-term water-level changes.

3.2.1 Water Supply Wells

3.2.1.1 Guaje Field

The annual nonpumping water-level elevations of wells in the Guaje field from 1950 through 2001 are shown in Figure 9, along with the annual water production from the field. The annual average depth to water in Guaje field wells is shown in Figure 10. Water-level data for the original Guaje wells end in 1998 and 1999 when the wells ceased production, and water-level data for the replacement wells begin in 1998 when the replacement wells were drilled. Routine water-level measurements in the new wells began in 1999.

Water levels in the Guaje field declined most during the first 15 years of production in response to field production of 400 to 600 Mg/yr. During the 1970s and most of the 1980s, production was about 450 Mg/yr and nonpumping water levels in the Guaje field were relatively stable. Slightly higher production of over 500 Mg/yr from 1989 through 1991 lowered water levels in some wells slightly, but lower production of about 250 Mg/yr in the mid 1990s allowed water levels to recover slightly (see Figure 9).

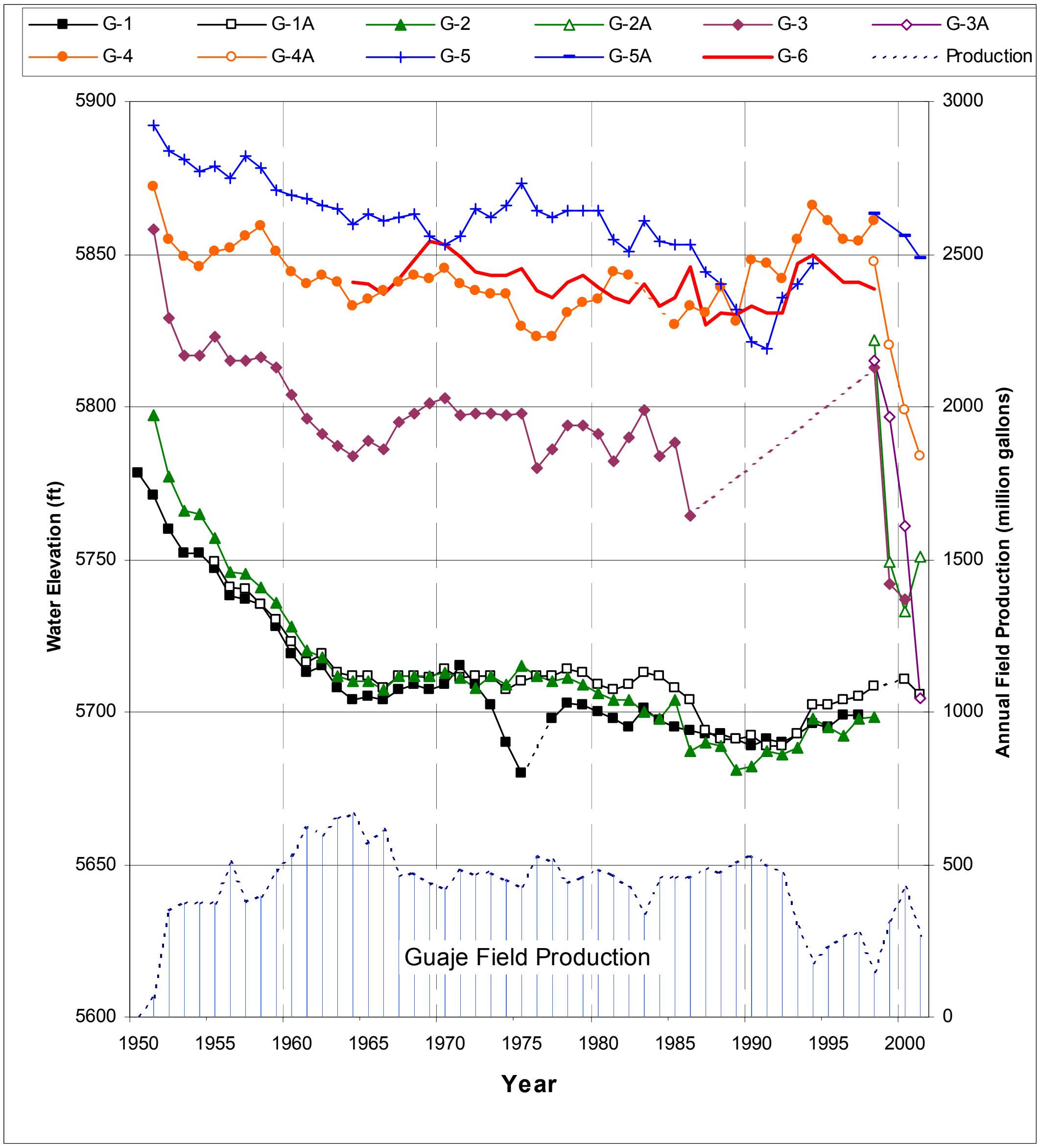

Figure 9. Average annual nonpumping water elevations of wells in the Guaje field, 1950 to 2001

Water levels in wells in the southeast portion of the Guaje field (G-1, G-1A, G-2) have shown the largest decline in water levels (these are also the best producing wells). In 1998, well G-1 had a total decline of about 80 ft, and well G-2 had a total decline about 100 ft. The nonpumping water levels in well G-1A in 2000 and 2001 were similar to those of the mid 1960s, although annual production from the field was less than in the 1960s.

In 1998, the water elevations of wells G-1, G-1A, and G-2 were each at about 5700 ft (Figure 9). The beginning static water elevations of replacement wells G-2A, G-3A, and G-4A in 1998 were 5821.6 ft, 5815.2 ft, and 5847.3 ft, respectively. However, within a year or two after these replacement wells were placed in service, the nonpumping water levels rapidly lowered to elevations similar to those of the old Guaje wells (5700 to 5750 ft).

The largest decline in nonpumping water level from static was at well G-3, which in 2001 had an average nonpumping water level that was 122 ft lower than the original static water level (Figure 10). Replacement well G-3A had an average nonpumping water level in 2001 that was 107 ft lower than the original static water level. In 2001, the average decline was 91 ft in nonpumping water levels from initial water levels for active production wells in the Guaje field (G-1A, G-2A, G-3A, and G-4A).

When well G-3 was converted to an observation well in 1998, the water level showed an average decline of 45 ft from the initial water level in 1951. Observation well G-3 is about 300 ft from replacement well G-2A; consequently, the water levels in well G-3 are influenced by pumping at well G-2A and correspond closely with the nonpumping water levels in well G-2A (Figure 9). In 1998 well G-2A had an initial water level that was 36 ft lower than what was observed initially at well G-3 in 1951, representing an annual decline of about 0.77 ft/yr.

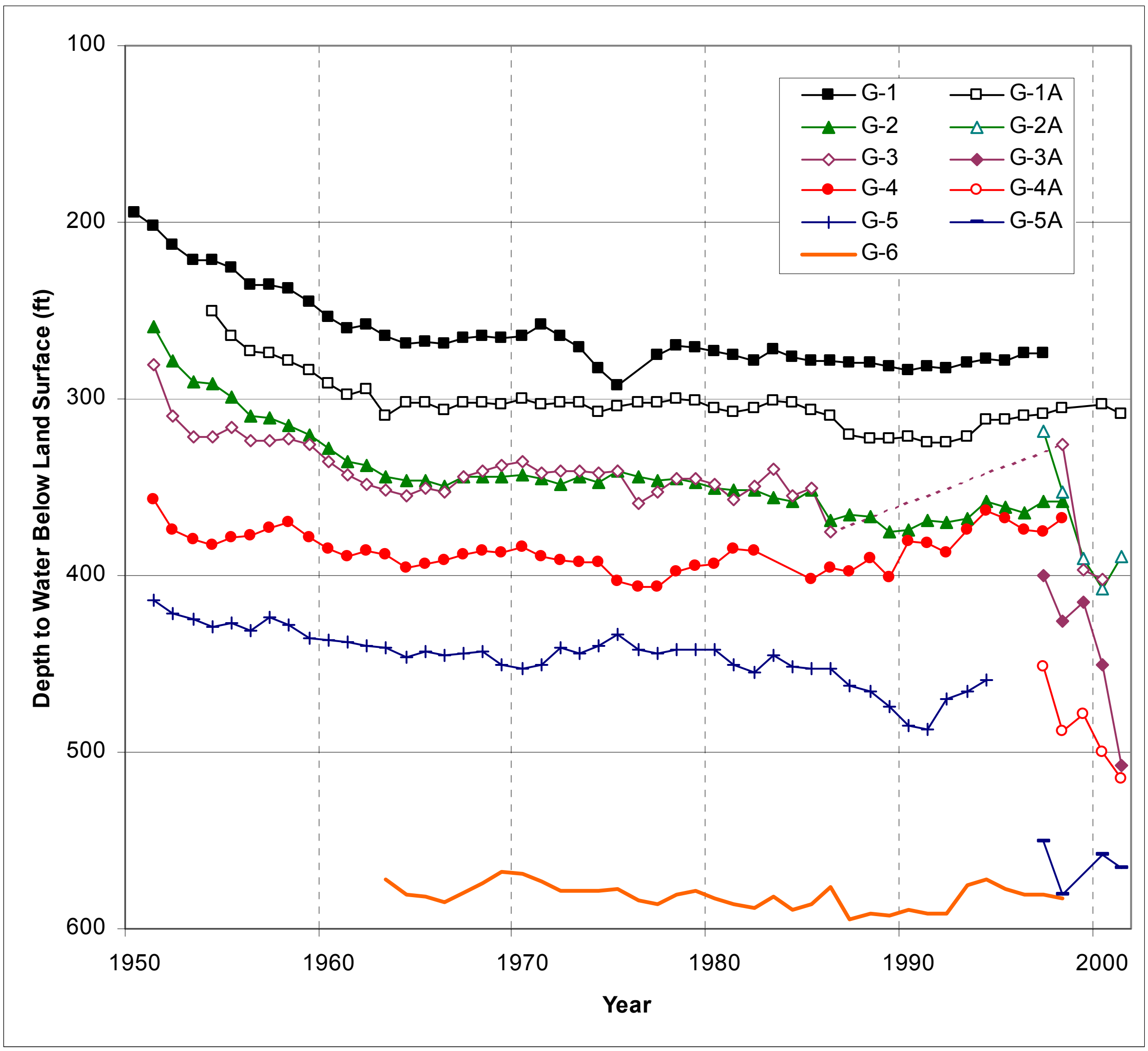

Figure 10. Average annual nonpumping water levels in wells from the Guaje field, 1950 to 2001

The initial water level in well G-3A was about 57 ft lower in 1998 than what was observed in nearby well G-4 in 1951, representing an annual decline of approximately 1.2 ft/yr. The initial water level in G-4A was about 48 ft lower in 1998 than what was observed in nearby well G-5 in 1951, representing an annual decline of approximately 1.0 ft/yr. The initial water level in well G-5A in 1998 was about 32 ft lower than the initial water level of well G-5 in 1951, representing an annual decline of approximately 0.7 ft/yr.

The long-term water-level observations from the Guaje field are consistent with the formation of a cone of depression in the regional water table in the area of the Guaje field. The cone developed during the initial 15 years of production, from 1950 until about 1964, when wells were added to the field and production from the field was increasing (Figure 9). With the addition of new wells in the Pajarito field in the mid 1960s, annual production levels from the Guaje field were relatively constant (about 500 Mg/yr) from 1967 through 1992, and water levels were relatively stable from 1967 through 1979. This period of stable water levels indicates that the cone of depression may have approached equilibrium with respect to the volume of withdrawals. Water levels in the Guaje field show a gradual decline from 1980 to 1990, suggesting an enlargement of the cone of depression in response to a possible external stimulus such as increased production from the Pajarito field (see Figure 3). Water levels in the Guaje field show a slight rise from 1990 to 1998, probably in response to the significantly reduced production from the Guaje field during this period (Figure 3).

During drilling of the Guaje replacement wells in 1998, nearby wells were not in full production for several months. The initial static water levels in the replacement wells were 32 to 57 ft lower than adjacent original Guaje wells, but after the wells were placed in service, water levels quickly lowered an average of 64 ft (the range is from 15 to 107 ft) by 2001 (Figure 10). Well G-1 was not routinely in service for about four months during early 1998 when the replacement wells were drilled. The nonpumping water levels in this well recovered about 10 ft during this period, not significantly different from when the well was not in routine service during winter months (see Appendix E).

The historical withdrawal rates and water-level data show that the water levels are relatively stable and resilient, readily responding to changes in withdrawal rates. Water levels naturally respond to changes in withdrawal rates from the Guaje field, and possibly to changes in withdrawals from other nearby well fields, although to a lesser degree. The long-term water-level trends in the Guaje field indicate that current groundwater withdrawals are not negatively impacting the aquifer.

3.2.1.2 Pajarito Field

The average annual nonpumping water elevations of wells in the Pajarito field are shown in Figure 11, and the average annual depth to water is shown in Figure 12. Wells PM-1 and PM-3 exhibit a gradual but steady decline through the years. In 1997, the total decline at PM-1 was 14 ft, representing an average annual decline of about 0.4 ft/yr. The total decline at well PM-3 was 37.5 ft in 1998, representing an average annual decline of about 1.25 ft/yr.

The water-level trends of wells PM-2, PM-4, and PM-5 are more varied from year to year, primarily in response to changes in annual withdrawals. In 1983, the maximum decline in well PM-2 was about 50 ft, representing an average annual decline of about 2.8 ft/yr. In 2001, the total decline at well PM-2 was about 32 ft from the initial static water level. Well PM-4 had a maximum decline of 33 ft in 1997, which represented an average annual decline of about 2.1 ft/yr. A reduced amount of annual production (at least 50%) from well PM-4 since 1997 (Appendix D) has resulted in a recovery of the nonpumping level; in 2001, the change from initial static water level was about 19 ft. The maximum decline at well PM-5 was 50 ft in 1996, but reduced production since then has allowed the water level to recover to 31 ft in year 2000, representing a total annual decline of about 1.7 ft/yr. In 1998 (the last year data were available for each Pajarito well), the average decline from initial water levels of nonpumping water levels for all wells in the Pajarito field was about 34 ft.

The Otowi field began production in 1993 when slightly lower water levels were observed at well PM-1 and possibly at PM-3 (Figure 11). Water levels rose slightly at PM-1 in 1994 and 1995, apparently in response to less production from the Otowi field in 1994 and no production in 1995. The available water-level data from wells PM-1 and PM-3 indicate that these wells appear to respond to production from the Otowi field.

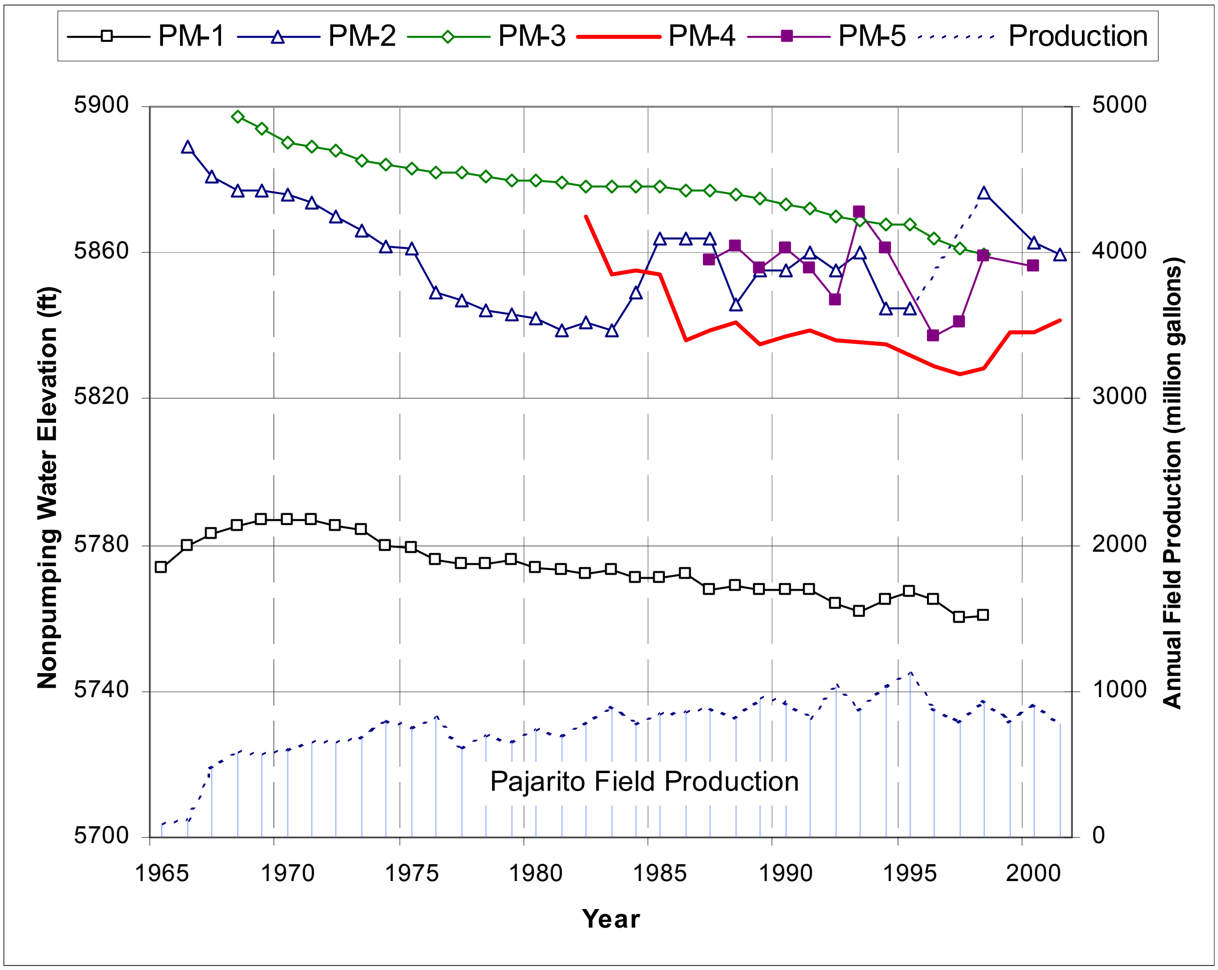

Figure 11. Average annual nonpumping water elevations of wells in the Pajarito field, 1965 to 2001

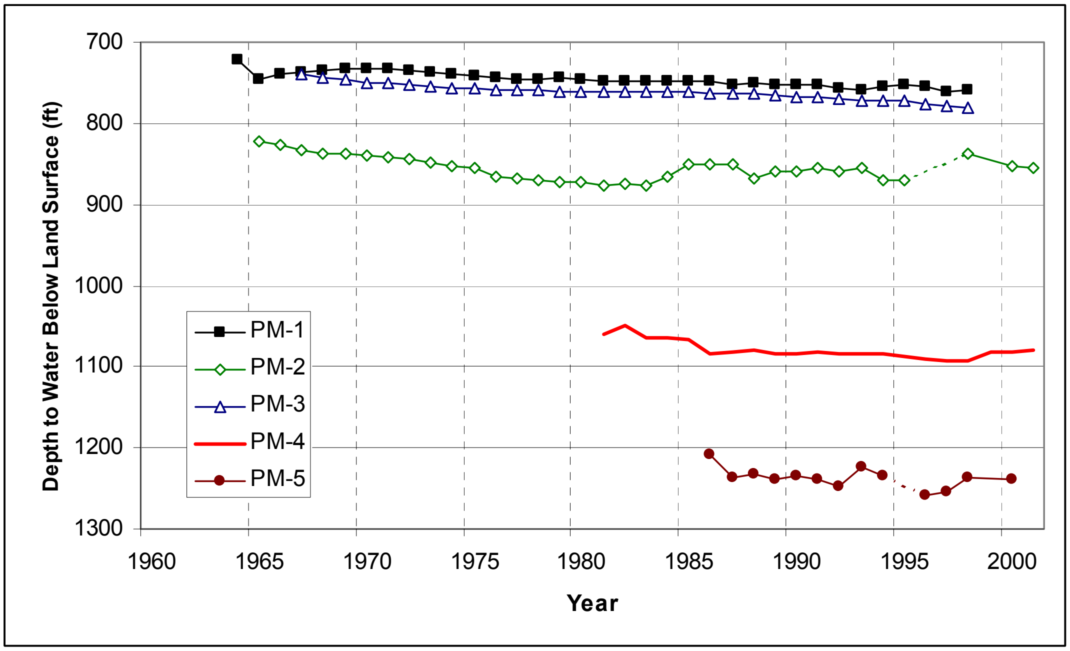

Figure 12. Average annual nonpumping water levels of wells in the Pajarito field, 1964 to 2001

3.2.1.3 Otowi Field

The average annual nonpumping water levels of wells in the Otowi field are shown in Figure 13, along with the annual production from the field. Water-level data have not been available for well O-4, although most of the production is from this well. Sporadic production from well O-1 caused a maximum decline of about 27 ft in 1999.

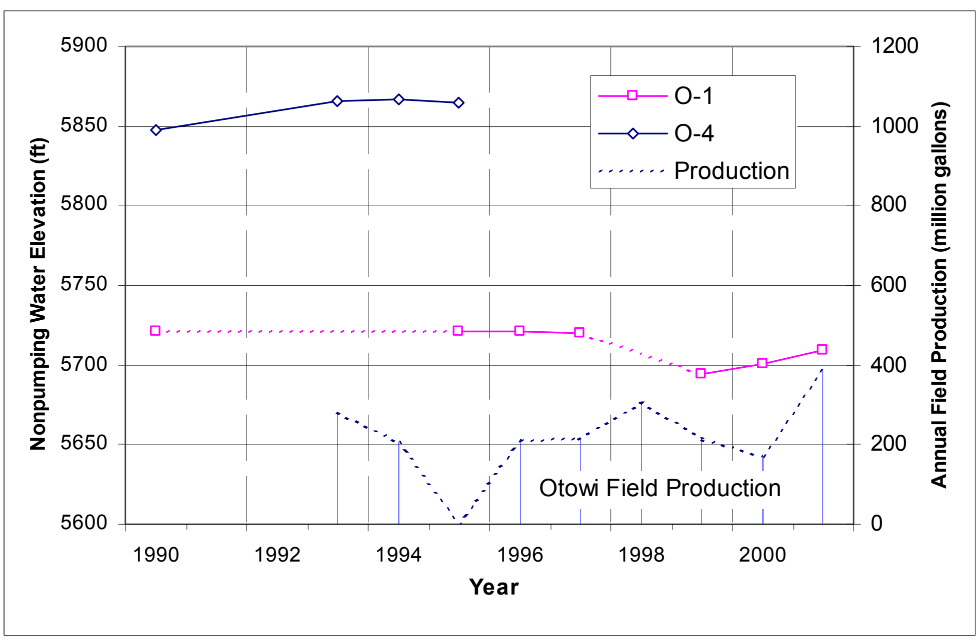

Figure 13. Average annual nonpumping water levels of wells in the Otowi field, 1990 to 2001

3.2.2 Test Wells

The regional aquifer test (observation) wells at Los Alamos are listed in Table 5 and the locations of the test wells are shown in Figure 14. The historical water-level data from the regional aquifer test wells are tabulated in Appendix Table E-1. The test well water-level data were compiled from the original records in the files of the Water Quality and Hydrology Group (RRES-WQH) and from previous water supply reports (e.g., McLin et al. 1998). Since 1992, WQH personnel have conducted a program to equip and maintain test wells with an automatic water-level recording device (McLin 1996). Some of the data in Appendix F represent averages when more than one measurement was obtained in a given year.

Table 5
Regional Aquifer Test Wells at Los Alamos

Well	Status	Date Completed	Total Depth (ft)	X-Coord (ft)	Y-Coord (ft)	Surface Elevation (ft)
TW-1	Monitor Well	Jan-50	642	1,650,041.5	1,772,076.9	6369.2
TW-2	Monitor Well	Nov-49	834	1,634,231.3	1,777,267.9	6648.6
TW-3	Monitor Well	Nov-49	815	1,637,727.5	1,773,138.1	6595.3
TW-4	Monitor Well	Mar-50	1205	1,624,028.1	1,777,680.1	7244.6
TW-8	Monitor Well	Dec-60	1065	1,632,573.9	1,769,506.8	6877.6
DT-5A	Monitor Well	Jan-60	1821	1,625,310.0	1,754,789.0	7144.0
DT-9	Monitor Well	Feb-60	1501	1,628,993.6	1,751,492.6	6935.0
DT-10	Monitor Well	Mar-60	1409	1,628,988.5	1,754,448.8	7020.0

Source: LANL RRES-WQH WQDB and Purtymun 1995. The coordinate system is NM State Plane, North American Datum of 1983 (NAD-83).

3.2.3 Regional Aquifer Characterization Wells

In 1998, a program to characterize the regional aquifer was initiated at LANL that included the planned installation of 32 characterization wells (called R-wells) to the regional aquifer (LANL 1998). As of 2001, nine characterization wells have been drilled to the regional aquifer. The locations of the R-wells are shown in Figure 14, and summary information for these wells is listed in Table 6. Well coordinates and water-level data were obtained from the respective R-well completion reports (Ball et al. 2002; Broxton et al. 2001a; Broxton et al. 2001b; Broxton et al. 2001c; Broxton et al. 2002; Kopp et al. 2002; Longmire et al. 2001; Stone et al. 2002; and Vaniman et al. 2002).

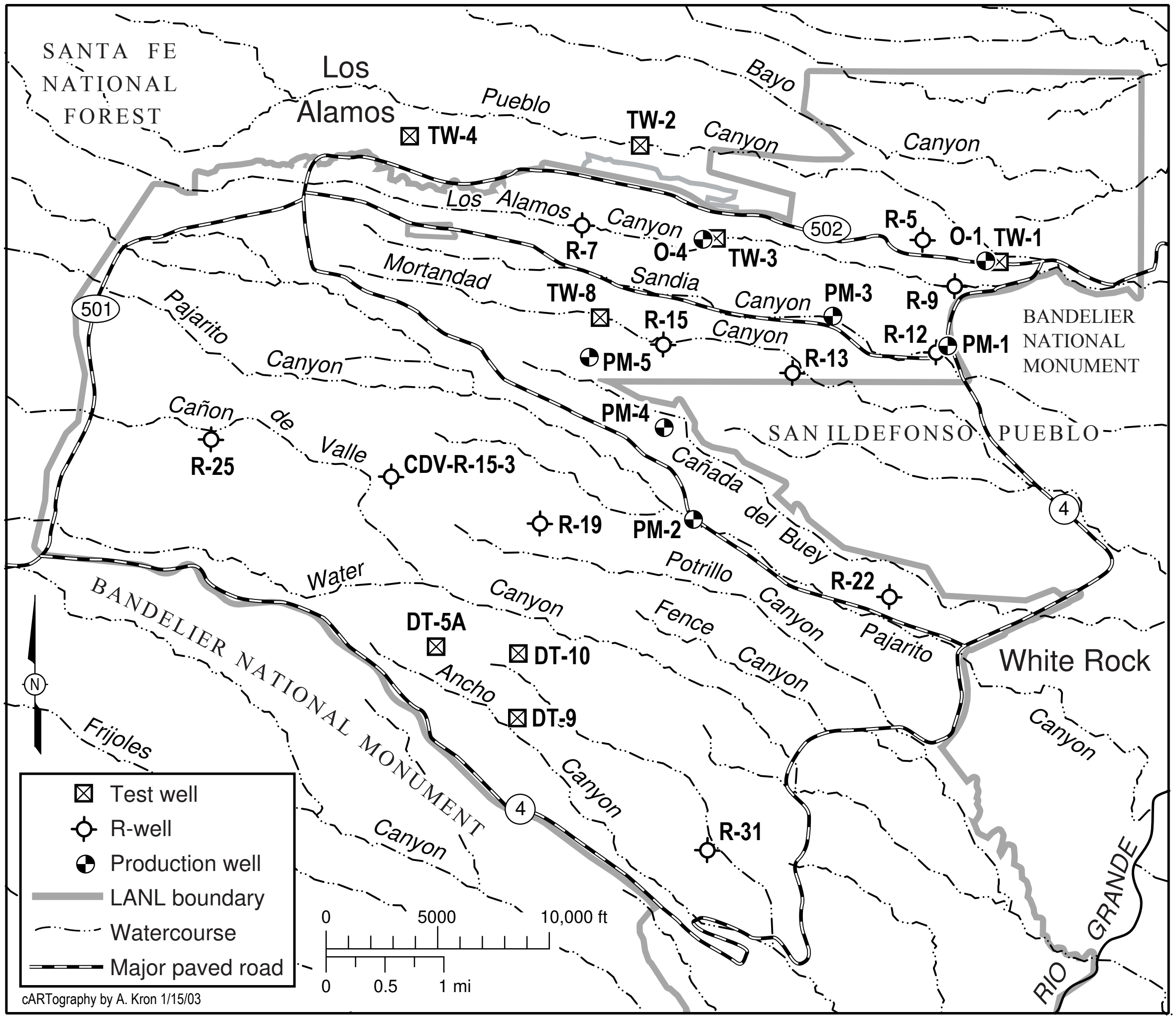

Figure 14. Locations of test wells and regional aquifer characterization wells

Table 6
Regional Aquifer Characterization Wells at Los Alamos

Well	Status	Date Completed	Total Depth (ft)	Depth Completed (ft)	X-Coord (ft)	Y-Coord (ft)	Surface Elevation (ft)	Depth to Water (ft)	Water Elevation (ft)	Water Level Date
CDV-R-15-3	Monitor Well	09/24/00	1722	1675	1,623,221.0	1,762,349.2	7,258.9	1,246.0	6012.9	05/03/00
R-5	Monitor Well	06/19/01	902	864	1,646,707.0	1,773,063.0	6,472.6	685.0	5787.6	05/20/01
R-7	Monitor Well	02/26/01	1097	977	1,631,666.0	1,773,653.0	6,779.2	902.8	5876.4	01/12/01
R-9	Monitor Well	10/18/99	771	758	1,648,236.5	1,770,847.1	6,382.8	688.0	5694.8	03/03/98
R-12	Monitor Well	03/21/00	886	869	1,647,424.2	1,767,913.4	6,499.6	805.0	5694.6	01/09/98
R-13	Monitor Well	10/30/01	1133	1029	1,640,991.7	1,766,994.2	6,673.1	834.0	5839.1	09/20/01
R-15	Monitor Well	09/07/99	1107	1031	1,635,308.6	1,768,272.5	6,820.0	964.0	5856.0	08/31/99
R-19	Monitor Well	09/19/00	1903	1877	1,629,918.4	1,760,252.1	7,066.3	1,178.0	5888.3	03/16/00
R-22	Monitor Well	12/10/00	1489	1473	1,645,324.4	1,757,111.1	6,650.5	883.0	5767.5	10/01/00
R-25	Monitor Well	09/28/00	1942	1934	1,615,178.4	1,764,060.5	7,516.1	1,286.0	6230.1	04/21/99
R-31	Monitor Well	12/01/00	1103	1078	1,637,353.8	1,745,648.4	6,362.5	525.0	5,837.5	02/05/00

Note: Water level dates approximate. The coordinate system is NM State Plane, North American Datum of 1983 (NAD-83); coordinates and elevations shown are for the brass cap in the concrete pad.

Table 6 lists the initial water levels to the regional aquifer that were observed in the characterization wells. The regional aquifer was encountered at an elevation of 5694.6 ft in well R-12 and at a similar elevation 5694.8 ft in well R-9. Groundwater at the top of the regional saturated zone at these wells is unconfined (Broxton et al. 2001a). The elevation at the top of the regional aquifer in wells R-9 and R-12 is lower than nonpumping water levels in supply wells PM-1 (5761 ft) and O-1 (5710 ft). The higher static water levels in nearby water supply wells probably result from their long screen lengths, allowing multiple zones to contribute to a composite hydraulic head in an area of upward gradient. Well PM-1 is screened over a 1554-ft interval; the higher water levels in the supply wells suggest that higher head zones occur in the regional aquifer at depths greater than those penetrated by shallower wells R-12 and R-9. In this area of the Pajarito Plateau, the deeper units of the regional aquifer may have upward hydraulic gradients (Broxton et al. 2001a; Broxton et al. 2001b). Additional information about recent water-level data and regional aquifer gradient is reported in the LANL Annual Groundwater Status Report (e.g., Nylander et al. 2002).

3.2.4 Summary of Long-Term Water Levels

Collectively, the individual trends in water levels near Los Alamos reflect a plateau-wide decline in regional aquifer water levels in response to municipal water production. This decline is gradual and has been about 0.7 to 2 ft per year for production wells and less than 1 ft per year for observation test wells. The highest declines have been observed in the Guaje field where nonpumping water levels in 2001 were about 91 ft lower than in 1951. The initial water levels of the Guaje replacement wells in 1998 were 32 to 57 ft lower than the initial water levels of adjacent original Guaje wells.

Approximately static water levels in well PM-4 in the spring of 1999 and 2001, after the well had not operated for several months, were about 19 ft below the initial water level of 1981. When production wells are taken off-line for pump replacement or repair, water levels have returned to within about 25 ft of initial static levels within 6 to 12 months.

The long-term water-level observations from production and test wells at Los Alamos are consistent with the formation of a cone of depression in response to pumping. Maximum declines are located at the well fields and smaller declines are observed in neighboring areas. The creation of a cone of depression in response to pumping is an essential component in the production of groundwater (e.g., Freeze and Cherry 1979). Production wells at Los Alamos were constructed to operate appropriately at present water levels. Thus, the water-level trends suggest no adverse impacts by production on long-term water supply sustainability at Los Alamos.

4.0 SUMMARY

In 1998, DOE transferred the operation of the water supply wells at Los Alamos to Los Alamos County. Four replacement wells were installed in the Guaje field in 1998 and were placed in service in 1999. Six of the old Guaje wells were plugged or abandoned in 1999. Wells in the Otowi and Pajarito fields continued to operate adequately. The operation of the wells and well fields from 1998 through 2001 provided adequate supply for Los Alamos and LANL.

Production of potable municipal water supplies from 1998 through 2001 ranged from 1322.8 Mg in 1999 to 1506.1 Mg in 2000; production of groundwater was from the Guaje, Pajarito, and Otowi fields. Nonpotable water use from Los Alamos reservoir ranged from zero gallons in 2001 to 9.3 Mg in 2000; this water is used to irrigate public parks and athletic fields in Los Alamos. Use of water from Los Alamos reservoir ended in 2000 after the Cerro Grande fire, when resulting storm runoff filled the reservoir with ash and sediment.

The long-term trends in water levels reflect a plateau-wide decline in regional aquifer water levels in response to municipal water production. This average annual decline is gradual and has ranged from 0.7 to 2 ft per year for production wells and from 0.4 to 0.9 ft/yr for observation (test) wells. The largest declines are in the Guaje field where nonpumping water levels were about 91 ft lower in 2001 than in 1951. The initial water levels of the Guaje replacement wells were 32 to 57 ft lower than initial water levels of adjacent original Guaje wells. When production wells are taken off-line for pump replacement or repair, water levels have returned to within about 25 ft of initial static levels within 6 to 12 months.

The long-term water level declines in production and observation wells at Los Alamos are consistent with the formation of a cone of depression in response to pumping. Based on review of the available water-level data, the water-level trends suggest no adverse impacts by production on long-term water supply sustainability at Los Alamos.

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Appendix A

List of Water Supply Reports—1972–1997

Appendix A List of Water Supply Reports—1972–1997

Previous water supply reports, published by the Los Alamos National Laboratory, are listed below in chronological order.

W.D Purtymun and J.W. Herceg, “Water Supply at Los Alamos during 1971,” Los Alamos Scientific Laboratory report LA-5039-MS (1972).

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Appendix B

Annual Water Production Data

Appendix B. Annual Water Production Data

Table B-1
Water Production from Well Fields, Springs, and Reservoirs at Los Alamos: 1947–2001
(millions of gallons)

	Ground Water					Springs and Reservoirs				
Year	Los Alamos Well Field	Guaje Well Field	Pajarito Well Field	Otowi Well Field	Ground Water Total	Water Canyon Gallery Spring	Los Alamos Reservoir	Guaje Reservoir	Spring-Reservoir Total	Total Annual Usage
1947	147				147	84.0	21.7	87.8	194	341
1948	264				264	97.0	21.9	119.8	239	503
1949	302				302	92.0	14.7	116.1	223	525
1950	547	3			550	54.0	20.6	79.9	155	705
1951	702	68			770	39.0	10.5	41.0	91	861
1952	448	350			798	48.0	33.6	131.0	213	1,011
1953	444	372			816	39.0	14.8	58.0	112	928
1954	380	374			754	40.0	16.9	66.0	123	877
1955	407	375			782	33.0	18.1	71.0	122	904
1956	437	506			943	23.0	4.8	24.0	52	995
1957	350	378			728	40.0	54.8	213.0	308	1,036
1958	372	395			767	60.0	49.4	193.0	302	1,069
1959	391	478			869	54.0	0.0	0.0	54	923
1960	530	533			1,063	48.0	0.0	0.0	48	1,111
1961	546	624			1,170	54.0	0.0	0.0	54	1,224
1962	577	597			1,174	67.0	0.0	0.0	67	1,241
1963	539	654			1,193	51.0	0.0	0.0	51	1,244
1964	627	665			1,292	45.0	0.0	0.0	45	1,337
1965	447	571	99		1,117	72.0	0.0	0.0	72	1,189
1966	450	613	127		1,190	82.0	0.0	0.0	82	1,272
1967	373	464	481		1,318	56.0	0.0	0.0	56	1,374
1968	345	474	584		1,403	65.0	0.0	0.0	65	1,468
1969	331	435	569		1,335	80.0	0.0	0.0	80	1,415
1970	360	423	595		1,378	65.0	0.0	0.0	65	1,443
1971	412	484	657		1,553	37.0	0.0	0.0	37	1,590
1972	380	467	662		1,509	40.0	0.0	5.8	46	1,555
1973	406	475	685		1,566	49.0	0.0	9.7	59	1,625
1974	369	453	802		1,624	35.0	0.0	4.9	40	1,664
1975	356	431	749		1,536	42.0	0.0	5.3	47	1,583
1976	343	531	817		1,691	41.0	0.0	4.4	45	1,736
1977	345	515	614		1,474	57.0	0.0	4.1	61	1,535
1978	302	444	690		1,436	45.0	0.0	2.8	48	1,484
1979	289	456	662		1,407	44.0	1.3	3.7	49	1,456
1980	339	485	743		1,567	32.0	2.3	4.7	39	1,606
1981	336	469	701		1,506	45.0	2.1	2.7	50	1,556
1982	317	422	773		1,512	46.0	2.8	3.4	52	1,564
1983	221	338	904		1,463	38.0	1.4	3.4	43	1,506
1984	326	460	780		1,566	34.0	1.3	3.0	38	1,604
1985	290	456	841		1,587	37.0	0.9	2.8	41	1,628
1986	179	460	858		1,497	28.0	1.5	2.4	32	1,529
1987	217	485	892		1,594	34.0	3.2	2.8	40	1,634
1988	158	477	824		1,459	34.5	1.4	2.4	38	1,497
1989	219	506	961		1,686	23.0	3.3	4.6	31	1,717
1990	187	532	923		1,642	9.3	4.6	2.2	16	1,658
1991	125	502	820		1,447	12.0	2.4	1.5	16	1,463
1992	13	472	1,044		1,529	0.1	0.0	0.0	0	1,529
1993		298	876	284	1,458	6.4	0.5	0.0	7	1,465
1994		179	1,042	206	1,427	11.6	0.0	0.0	12	1,439
1995		230	1,126	0	1,356	1.6	1.6	0.0	3	1,359
1996		269	889	210	1,368	0.0	2.6	0.0	3	1,371
1997		272	798	216	1,286	0.0	2.4	0.0	2	1,288
1998		148	941	307	1,396	0.0	1.6	0.0	2	1,397
1999		319	791	213	1,323	0.0	2.0	0.0	2	1,325
2000		422	912	172	1,506	0.0	9.3	0.0	9	1,515
2001		269	785	389	1,443	0.0	0.0	0.0	0	1,443
Total	16,445	22,079	28,016	1,997	68,537	2,171	330	1,277		72,315

Note: Guaje and Los Alamos reservoirs used as potable supply 1947-1958; irrigation only 1972 to 2000; Water Canyon gallery used for potable supply 1947–1987, and for nonpotable industrial supply 1988-1995. Production from Guaje reservoir is estimated for 1951-1958 (McLin et al. 1998).

Appendix C

Well Production Data and Aquifer Characteristics

Appendix C. Well Production Data and Aquifer Characteristics

Table C-1
Well Production Characteristics, 1997 through 2001

	Production (10^6 gallons)					% of Well Field Production					% of Total Production				
Well	**1997**	**1998**	**1999**	**2000**	**2001**	**1997**	**1998**	**1999**	**2000**	**2001**	**1997**	**1998**	**1999**	**2000**	**2001**
Guaje Field															
G-1	5.6	2.1	1.5			2.1	1.4	0.5			0.4	0.1	0.1		
G-2	81.1	43.4	45.4			30.6	29.2	14.2			6.3	3.1	3.4		
G-4	5.4	0.03				2.0	0.0	0.0			0.4	0.002			
G-5	82.3	6.5				31.0	4.3	0.0			6.4	0.5			
G-6	18.8	46.8	12.9			7.1	31.5	4.0			1.5	3.4	1.0		
G-1A	72.3	49.8	74.8	78.1	86.5	27.2	33.5	23.5	18.5	32.1	5.6	3.6	5.7	5.2	6.0
G-2A			82.0	178.0	148.2			25.7	42.2	55.0			6.2	11.8	10.3
G-3A			40.8	102.8	28.0			12.8	24.4	10.4			3.1	6.8	1.9
G-4A			61.2	61.7	6.5			19.2	14.6	2.4			4.6	4.1	0.4
G-5A			0.2	1.6	0.2			0.1	0.4	0.1			0.02	0.1	0.01
Field Subtotal	265.5	148.5	318.8	422.2	269.4	100.0	100.0	100.0	100.0	100.0	20.7	10.6	24.1	28.0	18.7
Otowi Field															
O-1		67.1	13.0	53.3	25.2		21.9	6.1	31.0	6.5	0.0	4.8	1.0	3.5	1.7
O-4	219.2	239.7	200.5	119.0	363.4	100.0	78.1	93.9	69.0	93.5	17.1	17.2	15.2	7.9	25.2
Field Subtotal	219.2	306.8	213.5	172.3	388.6	100.0	100.0	100.0	100.0	100.0	17.1	22.0	16.1	11.4	26.9
Pajarito Field															
PM-1	49.2	34.3	57.3	106.6	66.6	6.2	3.6	7.2	11.7	8.5	3.8	2.5	4.3	7.1	4.6
PM-2	158.1	386.2	249.2	333.9	303.3	19.8	41.1	31.5	36.6	38.6	12.3	27.7	18.8	22.2	21.0
PM-3	77.5	222.5	135.0	93.0	91.8	9.7	23.7	17.1	10.2	11.7	6.0	15.9	10.2	6.2	6.4
PM-4	414.7	74.9	112.2	192.8	197.8	51.9	8.0	14.2	21.2	25.2	32.3	5.4	8.5	12.8	13.7
PM-5	98.8	222.8	237.0	185.3	125.9	12.4	23.7	30.0	20.3	16.0	7.7	16.0	17.9	12.3	8.7
Field Subtotal	798.4	940.6	790.6	911.6	785.4	100.0	100.0	100.0	100.0	100.0	62.2	67.4	59.8	60.5	54.4
Total	1,283.1	1,395.9	1,322.8	1,506.1	1,443.4						100.0	100.0	100.0	100.0	100.0

Table C-2
Average Pumping Rate, Drawdown, and Specific Capacity, 1997 – 2001

	Average pumping rate (gpm)					Average Drawdown (ft)					Average Specific Capacity (gpm/ft)				
Well	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
Guaje Field															
G-1	191	183	60			180	-	-			1.1	-	-		
G-2	420	424	432			26	25.5	-			16.2	16.6	-		
G-4	174	170				185	-				0.9	-			
G-5	419	374				-	-				-	-			
G-6	258	243	247			77	82.9	-			3.4	2.9	-		
G-1A	416	413	405	400	400	31	29.7	-	30.8	25.1	13.4	13.9	-	13.0	15.9
G-2A			800	760	820		48.9	45.9	56.2	54.5			17.4	13.5	15.1
G-3A			656	580	650		76.6	-	50.5	-			-	11.5	-
G-4A			584	525	525		75.5	87.1	75.4	-			6.7	7.0	-
G-5A			400	400	375		79.6	-	126.3	-			-	3.2	-
Field Total	1,878	1808	3584	2665	2770										
Otowi Field															
O-1		918	973	973	973	-	-	100.3	133.8	141.3	-	-	9.7	7.3	6.9
O-4	1,505	1,471	1,479	1,450	1,450	-	-	-	-	-	-	-	-	-	-
Field Total	1,505	2,389	2,452	2,423	2,423										
Pajarito Field															
PM-1	560	534	586	586	586	24	26.9	-	-	-	23.3	19.8	-	-	-
PM-2	1,260	1,243	1,275	1,275	1,275	-	73.2	-	67.0	64.5	-	17.0	-	19.0	19.8
PM-3	1,398	1,395	1,400	1,400	1,400	26	27.1	-	-	-	53.8	51.5	-	-	-
PM-4	1,323	1,224	1,400	1,330	1,330	49	36.0	51.5	50.8	52.7	27.0	34.0	27.2	26.2	25.2
PM-5	1,213	1,161	1,175	1,175	1,175	88	84.4	-	81.1	-	13.8	13.7	-	14.5	-
Field Total	5,754	5,557	5,836	5,766	5,766										

Appendix D

Annual Well Data, Aquifer Characteristics, and Water Levels for Active Wells

Appendix D. Annual Well Data, Aquifer Characteristics, and Water Levels for Active Wells

Well G-1

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level: Nonpumping (ft)	Average Water Level: Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1950	-	2.8	-	195	-	-	-	5778
1951	1168	37.7	538	202	309	107	5.0	5771
1952	2476	75.5	508	213	295	82	6.2	5760
1953	3275	97.3	495	221	292	71	7.0	5752
1954	2616	77.8	496	221	290	69	7.2	5752
1955	2406	70.5	448	226	295	69	6.5	5747
1956	2958	83.2	469	235	303	68	6.9	5738
1957	2098	55.9	444	236	307	71	6.3	5737
1958	2460	68.1	461	238	308	70	6.6	5735
1959	2952	82.4	465	245	314	69	6.7	5728
1960	3564	96.0	449	254	325	71	6.3	5719
1961	4236	112.4	442	260	333	73	6.1	5713
1962	3431	93.6	455	258	342	84	5.4	5715
1963	4519	114.9	424	265	348	83	5.1	5708
1964	4374	113.8	434	269	352	83	5.2	5704
1965	3530	90.7	428	268	352	84	5.1	5705
1966	4074	102.6	420	269	363	94	4.5	5704
1967	2615	69.9	446	266	362	96	4.6	5707
1968	2996	78.9	439	264	366	102	4.3	5709
1969	2657	68.3	428	266	376	110	3.9	5707
1970	2712	64.7	398	264	377	113	3.5	5709
1971	2908	67.9	389	258	378	120	3.2	5715
1972	2865	66.1	385	264	389	125	3.1	5709
1973	2997	67.5	375	271	403	132	2.8	5702
1974	2767	62.3	375	283	412	129	2.9	5690
1975	2467	55.7	376	293	411	118	3.2	5680
1976	2962	65.1	366	-	-	-	-	-
1977	2734	57.9	353	275	426	151	2.3	5698
1978	2656	56.0	351	270	419	149	2.4	5703
1979	2998	61.7	343	271	422	151	2.3	5702
1980	3459	68.3	329	273	428	155	2.1	5700
1981	4427	81.6	307	275	444	169	1.8	5698
1982	3678	69.0	313	278	443	165	1.9	5695
1983	2871	52.2	303	272	443	171	1.8	5701
1984	3804	62.8	275	276	448	172	1.6	5697
1985	3004	48.3	268	278	450	172	1.6	5695
1986	2027	30.3	249	279	450	171	1.5	5694
1987	2070	29.2	235	280	451	171	1.4	5693
1988	395	5.4	277	280	445	165	1.7	5693
1989	2010	26.9	223	282	451	169	1.3	5691
1990	2121	30.8	242	284	454	170	1.4	5689
1991	1730	20.9	201	282	451	169	1.2	5691
1992	1077	12.0	186	283	439	156	1.2	5690
1993	2.5	0.03	200	280	-	-	-	5693
1994	1585	18.5	195	277	451	174	1.1	5696
1995	2542	28.5	187	278	450	172	1.1	5695
1996	1128	12.9	191	274	449	175	1.1	5699
1997	897	13.6	191	274	454	180	1.1	5699
1998	197	2.1	183	-	-	-	-	-
1999	417	1.5	60	-	-	-	-	-
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-
Total	125,913	2832.0						
Minimum	2.5	0.03	60	195	290	68	1.1	5680
Maximum	4519	114.9	538	293	454	180	7.2	5778
Average	2570	56.6	347	262	388	125	3.5	5711

Note: Well completed July 1950; initial depth to water: 192 ft; surface elevation: 5973 ft; plugged September 1999

Well G-1A

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1954	108	4.6	709	250				
1955	1531	53.0	577	265	316	51	11.3	5749
1956	3130	107.7	574	273	323	50	11.5	5741
1957	2470	87.0	587	274	327	53	11.1	5740
1958	2670	92.5	577	279	331	52	11.1	5735
1959	2965	102.7	577	284	333	49	11.8	5730
1960	3641	122.8	562	291	342	51	11.0	5723
1961	4297	147.3	571	298	350	52	11.0	5716
1962	3972	136.1	571	295	344	49	11.7	5719
1963	4525	1479.7	551	301	350	49	11.3	5713
1964	3852	129.3	559	302	353	51	11.0	5712
1965	3505	116.5	554	302	353	51	10.9	5712
1966	3964	133.4	561	306	355	49	11.4	5708
1967	2720	91.3	559	302	351	49	11.4	5712
1968	3089	103.2	557	302	352	50	11.1	5712
1969	2695	90.7	561	303	356	53	10.6	5711
1970	2772	92.5	556	300	357	57	9.8	5714
1971	3313	111.8	562	303	361	58	9.7	5711
1972	2879	94.0	544	302	361	59	9.2	5712
1973	2760	87.9	531	302	362	60	8.8	5712
1974	2974	92.7	520	307	355	48	10.8	5707
1975	2740	85.3	519	304	351	47	11.0	5710
1976	2983	91.6	512	302	350	48	10.7	5712
1977	2942	88.7	503	302	350	48	10.5	5712
1978	2631	77.9	494	300	345	45	11.0	5714
1979	2974	88.0	494	301	345	44	11.2	5713
1980	3480	103.2	494	305	345	40	12.4	5709
1981	4212	131.2	519	307	347	40	13.0	5707
1982	3618	109.7	505	305	347	42	12.0	5709
1983	2901	86.7	498	301	336	35	14.2	5713
1984	3798	113.9	501	302	345	43	11.7	5712
1985	4430	128.4	483	306	348	42	11.5	5708
1986	4644	130.4	468	310	351	41	11.4	5704
1987	4468	122.5	457	320	362	42	10.9	5694
1988	5016	133.5	443	323	364	41	10.8	5691
1989	4663	131.5	470	323	359	36	13.1	5691
1990	4860	145.5	499	322	362	40	12.5	5692
1991	5120	150.2	489	325	361	36	13.6	5689
1992	4676	134.1	478	325	361	36	13.3	5689
1993	3862	108.2	467	321	355	34	13.7	5693
1994	2629	68.2	432	312	347	35	12.4	5702
1995	2736	67.2	409	312	346	34	12.0	5702
1996	2853	71.3	417	310	342	32	13.0	5704
1997	2864	71.5	416	309	340	31	13.4	5705
1998	2104	49.8	414	305	335	30	13.9	5709
1999	3080	74.8	405	-	-	-	-	-
2000	3254	78.1	400	303	333	30	13.5	5711
2001	3606	86.5	400	309	334	25	15.9	5705
Total	160,976	6204.6						
Minimum	108	4.6	400	250	316	25	8.8	5689
Maximum	5120	1479.7	709	325	364	60	15.9	5749
Average	3354	129.3	511	302	348	44	11.7	5711

Note: Well completed December 1954; initial depth to water: 250 ft; surface elevation: 6,014 ft.

Well G-2

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Non-Pumping Water Elevation (ft)
1950								
1951	123	3.9	529	259	-	-	-	5797
1952	2372	78.3	550	279	327	48	11.5	5777
1953	3254	105.6	541	290	334	44	12.3	5766
1954	2682	86.3	536	291	335	44	12.2	5765
1955	2487	78.8	528	299	345	46	11.5	5757
1956	3109	95.8	514	310	357	47	10.9	5746
1957	2458	76.1	516	311	360	49	10.5	5745
1958	2707	80.1	493	315	361	46	10.7	5741
1959	2938	84.6	480	320	363	43	11.2	5736
1960	3535	96.6	455	328	370	42	10.8	5728
1961	3982	105.3	441	336	375	39	11.3	5720
1962	4076	99.8	408	338	374	36	11.3	5718
1963	4563	105.7	386	344	379	35	11.0	5712
1964	4541	105.3	387	346	380	34	11.4	5710
1965	3535	82.6	389	346	381	35	11.1	5710
1966	3994	94.7	395	349	383	34	11.6	5707
1967	2743	67.6	411	344	379	35	11.7	5712
1968	2732	66.5	406	344	379	35	11.6	5712
1969	3679	68.6	427	344	381	37	11.5	5712
1970	2431	62.8	431	343	381	38	11.3	5713
1971	3420	87.4	426	345	384	39	10.9	5711
1972	2887	73.4	424	348	388	40	10.6	5708
1973	2816	72.4	429	344	385	41	10.5	5712
1974	3056	82.0	447	347	390	43	10.4	5709
1975	2724	74.5	456	341	384	43	10.6	5715
1976	2990	81.1	452	344	388	44	10.3	5712
1977	2981	80.4	450	346	388	42	10.7	5710
1978	2562	71.6	452	345	386	41	11.0	5711
1979	2975	80.0	448	347	388	41	10.9	5709
1980	3478	92.4	443	350	389	39	11.4	5706
1981	1432	38.3	446	352	390	38	11.7	5704
1982	2833	25.7	476	352	399	47	10.1	5704
1983	624	16.5	441	356	399	43	10.3	5700
1984	2018	43.7	361	358	385	27	13.4	5698
1985	4339	96.6	371	352	381	29	12.8	5704
1986	4769	109.3	382	369	395	26	14.7	5687
1987	4526	109.7	404	366	399	33	12.2	5690
1988	4836	132.8	457	367	400	33	13.8	5689
1989	4820	133.9	463	375	408	33	14.0	5681
1990	5060	134.5	443	374	407	33	13.4	5682
1991	4762	123.3	428	369	401	32	13.4	5687
1992	5075	129.0	424	370	401	31	13.7	5686
1993	3871	97.1	418	368	399	31	13.5	5688
1994	2450	62.7	426	358	389	31	13.8	5698
1995	2829	70.1	413	361	390	29	14.2	5695
1996	3007	75.3	417	364	390	26	16.1	5692
1997	3195	80.5	420	358	384	26	16.2	5698
1998	1598	43.4	424	358	384	26	16.2	5698
1999	1751	45.4	432	-	-	-	-	-
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-
Total	155,625	4008.0						
Minimum	123	3.9	361	259	327	26	10.1	5681
Maximum	5075	134.5	550	375	408	49	16.2	5797
Average	3176	81.8	443	342	381	37	12.0	5714

Note: Well completed August 1951; initial depth to water: 259 ft; surface elevation: 6056 ft; plugged Sept. 1999.

Well G-3

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1950								
1951	192	7.3	634	281	-	-	-	5858
1952	2379	35.4	458	310	358	48	9.5	5829
3192	3192	76.4	399	322	360	38	10.5	5817
1954	2675	66.1	412	322	370	48	8.6	5817
1955	2369	69.4	488	316	368	52	9.4	5823
1956	3149	87.9	465	324	380	56	8.3	5815
1957	2517	70.2	465	324	385	61	7.6	5815
1958	2562	69.5	452	323	386	63	7.2	5816
1959	2931	74.6	424	326	395	69	6.1	5813
1960	3591	82.5	383	335	407	72	5.3	5804
1961	3612	79.9	369	343	414	71	5.2	5796
1962	4057	83.7	344	348	418	70	4.9	5791
1963	4555	86.7	317	352	422	70	4.5	5787
1964	4487	78.6	292	355	424	69	4.2	5784
1965	3498	65.6	313	350	419	69	4.5	5789
1966	3991	73.7	308	353	420	67	4.6	5786
1967	2752	52.9	320	344	418	74	4.3	5795
1968	3086	56.5	305	341	418	77	4.0	5798
1969	2672	50.8	317	338	417	79	4.0	5801
1970	2736	55.4	338	336	419	83	4.1	5803
1971	3337	64.2	321	342	423	81	4.0	5797
1972	2838	50.9	299	341	421	80	3.7	5798
1973	2843	47.3	277	341	418	77	3.6	5798
1974	3006	49.3	273	342	424	82	3.3	5797
1975	2632	43.1	273	341	428	87	3.1	5798
1976	2971	82.6	463	359	447	88	5.3	5780
1977	2961	78.9	444	353	448	95	4.7	5786
1978	2590	66.4	427	345	443	98	4.4	5794
1979	3014	69.0	381	345	450	105	3.6	5794
1980	3448	61.8	299	348	453	105	2.8	5791
1981	4315	66.6	257	357	467	110	2.3	5782
1982	3550	51.0	239	349	459	110	2.2	5790
1983	2183	31.3	239	340	463	123	1.9	5799
1984	1211	19.0	267	355	475	120	2.2	5784
1985	1587	22.1	232	351	470	119	2.0	5788
1986	2266	26.7	196	375	492	117	1.7	5764
1987	-	<0.1	-	-	-	-	-	-
1988	-	3.4	-	-	-	-	-	-
1989	-	<0.1	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-
1998	-	-	-	326	-	-	-	5813
1999	-	-	-	397	-	-	-	5742
2000	-	-	-	402	-	-	-	5737
2001	-	-	-	-	-	-	-	-
Total	105,755	2156.7						
Minimum	192	3.4	196	281	358	38	1.7	5737
Maximum	4555	87.9	634	402	492	123	10.5	5858
Average	2938	58.3	352	342	422	81	4.8	5797

Note: Completed July 1951; initial depth to water 280 ft; surface elevation: 6,139 ft; abandoned 1998.

Well G-4

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1951	-	12.5	-	357	477	12	-	5872
1952	2401	56.9	395	374	474	100	3.9	5855
1953	2677	55.2	344	380	472	92	3.7	5849
1954	2256	58.8	434	383	526	143	3.0	5846
1955	1172	22.7	322	378	481	103	3.1	5851
1956	1800	33.9	314	377	491	114	2.8	5852
1957	1324	24.2	305	373	498	125	2.4	5856
1958	1970	35.9	304	370	490	120	2.5	5859
1959	1819	31.6	290	378	494	116	2.5	5851
1960	2457	37.0	251	385	509	124	2.0	5844
1961	2787	45.0	269	389	512	123	2.2	5840
1962	2738	41.7	254	386	505	119	2.1	5843
1963	3519	46.4	220	388	504	116	1.9	5841
1964	3561	42.9	201	396	499	103	1.9	5833
1965	2100	23.8	189	394	492	98	1.9	5835
1966	2219	33.6	252	391	498	107	2.4	5838
1967	2690	44.8	278	388	509	121	2.3	5841
1968	2083	31.4	251	386	509	123	2.0	5843
1969	1309	17.4	222	387	505	118	1.9	5842
1970	606	7.7	212	384	504	114	1.9	5845
1971	1640	21.0	213	389	503	114	1.9	5840
1972	2840	33.3	195	391	507	116	1.7	5838
1973	3006	37.2	206	392	521	129	1.6	5837
1974	2672	34.3	214	392	519	127	1.7	5837
1975	1977	41.0	346	403	559	156	2.2	5826
1976	2859	57.8	337	406	571	165	2.0	5823
1977	2954	62.4	352	406	589	183	1.9	5823
1978	2607	49.5	317	398	589	191	1.7	5831
1979	2974	52.9	296	395	586	191	1.6	5834
1980	2235	35.6	266	394	580	186	1.4	5835
1981	432	8.2	316	385	573	188	1.7	5844
1982	3657	65.2	297	386	578	192	1.5	5843
1983	2604	42.2	270	-	-	-	-	-
1984	3766	49.7	220	-	-	-	-	-
1985	1747	21.7	207	402	572	170	1.2	5827
1986	2678	33.9	211	396	574	178	1.2	5833
1987	2011	25.1	208	398	573	175	1.2	5831
1988	301	4.1	227	390	545	155	1.5	5839
1989	1739	21.6	207	401	562	161	1.3	5828
1990	1539	16.8	182	381	564	183	1.0	5848
1991	1254	13.7	181	382	559	177	1.0	5847
1992	1116	12.0	179	387	544	157	1.1	5842
1993	0	0.0	-	374	-	-	-	5855
1994	8	<0.1	163	363	525	162	1.0	5866
1995	0	0.0	-	368	-	-	0.0	5861
1996	721	7.2	166	374	570	196	0.8	5855
1997	518	5.4	174	375	560	185	0.9	5854
1998	4	0.03	170	368	-	-	-	5861
1999	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-
Total	91,347	1455.2						
Minimum	0	0.0	163	357	472	12	0.0	5823
Maximum	3766	65.2	434	406	589	196	3.9	5872
Average	1944	31.0	254	386	530	140	1.8	5843

Note: Well Completed May 1951; initial depth to water: 347 ft; surface elevation: 6,229 ft; plugged: Sept. 1999.

Well G-5

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1951	-	6.7	-	414	-	-	-	5892
1952	2579	73.8	477	422	480	58	8.2	5884
1953	1433	37.8	440	425	467	42	10.5	5881
1954	2617	80.9	515	429	473	44	11.7	5877
1955	2529	80.4	530	427	472	45	11.8	5879
1956	3052	97.0	530	431	478	47	11.3	5875
1957	2385	64.1	448	424	466	42	10.7	5882
1958	1523	49.1	537	428	477	49	11.0	5878
1959	2917	101.7	581	435	495	60	9.7	5871
1960	2828	98.0	578	437	501	64	9.0	5869
1961	3908	134.0	572	438	507	69	8.3	5868
1962	4186	142.0	565	440	511	71	8.0	5866
1963	4528	151.0	556	441	513	72	7.7	5865
1964	4352	150.4	553	446	516	70	7.9	5860
1965	3520	117.1	555	443	516	73	7.6	5863
1966	2555	83.2	543	445	520	75	7.2	5861
1967	2405	80.0	554	444	519	75	7.4	5862
1968	2513	81.2	539	443	517	74	7.3	5863
1969	2649	83.3	524	450	520	70	7.5	5856
1970	2771	88.9	535	453	521	68	7.9	5853
1971	2657	88.3	554	450	521	71	7.8	5856
1972	2902	92.4	531	441	514	73	7.3	5865
1973	3003	97.5	541	444	515	71	7.6	5862
1974	2054	69.0	560	440	513	73	7.7	5866
1975	2266	74.7	549	433	500	67	8.2	5873
1976	2955	95.0	536	442	504	62	8.6	5864
1977	2836	92.1	541	444	504	60	9.0	5862
1978	2608	84.2	538	442	502	60	9.0	5864
1979	2766	86.5	522	442	502	60	8.7	5864
1980	2896	89.0	512	442	502	60	8.5	5864
1981	2124	66.7	523	451	528	77	6.8	5855
1982	1219	38.2	522	455	510	55	9.5	5851
1983	2904	73.2	420	445	492	47	8.9	5861
1984	3838	115.4	501	452	507	55	9.1	5854
1985	2193	67.9	516	453	509	56	9.2	5853
1986	2219	52.5	394	453	494	41	9.6	5853
1987	5732	116.7	379	462	504	42	9.0	5844
1988	4841	115.3	396	466	507	41	9.7	5840
1989	4715	110.9	392	474	514	40	9.8	5832
1990	5094	119.2	390	485	526	41	9.5	5821
1991	4981	113.0	378	487	534	47	8.0	5819
1992	5006	114.4	376	470	508	38	9.9	5836
1993	3859	92.2	398	466	503	37	10.8	5840
1994	109	2.5	388	459	494	35	11.1	5847
1995	807	17.6	364	-	-	-	-	-
1996	2686	66.9	415	-	-	-	-	-
1997	3238	81.5	419	-	-	-	-	-
1998	413	6.5	374	-	-	-	-	-
1999	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-
Total	138,171	4039.9						
Minimum	109	2.5	364	414	466	35	6.8	5819
Maximum	5732	151	581	487	534	77	11.8	5892
Average	2940	84.2	491	446	504	58	8.9	5860

Note: Well completed May 1951; initial depth to water: 411 ft; surface elevation: 6,306 ft; plugged Sept. 1999

Well G-6

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1964	1912	45.0	392	581	659	78	5.0	5841
1965	3200	74.9	390	582	660	78	5.0	5840
1966	3931	92.2	391	585	658	73	5.4	5837
1967	5454	57.8	393	580	653	73	5.4	5842
1968	2597	56.2	361	574	647	73	4.9	5848
1969	2698	55.6	344	568	636	68	5.1	5854
1970	2765	51.0	307	569	634	65	4.7	5853
1971	2932	42.8	243	573	629	56	4.3	5849
1972	2516	57.0	378	578	670	92	4.1	5844
1973	2991	65.3	364	579	667	88	4.1	5843
1974	2950	63.8	361	579	665	86	4.2	5843
1975	2717	56.7	348	577	659	82	4.2	5845
1976	2966	57.8	325	584	662	78	4.2	5838
1977	2954	54.4	307	586	659	73	4.2	5836
1978	2218	384.0	289	581	645	64	4.5	5841
1979	1030	18.2	295	579	645	66	4.5	5843
1980	1789	34.5	322	583	670	87	3.7	5839
1981	4302	76.5	296	586	673	87	3.4	5836
1982	3763	63.6	281	588	669	81	3.5	5834
1983	1960	35.4	301	582	668	86	3.5	5840
1984	3010	55.3	306	589	666	77	4.0	5833
1985	3980	71.4	299	586	664	78	3.8	5836
1986	4420	76.7	293	576	654	78	3.8	5846
1987	5100	81.4	266	595	671	76	3.5	5827
1988	5121	82.1	267	591	669	78	3.4	5831
1989	5000	81.6	272	592	669	77	3.5	5830
1990	5202	44.9	272	589	670	81	3.4	5833
1991	5063	81.2	267	591	674	83	3.2	5831
1992	4382	70.2	268	591	673	80	3.4	5831
1993	-	-	-	575	-	-	-	5847
1994	1660	27.5	276	572	652	80	3.5	5850
1995	2892	46.4	267	577	660	83	3.2	5845
1996	2311	36.0	260	581	661	80	3.2	5841
1997	1262	19.5	258	581	658	77	3.3	5841
1998	3311	46.8	243	583	666	83	2.9	5839
1999	867	12.9	247	-	-	-	-	-
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-
Total	111,226	2276.6						
Minimum	867	12.9	243	568	629	56	2.9	5827
Maximum	5454	384.0	393	595	674	92	5.4	5854
Average	3178	65.0	307	582	660	78	4.0	5840

Note: Well completed Mar. 1964; initial depth to water: 572 ft; surface elevation: 6,422 ft; plugged Sept. 1999.

Well G-2A

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1998			900	318.4	429.7	111.3	8.1	5821.6
1999	1708	82.0	800	390.6	428.9	38.3	20.9	5749.4
2000	3904	178.0	760	407.2	463.4	56.2	13.5	5732.8
2001	3012	148.2	820	389.3	443.8	54.5	15.0	5750.7
Total	8623	408.2						
Minimum	1708	82.0	760	318.4	428.9	38.3	8.1	5732.8
Maximum	3904	178.0	900	407.2	463.4	111.3	20.9	5821.6
Average	2874	136.1	820	376.4	441.5	65.1	14.4	5763.6

Note: Well completed March 1998, initial depth to water: 318.4 ft; surface elevation: 6,140 ft

Well G-3A

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1998			800	396.8	518.3	121.5	6.6	5815.2
1999	1036	40.8	656	415.3	428.0	12.7	51.7	5796.7
2000	2955	102.8	580	451.0	501.5	50.5	11.5	5761.0
2001	717	28.0	650	507.5	526.1	18.6	34.9	5704.5
Total	4709	171.6						
Minimum	717	28.0	580	396.8	428.0	12.7	6.6	5704.5
Maximum	2955	102.8	800	507.5	526.1	121.5	51.7	5815.2
Average	1570	57.2	672	442.7	493.5	50.8	26.2	5769.4

Note: Well completed May 1998, initial depth to water: 396.8 ft; surface elevatioin: 6,212 ft.

Well G-4A

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1998			780	451.7	590.3	138.6	5.6	5847.3
1999	1746	61.2	584	478.7	565.7	87.0	6.7	5820.3
2000	1959	61.7	525	500.1	575.5	75.4	7.0	5798.9
2001	206	6.5	525	515.0	557.0	42.0	12.5	5784.0
Total	3910	129.4						
Minimum	206	6.5	525	451.7	557.0	42.0	5.6	5784.0
Maximum	1959	61.7	780	515.0	590.3	138.6	12.5	5847.3
Average	1303	43.1	604	486.4	572.1	85.8	8.0	5812.6

Note: Well Completed April 1998; initial depth to water: 451.7 ft; surface elevation: 6299 ft.

Well G-5A

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1998			400	550.7	702.9	152.2	2.6	5863.3
1999	9.4	0.23	400	-	-	-	-	-
2000	64.8	1.6	400	558.4	684.8	126.4	3.2	5855.6
2001	9.3	0.21	375	565.6	599.0	33.4	11.2	5848.4
Total	83.5	2.0						
Minimum	9	0.2	375	550.7	599.0	33.4	2.6	5848.4
Maximum	65	1.6	400	565.6	702.9	152.2	11.2	5863.3
Average	28	0.7	394	558.2	662.2	104.0	5.7	5855.8

Note: Well Completed June 1998; initial depth to water: 550.7 ft; surface elevation: 6,414 ft.

Well O-1

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1990				675				5721
1991								
1992								
1993								
1994								
1995	-	-	-	675	-	-	-	5721
1996	-	-	-	675	-	-	-	5721
1997	-	-	-	676	-	-	-	5720
1998	1252	67.1	918	-	-	-	-	-
1999	222	13.0	973	701.9	802.2	100.3	9.7	5694
2000	914	53.3	973	695.4	829.2	133.8	7.3	5701
2001	431	25.2	973	686.3	827.6	141.3	6.9	5710
Total	2819	158.6						
Minimum	222	13.0	918	675.0	802.2	100.3	6.9	5694
Maximum	1252	67.1	973	701.9	829.2	141.3	9.7	5721
Average	705	39.7	959	683.5	819.7	125.1	8.0	5712

Note: Well completed August 1990; initial depth to water: 675 ft; surface elevation 6,396 ft.

Well O-4

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1990				780				5847
1991								
1992								
1993	2942	283.8	1603	761	789	28	57.3	5866
1994	2456	205.7	1396	760	781	21	66.5	5867
1995	0	0.0	-	762	-	-	-	5865
1996	2330	209.6	1499	-	-	-	-	-
1997	2396	216.4	1505	-	-	-	-	-
1998	2723	239.7	1471	-	-	-	-	-
1999	2260	200.5	1479	-	-	-	-	-
2000	1368	119.0	1450	-	-	-	-	-
2001	4177	363.4	1450	-	-	-	-	-
Total	20,651	1838.1						
Minimum	1368	119.0	1396	760.0	781.0	21.0	57.3	5847
Maximum	4177	363.4	1603	780.0	789.0	28.0	66.5	5867
Average	2581	229.8	1482	765.8	785.0	24.5	61.9	5861

Note: Well completed Mar. 1990; initial depth to water: 780 ft; surface elevation 6,627 ft.

Well PM-1

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1965	2754	99.2	600	746	786	40	15.0	5774
1966	3086	108.0	583	740	779	39	15.0	5780
1967	2870	111.0	644	737	781	44	14.6	5783
1968	1846	68.1	615	735	769	34	18.1	5785
1969	951	34.4	603	733	766	33	18.3	5787
1970	1781	66.2	620	733	769	36	17.2	5787
1971	2728	101.0	617	733	766	33	18.7	5787
1972	2415	84.9	586	735	762	27	21.7	5785
1973	1688	46.5	459	736	755	19	24.2	5784
1974	2649	96.3	606	740	768	28	21.6	5780
1975	2567	94.8	616	741	766	25	24.6	5779
1976	2933	106.8	607	744	767	23	26.4	5776
1977	2969	105.4	592	745	767	22	26.9	5775
1978	2544	90.6	593	745	767	22	27.0	5775
1979	2350	83.4	592	744	766	22	26.9	5776
1980	2786	98.5	589	746	769	23	25.6	5774
1981	2789	98.5	589	747	769	22	26.8	5773
1982	2820	99.6	589	748	770	22	26.8	5772
1983	2464	86.5	585	747	769	22	26.6	5773
1984	2667	92.8	580	749	772	23	25.2	5771
1985	2760	95.4	576	749	770	21	27.4	5771
1986	2130	73.9	578	748	770	22	26.3	5772
1987	2912	102.4	586	752	773	21	27.9	5768
1988	2758	98.0	592	751	775	24	24.7	5769
1989	3014	104.9	580	752	774	22	26.4	5768
1990	2620	88.2	561	752	772	20	28.1	5768
1991	2600	88.6	568	752	774	22	25.8	5768
1992	2503	92.7	617	756	780	24	25.7	5764
1993	1802	63.9	591	758	779	21	28.1	5762
1994	1254	43.4	577	755	778	23	25.1	5765
1995	870	29.7	569	753	776	23	24.7	5767
1996	1084	36.3	560	755	778	23	24.3	5765
1997	1406	47.7	560	760	784	24	23.3	5760
1998	1087	34.3	574	760	786	27	21.3	5761
1999	1629	57.3	586	-	-	-	-	-
2000	3032	106.6	586	-	-	-	-	-
2001	1895	66.6	586	-	-	-	-	-
Total	85,012	3002.4						
Minimum	870	29.7	459	733	755	19	14.6	5760
Maximum	3086	111.0	644	760	786	44	28.1	5787
Average	2298	81.1	587	746	772	26	23.7	5774

Note: Well completed Mar. 1965; initial depth to water: 722.1 ft; surface elevation 6,520 ft.

Well PM-2

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1965				823				
1966	221	18.9	1425	826	889	63	22.6	5889
1967	4336	370.0	1422	834	888	54	26.3	5881
1968	3865	328.2	1415	838	889	51	27.8	5877
1969	3304	279.9	1412	838	890	52	27.2	5877
1970	3529	300.6	1420	839	893	54	26.3	5876
1971	4035	339.5	1402	841	898	57	24.6	5874
1972	4611	385.3	1393	845	902	57	24.4	5870
1973	4571	380.6	1388	849	907	58	23.9	5866
1974	5443	450.9	1381	853	912	59	23.4	5862
1975	4644	385.3	1383	854	913	59	23.4	5861
1976	5382	442.0	1369	866	924	58	23.6	5849
1977	3306	272.8	1375	868	924	56	24.6	5847
1978	4743	388.4	1365	871	928	57	23.9	5844
1979	4671	381.8	1262	872	924	52	24.3	5843
1980	5023	409.6	1359	873	931	58	23.4	5842
1981	4551	370.1	1355	876	934	58	23.4	5839
1982	4319	359.3	1386	874	934	60	23.1	5841
1983	1922	157.9	1369	876	935	59	23.2	5839
1984	996	81.6	1365	866	930	64	21.3	5849
1985	1749	143.3	1365	851	916	65	21.0	5864
1986	1036	84.4	1359	851	915	64	21.2	5864
1987	351	28.3	1340	851	907	56	23.9	5864
1988	1843	146.8	1328	869	931	62	21.4	5846
1989	1639	130.0	1322	860	920	60	22.0	5855
1990	3164	250.4	1319	860	928	68	19.4	5855
1991	2141	170.7	1329	855	918	63	21.1	5860
1992	3486	277.7	1328	860	929	69	19.2	5855
1993	3420	267.8	1305	855	924	69	18.9	5860
1994	3922	298.9	1270	870	934	64	19.8	5845
1995	2778	217.7	1306	870	934	64	20.4	5845
4023	4023	302.2	1250	-	-	-	-	-
1997	2154	162.9	1260	-	-	-	-	-
1998	4835	386.2	1243	839	912	73	17.0	5876
1999	3257	249.2	1275	-	-	-	-	-
2000	4365	333.9	1275	852	919	67	19.0	5863
2001	3965	303.3	1275	855	920	64	19.8	5860
Total	121,600	9856.4						
Minimum	221	18.9	1243	826	888	51	17.0	5839
Maximum	5443	450.9	1425	876	935	73	27.8	5889
Average	3378	273.8	1344	856	917	60	22.6	5859

Note: Well completed July 1965; initial depth to water: 823 ft; surface elevation 6715 ft.

Well PM-3

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1965								
1966				740				
1967								
1968	2327	187.4	1342	743	771	28	47.9	5897
1969	3241	254.7	1310	746	772	26	50.4	5894
1970	2905	227.8	1307	750	774	24	54.5	5890
1971	2774	216.3	1300	751	774	23	56.5	5889
1972	2445	192.1	1310	752	775	23	56.9	5888
1973	3256	257.8	1320	755	778	23	57.4	5885
1974	3241	255.3	1313	756	779	23	57.1	5884
1975	3421	269.3	1312	757	780	23	57.0	5883
1976	3171	268.3	1410	758	784	26	54.2	5882
1977	2792	235.5	1406	758	784	26	54.1	5882
1978	2516	211.0	1398	759	784	25	55.9	5881
1979	2359	197.2	1393	760	784	24	58.0	5880
1980	2796	234.4	1397	760	785	25	55.9	5880
1981	2784	232.4	1391	761	786	25	55.7	5879
1982	2831	238.1	1402	762	785	23	61.0	5878
1983	2496	207.6	1386	762	785	23	60.3	5878
1984	3317	275.6	1385	762	787	25	55.4	5878
1985	2643	221.2	1395	762	784	22	63.4	5878
1986	2920	244.8	1397	763	787	24	58.2	5877
1987	2984	250.2	1397	763	788	25	55.9	5877
1988	2766	232.0	1397	764	788	24	58.2	5876
1989	2656	221.0	1386	765	791	26	53.3	5875
1990	2949	244.6	1382	767	790	23	60.1	5873
1991	2752	229.5	1385	768	791	23	60.2	5872
1992	3610	307.4	1419	770	794	24	59.1	5870
1993	2018	168.5	1391	771	797	26	53.5	5869
1994	966	78.8	1359	772	796	24	56.6	5868
1995	1971	159.7	1350	772	796	24	56.3	5868
1996	1401	118.5	1410	776	802	26	54.2	5864
1997	961	80.6	1398	779	805	26	53.8	5861
1998	2609	222.5	1395	780	808	27	51.5	5860
1999	1607	135.0	1400	-	-	-	-	-
2000	1107	93.0	1400	-	-	-	-	-
2001	1093	91.8	1400	-	-	-	-	-
Total	85,686	7059.8						
Minimum	961	79	1300	743	771	22	47.9	5860
Maximum	3610	307	1419	780	808	28	63.4	5897
Average	2520	208	1375	762	787	24	56.2	5878

Note: Well completed Nov. 1966; initial depth to water: 740 ft; surface elevation 6,640 ft.

Well PM-4

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1981				1060				
1982	869	76.2	1460	1050	1091	41	35.6	5870
1983	5267	452.5	1432	1066	1101	35	40.9	5854
1984	4059	325.8	1338	1065	1104	39	34.3	5855
1985	4759	379.2	1328	1066	1101	35	37.9	5854
1986	3925	307.4	1305	1084	1119	35	37.3	5836
1987	5071	392.2	1289	1081	1117	36	35.8	5839
1988	2435	218.7	1313	1079	1117	38	34.6	5841
1989	5387	418.9	1296	1085	1122	37	35.0	5835
1990	2827	219.3	1293	1083	1123	40	32.3	5837
1991	2832	219.5	1292	1081	1123	42	30.8	5839
1992	2064	158.3	1278	1084	1125	41	31.2	5836
1993	3901	249.7	1295	-	-	-	-	-
1994	6178	463.5	1250	1085	1128	43	29.1	5835
1995	5736	428.2	1244	-	-	-	-	-
1996	2721	207.4	1270	1091	1139	48	26.5	5829
1997	5222	414.5	1323	1093	1142	49	27.0	5827
1998	996	74.9	1224	1092	1128	36	34.0	5828
1999	1335	112.2	1400	1082	1133	52	27.2	5838
2000	2416	192.8	1330	1082	1133	51	26.2	5838
2001	2478	197.8	1330	1079	1131	53	25.2	5841
Total	70,479	5509.0						
Minimum	869	74.9	1224	1050	1091	35	25.2	5827
Maximum	6178	463.5	1460	1093	1142	53	40.9	5870
Average	3524	275	1315	1079	1121	42	32.3	5841

Note: Well completed Aug. 1981; initial depth to water: 1060 ft; surface elevation 6,920 ft.

Well PM-5

Year	Pump Time (h)	Production (10^6 gal.)	Pump Rate (gpm)	Average Water Level Nonpumping (ft)	Average Water Level Pumping (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Nonpumping Water Elevation (ft)
1982				1208				
1983	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-
1985	-	2.0	-	-	-	-	-	-
1986	2047	147.3	1,199	-	-	-	-	-
1987	1620	118.6	1,220	1,237	1,345	108	11.3	5858
1988	1754	128.6	1,221	1,233	1,345	112	10.9	5862
1989	1184	86.2	1,213	1,239	1,352	113	10.7	5856
1990	1611	121.0	1,252	1,234	1,347	113	11.1	5861
1991	1497	112.1	1,248	1,239	1,346	107	11.7	5856
1992	2823	208.4	1,233	1,248	1,345	97	12.7	5847
1993	1709	126.0	1,229	1,224	1,321	97	12.7	5871
1994	2131	156.9	1,227	1,234	1,314	80	15.3	5861
1995	3948	291.0	1,228	-	-	-	-	-
1996	2978	224.6	1,257	1,258	1,351	93	13.5	5837
1997	1261	91.8	1,213	1,254	1,342	88	13.8	5841
1998	3155	222.8	1,161	1236	1321	84	13.7	5859
1999	3361	237.0	1,175	-	-	-	-	-
2000	2628	185.3	1,175	1239	1320	81	14.5	5856
2001	1786	125.9	1,175	-	-	-	-	-
Total	35,493	2583.5						
Minimum	1184	2.0	1161	1224	1314	80	10.7	5837
Maximum	3948	291.0	1257	1258	1352	113	15.3	5871
Average	2218	152.1	1214	1240	1337	98	12.7	5855

Note: Well completed Sept. 1982; initial depth to water: 1,208 ft; surface elevation 7,095 ft.

Appendix E

Short-Term Water-Level Data

Appendix E. Short-Term Water-Level Data

The short-term water-level trends of water supply wells typically show the water level responses to the varying pumping demands placed on each well. The time series plots of pumping and nonpumping short-term water-level trends of active water supply wells are shown and discussed below for each active supply well. Each water level figure shows the monthly production from the well where water levels were obtained and for nearby wells that appear to indicate water level impacts. A summary of the short-term water-level data can be found in Section 3.1.

Water-level data for supply wells were obtained by LAC personnel using pressure transducers, except for wells G-1A, PM-1 and PM-3, which are equipped with bubble pressure lines. When pressure transducers are installed, water-level measurements are usually obtained manually to calibrate the transducer readings. Occasionally the pressure transducers fail and must be removed or replaced during well maintenance activities. When transducers are replaced, the measurement datum may change by up to 1 to 2 ft; as a result, some water-level records might indicate false.

Most water supply wells at Los Alamos are electric and are operated daily during nonpeak electrical demand times. Therefore, most wells are turned on and off each day, which does not allow sufficient time for static pumping or nonpumping water levels to be determined. Well PM-4 is usually operated continuously during summer peak demand periods and is usually not operated during winter months; thus, pumping and nonpumping water levels for this well may at times approach static conditions each year.

The pumping and nonpumping water-level data for the water supply wells were compiled for this report on approximately a weekly basis for each well and the average values for the year were determined (see Appendix D). Water levels in production wells are obtained by two methods: (1) some wells have chart recorders that continuously record water levels above the pump, whether the wells are pumping or not pumping, and (2) some wells have digital readouts in the well house that display the water level above the pump. For wells with digital readouts, Los Alamos County employees manually record the water level usually twice daily during routine inspections of the well equipment and note whether the pump was operating at the time the water level was recorded.

The pumping and nonpumping water levels of wells with chart recorders were determined by obtaining the highest water level when the well is not pumping and the lowest water level when the well is pumping for each week. For wells with digital readouts, the daily well inspection and water-level records were reviewed and the highest nonpumping water levels and the lowest pumping water levels were documented for each week. This approach attempts to obtain pumping and nonpumping water levels that approach static conditions and eliminates intermediate water levels obtained when the well was on or off for short periods of time. The weekly pumping and nonpumping water-level data were compiled for each well, and the data were entered into a database for data storage and retrieval.

Guaje Field

Figure E-1 shows the pumping and nonpumping water levels in well G-1A from 1997 through 2001, along with the monthly production history for the well. During 1997 and 1998, pumping and nonpumping water levels typically did not vary more than about 20 ft in response to changes in pumping demand.

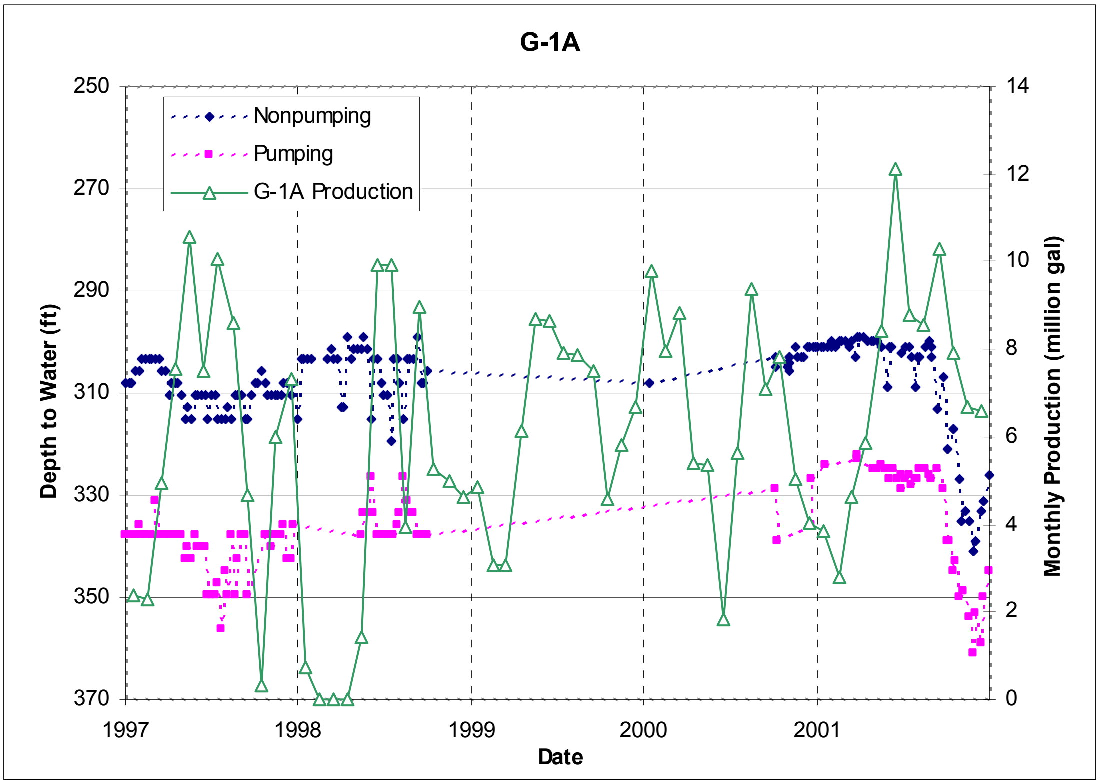

Figure E-1. Nonpumping and pumping water levels and monthly production, well G-1A, 1997 – 2001

During drilling of the Guaje replacement wells in late 1997 and early 1998, production from nearby wells was curtailed to allow water levels to recover in the Guaje field. Well G-1A was not pumped regularly during October 1997 and January through April 1998; during this time the nonpumping water level in well G-1A rose about 15 ft, from about 315 ft below surface to about 300 ft below surface. When the well was placed back in routine service in June 1998, the nonpumping water levels returned to an average of 310 ft below surface. Nonpumping water levels during the winter of 2000 and 2001 again recovered to about 300 ft below surface in response to seasonal lower water demand. During the last quarter of 2001, the pumping and nonpumping water levels in well G-1A declined about 100 ft. These water levels do not appear to correspond with the monthly production demand of the well or to nearby well G-2A (which exhibits a rising water level during this quarter); these water levels may represent a malfunction of the recording device in well G-1A.

The pumping and nonpumping water levels and monthly production for replacement well G-2A for 1998 through 2001 are shown in Figure E-2, along with monthly production from well G-2A and nearby well G-3A. The water levels shown for 1998 were obtained during the pumping tests performed upon completion of the well. The well was connected to distribution pipelines and placed in production in June 1999. Soon after production began from well G-2A, the nonpumping water level was about 400 ft below surface, until May and June of 2000 when production demand was greatest (during and after the Cerro Grande fire). During this time, the nonpumping water level declined about 60 ft, to around 460 ft below surface, in response to the higher production from G-2A and from nearby well G-3A. During the winter months of 2000–2001, well G-2A was not in routine service and the nonpumping water level recovered to about 350 ft below surface, within about 30 ft of the initial 1998 water level. In 2001, the nonpumping and pumping water levels responded to production in a similar manner; however, reduced production demands led to reduced declines in water levels. The lowest nonpumping water levels in well G-2A in 2001 resulted from pumping both wells G-2A and G-3A in June 2001 (Figure E-2).

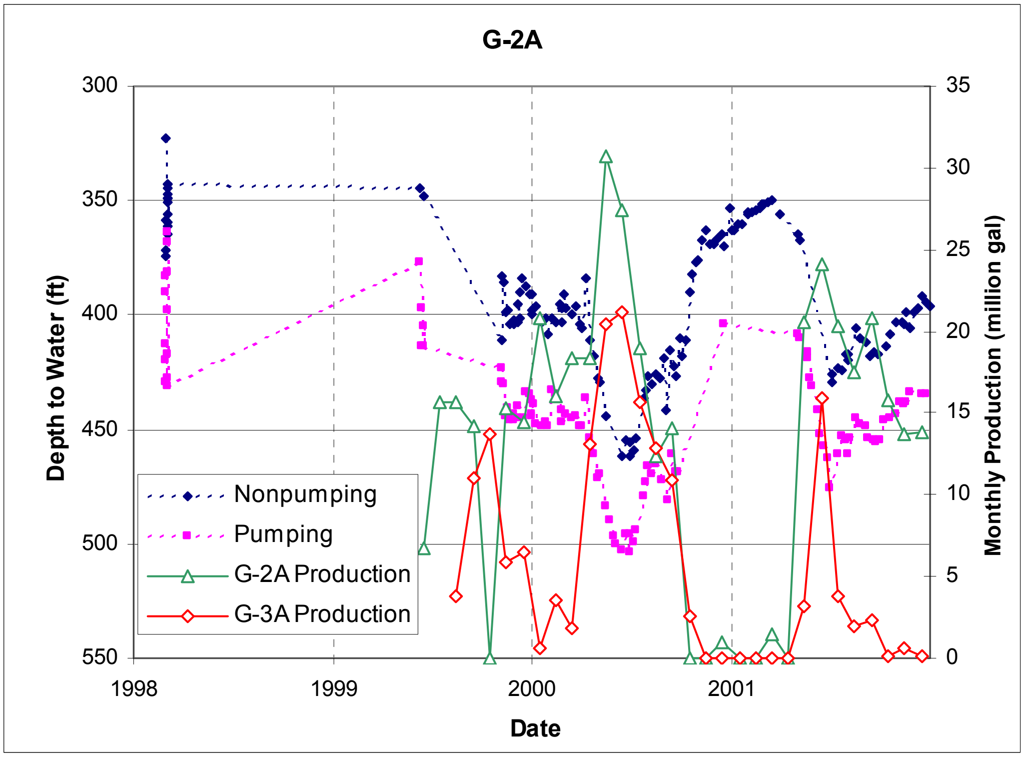

Figure E-2. Nonpumping and pumping water levels and monthly production, well G-2A, 1998 – 2001

The pumping and nonpumping water levels and monthly production for well G-3A for 1998 through 2001 are shown in Figure E-3. The 1998 water levels illustrate the range in pumping and nonpumping water levels that occurred during the pumping tests when the well was completed. Well G-3A was placed into production in August 1999; the first available water levels in October indicate that nonpumping water levels were about 425 ft below surface. During the low demand winter months of 1999–2000, the nonpumping water level recovered slightly to about 410 ft below surface. During the summer of 2000, the nonpumping water levels in well G-3A fell to about 480 ft below surface. Water-level data for well G-3A during the winter months of 2000–2001 indicate falling water levels when the well was not in production; these data suggest a problem with the recording device and are not reliable.

The pumping and nonpumping water levels and monthly production for well G-4A for 1998 through 2000 are shown in Figure E-4. The 1998 water levels illustrate the range in pumping and nonpumping water levels that occurred during the pumping tests when the well was completed. Well G-4A was placed into production in June 1999 when initial water levels were about 450 ft below surface. Pumping during the summer of 1999 lowered nonpumping water levels to about 490 ft below surface; during the winter of 1999–2000 the water level recovered to about 475 ft below surface. Pumping during the summer of 2000 lowered nonpumping water levels to about 510 ft below surface. Well G-4A was not in routine production through most of 2001, and water level data were not routinely obtained.

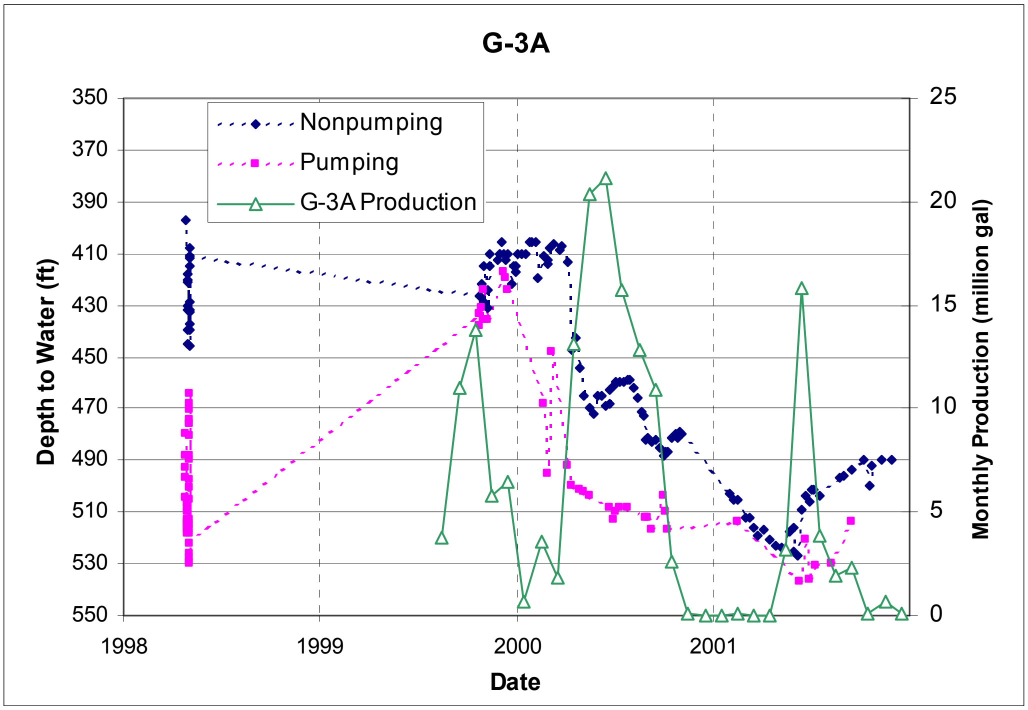

Figure E-3. Nonpumping and pumping water levels and monthly production, well G-3A, 1998 – 2001

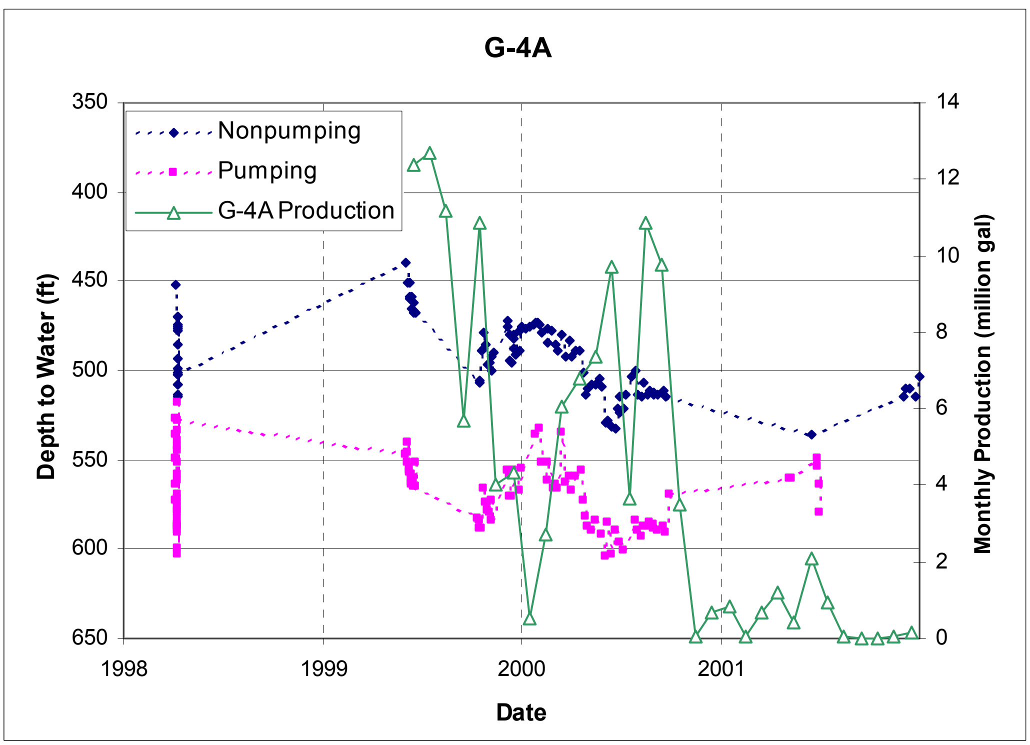

Figure E-4. Nonpumping and pumping water levels and monthly production, well G-4A, 1998 – 2001

The pumping and nonpumping water levels and monthly production for well G-5A for 1998 through 2001 are shown in Figure E-5. The 1998 water levels illustrate the range in pumping and nonpumping water levels that occurred during the pumping tests when the well was completed. Well G-5A was placed into production in September 1999, but few water levels are available because this well has not been in routine production. The nonpumping water levels in 2000 were about 560 ft below surface and in the latter part of 2001 were about 575 ft below surface.

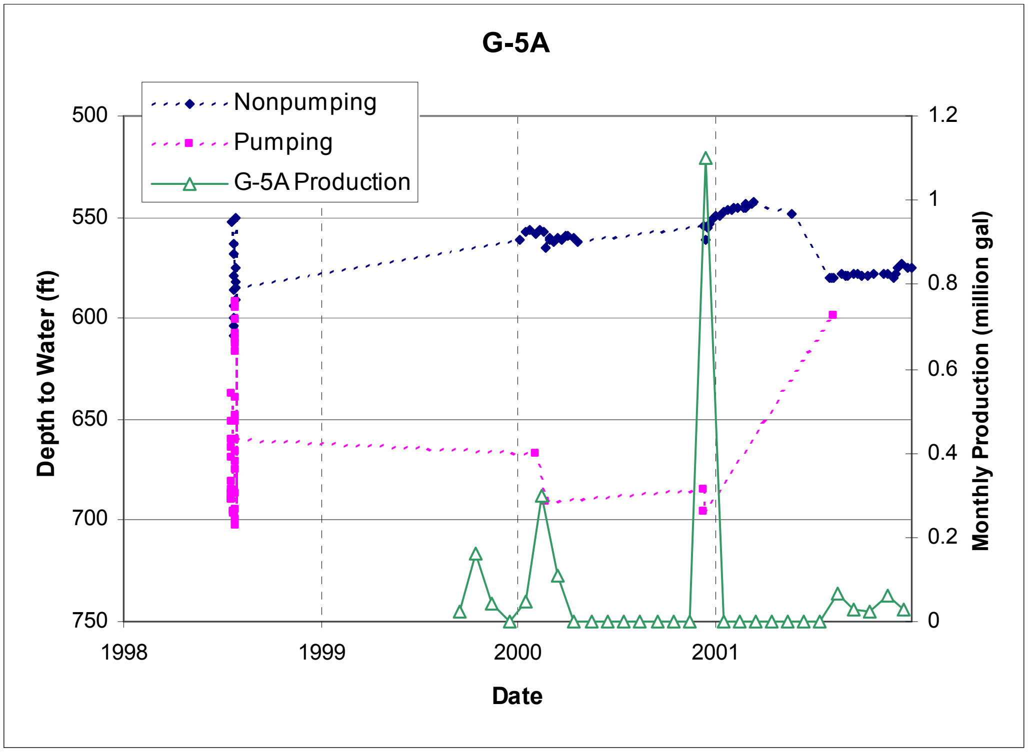

Figure E-5. Nonpumping and pumping water levels and monthly production, well G-5A, 1998 – 2001

Pajarito Field

The available pumping and nonpumping water levels and monthly production for well PM-1 for 1998 through 2001 are shown in Figure E-6. Water levels for well PM-1 are only available for 1998, when the nonpumping water levels ranged from 753 to 768 ft below surface in response to pumping demands.

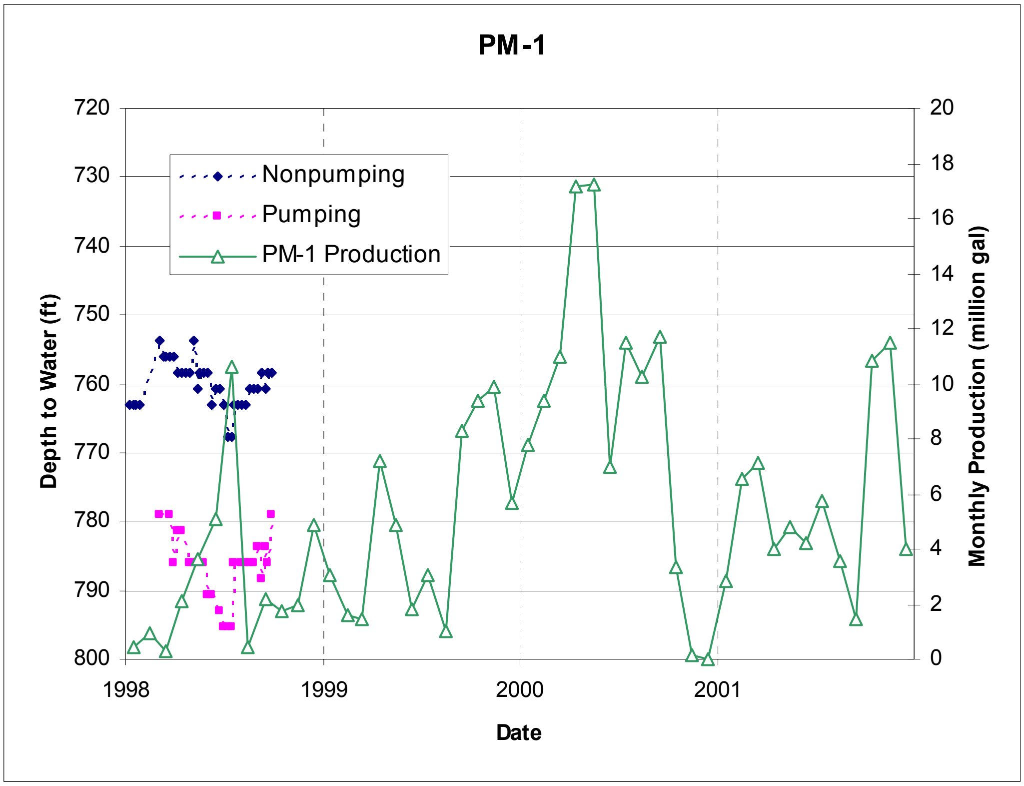

Figure E-6. Nonpumping and pumping water levels and monthly production, well PM-1, 1998 – 2001

The pumping and nonpumping water levels and monthly production for well PM-2 for 1998 through 2001 are shown in Figure E-7. Well PM-2 is usually pumped routinely so short-term nonpumping water levels show fluctuations depending on the amount of recovery time between pumping. Nonpumping water levels in well PM-2 in 1998 were about 830 to 850 ft below surface, and in 2000 about 840 to 860 ft below surface. In 2001, water levels ranged from 840 to 870 ft below surface. The water levels in well PM-2 respond to the pumping demand and during the winter months of 2000–2001, recovered about 20 ft in response to reduced production.

The monthly production from nearby well PM-4 is also shown on Figure E-7. The pumping and nonpumping water levels at well PM-2 show the impact of high volume pumping at PM-4. The lowest pumping and nonpumping water levels observed at well PM-2 in the summer of 2000 and 2001 occurred when nearby well PM-4 was operating at peak production.

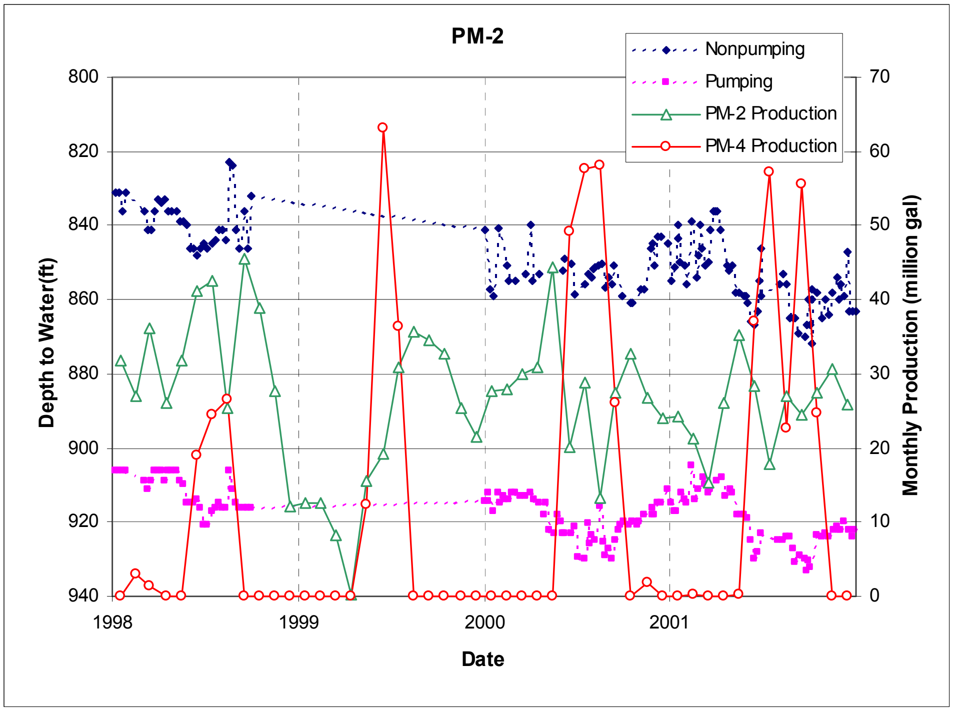

Figure E-7. Nonpumping and pumping water levels and monthly production, well PM-2, 1998 – 2001

The available pumping and nonpumping water levels and monthly production for well PM-3 for 1998 through 2001 are shown in Figure E-8. Water levels for PM-3 are only available for part of 1998, when the nonpumping water level was relatively stable at about 780 ft below surface. The nonpumping water level in well PM-3 varied only about 5 ft in response to pumping demand in 1998.

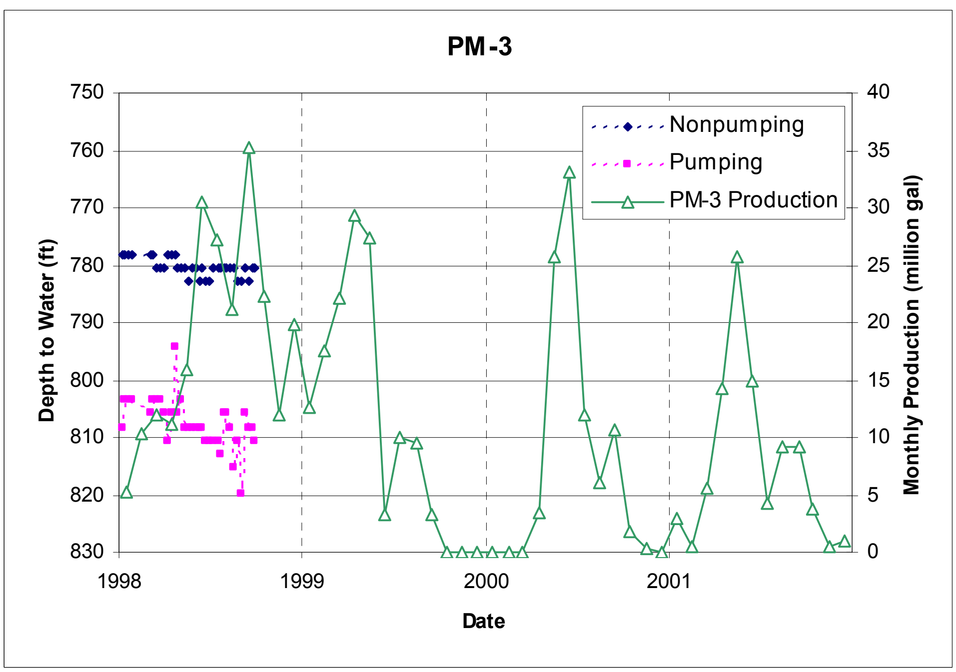

Figure E-8. Nonpumping and pumping water levels and monthly production, well PM-3, 1998 – 2001

The available pumping and nonpumping water levels and monthly production for well PM-4 for 1998 through 2001 are shown in Figure E-9. Only this well produces continually when put into service each summer; thus, nonpumping water levels are obtained when the well is shut down for the winter season or when the well is temporarily shut down for service. In 1998, the nonpumping water levels after production were around 1095 ft below surface, but in the spring of 1999 the water level had recovered about 20 ft to about 1075 ft below surface.

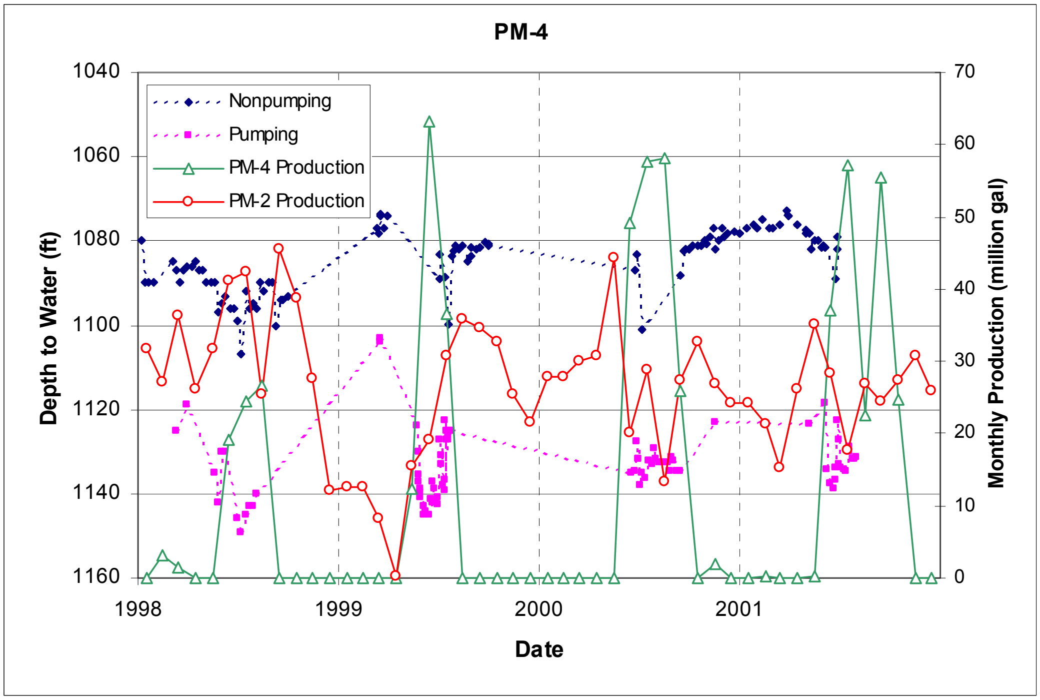

Figure E-9. Nonpumping and pumping water levels and monthly production, well PM-4, 1998 – 2001

During the winter of 1998–1999, the pump in PM-4 was removed and replaced. In March 1999, before the pump was replaced, a spinner log survey was obtained while pumping the well at 1000 gpm (Koch et al. 1999). The pumping and nonpumping water levels in March 1999 reflect the water levels observed before and during the spinner log survey.

The nonpumping water level after production in 2000 was about 1082 ft below surface, after which the water level recovered slowly over the winter months to about 1075 ft below surface in March 2001, similar to the level observed in March 1999. The nonpumping water level in well PM-4 began to decline in April 2001 in response to increased production from nearby well PM-2. The monthly production from well PM-2 is also shown in Figure E-9. Increased production at well PM-2 in April and May 2001, before well PM-4 was placed in service, caused a decline in the nonpumping water level in PM-4 of about 6 ft, from 1075 to 1081 ft. The transducer in well PM-4 malfunctioned in August 2001, so water levels after that date are not available.

The pumping and nonpumping water levels and monthly production for well PM-5 for 1998 through 2001 are shown in Figure E-10. Water-level data are available for 1998 and part of 2000. The transducer malfunctioned in September 2000; thus, water levels are not available after that date. The water levels in PM-5 respond within a range of about 10 to 15 ft to production demands on the well. The monthly production from nearby well PM-4 is also shown on Figure E-10. During the summer of 2000, a decline in pumping water levels in well PM-5 may have resulted from production from PM-4.

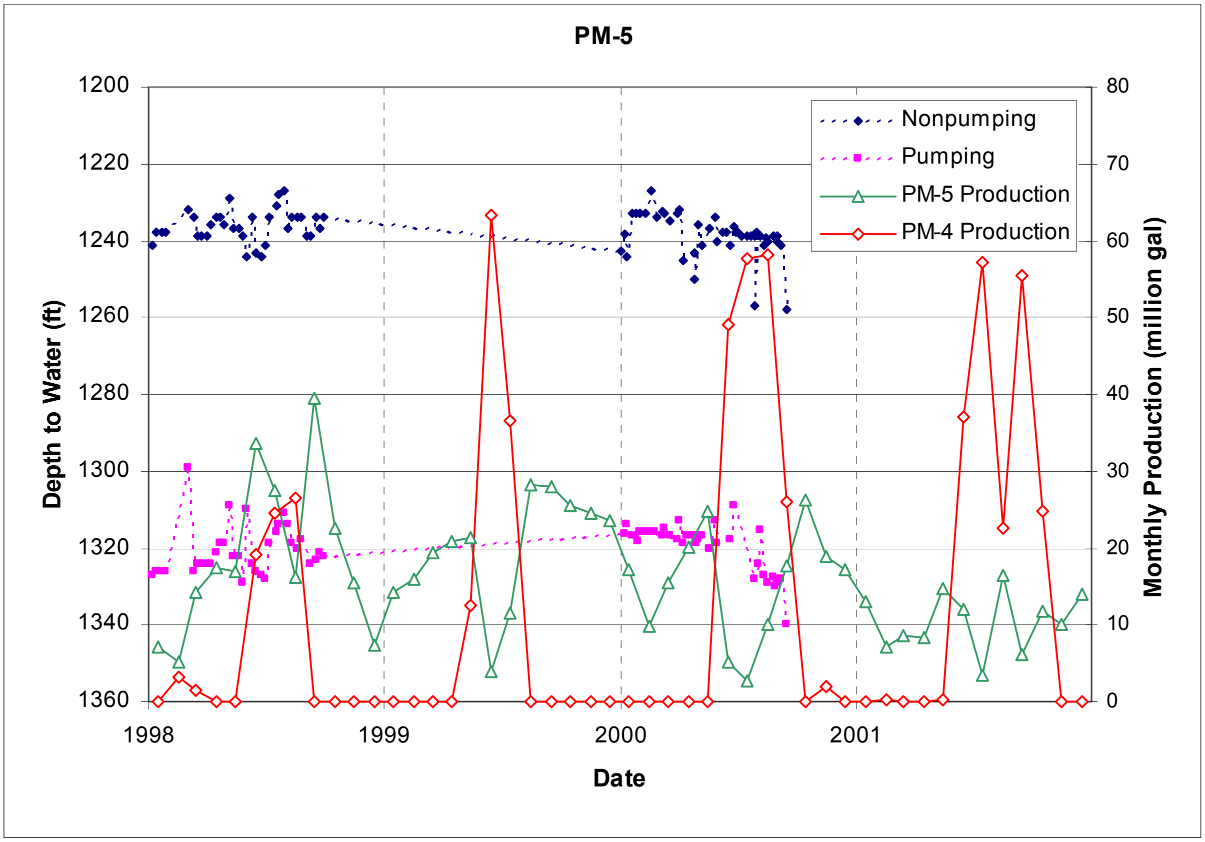

Figure E-10. Nonpumping and pumping water levels and monthly production, well PM-5, 1998 – 2001

Appendix F

Static Water Levels in Regional Aquifer Test Wells

Appendix F. Static Water Levels in Regional Aquifer Test Wells

Table F-1
Depth to Water Measurements in Regional Aquifer Test Wells

Date Drilled	1950	1949	1949	1950	1960	1959	1960	1960
Datum (ft)	6369.2	6647.6	6595.3	7244.6	6877.6	7143.9	6936.7	7019.9
Initial WL (ft)	584.9	758.9	743.3	1170.8	968.0	1173.2	1003.3	1090.6
Year	**TW-1**	**TW-2**	**TW-3**	**TW-4**	**TW-8**	**DT-5A**	**DT-9**	**DT-10**
1949		758.9	743.3					
1950	584.9			1170.8				
1951	592.3	760.1	750.9	1166.1				
1952	591.4		751.0	1166.6				
1953	591.2	759.9	751.4	1167.5				
1954	591.8	760.6	751.4	1166.2				
1955		760.2	751.3					
1956	592.0	759.9	750.9					
1957	593.1	759.9	751.3					
1958	593.8	759.7	751.7					
1959	593.9		751.8					
1960	593.4	760.5	751.8	1165.9	968.0	1173.2	1003.3	1090.6
1961	591.8	760.8		1165.9			1003.4	1090.6
1962	590.0	761.2	751.8				1004.0	
1963	588.3	762.8	753.6		968.7	1176.9	1004.6	1090.3
1964	587.8		754.2		968.7	1177.0	1005.0	1090.4
1965	588.4				968.7		1005.1	1090.5
1966							1005.2	1090.6
1967							1005.4	1090.6
1968							1005.5	
1969								
1970								
1971							1005.5	
1972							1005.2	
1973							1005.3	
1974							1005.6	
1975							1005.6	
1976							1005.8	
1977		775.5					1006.1	
1978							1006.2	
1979							1006.4	
1980							1006.2	
1981							1006.2	
1982							1006.2	
1983								
1984								
1985								
1986								
1987								
1988		787.0						
1989								
1990	508.4	787.2	772.0					
1991	507.0	789.0						
1992	536.5	792.5	777.5					
1993	545.8	794.2	778.2	1176.3	993.3	1183.4	1016.0	1096.9
1994	548.7	798.3	780.8	1176.9	993.1	1183.7	1016.3	1097.2
1995	550.2	795.8	781.8	1177.2	994.4	1183.5	1015.5	1097.0
1996	551.9	796.8	781.7	1176.4	994.7	1183.6	1015.8	1097.1
1997	528.8		782.2	1172.4	994.4		1016.0	1097.3

Note: Measurements are in feet below surface elevation datum.

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