STATE OF CALIFORNIA
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Planning and Local Assistance
Northern District, Groundwater Section

2004 DCID SUMMARY REPORT FOR THE TEHAMA COUNTY GROUNDWATER EXTRACTION PERMIT

This summary report was prepared by the Department of Water Resource, Northern District, Groundwater Section, on behalf of the Deer Creek Water District. It was prepared under the direct supervision of Toccoy Dudley, Chief of the Northern District Groundwater Section, Registered Geologist No. 3732, and was written by Dan McManus, Registered Geologist No. 6261, in accordance with the provisions of the Geologist and Geophysicists Act of the State of California.

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FOR THE
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Table of Contents

INTRODUCTION 1
PILOT WELL DESIGN 2
2004 PILOT WELL OPERATIONS 3
PILOT WELL MONITORING AND MANAGEMENT 4
Groundwater Level Monitoring and Program Management 4
Groundwater Level Monitoring Grids 5
Groundwater Level Monitoring Schedule 8
Groundwater Level Monitoring Results 8
Pilot Well Results 8
Key Well Results—Upper to Middle Aquifer Monitoring 9
Key Well 24N01W-05J03 10
Key Well 24N01W-05J01 10
Key Well 24N01W-05G01 11
Key Well 24N01W-05R02 11
Key Well 24N01W-05K01 12
Key Well 24N01W-05Q03 13
Lower Tuscan Aquifer Results 13
Lower Tuscan Well 24N01W-05J04 15
Lower Tuscan Well 24N01W-05Q04 16
Lower Tuscan Well 25N01W-34N03 16
Lower Tuscan Well 24N02W-01R02 16
Lower Tuscan Well 24N02W-01L02 17
Water Quality Monitoring and Management 17
Water Quality Monitoring Results 18
PILOT WELL OPERATING COSTS 18
FINDINGS 18

FIGURES

Figure 1. Project Location Map 1
Figure 2. As-Built Design of the Pilot Well 2
Figure 3. Pilot Well Head Configuration and Discharge Structure 3
Figure 4. Regional Groundwater Level Monitoring Grid 6
Figure 5. Local "Key Well" Monitoring Grid 5
Figure 6. 2003-2004 Groundwater Level Hydrograph for the DCID Pilot Well 9
Figure 7. 2004 Distance versus Drawdown Curve in the Lower Tuscan Aquifer. 14
Figure 8. 2004 Groundwater Drawdown in the Lower Tuscan Aquifer. 15

TABLES

Table 1. Pilot Well Operating Schedule, Pumping Rates and Volume Totals 3
Table 2. Key Monitoring Wells; Construction and Use 5
Table 3. Deep Aquifer Monitoring Well Construction 7
Table 4. Approximate Deep Aquifer Drawdown from 2004 Pilot Well Pumping 14

APPENDIX A
Tehama County Permit for Off-Parcel Use of Groundwater
2004 DCID Groundwater Management Objectives

APPENDIX B
Local Geology and Geologic Cross Section

APPENDIX C
Key Well Hydrographs

APPENDIX D
Deep Aquifer Hydrographs

APPENDIX E
Water Quality Data

INTRODUCTION

In May of 2004 Deer Creek Irrigation District applied for, and received, another Tehama County Groundwater Extraction and Off Parcel Use Permit. The permit follows many of the guidelines and conditions set forth in the 2003 permit. However, due to the lack of impacts and the knowledge gained during the 2003 operation of the Deer Creek pilot well, some modifications were made to the monitoring and reporting requirements. Instead of downloading dataloggers every two weeks, the 2004 permit was changed to download dataloggers every month, and instead of holding WAC meetings in Vina, information regarding the monitoring program was mailed to the 2004 WAC members and reported in person to the Tehama County Flood Control & Water Conservation TAC.

This document summarizes the 2004 pilot well operation, monitoring and management. A copy of the 2004 Tehama County Groundwater Extraction Permit and the Groundwater Management Objectives for the Pilot Program are presented in Appendix A. Key well hydrographs, deep aquifer hydrographs and water quality data are presented in Appendix B, C, and D, respectively. Project location map is shown in Figure 1.

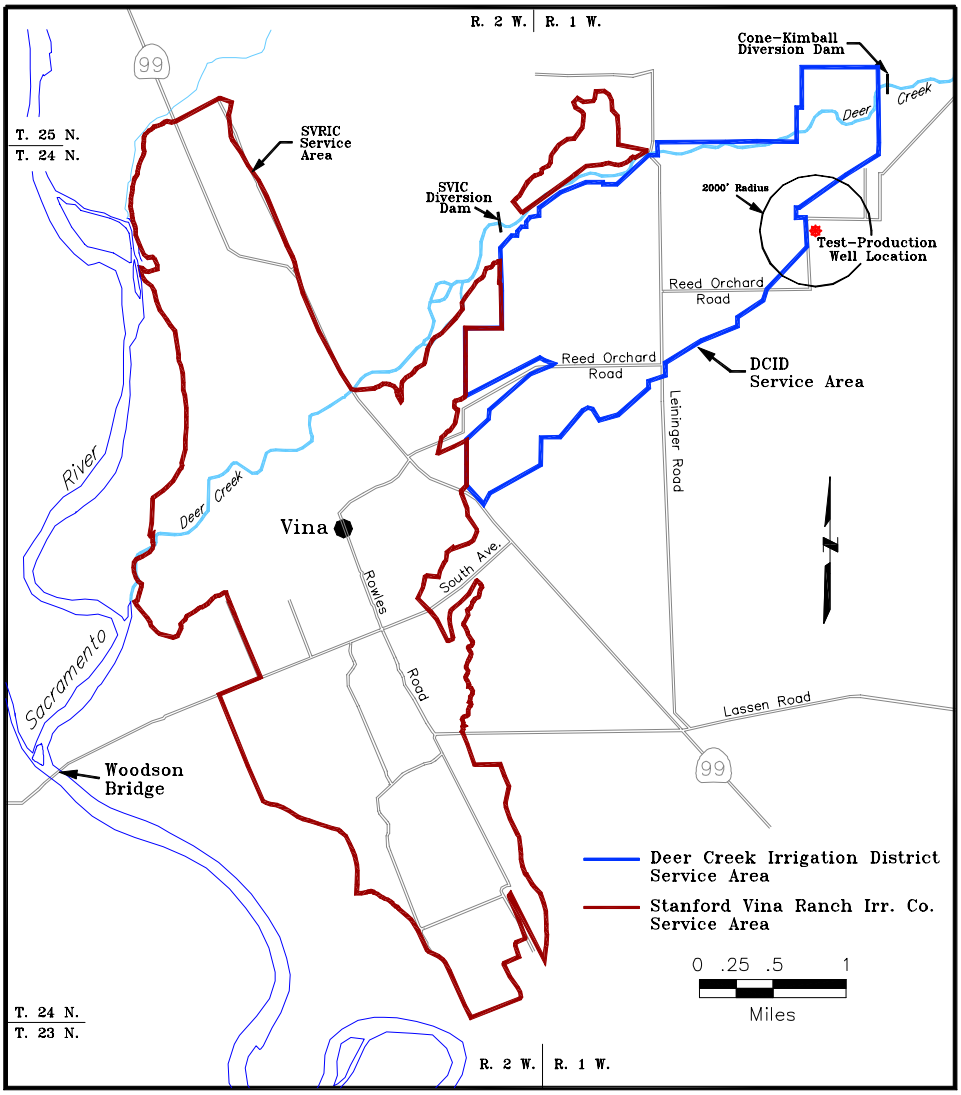

Figure 1. Project Location Map

PILOT WELL DESIGN

The pilot well was designed and constructed to produce from the lower portion of the Tuscan aquifer, and to eliminate any pumping related impacts to nearby wells constructed in the upper to middle portions of the Tuscan aquifer. The pilot well is 940-feet deep with perforations between 620 and 920 feet, and a cement-bentonite seal down to a depth of 580 feet. As-built design of the pilot-well is shown in Figure 2. The pilot well operates at approximately 1,200 gallons per minute. Discharge is monitored by a McCrometer flow meter along the discharge line. Groundwater from the pilot well runs beneath Reed Orchard Road and discharges into the DCID south canal via a 42-inch square outflow box. The well head configuration and discharge box is shown in Figure 3.

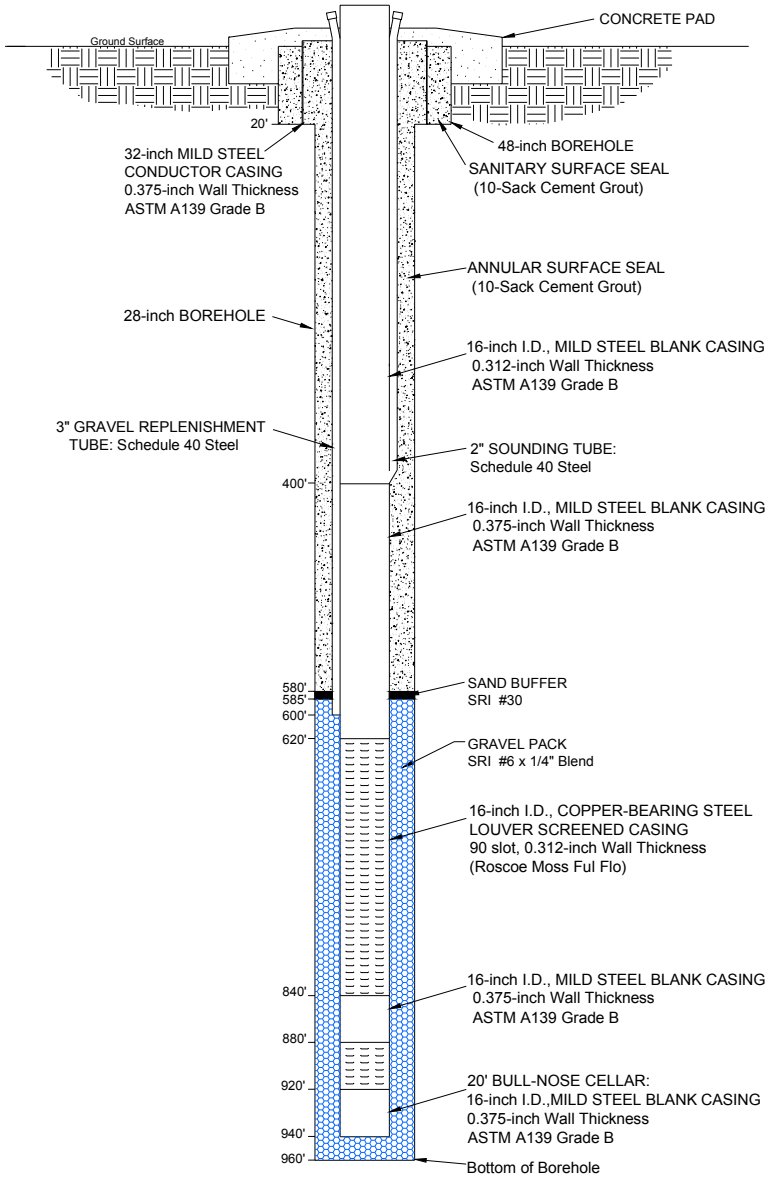

Figure 2. As-Built Design of the Pilot Well (SWN: 24N01W-04M01).

Figure 3. Pilot Well Head Configuration and Discharge Structure.

2004 PILOT WELL OPERATION

Operation of the pilot well was based on DCID's agricultural demand and the need for increased supply to reduce water delivery rotation times. The pilot started operation on July 12, 2004 and continued for approximately 69-days until September 19, 2004. The total volume of groundwater extracted during the program was approximately 364 acre-feet. The Tehama County Groundwater Extraction Permit allowed for a maximum of volume of 550 acre-feet between April and October. Table 1 lists the pilot well operating schedule, pumping rates and volumes.

Date & Time	Meter Reading			Total Days Pumping	Remarks
	Ave.Rate (gal/min)	Total Vol. (gallons)	Total Vol. (acre-feet)		
6/30/04 8:15	0	155,476,000	0.00	0	Meter reading prior to start of well
7/23/04 6:51	1,200	173,463,000	55.19	10.7	Pilot well on: 7-12-04 @ ~2pm
8/17/04 9:08	1,200	216,816,000	188.22	35.8	Pumping at 5.05 af/day
9/14/04 14:09	1,200	265,550,000	337.75	64.0	Pump Running
9/19/04 11:35	1,200	274,007,000	363.70	68.9	Well Off 9-19-04 @ 11:35 am
	Totals:	**118,531,000**	**363.7**	**68.9**	**End of 2004 Pumping**

Table 1. Pilot Well Operations Schedule, Pumping Rate and Volume.

PILOT WELL MONITORING AND MANAGEMENT

Management of the pilot program was adapted from the conditions set forth in the 2003 Tehama County Groundwater Extraction and Exportation permit and the guidelines outlined in the Deer Creek Water Exchange Program Groundwater Management Objectives. Due to the lack of impacts associated with the 2003 program some modifications were made to the 2003 guidelines and adapted to the management and monitoring of the 2004 program. Instead of downloading dataloggers every two weeks, the 2004 permit was changed download dataloggers every month, and instead of holding WAC meetings in Vina, information regarding the monitoring program was mailed to the 2003 WAC members and reported in person to the Tehama County Flood Control & Water Conservation TAC.

The overriding goal of the groundwater management objectives was to operate the program so as to maintain a sustainable supply of high quality and affordable groundwater for irrigation and domestic use. Management of the pilot program was designed to prevent third party impacts by linking a rigorous schedule of monitoring to a clear set of groundwater level and water quality objectives, and to a corresponding set of guidelines for program operations and management. A detailed explanation of the pilot program monitoring and management plan is provided in Appendix A. A summary of the management methods and the results from the groundwater level, water quality and surface water monitoring are provided below.

Groundwater Level Monitoring and Program Management

One of the key criteria for program operations was maintaining a predetermined range of acceptable groundwater levels in seven "key wells" surrounding the pilot well. The key wells were selected based on their depth and construction, their proximity to the pilot well, and their ability to represent groundwater levels in surrounding agricultural and domestic wells that extract groundwater from the upper to middle portions of the Tuscan aquifer. Groundwater levels in the key monitoring wells were monitored to determine compliance with the predetermined range of acceptable groundwater level fluctuations.

The acceptable range of groundwater level fluctuation during program operations was established based on professional judgment and the evaluation of:

- Historic seasonal fluctuation of groundwater levels in domestic and agricultural wells surrounding the pilot well,
- The 2003 operation of the pilot well, and
- Assurances that nearby third-party groundwater users will be able to maintain an adequate and affordable supply of good quality groundwater for agricultural and domestic use.

In order to have adequate time to respond and make appropriate adjustments to program operations, the groundwater level criteria were divided into three stages, or levels, which served as trigger points for reevaluating, altering, or shutting-down program operations and alleviating any additional groundwater level decline. Management guidelines allowed for the pilot program to proceed as long as groundwater level monitoring indicated compliance with the predetermined range of acceptable groundwater level decline. At the onset of the 2003 program it was

understood that adjustments to the warning stage criteria may be needed as additional data was collected and experience was gained during the pilot program.

The groundwater level warning stages were initially developed in 2003 by the DCID board in conjunction with technical assistance from the Northern District Department of Water Resources. The stage criteria were also reviewed by the Tehama County AB 3030 Technical Advisory Committee, the Tehama County Environmental Health Department, the State Regional Water Quality Control Board, and local landowners prior to adoption by the DCID board and approval by the Tehama County Board of Supervisors. Results from the 2003 program indicated that the 2003 groundwater level and water quality guidelines remained appropriate for the 2004 program.

Overall management of the pilot program was governed by the 2004 Deer Creek Water Advisory Committee. Membership for the Water Advisory Committee was solicited in 2003 through public meetings and notices, and ultimately consisted of six to eight local, county and state representatives. Water Advisory Committee (WAC) members were provided monthly updates regarding program operations and monitoring. Program updates were also presented to the Tehama County Flood Control & Water Conservation Board.

Groundwater Level Monitoring Grids:
Groundwater level monitoring was divided into local and regional monitoring grids. The regional grid covers much of the Stanford Vina Ranch Irrigation Company and consists of 19 agricultural wells, 12 domestic wells and 2 industrial wells. These wells range in depth from 100 to 500 feet and represent groundwater levels associated with the upper to middle portions of the Tuscan aquifer. Figure 4 shows the regional groundwater monitoring grid for the project area.

The local groundwater level monitoring grid covers approximately a 2-mile radius surrounding the pilot well. The local grid includes 16 domestic wells, 11 irrigation wells, and eight multi-completion monitoring wells. The multi-completion monitoring wells were installed as part of an earlier phase of the water exchange program and were constructed as a nested set of wells, to monitor the middle and lower portions of the Tuscan aquifer. Six local wells closest to the pilot well were selected as "key wells" and were used to evaluate potential groundwater level impacts to the middle and upper portions of the Tuscan aquifer, and compliance with the groundwater level criteria. Figure 5 shows the location of the Key Monitoring Wells and Key Water Quality sampling locations.

Key well construction and use information is provided below in Table 2. Well construction data in Table 2 shows that the groundwater level monitoring of the key wells allows evaluation of groundwater levels over a wide range of the upper to middle portions of the Tuscan aquifer, from 58 to 520 feet.

State Well Number	Distance from Pilot Well (ft)	Well Use	Aquifer Production Zone	Total Depth (feet)	Perforation Interval (feet)
24N01W-05J03	375	Monitoring Well	Upper Tuscan	385	271-385
24N01W-05J01	390	Cemetery Well	Upper Tuscan	178	58-178
24N01W-05G01	1823	Active Irrigation Well	Middle Tuscan	490	130-490
24N01W-05R02	2120	Domestic	Upper Tuscan	160	118-160
24N01W-05K01	2730	Idle Irrigation	Upper Tuscan	260	27-260
24N01W-05Q03	3200	Monitoring Well	Middle Tuscan	415	280-415

Table 2. Key Monitoring Wells, Construction and Use.

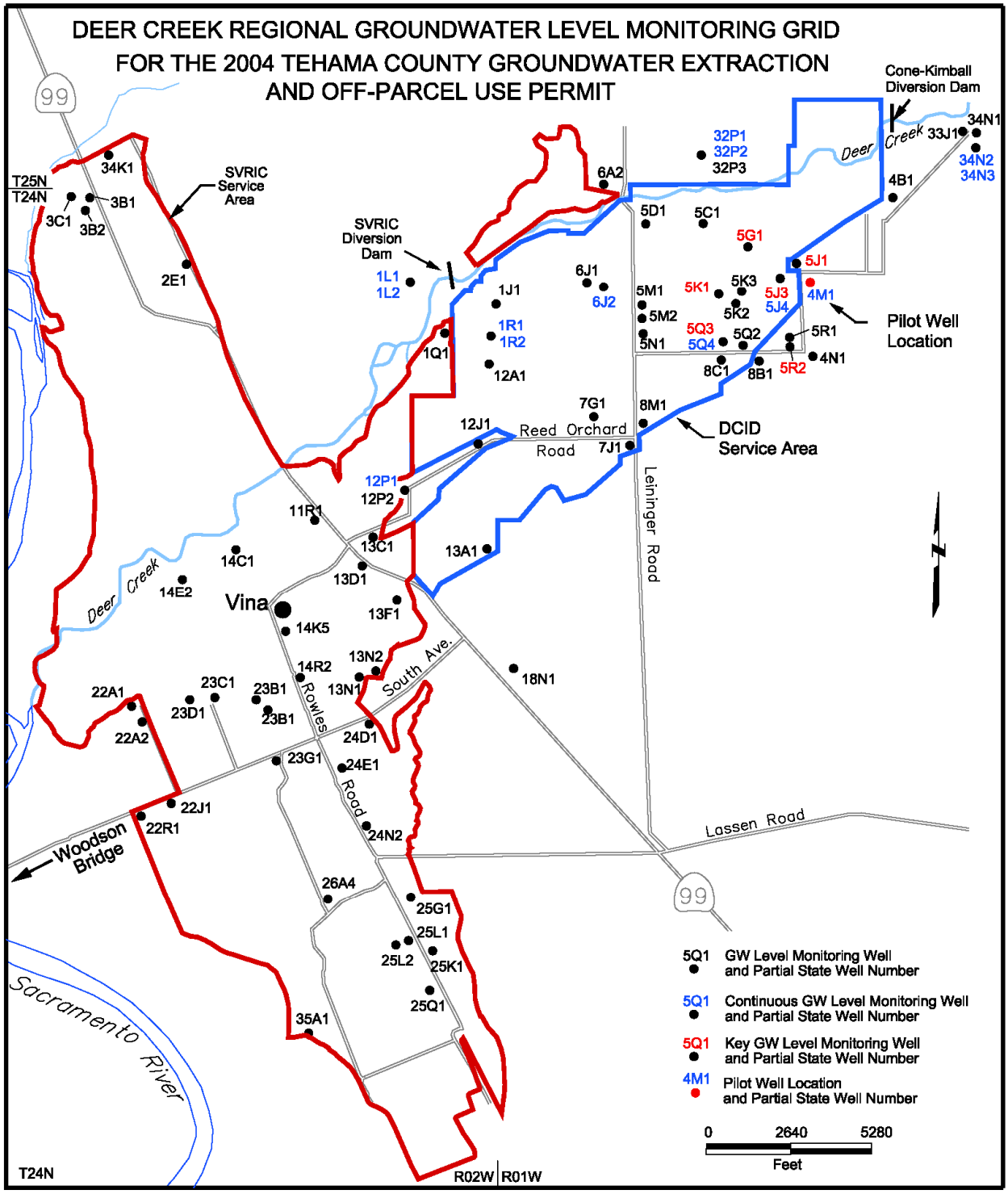

Figure 4. Regional Groundwater Level Monitoring Grid

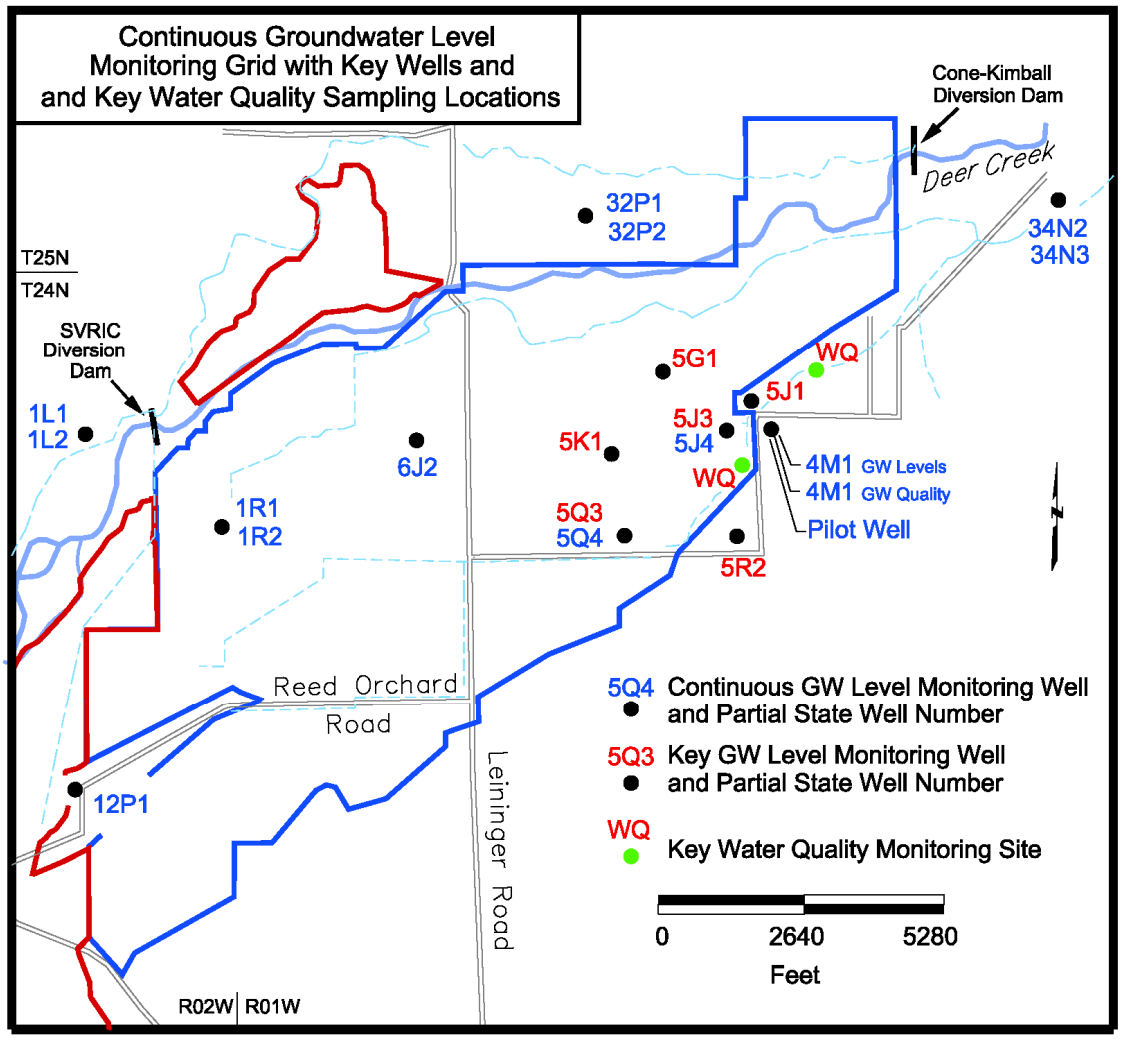

Figure 5. Local "Key Well" Monitoring Grid.

Groundwater level fluctuations within the lower Tuscan aquifer were monitored using the deep-zone of the dedicated multi-completion monitoring wells. Construction information for the deep aquifer wells is shown in Table 3.

State Well Number	Distance from Pilot Well (ft)	Well Use	Aquifer Production Zone	Total Depth (feet)	Perforation Interval (feet)
24N01W-05J04	375	Monitoring Well	Lower Tuscan	760'	650-722'
24N01W-05Q04	3200	Monitoring Well	Lower Tuscan	840'	700-790'
25N01W-32P03	5,180	Monitoring Well	Lower Tuscan	720'	640-720'
25N01W-34N03	6,930	Monitoring Well	Lower Tuscan	743'	468-743'
24N02W-01R02	9,960	Monitoring Well	Lower Tuscan	880'	765-880'
25N02W-01L02	12,480	Monitoring Well	Lower Tuscan	900'	660-900'
24N02W-12P02	14,070	Monitoring Well	Lower Tuscan	900	560-900'

Table 3. Deep Aquifer Monitoring Well Construction.

Geologic plan-view and cross-sectional maps are provided in Appendix B. The vertical distribution and construction of wells in the project area are illustrated in the geologic cross-section B-B, shown in Figure 4, Appendix B.

Groundwater Level Monitoring Schedule:
The frequency of groundwater level monitoring varied according to the monitoring well location and type, and the pilot well pumping schedule. During pilot program operations, the depth to groundwater was measured in the Deer Creek monitoring wells, east of Highway 99, at a frequency of once per month between April and October. The depth to groundwater in these wells was measured using a steel tape or a battery operated water level meter. Within the localized grid, the seven key wells and all but two of the remaining dedicated monitoring wells within the Deer Creek monitoring grid were equipped with automated groundwater level recording equipment (dataloggers). The dataloggers were set to measure groundwater levels at a frequency of 24-times per day (every hour). The groundwater level data stored in the dataloggers were downloaded once per month between April and October.

Groundwater Level Monitoring Results:
The results of the groundwater level monitoring were provided to the WAC and the Tehama County Flood Control and Water Conservation Board on monthly basis. Distribution of the groundwater level data was also made available to the general public over the Internet, through the Department of Water Resources Water Data Library web site at: http://wdl.water.ca.gov. Groundwater level data from key wells equipped with dataloggers required construction of a separate database and web site to distribute the information. The continuous groundwater level data associated with the key wells were provided via the Deer Creek Water Exchange Pilot Project web page at: http://wdl10.water.ca.gov/gw/projects/deer_creek/.

Pilot Well Results: Groundwater level monitoring results for the pilot well are illustrated in the 2003-2004 hydrograph shown in Figure 6. In addition to showing the change in groundwater levels over time, arrows and labels along the top of the hydrograph indicate the pilot well operating intervals during the 2003 and 2004 pumping programs. Figure 6 shows that the static groundwater level in the pilot well, prior to pumping in 2004, was approximately 94 feet below ground surface. During the first 24-hours of operation in 2004 the pumping level averaged about 172 feet below ground surface. Over the following 69 days, the pumping level in the pilot well dropped only slightly, reaching a maximum of about 174 feet below ground surface. Groundwater levels recovered quickly after termination of pumping, with 93 percent of total recovery occurring within the first eight hours. Groundwater level recovery in the pilot well continued slowly over the next 6-days, until groundwater levels reached a maximum of about 95-feet below ground surface or 98 percent recovery.

The relatively stable pumping levels over the 69-day pumping period, coupled with a quick recovery, indicate that aquifer properties of transmissivity and storage were sufficient to maintain a groundwater extraction rate of 1,200 gallon per minute and that mining of the aquifer was not occurring. The 1.5-foot difference in static groundwater levels at the beginning versus the end of the 2004 pilot well pumping could be related to a change in volume from dewatering of the aquifer, or it could just be a function of the normal seasonal fluctuation in groundwater levels.

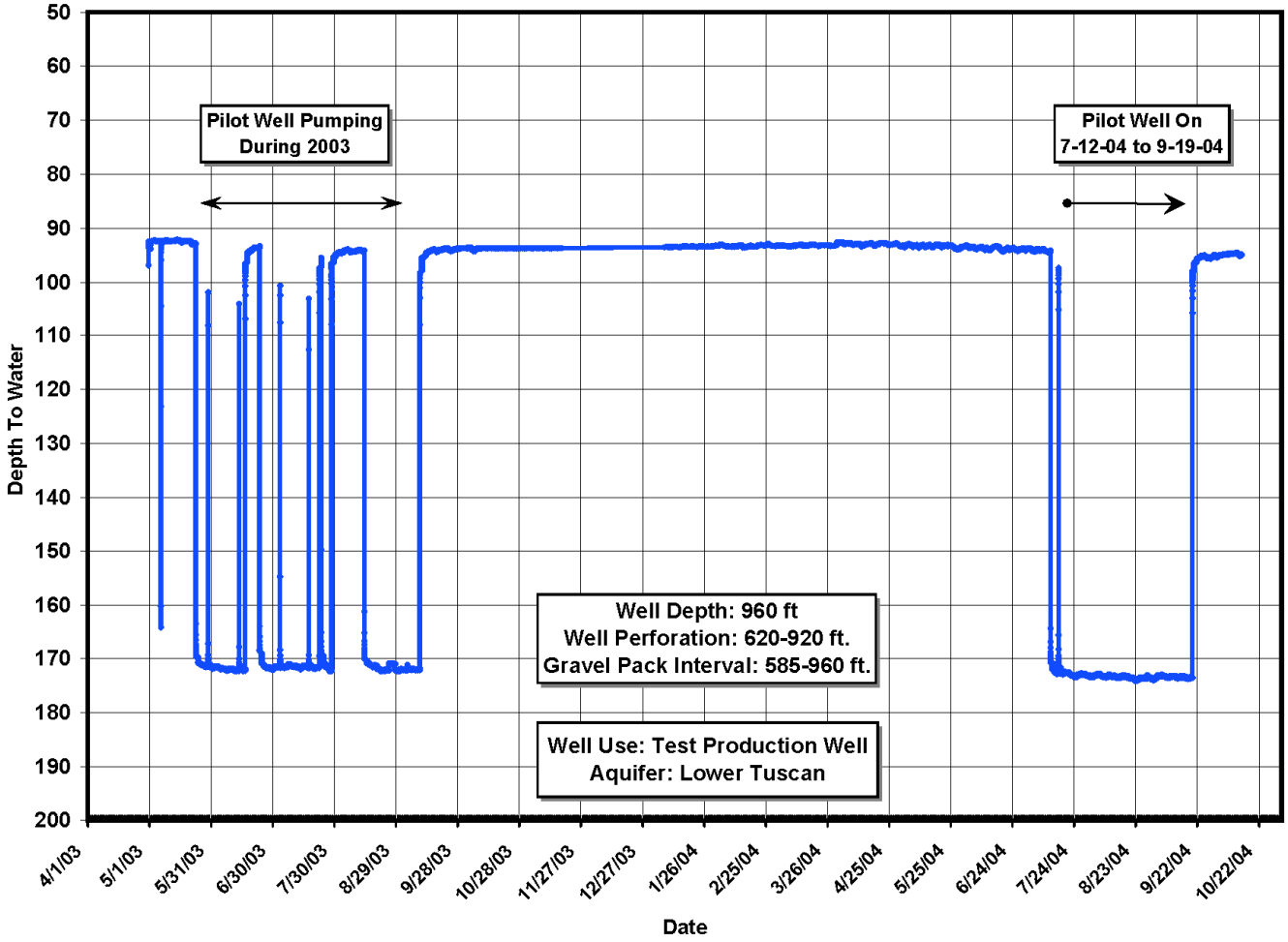

Figure 6. 2003-2004 Groundwater Level Hydrograph for the DCID Pilot Well

Key Well Results --Upper to Middle Aquifer Monitoring: The results of groundwater level monitoring of the key wells are illustrated in the hydrographs in Figures 1 through 12, Appendix C. To help with analysis, groundwater level data from the key wells were used to develop two hydrographs for each well, one showing the yearly, or long-term, fluctuation in groundwater levels and one showing monthly changes during the 2004 agricultural season. Figures 1 through 12, Appendix C also show the groundwater management "warning stages" associated with static water level data. Table 2 lists the six key wells, their distance from the pilot well and their construction. Figure 5 shows the plan-view distribution of the key monitoring wells and Figure 4, Appendix B shows the vertical distribution of the wells within the aquifer.

Care should be taken when analyzing the key well hydrographs to examine changes in seasonal groundwater levels as well as fluctuations occurring within the 2004 pumping period. Groundwater level impacts associated with nearby pumping are typically illustrated by an abrupt decline in groundwater level in the observation well at the onset of nearby pumping or, consequently, an abrupt rise in groundwater levels at the termination of nearby pumping. Groundwater level impacts to the key wells surrounding the pilot well were analyzed by looking for any change in groundwater levels before, during and after the 2004 pilot well pumping;

keeping aware that local groundwater levels commonly show a gradual decline and rise with the natural seasonal progression from summer to fall. Overall results from the 2004 groundwater level monitoring of the key wells within the upper to middle portion of the Tuscan aquifer indicates no groundwater level impacts due to pilot well pumping. A short interpretation of each of the key well hydrographs is provided below.

Key Well 24N01W-05J03: Key well 24N 01W-5J03 is a dedicated monitoring well and is the closest of key wells to the pilot well at a distance of 375 feet. It was installed in 1999 as the shallow well in a nested set of two monitoring wells installed within the same borehole. Well 5J3 is constructed to monitor the upper to middle Tuscan aquifer between 271 and 385 feet. The hydrographs for 5J3 are shown in Figures 3 and 4 of Appendix C. Well 5J3 has been equipped with a groundwater level datalogger since 1999. Prior to the pilot program, the datalogger was set to record groundwater levels every 4 to 6 hours. During the pilot program, the datalogger was set to record groundwater levels every hour. The three groundwater level warning stages for 5J3 are set at depths of 92, 97 and 102 feet below ground surface.

The long-term hydrograph for 5J3 shows that spring groundwater levels have ranged from 85 to 87 feet since 1999. Seasonally, groundwater levels fluctuate on an average of 2 to 3 feet, with temporary declines of 2 to 5 feet when nearby irrigation wells pump for agricultural beneficial use.

The 2004 monthly hydrograph for 5J3 illustrates groundwater level changes during the 2004 agricultural season. Periods of pilot well pumping (July 12th to Sep. 19th) are shown on the hydrograph with text boxes and arrows. The 2004 monthly hydrograph shows a gradual 2 to 3 foot decline starting prior to the pilot well operation and continuing through the middle of August, before beginning a gradual recovery into the fall. Comparison of seasonal groundwater level trends during 2002 versus 2004 (non-pilot well pumping years versus pilot well pumping years) indicates that the gradual decline and recovery is typical of the normal seasonal fluctuation in groundwater levels in 5J3, and other wells constructed in this portion of the aquifer. In addition to the gradual (seasonal) groundwater level changes, the 2004 monthly hydrograph shows a series of temporary groundwater level declines, or drawdowns (approximately 18 to 48-hours). The temporary drawdowns, shown as a series of uniformly spaced downward spikes, are attributed to groundwater pumping of 5C1, 5G1 and 5K2 (see Figure 4). Wells 5C1, 5G1 and 5K2 are nearby agricultural wells that supply irrigation water for the almond and walnut orchards to the west-northwest. Overall, groundwater levels in 5J3 remained relatively stable throughout the program, with no warning stages exceeded.

Key Well 24N01W-05J01: Key well 24N 01W-05J01 is an active well located in the Vina cemetery at a distance of about 390 feet from the pilot well. The well is used for cemetery landscape irrigation and produces water from the upper Tuscan aquifer between 58 and 178 feet. The hydrographs for 5J1 are shown in Figures 1 and 2 of Appendix C. Groundwater levels in 5J1 have been monitored since the early 1970's and were equipped with a groundwater level datalogger in May, 2003. During the pilot program, the datalogger was set to record groundwater levels every hour. The datalogger malfunctioned for the first two weeks in June resulting in a gap groundwater level data gap. The three groundwater level warning stages for 5J3 are based on static groundwater levels and are set at depths of 38, 42 and 45 feet below ground surface.

The long-term hydrograph for 5J1 shows that static spring groundwater levels have historically fluctuated between 25 and 35 feet below ground surface. During 1976, several pumping water

levels were recorded between 46 and 49 feet below ground surface. Seasonally, static groundwater levels fluctuate on an average of 2 to 5 feet.

The 2004 monthly hydrograph for 5J1 illustrates groundwater level fluctuations during 2004 pilot well pumping (July 12th to Sep. 19th). Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. The 2004 monthly hydrograph shows a gradual 2 to 3 foot decline starting prior to the pilot well operation and continuing into the fall. Comparison of seasonal groundwater level trends in 2002 versus 2004 (non-pilot well pumping years versus pilot well pumping years) indicates that the gradual decline is typical of the normal seasonal fluctuation of groundwater levels in 5J1, and other wells constructed in this portion of the aquifer. Closer examination of the hydrograph for 5J1 shows several trends in the series of temporary groundwater level drawdowns. The series of groundwater level drawdowns in the 45 to 50 foot range are associated with periods of pumping within the 5J1 well. The series of groundwater level drawdowns in the 35-foot range typically occur when 5J1 is not pumping, and are attributed to periods of pumping in nearby agricultural wells. No groundwater warning stages were exceeded.

Key Well 24N01W-05G01: Key well 24N 01W-05G01 is and agricultural irrigation well located 1,823 feet west of the pilot well. Well 5G1 was drilled to produce from the upper to middle portion of the Tuscan aquifer between 130 and 490 feet. Well 5G1 was idle between 1998 and 2004, due to fallowing followed by preparation for replanting. In early 2004 5G1 began, once again, being used for agricultural irrigation. During the 2004 pumping program 5G1 followed a fairly regular schedule of pumping about every 7 days for approximately 12 to 18-hours per day. The hydrographs for 5G1 are shown in Figures 5 and 6 of Appendix C. Groundwater level monitoring of 5G1 began in 1998, with dataloggers being used over most of the last three years. Prior to the 2003 pilot program, the datalogger was set to record groundwater levels every 4 to 6 hours. During the 2003 and 2004 pilot well pumping program, the datalogger was set to record groundwater levels every hour. The three groundwater level warning stages for 5G1 are based on static groundwater levels and are set at depths of 88, 92 and 94 feet below ground surface.

The long-term hydrograph for 5G1 shows that, since 1998, spring groundwater levels have remained consistent, ranging between 77 and 78 feet below groundwater surface. Seasonally, static groundwater levels fluctuate on an average of 2 to 3 feet, with temporary declines of 3 to 5 feet when nearby irrigation wells extract groundwater for agricultural beneficial use. Pumping levels within 5G1 range between 106 and 113 feet below ground surface.

The 2004 monthly hydrograph for 5G1 illustrates groundwater level fluctuations during 2004 pilot well pumping (July 12th to Sep. 19th). Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. The 2004 monthly hydrograph shows a 3 to 4 foot fluctuation in static groundwater levels between spring and fall of 2004. The fluctuation appears as a gradual change and does not appear to be associated with the pilot well pumping during 2004. The series of small (2-4 feet), temporary (~18-72 hours) groundwater level drawdowns are attributed to agricultural groundwater pumping of 5K2 and 5C1 (see Figure 4). Overall, groundwater levels in 5G1 remained fairly stable throughout the 2004 season, no groundwater warning stages were exceeded, and no impacts associated with pilot well pumping were identified.

Key Well 24N01W-05R02: Key well 24N 01W-05R02 is an active domestic well located 2,120 feet south of the pilot well. The well produces water from the upper Tuscan aquifer between 118

and 160 feet. The hydrographs for 5R2 are shown in Figures 11 and 12 of Appendix C. Groundwater levels in 5R2 have been monitored since 1998 and were equipped with a groundwater level datalogger beginning in May, 2003. During the 2004 pilot well pumping, the datalogger was set to record groundwater levels every hour. In June, 2004, prior to the pilot well pumping, the datalogger was down for about 20-days and is indicated by a straight line on the hydrograph. The three groundwater level warning stages for 5R2 were based on static groundwater levels and are set at depths of 82, 85 and 90 feet below ground surface.

The long-term hydrograph for 5R2 shows that static spring groundwater levels since 1998 have remained stable, fluctuating between 76 and 78 feet below ground surface. Seasonally, static groundwater levels in 5R2 fluctuate on an average of 2 to 4 feet. Prior to the installation of the datalogger in 2003, no pumping water levels were recorded. Figure 11 in Appendix C shows pumping levels since 2003 have ranged from 83 to 90 feet below ground surface.

The 2004 monthly hydrograph shows that, other than a short rise in groundwater levels during early June, static groundwater levels indicate a slight seasonal decline between spring and fall, with depths ranging between 78 and 80 feet below ground surface. Closer examination of the 2004 hydrograph for 5R2 shows a series of temporary groundwater level declines throughout the agricultural season. The temporarily declines in groundwater levels shown in Figure 12 could be due to pumping interference from nearby agricultural or domestic wells, or may be associated with the variable pumping duration of well 5R2. Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. Overall, groundwater levels in 5R2 remained relatively stable throughout the 2004 season, no groundwater warning stages were exceeded, and no impacts associated with pilot well pumping were identified.

Key Well 24N01W-05K01: Key well 24N 01W-05K01 is an idle irrigation well located 2,730 feet west of the pilot well. Well 5K1 was drilled to produce from the upper portion of the Tuscan aquifer between 27 and 260 feet. Obstructions within the well currently prevent it from being used for irrigation. The hydrographs for 5K1 are shown in Figures 7 and 8 of Appendix C. Groundwater level monitoring of 5K1 began in 1999, with dataloggers being installed at that time. Prior to the pilot program, the datalogger was set to record groundwater levels every 4 to 6 hours. During the pilot program, the datalogger was set to record groundwater levels every hour. The three groundwater level warning stages for 5K1 are set at depths of 74, 77 and 80 feet below ground surface.

The long-term hydrograph for 5K1 shows that spring groundwater levels between 1999 and 2002 have averaged about 64-feet below ground surface. Starting in 2002 the annual trend of groundwater levels tends to come up, with spring levels rising almost 5 feet from 2003 to 2004. The reason for the rise in groundwater levels over the last two years is unknown. Seasonally, the fluctuation in static groundwater levels have remained relatively consistent; averaging between 2 and 4 feet, with temporary declines of 3 to 5 feet when nearby irrigation wells extract groundwater for agricultural beneficial use.

The 2004 monthly hydrograph for 5K1 illustrates a gradual decline in static groundwater levels of about 2-3 feet from March through July, steady levels through the summer and a slight rise moving into October. Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. Comparison of the seasonal groundwater level trend in 2002 versus 2004 (non-pilot well pumping years versus pilot well pumping years) indicates that the gradual decline is typical of the normal seasonal fluctuation on groundwater levels in 5K1, and likely other wells constructed in this portion of the aquifer. The series of temporary (~18 to 72-hours) groundwater

level drawdown is very similar to the other key monitoring wells, and is similarly attributed to agricultural groundwater pumping of 5K2, 5G1 and 5C1 (see Figure 4). Overall, groundwater levels in 5K1 remained relatively stable throughout the program, with no warning stages exceeded.

Key Well 24N01W-5Q03: Key well 24N 01W-5Q03 is a dedicated groundwater level monitoring well located 3,200 feet southwest of the pilot well. It was installed in 1999 as the shallow well in a nested set of two monitoring wells at the same location. The well is constructed to monitor the upper to middle Tuscan aquifer between 280 and 415 feet. The hydrographs for 5Q3 are shown in Figures 9 and 10 of Appendix C. Well 5Q3 has been equipped with a groundwater level datalogger since 1999. Prior to the pilot program, the datalogger was set to record groundwater levels every 4 to 6 hours. During the pilot program, the datalogger was set to record groundwater levels every hour. The three groundwater level warning stages for 5Q3 are set at depths of 80, 83 and 87 feet below ground surface.

The long-term hydrograph for 5Q3 shows that, since 1999, spring groundwater levels have ranged from 67 to 69. Seasonally, groundwater levels fluctuate on an average of 3 to 4 feet, with additional temporary drawdowns of 3 to 6 feet when nearby irrigation wells extract groundwater for agricultural beneficial use.

The 2004 monthly hydrograph for 5Q3 illustrates groundwater level fluctuations during 2004 pilot well pumping (July 12th to Sep. 19th). Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. Similar to the other key monitoring wells, the 2004 hydrograph for 5Q3 shows a gradual seasonal decline of about 3 to 4 feet between spring and summer. Comparison of seasonal groundwater level trends in 2002 versus 2004 (non-pilot well pumping years versus pilot well pumping years) indicates that the gradual decline is typical of the normal seasonal fluctuation in groundwater levels in 5Q3. The 2004 hydrograph also shows a series of temporary groundwater level drawdowns throughout the agricultural season. Theses downward spikes in the groundwater hydrograph are similar to those seen in the other key wells and are attributed to groundwater pumping of 5C1, 5K2 and 5G1 (see Figure 4). Overall, groundwater levels in 5Q3 remained relatively stable throughout the program, with no warning stages exceeded.

Lower Tuscan Aquifer Results: Groundwater level monitoring of the lower Tuscan was conducted using the deep dedicated monitoring wells that were installed in 1999. Table 4 lists the deep aquifer monitoring wells, their distance from the pumping well, their construction and total drawdown after pumping the pilot well for 69 days in 2004. Figures 4 and 8 provide a plan-view distribution of the wells. The vertical distribution and construction of wells are illustrated in the geologic cross-section B-B, shown in Figure 4, Appendix B. The results of groundwater level monitoring of the lower Tuscan aquifer are illustrated in the hydrographs in Figures 1 through 10 in Appendix D. Two groundwater level hydrographs were developed for each of the lower Tuscan monitoring wells, one showing yearly long-term fluctuations in groundwater levels and one showing monthly changes during the 2004 pilot program. All of the deep aquifer monitoring wells are equipped with dataloggers. Prior to the 2004 pumping of the pilot well, the dataloggers were set to record groundwater levels every 4 to 6 hours. During the 2004 pilot well pumping the dataloggers were set to record groundwater levels every hour.

The lower Tuscan groundwater level monitoring results from continuously pumping the pilot well for 69 days in 2004 were very similar to the results from 85 days of intermittent pumping in 2003. Total drawdown to the lower aquifer ranged from approximately 16 feet in 5J4 (located

375 feet from the pilot well), to 0.7 feet in 12P2 (located 14,070 feet from the pilot well). Figure 7 is a graph showing the distance versus drawdown relationship for the lower Tuscan monitoring wells during pilot well pumping. Figure 8 is a plan view map showing the lower Tuscan monitoring wells, measured groundwater level impacts in the lower aquifer and interpreted groundwater drawdown contour lines during pilot well pumping. Figures 7 and 8 show that, although the majority of drawdown related impacts to the lower aquifer subside within a distance of 2,000 feet, a small amount of drawdown (~ 1.5 feet) continues outward from the pilot well at distances of about 10,000 feet. Additionally, although the majority of wells follow a fairly consistent relationship of exponentially decreasing impacts with distance, monitoring well 32P2 seems to fall outside the trend of the other monitoring wells. The anomalous drawdown in 32P2 could indicate lateral changes within the aquifer or could be a function of construction problems which occurred during the building of 32P2. Well 32P2 is the lowest zone of a triple completion monitoring well. During development of 32P2, groundwater level monitoring indicated that the lower zone could have been inadvertently connected to the upper zone. This connection could result in a false groundwater levels reading in the upper and lower zone. A short interpretation of the monitoring data from five of the lower Tuscan wells is provided below.

State Well Number	Distance from Pilot Well (ft)	Well Use	Aquifer Production Zone	Total Depth (feet)	Perforation Interval (feet)	Total Drawdown from Pilot Well Pumping (feet)
24N01W-05J04	375	MW	Lower Tuscan	760'	650-722'	-16.0
24N01W-05Q04	3200	MW	Lower Tuscan	840'	700-790'	-4.0
25N01W-32P03	5,180	MW	Lower Tuscan	720'	640-720'	-0.5
25N01W-34N03	6,930	MW	Lower Tuscan	743'	468-743'	-3.2
24N02W-01R02	9,960	MW	Lower Tuscan	880'	765-880'	-1.2
25N02W-01L02	12,480	MW	Lower Tuscan	900'	660-900'	-1.3
24N02W-12P02	14,070	MW	Lower Tuscan	900	560-900'	-0.7

Table 4. Approximate Deep Aquifer Drawdown from 2004 Pilot Well Operations.

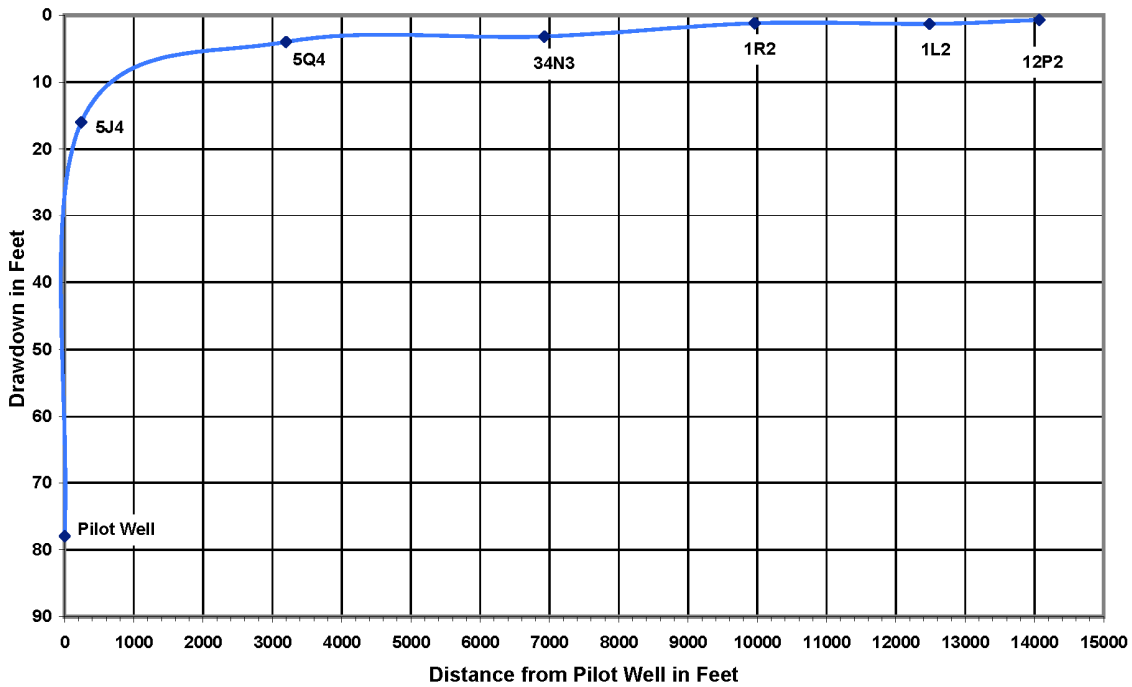

Figure 7. 2004 Distance versus Drawdown Curve in the Lower Tuscan Aquifer.

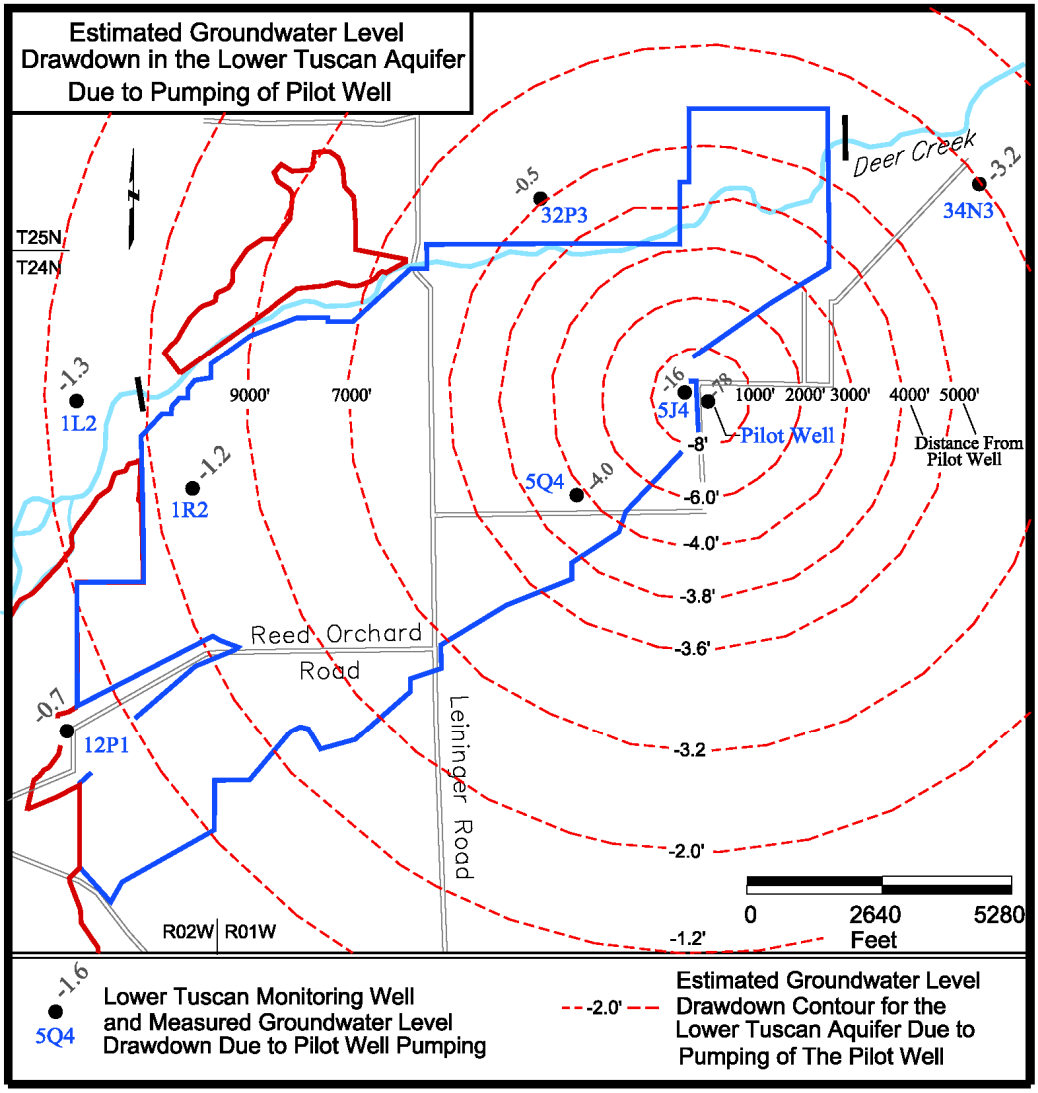

Figure 8. 2004 Groundwater Drawdown in the Lower Tuscan Aquifer During Pilot Well Pumping.

Lower Tuscan Well 24N01W-5J04: Key well 24N 01W-5J04 is located 375 feet northwest of the pilot well and represents the closest of lower Tuscan monitoring wells. Well 5J4 was constructed in 1999 to monitor the lower Tuscan aquifer between 650 and 722 feet. Groundwater levels in 5J4 are monitored with a datalogger that records data every hour during pilot well pumping, and every four hours during non-pumping. The hydrographs for 5J4 are shown in Figures 1 and 2, Appendix D.

The long-term hydrograph for 5J4 shows that since 2002 spring groundwater levels have slowly declined about 3 feet, from 87 to 90 feet. Seasonal groundwater level fluctuation during non-pilot well pumping years has averaged 1 to 2 feet, with additional temporary declines of 1 to 2 feet when nearby irrigation wells extract groundwater for agricultural beneficial use. Groundwater levels also indicate a drawdown of about 16 feet associated with pilot well pumping in 2003 and 2004. Subsequent to the initial drawdown after the pilot well begins pumping, groundwater levels in 5J4 tend to stabilize at approximately 107 feet and quickly rebound once the pilot well is shut down.

The 2004 monthly hydrograph clearly shows the large immediate response in groundwater levels associated with the pilot well operation. The 2004 hydrograph also shows a series of small (0.5 to 1.5 foot) groundwater level drawdown spikes that begin prior to pilot well operations and continue after the pilot well is shut down. These small fluctuations in groundwater levels are also noticeable during the previous years and are likely due to groundwater pumping for irrigation within the project area. Overall, groundwater level data from 5J4 indicates full annual recharge and recovery of the lower Tuscan aquifer in this area.

Lower Tuscan Well 24N01W-5Q04: Key well 24N 01W-5Q04 is a deep dedicated monitoring well located 3,200 feet to the west of the pilot well. Well 5Q4 was constructed in 1999 to monitor the lower Tuscan aquifer between 700 and 790 feet. Groundwater levels in this well are monitored with a datalogger that records data every one to four hours. The hydrographs for 5Q4 are shown in Figures 3 and 4, Appendix D.

Similar to monitoring well 5J4, the long-term hydrograph for 5Q4 indicates a gradual decline of about 2 feet in spring groundwater levels since 2000. During this period spring groundwater levels have ranged from 70 to 72 feet. Seasonally, during non-pilot well operations, groundwater levels fluctuate from 2 to 3 feet between spring and summer, with additional temporary declines of 1 to 2 feet when nearby irrigation wells extract groundwater for agricultural beneficial use. During pilot well operations in 2003 and 2004, groundwater levels temporarily declined an additional 4 feet. The 2004 monthly hydrograph for 5Q4 also shows a series of 1 to 2 foot of groundwater level fluctuation regardless of pilot well operations. These small fluctuations in groundwater levels are also noticeable during the previous years and are likely due to agricultural pumping within the project area. Overall, groundwater level data from 5Q4 indicates full annual recharge and recovery of the lower Tuscan aquifer in this area.

Lower Tuscan Well 25N01W-34N03: Key well 25N01W-34N03 is a deep dedicated monitoring well located 6,980 feet to the east of the pilot well. Well 34N3 was constructed in 1999 to monitor the lower Tuscan aquifer between 468 and 743 feet. Groundwater levels in this well are monitored with a datalogger that records data every one to four hours. The hydrographs for 34N3 are shown in Figures 5 and 6, Appendix D.

The long-term hydrograph for 34N3 shows that spring groundwater levels have slowly declined about 2-feet, from 146 to 148, since spring 2000. Seasonally, during non-pilot well operations, groundwater levels fluctuate only 1 to 2 feet between spring and summer. During pilot well operations in 2003 and 2004, groundwater levels temporarily declined an additional 3 feet. The 2004 monthly hydrograph for 34N3 also shows a daily series of 0.1 foot fluctuations in the groundwater level regardless of pilot well operations. Closer examination indicates that small 0.1 foot fluctuations are likely due to natural external forces and not associated with nearby groundwater pumping. Overall, groundwater level data from 34N3 indicates full annual recharge and recovery of the lower Tuscan aquifer in this area.

Lower Tuscan Well 24N02W-01R02: Key well 24N02W-01R02 is a deep dedicated monitoring well located 9,960 feet to the west of the pilot well. Well 1R2 was constructed in 1999 to monitor the lower Tuscan aquifer between 765 and 880 feet. Groundwater levels in this well are monitored with a datalogger that records data every one to four hours. The hydrographs for 1R2 are shown in Figures 7 and 8, Appendix D.

The long-term hydrograph for 1R2 also shows a gradual 1 to 2-foot decline demonstrated in the other deep aquifer wells, with spring static levels ranging from 33 to 35 feet. Somewhat different than the other deep aquifer wells, the long-term hydrograph for 1R2 indicates a slightly larger spring to summer fluctuation in groundwater levels. The spring to summer fluctuation in groundwater levels range between 2 and 4 feet with additional temporary declines of 1 to 3 feet as the result of nearby agricultural groundwater pumping. Pilot well pumping in 2003 and 2004 appears to contribute to an additional 1.2 feet of drawdown in 1R2. Overall, groundwater level data from 1R2 indicates full annual recharge and recovery of the lower Tuscan aquifer in this area.

Lower Tuscan Well 24N02W-01L02: Key well 24N02W-01L02 is a deep dedicated monitoring well located 12,480 feet west of the pilot well. Well 1L2 was constructed in 1999 to monitor the lower Tuscan aquifer between 660 and 900 feet. Groundwater levels in this well are monitored with a datalogger that records data every one to four hours. The hydrographs for 1L2 are shown in Figures 9 and 10, Appendix D.

The hydrographs for 1L2 show that spring groundwater levels have ranged from 37 to 38 feet below ground surface since 2000. Seasonally, groundwater levels fluctuate on an average of 2 to 3 feet between spring and summer, with additional temporary declines approximately 0.5 to 1.0 foot as the result of nearby agricultural groundwater pumping, and about 1.3 feet as the result of pilot well pumping during the summer of 2003 and 2004.

Water Quality Monitoring and Management

Maintaining a minimum level of acceptable water quality from the pilot well was the second criteria used to manage the 2004 pumping operations. The water quality criteria, established in the Groundwater Management Objectives (Appendix A), requires that groundwater from the pilot well will be maintained above the recommended water quality goals established by the California Regional Quality Control Board. Pumping of the pilot well will proceed as long as there is compliance with these pre-agreed to water quality criteria. A detailed explanation of the pilot program monitoring and management plan is provided in Appendix A. The analytical results of the water quality sampling are listed in Tables 1 through 3, Appendix E. Recommended water quality standards for agriculture and domestic use are listed in Tables 4 and 5, Appendix E. A summary of the management methods and the results from the water quality monitoring are provided below.

Three key sites were used to monitor water quality compliance. These sites are listed below and shown in Figure 5.

- Site 1: DCID distribution system canal above the pilot well discharge point.
- Site 2: Pilot well discharges prior to mixing with the DCID canal.
- Site 3: DCID distribution system canal below the pilot well discharge point.

The Department of Water Resources conducted the field collection and testing of surface and groundwater quality samples during the program. Analytical testing was conducted at a State of California approved laboratory and included analysis for minerals, trace metals and nutrients. Minerals analysis included testing for conductivity, pH, temperature, alkalinity, total dissolved solids, total hardness, boron, calcium, chloride, magnesium, potassium, sodium and sulfate. Trace metal analysis included testing for aluminum, arsenic, barium, cadmium, chromium,

copper, iron, lead, manganese, nickel, selenium and zinc. Nutrient analysis included testing for ammonia, dissolved orthophosphate, nitrite, nitrate, and total phosphorus.

Results from the water quality sampling during the 2003 pumping program showed no negative water quality impacts and consistently high water quality production from the pilot well. Based on the high water quality observed during the 2003 pumping program, the frequency of water quality monitoring was reduced during the 2004 program. The 2004 water quality monitoring schedule for the three key sites is listed below.

- Sample and provide laboratory analysis for full suite of minerals, metals and nutrients at the start of the pilot well pumping.
- Field sample for electrical conductivity from the pilot well and DCID canal approximately every two weeks (monitoring for unexpected increases in salinity).
- Sample and provide laboratory analysis for full suite of minerals, metals and nutrients just prior to the conclusion of the pilot well pumping.

Water Quality Monitoring Results: Detailed results from the field monitoring are provided in Table 1, Appendix E. Overall, field sampling indicated a consistent high quality water throughout the 69 days of pilot well pumping. Field results of groundwater temperature and electrical conductivity averaged 61.5 degrees Fahrenheit and 140 micromhos, respectively.

Laboratory samples for water quality were collected from the pilot well and in the DCID canal upstream and downstream of the pilot well discharge. Detailed results from the laboratory analysis are provided in Tables 2 and 3, Appendix E. Overall, the results from mineral, metals and nutrient testing, from all sample locations and times, show that the waters are of high quality, and concentration of mineral constituents are well within the recommended standards for agricultural or domestic use.

PILOT WELL OPERATING COSTS

The pilot well is powered by a 75 horsepower electrical pump and operates under the PG&E agricultural AG-4A rate structure. Operating 24 hours per day at an average production of 1,200 gallons per minute with 174 feet of lift the pilot well consumes approximately 2206 kilowatt-hours per day, or 434 kilowatt-hours per acre-feet. The averaged electrical cost to operate the pilot well translates to approximately $46.00 per acre-foot.

FINDINGS

Findings from the 2004 pilot well pumping indicate that 69-days of groundwater extraction from the lower portion of the Tuscan aquifer had no groundwater level or water quality related impacts to existing agricultural and domestic wells that produce from the upper-middle portions of the aquifer. Findings also indicate that:

- Groundwater level drawdown impacts to the lower Tuscan aquifer ranged from approximately 16 feet at a distance of 375 feet from the pilot well, to 0.7 feet at a distance of 14070 feet from the pilot well.
- Additional water supply from the pilot well helped to increase the head in the delivery system, reduce water rotation times, and improve DCID's water reliability.
- The annual operating costs associated with operating the pilot well are likely to high to be supported by agricultural benefit alone.