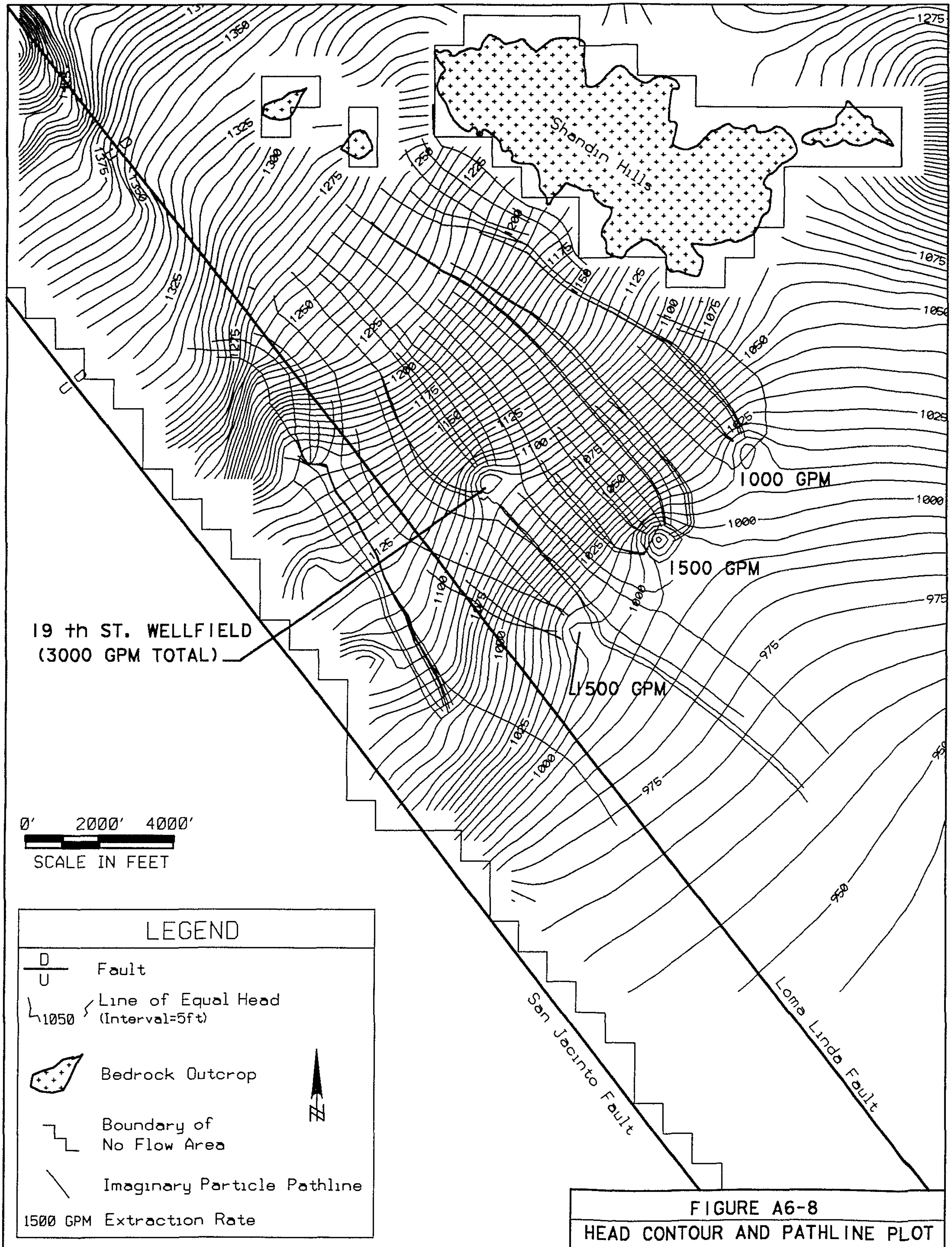

FIGURE A6-8
HEAD CONTOUR AND PATHLINE PLOT
FOR EXTRACTION SCENARIO NO. 3
LAYER 2 (LOWER AQUIFER)

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Table A6-8

EXTRACTION AREA LOCATIONS & PUMPING RATES FOR EXTRACTION SCENARIO NO. 4 (RUN 58E)

Extraction Area	Model Cell (i,j,k)	Pumping Ratio		Pumping Rate (gpm)
		Layer 1	Layer 2	
19th St. No. 1	(35,17,1) (35,17,2)	0.63	0.37	1,500
19th St. No. 2	(35,17,1) (35,17,2)	0.75	0.25	1,500
New Ext. Well	(34,24,1) (34,24,2)	0.33	0.67	1,000
New Ext. Well	(36,22,1) (36,22,2)	0.33	0.67	2,000
New Ext. Well	(38,20,1) (38,20,2)	0.33	0.67	1,000

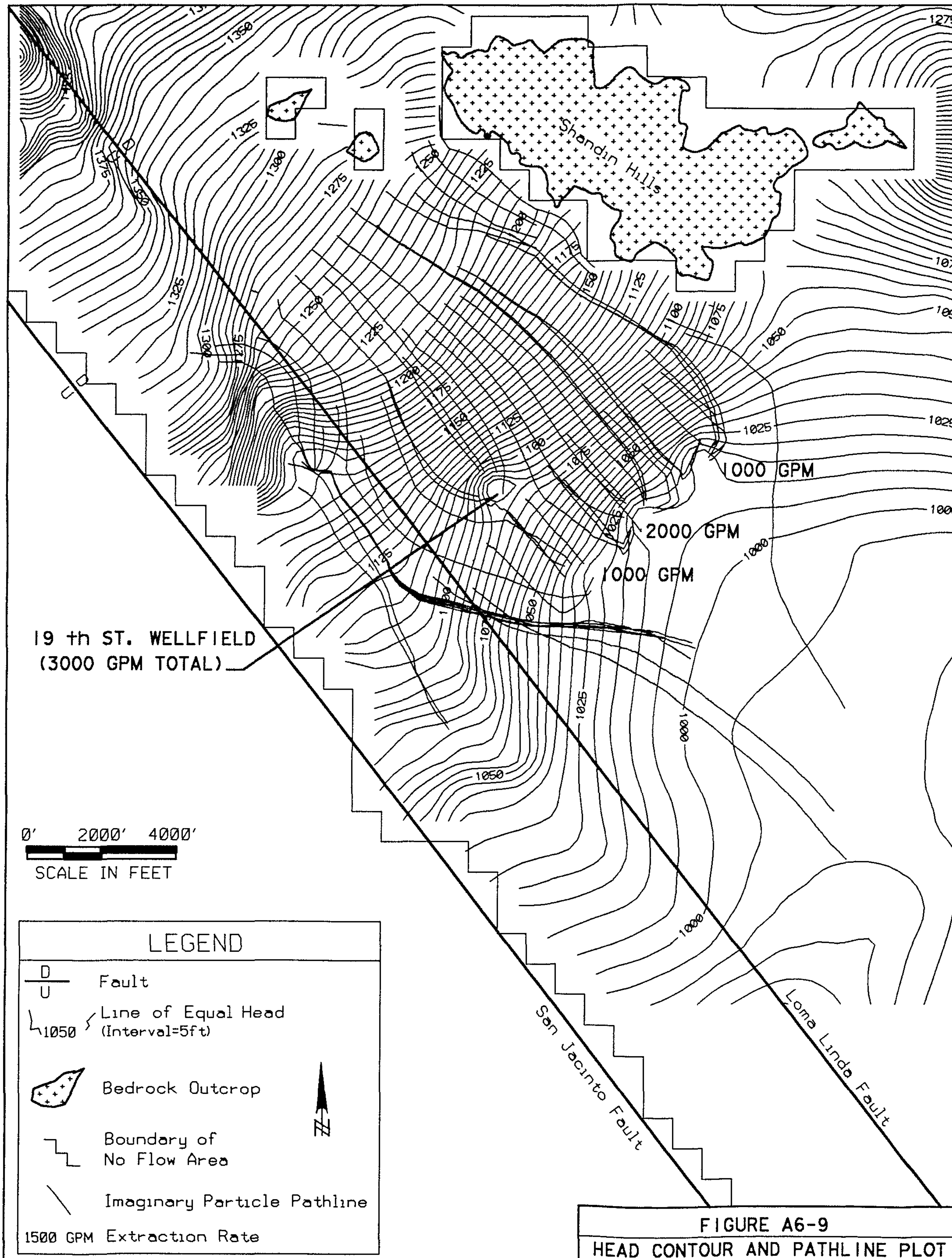

FIGURE A6-9

HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 4 LAYER I (UPPER AQUIFER)

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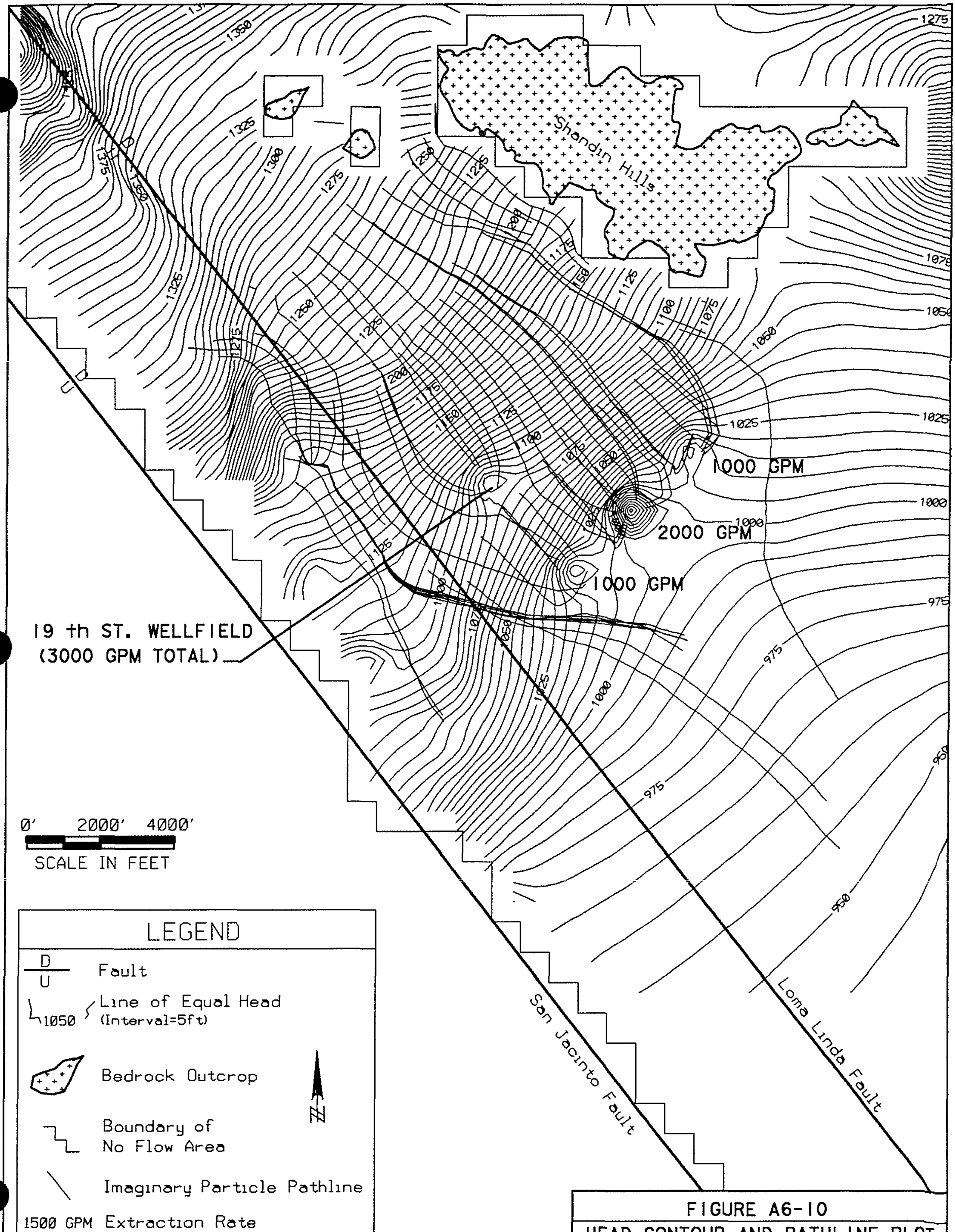

FIGURE A6-10

HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 4 LAYER 2 (LOWER AQUIFER)

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- For the next 30-year period, constant daily pumping of 1,500 gpm from 19th Street No. 1 and No. 2 wells was used.

The extraction in the four extraction areas were:

- No pumping the first 5-year period; and

- For the next 30 years, constant daily pumping of 1,000, 1,500, and 1,000 and 1,000 gpm from the four extraction areas.

Table A6-9 gives the locations of the extraction areas and their pumping rates used in the simulation run. Figures A6-11 and A6-12 show the head contours and pathlines of imaginary particles for layers 1 and 2, respectively. Some of the particles were captured by the extraction wells. A few particles south and north of the extraction areas were not captured. Also, a few particles escaped between the four extraction areas.

3.2.6 Extraction Scenario No. 6

This extraction scenario consisted of four extraction areas located near the downgradient edge of the plume. The extraction in the four extraction areas was as follows:

- No pumping the first 5-year period; and

- For the next 30 years, constant daily pumping of 1,500, 1,500, 1,700, and 1,500 gpm from the four extraction areas.

The 19th Street wellfield was pumped only during the first 5-year period at normal pumping rates, and no pumping was assumed during the following 30 years.

Table A6-10 gives the locations of the extraction areas and their pumping rates used in the simulation run. Figures A6-13 and A6-14 show the head contours and pathlines of imaginary particles for layers 1 and 2, respectively. All the imaginary particles were captured by the extraction areas.

3.2.7 Extraction Scenario No. 7

This extraction scenario consisted of four extraction areas located in the downgradient edge of the plume and the Baseline Feeder wellfield. The extraction in the four extraction areas was as follows:

- No pumping the first 5-year period; and

- For the next 30 years, constant daily pumping of 1,500, 1,500, 1,700 and 1,500 gpm from the four extraction areas.

The Baseline Feeder wellfield was turned on from January 1991, and normal pumping rates were used for the 3-year period starting from January 1991 through December 1993. For the remainder of the simulation period, starting from January 1994, the yearly pumping rate used in 1993 was repeated for the Baseline Feeder wellfield. The 19th Street wellfield was pumped only during the first 5-year period at normal pumping rate, and no pumping was assumed during the following 30 years.

Table A6-9

EXTRACTION AREA LOCATIONS & PUMPING RATES FOR EXTRACTION SCENARIO NO. 5 (RUN 59D)

Extraction Area	Model Cell (i,j,k)	Pumping Ratio		Pumping Rate (gpm)
		Layer 1	Layer 2	
19th St. No. 1	(35,17,1) (35,17,2)	0.63	0.37	1,500
19th St. No. 2	(35,17,1) (35,17,2)	0.75	0.25	1,500
New Ext. Well	(35,25,1) (35,25,2)	0.33	0.67	1,000
New Ext. Well	(37,23,1) (37,23,2)	0.33	0.67	1,500
New Ext. Well	(39,21,1) (39,21,2)	0.33	0.67	1,000
New Ext. Well	(40,19,1) (40,19,2)	0.33	0.67	1,000

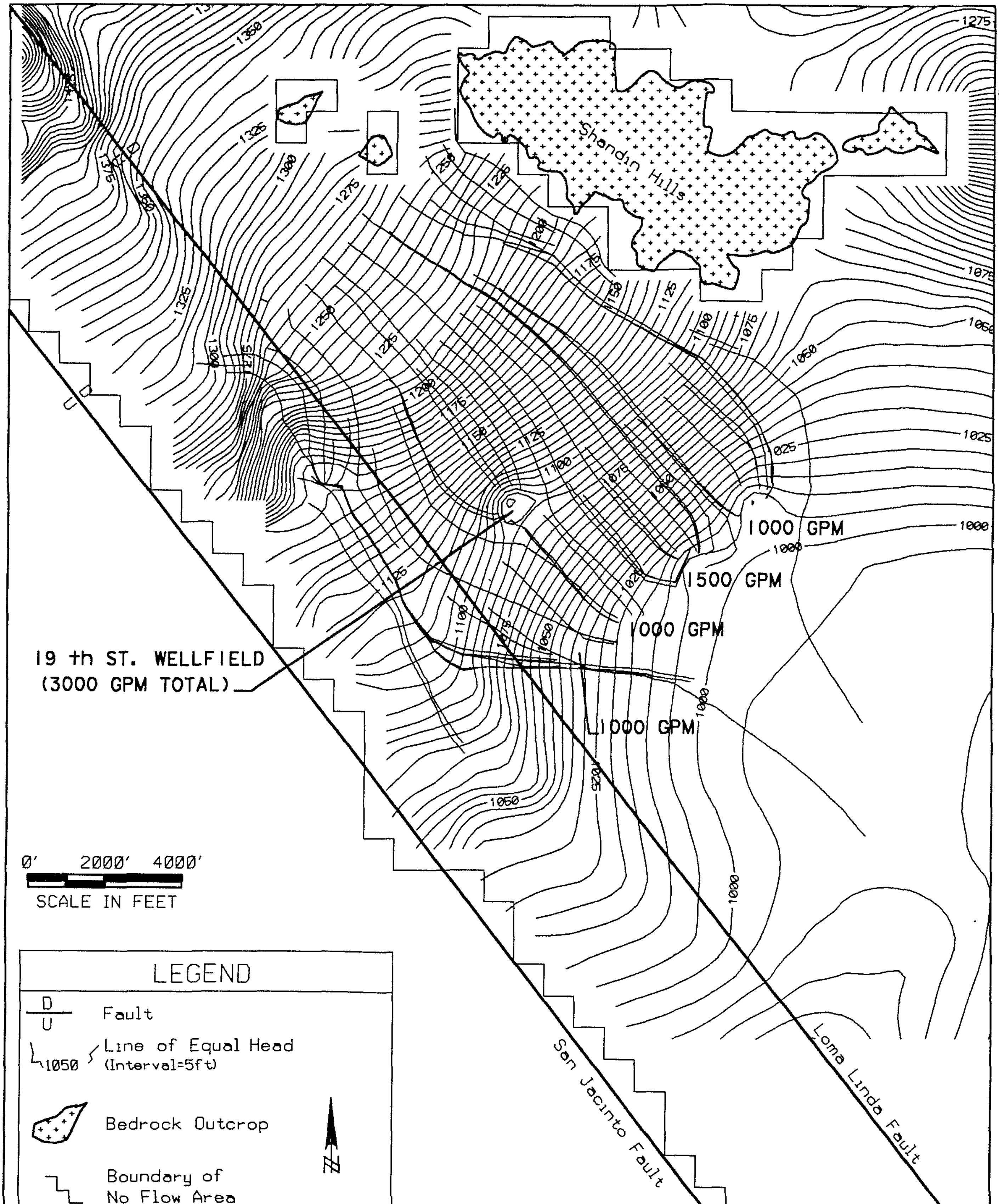

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FIGURE A6-11
HEAD CONTOUR AND PATHLINE PLOT
FOR EXTRACTION SCENARIO NO. 5
LAYER 1 (UPPER AQUIFER)

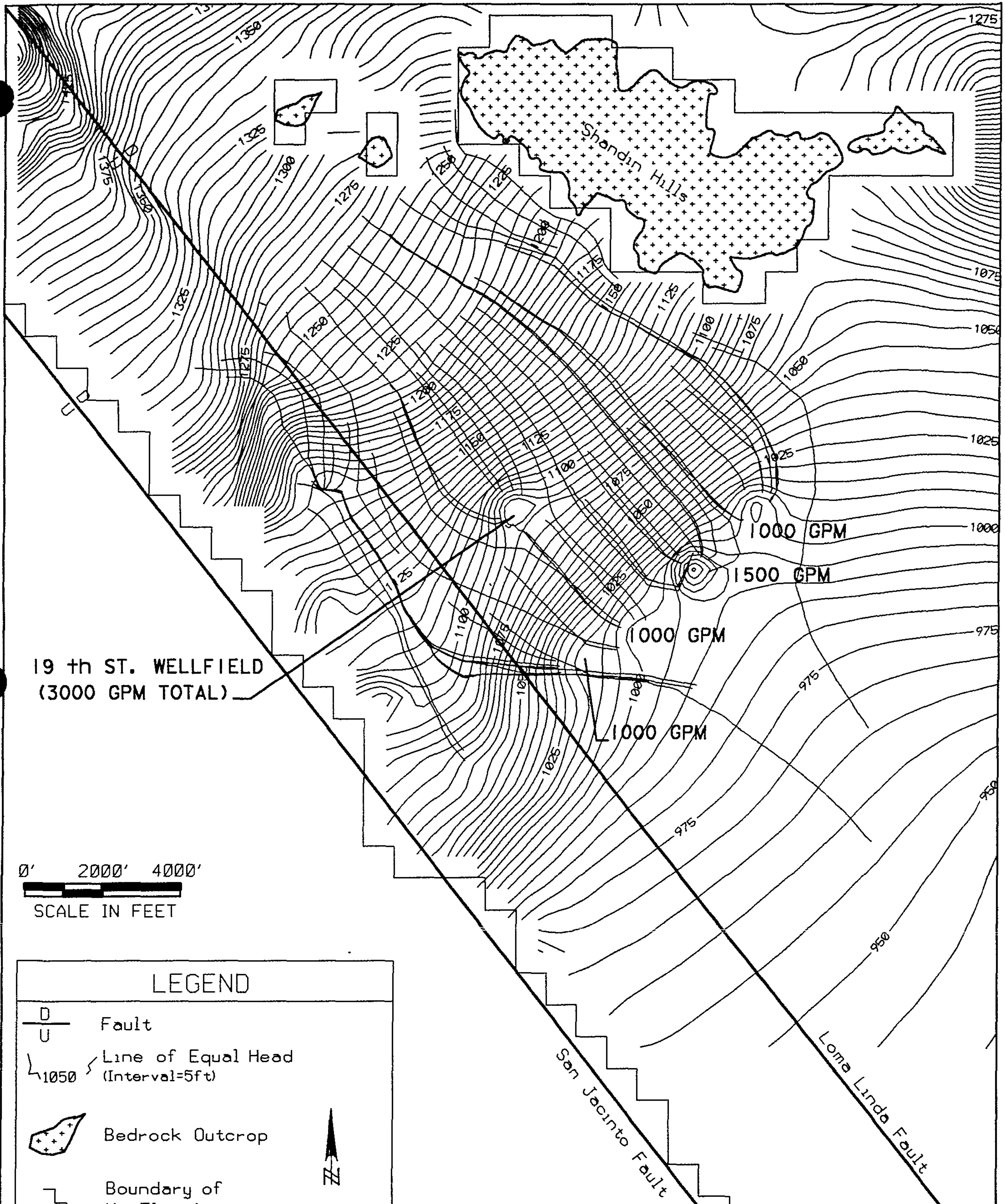

FIGURE A6-12
HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 5 LAYER 2 (LOWER AQUIFER)

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Table A6-10

EXTRACTION AREA LOCATIONS & PUMPING RATES FOR EXTRACTION SCENARIO NO. 6 (RUN 59J)

Extraction Area	Model Cell (i,j,k)	Pumping Ratio		Pumping Rate (gpm)
		Layer 1	Layer 2	
New Ext. Well	(35,25,1) (35,25,2)	0.33	0.67	1,500
New Ext. Well	(37,23,1) (37,23,2)	0.33	0.67	1,500
New Ext. Well	(39,21,1) (39,21,2)	0.33	0.67	1,700
New Ext. Well	(40,19,1) (40,19,2)	0.33	0.67	1,500

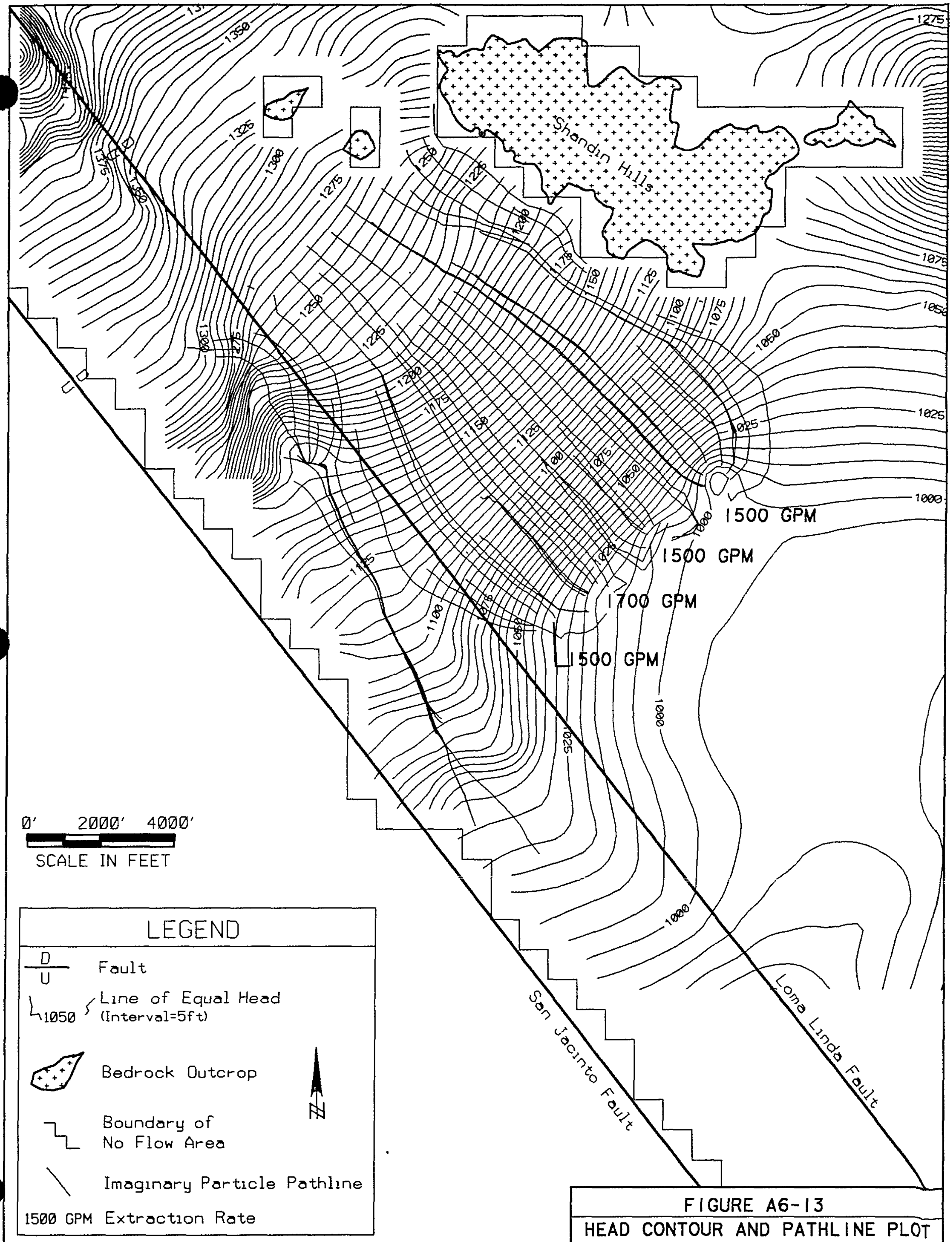

FIGURE A6-13

HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 6 LAYER I (UPPER AQUIFER)

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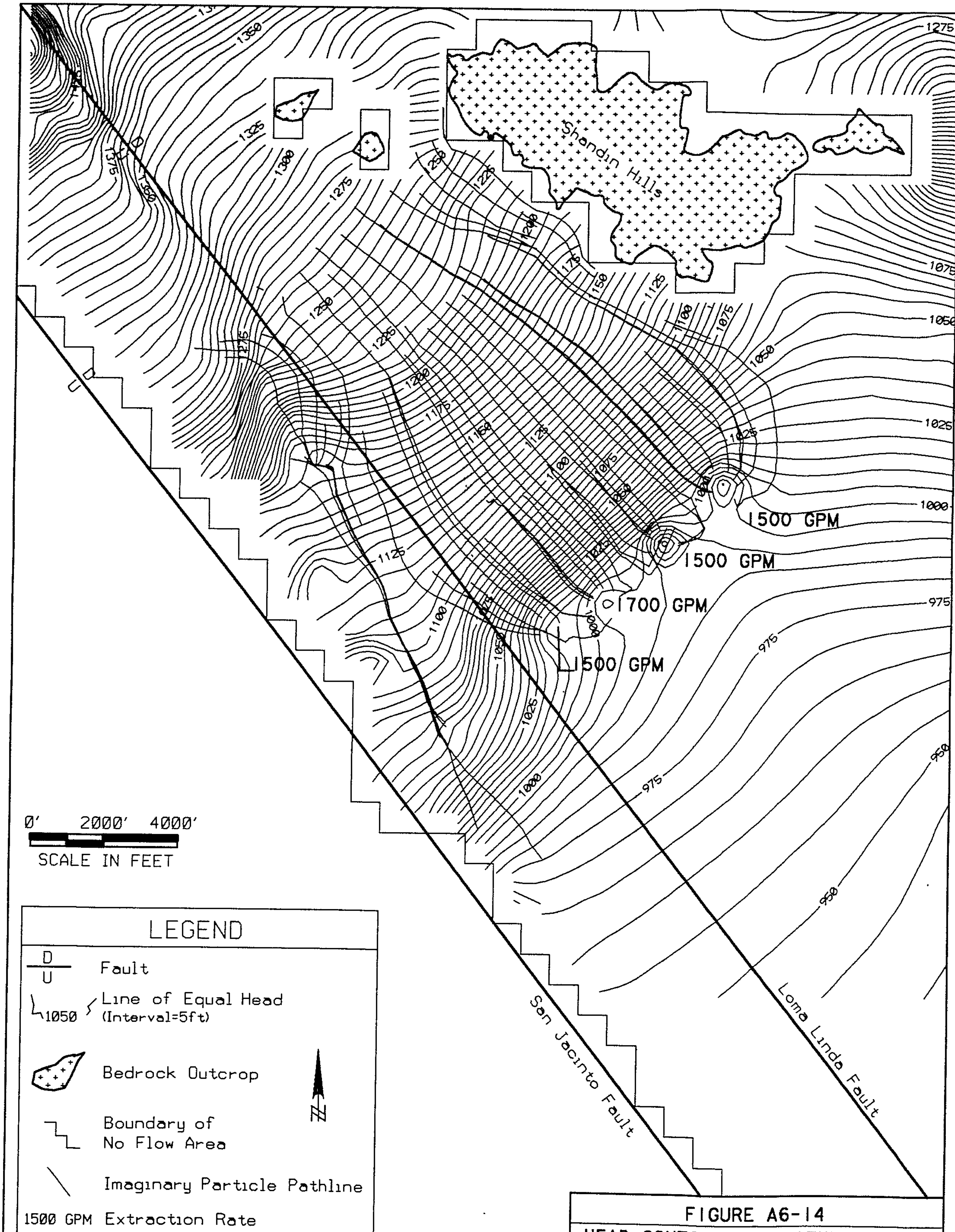


FIGURE A6-14
HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 6 LAYER 2 (LOWER AQUIFER)

Table A6-11 gives the locations of the extraction areas and their pumping rates used in the simulation run. Figures A6-15 and A6-16 show the head contours and pathlines of the imaginary particles for layers 1 and 2, respectively. All the imaginary particles were captured by the four extraction areas. It appeared that the pumping of the Baseline Feeder wellfield did not affect the capture of imaginary particles by the four extraction areas.

3.2.8 Extraction Scenario No. 8

This extraction scenario was identical to extraction scenario no. 7 except that pumping in the four extraction areas was changed to each quarter-year to simulate the seasonal water demand on the municipal supply system. This scenario consisted of four extraction areas located near the downgradient edge of the plume and Baseline Feeder wellfield. The extraction in the four areas was as follows:

- No pumping the first 5-year period; and
- For the next 30 years, a changing pumping rate to reflect the seasonal variation (or changing water demand) was used.

Based on the 3-year period between January 1991 through December 1993, the pumping history of Baseline Feeder wellfield (data provided by the SBVMWD) showed maximum pumping occurs in the 4th quarter. During the 1st, 2nd, and 3rd quarters, the pumping rates were 0.69, 0.64, and 0.9 times the 4th quarter pumping rate, respectively. These ratios were used to simulate the pumping from the four extraction areas for each quarter in a year with maximum pumping of 1,500, 1,500, 1,700, and 1,500 gpm in the 4th quarter. Thus, this one-year pumping cycle from the 4 extraction areas was repeated for the 30-year simulation period.

The Baseline Feeder wellfield was turned on from January 1991, and actual pumping rates were used for the 3-year period starting between January 1991 through December 1993. For the remainder of the simulation period, starting January 1994, the actual yearly pumping rate of 1993 was repeated. The 19th Street wellfield pumped only during the first 5-year period at normal pumping rates, and no pumping was assumed during the following 30-year period.

Table A6-12 gives the locations of the extraction areas and their pumping rates used in the simulation run. Figures A6-17 and A6-18 show the head contours and pathlines of the imaginary particles for layers 1 and 2, respectively. Most of the imaginary particles were captured by the four extraction areas. Two particles (one south and one north) of the four extraction areas were not captured. Also, one particle escaped capture through the space between two of the four extraction areas.

3.2.9 Extraction Scenario No. 9

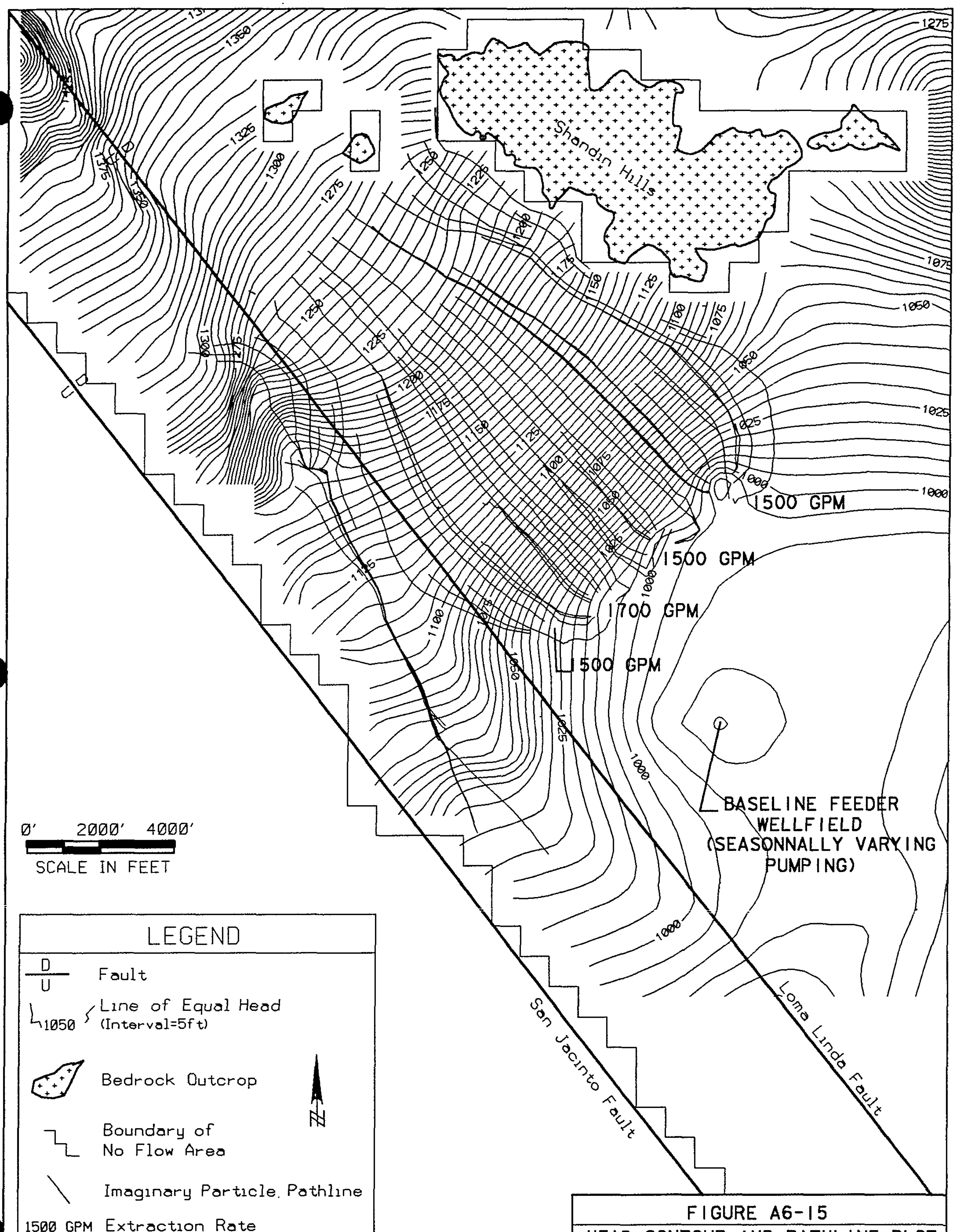
This extraction scenario consisted of four extraction areas located in the downgradient edge of the plume. The extraction in the four extraction areas was as follows:

- No pumping the first 5-year period; and
- For the next 30 years, constant daily pumping of 1,500, 1,500, 1,700, and 1,500 gpm from the four extraction areas.

Table A6-11

EXTRACTION AREA LOCATIONS & PUMPING RATES FOR EXTRACTION SCENARIO NO. 7 (RUN 60A)

Extraction Area	Model Cell (i,j,k)	Pumping Ratio		Pumping Rate (gpm)
		Layer 1	Layer 2	
Perris St.	(43,25,1) (43,25,2)	0.67	0.33	Normal Pumping
9th St.	(43,23,1) (43,23,2)	0.67	0.33	Normal Pumping
New Ext. Well	(35,25,1) (35,25,2)	0.33	0.67	1,500
New Ext. Well	(37,23,1) (37,23,2)	0.33	0.67	1,500
New Ext. Well	(39,21,1) (39,21,2)	0.33	0.67	1,700
New Ext. Well	(40,19,1) (40,19,2)	0.33	0.67	1,500



LEGEND

- D/U — Fault
- 1050 — Line of Equal Head (Interval=5ft)
- Bedrock Outcrop
- Boundary of No Flow Area
- Imaginary Particle Pathline
- 1500 GPM — Extraction Rate

URS Consultants, Inc. Sacramento, Ca	MUSCOY PLUME OU RI/FS REPORT NEWMARK GROUNDWATER CONTAMINATION SUPERFUND SITE	FIGURE A6-15 HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 7 LAYER 1 (UPPER AQUIFER)

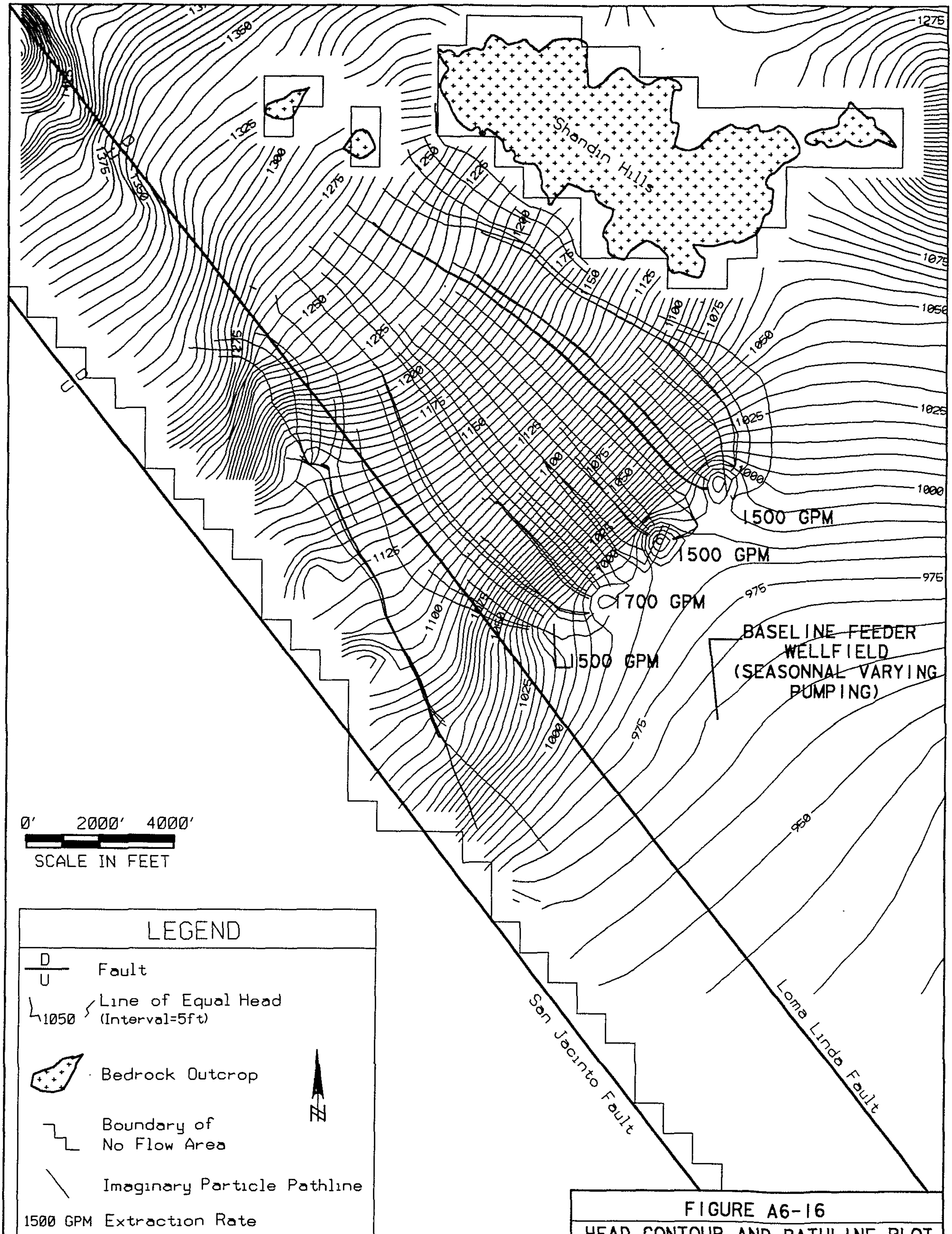


FIGURE A6-16
HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 7 LAYER 2 (LOWER AQUIFER)

Table A6-12

EXTRACTION AREA LOCATIONS & PUMPING RATES FOR EXTRACTION SCENARIO NO. 8 (RUN 60B)

Extraction Area	Model Cell (i,j,k)	Pumping Ratio		Pumping Rate (gpm)
		Layer 1	Layer 2	
Perris St.	(43,25,1) (43,25,2)	0.67	0.33	Normal Pumping
9th St.	(43,23,1) (43,23,2)	0.67	0.33	Normal Pumping
New Ext. Well	(35,25,1) (35,25,2)	0.33	0.67	1,500 (max)
New Ext. Well	(37,23,1) (37,23,2)	0.33	0.67	1,500 (max)
New Ext. Well	(39,21,1) (39,21,2)	0.33	0.67	1,700 (max)
New Ext. Well	(40,19,1) (40,19,2)	0.33	0.67	1,500 (max)

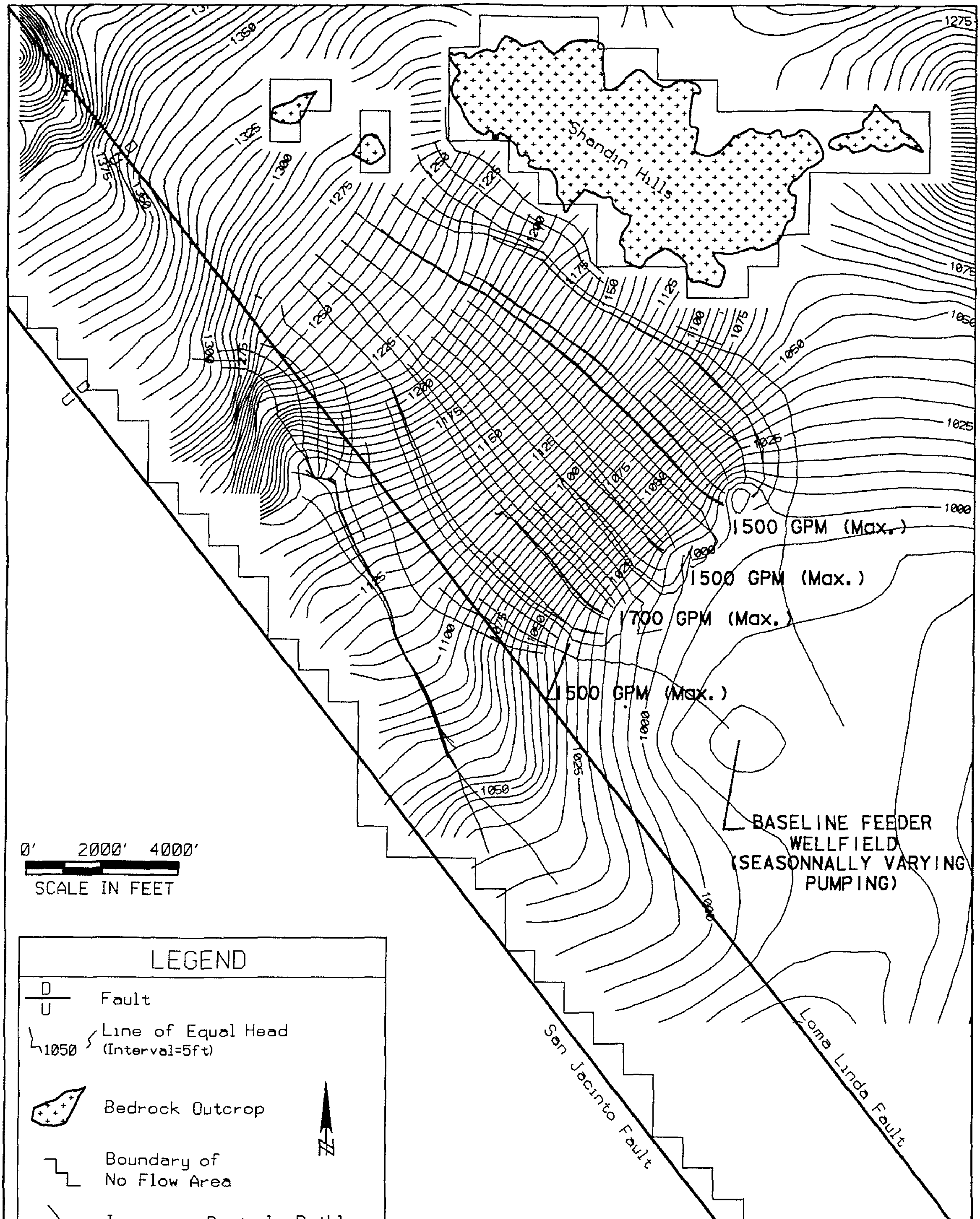


FIGURE A6-17

HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 8 LAYER 1 (UPPER AQUIFER)

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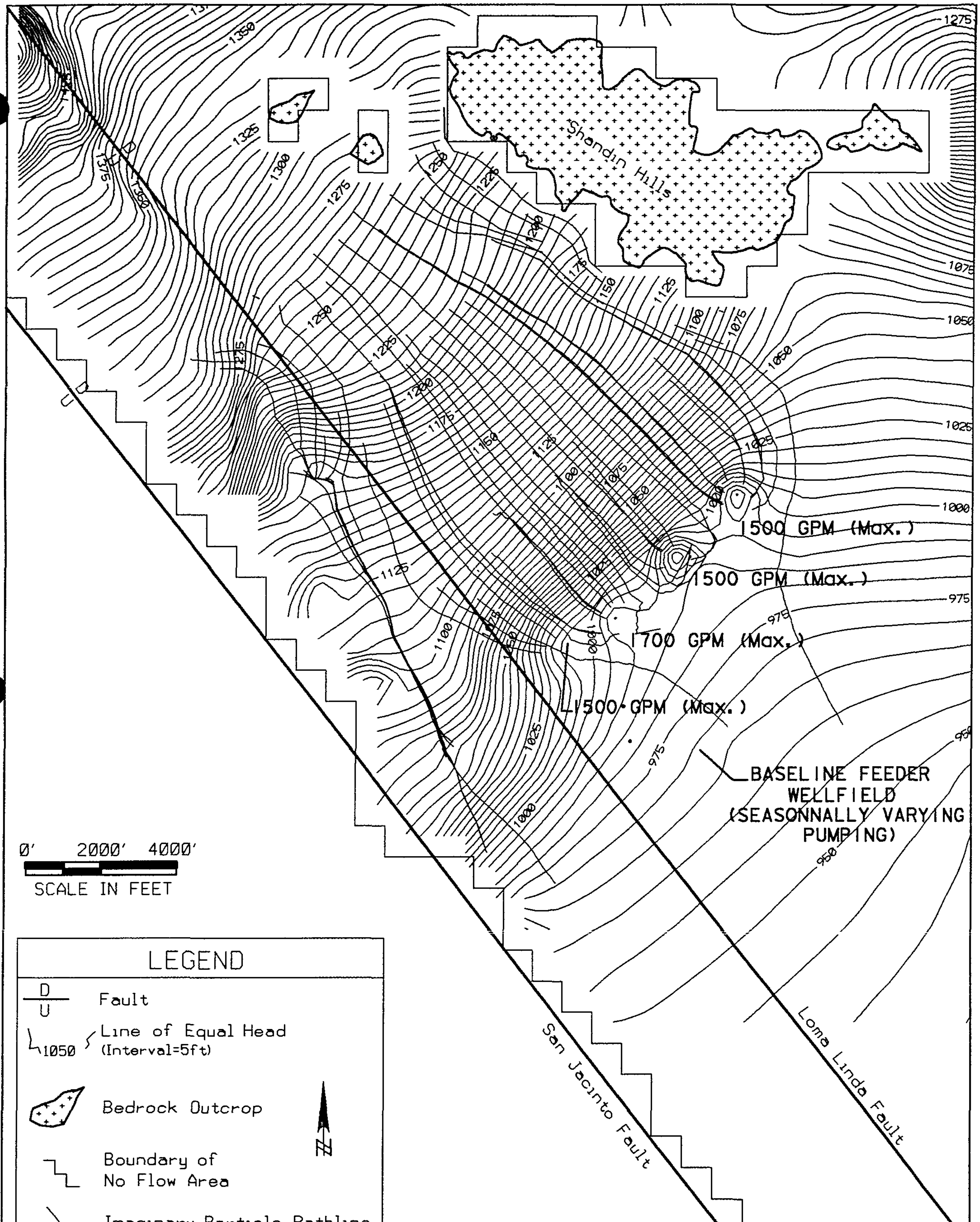

FIGURE A6-18
HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 8 LAYER 2 (LOWER AQUIFER)

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The 19th Street wellfield was pumped only during the first 5-year period at normal pumping rates, and no pumping was assumed during the following 30-year period.

As described in Subsection 3.1, two injection well regions were considered as shown in Figure A6-1: one region located adjacent to the eastern boundary of the plume, and the second region located adjacent to the western boundary of the plume. In each of these injection regions, 4 injection areas were considered. Consequently, a total of 8 injection areas each with an injection capacity of 775 gpm (=6,200/8) were considered for reinjection. It was assumed that the injection wells were suspended in the upper and lower layers of the aquifer. Several simulation runs were made to select the location of injection areas before arriving at this final simulation.

Table A6-13 gives the locations of the injection and extraction areas and their injection and pumping rates used in the simulation run. Figures A6-19 and A6-20 show the head contours and pathlines of imaginary particles for layers 1 and 2, respectively. All the imaginary particles were captured by the extraction areas.

It should be noted that a main purpose for considering groundwater injection was for an end-use alternative. Injection scenarios were not optimized during the current modeling effort. If the injection end-use alternative becomes part of the selected remedy, additional evaluation to optimize injection well locations and injection rates must be performed.

Table A6-2 provides a summary of the parameters used in the nine extraction scenarios.

3.3 PREFERRED EXTRACTION SCENARIO

The nine extraction scenarios were evaluated for their ability to capture imaginary particles. Based on this evaluation, extraction scenario no. 6 was chosen as the preferred scenario. Extraction scenario no. 6 corresponds to predictive model run 59J. This scenario involved four new extraction areas with a total pumping rate of 6,200 gpm. It should be noted that this pumping rate is an estimate based on model results and is, therefore, subject to the same degree of uncertainty as the model. Pumping rates for the extraction system should be determined after the new wells are constructed and tested. Regardless, the rate chosen here is considered adequate for FS purposes. The effects of pumping 19th Street wells or the Baseline Feeder wells (either beneficial or detrimental) could not be firmly established with the current information. It is evident that the most effective extraction remedy requires extraction of approximately 6,200 gpm in a series of new wells at the leading edge of the plume. The 6,200 gpm estimate should be considered the starting point for a refined model estimate developed from additional observations of the aquifer during the RD phase. For preliminary engineering calculations, a conservative estimate of approximately 7,000 gpm should be used. An extraction rate of 4,000 gpm (Scenario 3), appeared to be quite inadequate and several particle pathlines were not captured at extraction rates between 5,000 and 6,000 gpm. It may be possible that a more refined model based on additional site-specific observations could produce an estimated extraction rate in the 5,000 gpm range. Additionally, information was insufficient to predict the effects of seasonal differences in pumping rates.

Extraction scenario no. 9, as previously mentioned, was evaluated for an end-use alternative. This scenario is used in the feasibility study during detailed analysis of remedial Alternative 5.

Table A6-13

EXTRACTION AREA LOCATIONS & PUMPING RATES FOR EXTRACTION SCENARIO NO. 9 (RUN 61C)

Extraction Area	Model Cell (i,j,k)	Pumping or Injection Ratio		Pumping Rate (gpm)
		Layer 1	Layer 2	
New Ext. Well	(35,25,1) (35,25,2)	0.67	0.33	1,500
New Ext. Well	(37,23,1) (37,23,2)	0.67	0.33	1,500
New Ext. Well	(39,21,1) (39,21,2)	0.67	0.33	1,700
New Ext. Well	(40,19,1) (40,19,2)	0.67	0.33	1,500
New Inj. Well	(29,27,1) (29,27,2)	0.67	0.33	-775
New Inj. Well	(30,27,1) (30,27,2)	0.67	0.33	-775
New Inj. Well	(31,27,1) (31,27,2)	0.67	0.33	-775
New Inj. Well	(37,14,1) (37,14,2)	0.67	0.33	-775
New Inj. Well	(35,13,1) (35,13,2)	0.67	0.33	-775
New Inj. Well	(33,11,1) (33,11,2)	0.67	0.33	-775
New Inj. Well	(32,10,1) (32,10,2)	0.67	0.33	-775
New Inj. Well	(33,27,1) (33,27,2)	0.67	0.33	-775

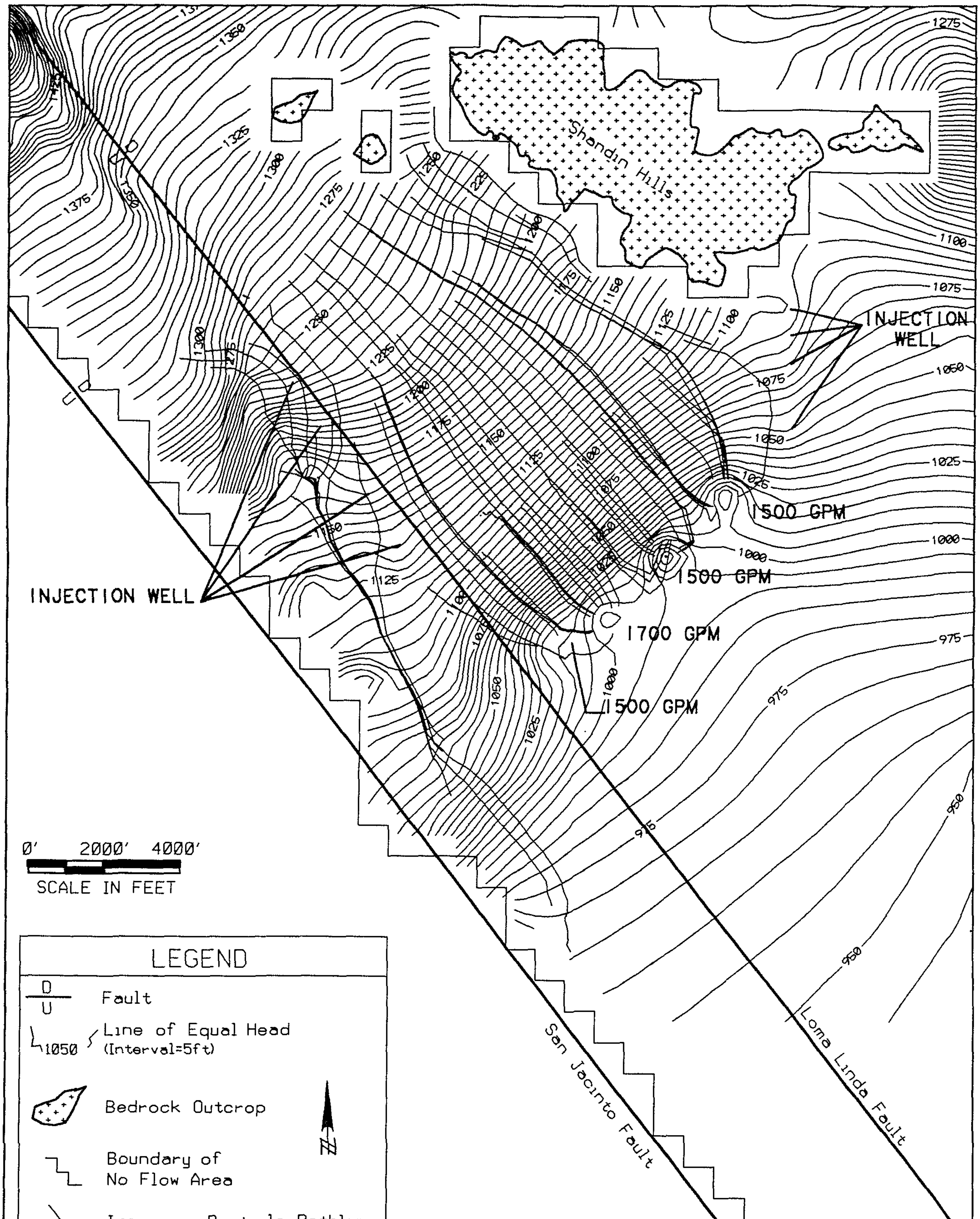

FIGURE A6-19

HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 9 LAYER 2 (LOWER AQUIFER)

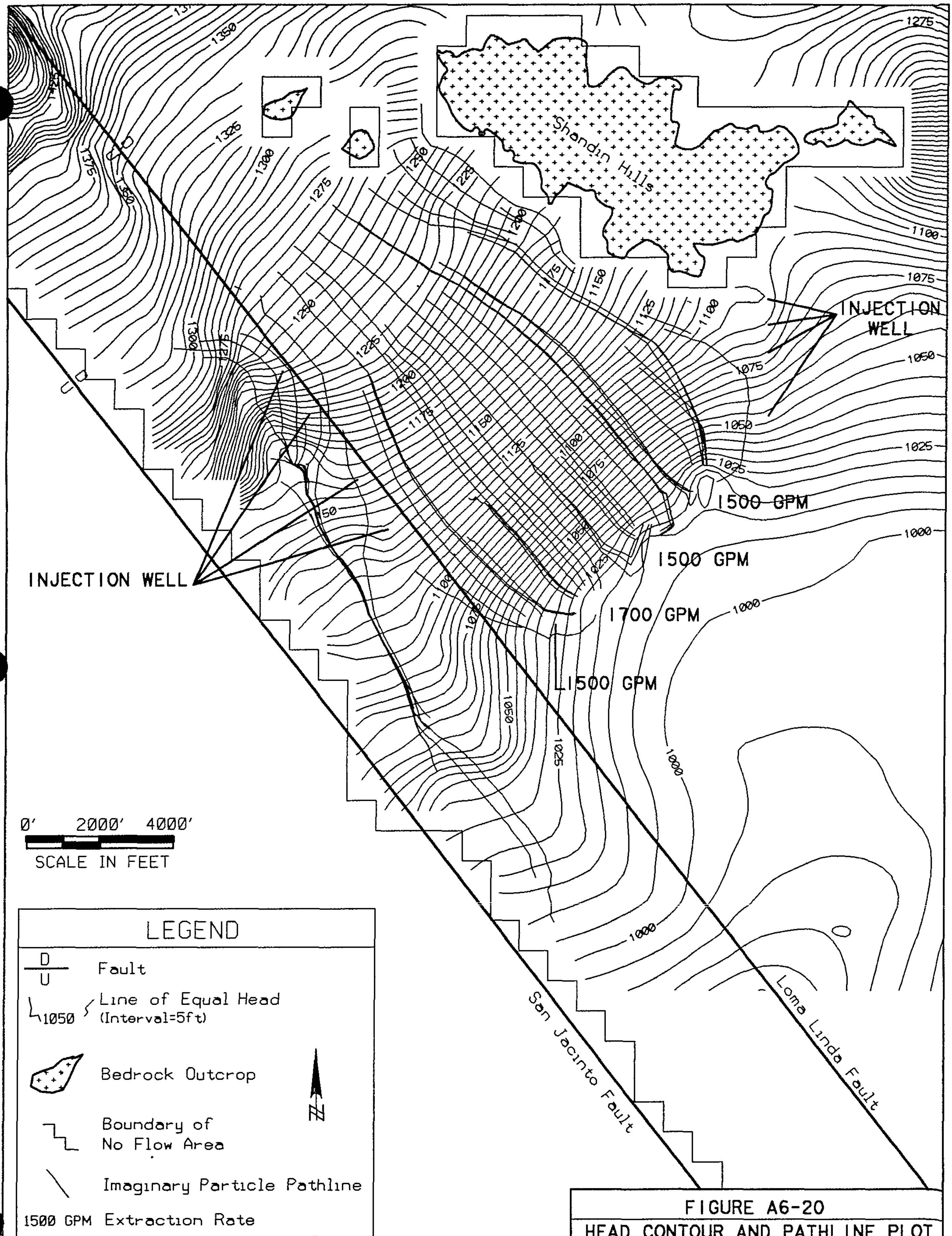

FIGURE A6-20
HEAD CONTOUR AND PATHLINE PLOT
FOR EXTRACTION SCENARIO NO. 9
LAYER 2 (UPPER AQUIFER)

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particles can migrate through, the pumping rates have to be increased to capture the particles. When in reality, extraction areas could be placed closer together and pumped at slower rates.

Second, MODFLOW allows for the simulation of individual model layers, but does not allow for separate screening intervals within the model areas. Therefore, when placing the extraction areas, they could only be screened throughout the model layer and in separate intervals within the model layers. Therefore, when simulating the extraction scenarios, more groundwater is extracted from one extraction area than may be feasible for that extraction area in the field.

The fourth set of limitations is the gridding and plotting resolution of SURFER and PATH3D that may cause difficulties in interpreting water elevation contours. SURFER only allows for gridding and plotting of water elevation contours to the mid points of the grid cells located next to no-flow areas. However, PATH3D allows for plotting of the imaginary particle pathlines to any area of the grid cells located next to the no-flow areas. This creates difficulties in interpreting water elevation contours in the no-flow areas. Additional limitations are provided in the Muscoy Groundwater Modeling Memorandum.

5.0 LIMITATIONS

It is always important to remember that groundwater flow models and other associated computer software are only tools used to interpret past, present and future groundwater flow conditions. Therefore, one needs to be aware of the limitations existing in the model software and project flow model that may have resulted in inaccuracies in the extraction scenario simulations. They are:

- Difficulties in the project flow model calibration due to lack of aquifer description data;
- Scaling effects in the project flow model;
- Grid spacing and model layer resolution for placing extraction areas; and
- Gridding and plotting resolution of SURFER and PATH3D.

The first set of limitations are due to lack of aquifer description data, which have created difficulties in the project flow model calibration. Aquifer description data (for example, hydraulic conductivities, streamflow values, elevations of model layers, and the distribution of heads within the aquifer) are seldom known accurately or completely, thus producing data error. This can create difficulties in accurately calibrating the project flow model. For example, streamflow values have been used as calibration data for the project flow model. Estimates of flux measurements usually have large errors associated with the field measurements. Nevertheless, it is advisable to use estimates of flow as calibration values, in addition to heads, for achieving a unique calibration (Anderson and Woessner 1992).

Furthermore, calibration is difficult because values for aquifer parameters and hydrologic stresses are typically known at only a few nodes and, even then, estimates are influenced by uncertainty. Calibration values ideally should coincide with nodes, but in practice this will seldom be possible. This introduces interpolation errors caused by estimating calibration values for grid cells.

Lack of aquifer data contributed particularly to dry cell and boundary condition problems in the calibration of the project flow model. These dry cell and boundary condition problems were avoided and minimized when possible.

The second set of limitations is the error produced in the simulation from scaling effects in the project flow model. For example, heads may be measured in wells with long screens but the model may require point values. Head measurements averaged over long screens may be appropriate for calibrating a two-dimensional areal model but are usually not representative of heads calculated by a three-dimensional model.

Also, another scaling effect discussed by Gelhar (1986) can cause errors in simulated heads. The cells of the grid represent average aquifer properties within the cell. Field-measured heads, however, may be influenced by small-scale heterogeneities that are not captured by the model. Unmodeled heterogeneity causes error in the simulated heads.

The third set of limitations is the grid spacing and model layer resolution, which eventually poses problems in placing extraction wells. First, the grid spacing for the project flow model is 820 feet in the x-direction and 820 feet in the y-direction. When pumping of extraction areas are assigned to a grid cell, they are placed at the center of the grid cell. Therefore, extraction areas cannot be placed any closer to one another than 820 feet. To make up for the distance between extraction areas, where modeled

Table A6-14

AVERAGE GROUNDWATER VELOCITIES FOR MUSCOY PLUME OU

Velocity (ft/day)	Velocity (ft/yr)
Average Groundwater Velocity	
1.4	500

4.0 AVERAGE GROUNDWATER VELOCITY

This section contains the calculation of average groundwater velocity for the Muscoy Plume OU. Groundwater velocity can be estimated from the output of MODFLOW runs. Groundwater velocity can vary from location to location and from time to time. Because of the variation, an average groundwater velocity is calculated, and then used in the calculation of travel time.

An average groundwater velocity was calculated for the entire Muscoy Plume OU. The groundwater velocity was represented by the velocities of the imaginary particles that were placed in the OU. The velocity of an imaginary particle equaled the travel-distance divided by the travel-time. Imaginary particles that were not affected by the boundary conditions of the project flow model and plotting limitations of SURFER® and PATH3D© were used to calculate an average groundwater velocity for the Muscoy plume area. Table A6-14 presents the calculated average groundwater velocity for the Muscoy Plume OU.

The estimated average groundwater velocity for the Muscoy Plume OU is a simple arithmetic average. The estimate of average groundwater velocity using particle travel times was considered a good estimate for the following reasons:

- The project flow model is a computer model and, therefore, groundwater velocities provided by the project flow model are estimates or averages over a much larger distance than estimates about a single well using pumping test derived data;

- It is not known how the groundwater velocity estimated for the Muscoy Plume OU compares with actual field conditions since they have not been measured. The calculated velocity could not be verified but represents the best possible estimate over the length of the investigation area. There are no reasonable methods for directly measuring groundwater velocity in this basin since trace studies are neither feasible nor warranted at this time. Indirect measurements are good alternatives but result in some uncertainty.

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