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**Summary of South Fence Road Phase II
1993 Field Operations at Site SFR-4**

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Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
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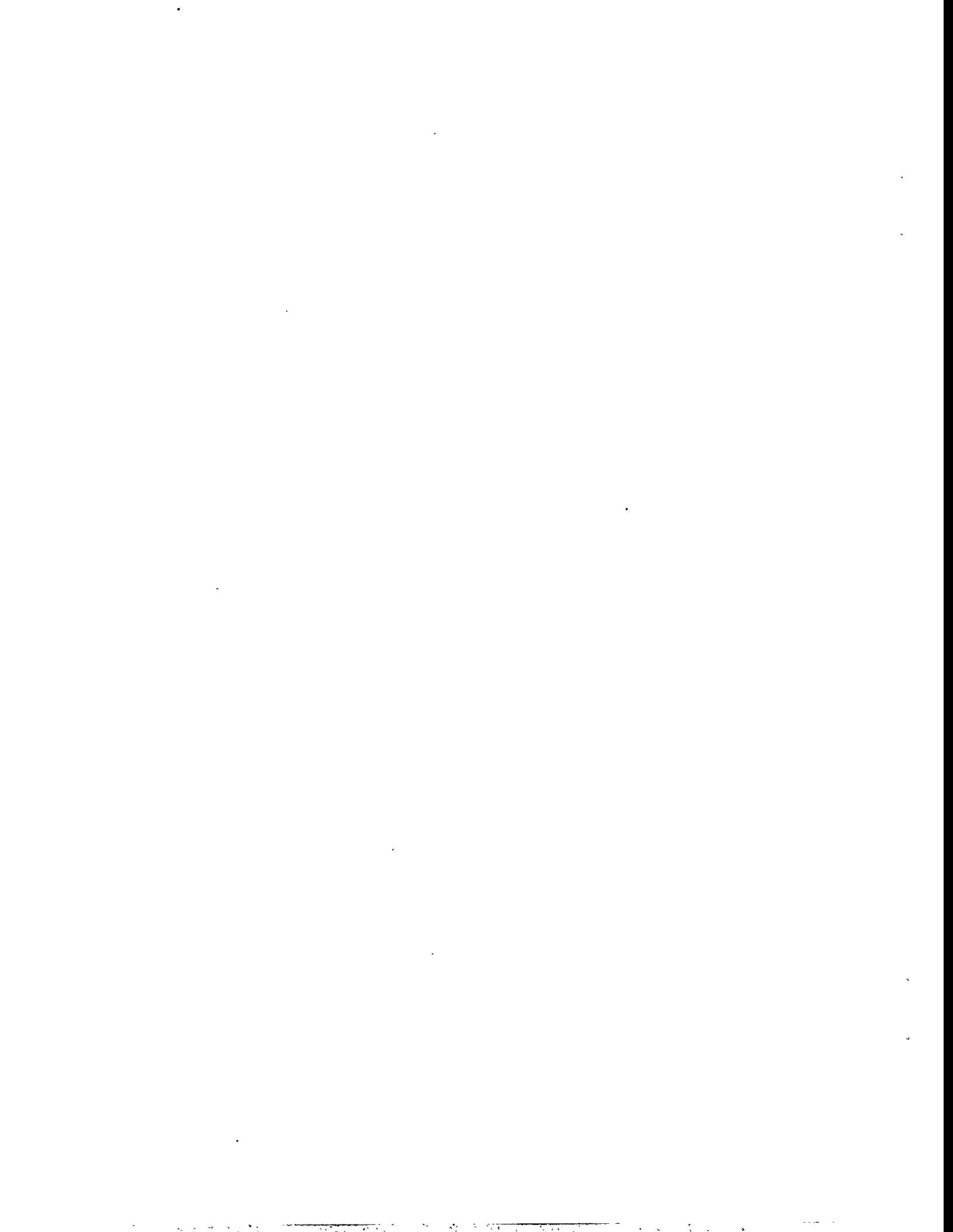
Site-Wide Hydrogeologic Characterization Project

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ABSTRACT

This report is a basic data report for field operations associated with the drilling, logging, completion, and development of South Fence Road Wells SFR-4P and SFR-4T. These test/monitoring wells were installed as part of Sandia National Laboratories, New Mexico, Environmental Restoration Project.



**SUMMARY OF SOUTH FENCE ROAD PHASE II
1993 FIELD OPERATIONS AT SITE SFR-4**

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1.0 EXECUTIVE SUMMARY

This report provides a summary of the field operations associated with the installation of the SFR-4P and SFR-4T test/monitoring wells. These wells were installed in 1993 as part of Phase II of the Site-Wide Hydrogeologic Characterization task South Fence Road project. The Site-Wide Hydrogeologic Characterization task is part of Sandia National Laboratories, New Mexico, Environmental Restoration Project carried out by the Environmental Operations Center, 7500.

SFR-4P was drilled to a total depth of 510 feet through the Santa Fe Group into the underlying bedrock. The Santa Fe Group/bedrock contact in this well was at a depth of 35 feet. After drilling to total depth the borehole was logged, and then plugged back to a depth of 371.5 feet. The borehole was then completed as a bedrock test/monitoring well. The sand pack completion interval for this well is 319 feet to 371.5 feet.

SFR-4T was drilled to a total depth of 384 feet through the Santa Fe Group into the underlying bedrock. The Santa Fe Group/bedrock contact in this well was at a depth of approximately 38 feet. After drilling, the borehole was completed as a bedrock test/monitoring well with the sand pack completion interval from 303 feet to 384 feet.

During these field operations, important subsurface geologic and hydrologic data were obtained. Subsurface geologic data include drill cuttings, core, and borehole geophysical logs. These data will improve the understanding of fault displacement across the Hubbell Spring fault, define the lithologic framework within the Santa Fe Group at this location, identify the stratigraphic relationship across the Santa Fe Group/bedrock contact, and establish the local stratigraphic sequence in the uppermost 480 feet of the underlying bedrock. Subsurface hydrologic data include borehole geophysical logs, and qualitative information obtained during well completion/well development. These data will help define the local hydrostratigraphic framework within the underlying confined bedrock aquifer. SFR-4P and SFR-4T are collectively referred to as the SFR-4 hydropad. Future aquifer testing at the SFR-4 hydropad will generate data for the interpretation of aquifer parameters (transmissivity and storativity), and may yield information on anisotropy within the bedrock aquifer.

2.0 INTRODUCTION

The Environmental Restoration (ER) Project at Sandia National Laboratories, New Mexico (SNL/NM), is managing the program to assess and, when necessary, to remediate sites on Kirtland Air Force Base (KAFB) that were potentially contaminated by SNL/NM operations. Within the ER Department, the Site-Wide Hydrogeologic Characterization (SWHC) task is responsible for the area-wide hydrogeologic investigation. The purpose of this project is to reduce the uncertainty about the rate and direction of groundwater flow beneath KAFB and across its boundaries. Phase II of the South Fence Road project is part of the SWHC task.

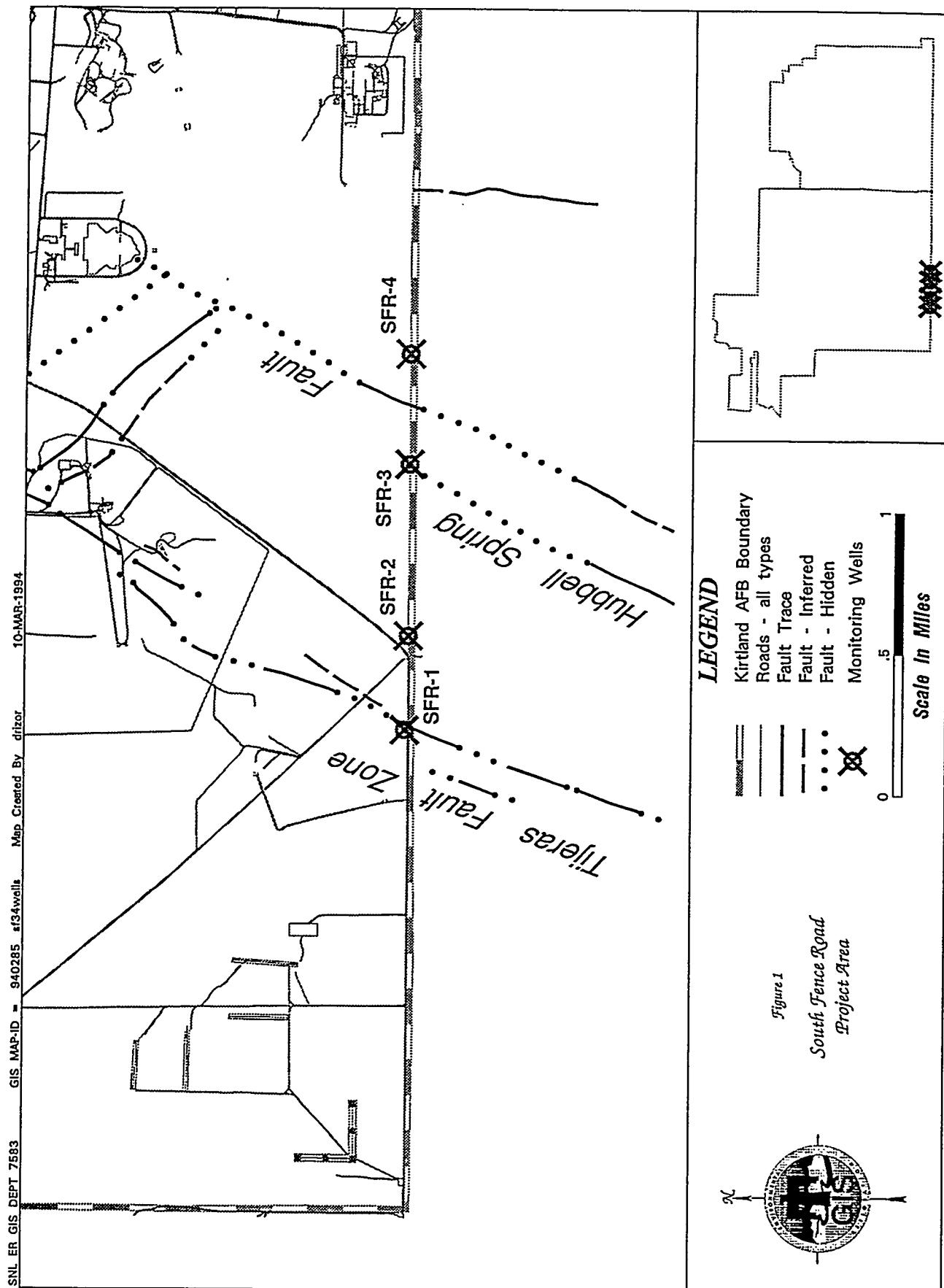
2.1 Background

The South Fence Road (SFR) project area is located along the southern boundary of SNL/KAFB. This area is structurally and stratigraphically complex, primarily because it is crossed by the north-trending Hubbell Spring fault and the northeast-trending Tijeras fault zone. Figure 1 shows the location of the South Fence Road project area.

The South Fence Road project was initiated to assess characteristics of subsurface lithologies in the vicinity of these faults, and to provide information on the rate and direction of groundwater flow in Santa Fe Group and underlying bedrock aquifers. Initial activities (Phase I) took place during the summer of 1992 and included installing monitoring wells at four sites along South Fence Road (Neel and McCord, 1994). Four additional boreholes were drilled at the SFR-3 and SFR-4 locations during 1993 (Phase II). This report provides a summary of the Phase II field operations at the SFR-4 location. A complete set of all the data obtained at the SFR-4 location is on file in the SNL ER Records Center.

2.2 Objective

The South Fence Road wells were drilled to investigate the subsurface geology and hydrology along the southern boundary of SNL/KAFB. Geologic objectives included: 1) identifying depth to bedrock; 2) determining and locating displacements of the Hubbell Spring and Tijeras fault zones; and 3) characterizing subsurface lithologies. Hydrologic objectives included obtaining information to reduce uncertainty about rates and directions of groundwater flow within the alluvial and bedrock aquifers, and installing monitoring/test wells in the Santa Fe Group and underlying bedrock aquifers.



3.0 WELL-SITE GEOLOGY

The following discussion of the well-site geology at the SFR-4 location is a brief summary of the area geology included in the Site-Wide Hydrogeologic Characterization Project Calendar Year 1993 Annual Report (SNL, 1994).

3.1 Surface Geology

South Fence Road is located on the broad, west-sloping piedmont that makes up the Upper Llano de Manzano geomorphic subprovince. The piedmont is dissected by numerous drainages that flow west to closed depressions in the McCormick Ranch geomorphic subprovince or to Hells Canyon Wash. Surficial deposits within the area are derived from the Manzanita Mountains, located about 3.1 miles to the east. Previous investigations show that the South Fence Road is underlain by piedmont-slope alluvium (gravelly sand/silt/clay) (Hawley and Haase, 1992).

3.2 Stratigraphy

The subsurface stratigraphy along the south boundary of KAFB is impacted by local and regional structural complexities, and the presence of significant unconformities. It is not well understood due to sparse sedimentary outcrops and the lack of drillholes that penetrate the full sedimentary section. The expected surface and subsurface stratigraphy is summarized in Figure 2.

The deepest and oldest bedrock formation penetrated by South Fence Road wells is tentatively identified as the Permian Yeso Formation (SNL, 1994). The top was penetrated at 865 feet at the SFR-3 site, and not encountered at the SFR-4 site. Unconformably overlying the Yeso Formation is a grey interbedded shale, siltstone, and sandstone tentatively dated as Lower Tertiary. At SFR-4, light- to medium-gray sediments are interbedded with light- to medium-gray strata having light reddish-brown color tones. These Lower Tertiary rocks are tentatively correlative to the strata described by Lozinsky (1988) as the "Unit of Isleta 32 well". Depths to bedrock and total depths for the SFR-4P and SFR-4T wells are shown in Table 1.

Unconformably overlying bedrock is the Upper Tertiary Santa Fe Group. At the SFR-4 location this unit is approximately 35 feet thick, and is made up of variegated gravelly sandy silt with some clay.

KAFB AREA STRATIGRAPHY

ERATHEM/SYSTEM/ SERIES			UNIT/FORMATION		STRAT. COLUMN	DESCRIPTION
CENOZOIC	NEOGENE	Holocene to Middle Pleistocene	Surficial Units			Cross-bedded, fine-to-medium eolian sand Poorly sorted silty sandy cobble to boulder gravel Local unconformity Poorly sorted silty sandy cobble to boulder gravel with relict and buried soils Unconformity Basinal: coarse-to-fine grained sandstones; common buried soils Marginal: pebbles, cobbles in fine-grained matrix Basinal: Medium- to fine-grained sandstone and mudstone; common buried soils Marginal: conglomeratic sandstone to pebbles and cobbles; common buried soils Basinal: medium-to-fine sandstones, sandy mudstones Marginal: conglomeratic sandstone and mudstone Unconformity Fine-to-coarse-grained sandstone with claystones and silty interbeds Unconformity Sandstone, variegated mudstone, and conglomerate Unconformity Claystone w/ calcareous lenses, carbonaceous beds Unconformity Upper: gypsumiferous sandstone, siltstone, limestone Lower: fine-grained sandstone and siltstone
		Early Pleistocene to Early Miocene	Santa Fe Group	Upper Santa Fe Unit		Basinal: coarse-to-fine grained sandstones; common buried soils Marginal: pebbles, cobbles in fine-grained matrix Basinal: Medium- to fine-grained sandstone and mudstone; common buried soils Marginal: conglomeratic sandstone to pebbles and cobbles; common buried soils Basinal: medium-to-fine sandstones, sandy mudstones Marginal: conglomeratic sandstone and mudstone Unconformity Fine-to-coarse-grained sandstone with claystones and silty interbeds Unconformity Sandstone, variegated mudstone, and conglomerate Unconformity Claystone w/ calcareous lenses, carbonaceous beds Unconformity Upper: gypsumiferous sandstone, siltstone, limestone Lower: fine-grained sandstone and siltstone
				Middle Santa Fe Unit		Basinal: coarse-to-fine grained sandstones; common buried soils Marginal: pebbles, cobbles in fine-grained matrix Basinal: Medium- to fine-grained sandstone and mudstone; common buried soils Marginal: conglomeratic sandstone to pebbles and cobbles; common buried soils Basinal: medium-to-fine sandstones, sandy mudstones Marginal: conglomeratic sandstone and mudstone Unconformity Fine-to-coarse-grained sandstone with claystones and silty interbeds Unconformity Sandstone, variegated mudstone, and conglomerate Unconformity Claystone w/ calcareous lenses, carbonaceous beds Unconformity Upper: gypsumiferous sandstone, siltstone, limestone Lower: fine-grained sandstone and siltstone
				Lower Santa Fe Unit		Basinal: coarse-to-fine grained sandstones; common buried soils Marginal: pebbles, cobbles in fine-grained matrix Basinal: Medium- to fine-grained sandstone and mudstone; common buried soils Marginal: conglomeratic sandstone to pebbles and cobbles; common buried soils Basinal: medium-to-fine sandstones, sandy mudstones Marginal: conglomeratic sandstone and mudstone Unconformity Fine-to-coarse-grained sandstone with claystones and silty interbeds Unconformity Sandstone, variegated mudstone, and conglomerate Unconformity Claystone w/ calcareous lenses, carbonaceous beds Unconformity Upper: gypsumiferous sandstone, siltstone, limestone Lower: fine-grained sandstone and siltstone
	PALEOGENE	Oligocene	Unit of Isleta # 2 Well			Fine-to-coarse-grained sandstone with claystones and silty interbeds Unconformity Sandstone, variegated mudstone, and conglomerate Unconformity Claystone w/ calcareous lenses, carbonaceous beds Unconformity Upper: gypsumiferous sandstone, siltstone, limestone Lower: fine-grained sandstone and siltstone
		Eocene to Paleocene	Baca/Galisteo/Nacimiento Formations			Sandstone, variegated mudstone, and conglomerate Unconformity Claystone w/ calcareous lenses, carbonaceous beds Unconformity Upper: gypsumiferous sandstone, siltstone, limestone Lower: fine-grained sandstone and siltstone
UPPER MESOZOIC	Upper Cretaceous	Upper Cretaceous	Mancos Equivalent			Claystone w/ calcareous lenses, carbonaceous beds Unconformity Upper: gypsumiferous sandstone, siltstone, limestone Lower: fine-grained sandstone and siltstone
		Lower Permian	Yoso Formation			Unconformity Upper: gypsumiferous sandstone, siltstone, limestone Lower: fine-grained sandstone and siltstone
			Abo Formation			Fine- to coarse-grained sandstone and conglomerate with interbedded siltstone
	Upper Paleozoic	Upper to Middle Pennsylvanian	Madera Formation	Wild Cow Member		Rhythmically bedded sequence: conglomerate, sandstone, siltstone, shale, limestone
				Los Mayos Limestone		Gray calcarenite with chert
		Middle Pennsylvanian	Sandia Formation			Fining-upwards clastic sequence: conglomerate to calcareous siltstone
	Mississippian	Mississippian	Arroyo Peñasco Group			Dense, gray, fine-grained to oolitic limestone Unconformity Microcline and biotite granite; metarhyolite; quartzite; greenstone
		Sandia Granite Tijeras Greenstone Coyote Canyon Sequence Sevilleta Rhyolite				Microcline and biotite granite; metarhyolite; quartzite; greenstone

182.29A/4 1.3LAI012

Figure 2. Generalized Stratigraphic Column for KAFB

Table 1 - Depth to Bedrock* and Total Depth of the SFR-4P and SFR-4T Wells

BOREHOLE	SFR-4P	SFR-3T
Estimated Bedrock Depth from Gravity Data (ft. bgs) [1992 Revision]	229	229
Total Depth of Wells (ft. bgs)	510	384
Actual Depth to Bedrock Contact of Wells Drilled in 1993 (ft. bgs)	35	38
Difference [Actual-Estimated (ft.)]	194	191

* - Bedrock defined as consolidated rock below Santa Fe Fm.

3.3 Structure

Several regional faults intersect in the South Fence Road area and are shown in Figure 1. The Hubbell Spring fault is a normal fault with down-to-the-west displacement. The northeast-southwest Tijeras fault zone has numerous documented horizontal and vertical displacements. The interaction of these major faults resulted in a complexly faulted area, with a number of short cross faults.

The main western strand of the Hubbell Spring fault is directly west of the SFR-4 site, and is penetrated by SFR-3P and SFR-3T at 485 feet and 530 feet, respectively. Based on core evidence from both SFR-3 site wells, beds in the faulted zone are highly contorted and fractured. This fault, with a disrupted zone of approximately 60 feet true thickness, juxtaposes Santa Fe Group and lower Tertiary bedrock. There is an estimated 900 feet or greater pre-Santa Fe Group displacement on the fault, which precludes correlation with SFR-4 wells (SNL, 1994).

4.0 BOREHOLE/WELL CONSTRUCTION INFORMATION

Drilling operations at the SFR-4 site were conducted by the United States Geological Survey (USGS) and supervised by SNL/NM personnel. Drilling techniques included air rotary, mud rotary, and mud rotary coring. The following sections summarize the drilling, well installation, and well development operations carried out at the SFR-4 site.

4.1 Background

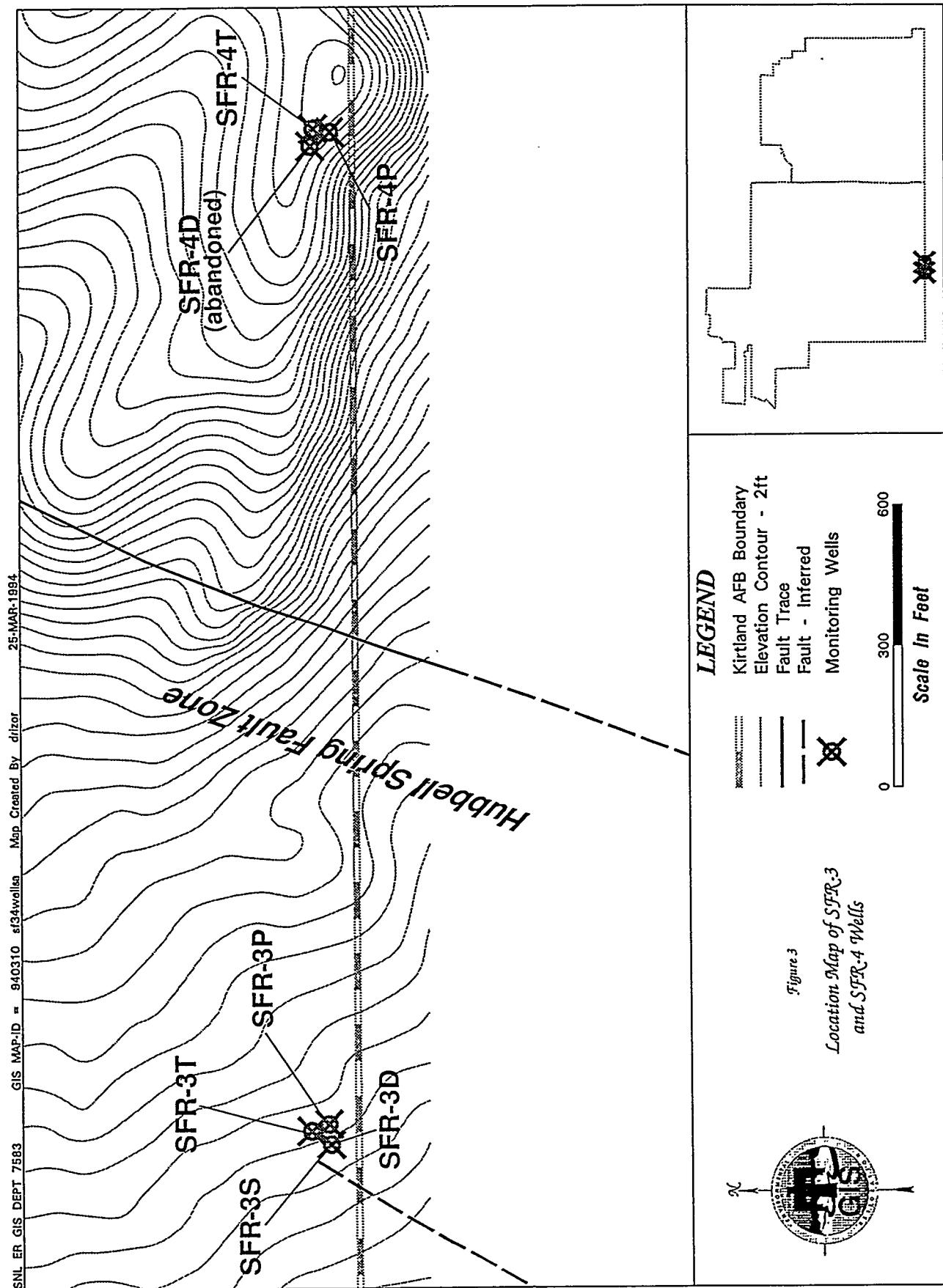
Drilling activities for the South Fence Road (SFR) project were conducted in two phases over a period of 18 months. Phase I, undertaken during the summer of 1992, involved drilling four boreholes and completing five monitoring wells (including two dual completions) (Neel and McCord 1993). Phase II, undertaken during the spring/summer of 1993, involved drilling four boreholes, and completing three monitoring/test wells and one observation well. The well names are based on a system where a number designates the well site location, and various letters designate the type of well; the letters are "S" for shallow, "D" for deep, "P" for pilot, and "T" for test. Phase I resulted in the installation of the SFR-1S, SFR-1D, SFR-2, and SFR-3S and SFR-3D test/monitoring wells. Phase II resulted in the installation of the SFR-3P, SFR-3T, SFR-4P, and SFR-4T test/monitoring wells. Figure 3 shows a map view of the different wells at the SFR-3 and SFR-4 locations. This report provides a summary of the field operations associated with SFR-4P and SFR-4T.

4.2. SFR-4 Well Installation Plan

The SFR-4 location is located approximately 2,500 feet east of SFR-3 (Figure 3). During Phase I drilling at this site, bedrock was penetrated at an approximate depth of 40 feet. However, groundwater was not encountered. The objective at this site during Phase II was to drill a pilot hole (SFR-4P) to reach the uppermost bedrock aquifer with a maximum projected depth of 500 feet. This borehole would then be plugged back to an appropriate screen interval in the bedrock and completed as an observation well. Based on the information gained from this pilot hole, a bedrock test/monitoring well (SFR-4T) would then be drilled and installed adjacent to SFR-4P. A schematic map and cross section of the SFR-4 location is shown in Figure 4. Because this location will provide the opportunity to accomplish aquifer testing involving a test well and an observation well, it is referred to as the SFR-4 hydropad.

4.3 Drilling Operations

Drilling chronologies for both wells at the SFR-4 location are presented in graphic format in Figures 5 and 6. All drilling, well completion and well development was performed by USGS personnel and equipment. Typically, drilling operations were conducted in 10-day work cycles.



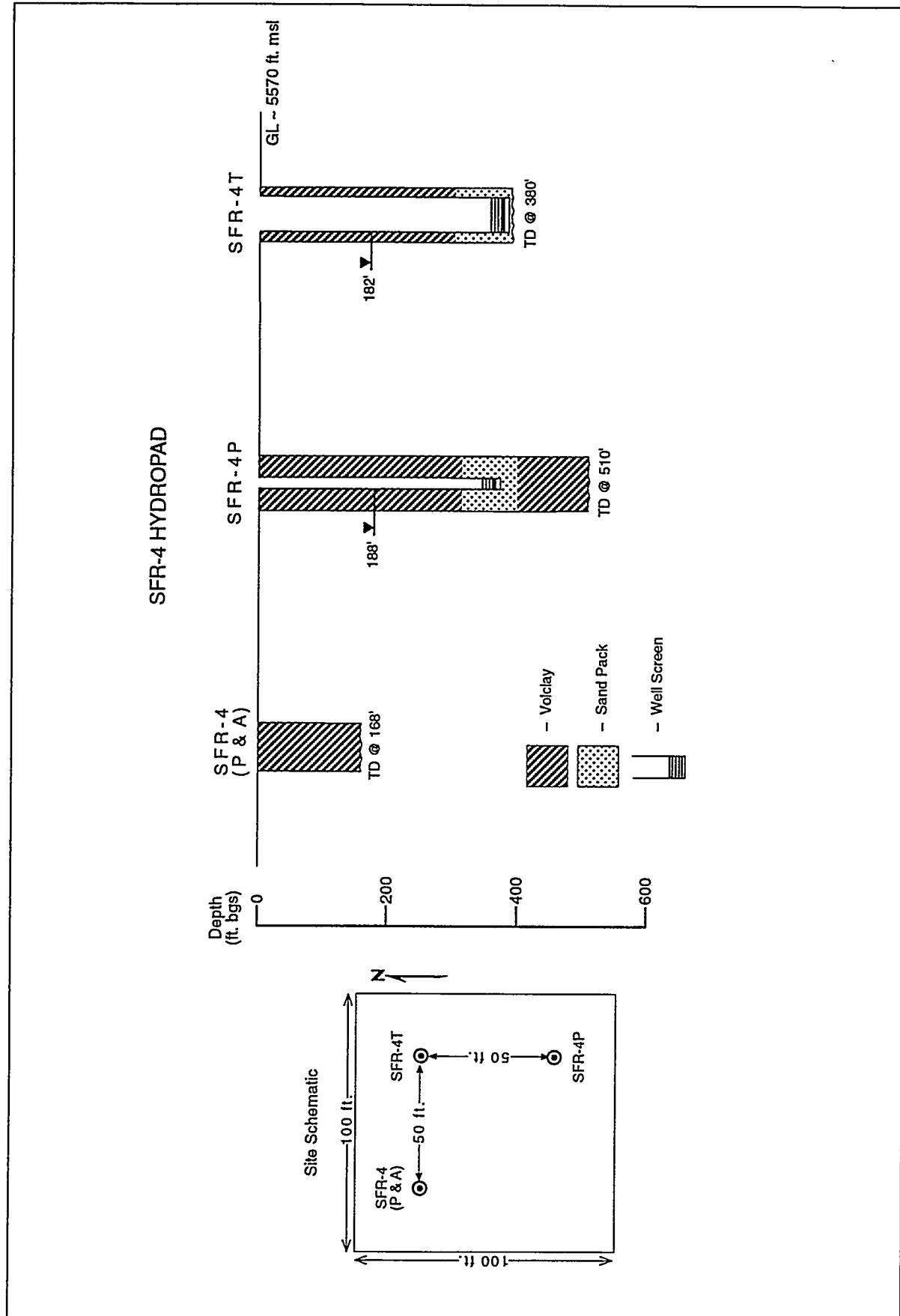


Figure 4. Schematic Map and Cross Section of the SFR-4 Hydropad

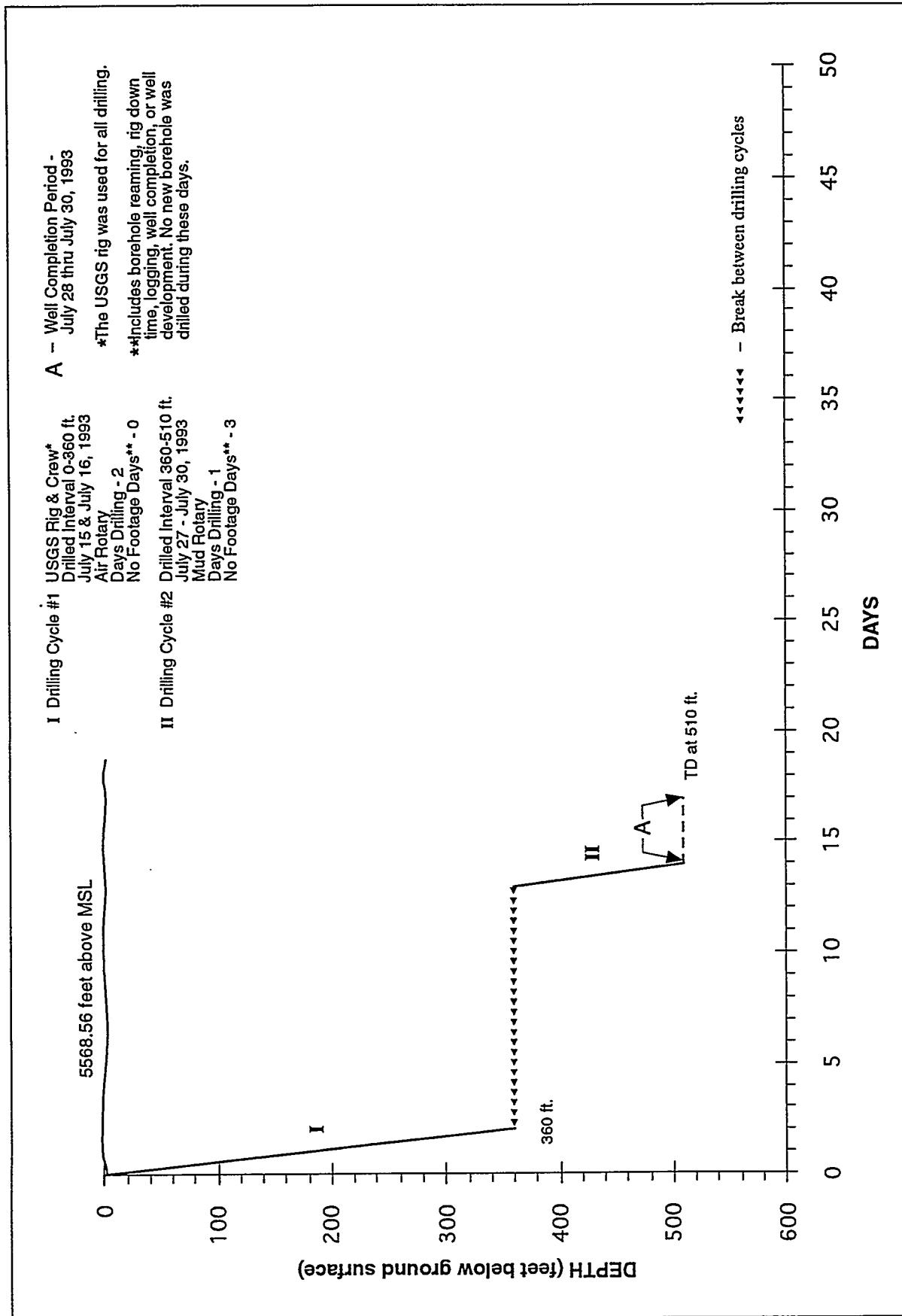


Figure 5. Summary of Drilling Chronology for SFR-4P

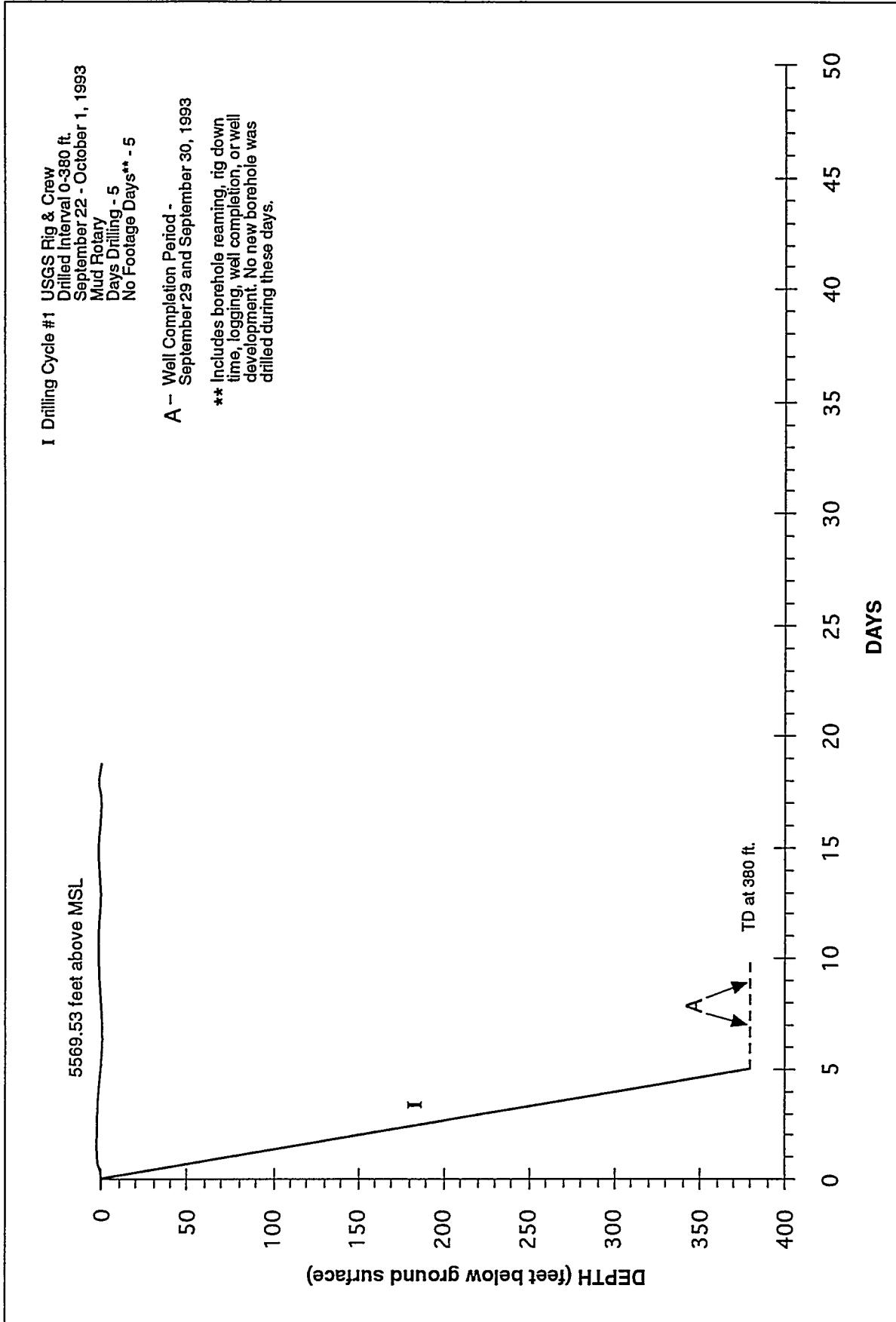


Figure 6. Summary of Drilling Chronology for SFR-4T

4.3.1 SFR-4P Drilling Operations

Drilling commenced on July 15 using air and mud rotary drilling. During drilling the borehole diameter changed with depth as follows: an 10-inch borehole was drilled from surface to 40 feet; and a 5-7/8 inch borehole was drilled from 40 feet to the total depth at 510 feet. Figure 7 shows the generalized bedrock lithology, and a well completion schematic for SFR-4P. A total of 3 days of drilling over two cycles were required to reach this total depth. The open hole was then logged first by COLOG, Inc. and then by the USGS. The well was completed on July 30.

During air-drilling, cuttings returns stopped at a depth of 180 feet. It was hypothesized that this was a result of moisture in the formation which lead to the creation of a cuttings collar in the annulus between the drill pipe and the borehole wall. Foam was then added to the compressed air to break up this cuttings collar and lift the cuttings to the surface. Drilling continued with air-foam to a depth of 313 feet, where the driller first noticed formation water in the borehole. A slug of EZ-Mud was then added to the borehole to help lift the cuttings, and drilling continued using air-foam to a depth of approximately 360 feet. At this point, anomalous organic vapor readings up to 26 PPM were recorded using a PID field screening instrument. This occurred late on the last day of a drilling cycle, just prior to a scheduled 10 day drilling break. Therefore it was decided to terminate operations and investigate possible causes for the high organic vapor readings. This investigation concluded that these readings were probably due to elevated humidity in the borehole caused by air-foam rotary drilling in moist to wet rock intervals. During the drilling break, formation water filled the borehole to a depth of approximately 242 feet.

Drilling resumed on July 27 using the mud rotary technique, and was completed on the same day at a total depth of 510 feet. During this portion of drilling, all organic vapor field screening readings were less than 1 PPM.

4.3.2 SFR-4T Drilling Operations

Drilling commenced on September 23 using the mud rotary method to drill a 12-inch borehole from the surface to 40 feet, where surface casing was set. Air rotary drilling was used to drill a 6-inch borehole to a depth of 200 feet. The borehole was then left overnight to monitor for groundwater inflow. The borehole was dry the next morning, indicating that the uppermost aquifer was deeper than 200 feet.

Drilling resumed using the mud rotary technique and a 10-inch bit. The borehole was drilled to a total depth of 384 feet on September 29. Figure 8 shows the generalized bedrock lithology, and a well completion schematic for SFR-4T. One core was taken from 340 feet to 341 feet. The borehole was logged by the USGS on September 29, and the test/monitoring well was completed on September 30. Well development was started on October 1.

BOREHOLE: SFR-4P

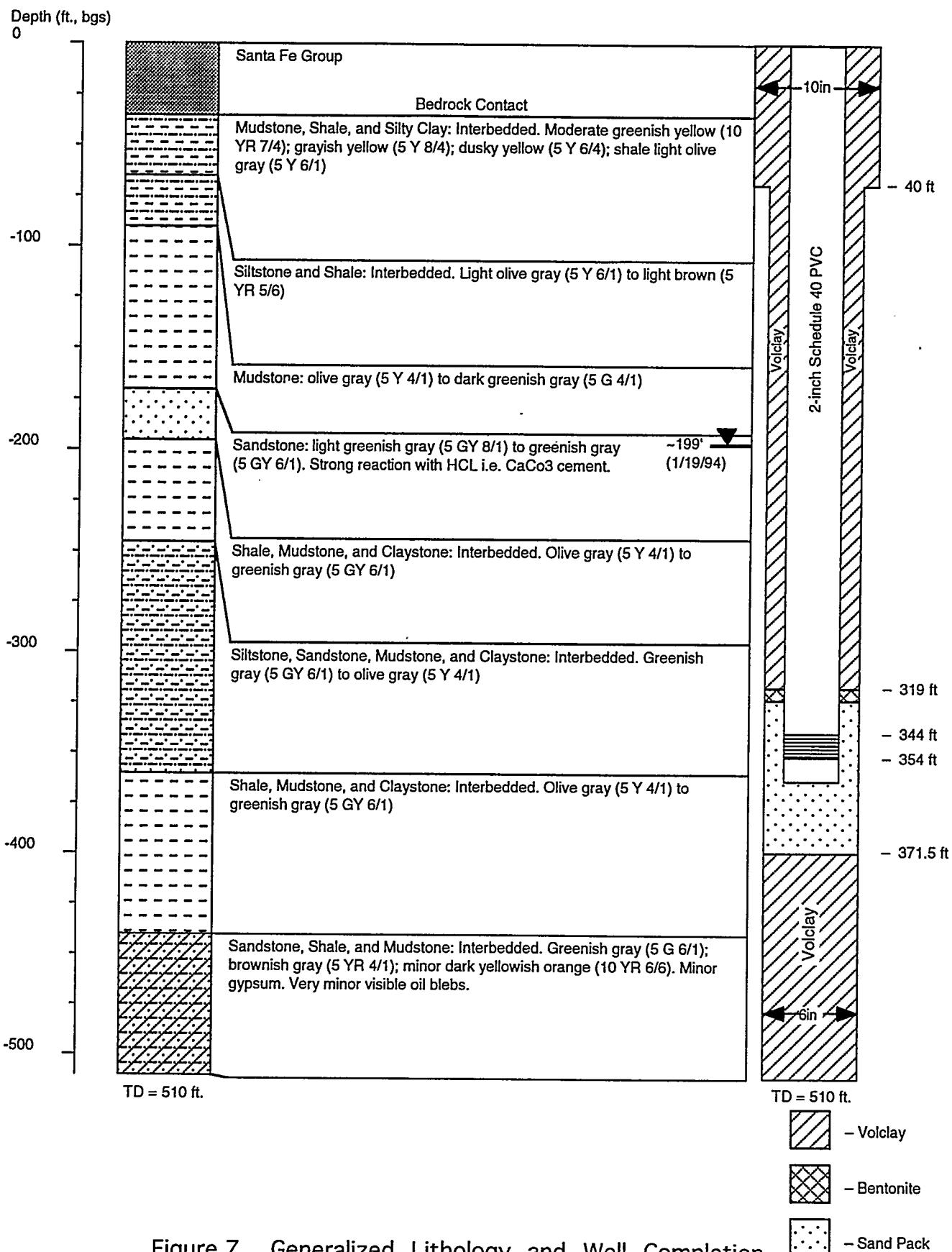


Figure 7. Generalized Lithology and Well Completion
SFR-4P

BOREHOLE: SFR-4T

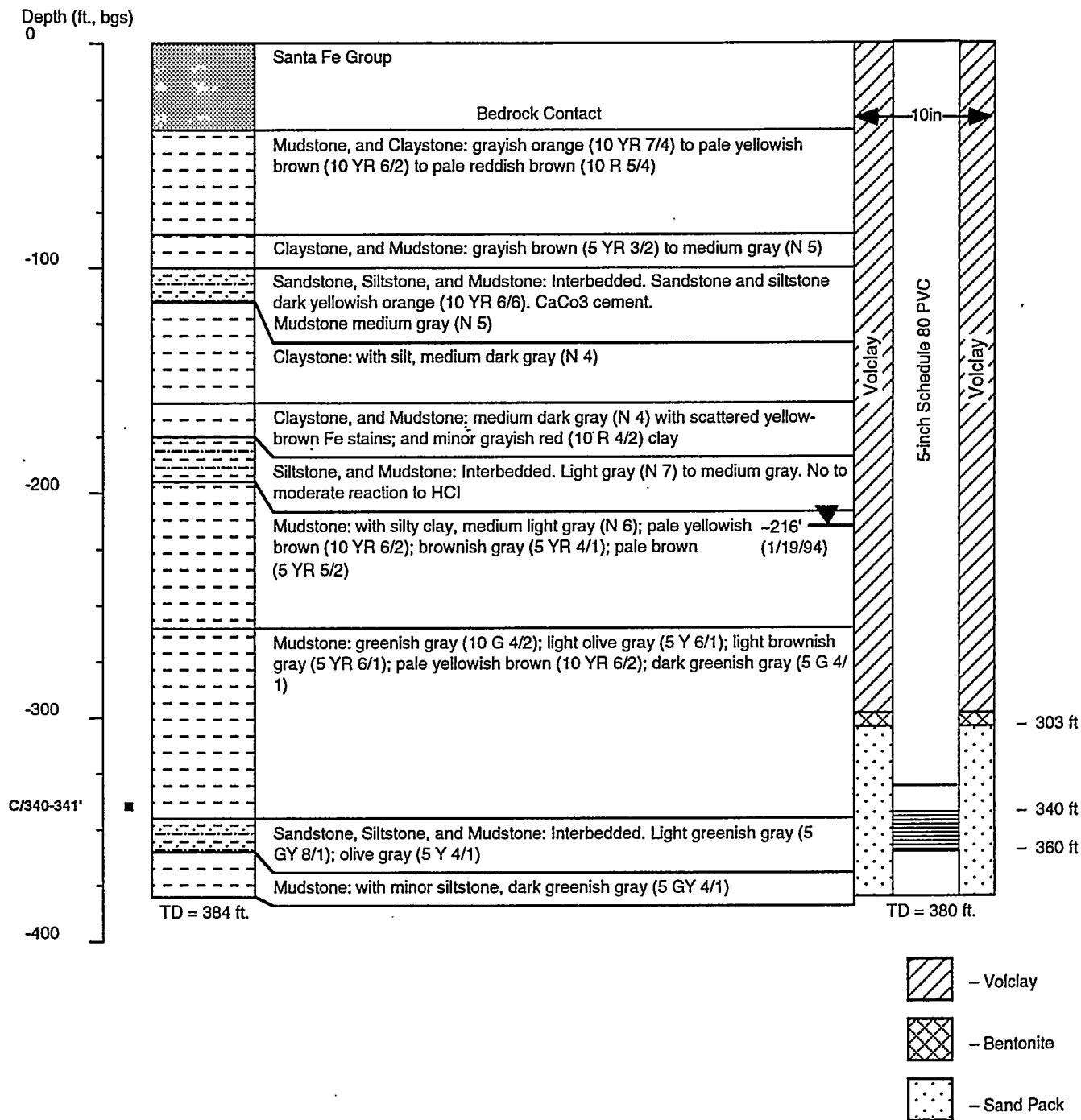


Figure 8. Generalized Lithology and Well Completion
SFR-4T

4.4 Well Completion

Well completion relationships at the SFR-4 hydropad are shown in Figure 4. Standard SNL well completion diagrams for SFR-4 wells are presented in Appendix A. All depths mentioned in the following sections on well completion are feet below ground level. SFR-4T is a test/monitoring well completed in the uppermost permeable interval of the bedrock aquifer. SFR-4P is an observation well completed in the same interval.

4.4.1 SFR-4P Well Completion

SFR-4P was completed as an aquifer testing observation well. This borehole was plugged back from a total depth of 510 feet to 397 feet with volclay (powdered bentonite slurry). A bentonite pellet seal was then placed from 397 feet to 371.5 feet. SFR-4P was completed using 2-inch Schedule 40 PVC well with a 10-foot sump below a 10-foot 0.020-inch slotted PVC screen. The screened interval is from 344 feet to 354 feet. The sand pack in the completion interval includes size 10/20 silica sand from 371.5 feet to 322 feet, and size 16/40 sand from 322 feet to 319 feet. Above this sand pack, the annulus is filled with a volclay bentonite slurry (319 feet to surface). The surface completion is a steel protective casing with a locked lid, surrounded by a concrete apron. Well completion details and water-level elevations for SFR-4P are summarized in Table 2.

4.4.2 SFR-4T Well Completion

SFR-4T was completed in bedrock as a 5-inch Schedule 80 PVC well with a 20-foot stainless steel sump below a 20-foot 0.020-inch slot continuous wire-wound stainless steel screen. There is a 10-foot stainless steel riser above the screen. The screened interval is 340 feet to 360 feet. The sand pack in the completion interval includes 10/20 silica sand from 380 feet to 303 feet. Overlying this sand pack is a 6-foot thick bentonite pellet seal (297 to 303 feet). Above this seal, the annulus is filled with a volclay bentonite slurry (297 feet to surface). The surface completion is a steel protective casing with a locked lid, surrounded by a concrete apron. Well completion details and water-level elevations for SFR-4T are summarized in Table 2.

4.5 Well Development

Well development is performed to promote the removal of foreign material that may have been introduced into the well annulus or well screen during the drilling/well completion process. Well development was performed according to the ER department procedure, PRO 92-08 (Wood, 1992). This field operations procedure (FOP) identifies the methodology and standards for developing a well until representative formation water can be accessed through the well. Representative formation water is defined as water produced from the formation that is considered to be free of drilling fluids, cuttings, and other material introduced into a well during the drilling/well completion process. Standards used to make this determination include water that is visually clear (low turbidity), and water with relatively stable (+/- 10%)

Table 2 - Ground, Casing and Water Level Elevations and Measured Water Levels

SURVEYED ELEVATIONS SFR WELLS 1/19/94	SFR-4P	SFR-4T
Ground Elevation (ft. above MSL)	5568.56	5569.53
Top of Casing (ft. above MSL)	5570.66	5571.28
Water Levels¹ (ft. below top of casing) Measured 3/21/94	188.45	182.13
Water Level Elevations (ft. above MSL)	5371.43	5355.22
Monitored Formation	Lower Tertiary bedrock	Lower Tertiary bedrock
Gravel Pack Depth Interval (ft. below ground level)	319-371.5	303-380
Gravel Pack Elevation Interval (ft. above MSL)	5249.6-5197.1	5266.5-5189.5
Screen Depth Interval (ft. below ground level)	344-354	340-360
Screen Elevation Interval (ft. above MSL)	5224.6-5214.6	5229.5-5209.5

¹ Water level measured 3/21/94

pH, temperature, and specific conductivity. In addition, the FOP calls for the removal of a minimum of 5 well-bore volumes. Well development information for SFR-4P and SFR-4T are summarized in Table 3.

4.5.1 SFR-4P Well Development

Development of SFR-4P occurred immediately after well completion in July 1993. Drilling mud was evacuated from the well by airlifting, which is accomplished by jetting the hole with compressed air. The well was then surged with 125 gallons of clean water and airlifted dry several times. Air lifting and surging the well proved to be ineffective due to the very slow recharge rate. The well was bailed dry repeatedly. It is estimated that the total volume of water removed during well development was approximately 215 gallons. Water quality measurements (temperature, pH, and electrical conductivity) were not accomplished. Turbidity measurements were taken and ranged between 248 and 16.2 NTU. This well will require additional development.

4.5.2 SFR-4T Well Development

Development of SFR-4T was conducted in October 1993 after drilling operations had ceased for the season. The initial water level was 293 feet, bgl. This well is a poor water producer, indicated by the fact that the well could be bailed dry using a 4-gallon bailer. The well was repeatedly bailed dry and allowed to recover. Total water production over the course of development was approximately 300 gallons. The final turbidity reading was 8 NTU. This well will require additional development.

Table 3 - Well Development Information for SFR-4P and SFR-4T

WELL DEVELOPMENT	SFR-4P*	SFR-4T*
Casing Diameter [O.D.] (inches)	2	5
Well Bore Volume (gal.)	29.3 ¹ (.16 gal/ft)	201.8 ¹ (1.02 gal/ft)
Volume Purged (gal.)	≈215	200-300
Method	Air Lift & Surge/ Bailer [4 gal.]	Air Lift & Surge/ Bailer [4 gal.]
Discharge Rate (gpm)	< 1.0	< 1.0
Date	July 30-31, 1993	Oct 19-26, 1993
Water Level [Start/End] (ft.)	322/365	293/377
Temperature [Start/End] (°C)	nm	nm
pH [Start/End]	nm	nm
Conductivity [Start/End] (mmhos)	nm	nm
Turbidity² [Start/End] (NTU)	variable 248 to 16.2	variable 314 to 8

¹ Based on static water levels measured on 1/19/94

² Measured with Hach 2100P Turbidimeter.

nm - not measured.

* Further well development required.

5.0 BOREHOLE GEOLOGY

In SFR-4P, bedrock was encountered at a depth of 35 feet, bgl. In SFR-4T, bedrock was encountered at a depth of 38 feet, bgl. Bedrock in both wells consisted of light olive-gray to medium greenish-gray interbedded sandstone, siltstone, shale, and mudstone. Near the bottom of SFR-4P, minor dark yellowish-orange sandstone and minor gypsum were identified in cuttings. No carbonaceous material was identified in either of the SFR-4 boreholes. Two samples from SFR-4P were collected for palynological analysis to determine the approximate age of the bedrock section. However, both samples were barren of pollen and spores. Based on the lithologic information, the bedrock at the SFR-4 location is tentatively correlated to strata described by Lozinsky (1988) and identified as the "Unit of Isleta #2 Well" (SNL, 1994).

Generalized lithology and well completion diagrams are shown in Figures 7 and 8.

6.0 BOREHOLE HYDROLOGY

Both wells at the SFR-4 Hydropad have poor water production capacity. These wells are completed in a silty sandstone interval, and were developed with difficulty (see Section 3.5). Water levels have been steadily rising at SFR-4. Measured water levels and elevations are shown in Table 4.

Table 4 - Water-Level Depths in SFR-4P and SFR-4T

WATER LEVELS (ft. below top of casing)		
Date	SFR-4P	SFR-4T
1/19/94	199.23	216.06
10/21/93	206	372.4
9/30/93	213.67	-
9/22/93	223.96	-

7.0 BOREHOLE GEOPHYSICS

The SFR-4 wells were logged by USGS equipment and personnel. In addition, SFR-4P was logged by a private contractor, COLOG, Inc., of Golden, Colorado. A summary of field operations and a synopsis of the data is presented in this section. A more complete interpretation of COLOG data is presented in "Geophysical Logging Results for South Fence Road Project Wells SFR-3P and SFR-4P", COLOG, Inc., November, 1993.

Table 5 provides a summary of the logs run in the SFR-4 boreholes. The complete suite of logs run by USGS and COLOG is available for copying from the SNL ER Records Center. Both digital and analog data are available.

7.1 SFR-4P Borehole Geophysics

The hole was logged by COLOG immediately after the drill pipe was tripped out of the hole. USGS logs were run after COLOG had left the site. The USGS log suite consisted of gamma, caliper, neutron, density, and short/long normal resistivity logs. The suite produced by COLOG included:

- Full Waveform Sonic
- Uncompensated Density/Caliper
- Density/Caliper
- Density Porosity/Caliper
- Natural Gamma/Neutron
- Temperature/Fluid Resistivity
- 16"/64" Normal Resistivity/Single Point
Resistance/Spontaneous Potential
- E Conductivity/16" Normal Resistivity/Neutron

The log sequence used in SFR-4P was altered for several reasons. The 16"-64" normal resistivity tool was run second, after the sonic log, but did not seem to respond. The tool calibrated properly but the response in the hole was nearly a straight line. While trying to resolve this problem, the other logs were run, including the nuclear logs which are normally run last.

The normal resistivity tool was replaced with a backup, which had the same response as the first tool. The tool response was compared to the tool response from SFR-3P, which showed a difference in the range of 100 ohm/m (SFR-3P being lower). After the induction log was run, the derived resistivity compared favorably with the 16"-64" normal resistivity curves, and it was determined that the normal resistivity tools had been responding properly. However, the resistivity of the mudstone bedrock in SFR-4P is much lower than the Santa Fe alluvium in SFR-3P. Well logging was completed at 5:00 AM on July 28.

Table 5 - Geophysical Log Suites for SFR-4P and SFR-4T

Log Type	Well	
	SFR-4P	SFR-4T
<u>USGS:</u>		
Natural Gamma	X	X
Neutron	X	X
Density	X	X
Short/Long Normal Resistivity	X	X
Caliper	X	X
<u>COLOG:</u>		
16"/64" Normal Resistivity	X	
Single Point Resistance	X	
Spontaneous Potential	X	
EM Conductivity	X	
Induced Polarization	X	
Neutron	X	
Natural Gamma	X	
Guard Resistivity	X	
Density	X	
Caliper	X	
Density Porosity	X	
Full Wave Form Sonic	X	
Temp/Fluid Resistivity	X	
Depth Logged (feet)	510	374

Preliminary evaluation of perched water zones, first saturated sand, and well completion recommendations based on geophysical logs were performed at the well site before the logging crew was released. It was noted that wet zones were present at 179 to 185 feet (probably not saturated), 312 to 314 feet, and 343 to 355 feet. The latter interval appeared to have the highest water saturation based on resistivity and neutron logs. This well was completed as a 2-inch well screened from 344 to 354 feet. (Foutz and Hyndman, 1993).

The location of sandstone beds and other lithologic units are best shown by the separation of the gamma and 16" normal resistivity curves shown in Figure 9. In well SFR-4P it is apparent that there is a major separation between the sonic velocity and the density porosity logs in the sandstone from about 280 to 300 feet. This suggests incomplete saturation. The deeper sandstones in this well do not show significant sonic-density porosity separation and are likely to be saturated. Distinguishing the degree of saturation in fine-grained rocks is much more difficult, in part because such rocks may still be quite moist in the unsaturated zone. The amount of curve separation appears to gradually decrease downward to the siltstone from approximately 250 to 270 feet, which may be completely saturated. Below that depth, curve separation is relatively uniform, suggesting saturation (CLOG, 1993).

7.2 SFR-4T Borehole Geophysics

SFR-4T was logged by USGS personnel and equipment immediately after reaching TD. The USGS log suite includes natural gamma, density, neutron, caliper and 16"/64" normal resistivity logs. A weakness of USGS logs is a lack of calibration data that can be used to calculate quantitative values, such as water saturation and percent clay. USGS resistivity logs correlate very well with CLOG logs (at SFR-4P), but the USGS does not have an induction tool, which would be very useful for locating perched water in an air-filled hole above the saturated zone.

The USGS neutron probe is not regularly calibrated and uses a NaI crystal that is subject to significant degradation. For these reasons, neutron porosity, specific yield, and other values calculated from the neutron log are not possible. The USGS also uses an old Cobalt-60 source that is significantly decayed and produces a weak gamma density log. The USGS plans to replace its obsolete tools, but the logs run on SFR wells should only be used for qualitative purposes (Foutz and Hyndman, 1993).

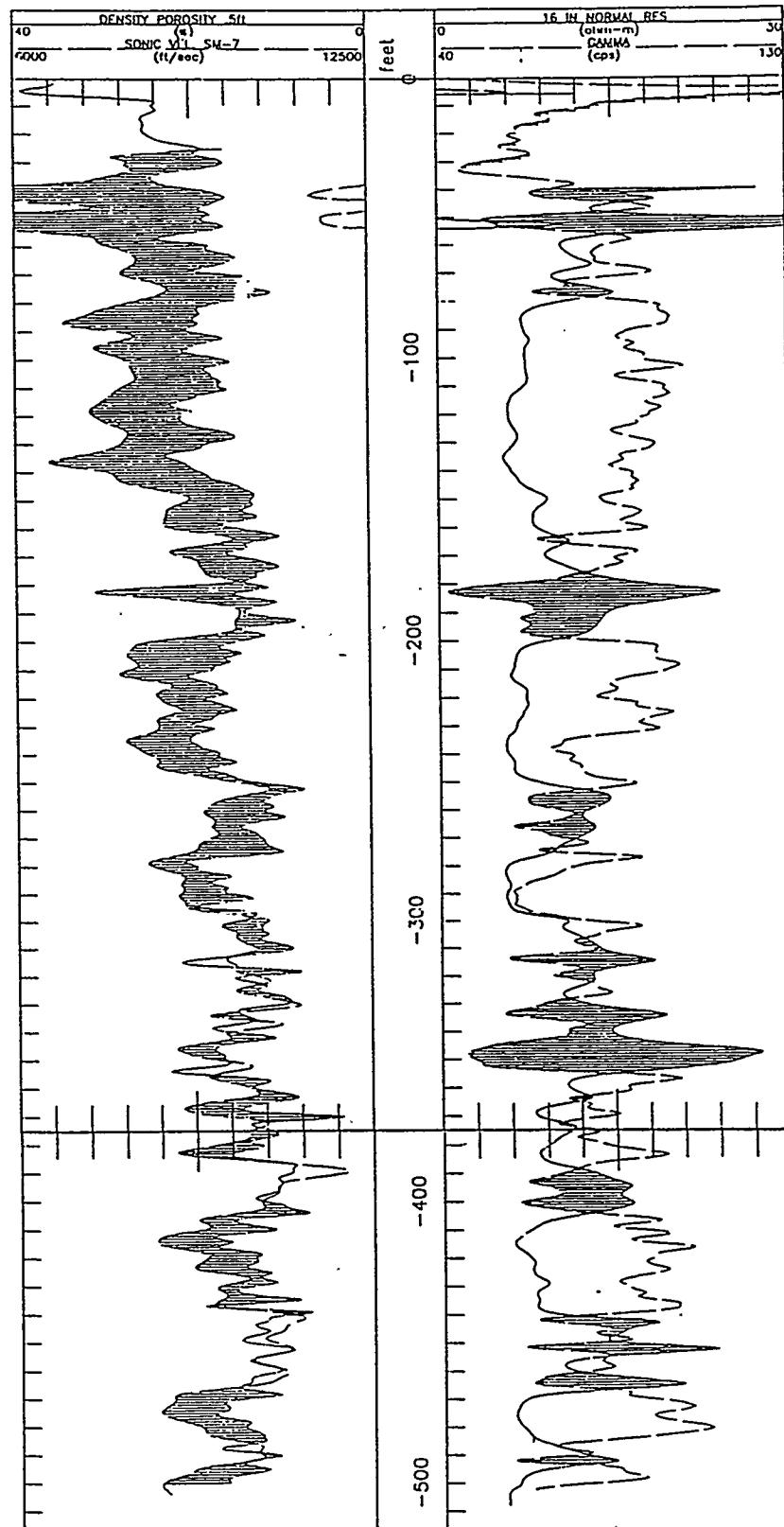


Figure 9. SFR-4P Density Porosity/Sonic Velocity Difference and 16" Normal Resistivity/Natural Gamma Difference Logs

8.0 SUMMARY

The objectives of installing test/monitoring wells in the uppermost bedrock aquifer (SFR-4T) at the SFR-4 location were accomplished during the South Fence road Phase II field operations summarized in this report. During these field operations, important subsurface geologic and hydrologic data were obtained.

Subsurface geologic data include drill cuttings, core, and borehole geophysical logs. These data will improve the understanding of fault displacement across the Hubbell Spring fault, identify the stratigraphic relationship across the Santa Fe Group/bedrock contact, and establish the local stratigraphic sequence in the uppermost 500 feet of the underlying bedrock.

Subsurface hydrologic data include borehole geophysical logs, and qualitative information obtained during well completion/well development. These data will help define the local hydrostratigraphic framework within the underlying bedrock water-bearing intervals. The two wells at the SFR-4 location include an aquifer test well and an observation well. These two wells are referred to as the SFR-4 hydropad. Future aquifer testing at the SFR-4 hydropad will generate data for the interpretation of aquifer parameters (transmissivity and storativity) for the uppermost bedrock water-bearing interval.

9.0 REFERENCES

COLOG, 1993. Geophysical Logging Results for South Fence Road Project Wells SFR-3P and SFR-4P, Sandia National Laboratory, Kirtland Air Force Base, New Mexico.

Foutz, W.L. and D.A. Hyndman, 1993. Coordination and Interpretation of the Geophysical Logging of the South Fence Road Phase II Wells, prepared for Department 7584, Sandia National Laboratories, New Mexico, by Lamb Associates, Inc.

Hawley, J.W. and C.S. Haase (editors), 1992. Hydrogeologic Framework of the Northern Albuquerque Basin, New Mexico Bureau of Mines and Mineral Resources Open-File Report 387.

Lozinsky, R.P., 1988. Stratigraphy, Sedimentology, and Sand Petrology of the Santa Fe Group and Pre-Santa Fe Tertiary Deposits in the Albuquerque Basin, Central New Mexico. unpublished Ph.D dissertation. New Mexico Institute of Mining and Technology, Socorro, NM.

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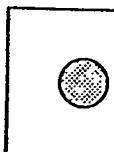
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Wood, C., 1992. Field Operating Procedure - Monitor Well Development, PRO-92-08, Sandia National Laboratories Environmental Restoration Division, 7723.

APPENDIX A
SNL STANDARD WELL COMPLETION DIAGRAMS

SNL GROUND-WATER MONITOR WELL DATA SHEET

PLAN VIEW SURVEY POINTS

GS NW CORNER ELEV. "B" 

GS NE CORNER ELEV. "C"

GS SW CORNER ELEV. "E"

GS SE CORNER ELEV. "D"

TOP OF CONCRETE PAD

WELL NUMBER: SFR-4P
 LOCATION: South Fence Road
 DATE INSTALLATION COMPLETED 7/29/93
 DATE OF DEVELOPMENT 7/30-7/31 (development not completed)

PROTECTIVE COVER: 5571.183
 elev. "F."

RISER ELEVATION
 "A": 5570.664
 (DATUM) FASL

CONCRETE PAD

SURVEY POINTS

WELL NO. <u>SFR-4P</u>	
ELEV. "A"	<u>5570.664</u>
ELEV. "B"	<u>5568.606</u>
ELEV. "C"	<u>5568.600</u>
ELEV. "D"	<u>5568.548</u>
ELEV. "E"	<u>5568.487</u>
	"F" <u>5571.183</u>

ELEV. = FASL

SURVEY DATE: Survey requested 9/24/93

REMARKS: _____

<u>Volclay</u>	<u>0-319'</u>
ELEV FASL	ELEV FBGS, <u>314</u>
ELEV FASL	ELEV FBGS, <u>344</u>
ELEV FASL	ELEV FBGS <u>354</u>
ELEV FASL	ELEV FBGS, <u>364</u>
ELEV FASL	ELEV FBGS, <u>371.5</u>
	ELEV FBGS <u>397</u>

TOP OF SEAL

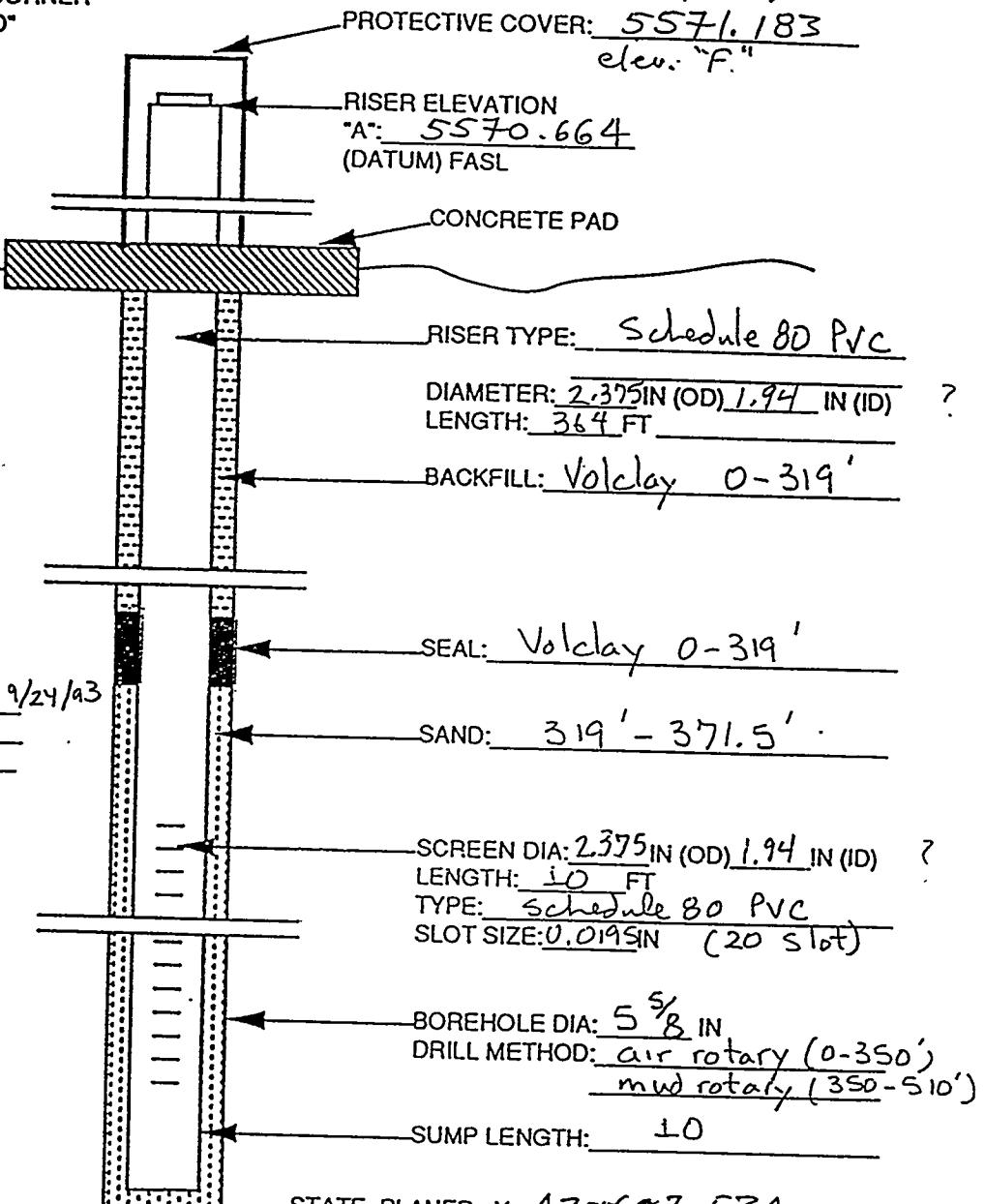
TOP OF SAND

TOP OF SCREEN

BOTTOM OF SCREEN

BOTTOM OF SUMP

BOTTOM OF HOLE



KEY:

GS = GROUND SURFACE

FBGS = FEET BELOW GROUND SURFACE

FASL = FEET ABOVE MEAN SEA LEVEL

GENERAL COMMENTS: Borehole drilled to TD @ 510'. Plugged back w/ Volclay 397' to 510'; Bentonite Plug: 371.5' to 397'.

SNL GROUND-WATER MONITOR WELL DATA SHEET

PLAN VIEW SURVEY POINTS

GS NW CORNER
ELEV. "B"
GS SW CORNER
ELEV. "E"

GS NE CORNER
ELE. "C"
GS SE CORNER
ELEV. "D"

TOP OF
CONCRETE PAD

WELL NUMBER: SFR - 4 T
LOCATION: South Fence Road
DATE INSTALLATION COMPLETED 9/30/93
DATE OF DEVELOPMENT 9/30-10/1

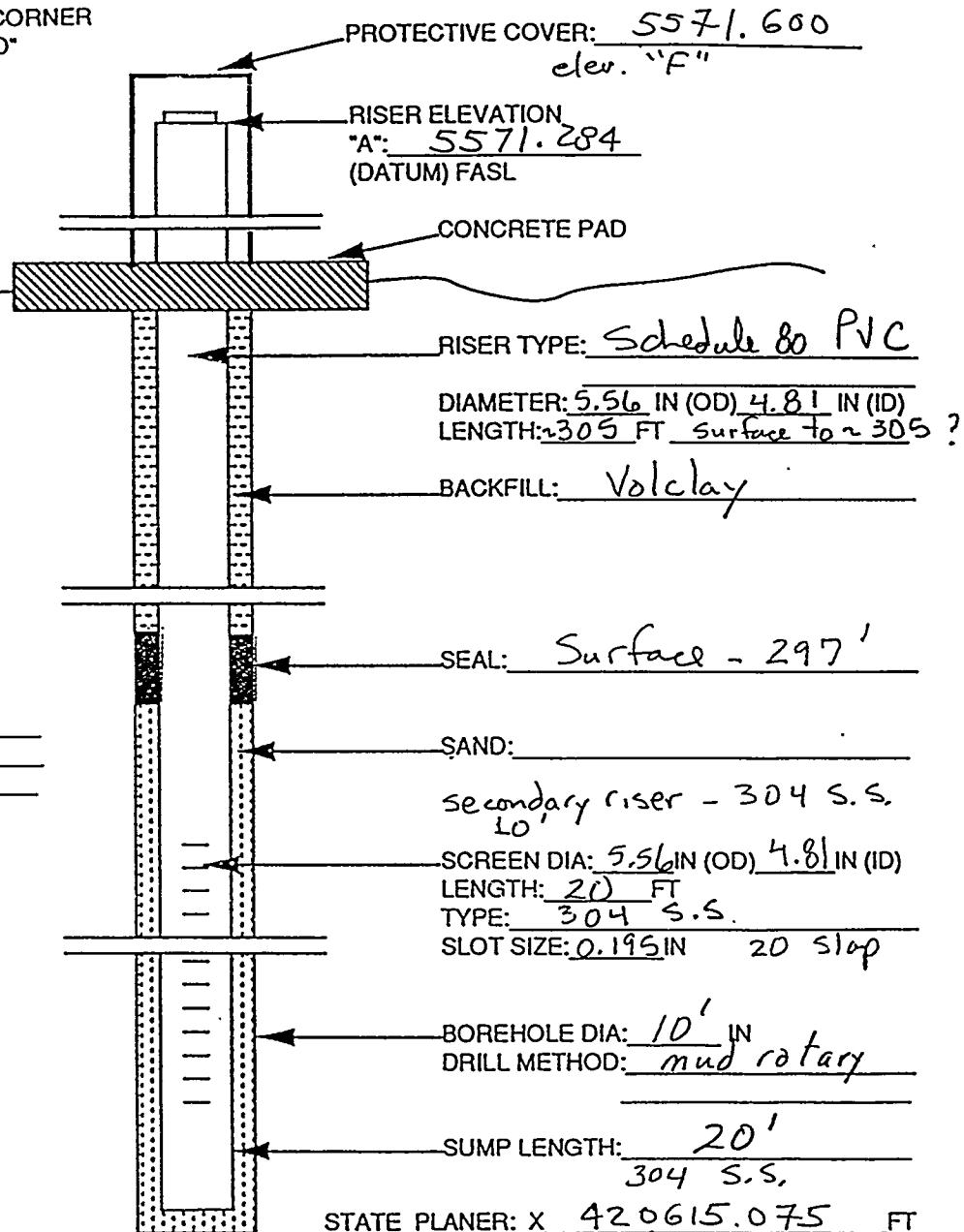
SURVEY POINTS	
WELL NO.	<u>SFR-4 T</u>
ELEV. "A"	<u>5571. 284</u>
ELEV. "B"	<u>5569. 532</u>
ELEV. "C"	<u>5569. 549</u>
ELEV. "D"	<u>5569. 488</u>
ELEV. "C"	<u>5569. 556</u>

ELEV. = FASL

SURVEY DATE: _____

REMARKS: _____

Surface		TOP OF SEAL
ELEV FASL	ELEV FBGS	27.9 24.7
ELEV FASL	ELEV FBGS	34.0
ELEV FASL	ELEV FBGS	36.0
ELEV FASL	ELEV FBGS	38.0
ELEV FASL	ELEV FBGS	38.0
ELEV FASL	ELEV FBGS	Bottom of Hole



GENERAL COMMENTS: _____

KEY:

GS = GROUND SURFACE

FBGS = FEET BELOW GROUND SURFACE

FASL = FEET ABOVE MEAN SEA LEVEL

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