REPORT
June, 1974
R-900-74-2

GROUNDWATER CONDITIONS OF THE LOWER HASSAYAMPA - CENTENNIAL AREA, MARICOPA COUNTY, ARIZONA

For

PALO VERDE NUCLEAR GENERATING STATION

Submitted To

FUGRO ENGINEERS AND GEOLOGISTS
and
NUS CORPORATION

HARSHBARGER AND ASSOCIATES
CONSULTANTS IN HYDROGEOLOGY
1525 EAST KLEINDALE ROAD
TUCSON, ARIZONA 85719

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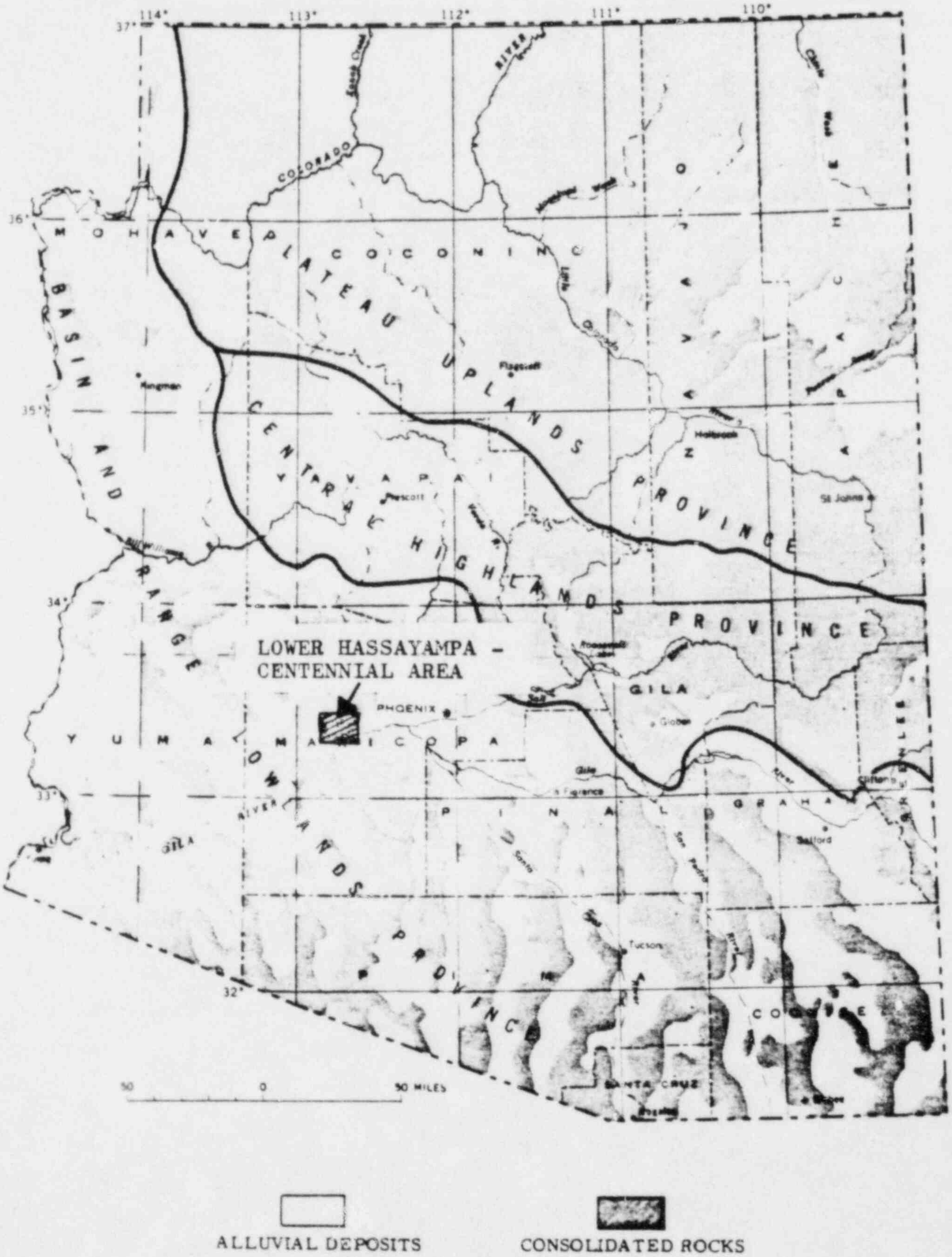


FIGURE 1-1-AREA OF REPORT AND ARIZONA'S WATER PROVINCES.

GROUNDWATER CONDITIONS OF THE LOWER HASSAYAMPA - CENTENNIAL AREA, MARICOPA COUNTY, ARIZONA

I. INTRODUCTION

This report comprises a reference document on the general groundwater conditions in the Gila River Valley and the specific conditions known to occur in the Lower Hassayampa - Centennial Area (Frontispiece).

The report was prepared in accordance with a request from FUGRO, INC. and NUS CORPORATION, Geotechnical and Environmental Systems Consultants for the Environmental and Preliminary Safety Analysis Investigations on the Palo Verde Nuclear Generation Station (PVNGS). The principal objectives of the assignment to Harshbarger and Associates were as follows:

1. Describe and prepare an analysis of the groundwater hydrology of the PVNGS Site area and the surrounding basin;
2. Ascertain the source of groundwater, including water well inventory, regional water use, and quality of groundwater;
3. Provide assistance for determining the aquifer flow characteristics from the basic records and aquifer parameters;
4. Suggest and outline a monitor well program for the safeguard requirements pertaining to the groundwater levels and chemical quality;

5. Provide general guidance on the collection of hydrogeological data and documentation of records to field personnel (FUGRO and NUS). Supervise the performance of selected aquifer tests. Compile and review all hydrogeological data collected during the study.

Most of the basic data presented in this report were compiled from publications and files of the Water Resources Division of the U.S. Geological Survey, the Arizona State Land Department, and Arizona Water Commission. A list of Selected References is included from which this information was obtained. Additional data were collected by FUGRO, INC. and Harshbarger and Associates personnel during the exploration and testing programs conducted in the site area.

An exploratory drilling and pump testing program was initiated on the Site in accordance with the following guidelines: Delineate groundwater productivity zones in the regional aquifer system; determine groundwater levels and conditions (water table or artesian); define aquifer characteristics of transmissivity and storage coefficient; delineate chemical quality distribution of groundwater. Results from these procedures are included in Appendix I.

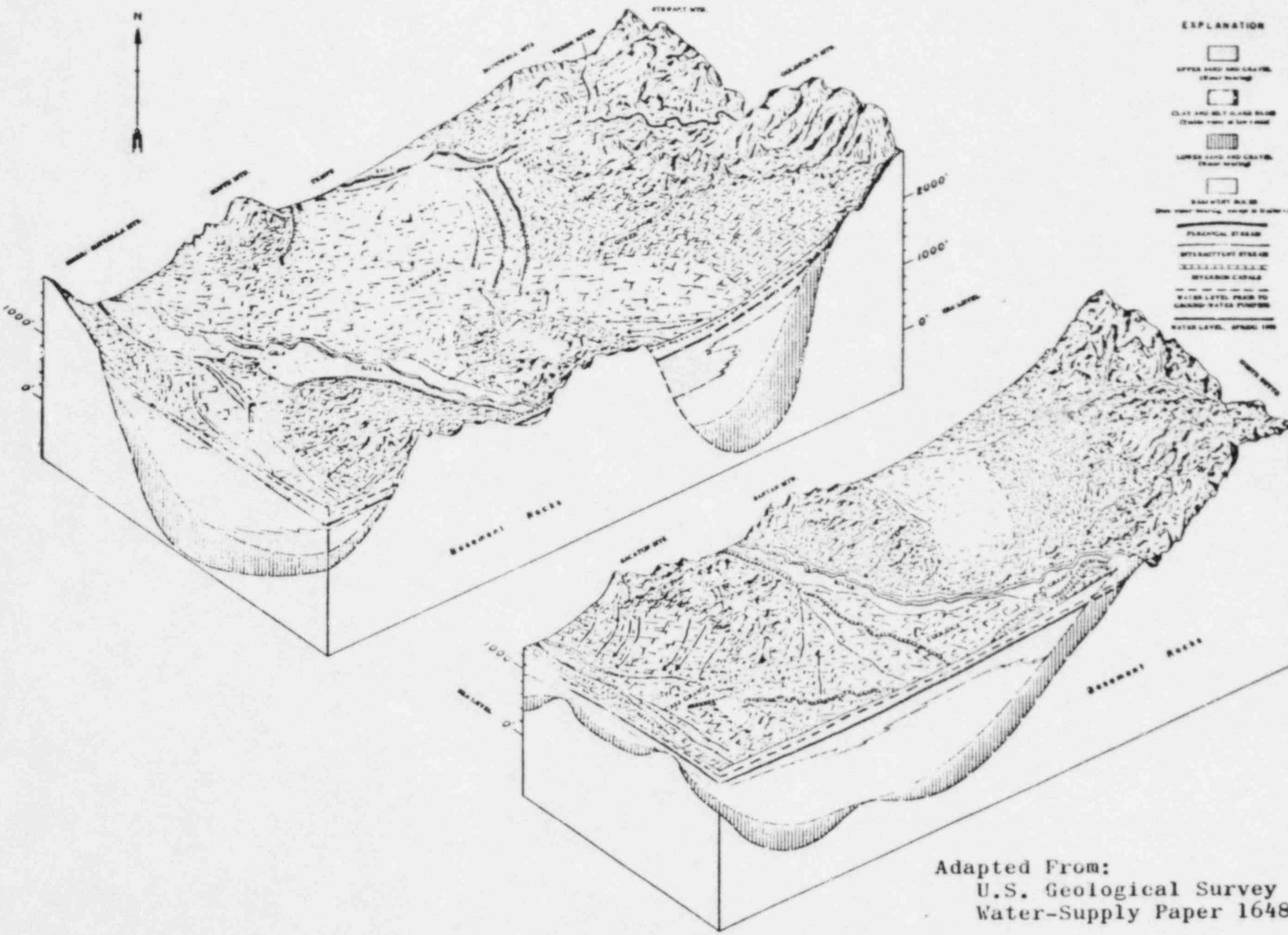
Assistance by FUGRO, INC. personnel in collection of field data and pump test data and the well testing program is greatly appreciated. The U.S. Geological Survey was most cooperative in furnishing basic data. Mr. R. S. Stulik, U.S. Geological Survey Office in Phoenix, was particularly helpful for the compilation of the water well inventory and chemical analyses of groundwater.

2. GROUNDWATER

All of southwestern Arizona lies within the Basin and Range Lowlands physiographic province. Hydrologic conditions, in general, are similar throughout the province. More than 6.5 million acre-feet of water is diverted or pumped annually for irrigating about one million acres in this province. Nearly 5 million acre-feet of the water used annually is obtained from groundwater reservoirs. The stage of exploitation of groundwater differs in various areas. The natural recharge of groundwater has been curtailed by upstream water use, so groundwater levels in the region would decline even if no groundwater were pumped.

Most alluvial valleys in Arizona exhibit three principal stages of erosion and sedimentation. Coarse sand and gravel were deposited on the basement rocks along the floor of the ancient structural valley. In past geologic times, the Arizona climate was more humid than it is now, and large fresh-water lakes occupied the basins after the old gravel was deposited. Clay and silt beds accumulated in these lakes. These deposits rest on the old gravel at many places. Later the mountains were uplifted and the lakes were drained again. Rapid erosion of the mountains again provided coarse materials which were deposited as valley alluvium. Erosion and sedimentation are continuing in the modern stage. Figure 2 - 1 shows the general geologic features of alluvial basins in the Basin and Range Lowlands. Granite, gneiss, and schist are the principal rocks in the mountain blocks, but several areas contain consolidated ancient sedimentary rocks. Some of the mountain blocks are capped with volcanic rocks.

Desert basins in Arizona contain no natural lakes and groundwater reservoirs hold the natural water reserves. Alluvial basins once stored about 4.5 billion acre-feet of groundwater.



Adapted From:
U.S. Geological Survey
Water-Supply Paper 1648

FIGURE 2 - 1 ALLUVIAL BASINS IN CENTRAL ARIZONA

About 20 percent (900 million acre-feet) of this original volume of water could be feasibly recovered for use by man. More than 100 million acre-feet of this recoverable water has been withdrawn, most of it in less than 25 years (1949-1974). Development was intensive after World War II, and the amount of groundwater used for agricultural purposes in 1949 was about 3.25 million acre-feet. The pumpage increased gradually to a peak of nearly 4.75 million acre-feet in 1953. From 1958 to 1972, the annual pumpage ranged from 4.75 to slightly more than 5 million acre-feet. More than 80 percent of all groundwater pumped in Arizona was withdrawn in Maricopa and Pinal Counties.

Most water wells are located within irrigated areas. Ordinarily, irrigation water is applied somewhat in excess of the amount needed for optimum growth of crops, and some of the surplus returns by deep percolation to the subsurface reservoir. The amount of irrigation water returned to ground storage is an important item in the water budget, but data on the amount returned are not available. Under some conditions, the return water may amount to 25 percent of the water applied for irrigation.

2.1 Description and Onsite Use

The Site area (5-mile radius) lies within the Lower Hassayampa and Centennial drainage basins which comprise the specific groundwater basin deemed vital for hydrogeological consideration. The Lower Hassayampa - Centennial area (Figure 2 - 2) is about 21 miles by 23 miles, within Townships: T. 2 N., T. 1 N., T. 1 S., and north one-half of T. 2 S.; and Ranges R. 4 W. through R. 7 W. The basin is bounded to the west by Palo Verde Hills, to the north by the Tonopah Desert, to the east by the White Tank Mountains, and on the south by Centennial Wash and the Gila River. The Site area (Figure 2 - 3) lies within

the Lower Hassayampa - Centennial basin, and comprises an area of about 10 miles by 12 miles, within an approximate five-mile radius of the plant site.

Prior to heavy irrigation practices in the Lower Centennial-Hassayampa area, the groundwater gradient was similar to the slope of the land surface, and the flow direction was generally southeast toward the Gila River. In the early 1950's, the area underwent extensive agricultural development and by 1960 about 24,000 acres of land were being irrigated annually. In 1969 about 95,000 acre-feet of water was withdrawn from the groundwater reservoir for irrigational use. The amount of groundwater pumped for stock and domestic purposes was probably less than 100 acre-feet in 1969.

2.1.1 Hydrogeology of Plant Site Area

In order of descending stratigraphic position, the units within the groundwater basin at the Site area are:

- Younger Fan deposits (Pleistocene to Holocene)
- "Upper" sand and gravel deposit
- "Upper" silt deposit
- Palo Verde Clay (Upper Pliocene)
- "Lower" silt, sand, and gravel deposits
- Fanglomerate (Miocene - Pliocene)
- Basalt-andesite sequence
- Volcanic-sedimentary sequence

(The first six units are bracketed: BASIN SEDIMENTS (FUGRO, 1974))

The volcanic-sedimentary sequence consists of volcanic conglomerate and tuffaceous sands and clays. These do not crop out in the Site area. The lithology and thickness of these sediments is not well defined, as the Palo Verde exploratory boreholes did not fully penetrate the overlying andesite. The volcanic-sedimentary sequence locally surrounds granitic monadnocks.

The basalt-andesite unit consists of felty to trachytic basalt, with a groundmass of augite and plagioclase and coarse textured hypersthene-augite andesite. The unit has been fractured in places. The thickness is not well defined, due to the scarcity of exploratory boreholes that penetrate the unit.

The fanglomerate is exposed along the lower slopes of the Palo Verde Hills, unconformably overlying the basalt-andesite sequence. The thickness of the fanglomerate ranges from about 35 to more than 285 feet.

The fanglomerate is overlain, in most places, by the "lower" silt, sand and gravel deposits and the boundary demarcation comprises an erosional unconformity.

The Palo Verde Clay is generally 80 to 100 feet thick; and the maximum known thickness is 136 feet. The known area of this continuous clay layer is more than 40 square miles. It is continuous within the area to at least 5 miles southeast and 5 miles northeast from the Site.

The "upper" silt is 150 to 200 feet thick and contains silt, clayey silt, and fine sand with lenses of silty clay. The upper contact of this unit is not everywhere well defined.

The "upper" sand and gravel deposit ranges from 25 to 50 feet thick and contains more coarse-grained material than the underlying unit. Local caliche concentrations appear as stringers and nodules.

The younger Fan deposits occur in the site area as erosional remnants of the more prominent Fan deposits east of the Site area in the Hassayampa River drainage.

2.1.1.1 Regional Aquifer

The regional aquifer, as determined in the Site area, is a volcanic-sedimentary sequence, which underlies the basalt-andesite unit. (FUGRO, 1974). The regional aquifer is more than 400 square miles in size, extending beyond the Site area, and is defined by the mountain masses which encompass the Lower Hassayampa - Centennial basin. The aquifer is continuous beneath the basalt outcrops in the Site area. The thickness and lithology of the volcanic-sedimentary sequence is not well defined, as the data included on drillers' logs from irrigation wells are not definitive. Anisotropic conditions prevail within the aquifer, as highly permeable volcanic conglomerate layers are interbedded with low permeable tuffaceous sands and clays, and basalt flows. The regional aquifer is believed to be overlain in areas by these low permeable units which occur in the upper part of the volcanic-sedimentary sequence (Figure 2 - 4).

Yields from irrigation wells which tap the regional aquifer range from 400 to 2,800 gpm (gallons per minute), but most wells yield between 1,500 to 2,500 gpm (Figure 2 - 2). The average specific capacity is 35 gpm/foot of drawdown. The depth to water ranges from 150 to 250 feet below land surface, and the groundwater occurs under both water table and artesian conditions, depending on the areal occurrence of leaky aquitards.

A pump test was conducted on an existing well within the Site to assess the aquifer transmissivity and storage. The pump test design and data analysis are given in Appendix I. The results of the pump test revealed a transmissivity of 100,000 gpd/ft (gallons per day per foot) and a storage coefficient of 5×10^{-3}. Artesian conditions prevail at the Site, but in the western part of the Site area, water table conditions predominate. The low permeable layers transmit water from the perched water zone to the regional aquifer via vertical leakage.

2.1.1.1.1 Water Levels and Water Movement

A piezometric contour map of the regional aquifer in the Lower Hassayampa - Centennial area was constructed from 1969-73 water level data collected by the U.S. Geological Survey (Figure 2 - 2). The most conspicuous hydrological features indicated by the water level contours are: the large cone of depression north of Palo Verde Hills; the large cone of depression south of Palo Verde Hills; and the cone of depression in the basin surrounded by Palo Verde Hills outliers. The major cones of depression have been formed by long-term pumpage from irrigation wells in the central part of the cones. The water level contours indicate that the volcanic rocks in the subsurface do not comprise barrier conditions, but demonstrate that subsurface rocks near and beneath the surficial outcrops are hydraulically connected with the main groundwater system,computations of the average flow velocity are given on following page.

2.1.1.1.2 Sources and Sinks

The recharge sources to the regional aquifer are: underflow from upper Hassayampa Valley, infiltration of surface runoff, return flow from irrigation. The principal source of recharge is via underflow from upper Hassayampa Valley, north of the Site area. Groundwater movement is generally north to south, except in the vicinity of the depression cones. Infiltration of surface runoff comprises a small fraction of the natural recharge. An estimated 25 percent of the water pumped for irrigation returns to the groundwater reservoir via vertical percolation, which would account for approximately 20,000 AF/yr.

Discharge from the groundwater reservoir occurs as underflow, pumpage from irrigation wells, and evapotranspiration. Groundwater is discharged from the regional aquifer via underflow in the Arlington Valley. Irrigation wells withdraw an average of 78,000 AF/yr from the groundwater reservoir. Of this volume, an estimated 58,000 AF/yr is discharged to the atmosphere via consumptive use by crop irrigation. The discharge to the

DATA FOR GROUNDWATER FLOW VELOCITY DOWN-GRADIENT FROM POWER BLOCK

DISTANCE FROM POWER BLOCK TO CLOSEST WELL (T1S; R6W) 14- dbb	GROUNDWATER GRADIENT (Feet/Mile)	PERMEABILITY (Gallons per square foot 1:1 gradient)	VELOCITY (Feet/ day)	TRAVEL TIME (Years)
3.3 miles (17,425 feet)	15.6	200[1/]	0.26	185
3.3 miles (17,425 feet)	15.6	500[2/]	0.66	75

1/ Two times the average permeability as estimated from the pump test analysis (Appendix I, Harshbarger & Associates, this report)

2/ Five times average permeability as estimated from pump test (Appendix I, Harshbarger & Associates, this report)

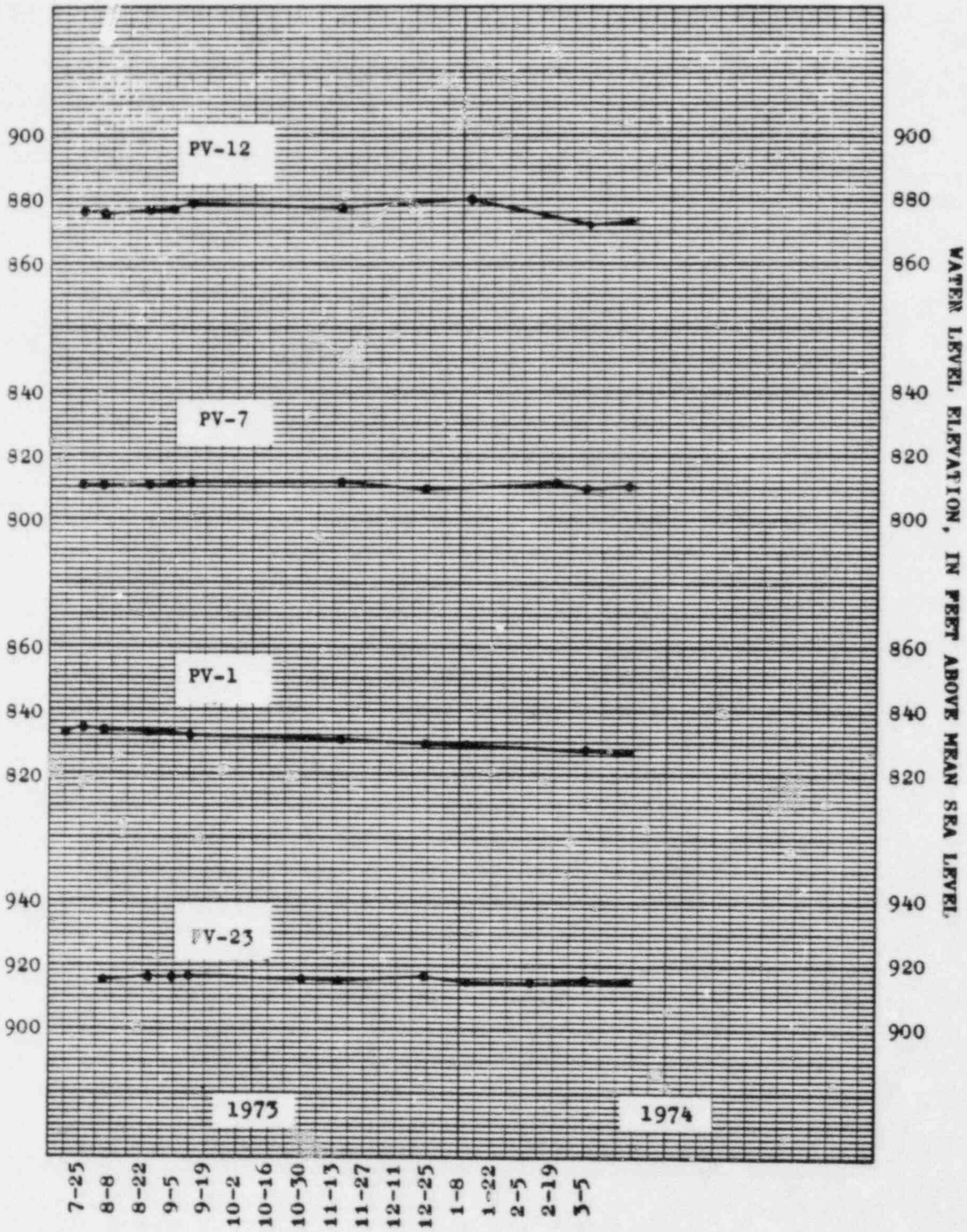
The above computations are the considered average flow of groundwater in the regional aquifer. The travel time of fluid to the regional aquifer from the ground surface via the perched water zone has not been estimated.

atmosphere from phreatophyte transpiration has not been calculated, but it is a significant output, primarily in the Gila River flood-plain. Hydrographs of selected wells in the Lower Hassayampa - Centennial area are shown in Figure 2 - 5. A uniform rate of decline of the water levels in the area began about 1955 due to the increase in pumping of groundwater for agriculture. The cumulative average change in the water level in the Buckeye-Hassayampa area from 1930 through 1971, as calculated by the U.S. Geological Survey (Arizona Water Commission Bulletin 5, 1973), is 24 feet. The water level has declined by as much as 100 feet near the depression cone centers during the past 20 years.

2.1.1.2 Perched Water Zone

A water level contour map was constructed from the Palo Verde borehole water level data. These data indicate there is a perched water table condition in the area of the irrigated cropland (Figure 2 - 6). Periodic water level measurements were obtained in all cased Palo Verde boreholes (Figure 2 - 6). The water levels in these boreholes, in and adjacent to the irrigated cropland (Figure 2 - 6), are significantly higher than in the existing irrigation wells. The water levels range from about 5 to 80 feet below the land surface. Periodic water level measurements were also obtained from boreholes which did not penetrate the Palo Verde Clay. Hydrographs were plotted from these data and compared with hydrographs which were plotted from data from wells which penetrated the clay (Figure 2 - 7). The similarity of water levels in the boreholes suggests a continuous hydraulic connection in the heterogeneous mixture of alluvial material. It also suggests that clay layers within the perched zone, particularly the Palo Verde Clay, are not effective confining layers but comprise a leaky aquitard (Figure 2 - 4).

The "Basin Sediments" which contain the perched water zone are described in detail in the geology section (FUGRO, 1974). These units comprise sediments above the basalt-andesite sequence. The perched water zone lies beneath the Site and extends toward Hassayampa



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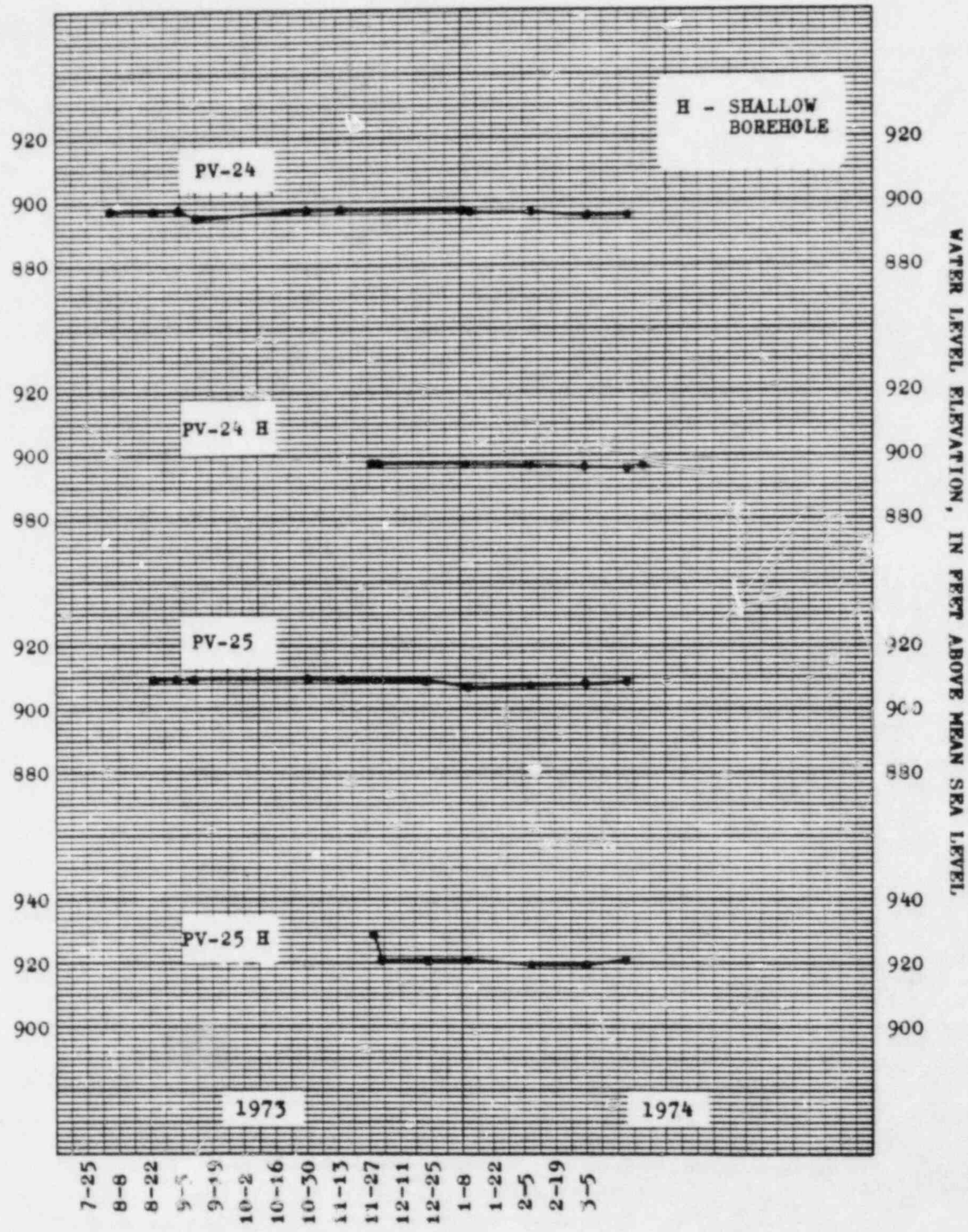
Units 1, 2 & 3

HYDROGRAPHS OF SELECTED PALO VERDE BOREHOLES SHEET 1 of 5

Figure 2-7



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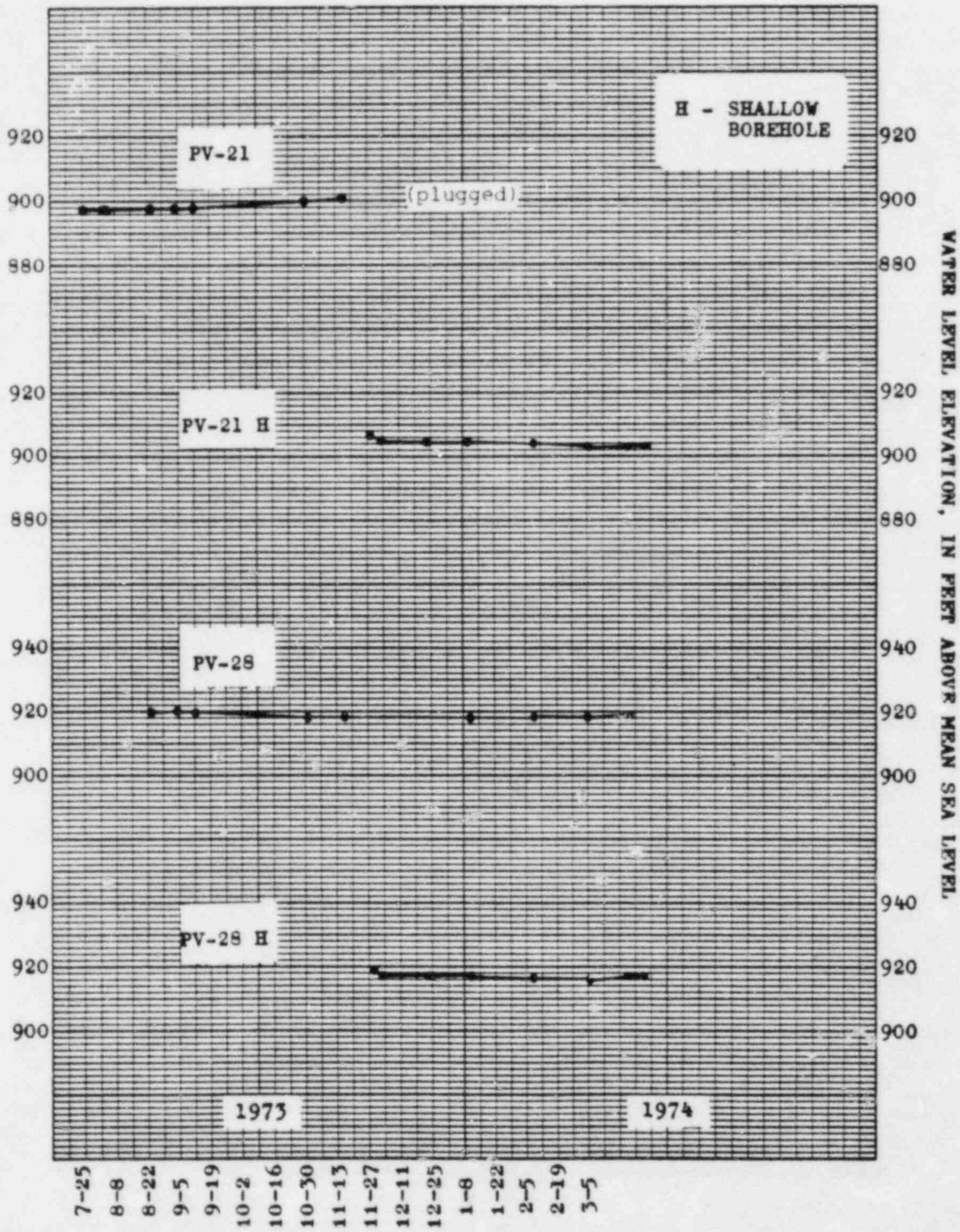
Units 1, 2 & 3

HYDROGRAPHS OF SELECTED PALO VERDE BOREHOLES SHEET 2 of 5

Figure 2-7



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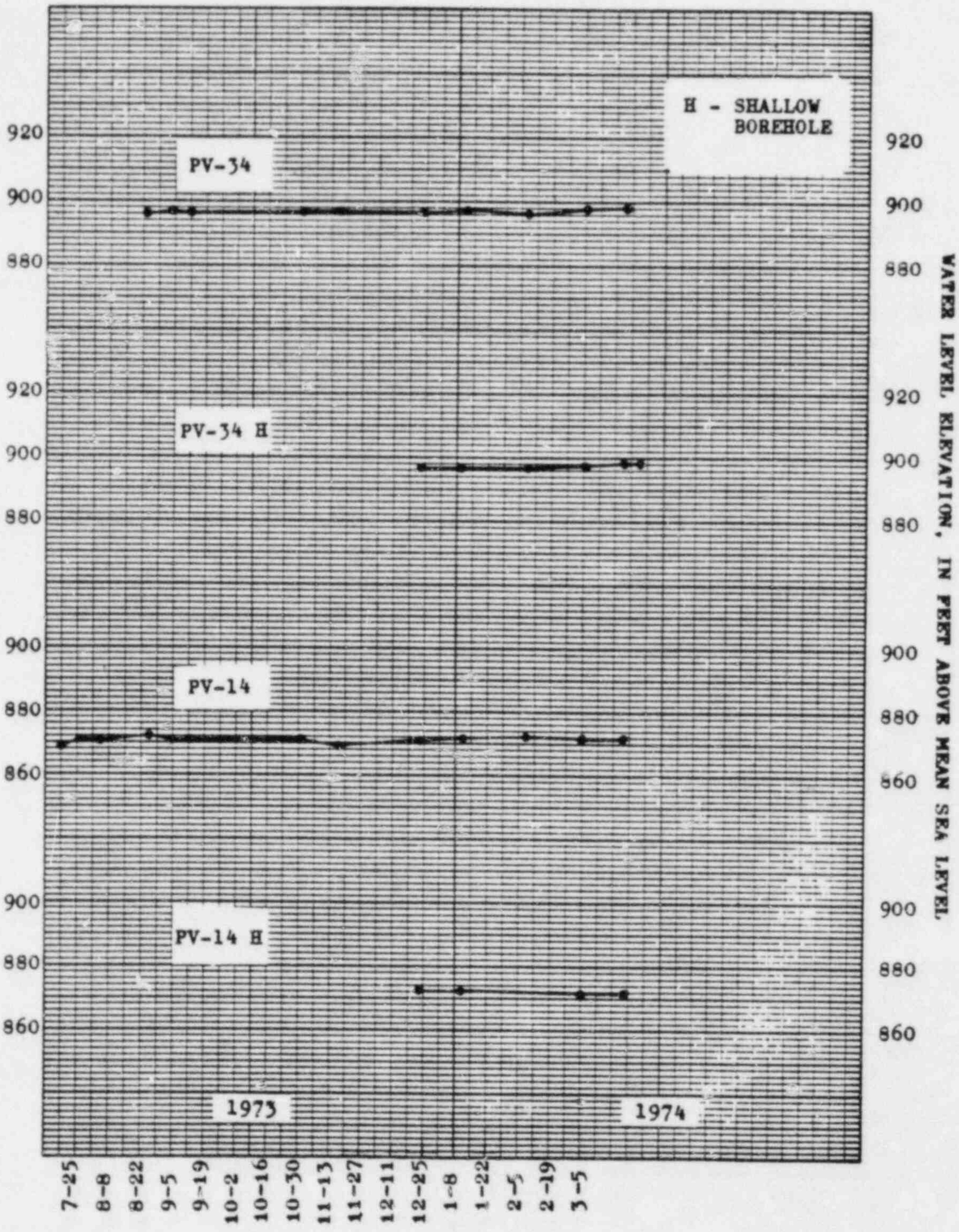
Units 1, 2 & 3

HYDROGRAPHS OF SELECTED PALO VERDE BOREHOLES SHEET 3 of 5

Figure 2-7



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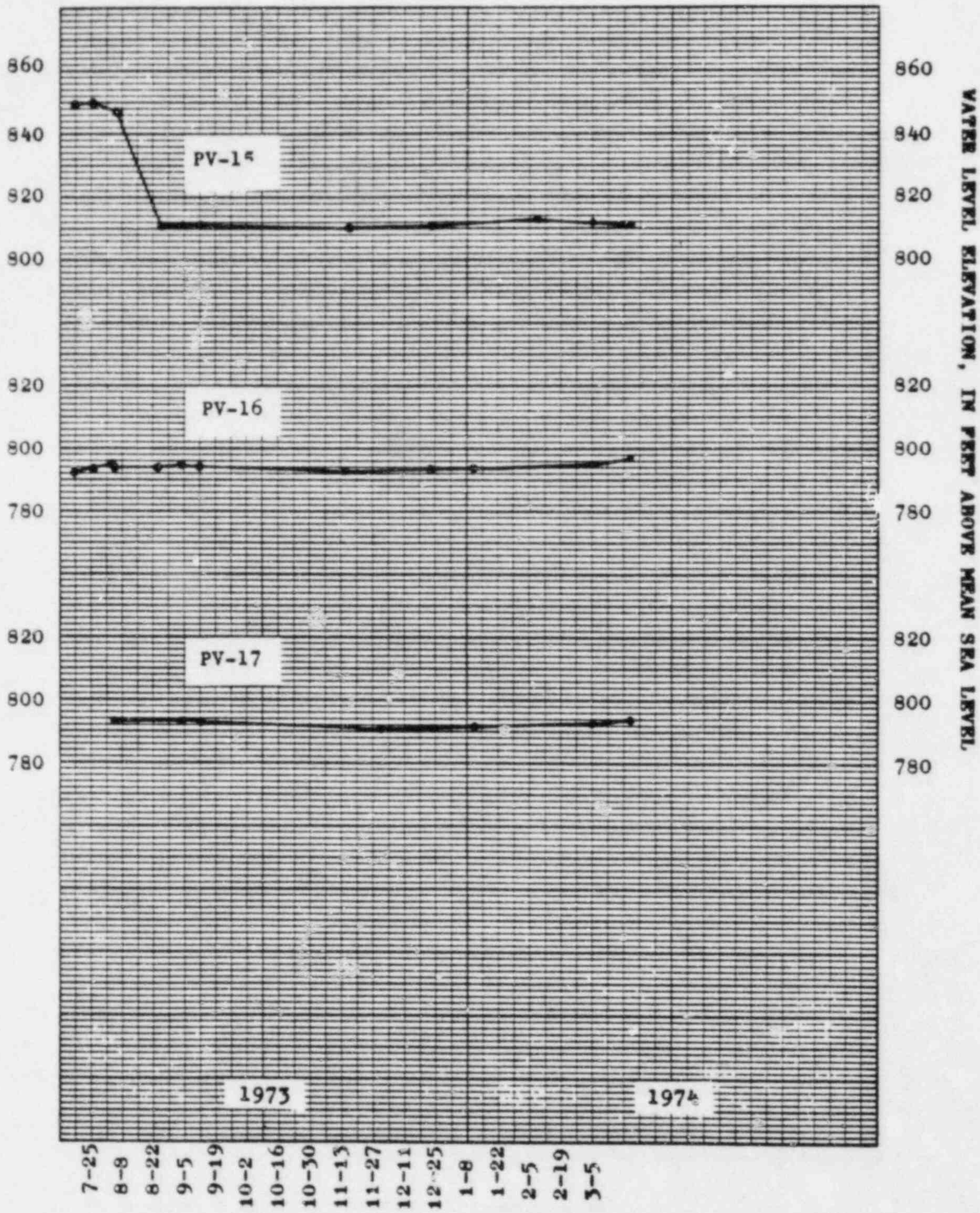
HYDROGRAPHS OF SELECTED PALO VERDE BOREHOLES SHEET 4 of 5

Figure 2-7



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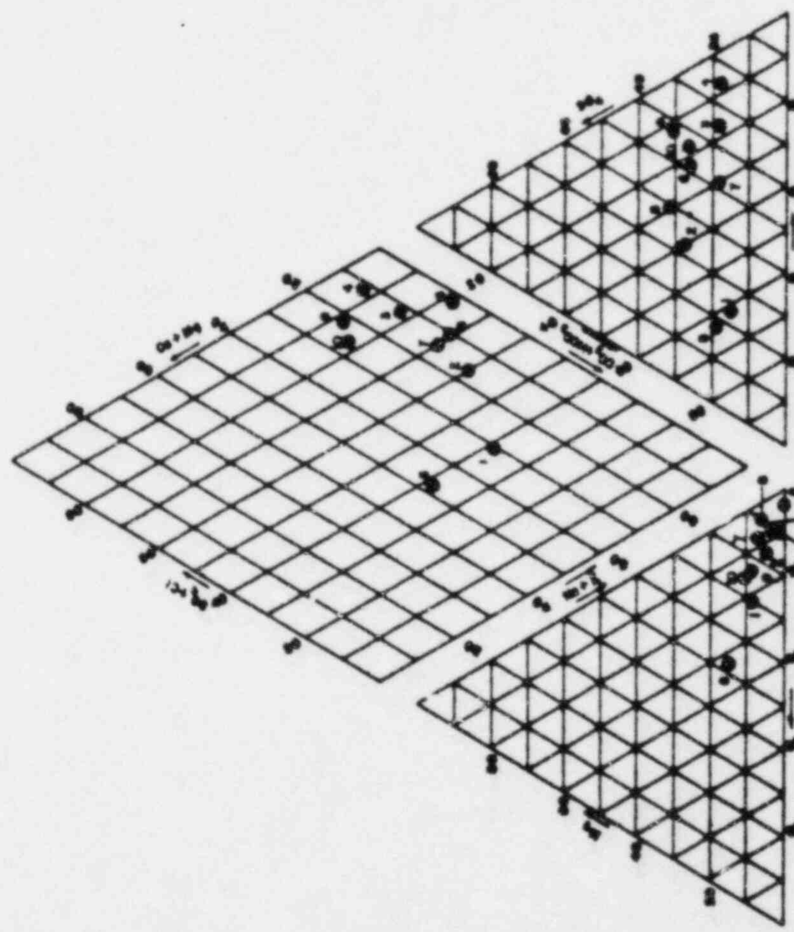
HYDROGRAPHS OF SELECTED PALO VERDE BOREHOLES SHEET 5 of 5

Figure 2-7



Number	Well Location	Date of Collection
1	(B-2-6) 23aba	9-26-52
2	(B-2-6) 28bab	7-29-53
3	(B-2-7) 14cbb	7-29-53
4	(B-2-7) 26aaa	7- 8-46
5	(B-1-5) 4adb	4- 8-46
6	(B-1-6) 29dcd	9-17-71
7	(B-1-6) 34abb	7-22-53
8	(C-1-6) 18bbb	7-22-53
9	(C-1-6) 26aba	7-22-53
10	(C-1-7) 11baa	3-21-46

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TRILINEAR DIAGRAM OF GROUNDWATER SAMPLES
LOWER HASSAYAMPA/CENTENNIAL AREA

Figure 2-11

All the samples except Nos. 1 and 5, are the same general water type, sodium chloride. The variance exhibited by samples 1 and 5 as compared to the other wells may be explained by their location with respect to the depression cones. Samples 1 and 5 were obtained from wells along the outer fringe of the depression cone, whereas all the other wells are located within the influence of a depression cone. These data reveal the recycling effect on the quality of water in the aquifer.

2.3 Monitoring or Safeguard Requirements

Due to the dependence of agriculture and municipalities on groundwater for their water source, the impact of an additional groundwater user on the hydrologic environment should be given careful consideration. In order to detect the impact of the plant on the groundwater system, a monitoring program is designed to document the fluctuations of the groundwater levels and variations in groundwater quality.

2.3.1 Groundwater Level Monitoring

2.3.1.1 Well Selection

A list of candidate wells for monitoring the water levels is presented in Table 2 - 4. Water levels from selected wells would provide data to show groundwater level variation of the depression cone in the vicinity of the site. A final selection of water level monitor wells is dependent on the availability and suitability of existing wells for monitoring purposes.

2.3.1.2 Data Collection Procedures

Water levels in the proposed monitor wells should be measured biannually. Date and measurement should be recorded prior to the irrigation pumping season in early April and after the main pumping season in late September - early October. This particular

TABLE 2 - 4 PROPOSED WATER LEVEL MONITOR WELLS[1/]
(SEE TABLE 2 - 1)

T. 1 N.; R. 6 W.	T. 1 S.; R. 6 W.
Section	Section
13aaa	3bbb
13abd	9abc
16ddd$_3$	12bbc
17ada$_1$	13cab
20bba	14dbb
20dab	17abb
22add$_1$	20aab$_2$
25add	21cbb
26baa	23adb
27cbc	
27ddc	
32cbb	
34abb	
34acc	

1/ Well designation conforms to the well location system used in the State of Arizona (Figure 2- 9).

River to the east, but terminates at about 2 miles west of the Site (Figure 2 - 6). Water has not been withdrawn from the perched zone within the Site area; however, the yield to a well from the perched water zone is estimated to be less than 50 gpm, and the main productive zones are the interbedded sand and gravel units.

The general flow direction of the perched groundwater is radially outward from the center of the irrigated cropland (Section 34, T. 1 N., R. 6 W.) (Figure 2 - 6). Discharge from the perched water zone is via underflow and vertical downward leakage. As the groundwater moves radially outward, it migrates to the regional aquifer west of the irrigated cropland where the low-permeable layers are believed to be absent. Downward leakage from the perched water zone through the leaky aquitards into the regional aquifer is due to a posit ve head differential between the perched and regioı al aquifer water levels.

Pumping from the regional aquifer for irrigation use during the past years has created the recharge mound in the perched zone. Groundwater is pumped from the regional aquifer onto the land surface; and a significant portion, which comprises return flow from irrigation, infiltrates and contributes recharge to the perched zone. This return flow provides water for growth and/or mainteanance of the recharge mound in the perched water zone.

2.1.2 Groundwater Use for Plant Operations

The groundwater reservoir in the Site area is the primary source of water for the service water supply (1,000 gpm) for the plant construction personnel and plant operations.

The continuous withdrawal of 1,000 gpm (1,600 AF/yr) from the groundwater reservoir is slightly less than the annual withdrawal

from an existing irrigation well in the site area. The regional aquifer could sustain additional withdrawal of such magnitude without significantly effecting the groundwater system. In the event existing irrigation wells in the immediate site area are retired, the net result would be a decrease in annual withdrawal from the groundwater reservoir.

A prediction of the drawdown in the pumped well and the interference effects on existing wells was based on calculations made using the modified Theis non-equilibrium equation (Appendix II). The values of transmissivity (100,000 gpd/ft) and storage (0.005) used in the prediction model were derived from a pump test conducted on an existing well within the well field location. Based on this model, the drawdown in the production well after 35 years of continuous pumping at the rate of 1,000 gpm would be 30 feet. The drawdown at distances of 0.5, 1, 2, 5, and 10 miles would be 10.6, 9.1, 7.5, 5.3, and 3.7 feet, respectively. These predictions are based on the assumption that all water is withdrawn from storage and negative boundaries are not encountered by the depression cone. These values indicate that the withdrawal of 1,000 gpm for plant operations would not create a serious impact on the groundwater reservoir, or impose major interference effects on other water users in the Palo Verde Site area. The well field for the production of 1,000 gpm is proposed to be in the northern half of Section 34 in T. 1 N., R. 6 W., and consists of two wells (Figure 2 - 2). One well could supply the water for normal plant operations, and a second well would be for standby purposes. The total depth of each of these wells should be 1,500 feet; cased with blank casing from land surface to 500 feet; and equipped with 1,000 feet of louvered screen from 500 feet to the bottom of the borehole.

2.2 Sources

Water for irrigated agriculture constitutes the single major use in the Lower Hassayampa - Centennial area. The source of water for irrigation is the groundwater reservoir. An average of 78,000 AF/yr was pumped during the period 1966 through 1972, from the Lower Hassayampa - Centennial area. The total accumulated pumpage for the 1966 - 1972 period was 544,000 acre-feet. The locations of irrigation wells and irrigated cropland are shown in Figure 2 - 8. The source of water for municipal and domestic use is also obtained from the groundwater reservoir. Annual pumpage for municipalities and stock and industrial purposes is very small, less than 100 AF/yr.

Quantitative estimates of annual consumptive-use of water by phreatophytes are not available; however, areal extent and plant density indicate significant amounts of consumptive use. Phreatophytes occur extensively, and the greatest plant density occurs in the floodplains of Centennial Wash, Hassayampa River, and Gila River in the southeastern part of the Lower Hassayampa-Centennial area. Phreatophyte growth is relatively minor near the proposed plant site along Winters Wash and several other unnamed intermittent tributaries. Phreatophytes are considered a major user of groundwater in the floodplain area along the major drainages.

The general flow direction of groundwater in the regional aquifer is north to south, and the approximate gradient is 30 feet per mile.

2.2.1 Water Well Inventory

A well inventory was conducted by the U.S. Geological Survey in the Lower Hassayampa - Centennial area. Well locations are shown in Figure 2 - 2. The well numbering system used in

Arizona is given in Figure 2 - 9. The inventory includes information on the following: well location, type of well, altitude of land surface, depth of well, casing diameter, water depth and date of measurement, altitude of water level, yield and drawdown, specific capacity, driller's log availability, and water quality data availability (Table 2 - 1). The data were obtained from U.S. Geological Survey files, Arizona State Land Reports, Arizona Water Commission Bulletins, and from field surveys.

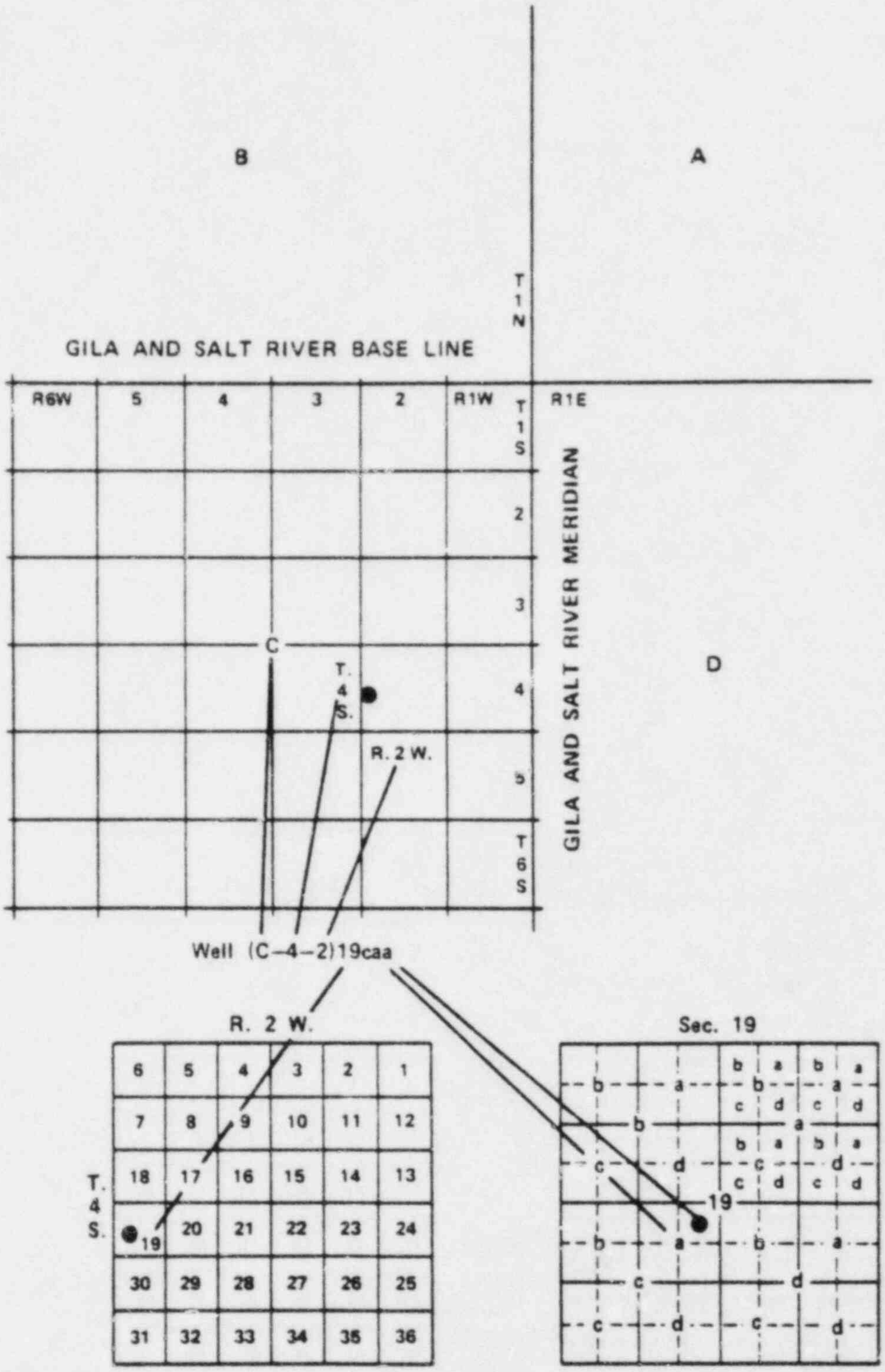
2.2.2 Present Regional Water Use

The production history of the wells in the Lower Hassayampa-Centennial area is compiled in Table 2 - 2. The table contains a list of well locations for all known active wells and the annual pumpage rate for each well for the years 1966 through 1972. Water levels in the area began a steady rate of decline in 1955, due to increased groundwater pumpage for agriculture. The average change in the water level is 24 feet, as discussed in Section 2.1.1.1.2. Locally, the water level has declined as much as 100 feet near the depression cone centers during the past 20 years (1954-74). These depression cones are described in Section 2.1.1.1.

There is no large public water supply within the Lower Hassayampa - Centennial basin. The nearest public supply is at Buckeye, Arizona which is about 16 miles east of the plant site.

2.2.3 Projected Future Water Use

The production of water from the groundwater reservoir varies directly with the acreage of irrigated cropland. Available records indicate no significant change has occurred in the total acreage of irrigated cropland from 1968 through 1973. Pumpage records indicate a nearly constant withdrawal rate for the



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WELL NUMBERING SYSTEM IN ARIZONA

Figure 2-9

TABLE 2-1.---RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA

(Data Compiled from Files of Water Resources Division, U.S. Geological Survey, Phoenix, Arizona)

Type of Well: I-Irrigation; D-Domestic;
S-Stock; U-Unused; X-Destroyed

Remarks: L - Well Log Available
SC - Specific Conductance
C - Chemical Quality

Land Surface Altitude from U.S. Geological Survey Topographic Maps

WELL LOCATION	TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL			PUMPING DATA		SPECIFIC CAPACITY (gpm/ft)	REMARKS
					DEPTH (feet)	DATE MEAS.	ALTITUDE (feet above msl)	YIELD (gpm)	DRAWDOWN (feet)		
(B-2-4) 29dcd	S	1,187		10	218.3	1/70	968.7				
(B-2-5) 15bbc	S	1,160		16	125	1/70	1,035				
29aac	D	1,133	155	8	140.6	1/70	992.4				
29dac	U	1,127	270	16	136.8	1/73	990.2				L
29ddb		1,123			136.78	2/67	986.22				
31bca	D	1,098	200	16	111.7	3/62	986.3				
32aba	U	1,120	285	16	128.7	3/62					L
(B-2-6) 4caa	I	1,208	1,000	15	283.8	1/70	924.2				
4cad	U	1,198	505	16							
5daa	I	1,201	890	16, 14	285.0	2/71	916.0	2,350	45	53	L SC
6cbb	U	1,216	663	16	288.3	2/71	927.7				L
6daa	I	1,198	1,000	16, 12	282.1	1/70	915.9	2,290	83	28	L SC
8aaa	I	1,190	710	16	265.4	1/70	924.6				L SC
8caa	I	1,170			241.5	1/70	928.5				
9aba	I	1,197	1,090	20							L
9bba	I	1,194	600	20				2,480			
10aac	U	1,200	250	6	Dry	1/70					
12aaa	S	1,233	250	6							
16[illegible]aa	I	1,157	520	20	228.4	1/70	928.6	600	93	11	SC
17aaa	I	1,160	675	20	233.1	1/70	926.9	2,830	93	30	L SC
17bdb	U	1,142	220	12	190.7	3/61	951.3				
17daa	I	1,144	1,000	20	214.7	1/70	929.3	1,710	88	19	L SC
19bbb	I	1,130	300	8							L
19daa	I	1,114	525	22	193.2	1/70	920.8				SC

TABLE 2-1.---RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL			PUMPING DATA		SPECIFIC CAPACITY (gpm/ft)	REMARKS
					DEPTH (feet)	DATE MEAS.	ALTITUDE (feet above msl)	YIELD (gpm)	DRAWDOWN (feet)		
(B-2-6) 20bba	I	1,124	500	16	205.5	1/70	918.5	1,120	76	15	SC
$20cdd_1$	X	1,102		4	123.2	3/54	978.8				
$20cdd_2$	U	1,100		8							
20daa	I	1,118	1,032	14, 12	172.0	3/61	946	720			L SC
20dcc	D	1,103	715	8							
21bba	I	1,136			209.0	1/70	927.0	980	148	7	SC
21bbb		1,134	1,100								L
21dbb	I	1,127	500		200.0	1/70	927.0				
23aab	I	1,160	1,002	16	182.8	3/63	977.2	1,070			L SC
23aba	U	1,162	382	20, 16	181.05	3/66	980.95				L C SC
23ddc	U	1,138		6	147.2	3/63	990.8				
24caa	X	1,154	300	16							L
24cba	I	1,150	485	16	164.5	1/70	985.5	350	21	17	SC
24dab	D	1,155	300	8							
$24dbc_1$	D	1,123		8							
$24dbc_2$	D	1,122		6							
25baa	U	1,139		6	152.1	1/58					
27ada	I	1,118	405	16	135.3	1/70	982.7				L
27bab	I	1,122	610	16, 14	144.8	3/62	977.2				L
28aab	D	1,114	502								
28bab	I	1,111	1,000	16	182.8	1/70	928.2	2,000	117	17	L C SC
31daa	I	1,065			158.0	3/69	907.0	2,450	106	23	SC
33caa	I	1,075	1,208	20, 16	170.5	1/70	904.5	1,740	227	8	L SC
(B-2-7) 12cbb	D, I	1,194	600	12	260.2	1/70	933.8				
14cbb	I	1,184	685	16	254.5	1/70	929.5	1,730	42	41	C SC
20cdd	D	1,188		8	259.3	1/70	928.7				
22bbb	I	1,194	800	20, 16	265.7	1/70	928.3	1,280	23	55	L SC
22cbb	I	1,175	800	16	247.2	1/70	927.8	780	23	34	L SC
22dbc	I	1,158	325	12				310			L

TABLE 2-1.---RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL			PUMPING DATA		SPECIFIC CAPACITY (gpm/ft)	REMARKS
					DEPTH (feet)	DATE MEAS.	ALTITUDE (feet above msl)	YIELD (gpm)	DRAWDOWN (feet)		
(B-2-7) 23acd	U	1,140		12	222.0	1/70	918.0				
23bbb	U	1,165	338	12	Dry	1/70					
23cca	U	1,140	390	10	223.7	1/70	917.6				L
23ccb	I	1,145	600	20	227.4	1/70	917.6	1,910	38	51	L SC
23cda	U	1,132	160	6	Dry	5/68					
23cdc	U	1,134	208	8	187.1	2/63	946.9				
24bba	D	1,145	360	10							L
24bbb			360	10							L
25bca	I	1,109	345	16	196.5	1/70	912.5	760	34	22	SC
26aaa	U	1,119	208	8							C SC
26aab	I	1,122	400	16				860			L
26aac	D	1,117	342	8, 7							
26aba	U	1,125	188	10	Dry	3/66					L
26abb	I	1,127	400	16	210	1/69	917	900	72	12	L SC
26acb	I	1,119	500	18	203	1/69	916	1,920	44	44	L SC
26bab	I	1,128	450	16	215.1	3/69	912.9	1,110			L
27aab	I	1,146	350	16	247.6	2/73	898.4	1,080	183	6	L
28aaa	U	1,164		6	192.3	1/58	971.7				
28bab	I	1,168									
28bbb	I	1,175	1,047	20,16	255.4	1/70	919.6	660	113	6	L SC
28bdd	I	1,155			242.6	1/70	912.4	400	97	4	SC
28caa	I	1,150			243.3	1/70	906.7	1,100	86	13	
28daa	U	1,140			225.4	3/69	914.6				
29aaa	S	1,180		10	253.4	3/69	926.6				
33baa	X	1,143	817	None				150	430		L
34bba	I	1,126	1,000	20,16	214.9	1/70	911.1				L
36abb	I	1,082	990	20,16	172.0	3/69	910.0	2,300	37	62	L SC
36bba	I	1,092	340	16	170.3	3/69	921.7	910	46	20	L
36cbb	I	1,080	970	20,16				1,200			L

TABLE 2-1.---RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL			PUMPING DATA		SPECIFIC CAPACITY (gpm/ft)	REMARKS
					DEPTH (feet)	DATE MEAS.	ALTITUDE (feet above msl)	YIELD (gpm)	DRAWDOWN (feet)		
(B-1-4) 4bad	U	1,144.8		12	244.5	12/56					
5bba		1,125	1,690								L
5dad	D	1,110	300	6	208.7	1/70					
7cdb			300		90	5/58					L
7daa			610		160	6/56					
16aab		1,062.4	330		182.4	2/71	880				
16baa		1,059.5	168								L
19cdb											
19dad	U		292								L
20cba			1,100								L
20dda	U		400								L
21aad	I		320								L
21add											
23dda	I		300								L
25caa			85.4								
26baa											
27aad			300					1,570	58	27	L
27abb	I	988	350		136.0	1/70	852	1,100	70	16	L
27dbb			292		120	4/51					
28daa	I		385								L
29ccc	U		700								L
29daa	U		570		109	8/51					L
30cbb	U		300		13	9/51					L
31cba	I		946		40.5	1/48		1,965	135	15	L
31ccd		919.7	250								C
$32bbb_1$	U	939	770								L
$32bbb_2$	I	939	1,580								L
32daa			1,105								L
33ada	I		268					3,000	31	97	L
34bab			280								C
34cba			1,288								L
34dcc	U	903.9	212		68.2	2/71	835.7				L C

TABLE 2-1.---RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION		TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL			PUMPING DATA		SPECIFIC CAPACITY (gpm/ft)	REMARKS
						DEPTH (feet)	DATE MEAS.	ALTITUDE (feet above msl)	YIELD (gpm)	DRAWDOWN (feet)		
(B-1-4)	35aad	I	880	1,810								L
	35acb$_1$		930	117.8		67.60	2/46	862.4				
	35acb$_2$	I	930	1,990					1,500			L C
	35bbc	I		1,152								L
	36abb											
	36cbb	I		280					3,058			L C
(B-1-5)	3ccb		1,018	250		200	9/70	818				L
	4adb	U	1,044	70	48	Dry	9/69					C SC
	6ccd	U	1,064		60	Dry	12/56					
	6dab	S	1,061		8	89.7	1/70	971.3				
	6ddb$_1$	D	1,060	100	8	88.5	1/70	971.5				
	6ddb$_2$	I	1,060	160	12	8[illegible]	1/70	970.1				
	7aab	I	1,047.7	253	16	75.79	2/63	971.91				L
	7abb	I	1,060	350	12 1/2	89.4	1/70	970.6				L
	7baa	D,S	1,060									
	7bcb		1,048	156		90	3/71	958				L
	8dab	U	1,057	304	16	89.1	2/73	967.9	1,100	88	13	L
	10bbc	U	1,010		16	40.0	1/70	970.0				
	10bcc	I	1,001	352	16,12 3/4	37.8	1/70	963.2				L
	10cbb	D	1,000	44.5	None	38.5	1/70	961.5				
	10ccb	U	1,000		60	39.8	1/70	960.2				
	10ccc	I,D,S	998	44	36	37.6	1/70	960.4				
	15bbb$_1$	D,S	994		8							
	15bbb$_2$	I	994		12	37.6	1/70	956.4				
	15cbb$_1$	U	980	140	12	40.84	2/63	939.16				
	15cbb$_2$	U	978	100	12	36.90	2/63	941.1				
	15cbc	I	980	159	16	45.1	1/70	934.9				L
	15cdc	U	962.9	150	20	17.0	2/73	945.9				

TABLE 2-1.---RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL DEPTH (feet)	WATER LEVEL DATE MEAS.	WATER LEVEL ALTITUDE (feet above msl)	PUMPING DATA YIELD (gpm)	PUMPING DATA DRAWDOWN (feet)	SPECIFIC CAPACITY (gpm/ft)	REMARKS
(B-1-5) 16bbb	I	1,040	320	16	86.1	1/70	953.9	500			L
16bca	I	1,034	850	16, 10	92.1	1/70	941.9				L
17acd	I	1,023	303	16	83.5	1/70	939.5				
17adb	U	1,025	205	16	83.4	3/69	941.6				L
17add	D,S	1,028	142	16							L
17dab		1,023	300		90	6/70	933				L
17ddc	D	1,014	270	8							L
17ddd	D	1,006	330	6							
19bcd1	U	990	125.5	8	62.4	1/70	927.6				
19bcd2	D	990		8							
20acc	X	1,005	73.5	60	71.30	5/49	933.7				
20dcb	U	995	92	6	66.5	12/54	928.5				
21bbb	I	1,004	320	16	63.8	1/70	940.2	500			
21ddb	I	980.5	275	12	65.4	1/70	915.1	340	52	6	SC
21ddd	D	982		8							
22bbb	D	980.5		6	39.32	2/63	941.18				
27bbc	I	977.3	384	16	68.0	2/73	909.3	430	63	7	L SC
28aaa1	D	981	160	8							
28aaa2	I	981	1,115		71.2	1/70	909.8				
28ada	U	973	320	16							
28adb	D	965	150	8							
28dab	D	958		10	58.6	1/70	899.4				
29aab	U	975	120	8	57.65	1/70	917.35				
30cba	U	967.6	177.0	7	67.5	1/70	900.1				
30dcc		950	252								
31caa	D	941	160	8							
34bbb		957	240		78	8/66	879				L
34bdc	U	944	3,505								
35aba	I	920	300	16	49.0	1/70	871	640			
35daa1	U	917		20				1,510			
35daa2	I	917	337	16				1,300			L SC
36ccb	I	900	300	16	69.8	3/69	830.2				L

TABLE 2-1.---RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL DEPTH (feet)	WATER LEVEL DATE MEAS.	WATER LEVEL ALTITUDE (feet above msl)	PUMPING DATA YIELD (gpm)	PUMPING DATA DRAWDOWN (feet)	SPECIFIC CAPACITY (gpm/ft)	REMARKS
(B-1-6) 1abb	U	1,082	1,223	16, 12, 10 3/4	108.4	1/73	973.6				L
1cbb	I	1,062	358	16	95.5	1/70	966.5				L
1ccb	S	1,060									
2abb	I	1,077	1,001	16	103.2	1/70	973.8				L
3bbc	U	1,069.1	400	8	107.2	1/70	961.9				L
7abd$_1$	U	1,024	95	96	35.3	1/70	988.7				
7abd$_2$	U	1,024	185	6	33.0	12/56	991.0				
7bdd	I	1,024	340	16	146.5	2/73	877.5	600	65	9	L
8abb	I	1,030	805	20	134.15	2/63	895.85	1,360			L SC
9bba	U	1,034	670	16	134.6	1/70	899.4				L
10aab	I	1,044	1,690	20, 16	162.5	1/70	881.5	1,640	206	8	L SC
10bab	S	1,052.3		10	100.21	1/58	952.09				
11bca	I	1,040.7			81.2	1/73	959.5	320	160	2	SC
11ccc	D	1,024	220	8							
11ccd	D	1,030	350	12							
11dad	D	1,018		7							
11dbb	D	1,040									
11dbc	D	1,036	260	8							L
12baa	I	1,054	470	16	89.16	2/63	964.84				L
13aaa	U	1,018	962	16	66.4	2/71	951.6				L
13acb	U	1,025	695	16	85.5	1/70	939.5				L
14aab	D	1,021	180	8							
14bcd	S	1,021		8							
14ccc	D	1,004									
15aaa	D	1,023			67.4	1/70	955.6				
15abd		1,018	275		70	11/71	948				L
15add	U	1,012		12	70.5	3/69	941.5				
15bba$_1$	D	1,025	250	8							
15bba$_2$	U	1,024	86	8	Dry	1/70					

TABLE 2-1.—RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL			PUMPING DATA		SPECIFIC CAPACITY (gpm/ft)	REMARKS
					DEPTH (feet)	DATE MEAS.	ALTITUDE (feet above msl)	YIELD (gpm)	DRAWDOWN (feet)		
(B-1-6) $16dda_1$	X	1,009	119	10	82.9	3/60					
$16dda_2$	D	1,009	200	8							
$16ddd_1$	U	1,006	402	8							L
$16ddd_2$	D	1,008									
$16ddd_3$	D	1,002		14	85.3	1/70	916.7				
$17ada_1$	D	1,002.1	300	16	176.6	1/70	825.5	1,070			L
$17ada_2$	I	1,002			179.7	11/73	822.3				
$18aaa_1$	U	1,007.4	200	20	33.9	12/56	973.5				L
$18aaa_2$	U	1,007			87.11	2/63	919.89				
20adb	U	978	188	16							L
20bba	U	985	254	20	132.5	5/70	852.5				
20dab	I	965	229	16	184.06	3/69	780.94	410			L
20dbb	I	970	792	20, 16	186.4	1/70	783.6	1,360			L
$22add_1$	U	994.9	115.7	8	85.1	3/69	909.8				
$22add_2$	D	995	218	6							
$22bab_1$	U	1,003	86.7	10	67.87	12/63	935.13				
$22bab_2$	D	1,003	200	8							
23dcd	D	987	460	8	138.1	8/68	848.9				L C
25add	S	960			68.0	1/70	892.0				
26baa	U	983		20	188.2	1/70	794.8				
27acc	X	970	656								L
27cbc	I	965.4	1,200	20,16,14	174.0	11/73	791.4	120	119	1	SC
27ddc	I	952.9	1,050	20, 16	172.4	12/53		1,250			L
32cbb	S	930			139.2	1/70	790.8				
34abb	I	958	1,413	20	128.73	8/54	829.27	2,260			L C SC
34acc	I	945	1,100	20, 16	207.0	11/73	738.0	1,840			SC
34adc	I	945	1,122	20, 16	257.02	3/63	687.98				L
35aba	X	960	1,090								L
36abb	X	940	205		138	2/63	802				L

TABLE 2-1.—RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION		TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL			PUMPING DATA		SPECIFIC CAPACITY (gpm/ft)	REMARKS
						DEPTH (feet)	DATE MEAS.	ALTITUDE (feet above msl)	YIELD (gpm)	DRAWDOWN (feet)		
(B-1-7)	1bbb	I	1,070			166.7	1/70	903.3	3,180			
(C-1-4)	5dca											
	7caa											
	12dcc			890								L
	14aaa			441					1,420			L
	17daa		825	275		20	4/70	805				L
	18ada			186					3,152			L
	18baa			195					2,805			L
	18daa			75					3,360			
	19cbb			450								L
	24caa			321					2,000	85	24	L
	24cdd			277					1,900			
	26abc			530								L
	27bdc			321					1,600			L
	28aad$_1$			410					1,845	65	28	L
	28aad$_2$			501								L
(C-1-5)	1aab	U	919	185	6	Plugged	2/65					
	1bab		898	310	16	68	1/72	830	2,200			L SC
	1dcc	I	870	202	20	45.0	1/70	825				L
	3baa$_1$	U	931	170	20	103.8	2/73	827.2				L
	3baa$_2$	I	931	390	16				110			
	3bab$_1$	D	930									
	3bab$_2$	I	930	200	16							
	4aaa$_1$	D	930	100	6							
	4aaa$_2$	I	930	600	16	99.9	3/54	830.1				L
	4ddd	U	897	97		95.6	8/70	801.4				
	5bab		920			55.6	9/71	864.4				
	7abc		870	670	12							L
	11adb	U	856	44	36	34.4	10/48	821.6				
	13aab	I	837	184	20	26.6	1/70	810.4	2,500	29	86	L SC
	13aad	I	835	150	20				1,930			L SC

TABLE 2-1.---RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL			PUMPING DATA		SPECIFIC CAPACITY (gpm/ft)	REMARKS
					DEPTH (feet)	DATE MEAS.	ALTITUDE (feet above msl)	YIELD (gpm)	DRAWDOWN (feet)		
(C-1-5) 13bad	I	835	154	20				2,060			L SC
13bba	I	849	236	20	39.3	1/70	809.7	2,080			L
13cdd	I	823						1,820			SC
$17abb_1$	U	862.6	417	10	75.6	1/70	787.0				
$17abb_2$	U	863			75.0	1/70	788.0				
17dda	U	838	87	48	49.0	1/70	789				L
21bbb	U	834	57	6, 4	51.2	12/56	782.8				
21cdd	I	798	569	16,12	48.6	1/70	749.4	1,760			L
22ccc	I	788	170	20	19.8	1/70	768.2	2,710			L SC
23ccc	I	787	664	20,16							L
23dca	I	795	740	20,18	69.3	1/70	725.7				
24ccb	I	800	114	20				2,240			L
26abb	I	795	842	16							
$27ddd_1$	U	782	150	20							L
$27ddd_2$	I	782	525	18,16,12	47.3	1/70	734.7	2,240			L SC
28aab	I	787	597	16,12,10				1,680			L SC
$29adc_1$		788	114		43.94	1/56	744.06				L
$29adc_2$	I	788	650	20	67.0	2/73	721.0	1,940	129	15	L SC
32baa	I	780	843	20,14				2,800			L SC
32ccb	I	796	910	20,16	85.0	1/70	711.0				L
34adc	I	778	443	20	20.1	5/73	757.9	1,210	108	11	L SC
34daa	U	790	30	16	Dry	7/63					
34dbd	I	774	532	20	32.6	1/70	741.4	1,700			L
(C-1-6) 2aba	X	945	952								L
3aaa	X	926	657								
3baa	X	932	1,100	20,16	84.9	1/51	847.1				L
3bbb	X	939	1,085	20	84.9	1/51	854.1				
9abc	U	917	176	4	168.5	1/70	748.5				
9cbd	U	901									
12bbc	U	925	1,000	20,16							L

TABLE 2-1.---RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL			PUMPING DATA		SPECIFIC CAPACITY (gpm/ft)	REMARKS
					DEPTH (feet)	DATE MEAS.	ALTITUDE (feet above msl)	YIELD (gpm)	DRAWDOWN (feet)		
(C-1-6) 13cab	I	890	1,200	20	195.3	11/73	694.7	690	115	6	SC
14aaa	U	904	1,000	18,16,14	211.3	1/69	692.7				L
14dbb	I	891.2	1,114	20,16	204.8	2/73	686.4	2,700	180	15	L SC
17abb	I	890	1,219	20	222.3	1/71	667.7	2,690			L
18bbb	I	911.8	1,333	20,16, 12 3/4	205.8	2/73	706.0	2,840			C SC
19abb	I	890	1,045	20,16	193.7	1/70	696.3	1,900	110	17	L
19cbb	S	876	168	6	154.0	3/62	722.0				
$20aab_1$	U	875	340	20							L
$20aab_2$	I	875	1,110	20,16	178	1/70	697				L
20aba		880	280		170	11/68	710				L
21abb	X	880	1,252								
$21cbb_1$	U	866.6	408	20	171.1	1/70	695.5	1,200			
$21cbb_2$	I	867	1,012	20,16	175.3	1/70	691.7	1,360			L SC
23adb	I	869	1,158	20	180.7	1/70	688.3	1,740			L SC
23bab	I	876	1,010	20,16	170.5	1/58	705.5	610			L SC
23caa	I	873	1,157	20,16	200.2	1/70	672.8	1,900			L
26aba	I	864	1,130	20	174.5	1/70	689.5	1,870			L C SC
26dad	I	828	1,135	20	103.5	12/56	724.5	2,680			L SC
27acc	X	838	655								L
27bbc	I	847	1,090	20				2,130			L
$28acc_1$	U	848			144.4	1/70	703.6	780			
$28acc_2$	I	848	337	15				2,470			SC
31adb	S	890		6	196.2	5/70	693.8				
34cab	U	820	116	6	61.6	12/56	758.4				

TABLE 2-1.---RECORDS OF WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	TYPE OF WELL	LAND SURFACE ALTITUDE (feet above msl)	DEPTH OF WELL (feet)	CASING DIAMETER (inches)	WATER LEVEL			PUMPING DATA		SPECIFIC CAPACITY (gpm/ft)	REMARKS
					DEPTH (feet)	DATE MEAS.	ALTITUDE (feet above msl)	YIELD (gpm)	DRAWDOWN (feet)		
(C-1-7) 11baa	U	970	286	6	262.9	1/70	707.1				C SC
12cbb	U	943	1,300	18	228.4	1/70	714.6				
14add	U	920		16	233.0	12/71	687.0				
14bbb	U	939	1,200	20	225	1/70	714				L
14dcd	U	910	165	12	Dry	6/69					
15abb	U	947		20	225.8	1/70	721.2				
15bbb	U	948.6	650	20	227.0	2/73	721.6				L
15dbb	U	930		10							
22adc	U	903	187	8	151.5	6/69	751.5				
32dab	U	965		20	54.4	5/70	910.6				
(C-2-5) 3aaa	I	783	501	16				1,310			SC
5bcd	I	790	900	20,16	78.5	3/69	711.5	3,150			SC
5ccb	I	790						2,300			SC
8aab	U	772	150	20	15.5	2/70	756.5				L
8aba	D	775	300	6							L
8abb	I	787	502	10	65.6	3/69	721.4				L
8bca	D	783	98	4	23.6	2/71	759.4				
8ccc	I	779			61.8	1/70	717.2	2,980			SC
9cbb	I	768	590	20	40.8	1/70	727.2				L SC
16abb	I	763	112	20	29.4	2/71	733.6				L
16daa	I	762		20	32.5	1/70	729.5				
17cca	S	778	102	6	58.7	1/66	719.3				
18adc	S	785	850	16							L
18cbb	D	812	793	10 3/4	104.4	5/70	707.6				L

TABLE 2-2.---RECORDS OF PUMPAGE FROM WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA
(Data Compiled from Files of Water Resources Division, U.S. Geological Survey, Phoenix, Arizona)

WELL LOCATION		ANNUAL PUMPAGE IN ACRE FEET						
		1966	1967	1968	1969	1970	1971	1972
(B-2-6)	5daa				1,374	1,363	1,277	1,707
	6daa				1,827	1,659	1,997	2,087
	8aaa				1,580	1,372	2,193	2,303
	9bba				1,334	979	1,995	1,896
	16caa				561	414	448	647
	17aaa				1,925	2,200	2,193	2,412
	17daa				1,022	1,479	1,463	1,565
	19bbb						20	
	19daa				89	207	680	998
	20bba				841	806	981	890
	20daa	758	762	827	661	545	802	604
	21bba				386	662	466	670
	23aab	364	1,140	1,205	706	807	805	705
	24cba						100	
	28bab	1,184	1,494	1,829	984	1,340	1,661	1,767
	31daa	1,557	2,325	2,581	2,394	2,365	2,258	2,505
	32db							
	33caa	658	1,341	994	962	1,134	1,069	2,038
(B-2-7)	12cbb						20	
	14cbb				1,241	1,489	1,461	1,866
	22bbb							
	22cbb	549	670	355	353	144	246	
	23ccb	773	1,399	1,454	1,453	1,685	1,631	1,562
	25bca	15	35	475	386	588	1,058	946
	26aac	1.9	2.1	3	4	4		
	26abb	619	884	682	724	759	713	697
	26acb	1,286	1,588	1,305	1,216	1,340	1,467	1,479
	26bab	318	516	674	802	1,106	970	823
	27aab	358	491	607	594	598		
	28bab	1,020	1,067	909	919	667	1,283	1,390
	28bbb	528	564	442	394	410	466	559

TABLE 2-2.---RECORDS OF PUMPAGE FROM WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION		ANNUAL PUMPAGE IN ACRE FEET						
		1966	1967	1968	1969	1970	1971	1972
(B-2-7)	34bba	653	822	393	80			
	36abb	1,324	1,996	2,012	2,041	3,198	3,407	3,414
	36bba	477	952	895	845	776	720	606
	36cbb	503	1,110	1,121	1,056	887	986	832
(B-1-5)	6ddb[2]						80	
	7aab						80	
	10bcc				1		2	5
	10ccc				1	5		
	15bbb[2]				2	2		
	16bbb	556	654	470	663	0		
	16bca	558	550	372	448	0		
	17acd	105	117	92	96	212	328	140
	21bbb	249	284	34	14	0		
	21ddb	82	75	58	81	30	36	
	27bbc	101	48	54	49	41	55	48
	28aaa[2]	83	74	61	81		15	56
(B-1-6)	7bdd	258	240	249	309	290	302	154
	8abb	398	1,959	799	852	435	758	715
	10aab	592	812	763	709	492	661	813
	11bca	40	35	97	33	18	103	161
	20dab	57	76	42	76			
	20dbb	25	43	129	486	478	1,155	849
	27cbc	63	106	315	97	22	24	44
	27ddc	723	957	790	916	655	779	1,277
	34abb	2,099	2,684	2,373	2,176	2,157	2,105	2,583
	34acc	2,279	2,960	2,319	2,914	2,247	2,343	3,638
	34adc				166	31	45	0
(B-1-7)	1bbb	1,725	1,820	2,690	2,800	3,064	2,991	3,815

TABLE 2-2.---RECORDS OF PUMPAGE FROM WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

E- estimated

WELL LOCATION	ANNUAL PUMPAGE IN ACRE FEET						
	1966	1967	1968	1969	1970	1971	1972
(C-1-5) 1cdd						500	
3baa2				422	300	502	106
4aaa2				26	21	44	46
13aab				2,429	2,028	1,633	2,193
13aad				1,624	1,310	790	1,018
13bad				917	1,578	1,431	1,255
13bba				1,076	1,647	787	1,049
13cdd				910	1,616	1,245	1,167
21cdd	501	736	382	476	678	1,330	556
22ccc	614	1,541	531	858	1,328	1,875	1,060
23ccc				2,513	2,545	3,614	1,496
23dca				951	747	1,071	360
24ccb				574	861	1,302	502
26abb				1,838	2,352	4,336	2,380
27ddd2	1,117	1,201	1,763	1,751	1,212	1,704	1,536
28aab	343	490	405	356	583	621	608
29adc	571	820	471	910	588	1,490	614
32baa	1,395	1,988	1,600	2,578	2,000 E	2,547	1,475
32ccb	713	526		1,113	1,250	1,944	986
34adc	301	548	862	755	660	890	677
34dbd	36		0	308	359	255	63
(C-1-6) 13cab	397	545	513	544			
14dbb	1,510	2,019	1,935	1,538	1,270	1,763	1,892
17abb	1,738	673	1,269	1,242	1,231	1,310	2,260
18bbb	1,196	1,005	752	1,496	728	1,750	1,300
19abb	79	867	772	1,388	66		
21cbb2	153	816	870	1,016			
23adb	1,026	1,500	1,219	1,131	1,120	974	1,468
23bab	410	260	396	374	234	478	488
23caa		965	901	772	878	1,016	1,345
26aba	711	956	926	830	561	604	539
26dad	1,510	1,714	1,672	1,939	1,685	2,066	2,130
27bbc	2,391	2,560	2,239	2,454	2,046	1,955	894
28acc2	1,560	2,610	1,996	1,992	1,792	1,384	985

TABLE 2-2.---RECORDS OF PUMPAGE FROM WELLS IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	ANNUAL PUMPAGE IN ACRE FEET						
	1966	1967	1968	1969	1970	1971	1972
(C-1-7) 14bbb	141	78	135		114		
(C-2-5) 3aaa				928	752	999	764
5bcb		913	718	959	1,126	1,595	745
5ccb	617	1,022	511	518	588	999	333
8abb		1,281	906	1,160	1,130	1,064	1,317
8ccc	2,237	2,726	1,541	2,135	1,770	2,546	3,254
9cbb		2,865	2,189	2,726	2,238	1,145	907
16abb	0		1,450	1,106	1,197	1,265	840
16daa	1,111	1,060	1,342	530	530	1,490	1,641

seven year period from 1966 through 1972 (Table 2 - 2). It is projected that the acreage of irrigated cropland would remain constant, which would maintain the present withdrawal rate from the groundwater reservoir; therefore, the groundwater flow directions and gradients would not change significantly.

2.2.4 Groundwater Quality

Water samples from wells in the Lower Hassayampa - Centennial area have been collected by the U.S. Geological Survey for chemical quality analyses. Temperature and specific conductance of the groundwater from each sampled well are listed in Table 2 - 3. The range in specific conductance is from 290 µmhos to 6,000 µmhos. Distribution of the total dissolved solids concentrations, represented by specific conductance, is shown in Figure 2 - 10.

The lower concentrations occur in the northeastern part of the area where only small amounts of water are pumped for irrigation use. The larger total dissolved solids concentrations occur near the major pumping centers, due to the recycling effect of return of waters from irrigation by continual pumping from the groundwater reservoir. This concentration decreases as the distance from the pumping centers increases, due to less influence of the recycling of water. The zoning of total dissolved solids concentrations is well demonstrated in the cones of depression northwest and southeast of the Palo Verde Hills.

Constituent concentration data of water from 11 wells in the Lower Hassayampa - Centennial area are listed in Table 2 - 3. A trilinear diagram of the percentage ion concentrations was made of samples from selected wells (Figure 2 - 11). This diagram provides a ready comparison of water quality types.

TABLE 2-3.---CHEMICAL ANALYSES OF GROUNDWATER IN THE LOWER HASSAYAMPA - CENTENNIAL AREA
(Data Compiled from Files of Water Resources Division, U.S. Geological Survey, Phoenix, Arizona)

Results in Milligrams Per Liter (mg/l) - I-Irrigation, D-Domestic, U-Unused

WELL LOCATION	DATE COLLECTED	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+k)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Hardness (Calcium, Magnesium)	Percent Sodium	Specific Conductance (micromhos at 25°C)	Dissolved Solids (milligrams per liter)	Conversion Factor (micromhos to milligrams per liter)	Water Use
(B-2-6) 5daa	8- 7-68	28														830			I
6daa	8- 7-68	35														750			I
8aaa	5-16-68	29														750			I
16caa	8- 7-68	26														650			I
17aaa	8- 6-68	27														780			I
17daa	8- 7-68	27														740			I
17daa	5-16-68	26														650			
19daa	5-16-68	28														1,100			I
20bba	8- 7-68	28														750			I
20bba	5-16-68	28														730			
20daa	8- 7-68	27														700			I
21bba	8- 7-68	26														640			I
23aab	9-17-69	27														500			I
23aba	9-26-52	26	29	-	22	5.7	83	189	37	42	-	8.9	-	78	70	523	321	.61	U
24cba	6-10-70	26														500			

TABLE 2-3.---CHEMICAL ANALYSES OF GROUNDWATER IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	DATE COLLECTED	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+k)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Hardness (Calcium, Magnesium)	Percent Sodium	Specific Conductance (micromhos at 25°C)	Dissolved Solids (milligrams per liter)	Conversion Factor (micromhos to milligrams per liter)	Water Use
(B-2-6) 28bab	8- 7-68	26														680	415	.61	I
28bab	7-29-53	26	31	-	15	3.3	119	132	74	61	10	14	-	51	83	637	392	.61	
31daa	8- 5-68	33														1,130			I
33caa	8- 5-68	27														550			I
(B-2-7) 14cbb	8- 6-68	38														1,100	627	.57	I
14cbb	7-29-53	36	32	-	17	3.3	219	114	92	231	5.2	3.7	-	56	89	1,140	659	.57	
22bbb	8- 6-68	31														500			I
22cbb	8- 6-68	32														510			I
23ccb	5-15-68	33, 36														700, 740			I
25bca	8- 6-68	42														1,400			I
26aaa	7- 8-46	48	-	0.04	29	2.4	306	73	125	381	6.9	4.0	-	82	-	1,600	890	.55	U
26abb	8- 5-68	43														1,420			I
26abb	5-15-68	42														1,500			
26abb	9-16-71	44	28	0.01	24	1.9	252	162	110	290	5.1	1.2	0.8	68	89	1,370	797		
26acb	8- 6-68	37														1,900			I

TABLE 2-3.---CHEMICAL ANALYSES OF GROUNDWATER IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

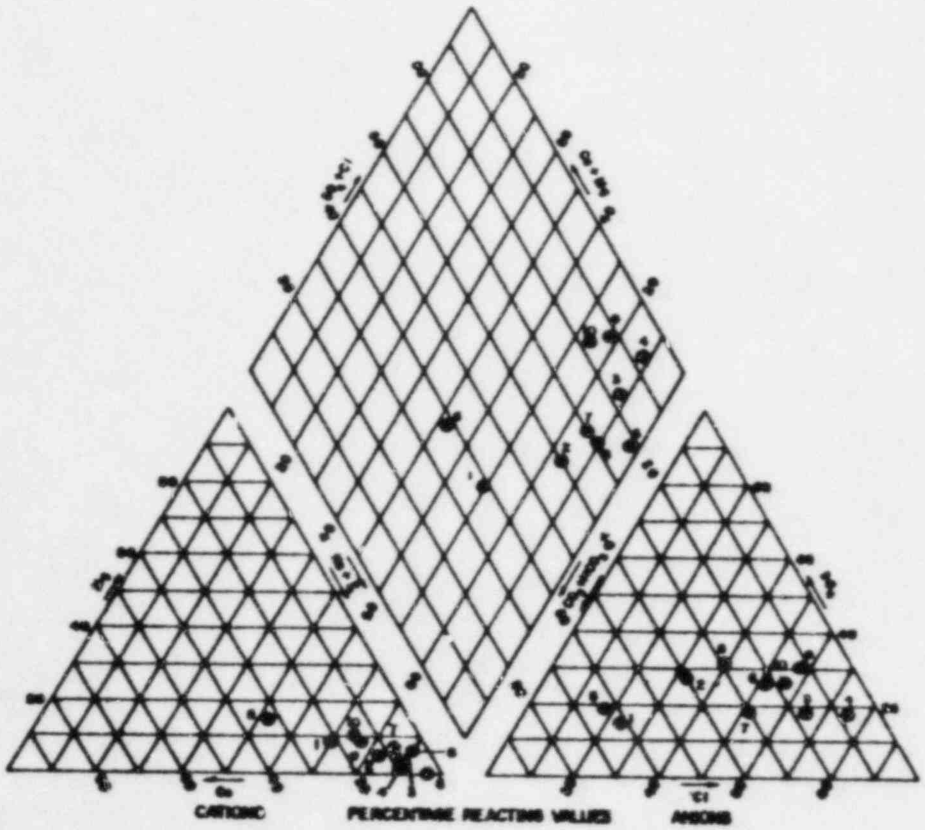
WELL LOCATION	DATE COLLECTED	Temperature (°C)	Silica (SiO_2	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+k)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Hardness (Calcium, Magnesium)	Percent Sodium	Specific Conductance (micromhos at 25°C)	Dissolved Solids (milligrams per liter)	Conversion Factor (micromhos to milligrams per liter)	Water Use
(B-2-7) 28bbb	8- 6-68	32														800			I
28bdd	8- 5-68	33														1,080			I
36abb	8- 6-68	38														1,320			I
(B-1-5) 4adb	4- 8-46	24	-	-	44	11	84	248	59	41	1.2	16	0.6	155	-	627	378	.60	U
21ddb	9-25-69	25														1,400			I
27bbc	8-27-68	26														520			I
35daa$_2$	8-21-69	27														700			I
(B-1-6) 8abb	8- 7-69	31														900			I
10aab	8- 5-68	31														560			I
11bca	8- 5-68	26														740			I
23dcd	9-25-68	28	16	0.01	4.5	0.0	140.4	71	66	98	13	4.0	.74	11	96	673			D
27cbc	8-21-69	33														290			I
34abb	8- 5-68	29														1,020	622	.61	I
34abb	7-22-53	29	58	-	20	8.3	244	218	101	220	6.4	5.6	-	84	-	1,270	770	.61	I
34acc	8- 5-68	31														1,540			I

TABLE 2-3.---CHEMICAL ANALYSES OF GROUNDWATER IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	DATE COLLECTED	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+k)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Hardness (Calcium, Magnesium)	Percent Sodium	Specific Conductance (micromhos at 25°C)	Dissolved Solids (milligrams per liter)	Conversion Factor (micromhos to milligrams per liter)	Water Use
(C-1-5) 1bab	5-17-72	26														3,440			
13aab	6-10-70	23														5,000			I
13aad	6-10-70	23														6,000			I
13bad	8- 7-68	20														3,500			I
13cdd	6-11-70	22														4,400			I
22ccc	8-21-69	26														2,400			I
$27ddd_2$	8- 7-68	30														3,400			I
28aab	8- 6-68	34														620			I
29adc	8- 6-68	32														980			
32baa	6-11-70	31														1,800			I
34adc	6-11-70	29														5,000			I
34adc	8- 6-68	28														5,500			
(C-1-6) 13cab	8- 6-68	31														1,620			I
14dbb	8-21-69	30														1,500			I
17abb	8- 5-68	31														840			I
18bbb	7-22-53	35	46	-	19	11	387	324	275	246	10	11	-	92	90	1,880	1,160	.62	I

TABLE 2-3.---CHEMICAL ANALYSES OF GROUNDWATER IN THE LOWER HASSAYAMPA - CENTENNIAL AREA (CONTINUED)

WELL LOCATION	DATE COLLECTED	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+k)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Hardness (Calcium, Magnesium)	Percent Sodium	Specific Conductance (micromhos at 25°C)	Dissolved Solids (milligrams per liter)	Conversion Factor (micromhos to milligrams per liter)	Water Use
(C-1-6) $21cbb_2$	8- 6-68	33														1,650			I
23adb	8- 6-68	27														1,070			I
23bab	9-14-61	26														1,020			I
26aba	3- 7-69	29														1,900	1,140	.60	I
26aba	7-22-53	29	50	-	45	17	278	126	222	308	2.6	13	-	182	77	1,650	998	.60	
26daa	8- 6-68	32														1,720			I
$28acc_2$	8-21-69	27														2,350			I
(C-1-7) 11baa	3-21-46		-	-	42	16	227	144	163	262	1.3	6.4	1.4	171	-	1,390	789	.57	U
(C-2-5) 3aaa	8- 7-68	26														5,200			I
5bcb	8-21-69	32														1,300			I
5ccb	8-21-69	30														1,000			I
8ccc	8-6-68	29														1,400			I
9cbb	2-9-67	32														1,300			I



Number	Well Location	Date of Collection
1	(B-2-6) 23aba	9-26-52
2	(B-2-6) 28bab	7-29-53
3	(B-2-7) 14cbb	7-29-53
4	(B-2-7) 26aaa	7- 8-46
5	(B-1-5) 4adb	4- 8-46
6	(B-1-6) 29dcd	9-17-71
7	(B-1-6) 34abb	7-22-53
8	(C-1-6) 18bbb	7-22-53
9	(C-1-6) 26aba	7-22-53
10	(C-1-7) 11baa	3-21-46

Arizona Nuclear Power Project
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Units 1, 2 & 3

TRILINEAR DIAGRAM OF GROUNDWATER SAMPLES
LOWER HASSAYAMPA/CENTENNIAL AREA

Figure 2-11

All the samples except Nos. 1 and 5, are the same general water type, sodium chloride. The variance exhibited by samples 1 and 5 as compared to the other wells may be explained by their location with respect to the depression cones. Samples 1 and 5 were obtained from wells along the outer fringe of the depression cone, whereas all the other wells are located within the influence of a depression cone. These data reveal the recycling effect on the quality of water in the aquifer.

2.3 Monitoring or Safeguard Requirements

Due to the dependence of agriculture and municipalities on groundwater for their water source, the impact of an additional groundwater user on the hydrologic environment should be given careful consideration. In order to detect the impact of the plant on the groundwater system, a monitoring program is designed to document the fluctuations of the groundwater levels and variations in groundwater quality.

2.3.1 Groundwater Level Monitoring

2.3.1.1 Well Selection

A list of candidate wells for monitoring the water levels is presented in Table 2 - 4. Water levels from selected wells would provide data to show groundwater level variation of the depression cone in the vicinity of the site. A final selection of water level monitor wells is dependent on the availability and suitability of existing wells for monitoring purposes.

2.3.1.2 Data Collection Procedures

Water levels in the proposed monitor wells should be measured biannually. Date and measurement should be recorded prior to the irrigation pumping season in early April and after the main pumping season in late September - early October. This particular

TABLE 2 - 4 PROPOSED WATER LEVEL MONITOR WELLS[1/]
(SEE TABLE 2 - 1)

T. 1 N.; R. 6 W.	T. 1 S.; R. 6 W.
Section	Section
13aaa	3bbb
15abd	9abc
$16ddd_3$	12bbc
$17ada_1$	13cab
20bba	14dbb
20dab	17abb
$22add_1$	$20aab_2$
25add	21cbb
26baa	23adb
27cbc	
27ddc	
32cbb	
34abb	
34acc	

1/ Well designation conforms to the well location system used in the State of Arizona (Figure 2- 9).

timing of data collection would provide a near-static water level and a near-maximum decline due to pumping for each calendar year.

2.3.1.3 Annual Report Procedures

An annual report should be compiled on the water level monitor program. This report would include a tabulation of all historical and recent water level data listed by well location, a water level difference map of conditions before and after pumping, and a water level contour map overlay of the annual water level data. Presentation of annual data in this form would facilitate comparison with past water level data. Comments, concerning annual water level trends and suggestions as to any modification of the water level monitor program, should accompany the data presentation.

2.3.2 Groundwater Quality Monitoring

Criteria for selection of water quality monitor wells from existing wells include the groundwater flow system and distribution of chemical quality in relation to the plant site. Wells are proposed up-gradient and down-gradient, in respect to the groundwater flow system; and adjacent to the plant site. This suite of sample points would provide data on the quality of water which enters the Site area; the existing quality of water at the plant site before operations; and the quality of water in the area during the construction and operation periods of the plant. The water samples for chemical quality analysis should be obtained from pumping wells to insure that a representative sample of the groundwater is obtained from the aquifer system.

2.3.2.1 Well Selection

Candidate water quality monitoring wells are given in Table 2 - 5. All of the wells given for the water quality monitoring program may not be readily usable. Field inspection is needed to determine which wells would be suitable and available for the final selection of monitor wells.

The water quality monitor well program would consist of sampling the wells at quarterly intervals, or more frequently if warranted. Samples should be taken during the following periods: in late May after pumping for the summer irrigation begins; in late August during the end of the summer pumping season; near the end of December; and during the early part of March. The quarterly sampling program should begin prior to the plant construction, and should continue until water quality trends indicate that a less frequent sampling program would be adequate.

2.3.2.2 Sampling Procedures

The water quality data to be obtained from the monitoring program would include specific conductance, temperature, and constituent concentrations of groundwater obtained from all monitor wells. The complete selection of constituents to be determined by chemical analysis is dependent upon the potential elements that might be in the plant effluent. It should be borne in mind that boron, bromide, iodide, lithium, and strontium have special importance in relation to water quality as related to crystalline rock. Additional determinations are important from the viewpoint of geochemical interpretation and possible toxicity of selected trace metals. Several constituents may be added or deleted from future analyses with additional experience.

TABLE 2 - 5 PROPOSED WATER QUALITY MONITOR WELLS[1/]
(SEE TABLES 2 - 1 AND 2 - 3)

T. 1 N.; R. 6 W.	T. 1 S.; R. 6 W.
Section	Section
16ddd	9abc
20dab	13cab
23dcd	14dbb
27cbc	17abb
27ddc	21cbb$_2$
34abb	26aba
34acc	

1/ Well designation conforms to the well location system used in the State of Arizona (Figure 2 - 9).

2.3.2.3 Annual Report Procedures

An annual report should be prepared on the water quality monitor program and should include the following: 1) A table containing all recent and historical data; 2) an annual water quality map showing contours of equal specific conductance; 3) a trilinear diagram of the constituent percentage concentrations of samples from selected monitor wells; and 4) a water quality change map. Suggestions concerning modification of the water quality monitor program should be included in the annual report.

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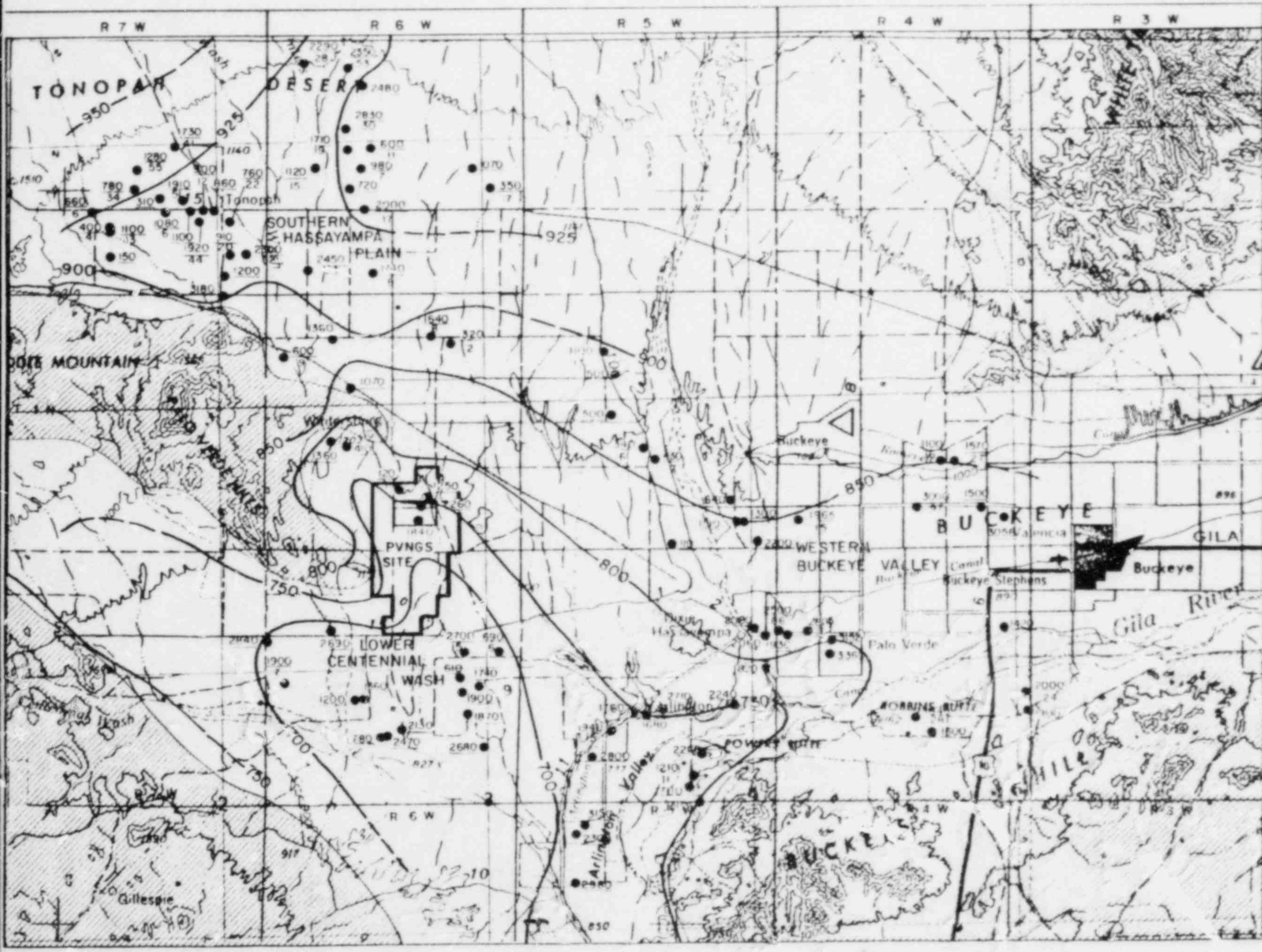

EXPLANATION

• PUMP YIELD / SPECIFIC CAPACITY — WATER WELL

——— 850 — — — PIEZOMETRIC CONTOUR REGIONAL AQUIFER (1969—1973 DATA) IN FEET, MSL DATUM, DASHED WHERE INDEFINITE

PRODUCTIVITY ZONES (GALLONS PER MINUTE)

500 TO 2500

LESS THAN 500

PALO VERDE PLANT WELL FIELD

PRIMARY LOCATION

HARSHBARGER AND ASSOCIATES
TUCSON, ARIZONA 1974

NORTH

0 2 4
MILES

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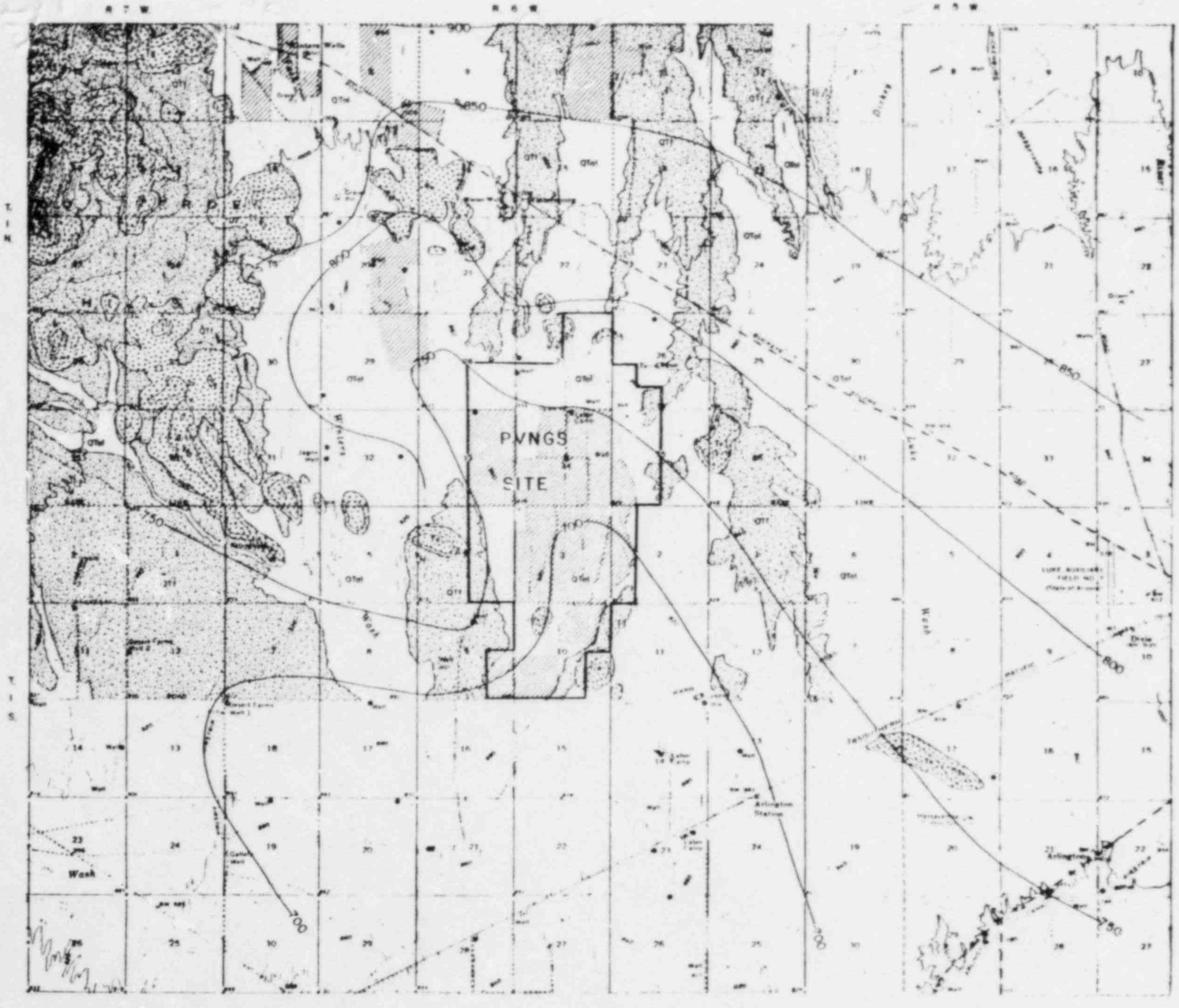
GROUNDWATER PRODUCTIVITY ZONES AND PROPOSED WELL FIELD

Figure 2-2



EXPLANATION

QTal — ALLUVIUM: BROWN SILT AND CLAY, GRAVEL AND SAND LENSES (UNDIFFERENTIATED)

QTf — POORLY CEMENTED DEPOSITS OF GRAYISH BROWN SILT, SAND, AND GRAVEL

Tv — VOLCANICS: GRAY ANDESITE AND BROWN BASALT (UNDIFFERENTIATED)

GEOLOGICAL CONTACT

• WATER WELL OR BOREHOLE

——850—— PIEZOMETRIC CONTOUR REGIONAL AQUIFER 1969-1973 DATA IN FEET, MSL DATUM

IRRIGATED CROPLAND IN 1973

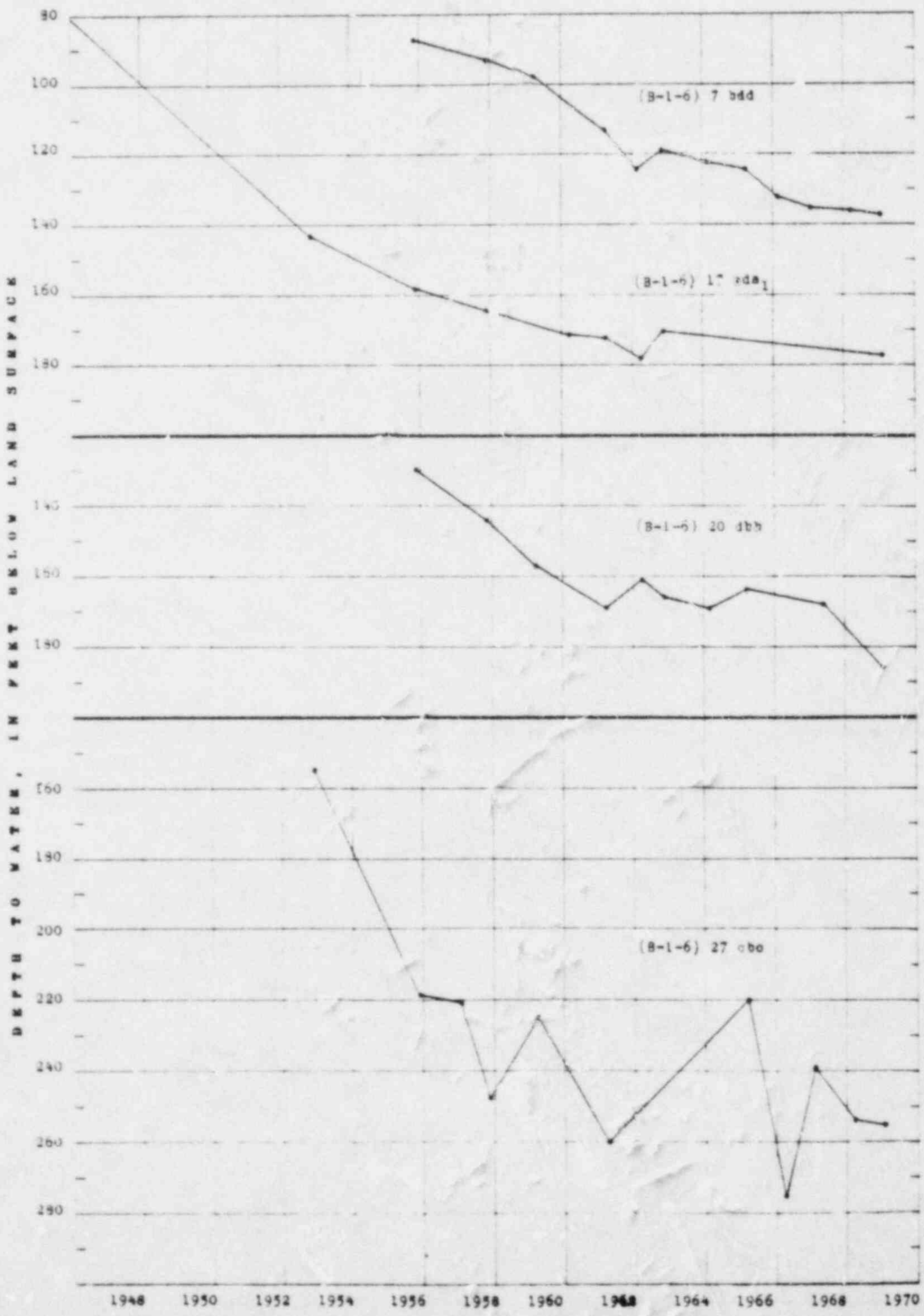
GEOLOGY MODIFIED FROM: FURGO FIELD MAP, 1973

N

0 1 2 MILES

HARSHBARGER AND ASSOCIATES
TUCSON, ARIZONA 1974

HYDROGEOLOGICAL MAP OF THE PALO VERDE SITE AREA
FIGURE 2-3



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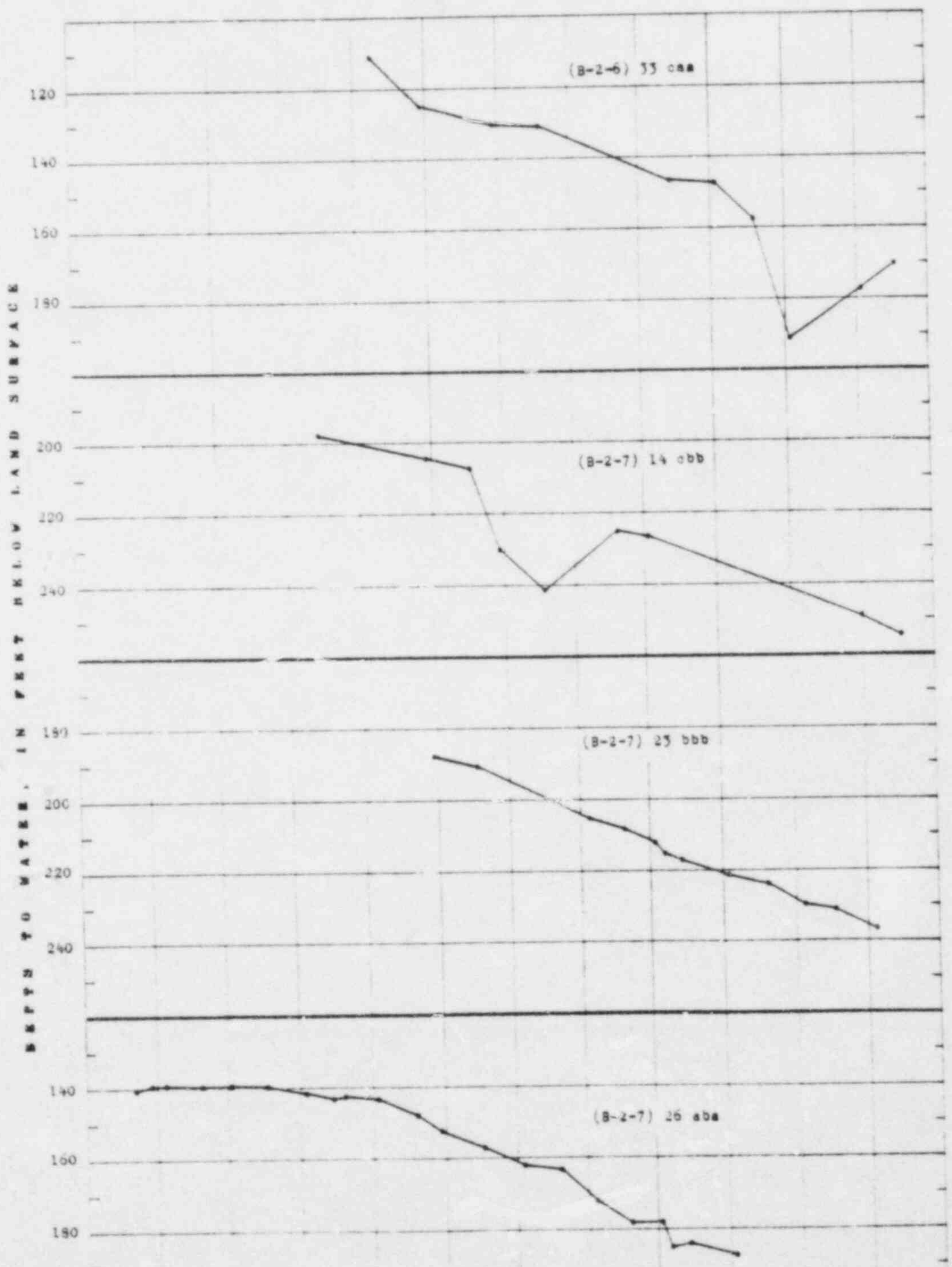
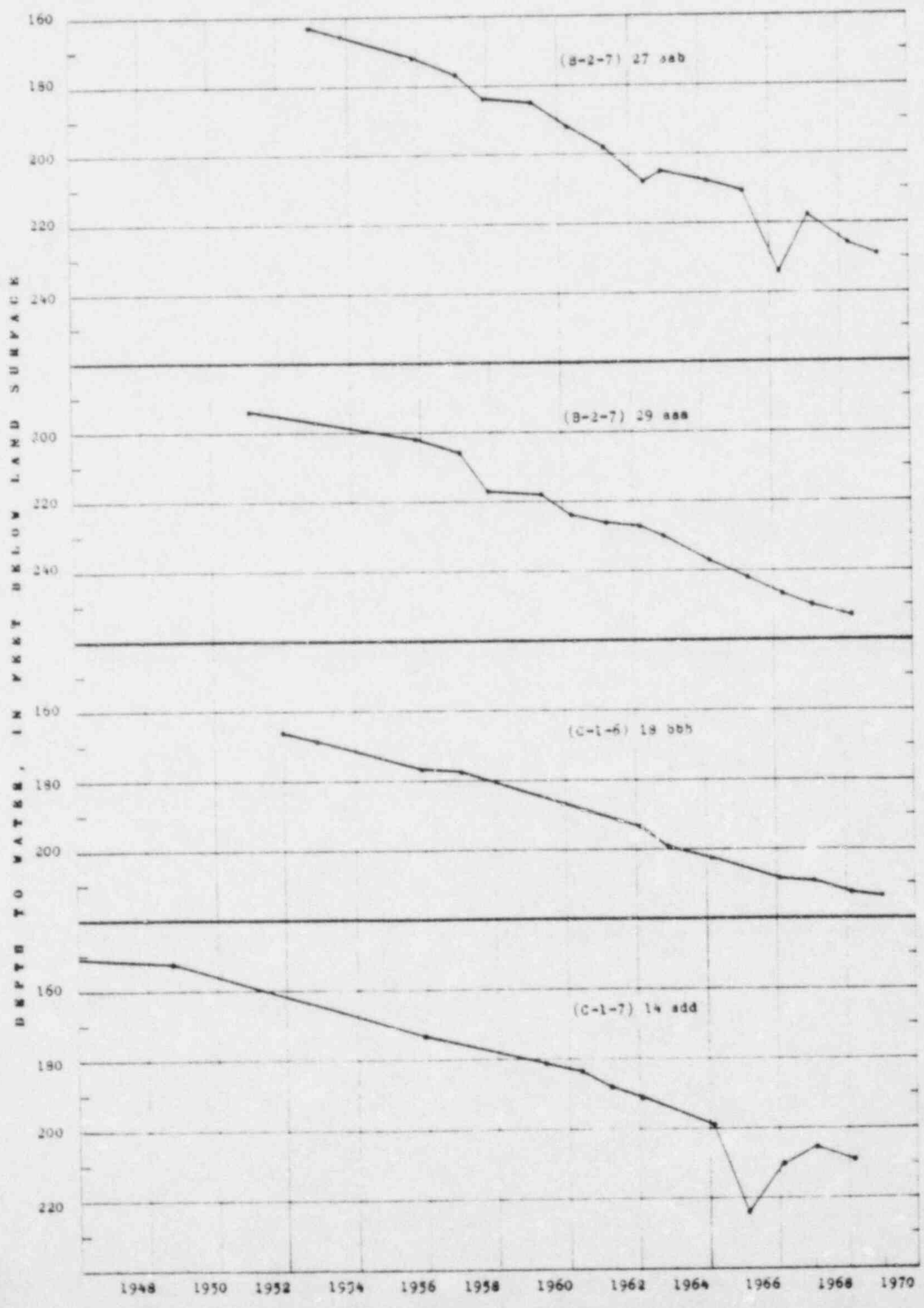
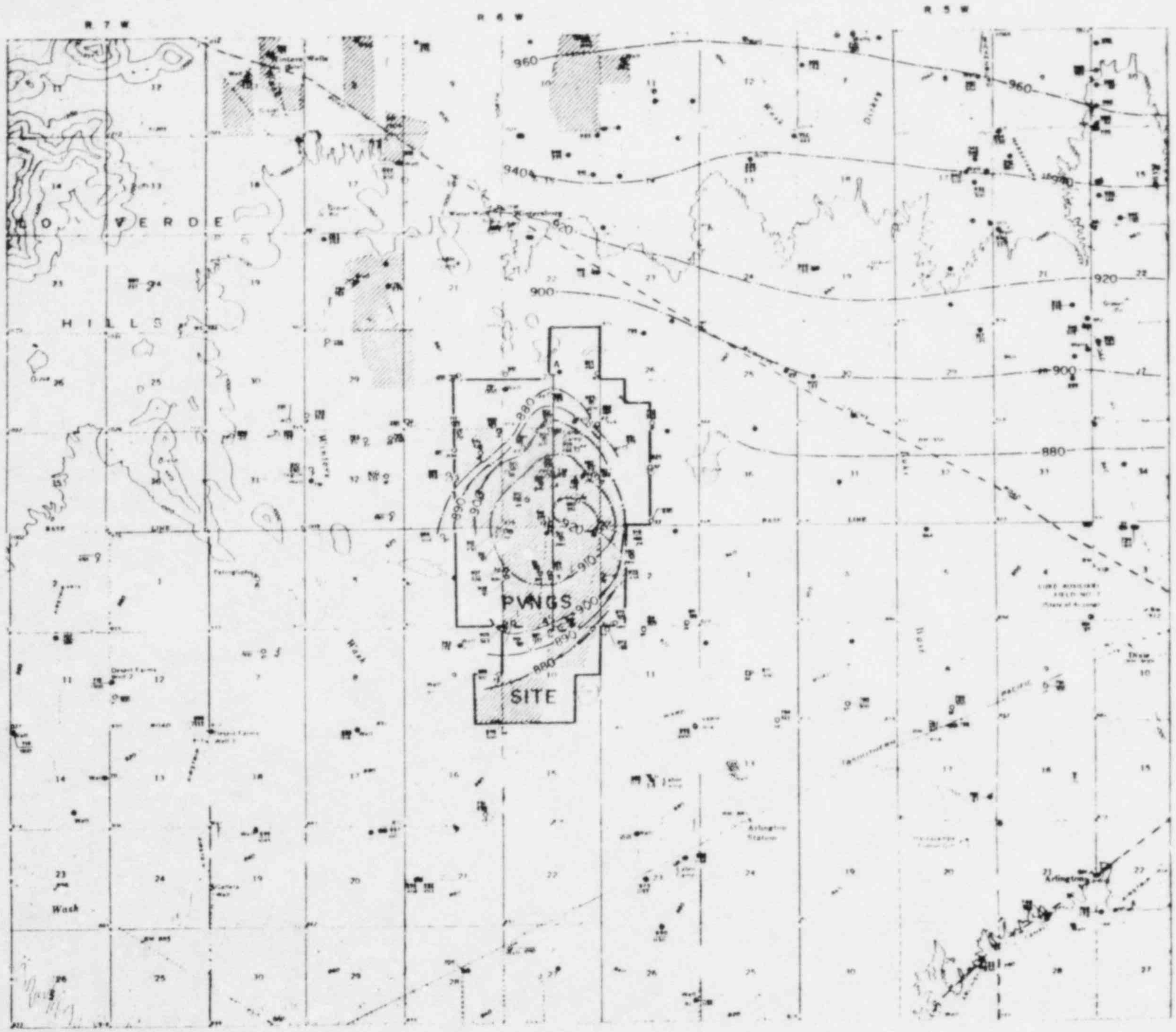
2-5


DEPTH TO WATER, IN FEET BELOW LAND SURFACE
(B-2-6) 33 caa
120
140
160
180
(B-2-7) 14 cbb
200
220
240
(B-2-7) 25 bbb
180
200
220
240
(B-2-7) 26 aba
140
160
180
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970



Nuclear Power Project
Nuclear Generating Station
Units 1, 2 & 3

2-5



EXPLANATION

WATER WELL
940 WATER LEVEL
303 WELL DEPTH

PALO VERDE BOREHOLE
783 WATER LEVEL
268 BOREHOLE DEPTH
51 BOREHOLE NUMBER

900 WATER LEVEL CONTOUR
PERCHED AQUIFER (1969-1974 DATA)
IN FEET, MSL DATUM

IRRIGATED CROPLAND IN 1973

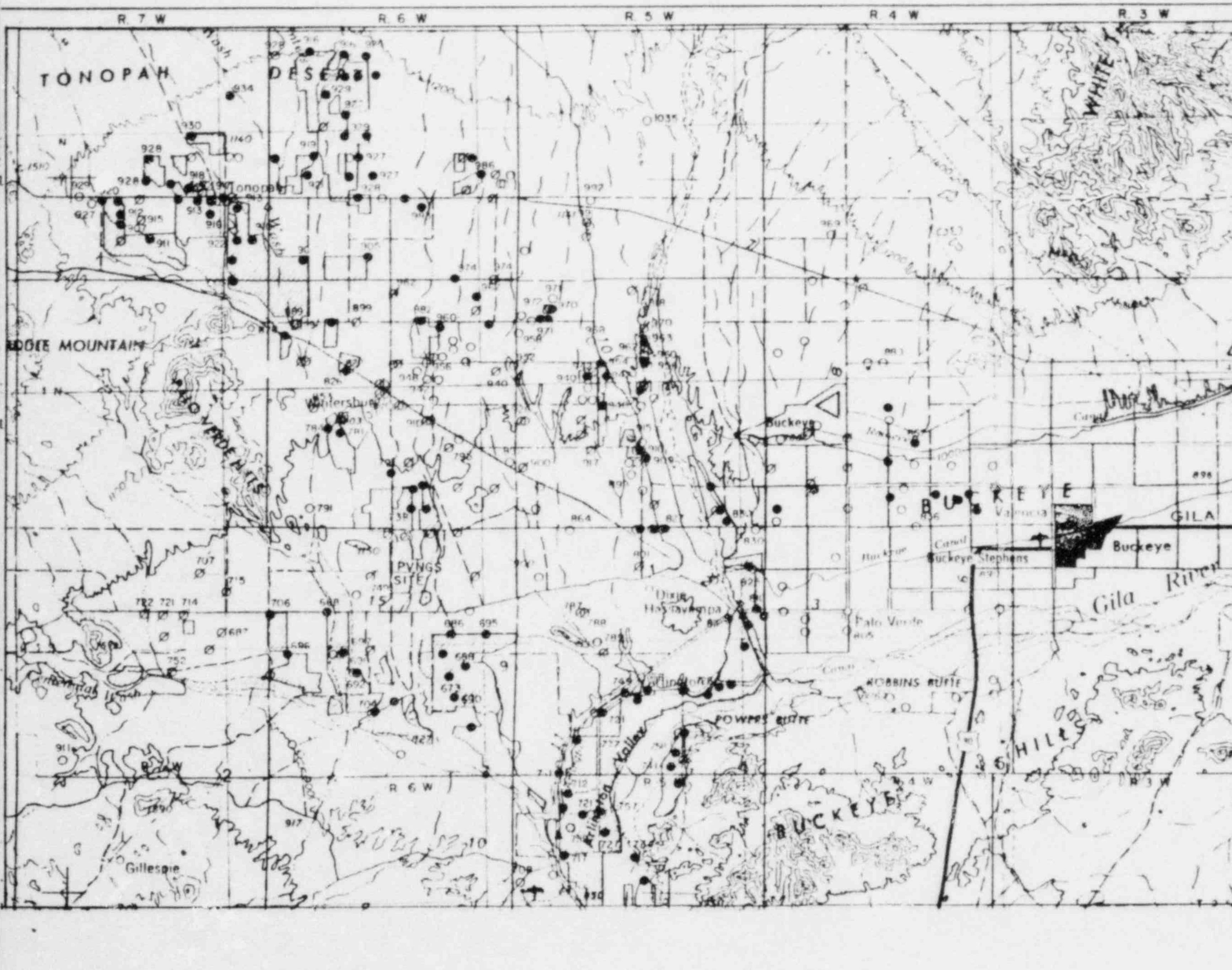
A — A LINE OF SECTION

N

0 — 2 MILES
0 — 8000 FEET

HARSHBARGER AND ASSOCIATES
TUCSON, ARIZONA 1974

HYDROLOGICAL FEATURES IN
THE PALO VERDE SITE AREA
FIGURE 2-6



EXPLANATION

WELLS

● IRRIGATION
NUMBER INDICATES WATER LEVEL IN FEET ABOVE MSL (1969-

○ STOCK, DOMESTIC

ø UNUSED, DESTROYED

▲ STREAM GAGING STATION

△ CREST-STAGE GAGING STAT

IRRIGATED CROPLAND IN 1968

HARSHBARGER AND ASSOCIATES
TUCSON, ARIZONA 1974

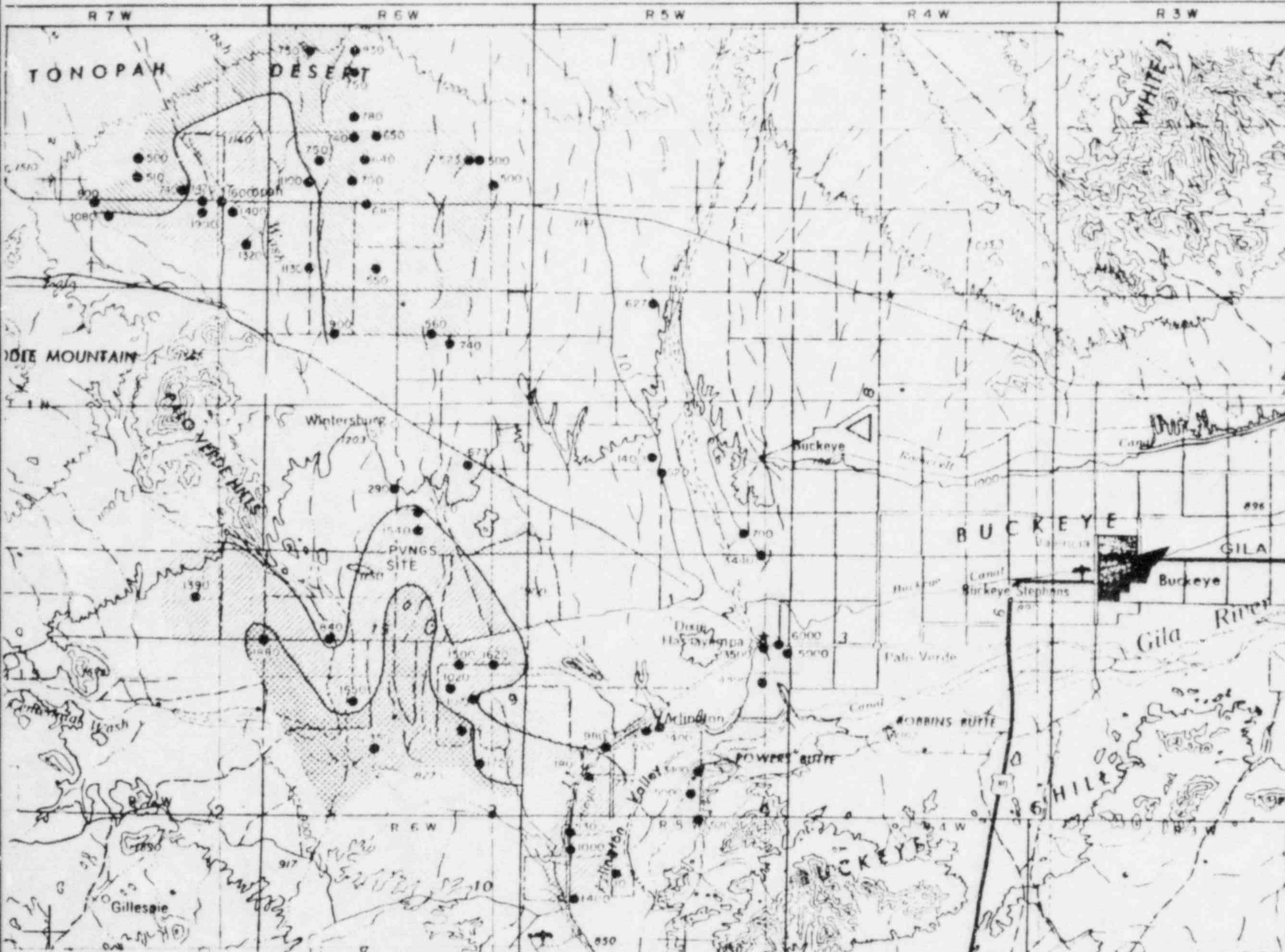
NORTH

0 2 4
MILES

Arizona Nuclear Power Proje
Palo Verde Nuclear Generating St
Units 1, 2 & 3

HYDROLOGICAL FEATURES IN LOWER
HASSAYAMPA/CENTENNIAL AREA

Figure 2-8



EXPLANATION

● 740 WATER WELL SPECIFIC CONDUCTANCE IN MICROMHOS

500–1000

1000–1750

1750–3000

3000–6000

HARSHBARGER AND ASSOCIATES
TUCSON, ARIZONA 1974

NORTH

0 2 4
MILES

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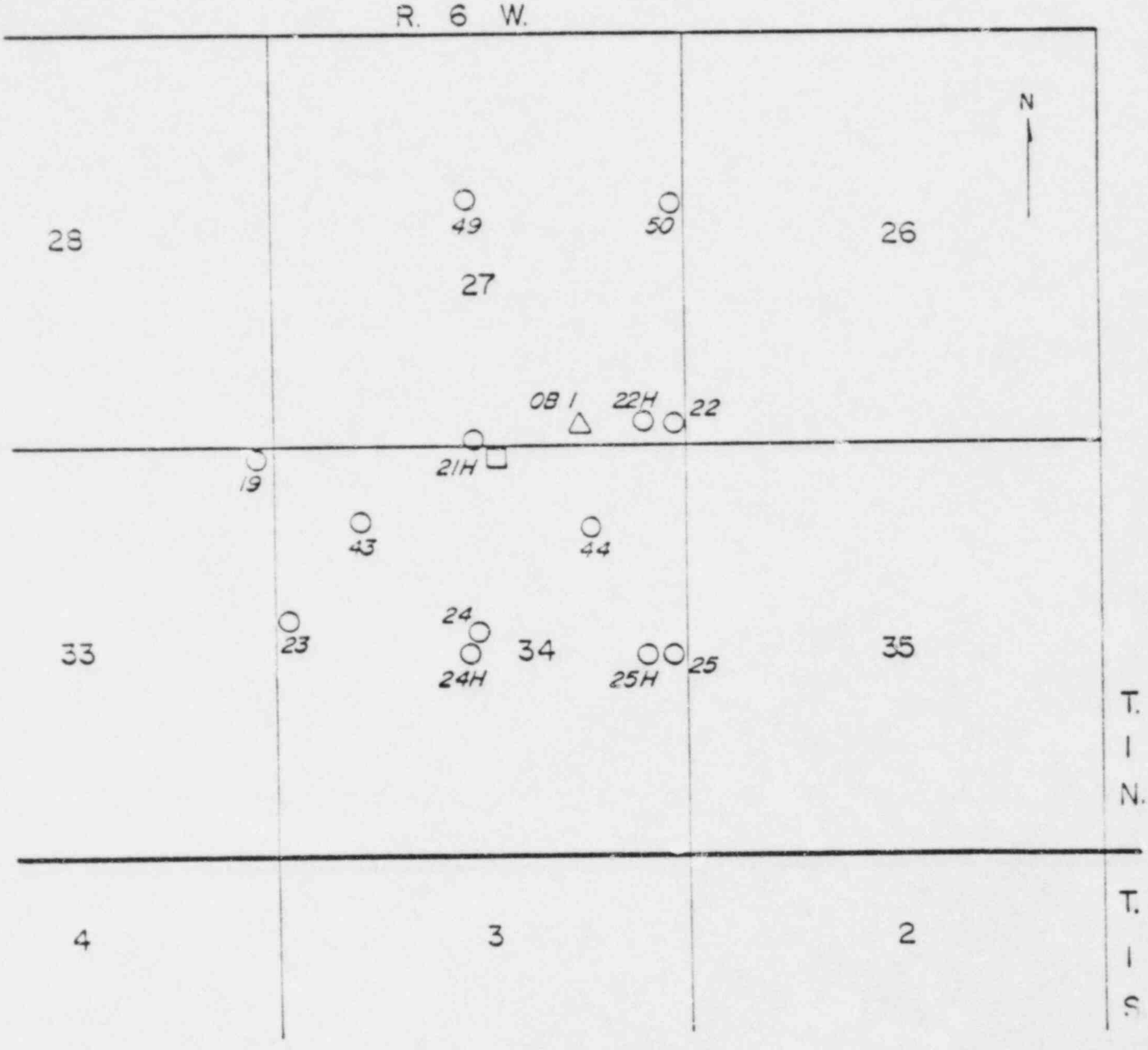
DISTRIBUTION OF DISSOLVED SOLIDS IN GROUNDWATER

Figure 2-10

APPENDIX I

PALO VERDE SITE PUMP TEST

ILLUSTRATIONS



PUMPING WELL
□

OBSERVATION WELLS
○ PALO VERDE BOREHOLE
24 Borehole and observation well number

△ EXISTING IRRIGATION WELL
OB1 Observation well number

FIGURE I-A WELL LOCATION MAP FOR PALO VERDE SITE PUMP TEST

Discharge

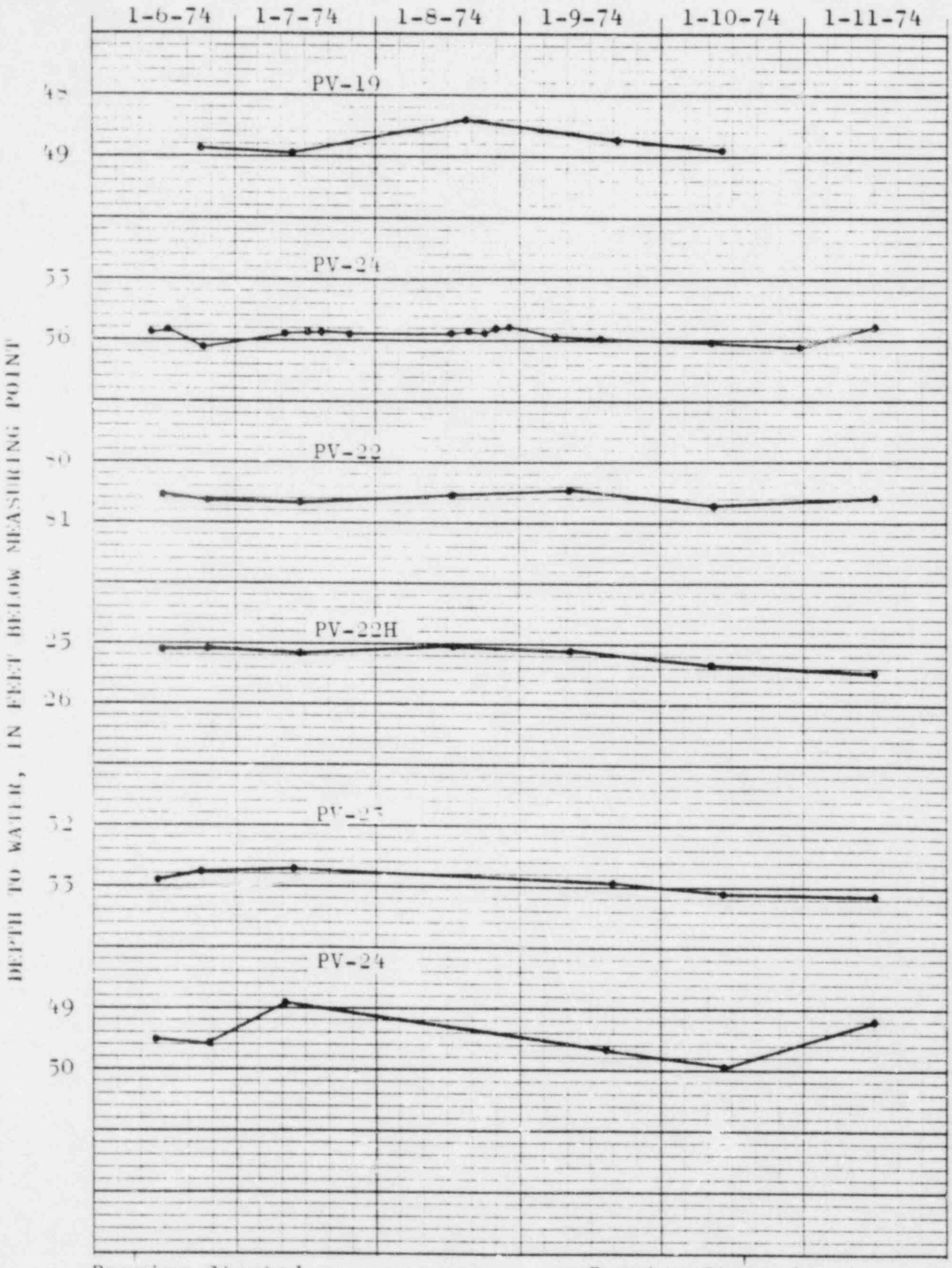
The discharge rate during the pump test was monitored by a 10-inch orifice plate mounted on the 12-inch discharge pipe. Head measurements were made from a manometer tube located approximately 2 feet from the orifice plate. The average discharge for the 4 day pump test was 2,360 gpm (gallons per minute).

Water Level Measurements

Water levels in the observation wells were measured periodically during the pump test with an electric sounder. Hydrographs were made from the water level measurements and are shown in Figure I-B. No water level decline was detected in any of the observation wells except for observation well OB 1 ((B-1-6) 27ddc) (Figure I-C). The water level in this well was monitored for 6 days after pumping stopped in order to procure recovery data.

ANALYSIS OF PUMP TEST DATA

A semi-log plot of depth to water versus time since pumping started was made from the water level data from observation well OB 1 (Figure I-D). The Jacob[a] modification o. the Theis[b] non-equilibrium equation was employed as the mathematical model to determine aquifer coefficients of transmissivity and storage. The calculations for these parameters are as follows:



Pumping Started
6:55 A. M. January 6, 1974

Pumping Stopped
2:00 P. M. January 10, 1974

FIGURE I-B HYDROGRAPHS OF OBSERVATION WELLS FOR PALO VERDE PUMP TEST

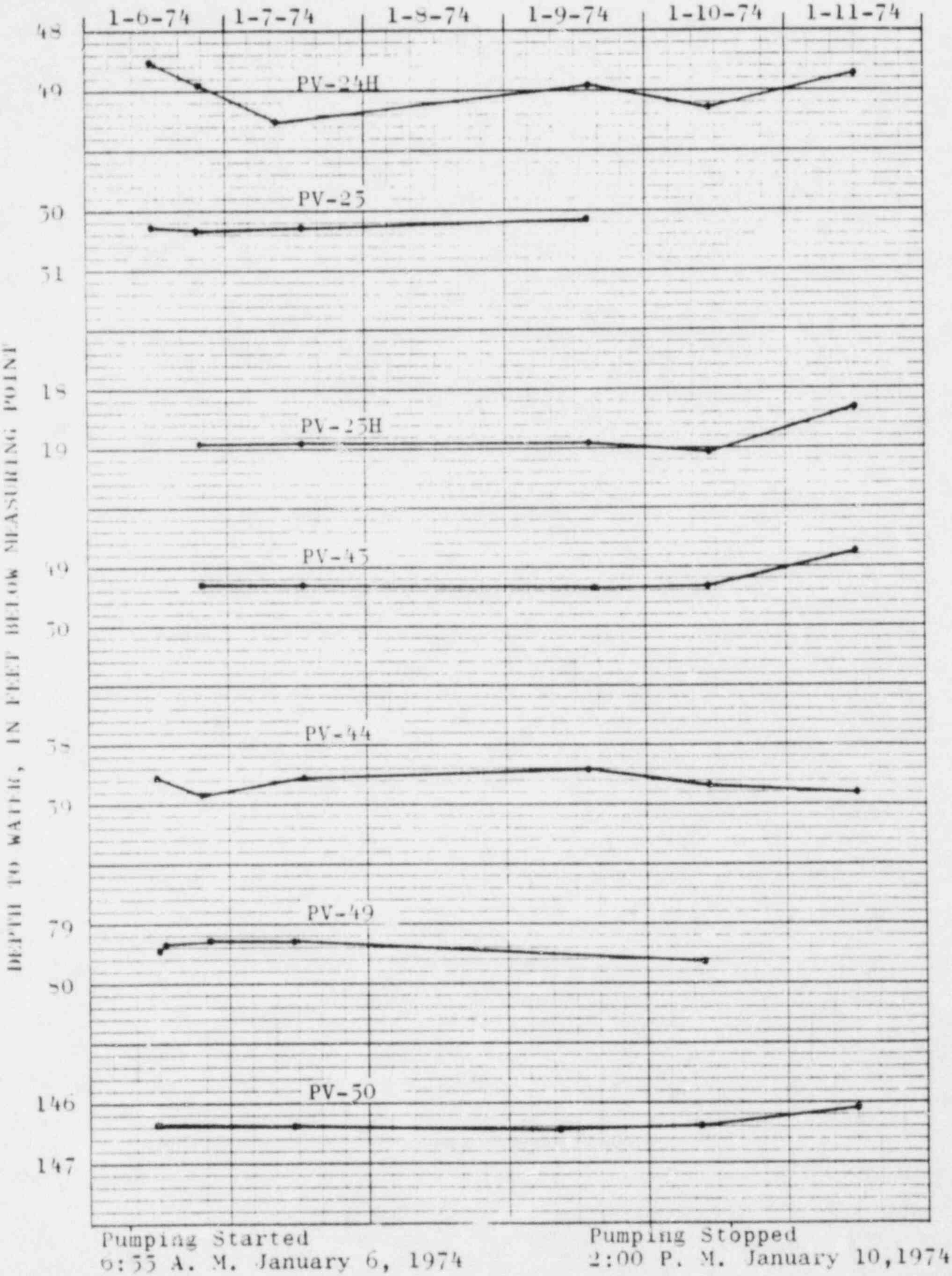


FIGURE I-B HYDROGRAPHS OF OBSERVATION WELLS FOR PALO VERDE PUMP TEST (continued)

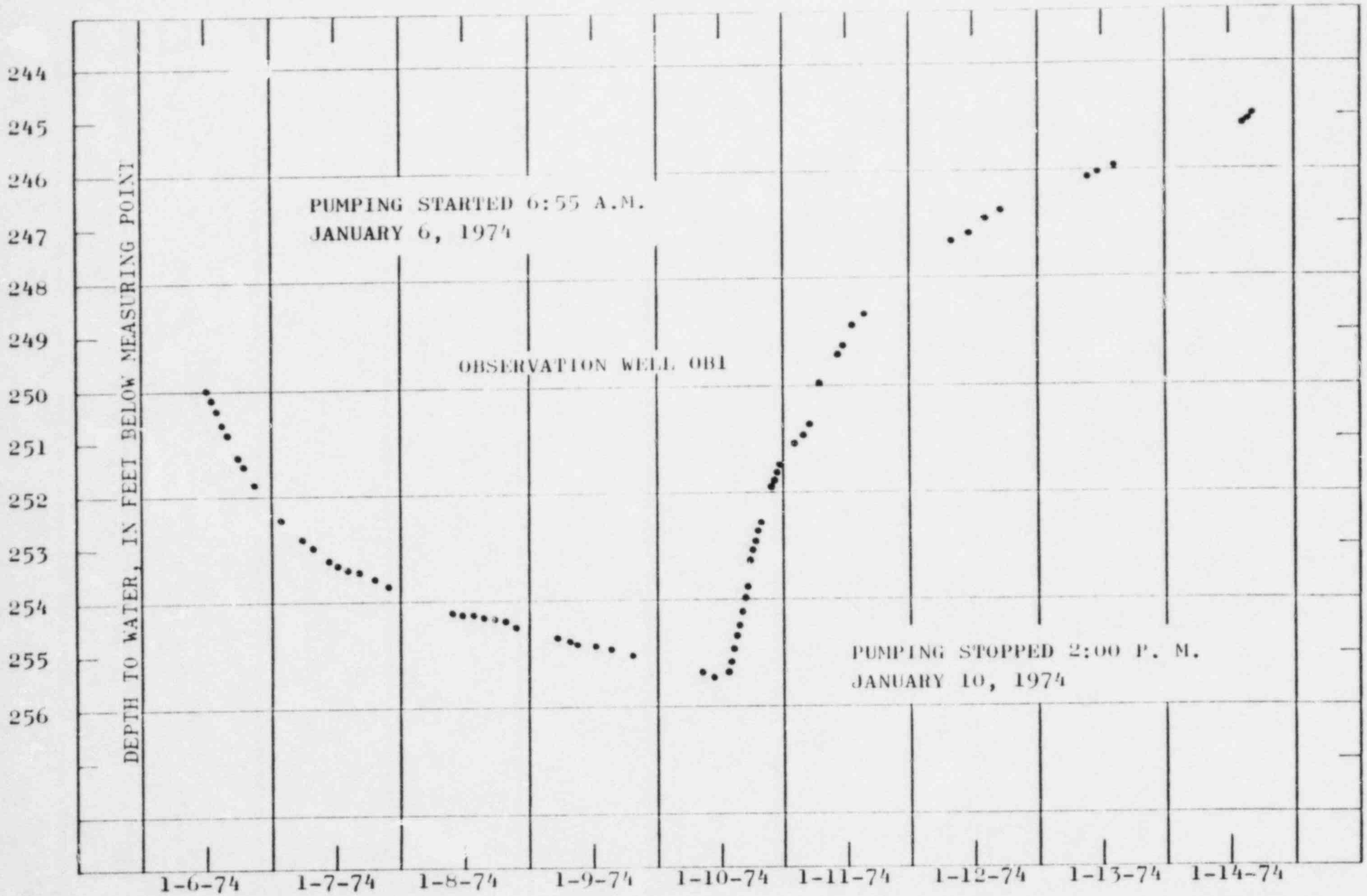


FIGURE I-C HYDROGRAPH OF IRRIGATION WELL (B-1-6) 27ddc FOR PALO VERDE SITE PUMP TEST

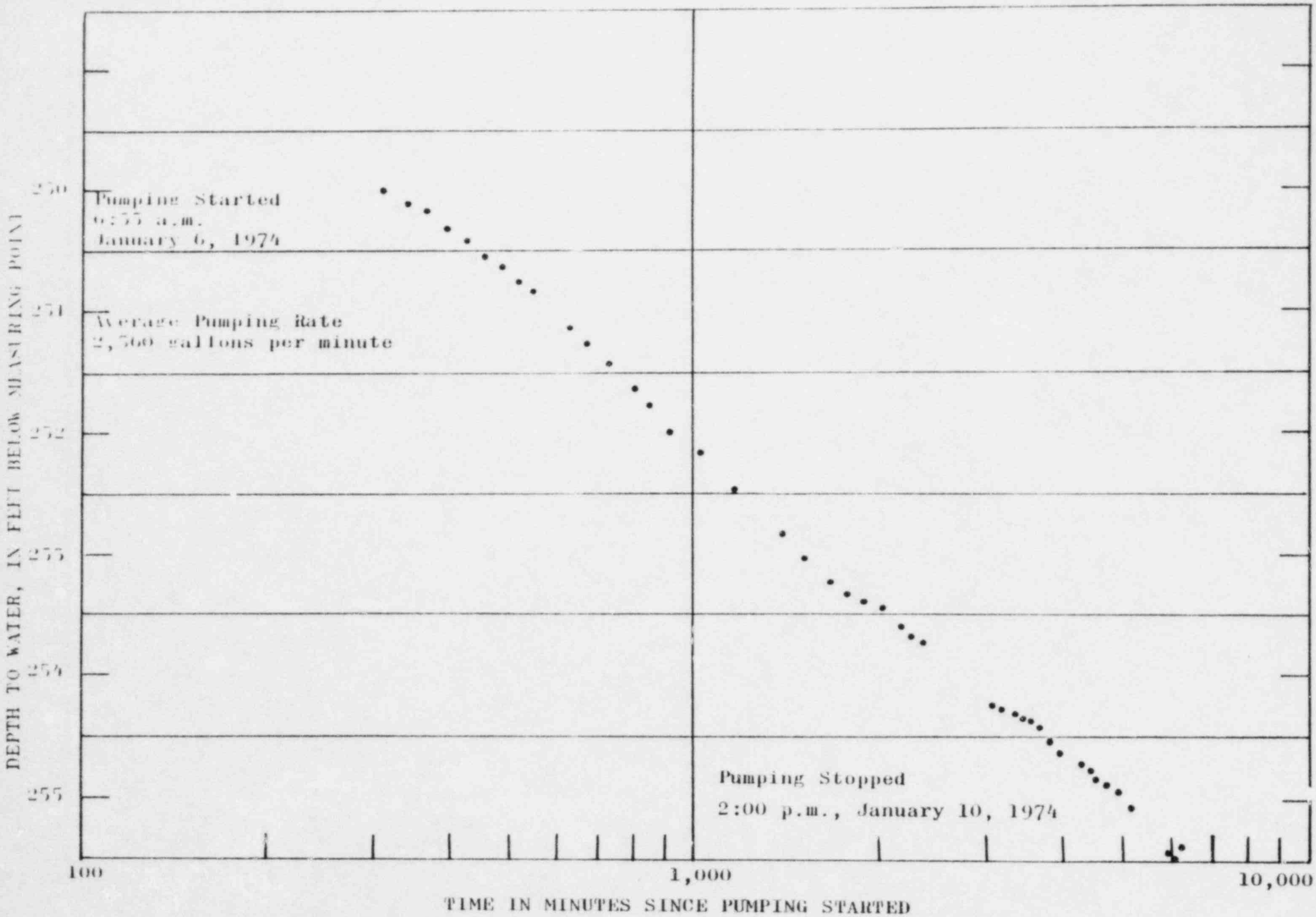


FIGURE I-D TIME-DRAWDOWN GRAPH, OBSERVATION WELL OB 1, PALO VERDE SITE PUMP TEST

$$T = \frac{264\ Q}{\Delta s}$$

(T = 140,000 gpd/ft)

Where: T - Transmissivity, gpd/ft

Q - Discharge, gpm (2360 gpm)

Δs - Slope of straight line determined over one log cycle, ft (4.4 ft)

$$S = \frac{0.3Tt_o}{r^2}$$

(S = 0.007)

Where: S - Storage Coefficient (unitless)

T - Transmissivity, gpd/ft

t_o - Intercept of straight line with zero drawdown, days (.24 days)

r - Distance from pumped well to observation well, ft (1000 ft)

A plot of the calculated recovery data versus time after pumping stopped was treated by the Jacob model and yielded a transmissivity value of 77,000 gpd/ft and storage coefficient of 0.003. A plot of the residual drawdown data versus the ratio of time since pumping started with time since pumping stopped (Figure I-E) was treated by the Jacob model and yielded a transmissivity of 80,000 gpd/ft. These recovery data analyses indicate a transmissivity and storage coefficient values somewhat less than those values obtained from the time-drawdown data analysis. Based on these data analyses, an overall transmissivity is estimated to be about 100,000 gpd/ft and the storage coefficient of 0.005.

[a] Cooper, H.S., Jr., and C.E. Jacob, 1946, A generalized graphical method for evaluating formation constants and summarizing well-field history: Trans. Am. Geophys. Union, V. 27, n. 4.

[b] Theis, C.V., 1935, The relation between the lowering of piezometric surface and the rate and duration of discharge of a well using groundwater storage: Trans. Am. Geophys. Union, 16th Ann. Meeting, pt. 2, p. 519-524.

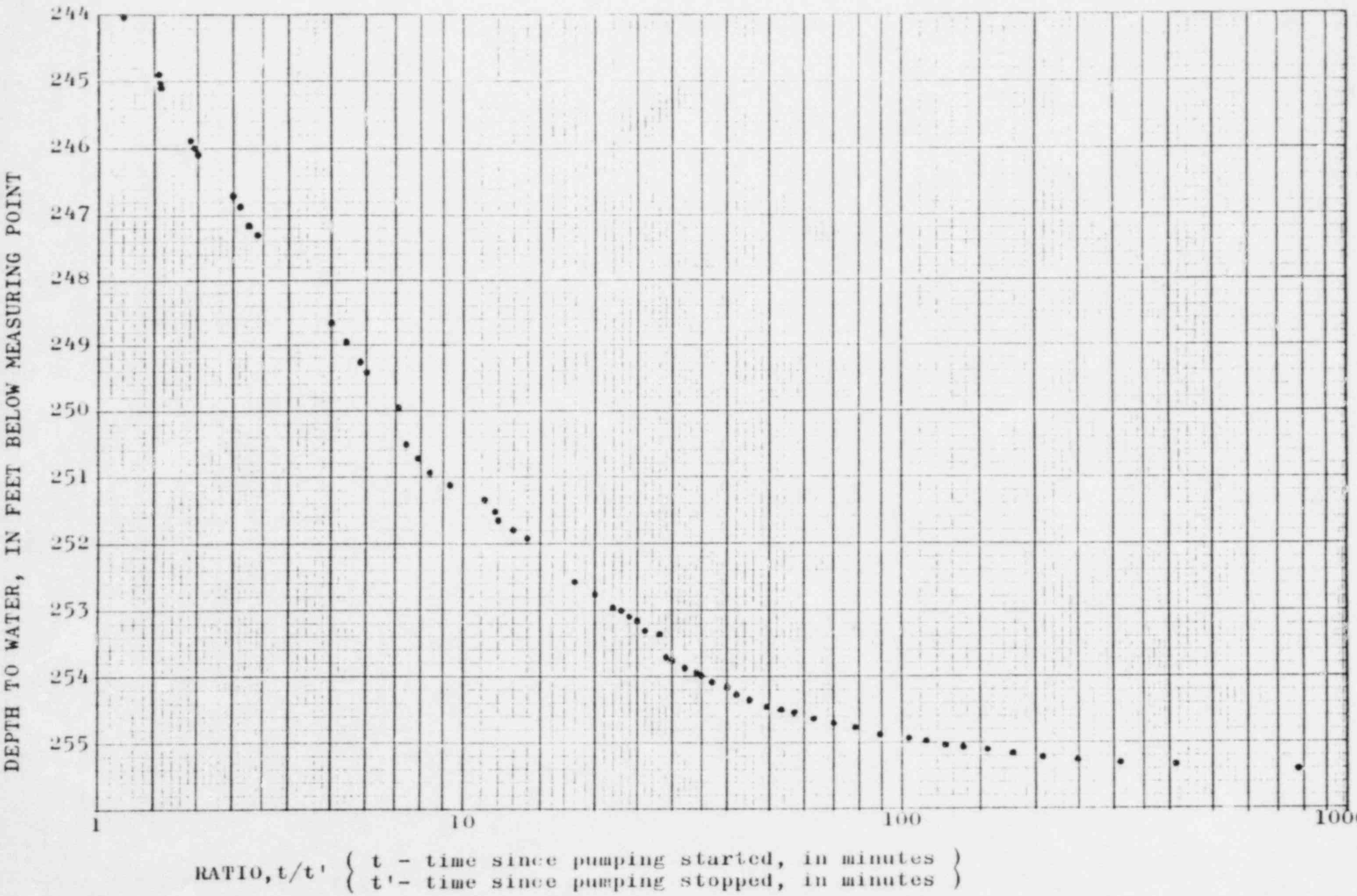


FIGURE I-E RESIDUAL-DRAWDOWN GRAPH, OBSERVATION WELL OB 1, PALO VERDE SITE PUMP TEST

APPENDIX II

PALO VERDE SITE PUMP TEST

ILLUSTRATION

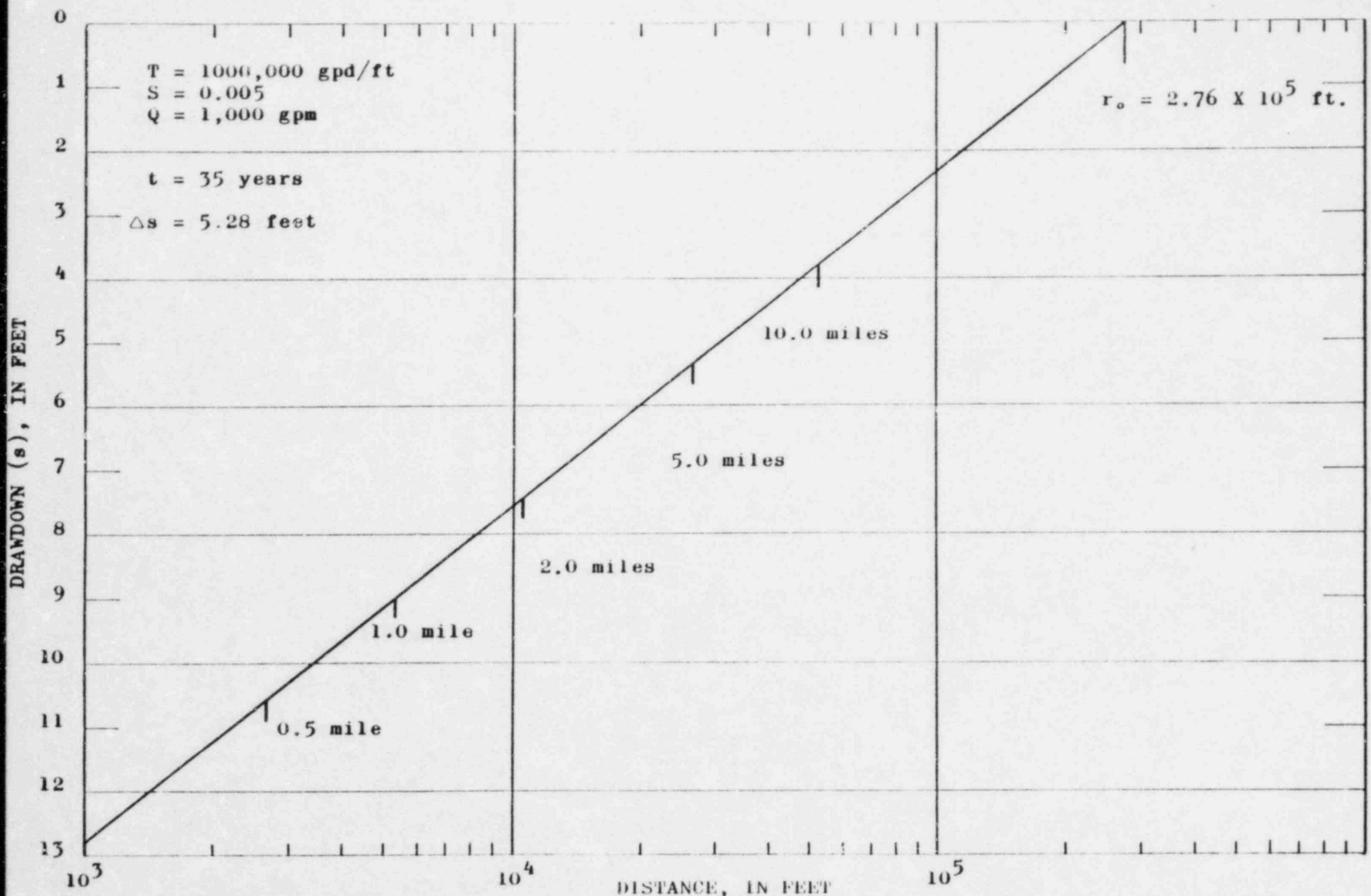


FIGURE II-A HYPOTHETICAL DISTANCE-DRAWDOWN GRAPH

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Prepared for the U.S. Atomic Energy Commission, Division of Reactor Development and Technology Under Contract No. AT(11-1)-2221

February 1973

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March 4–6, 1974

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Coordinators
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Jerry Pell

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