RESULTS OF THE FINAL GROUNDWATER QUALITY MONITORING PHASE NOVEMBER 1981-SEPTEMBER 1983

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Maricopa Association of Governments
208 Water Quality Management Program
Phoenix, Arizona

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TABLE OF CONTENTS

	Page
LIST OF TABLES	ii
LIST OF ILLUSTRATIONS	iii
INTRODUCTION	I-1
Past Phases	I-2
Final Phase	I-3
Cascading Water	I-3
Selection of Target Area for Monitor Wells	I-4
Sampling and Analysis	I-5
Water Quality Criteria	I-7
Drinking Water	I-7
Irrigation	I-8
STUDIES OF CASCADING WATER	II-1
Water-Level Measurements	II-1
Water Sampling	II-5
Inorganic Chemical Composition	II-5
Stable Isotopes	II-13
Pesticides	II-14
GILBERT MONITOR WELLS	III-1
Soils Conditions	III-4
Monitor Well Installation	III-4
Locations	III-4
Construction Details	III-6
Development and Sampling	III-9
Constituents Analyzed	III-9
Water-Level Trends	III-10
Results of Water Sampling	III-10
Inorganic Chemical Constituents	III-10
Pesticides	III-14
Stable Isotopes	III-17
SUMMARY	IV-1
References	IV-3
APPENDIX A	
APPENDIX B	

LIST OF TABLES

No.	Title	Page
1	Chemical Composition of Canal Water and Cascading Water from Canal Seepage	II-9
2	Chemical Composition of Cascading Water from Irrigation Return Flow	II-11
3	Chemical Composition of Cascading Water of the Intermediate Type	II-12
4	List of Pesticides Analyzed	II-15
5	Construction Data for Gilbert Monitor Wells	III-8
6	Chemical Analyses for Water from Gilbert Monitor Wells, August 1983	III-12
A-1	Water Levels in Cascading Wells Measured by MAG During Winter 1981-82	A-1
A-2	Water Levels in Other Cascading Wells Measured During 1980-83	A-2
B-1	Chemical Analyses of Water from Monitor Well G-1	B-1
B-2	Chemical Analyses of Water from Monitor Well G-2	B-2
B-3	Chemical Analyses of Water from Monitor Well G-3	B-3
B-4	Chemical Analyses of Water from Monitor Well G-4	B-4
B-5	Chemical Analyses of Water from Monitor Well G-5	B-5
B-6	Chemical Analyses of Water from Monitor Well G-6	B-6

LIST OF ILLUSTRATIONS

Figure No.	Title	Page
1	Location of Cascading Wells Measured in the East Basin	II-2
2	Location of Cascading Wells Measured in the West Basin	II-3
3	Location of Sampled Cascading Wells in the East Basin	II-6
4	Location of Sampled Cascading Wells in the West Basin	II-7
5	Location of Monitor Wells near Gilbert	III-5
6	Depth to Water in Shallow Monitor Wells	III-11
7	Total Dissolved Solids Contents in Water from Shallow Monitor Wells	III-15
8	Nitrate Content in Water from Shallow Monitor Wells	III-16

RESULTS OF THE FINAL GROUNDWATER QUALITY MONITORING PHASE NOVEMBER 1981 - SEPTEMBER 1983

INTRODUCTION

This report describes the results of the fourth and final phase of the Maricopa Association of Governments (MAG) 208 groundwater quality program. The program was conducted in accordance with Section 208 of the Water Pollution Control Act Amendments of 1972 (Public Law 92-500). The U.S. Environmental Protection Agency (EPA) designated MAG as the agency responsible for 208 planning in Maricopa County. Since 1977, major consideration has been given in the program to the impact of various potential sources of pollution on groundwater quality. The Salt River Valley has been emphasized primarily because a substantial portion of the total pumpage for public supply in Arizona is centered in the Phoenix urban area.

The purpose of the final phase of the program was to evaluate the effect of irrigation practices on the quality of the underlying groundwater. In general, the amount of water applied to crops exceeds the amount that is consumed by the crops. This extra water usually percolates downward and eventually reaches the underlying groundwater. In this report, such water is termed "deep percolation of irrigation return flow." Deep percolation of irrigation return flow is a major source of recharge to groundwater in the Salt River Valley. It is well recognized that irrigation practices can result in increases in salinity of groundwater. In addition, fertilizers and pesticides applied to farmland can affect quality of the the groundwater.

Past Phases

The first phase of the program was completed in December 1978, and the results were presented in the report "Groundwater Quality in the Major Basins of Maricopa County" (Schmidt, 1978). This phase dealt primarily with the distribution of inorganic chemical constituents in groundwater in the major basins of Maricopa County. Historical records were collected, tabulated, and organized into a usable format. The geographic and vertical distribution of selected chemical constituents was evaluated. Long-term time trends for contents of particular constituents were also evaluated. This information was used as an aid to differentiate between the effect of natural factors and those due to man's activities.

The second phase focused on identifying the major potential sources of groundwater pollution, and was completed in June 1979. Results were presented in the MAG 208 report "Nonpoint Sources of Groundwater Pollution" (Schmidt, 1979). The general impact of some major sources, such as deep percolation of irrigation return flow, was obvious from the existing data. However, because there was virtually no specific monitoring in effect at that time, the specific impacts of most sources on groundwater quality could not be determined. Therefore, at the end of the second phase, an extensive monitoring program was recommended.

The third phase was completed in January 1981 and involved specific monitoring activities in the Salt River Valley. The results of this phase were described in the MAG 208 report "Results of the Initial Groundwater Quality Monitoring Phase" (Schmidt, 1981). Urban storm runoff, landfills, altered groundwater flow directions, perched groundwater, and numerous sources along the

Salt River were monitored during this phase.

Final Phase

The fourth and final phase of this program, which is described in this report, commenced in November 1981 and was completed in September 1983. There were two primary components of this phase. One was an evaluation of cascading water from existing wells. The second involved the construction and sampling of six shallow monitor wells installed in irrigated areas.

Cascading Water

Cascading water occurs in some wells where there is perched groundwater. A "perched zone" comprises saturated strata above the main aquifer. Perched water usually occurs above a layer of low permeability materials, such as clay. If a well penetrates a perched zone and has perforations or other openings opposite the perched zone and the main aquifer, water from the perched zone can enter the well and fall down the inside of the casing to the main aquifer. This water can often be heard falling down the well, and is thus termed "cascading water." Cascading wells thus indicate the location of perched zones. Previous studies have indicated that cascading water is present in wells in large parts of the Salt River Valley. Known areas of perched water as of 1981 were shown in Figure 9 of the report on the third phase (Schmidt, 1981). Sampling of water from perched zones can possibly be used to determine the quality of deep percolation of irrigation return flow before this water mixes with other water in the main aquifer. In addition, if monitor wells can be drilled into perched zones, they can be economical due to the relatively shallow depth

required. Thus the initial step in the final phase was to further evaluate the existence of perched water in the valley. This was done with a view toward locating areas where monitoring could be done. Parts of city planning areas that were primarily rural, but subject to urbanization, were given a high priority in this evaluation.

In the East Basin of the Salt River Valley, major consideration was given to the area south of Baseline Road, that lies within the City of Mesa and Town of Gilbert planning areas. A regional perched groundwater zone was known to underlie most of this area.

In the West Basin of the Salt River Valley, major consideration was given to two areas. The first was irrigated lands north of Buckeye Road, west of the Black Canyon Highway, and east of the Agua Fria River, primarily in the City of Phoenix planning area. Little information on cascading wells or perched groundwater was available for this area. The second area was the portion of the City of Glendale planning area west of the Agua Fria River, near the Luke Air Force Base. A regional perched zone was known to be present in this area.

Selection of Target Area for Monitor Wells

A field inventory conducted during winter 1981-82 indicated that few cascading wells were present in the part of the City of Mesa planning area south of Baseline Road. In addition, few cascading wells were present in the southern part of the Gilbert planning area, south of Ray Road. However, there were numerous cascading wells in the remainder of the Gilbert planning area. This part of the planning area also has the highest priority for

urban development. Thus, the north part of the Gilbert planning area became a prime candidate for installation of monitor wells.

Almost no cascading wells were found in the West Basin east of the Agua Fria River, except close to the river. Numerous cascading wells were present in the portion of the Glendale planning area west of the Agua Fria River. However, depth to the perched groundwater was often found to be excessive, and thus the area was not considered suitable for installation of monitor wells.

Based on these and other considerations, the portion of the Gilbert planning area north of Ray Road was selected as the target area for monitor well installation. Salinity of the groundwater has increased in this area during past decades, as documented in the first phase of this program. Nitrate contents in water from some wells also increased markedly between 1977 and 1981, and values now generally exceed the drinking water limit. These changes in groundwater quality are suggestive of the influence of irrigation return flow.

Sampling and Analysis

An important aspect of a groundwater quality monitoring program is the methodology for sample collection and preservation and laboratory analyses. Wood (1976) discussed guidelines for collection and analysis of groundwater samples for selected unstable constituents. This reference is based on the extensive experience of the U.S. Geological Survey in groundwater quality sampling over many decades. These procedures were generally followed during this program.

In general, temperature, electrical conductivity and pH were

measured in the field at the time of water sample collection. Taylor pocket thermometers were used to measure temperature. A Hach portable conductivity meter, equipped with an automatic temperature compensator, was used to measure electrical conductivity. The meter was periodically calibrated with a standard solution. A Hach portable digital pH meter, equipped with an automatic temperature compensator, was used to measure pH. This meter was calibrated before every measurement with standard solutions of pH 4 and 9. Water samples for laboratory analysis from monitor wells were collected after a sufficient period of pumping that temperature, pH, electrical conductivity, and pumping water level had stabilized. Samples of cascading water were bailed from a point just below where the water entered the well. The water sample preservation procedures were generally those of the U.S. Environmental Protection Agency (1979).

Water samples for analyses of many inorganic chemical constituents were collected in one pint untreated polyethylene containers. However, samples for trace metals were placed in a one pint polyethylene bottle previously treated with nitric acid. Samples for nitrate were placed in a one pint polyethylene bottle treated with sulfuric acid. Samples for organic carbon were placed in an amber glass bottle, previously treated with phosphoric acid. Samples for nitrate and total organic carbon were immediately cooled and shipped to the laboratory within 24 hours of collection. BC Laboratories, Inc. of Bakersfield, California analyzed the inorganic constituents and total organic carbon.

Samples for pesticides were collected in duplicate in 100 ml amber glass bottles for analyses of some volatile constituents

(i.e. DBCP). The remaining pesticides were analyzed from samples placed in duplicate untreated one liter glass bottles. The samples for pesticides were immediately cooled and air-freighted to Stoner Laboratories in Santa Clara, California for analysis. For stable isotopes, samples were collected in one-half gallon polyethylene containers, which were then shipped to Global Geochemistry Corporation in Canoga Park, California. Duplicate sampling, cation-anion balances, comparison of calculated total dissolved solids to values determined from evaporation to a residue, repetitive sampling, and rigorous scrutiny provided quality control during this program.

Water Quality Criteria

Drinking Water

The Arizona Department of Health Services (1978) issued drinking water regulations for the State of Arizona. Primary regulations concern constituents affecting the health of consumers and are applicable to all public water systems. Maximum contaminant levels for inorganic chemical constituents are as follows:

Constituent	Level (mg/l)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Fluoride (Phoenix area)	1.4
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.0
Selenium	0.01
Silver	0.05

Nitrate values in this report are shown as nitrate, for which the maximum contaminant level is 45 mg/l. Maximum contaminant levels

for organic chemicals are as follows:

Constituent	Level (mg/l)
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4-5-TP Silvex	0.01

The maximum contaminant level for nitrate is applicable to both community and non-community water systems. The levels for the other chemicals apply only to community water systems.

Irrigation

Ayers (1977) summarized water quality criteria for irrigation. These criteria are based on problems with 1) salinity, 2) permeability, 3) toxicity, and 4) other factors. Permeability problems are normally associated with irrigation water of very low salt content or a high sodium content relative to calcium and magnesium. Boron, chloride, and sodium can exert a direct toxic effect on certain sensitive crops. Following are recommended guidelines that are significant in the Salt River Valley.

Constituent	Extent of Problem		
	None	Increasing	Severe
Salinity (Electrical Conductivity in micromhos)	<750	750-3,000	>3,000
Chloride (mg/l)	<140	140-350	>350
Boron (mg/l)	<0.5	0.5-2.0	>2.0
Ammonia-N and Nitrate-N for Sensitive Crops (mg/l)	<5	5-30	>30

The guidelines are flexible and intended for use in estimating potential hazards to crop production associated with long-term use of the particular water being evaluated.

STUDIES OF CASCADING WATER

Records were obtained from the U.S. Geological Survey and U.S. Bureau of Reclamation on cascading wells inventoried in 1972. Prior to this program, no field inventory of cascading wells had been made since 1972. During November 1981 -February 1982, a field reconnaissance was undertaken for several purposes. It was desired to determine the distance of the cascading water above the water level in the main aquifer. Little information was available on the chemical quality of cascading water before this field program. Thus whenever possible, water samples were collected from cascading wells.

Water Level Measurements

As part of this program, depth to the top of cascading water was measured in seventeen wells in the East Basin (Figure 1) during November 1981-January 1982. During February-March 1982, depth to the top of cascading water was measured in seven wells in the West Basin (Figure 2). Whenever possible, depth of the water level in the main aquifer was also measured in the same wells. These measurements are tabulated in Appendix A. These measurements were primarily focused on irrigated areas, although some SRP wells in urbanized areas were included. Other measurements for cascading water in recent years are also tabulated in Appendix A. Most of these were provided by the Groundwater Planning Division of the SRP. This provides coverage to the north and west of that covered by the winter 1981-82 program in the East Basin.

For the East Basin, depth to the top of the cascading water

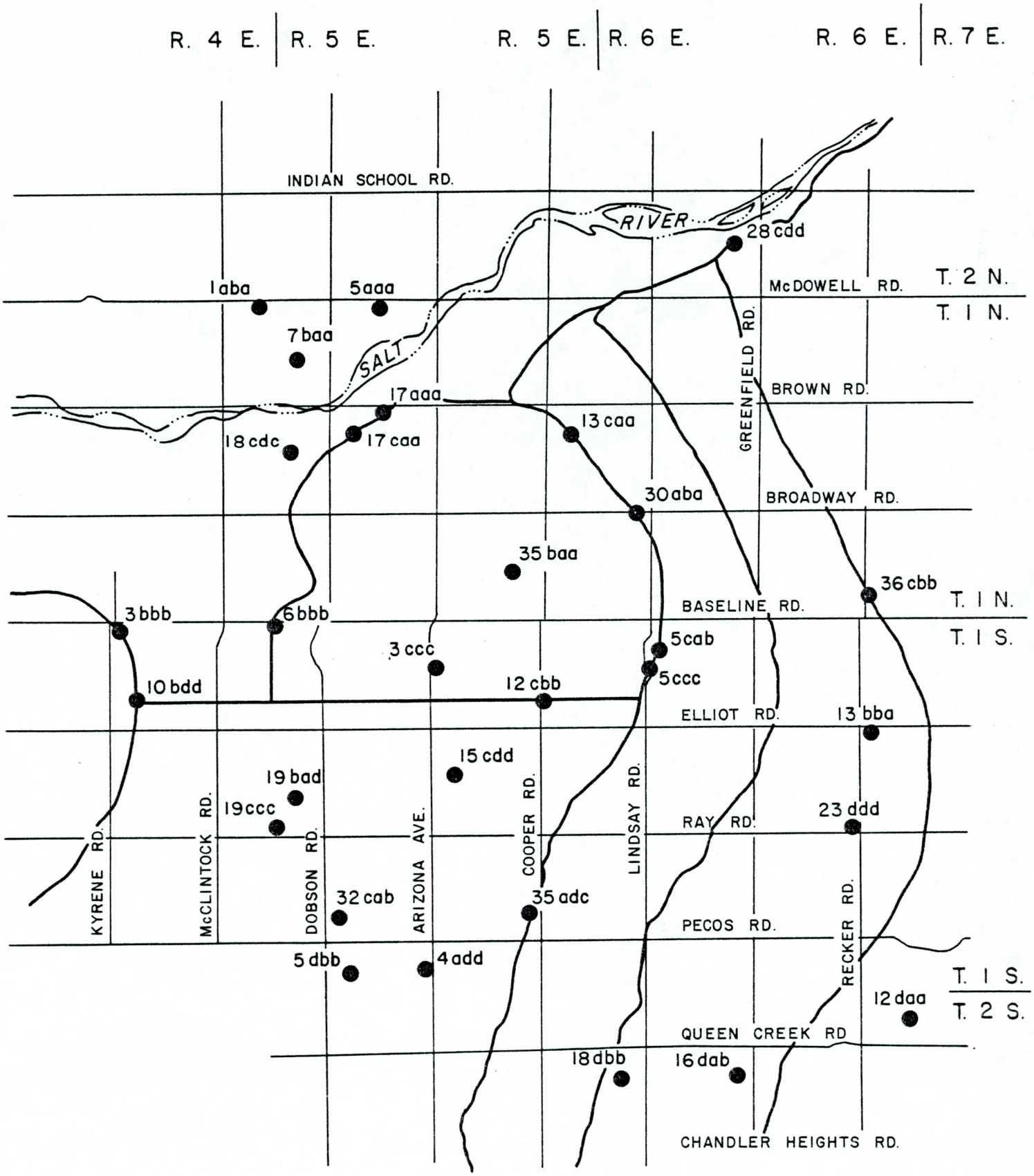

FIGURE 1.- LOCATION OF CASCADING WELLS MEASURED IN THE EAST BASIN

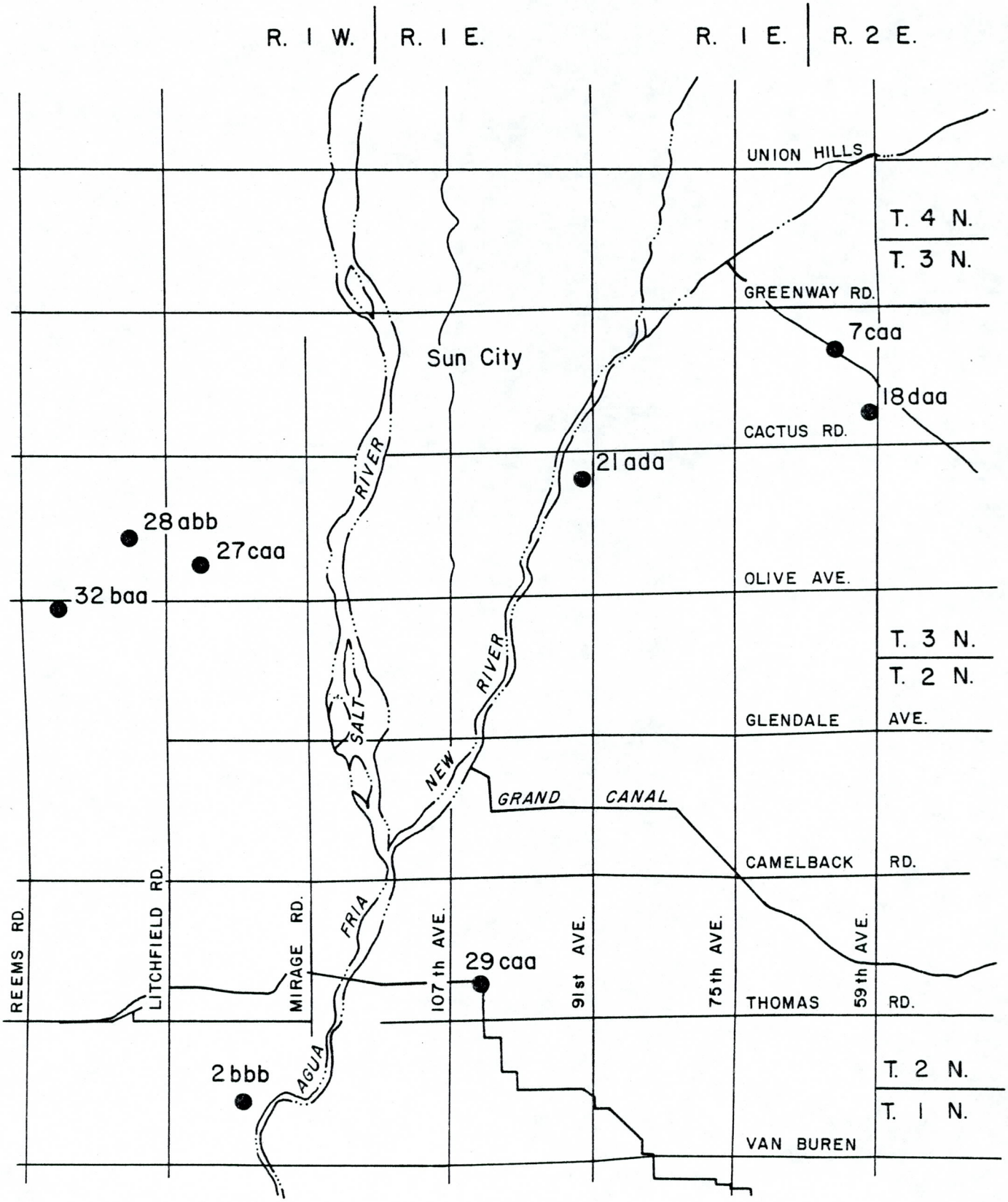

FIGURE 2.-LOCATION OF CASCADING WELLS MEASURED IN THE WEST BASIN

ranged from 83 to 360 feet, but was usually between 120 and 220 feet in 1981-82. The distance between the top of the cascading water and the main water table ranged from 5 to 155 feet, however most values were between 15 and 40 feet. Thus for most of the cascading wells, the top of the cascading water was not far above the water level in the main aquifer. The Groundwater Planning Division of the SRP has conducted television surveys down cascading wells (Small, 1982). In some cases, cascading water is entering wells at several different depths. The top of the cascading water may correspond to the uppermost opening in the well opposite the perched zone. In addition, television surveys have indicated that perched water can fall down the well in the annular space on the outside of the well casing. When a constriction around the well casing is encountered, the cascading water then enters the well. Thus the true static water level in the perched zone is often higher than the top of the cascading water.

In the West Basin, virtually no cascading wells were found in the area east of the Agua Fria River and southwest of Grand Avenue, except near the river. Depth to top of the cascading water ranged from about 25 to 400 feet, and except for one well was greater than 210 feet in 1981-82. The distance between the top of the cascading water and static level in the main aquifer ranged from about 20 to 90 feet.

In summary, many cascading wells were found to be near major canals or laterals, and some were near the Salt and Agua Fria Rivers. Cascading water beneath most of the valley is not normally far above the water level in the main aquifer.

Water Sampling

Previous to the MAG 208 program, only one sample of cascading water in the valley is known to have been collected and analyzed. As part of the MAG 208 program, samples of cascading water have been collected and analyzed since 1980. Between March 1980 and January 1983, water samples were collected by bailing from eight cascading wells. The major inorganic chemical constituents were analyzed for all of these samples. A selected group of pesticides were analyzed in the seven of the samples, that were collected during this phase of the MAG 208 program (November 1981-January 1983). In addition, deuterium and oxygen-18 contents were determined on two of these samples. Stable isotopes are useful in differentiating between recharge from canal seepage and deep percolation of irrigation return flow. Thirteen samples of canal water were collected by Salt River Project personnel and made available for stable isotope analyses as part of this program. These samples were primarily collected from the Tempe Canal, Consolidated Canal, and South Canal during March-July, 1983.

SRP personnel also collected samples of cascading water from six other SRP wells between June 1981 and March 1982 (Small, 1982). These samples were analyzed by the SRP laboratory for major inorganic chemical constituents. The results were made available for use in the MAG 208 program. Locations of sampled wells and nearby sites where canal water was sampled by the Salt River Project are shown in Figures 3 and 4.

Inorganic Chemical Composition

Based on total dissolved solids (TDS) and nitrate contents, the

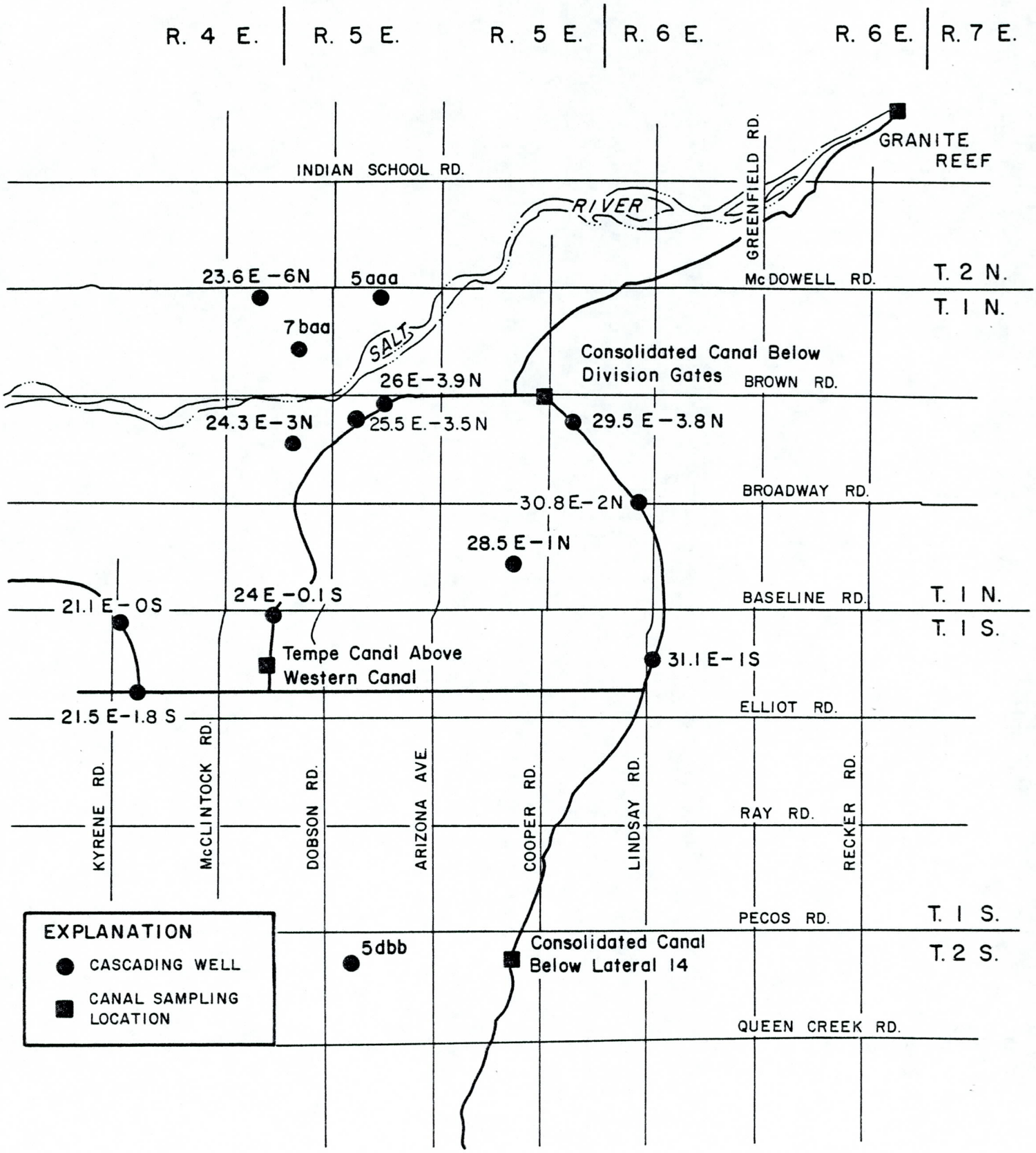

FIGURE 3.-LOCATION OF SAMPLED CASCADING WELLS IN THE EAST BASIN

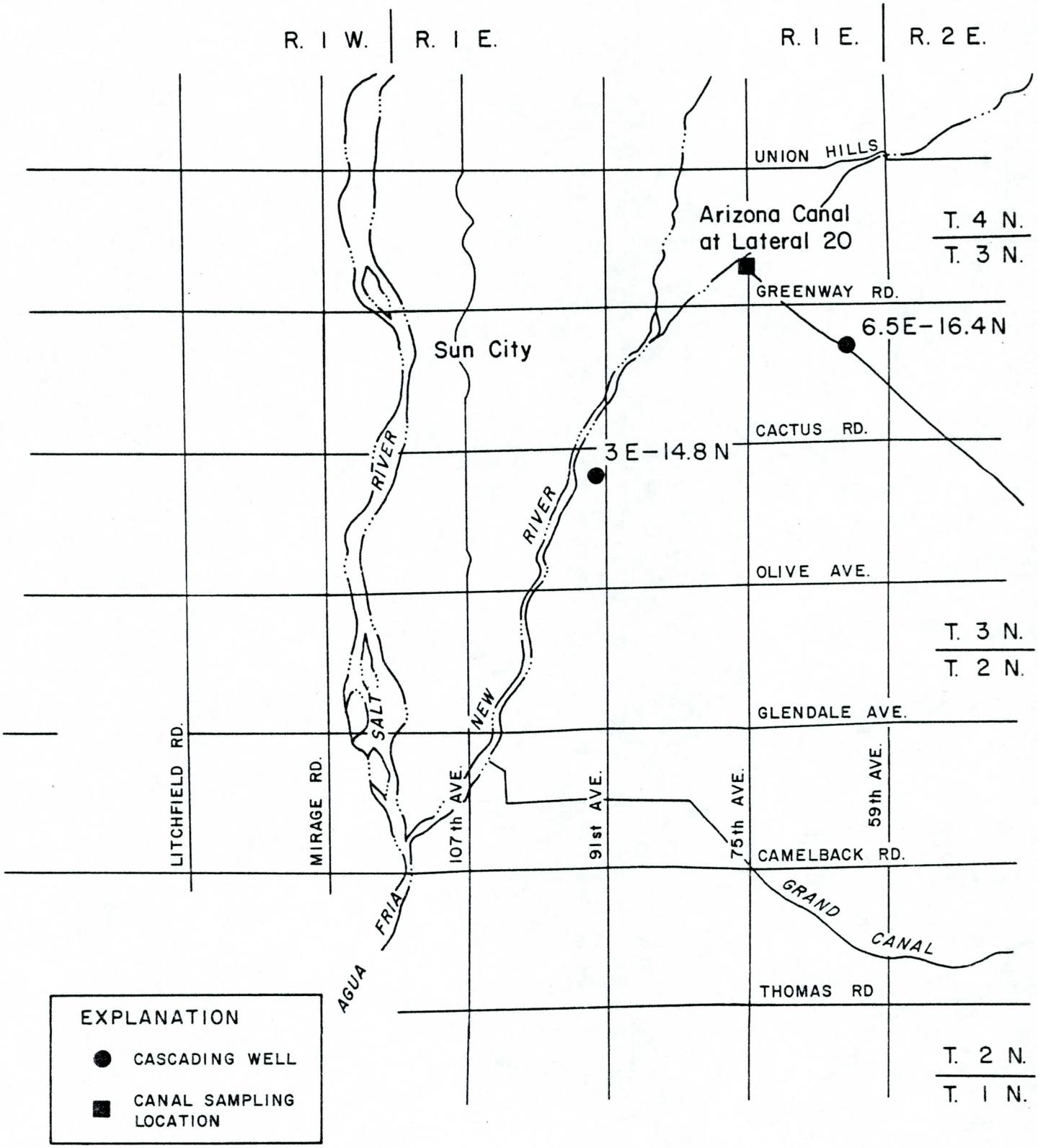

FIGURE 4. - LOCATION OF SAMPLED CASCADING WELLS IN THE WEST BASIN

samples of cascading water can be grouped into three categories:

Type	No. of Wells	Nitrate (mg/l)	Total Dissolved Solids (mg/l)
A	4	<10	440-500
B	5	15-25	830-940
C	6	40-52	1,010-1,220

On a long-term basis, the TDS content of canal water in most of the SRP averages between about 400 and 500 mg/l. Smith, et al (1982) showed that the inorganic chemical composition of cascading water of the first type was identical to that of canal water. Thus the first type is derived from recharge due to canal seepage. The third type, characterized by relatively high salinity and nitrate content, is derived primarily from deep percolation of irrigation return flow. The salinity of irrigation return flow is increased compared to that of the applied water, which is usually from canals, due to crop evapotranspiration. The high nitrate contents are likely due to the use of nitrogen fertilizers. Comparing the TDS contents for canal water and cascading water of Type C, a concentration factor of about 2.4 is apparent. This would be expected with an irrigation efficiency of about 60 percent, which is in agreement with previous estimates made by the water-budget approach for the area. Water of Type B is of intermediate composition between that of the other two types. This water appears to be derived from a mixture of canal seepage and deep percolation of irrigation return flow.

Table 1 shows the chemical composition of cascading water derived primarily from canal seepage. For comparison, analyses are provided for composite samples of canal water from points nearest

TABLE 1 - CHEMICAL COMPOSITION OF CANAL WATER
AND CASCADING WATER FROM CANAL SEEPAGE

Constituent (mg/l)	6.5E-16.4N	Arizona Canal @ Lat. 20	25.5E-3.5N	26E-3.9N	30.8E-2N	Consolidated Canal
Calcium	45	50	42	47	44	59
Magnesium	23	32	17	16	17	5
Sodium	83	71	120	103	119	115
Potassium	5	3	4	3	2	4
Carbonate	0	0	0	0	0	0
Bicarbonate	230	189	178	196	213	159
Sulfate	60	69	65	70	53	51
Chloride	97	113	154	138	147	173
Nitrate	10	19	5	0	6	0
Fluoride	0.4	-	0.4	-	-	-
Boron	0.1	-	0.1	0.1	0.2	-
Arsenic	<0.01	-	<0.01	-	-	-
pH	7.4	8.4	7.3	8.4	8.3	8.1
Electrical Conductivity (micromhos/cm @ 25°C)	800	800	880	890	915	920
Total Dissolved Solids	440	454	497	477	498	485
Depth (feet)	290	-	145	109	219	-
Date	10/27/83	Composite	11/5/81	9/28/81	6/30/81	Composite
Laboratory	BC Labs	SRP	BC Labs	SRP	SRP	SRP

the cascading wells. All of the wells with this type of cascading water are located adjacent to major canals. Well 6.5E-16.4N is located adjacent to the Arizona Canal in the West Basin. Wells 25.5E-3.5N and 26E-3.9N are located along the Tempe Canal, and Well 30.8E-2N is located along the Consolidated Canal. The analyses of cascading water and canal water are virtually identical. The cascading waters are of the sodium bicarbonate-chloride type, and chloride contents range from about 100 to 150 mg/l.

Table 2 shows the chemical composition of cascading water derived primarily from the deep percolation of irrigation return flow. All of the wells with this type of cascading water are located at some distance from major canals. Wells (A-1-5)5aaa and 7baa are located on Salt River Indian Community irrigated lands. Well 3E-14.8N is located just east of the New River, about three miles southwest of the Arizona Canal. Well 24.3E-3N is located about one mile south of the Salt River and about two-thirds of a mile northwest of the Tempe Canal. Well 28.5E-1N is located about two and one-half miles west of the Consolidated Canal. These waters are of the sodium chloride or sodium chloride bicarbonate type, and chloride contents range from about 320 to 440 mg/l.

Table 3 shows the chemical composition of cascading water probably derived from a mixture of canal seepage and irrigation return flow. All of the wells with this type of cascading water are located along major canals. Wells 21.1E-0S and 21.5E-1.8S are located along the Western Canal, just below the Tempe Canal. Well 24E-0.1S is located along the Tempe Canal just above the Western Canal. Wells 29.5E-3.8N and 31.1E-1S are located along the Consolidated Canal. These waters are of the sodium chloride or sodium

TABLE 2 - CHEMICAL COMPOSITION OF CASCADING WATER FROM IRRIGATION RETURN FLOW

Constituent (mg/l)	(A-1-5) 5aaa	(A-1-5) 7baa	3E-14.8N	24.3E-3N	28.5E-1N
Calcium	124	68	167	87	115
Magnesium	42	35	50	34	46
Sodium	301	315	53	247	280
Potassium	8	8	4	6	8
Carbonate	0	0	0	12	0
Bicarbonate	407	434	163	347	460
Sulfate	144	133	78	91	130
Chloride	440	341	345	319	394
Nitrate	46	50	43	41	40
Fluoride	0.3	0.4	0.1	-	0.2
Boron	-	0.9	0.1	0.5	0.5
Arsenic	<0.01	<0.01	<0.01	-	<0.01
pH	7.4	7.9	7.2	8.2	7.5
Electrical Conductivity (micromhos/cm @ 25°C)	1,820	1,250	1,560	1,780	2,200
Total Dissolved Solids	1,187	1,047	1,077	1,011	1,217
Depth (feet)	140	102	187	142	194
Date	3/7/80	11/23/81	11/5/81	3/12/82	1/18/83
Laboratory	BC Labs	BC Labs	BC Labs	SRP	BC Labs

TABLE 3 - CHEMICAL COMPOSITION OF CASCADING WATER OF THE INTERMEDIATE TYPE

Constituent (mg/l)	21.1E-0S	21.5E-1.8S	24E-0.1S	29.5E-3.8N	31.1E-1S
Calcium	28	64	70	29	84
Magnesium	37	24	32	37	27
Sodium	248	249	255	237	190
Potassium	6	4	7	7	10
Carbonate	12	0	0	0	0
Bicarbonate	158	378	445	188	272
Sulfate	153	126	100	108	100
Chloride	297	249	266	343	275
Nitrate	16	29	21	23	18
Fluoride	-	-	0.5	-	1.0
Boron	0.5	0.5	0.8	0.1	-
Arsenic	-		<0.01	-	<0.01
pH	8.5	8.1	8.0	8.4	7.5
Electrical Conductivity (micromhos/cm @ 25°C)	1,610	1,610	1,725	1,630	1,400
Total Dissolved Solids	880	938	887	882	830
Depth (feet)	132	144	159	280	216
Date	12/21/81	2/9/82	11/23/81	12/15/81	1/7/82
Laboratory	SRP	SRP	BC Labs	SRP	BC Labs

bicarbonate type, and chloride contents range from about 250 to 340 mg/l.

Stable Isotopes

Stable isotope contents were determined on thirteen samples of canal water and two samples of cascading water. Values are referenced to Standard Mean Ocean Water (SMOW). Most of the samples of canal water are from the Tempe Canal above the Western Canal, the Consolidated Canal below Lateral 14, and the South Canal at Granite Reef. Results indicate that $\delta^{18}O$ values of canal water were always less than -8.7 °/oo, and usually less than -9.1 °/oo. Other evidence, to be presented later, indicates that $\delta^{18}O$ values for irrigation return flow in this area are normally -8.6 °/oo or greater. Stable isotopes of oxygen and hydrogen would not be expected to be fractionated during seepage from canals, because evaporation losses are relatively insignificant in relation to the amount of seepage. However, in the case of irrigation return flow, evapotranspiration should result in a fractionation which increases the relative contents of the heavier isotopes. The sample of cascading water from Well 6.5E-16.4N had a $\delta^{18}O$ value of -9.3 °/oo, indicative of canal seepage. The sample of cascading water from Well 28.5E-1N had a $\delta^{18}O$ value of -8.6 °/oo, indicative of irrigation return flow. The results thus confirm the interpretations previously made based on the inorganic chemical composition of the cascading water. Deuterium analyses for samples collected during this program did not allow differentiating canal seepage from irrigation return flow as well as did oxygen-18 values. However, the same general pattern was evident.

Pesticides

Table 4 shows the organic pesticides analyzed during this program and their respective detection limits. This list includes the pesticides listed in the Arizona drinking water regulations in addition to those ranked highest by Rich and Associates (1982). DBCP has been found in groundwater beneath some parts of the Salt River Valley, but generally these areas coincide with citrus groves. Samples of cascading water that were collected as part of this program were not from wells in known DBCP areas. Analysis of numerous pesticides by Stoner Laboratories of Santa Clara for samples from seven cascading wells indicated no contents above detection limits. Arsenic acid was an inorganic pesticide that was ranked high, but arsenic contents in cascading water were below the detection limit of 0.01 mg/l for all samples of cascading water that were analyzed (Tables 1, 2, and 3).

TABLE 4 - LIST OF PESTICIDES ANALYZED

	Detection Limit (ppb)
Aldrin	0.05
BHC Isomers	0.05
Chlordane	0.10
DBCP	0.01
DDE	0.05
DDD	0.10
DDT	0.10
Dieldrin	0.05
Endrin	0.05
Heptachlor	0.05
Heptachlor epoxide	0.05
Hexachlorobenzene	0.05
Methoxychlor	0.10
Parathion	1.0
PCNB	0.05
Polychlorinated Biphenyl Mixtures	0.10
Toxaphene	1.0
2,4-D	0.1
2,4,5-T	0.1
2,4,5-TP	0.1

GILBERT MONITOR WELLS

The northern part of the planning area for the Town of Gilbert was selected for installation of monitor wells for a number of reasons:

1. The area was recognized, during the first phase of the MAG 208 program, to have experienced increases in groundwater salinity during the past few decades.
2. There were also substantial increases in nitrate content in water from wells in this area in the late 1970's. Nitrate contents in water from most wells exceeded 45 mg/l after 1979.
3. The area is rapidly urbanizing and is presently solely dependent on groundwater.
4. Depth to groundwater is moderate for the Salt River Valley, thus simplifying monitoring efforts, compared to areas with deeper water levels.
5. The community showed an interest in the objectives of the proposed monitoring program.

The Gilbert area lies within the SRP and canal water fed by the Salt and Verde Rivers and groundwater is used for irrigation. Groundwater alone is presently used in the Gilbert area for public supply and domestic use. Alluvial deposits comprise the aquifer. Near Gilbert, sand, gravel, cobbles, and boulders deposited by the ancestral Salt River predominate above a depth of about 250 feet. Depth to water in recent years has ranged from about 150 to 200 feet, and fluctuates with canal deliveries. When adequate canal water is available for irrigation, there is little pumpage, and

water levels rise. On the other hand, during periods of low canal deliveries, groundwater pumpage is increased and water levels decline. There appears to be virtually no overdraft at present. Most irrigation wells in the vicinity range from about 600 to 1,000 feet in depth, and are perforated opposite several hundred feet or more of alluvium. Domestic wells usually are not perforated opposite the shallowest strata, because of high salinity in the groundwater. The TDS content of shallow groundwater in the Gilbert area normally ranges from about 1,600 to 2,200 mg/l.

The Town of Gilbert utilizes four wells for public supply at present. Presently, groundwater is the sole source of drinking water in the Gilbert planning area (excluding bottled water). In the future canal water could be used in the area. However, even if canal water is developed, it is usually necessary to rely on groundwater during annual canal dry up periods for maintenance. As of the present, no plans have been developed by the Town of Gilbert to develop a canal water supply.

Field crops, primarily cotton, grains, and alfalfa, comprise the major crops grown in the northern part of the Gilbert planning area. Irrigation has been practiced in the vicinity since the early 1900's. The predominant method of irrigation is by furrows. Nitrogen fertilizers have been widely used in the Salt River Valley since the late 1940's. Numerous pesticides have also been used, but types and amounts are not documented in specific areas. However, a study by Rich and Associates (1982) has indicated which pesticides might be of most concern in terms of groundwater quality.

Prior to this program, the quality of the shallow groundwater

near Gilbert was not being directly monitored. This is partly because large-capacity wells generally tap a mixture of both shallow and deep groundwater. Also, the few domestic wells present in the area usually tap only deeper strata, because of the poor quality of shallow groundwater for domestic use. The previously discussed trends are based on sampling of only large-capacity wells. Causative factors for these trends are difficult to determine without direct monitoring of the quality of shallow groundwater.

Measurements in cascading wells indicated that perched groundwater is not located far above the water table beneath the target area. That is, the perched groundwater is often only about 30 feet above the water table in the main aquifer. Because the amount of water in the perched zone is limited, and because these zones may be transitory in nature, they offer limited potential for monitoring. Also, they are so close to the water table that they offer little advantage over monitoring groundwater in the uppermost part of the aquifer. Also, the majority of the cascading wells that were inventoried were along major canals or laterals. Chemical analyses of canal water and cascading water confirm that canal seepage is the major source of much of the perched water, particularly near major canals.

Due to these considerations, locations for the monitor wells were intentionally selected at some distance from major canals or laterals, in order to minimize the influence of canal seepage. This maximizes the opportunity to evaluate the impact of deep percolation of irrigation return flow on groundwater quality. It was decided to drill the monitor wells by the cable-tool method.

This would allow the detection of perched water. If adequate amounts were present, a monitor well could be completed in the perched zone instead of the main aquifer. Otherwise, the monitor well would be completed in the uppermost part of the main aquifer.

Soils Conditions

It is important to characterize the soils of the area, because they could be important in influencing the impact of irrigation return flow. Adams (1974) mapped soils in much of the East Basin, including the Gilbert area. Soils of the Mohall-Contine association comprise the most widespread soil association in the East Basin. Soils of the association cover most of the Gilbert planning area, the central part of the Mesa planning area, and much of the Chandler planning area. The most prevalent soil in the Gilbert area is the Contine clay loam. The representative profile for this soil is located within the Town of Gilbert planning area. The upper foot of this soil, or topsoil, is typically a brown clay loam. The subsoil, from a depth of about one to three feet, is normally reddish brown clay. From a depth of three to five feet, soils are normally reddish brown clay loam and loam. The Contine clay loam is moderately alkaline and slightly to strongly calcareous.

Monitor Well Installation

Locations

Locations for the monitor wells were selected in cooperation with the Town of Gilbert. Figure 5 shows the locations chosen for the six monitor wells. The direction of groundwater flow in the area was primarily to the north in December 1982. Five monitor

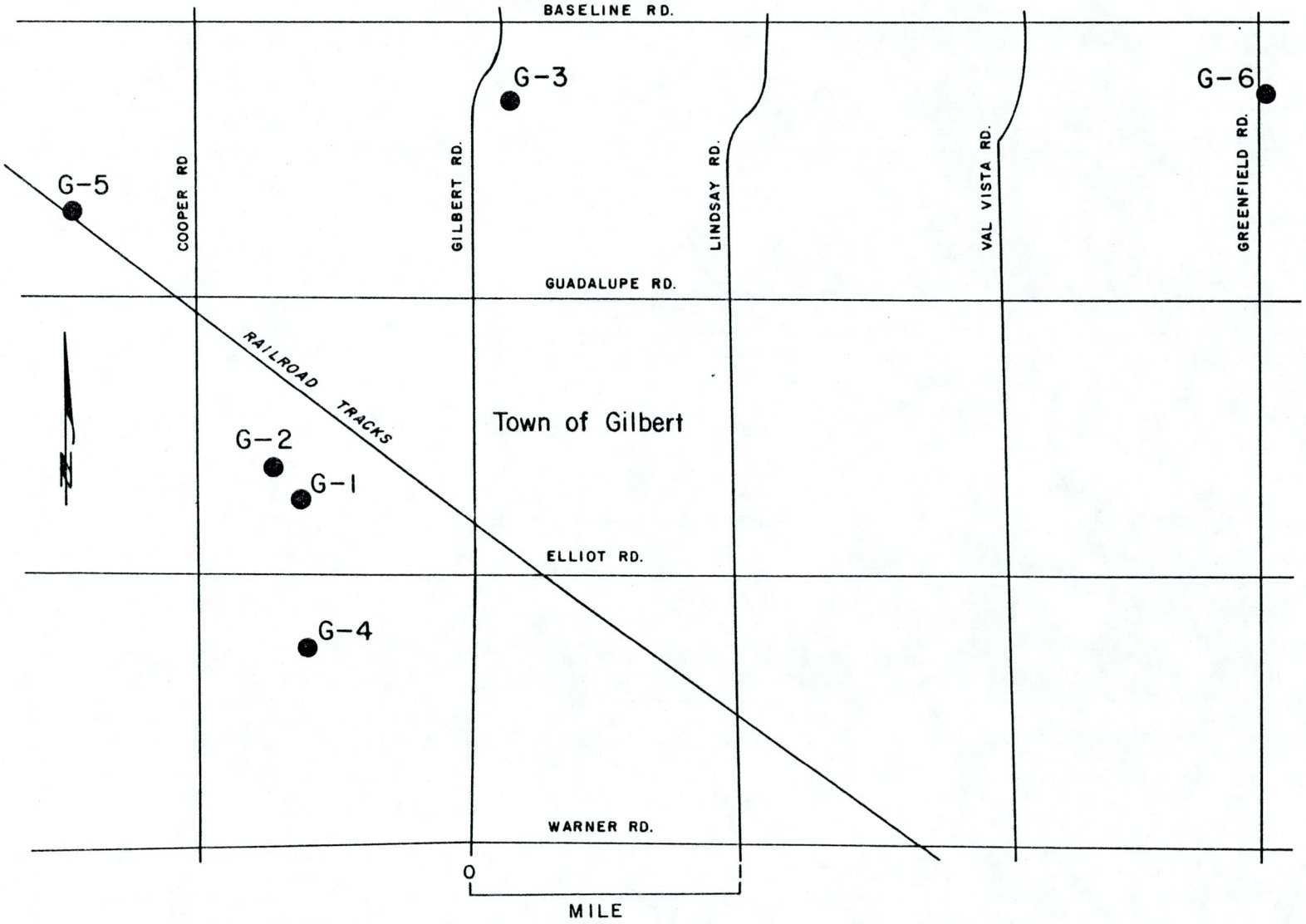

FIGURE 5.- LOCATION OF MONITOR WELLS NEAR GILBERT

wells were located on lands belonging to the Town of Gilbert. Wells G-1 and G-2 are near the sewage effluent disposal field for the Town of Gilbert. Well G-1 is south and thus upgradient of the effluent disposal field. Lands to the south of this well were irrigated, whereas land immediately to the north was idle during this program. Well G-2 is on the west edge of the effluent disposal area. Lands to the west of this well were irrigated during this program. Well G-3 is located near a newly developed park. Lands to the west of this well were still irrigated during this program. Well G-4 is located adjacent to a housing tract, near a small urban storm runoff holding pond. Lands to the west and north of this well were still under irrigation during this program. Well G-5 is located near a site where the Town of Gilbert plans to construct a water storage tank. Land to the north, west, and south of this well was irrigated during this program, but rural residential development was present to the east.

A suitable site for the sixth monitor well (G-6) could not be found on lands controlled by the Town of Gilbert. However, a site was found on land owned by the Gilbert Unified School District. Land to the north, east, and west of this well was still irrigated during this program, but some rural residential development was present to the southeast.

Construction Details

Specifications were prepared for the monitor wells and Bert E. Perry Drilling of Mesa was selected as the drilling contractor in September 1982. The wells were drilled by the cable-tool method. Drilling commenced in late 1982 and the last well was completed in

May 1983. Perched water was not encountered by any of the wells, and they were thus completed in the main aquifer. Table 5 provides information on the construction details of the monitor wells. Originally, it was estimated that a depth of 280 feet would be necessary, but drilling conditions indicated that a depth of about 250 feet was sufficient for the first five wells. An eight and five-eighths inch diameter steel casing was driven and open-bottomed (unperforated) wells were completed. Water-bearing strata were normally penetrated at a depth ranging from 200 to 220 feet. The wells were drilled to a greater depth to allow sufficient amounts of water to be obtained from the well and to allow for expected water-level declines in the future. Static water levels at the time of drilling normally ranged from about 160 to 180 feet, indicating that there was some confinement of groundwater.

Drill cuttings were logged by a geologist and upon completion of drilling, gamma neutron logs were run in order to help delineate the nature of the deposits. The first five monitor wells primarily tapped coarse-grained deposits of the Recent alluvium. The top of these materials was usually penetrated between about 70 and 100 feet in depth. Sandy clay was the predominant material overlying these deposits. Well G-6, which is located about three miles east of Gilbert Road, penetrated substantially different materials. Cross sections developed previously indicate that the coarse-grained deposits of the Recent alluvium thin to the east and are probably above the water table. Water was not encountered until a depth of about 320 feet at Well G-6, thus it was completed to a depth of about 350 feet. Water stood at a depth of about 300 feet in this well when it was completed.

TABLE 5 - CONSTRUCTION DATA FOR GILBERT MONITOR WELLS

State Well No.	Local No.	Date Drilled	Depth (feet)	Cased Depth (feet)
(D-1-5) 2dbc	G-5	3/83	250	243
12caa	G-2	3/83	240	231
12cac	G-1	1/83	252	242
13bad	G-4	1/83	250	234
(D-1-6) 3bbc	G-6	5/83	350	342
6bdb	G-3	3/83	250	244

Wells drilled by Bert E. Perry Well Drilling, Mesa.

Development and Sampling

Each well was developed by bailing, and then a permanent submersible pump was installed. These pumps are three-horsepower and capable of delivering about 30 gpm at a lift of 250 feet. A 3/4-inch PVC sounding tube was installed in each well to facilitate water level measurements. A concrete pump base was poured at each well. After pump installation, a locking cover was installed. Single-phase electrical connections were provided, and the wells were pumped during each sampling round by use of a portable generator. The initial sampling was conducted after four hours of pumping. Pumping level, temperature, pH, and electrical conductivity were frequently measured during pumping, and the results indicated stabilization of these parameters within one to two hours after pumping commenced. Thenceforth, a two hour pumping period was used prior to collection of water samples for laboratory analyses. Static water level was measured before pumping commenced. Water levels were measured with two-line electric sounders. Discharge was measured several times during each sampling round by timing the filling of a five gallon container.

Constituents Analyzed

The major chemical constituents, iron, manganese, boron, arsenic, fluoride, pH, electrical conductivity, total organic carbon, and total dissolved solids were determined on most samples. These constituents help characterize the water type and also include those thought to be of concern based on previous studies. Arsenic has been used as a pesticide in the valley and received a high ranking in the study by Rich and Associates (1982). Iron and

manganese indicate whether oxidizing or reducing conditions are present in the aquifer. Boron and total organic carbon are potential tracers of sewage effluent and possibly septic tank effluent. There was some indication before this study, particularly from other basins in Maricopa County, that fluoride was an important constituent in irrigation return flow. The pesticides selected were the same as discussed previously for the sampling of cascading water (Table 4).

Water Level Trends

Depth to water in the monitor wells was measured approximately on a bi-monthly basis. Results for the five shallow monitor wells are shown in Figure 6. Water levels in these wells rose at an average rate of about ten feet per year during 1983. This is attributed to the abundance of canal deliveries and minimal pumping of SRP wells during the past several years. On the other hand, water levels in Well G-6 showed no overall change. Water level measurements are shown in Appendix B.

Results of Water Sampling

Initially it was planned to sample the monitor wells on a monthly basis. However, little variation in chemical quality was observed during the initial sampling rounds, thus samples were collected approximately bi-monthly.

Inorganic Chemical Constituents

Table 6 shows the results of analyses for inorganic chemical constituents and total organic carbon for samples collected in August 1983. All waters were of the sodium chloride type. Except

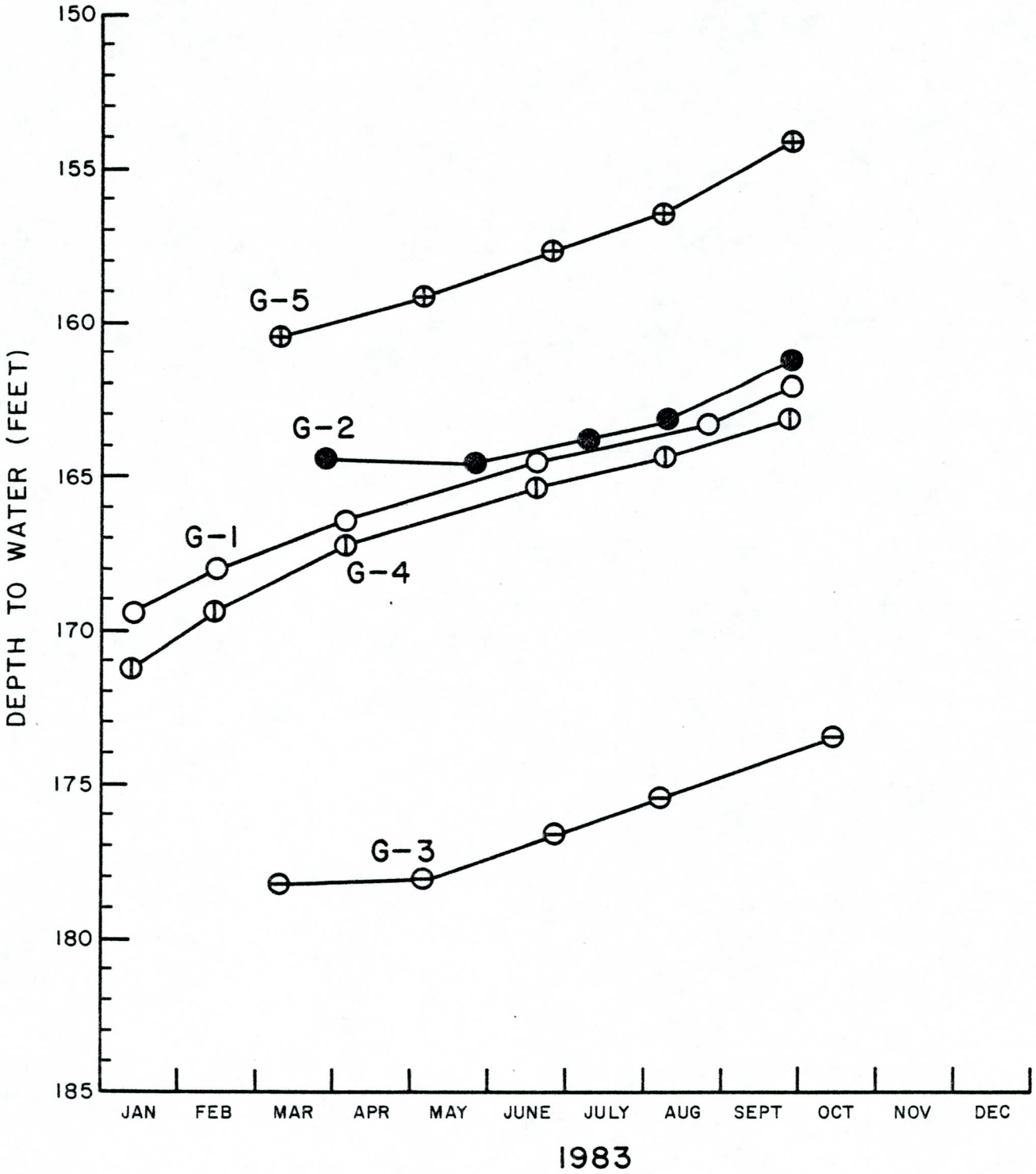

FIGURE 6.-DEPTH TO WATER IN SHALLOW MONITOR WELLS

TABLE 6 - CHEMICAL ANALYSES FOR WATER FROM GILBERT MONITOR WELLS, AUGUST 1983

Constituent (mg/l)	G-1	G-2	G-3	G-4	G-5	G-6
Calcium	190	170	130	145	170	83
Magnesium	68	78	65	54	98	18
Sodium	365	370	375	350	430	175
Potassium	11	12	10	11	12	10
Carbonate	0	0	0	0	0	0
Bicarbonate	352	430	416	407	501	140
Sulfate	320	290	215	225	260	93
Chloride	606	597	577	542	761	302
Nitrate	60	56	48	56	53	32
Fluoride	0.2	0.2	0.2	0.5	0.2	0.3
Boron	1.9	1.9	1.6	1.8	1.4	0.3
Iron	0.12	0.22	0.12	0.11	0.11	0.17
Manganese	0.01	0.02	0.02	0.02	0.01	0.02
Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Organic Carbon	1.0	2.5	2.6	3.0	2.3	2.5
pH	7.2	7.2	7.2	7.2	7.2	7.7
Electrical Conductivity (micromhos/cm @ 25°C)	3,000	3,000	2,600	2,600	3,500	1,350
Total Dissolved Solids	1,910	1,877	1,660	1,650	2,190	833
Temperature (°F)	76	75	75	77	73	88
Cased Depth (feet)	240	230	244	233	243	342
Date	8/24/83	8/10/83	8/10/83	8/10/83	8/10/83	8/10/83

Analyses by BC Laboratories, Inc. of Bakersfield, California.

for Well G-6, TDS contents ranged from 1,650 to 2,190 mg/l, and chloride contents from about 540 to 760 mg/l. For water from the shallow wells, nitrate content ranged from 48 to 60 mg/l, exceeding the drinking water limit.

Smith, et al (1982) presented analyses of water from the Consolidated Canal. The long-term average TDS below the division gates was 425 mg/l, whereas below lateral 14, near the bottom end of the canal, the average TDS was 640 mg/l. The higher salinity in the lower part of the canal is due to pumpage of higher salinity groundwater into the canal. For the area near Gilbert, an average TDS of 530 mg/l for canal water was calculated, based on the previous two measurements. Thus irrigation return flow, as sampled by the five shallow wells, appears to be concentrated by a factor of from 3.1 to 4.1 in terms of TDS. Chloride content of the canal water near Gilbert averages about 215 mg/l on the long-term. In terms of chloride, the irrigation return flow is concentrated by a factor of from 2.5 to 3.5, slightly lower than the values based on TDS. Historical irrigation efficiencies ranging from about 60 to 70 percent can explain such concentrations. These results are comparable to those discussed previously for cascading water. The presence of high nitrate contents is ascribed primarily to nitrogen fertilizers applied to farmland in the area.

The relatively low total organic carbon contents in water from all wells indicates that disposal of sewage effluent near Wells G-1 and G-2 has not noticeably affected the quality of water from these wells. Fluoride contents were usually less than 0.5 mg/l, well below the drinking water limit. Boron contents in water from the shallow monitor wells ranged from 1.4 to 1.9 mg/l, high enough

levels to affect boron sensitive crops. Iron contents normally ranged from 0.1 to 0.2 mg/l, somewhat less than the recommended value for drinking water of 0.3 mg/l. Arsenic contents were less than the detection limit of 0.01 mg/l, indicating that arsenic compounds used in some pesticides have not impacted the groundwater in this area.

Tables showing the results of analyses for inorganic chemicals for samples from the monitor wells are presented in Appendix B. The overall trend during the sampling period was a constancy of salinity and nitrate content (Figures 7 and 8). There were no apparent changes in the quality of water from the monitor wells during this time period, which spanned six to eight months for most of the wells. Longer-term monitoring, encompassing seasonal variations, would be necessary to determine long-term trends.

Pesticides

For most rounds, the pesticides analyzed were as shown in Table 4. However, during the last sampling round, determinations were also made for ethylene dibromide (EDB), at a detection limit of 0.002 ppb, and four D-D components at a detection limit of 1 ppb. These additional constituents were analyzed because of their discovery in groundwater of the San Joaquin Valley of California in previous months. As in the case of cascading water, no detectable levels of the pesticides analyzed were found during any of the sampling rounds. This indicates that these pesticides have not affected the quality of shallow groundwater in the northwest part of the Gilbert planning area. Pesticide analyses were also performed on samples of water from four large-capacity wells in this

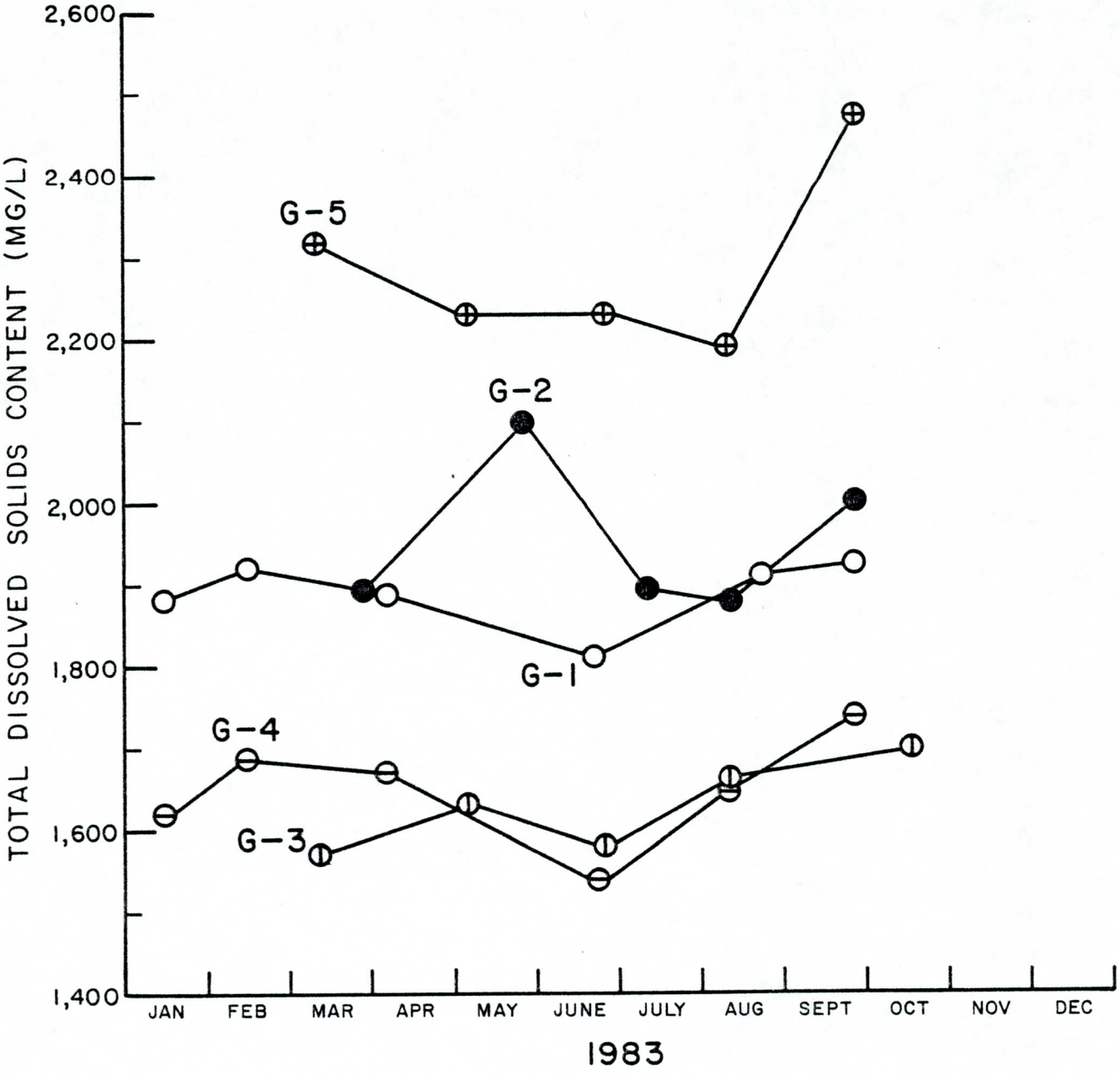

FIGURE 7.-TOTAL DISSOLVED SOLIDS CONTENTS IN WATER FROM SHALLOW MONITOR WELLS

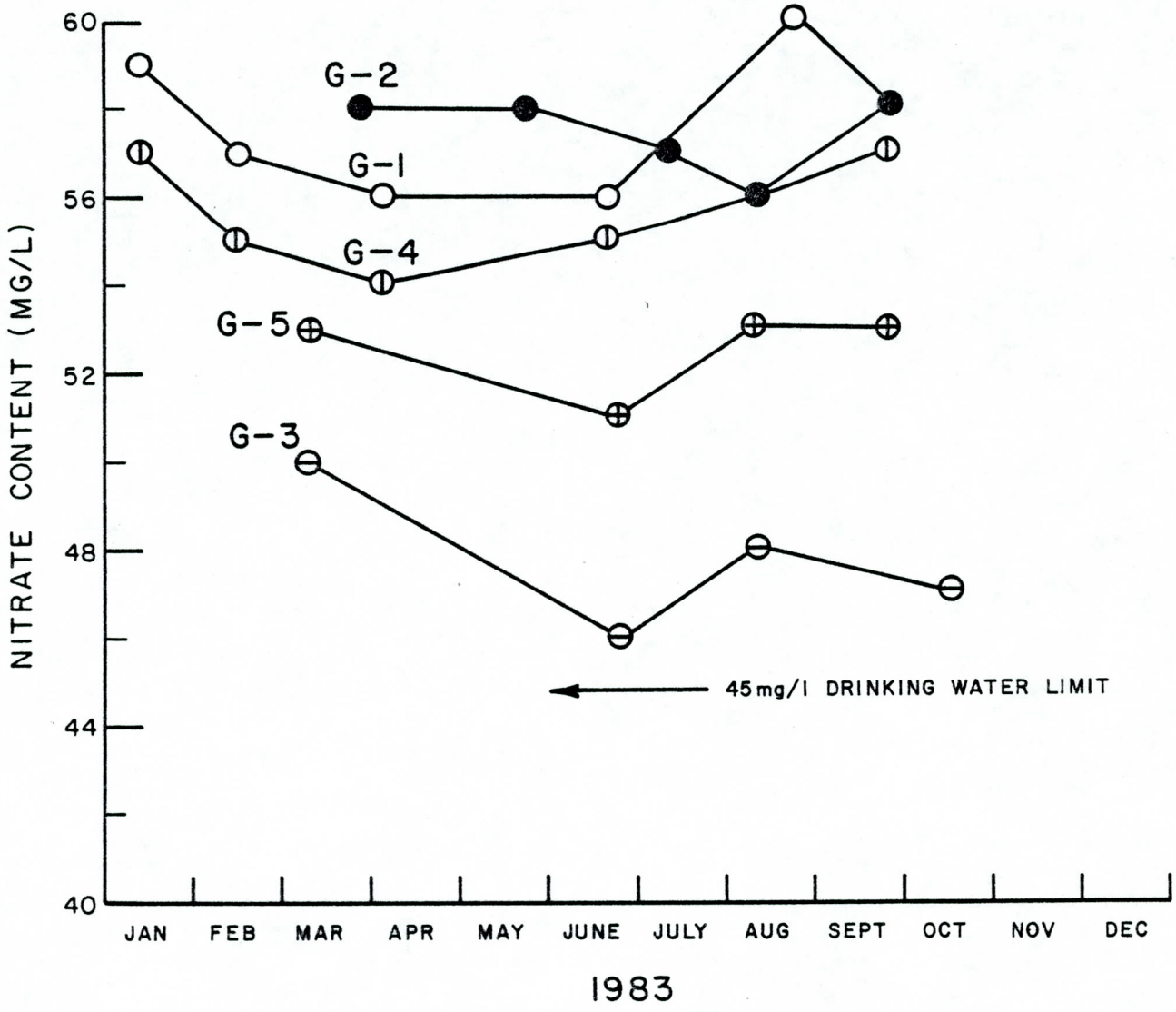

FIGURE 8.-NITRATE CONTENTS IN WATER FROM SHALLOW MONITOR WELLS

vicinity in September, 1981. Results also indicated that none of the pesticides analyzed were present at detectable levels.

Stable Isotopes

Deuterium and oxygen-18 analyses were performed on the first two sets of samples collected from each monitor well. $\delta^{18}O$ values for water from the five shallow monitor wells were usually heavier than -8.6 °/oo, comparable to the values previously described for a sample of cascading water which is believed to be derived from irrigation return flow. In contrast, most samples of canal water in the vicinity have $\delta^{18}O$ values lighter than -9.1 °/oo. Thus the stable isotope values confirm the conclusions previously drawn on the basis of inorganic chemical composition. That is, the quality of shallow groundwater beneath the northwest part of the Gilbert planning area has been primarily influenced by irrigation return flow.

SUMMARY

The purpose of this study was to evaluate the effect of irrigation practices on the quality of groundwater in the Salt River Valley. Recharge to groundwater beneath the valley is derived primarily from deep percolation of irrigation return flow and canal seepage. As part of the final phase of the MAG 208 groundwater quality program, samples of water representing both types of recharge were collected and analyzed. These samples were collected from existing cascading wells and from specially installed shallow monitor wells tapping the main aquifer.

Sampling of cascading water from wells with perforations or other openings extending above the water table indicated that cascading wells near major canals are affected by canal seepage. Cascading water in wells near such canals is often of relatively low salinity and of a composition similar to that of canal water. Canal seepage appears to be virtually the sole source of recharge to perched zones near these wells. In other cases, the cascading water from wells near major canals appears to be a mixture of canal seepage and deep percolation of irrigation return flow. The chemical composition of cascading water from some wells away from major canals is indicative of irrigation return flow. Higher salinity and nitrate content and higher contents of the heavier isotopes of oxygen and deuterium compared to canal water are present in such cascading water. Because much of the cascading water is present near major canals, and because perched zones aren't far above the water level in the main aquifer in much of the valley, perched

zones have limited potential for allowing monitoring of deep percolation of irrigation return flow.

Six specially designed shallow monitor wells were installed near the Town of Gilbert in the East Basin. These wells tap the shallow part of the main aquifer and were sampled bi-monthly during a period of about nine months. The results indicated that deep percolation of irrigation return flow in this vicinity is concentrated in terms of salinity by a factor of about three to four compared to that of the applied water used for irrigation. This concentration is due to evapotranspiration, and irrigation efficiencies of about 70 percent can explain this concentration. Such efficiencies have previously been derived independently, based on water-budget considerations. Nitrate contents in water from deep percolation of irrigation return flow in the Gilbert area usually range from 46 to 60 mg/l, exceeding the drinking water limit. These nitrate contents are ascribed to use of nitrogen fertilizers in the area. Water from the monitor wells was also analyzed for an extensive suite of organic pesticides and arsenic, but all values were below the detection limits.

In terms of future groundwater management in the valley, monitoring of shallow groundwater beneath irrigated lands can enable early detection of problems, such as occurred with the pesticide DBCP. Nitrogen fertilizer management practices in the Gilbert area could possibly be altered to decrease nitrate contents in groundwater beneath irrigated areas. However, urbanization is imminent, and this factor along should decrease nitrogen loading to most of the aquifer. If pesticides are found at sufficient levels to pose a threat to drinking water, consideration should be given to their

ban, at least in local areas. Enhanced knowledge of the chemical composition of various sources of recharge can lead to improved management practices. Results of the last phase of the MAG 208 program have documented the importance of canal seepage in counterbalancing the effects of deep percolation of irrigation return flow.

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APPENDIX A

TABLE A-1 - WATER LEVELS IN CASCADING WELLS
MEASURED BY MAG DURING WINTER 1981-82

	Depth Cascading Water (feet)	Depth Water Main Aquifer (feet)
East Basin (November 1981-January 1982)		
(A-1-6) 36cbb	360	455.2
(A-2-6) 28cdd	349	N.M.
(D-1-5) 3ccc	200	228.2
(D-1-5) 6bbb	159	172.7
(D-1-5) 12cbb	186	214.1
(D-1-5) 15cdd	188	207.6
(D-1-5) 19bad	83	131.4
(D-1-5) 19ccc	121	126.1
(D-1-5) 32cab	134	160.1
(D-1-5) 35adc	N.M.	184.5
(D-1-6) 5cab	170	204.2
(D-1-6) 5ccc	219	229.9
(D-1-6) 13bba	242	250.5
(D-1-6) 23ddd	149	303.9
(D-2-5) 4add	137	163.4
(D-2-6) 12daa	258.5	277.1
(D-2-6) 16dab	149	209.5
(D-2-6) 18dbb	177	183.6
West Basin (February-March, 1982)		
(A-2-1) 29caa	25	126.0
(A-3-2) 18daa	216	306.5
(B-1-2) 2bbb	351	379.6
(B-2-1) 2baa	305	324.9
(B-3-1) 27caa	390	N.M.
(B-3-1) 28abb	403	447.3
(B-3-1) 32baa	375	447.4

TABLE A-2 - WATER LEVELS IN OTHER CASCADING WELLS MEASURED DURING 1980-83

	Date	Depth Cascading Water (feet)	Depth Water Main Aquifer (feet)
East Basin			
(A-1-4) 1aba	1/7/82	87	201
(A-1-5) 5aaa	3/7/80	140	187.3
(A-1-5) 7baa	11/23/81	102	N.M.
(A-1-5) 13caa	12/14/81	280	283
(A-1-5) 17aaa	12/11/81	109	228
(A-1-5) 17caa	7/27/81	145	236
(A-1-5) 18cdc	3/12/82	142	167
(A-1-5) 35baa	1/18/83	194	210
(A-1-6) 30aba	6/30/82	219	258
(D-1-4) 3bbb	12/29/81	132	139
(D-1-4) 10bdd	2/5/82	144	170
West Basin			
(A-3-1) 21ada	12/4/80	187	224
(A-3-2) 7caa	3/22/82	285	335

Data supplied by Groundwater Planning Division of the Salt River Project, except for wells (A-1-5) 5aaa and (A-1-5) 7baa, which were measured by MAG.

APPENDIX B

TABLE B-1 - CHEMICAL ANALYSES OF WATER FROM MONITOR WELL G-1

Constituent (mg/l)	1/13/83	2/16/83	4/4/83	6/23/83	8/24/83	9/28/83
Calcium	195	200	200	200	190	200
Magnesium	70	64	71	66	68	72
Sodium	350	365	345	360	365	360
Potassium	12	12	12	10	11	11
Carbonate	0	0	0	0	0	0
Bicarbonate	412	402	404	395	352	407
Sulfate	285	280	270	280	320	280
Chloride	609	620	612	633	616	641
Nitrate	59	57	56	56	60	58
Boron	1.8	2.0	-	1.9	1.9	1.6
Fluoride	0.3	0.2	0.3	0.3	0.2	0.3
Iron	0.10	<0.05	0.05	0.09	0.12	<0.05
Manganese	0.02	0.01	0.02	0.01	0.01	<0.01
Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Organic Carbon	4.3	9.7	3.5	1.5	1.0	-
pH	7.3	7.3	7.8	7.7	7.2	7.2
Electrical Conductivity (micromhos/cm @ 25°C)	3,000	3,000	2,700	3,000	3,000	3,100
Total Dissolved Solids	1,877	1,923	1,893	1,813	1,910	1,923
Temperature (°F)	73	74	74	76	76	76
Static Water Level (feet)	169.4	168.0	166.4	164.7	163.3	162.3

Analyses by BC Laboratories, Inc. of Bakersfield, California.

TABLE B-2 - CHEMICAL ANALYSES OF WATER FROM MONITOR WELL G-2

Constituent (mg/l)	3/31/83	5/27/83	7/11/83	8/10/83	9/28/83
Calcium	200	164	150	170	150
Magnesium	68	77	60	78	78
Sodium	365	400	420	370	375
Potassium	11	9	10	12	11
Carbonate	0	0	0	0	0
Bicarbonate	435	435	423	430	436
Sulfate	294	297	295	290	260
Chloride	609	627	605	597	616
Nitrate	58	58	57	56	58
Boron	-	2.0	2.0	1.9	1.8
Fluoride	0.2	0.4	0.2	0.2	0.2
Iron	0.16	0.14	0.27	0.22	0.42
Manganese	0.04	0.04	0.03	0.02	0.02
Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01
Total Organic Carbon	3.8	4.5	-	2.5	-
pH	7.7	7.5	7.4	7.2	7.3
Electrical Conductivity (micromhos/cm @ 25°C)	2,750	2,900	3,000	3,000	3,100
Total Dissolved Solids	1,893	2,100	1,890	1,877	2,000
Temperature (°F)	75	77	75	75	75
Static Water Level (feet)	164.4	164.6	163.8	163.1	161.2

Analyses by BC Laboratories, Inc. of Bakersfield, California

TABLE B-3 - CHEMICAL ANALYSES OF WATER FROM MONITOR WELL G-3

Constituent (mg/l)	3/10/83	5/5/83	6/28/83	8/10/83	10/18/83
Calcium	153	76	160	130	128
Magnesium	58	55	64	65	64
Sodium	335	350	360	375	350
Potassium	10	9	9	10	9
Carbonate	0	0	0	0	0
Bicarbonate	418	275	425	416	423
Sulfate	210	116	225	215	200
Chloride	543	559	584	566	552
Nitrate	50	38	46	48	47
Boron	1.6	1.5	1.8	1.6	-
Fluoride	0.2	0.2	0.2	0.2	0.2
Iron	0.10	0.08	0.10	0.12	-
Manganese	0.02	<0.01	0.01	0.02	-
Arsenic	<0.01	<0.01	<0.01	<0.01	-
Total Organic Carbon	2.5	2.0	0.5	2.6	-
pH	7.5	7.6	7.7	7.2	7.5
Electrical Conductivity (micromhos/cm @ 25°C)	2,500	2,600	2,800	2,600	2,900
Total Dissolved Solids	1,573	1,627	1,577	1,660	1,700
Temperature (°F)	73	74	75	75	74
Static Water Level (feet)	178.3	178.1	176.7	175.5	173.4

Analyses by BC Laboratories, Inc. of Bakersfield, California.

TABLE B-4 - CHEMICAL ANALYSES OF WATER FROM MONITOR WELL G-4

Constituent (mg/l)	1/13/83	2/16/83	4/4/83	6/23/83	8/10/83	9/28/83
Calcium	175	188	182	175	145	170
Magnesium	46	46	53	50	54	48
Sodium	330	335	325	340	350	355
Potassium	12	12	11	10	11	11
Carbonate	0	0	0	0	0	0
Bicarbonate	413	405	400	404	407	414
Sulfate	230	230	225	235	225	245
Chloride	540	549	545	538	542	545
Nitrate	57	55	54	55	56	57
Boron	1.8	1.9	-	2.1	1.8	1.7
Fluoride	0.5	0.4	0.5	0.4	0.5	0.5
Iron	0.09	<0.05	0.08	0.12	0.11	0.09
Manganese	0.03	0.02	0.03	0.02	0.02	0.01
Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Organic Carbon	1.5	3.0	2.0	5.3	3.0	-
pH	7.4	7.5	7.7	7.8	7.2	7.4
Electrical Conductivity (micromhos/cm @ 25°C)	2,700	2,600	2,500	2,700	2,600	2,800
Total Dissolved Solids	1,623	2,687	1,670	1,537	1,650	1,740
Temperature (°F)	75	74	74	77	77	75
Static Water Level (feet)	171.2	169.3	167.2	165.4	164.5	163.3

Analyses by BC Laboratories, Inc. of Bakersfield, California

TABLE B-5 - CHEMICAL ANALYSES OF WATER FROM MONITOR WELL G-5

Constituent (mg/l)	3/10/83	5/5/83	6/28/83	8/10/83	9/28/83
Calcium	210	116	230	170	230
Magnesium	98	90	96	98	94
Sodium	410	407	415	430	410
Potassium	11	10	10	12	11
Carbonate	0	0	0	0	0
Bicarbonate	480	262	502	501	485
Sulfate	270	242	275	260	270
Chloride	797	750	789	761	779
Nitrate	53	45	51	53	53
Boron	1.4	1.3	1.4	1.4	1.2
Fluoride	0.1	0.2	0.1	0.2	0.2
Iron	0.19	0.12	0.11	0.11	<0.05
Manganese	0.01	<0.01	0.01	0.01	<0.01
Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01
Total Organic Carbon	3.5	10.8	0.5	2.3	-
pH	7.2	7.5	7.6	7.2	7.3
Electrical Conductivity (micromhos/cm @ 25°C)	3,400	3,300	3,500	3,500	3,600
Total Dissolved Solids	2,317	2,227	2,230	2,190	2,473
Temperature (°F)	72	74	73	73	72
Static Water Level (feet)	160.3	159.1	157.7	156.4	154.2

Analyses by BC Laboratories, Inc. of Bakersfield, California.

TABLE B-6 - CHEMICAL ANALYSES OF WATER FROM MONITOR WELL G-6

Constituent (mg/l)	5/27/83	7/11/83	8/10/83	10/18/83
Calcium	84	74	83	74
Magnesium	18	19	18	17
Sodium	174	180	175	180
Potassium	10	8	9	8
Carbonate	0	0	0	0
Bicarbonate	128	121	140	133
Sulfate	95	100	93	85
Chloride	315	302	302	304
Nitrate	32	31	32	31
Boron	0.4	0.3	0.3	-
Fluoride	0.5	0.3	0.3	0.3
Iron	0.21	0.33	0.17	-
Manganese	0.03	0.04	0.02	-
Arsenic	<0.01	<0.01	<0.01	-
Total Organic Carbon	7.3	-	2.5	-
pH	7.9	7.8	7.7	7.7
Electrical Conductivity (micromhos/cm @ 25°C)	1,320	1,340	1,350	1,390
Total Dissolved Solids	877	820	833	830
Temperature (°F)	89	89	88	87
Static Water Level (feet)	296.9	300.3	299.9	296.9

Analyses by BC Laboratories, Inc. of Bakersfield, California.