Salinity of the Ground Water in Western Pinal County Arizona

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1819-E

Prepared in cooperation with the Arizona State Land Department

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By L. R. KISTER *and* W. F. HARDT

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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CONTENTS

ILLUSTRATIONS

[Plates are in pocket]

208-555-66——1

TABLES

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

SALINITY OF THE GROUND WATER IN WESTERN PINAL COUNTY, ARIZONA

By L. R. KISTER and W. F. HARDT

ABSTRACT

The chemical quality of the ground water in western Pinal County is nonuniform areally and stratigraphically. The main areas of highly mineralized water are near Casa Grande and near Coolidge. Striking differences have been noted in the quality of water from different depths in the same well. Water from one well, (D–6–7)25cdd, showed an increase in chloride content from 248 ppm (parts per million) at 350 feet below the land surface to 6,580 ppm at 375 feet; the concentration of chloride increased to 10,400 ppm at 550 feet below the land surface. This change was accompanied by an increase in the total dissolved solids as indicated by conductivity measurements. The change in water quality can be correlated with sediment types. The upper and lower sand and gravel units seem to yield water of better quality than the intermediate silt and clay unit. In places the silt and clay unit contains zones of gypsum and common table salt. These zones yield water that contains large amounts of the dissolved minerals usually associated with water from playa deposits.

Highly mineralized ground water in an area near Casa Grande has moved southward and westward as much as 4 miles. Similar water near Coolidge has moved a lesser distance.

Good management practices and proper use of soil amendments have made possible the use of water that is high in salinity and alkali hazard for agricultural purposes in western Pinal County.

The fluoride content of the ground water in western Pinal County is usually low; however, water from wells that penetrate either the bedrock or unconsolidated sediments that contain certain volcanic rocks may have as much as 9 ppm of fluoride.

INTRODUCTION

PURPOSE AND SCOPE

The study of the ground-water resources of western Pinal County was undertaken by the U.S. Geological Survey as part of the water-resources investigation of Arizona in cooperation with the Arizona State Land Department, Obed M. Lassen, Commissioner. This report presents an analysis and evaluation of the quality of the ground water in western Pinal County in relation to its environment and to its use for agricultural purposes.

During the course of the investigation, 375 water samples were collected and analyzed for dissolved-chemical constituents. In addition, specific conductances were measured in the field on the water from 653 wells. Water samples also were collected at specific levels in some wells by a deep-well sampler. Analyses of the water samples are shown in the basic-data report (Hardt and others, 1964).

LOCATION OF THE AREA

Pinal County is in south-central Arizona in the Basin and Range physiographic province—referred to locally as the Basin and Range lowlands. The Santa Cruz River and the Santa Rosa Wash, tributaries of the Gila River, form the major part of the surface drainage, which is to the north and northwest (fig. 1).

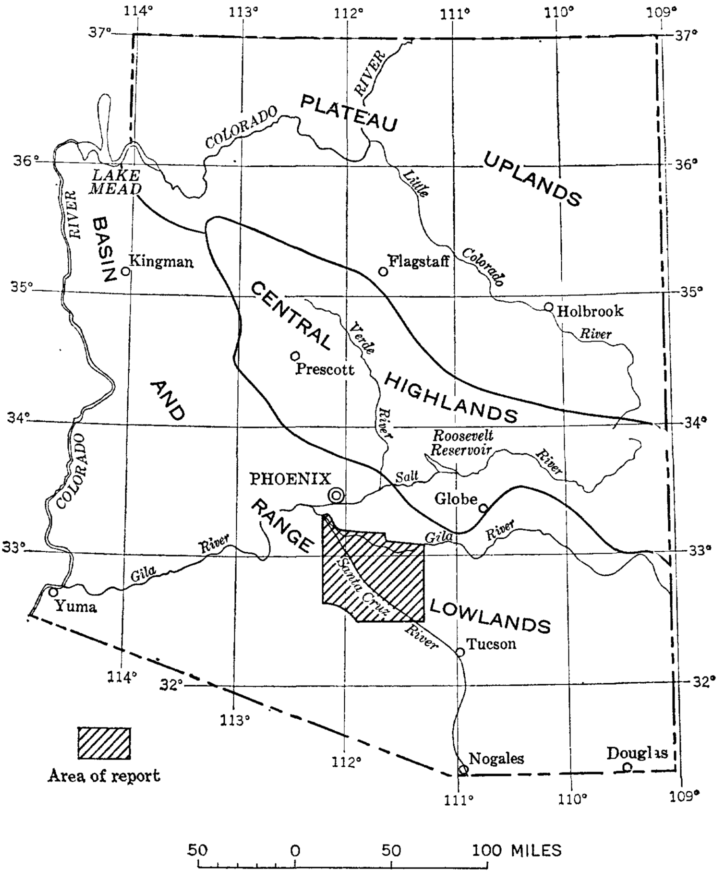

FIGURE 1.—Location of the three water provinces of Arizona and the area of study.

WELL-NUMBERING SYSTEM

The well numbers used by the Geological Survey in Arizona are in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River meridian and base line, which divide the State into four quadrants (fig. 2). These quadrants are designated counterclockwise

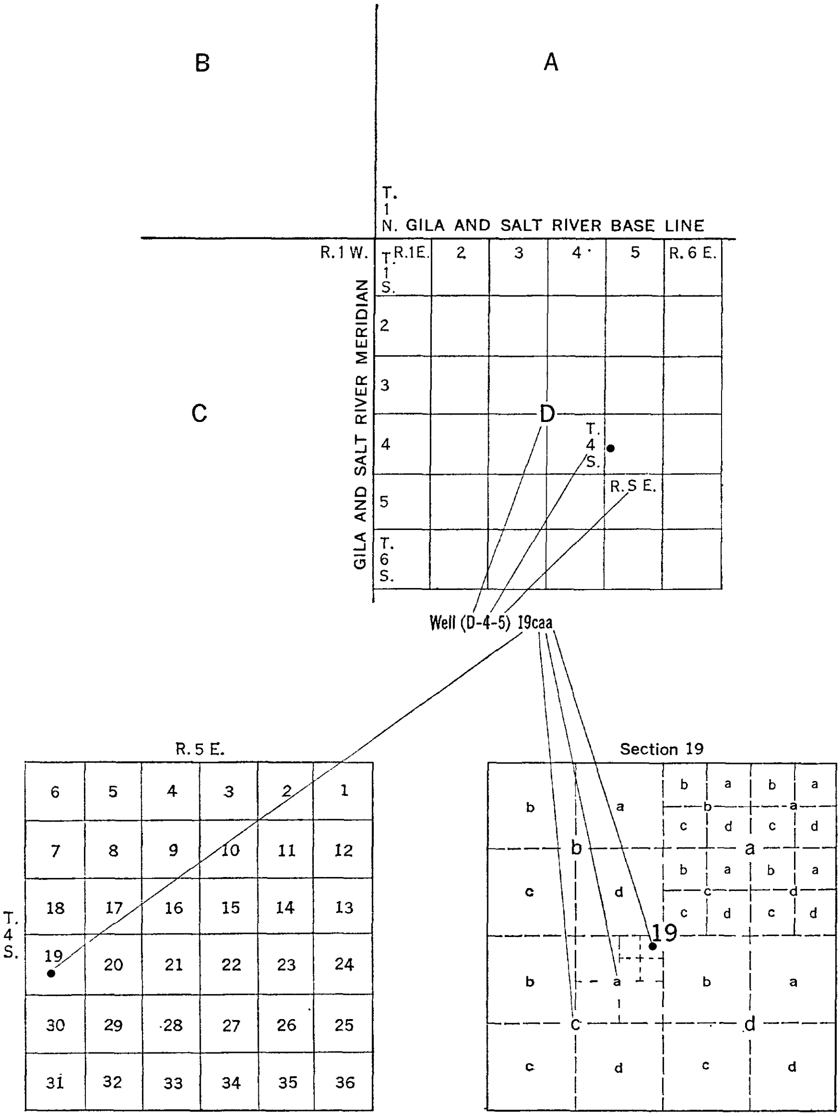

FIGURE 2.—Well-numbering system in Arizona.

by the capital letters A, B, C, and D. All land north and east of the point of origin is in A quadrant, that north and west in B quadrant, that south and west in C quadrant, and that south and east in D quadrant. The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The lowercase letters a, b, c, and d after the section number indicate the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters also are assigned in a counterclockwise direction, beginning in the northeast quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. In the example shown, well number (D–4–5)19caa designates the well as being in the NE¼NE¼SW¼ sec. 19, T. 4 S., R. 5 E. Where there is more than one well within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes. Where a section is more than a mile long in either direction, the designation S½, N½, E½, or W½ is added to indicate the part of the section in which the well is located.

ACKNOWLEDGMENTS

Many people in western Pinal County materially aided in the investigation. Local farmers, ranchers, landowners, well drillers, business people, and public and private companies graciously furnished data used in this report. Special thanks are given to personnel of the Pinal County Agricultural Agent's office, Casa Grande, and to personnel of the San Carlo Irrigation District and Project, Coolidge.

GENERAL ASPECTS OF WATER QUALITY

The chemical quality of the water in the alluvium of western Pinal County is nonuniform areally and stratigraphically. The dissolved solids of the ground water are derived mainly from the solution of rock constituents of the alluvial deposits. Some of the dissolved solids are introduced by surface water that infiltrates through stream channels and sediments along the mountain fronts.

The dissolved material is a result of weathering, which is the group of processes that cause rocks to change in character, to decay, and finally to crumble into soil. Some weathering products are soluble, but others are not. Water is an important agent in the weathering cycle because it dissolves and removes the products of weathering. The solubility of many minerals is increased by carbon dioxide (CO_2) in the water. Water obtains this carbon dioxide from the atmosphere and from soil in which organic material is decomposing.

Specific conductance serves as a general indication of the amount of dissolved material in the water. It is expressed in micromhos per centimeter at 25°C and is a measure of the ability of the ions in solution to conduct an electric current. Results of specific-conductivity measurements, made in the field by the authors, were divided into four ranges of conductivity without regard to well depth, location of casing perforations, or material penetrated. The four conductivity ranges are delineated by patterns on plate 1. In addition, analyses typical of water in the area are shown by means of Stiff pattern diagrams (adopted from Stiff, 1951). This graphical method of presenting water-quality data consists of four parallel lines and one vertical axis. The positive ions (cations) are plotted, one along each horizontal line to the left of the vertical axis (zero point). The negative ions (anions) are plotted in a like manner to the right of the vertical axis. Concentrations of the ions are expressed in equivalents per million. The plotted points are connected to form a closed pattern whose shape is characteristic of a given water.

Plate 1 shows two large areas of highly mineralized water—one near Casa Grande and the other near Coolidge. The poorer water quality near Casa Grande probably was caused by solution of calcium, sodium, sulfate, and chloride minerals contained in the sediments in this area or may be due, in part, to the upward movement of saline water from depth along fissures or faults. The Gila River probably is the source of the highly mineralized water in the Coolidge area because the character of the Gila River water is similar to the character of the ground water in that area. Much of the sediment in western Pinal County contains water that has less than 600 ppm (parts per million) of dissolved solids.

CORRELATION OF WATER QUALITY WITH SEDIMENT TYPES

Most of the data on the quality of the ground water in the lower Santa Cruz basin have been obtained from chemical analyses of water samples from wells that penetrate several water-bearing strata. The water discharged by the well pump is a composite sample from several depths, and the analysis will not indicate the differences in the quality of water from the different water-bearing zones. The depth-quality relation is more complex in deep wells because more water-bearing zones are penetrated.

The quality of the water yielded by a well can be regulated by perforating the well casing at selected depths; this selective perforating prevents water of poor quality from entering the well. Such perforating might result in a lower specific capacity of the well, but the improved quality of the water discharged could make this regulation worth while.

Probably the best way of obtaining information to describe the quality of the water from the various strata in the basin sediments is to collect water samples at the time of drilling, either by means of a bailer on cable-tool rigs or by packers on the drill stems of rotary rigs. Until the practice of collecting water samples becomes an accepted part of a drilling operation, the hydrologist must rely on substitute methods of sampling.

The deep-well point sampler was used successfully in this study for obtaining water samples at selected depths in wells. This type of sampler is a metal tube closed at both ends by ball valves. If the sampler is raised and lowered several times in rapid succession at the desired depth, water will pass the ball valves and be trapped in the tube.

In April 1961, water samples were collected from 15 wells at depths from 100 to 1,000 feet below the land surface. Measurements of the specific conductance of the water samples revealed differences in water quality at various depths.

The most striking difference in the quality of water from various depths was found in three wells that are about 6 miles east of Casa Grande and about 10 miles southwest of Coolidge in T. 6 S., R. 7 E. These wells are spaced from 1½ to 2 miles apart and range in depth from 810 to 1,385 feet. The wells are perforated from the water table to the bottom of the casing. The results of the chemical analyses (table 1) show that changes in specific conductance and temperature of the water from these wells with increasing depth are accompanied by corresponding changes in hardness and in sulfate and chloride content. The observed change in quality as depth increases is significant because it correlates with certain changes in the lithology of the sediments penetrated by the wells.

To correlate water quality with sediment types, a cross section (fig. 3) showing the subsurface geology was prepared from drillers' logs of the three wells. A permeable zone of sand, gravel, and clay extends from the surface to a depth of 260–375 feet (upper sand and gravel unit); this zone is underlain by a sequence of relatively impermeable clay and silt beds containing gypsum and salt in some places (silt and clay unit). Beneath the silt and clay unit are beds of sand, gravel, and clay (lower sand and gravel unit), which are underlain by bedrock. This unit formed by bedrock has low permeability and consists of tightly cemented sedimentary rocks, crystalline metamorphic rocks, or igneous rocks. Hardt, Cattany, and Kister (1964, p. 6) term this unit "hydrologic bedrock."

TABLE 1.—*Quality of water at different depths in wells in western Pinal County*

[Analyses in parts per million, except as indicated]

Depth of sample (feet below land surface)	Temperature (°F)	Hardness as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Specific conductance (micromhos at 25°C)
(D-6-7)25cdd [Total depth 810 ft]					
300	75	404			1,480
350	75	522	187	248	1,460
375	77	1,610	528	6,580	19,300
400	76	1,600			20,500
500					23,200
550	80	2,230	817	10,400	29,400
(D-6-7)27ddd [Total depth 1,385 ft]					
250	71	545			1,460
500	77	1,770	1,140	2,950	10,400
1,000	77	1,230	742	1,780	6,730
(D-6-7)32aaa [Total depth 1,000 ft]					
200	76				1,450
350	76				1,020
500	77	274	81	194	1,010
940	78				1,030

The difference in water quality from the three wells may be explained by a study of table 1 and figure 3. The specific conductance of the water in well (D-6-7)25cdd ranged from 1,460 micromhos at 350 feet below the land surface to 29,400 micromhos at 550 feet. An abrupt change in conductivity occurred between 350 and 375 feet, near the point of contact of the upper sand and gravel unit with the gypsum and salt zone in the silt and clay unit.

Laboratory tests were made to estimate the proportion of the water from well (D-6-7)25cdd that comes from the upper sand and gravel unit and from the silt and clay unit. Water having a specific conductance of 1,480 micromhos and a composition assumed to be equivalent to the average composition of that in the upper sand and gravel unit was mixed with water having a specific conductance of 24,000 micromhos and a composition assumed to be equivalent to the average composition in the silt and clay unit. The proportion of 10 parts of water of 1,480 micromhos and 1.4 parts of water of 24,000 micromhos, gave a solution having a specific conductance of 5,960 micromhos, which is equivalent to the specific conductance of the water from well (D-6-7)25cdd.

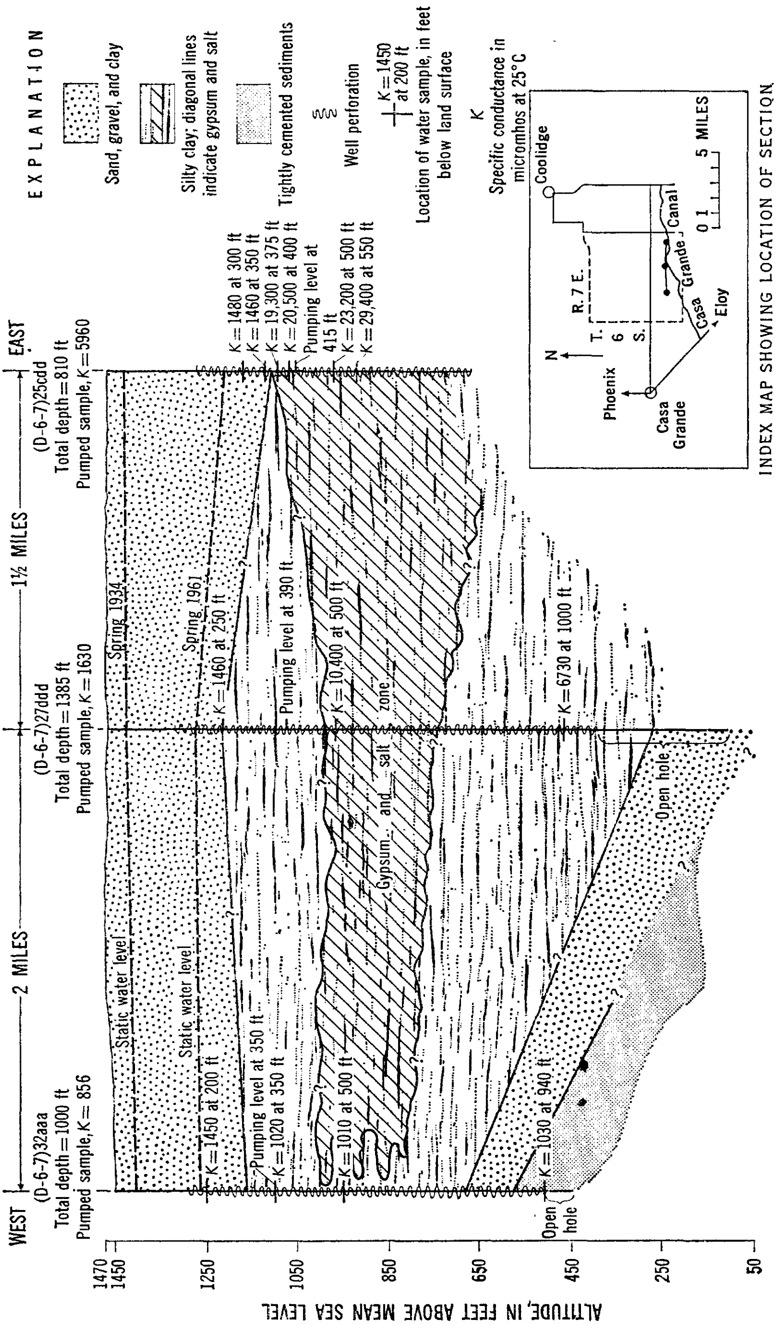

FIGURE 3.—Geologic section showing changes in conductance of ground water.

These tests indicated that less than one-fifth of the yield of well (D–6–7)25cdd is from the silt and clay unit. Small increases in the proportion of water yielded by this unit will result in a disproportionate increase in the specific conductance of water yielded by this well.

Similar data were collected from well (D–6–7)27ddd, which is about 1½ miles west of well (D–6–7)25cdd. The specific conductance of the water yielded by the well was 1,630 micromhos. The specific conductance of the water sampled at 250 feet below the land surface was 1,460 micromhos; at 500 feet below the land surface the conductivity was 10,400 micromhos, and at 1,000 feet it was 6,730 micromhos. The water at 1,000 feet probably is a mixture of the more dense saline water from the overlying silt and clay unit and the fresh water from the lower sand and gravel unit.

Assuming that the average conductivity of the water from the gypsum and salt zone in the silt and clay unit at well (D–6–7)27ddd is 8,500 micromhos—the average specific conductance of the samples collected at 500 and 1,000 feet—only about 2 percent of the yield is from the evaporite zone. The rest of the yield is from the upper sand and gravel unit above 260 feet and from the lower sand and gravel unit below 1,200 feet.

The specific conductance of the composite sample of water from well (D–6–7)32aaa was 856 micromhos, whereas the specific conductance of the point samples was 1,450 micromhos in the upper sand and gravel unit and ranged from 1,010 to 1,030 micromhos in the silt and clay and bedrock units. This difference in specific conductance probably indicates that water of excellent quality under artesian pressure is coming from the lower sand and gravel unit at 770–870 feet below the land surface. Unfortunately no water samples were collected from this zone. Water of high conductivity probably is penetrated by the well in the silt and clay unit, but its presence in the well bore is masked by the upward flow of good water. Well logs indicate gypsum in the silt and clay unit at about 450 feet below the land surface.

An analysis of the geohydrologic factors that affect the quality of water yielded by wells (D–6–7)25cdd and (D–6–7)27ddd shows that a serious problem of deteriorating quality will arise if overpumping of these wells continues. The quality will deteriorate in these wells because, as the water levels decline, the gypsum and salt in the silt and clay unit will yield progressively larger proportions of water. In well (D–6–7)32aaa the lower sand and gravel unit contributes substantial amounts of good-quality water to the well; if this contribution continues, the quality change in this well will be less than in the other two wells.

This study shows that chemical analyses of water samples collected from the discharge pipe of a pumping well are not necessarily indicative of the quality of the water throughout the sequence of sediments penetrated by the well. To collect quality-of-water data at the time of drilling or from point samples under static conditions and to correlate these data with lithology will assist materially in obtaining an accurate interpretation of the hydrologic regime and the changes imposed upon it by man's manipulations.

CHANGES IN GROUND-WATER QUALITY

Two main reasons for expecting changes in the quality of water from a pumped well, over a period of time, are (1) migration of water of different quality because of ground-water withdrawal by pumping, and (2) percolation of irrigation water to the water table.

EFFECT OF GROUND-WATER WITHDRAWAL ON WATER QUALITY

About 1 million acre-feet of ground water was pumped from the lower Santa Cruz basin for agricultural, domestic, and industrial uses in 1963. About 250,000 acre-feet of this amount came from the Eloy area, about 440,000 acre-feet from the Stanfield-Maricopa area, and about 290,000 acre-feet from the Casa Grande–Florence area. Other nonirrigation uses of water in the basin amounted to about 20,000 acre-feet. In some places water levels have declined more than 275 feet since 1923 because of ground-water withdrawal. Changes in water quality have coincided with decline in water level, most noticeably in the Casa Grande–Florence area.

Hem (in Turner and others, 1943, pl. 3) shows that in 1941–42 the western boundary of the highly mineralized water near Casa Grande was on a line extending about 12 miles west-northwest from the Casa Grande Mountains. (See heavy line in pl. 1.) Data collected in 1960 show that the western boundary of this highly mineralized water has migrated in a general southwesterly direction. In 1960 the approximate position of the boundary represented by water containing 500 ppm dissolved solids is the heavy dashed line between the 1,000–2,000 specific-conductance and the $<1,000$ specific-conductance values. The ground-water movement in this area is toward a depression in the water table caused by pumping in the area west of a ground-water barrier known locally as the Casa Grande ridge.

A similar but slower movement of highly mineralized water has occurred near Coolidge. Here also the rate and direction of the movement are influenced by heavy pumping, but the decline of the water table in this area is not as great as that near Casa Grande.

EFFECT OF IRRIGATION ON WATER QUALITY

When land is irrigated, evaporation and transpiration and the resultant loss in water cause dissolved minerals to be concentrated or to be precipitated; the increase in dissolved minerals forms saline soils. The formation of these soils depends on the amount of water used and the concentration of dissolved solids in the irrigation water. Where salts are being deposited, they must be removed from the plant root zone by leaching to prevent an excessive buildup of salts that eventually would adversely affect crop production. If a saline soil solution is formed and this water seeps to the ground-water reservoir, deterioration in the quality of the ground water may result.

Recharge from irrigation probably has not affected the quality of the ground water in most of western Pinal County, although saline soil solutions probably are being formed locally. The depth to water is more than 200 feet in most places, and it may be many years before the salts from the irrigation water reach the water table. The rate of decline of the water level in some areas may be faster than the rate of downward movement of the irrigation water. If the water table continues to decline, the cost of pumping may force an end to irrigation from wells long before the quality of the ground water is affected by irrigation recharge.

RELATION OF CHEMICAL QUALITY TO AGRICULTURAL USE

The main factors to be considered in analyzing the suitability of water for irrigation are dissolved-mineral concentration expressed as dissolved solids, specific conductance, sodium-adsorption-ratio (SAR), and the concentration of boron and bicarbonate; however, water for irrigation cannot be evaluated solely on its chemical character. Other factors, such as permeability of the soil, effectiveness of drainage, amount of water used, and salt tolerance of the crop to be irrigated also must be considered.

Irrigation generally increases the salinity of the soil water unless the soils are well drained. In heavily irrigated sandy soils the soil solution may have about the same concentration as the irrigation water. In heavy soils, where evaporation is greater than drainage losses, the concentration of the soil solution may be as much as 100 times that of the irrigation water. This concentration is enough to retard plant growth.

Calcium and sodium are two of the principal dissolved constituents in ground water in western Pinal County. Both exert important effects on the soil texture by ion-exchange reactions. As water seeps through the soil, some of the dissolved constituents in the water may be exchanged for other constituents in the soil; for example, where water containing high sodium concentrations comes in contact with soil, sodium ions may be adsorbed on the framework of the soil particles, and calcium and magnesium ions may be released to the soil solution. This exchange of elements is called ion exchange or base exchange. Large amounts of calcium in irrigation water generally improve or maintain the permeability of soils and allow water to penetrate readily. On the other hand, high sodium concentrations in irrigation water may cause the soil to become impermeable and difficult to till. Eaton (1950, p. 127–128) states: "The replacement by sodium of the exchange calcium and magnesium of the soil brings about progressive destruction of particle aggregates and, with particle dispersion, impermeability, provided the soil solution is not very saline. A sodium soil may be permeable to saline water and yet be extremely impermeable to rain."

CONDUCTIVITY

It has been accepted generally that 2,250 micromhos is about the upper limit of conductivity for irrigation water; however, water which has higher conductivity apparently is used successfully in parts of western Pinal County. The moderate salinity of the soil, efficient leaching practices, application of soil amendments, and cultivation of salt-resistant crops make the use of water of fairly high conductivity possible.

SODIUM-ADSORPTION-RATIO (SAR)

Water used for irrigation can be rated according to salinity hazard and sodium or alkali hazard, according to a method formulated by the staff of the U.S. Salinity Laboratory (1954). This method utilizes SAR and conductivity as a basis for rating irrigation water.

The SAR values of an irrigation water are used as a basis for predicting the alkali or sodium hazard that may result from the use of the water. High SAR values may cause damage to soils. Use of SAR as a method for rating water depends on the equilibrium between exchangeable positive ions (cations) on the soil and cations in the irrigation water. The equilibrium established between the ions adsorbed on the soil complex (X) and the calcium and sodium ions in solution is as follows:

$$Ca^{2+}X_2+2Na^+ \rightleftharpoons 2Na^+X+Ca^{2+}.$$

The SAR value for a water is calculated by the following formula in which sodium, calcium, and magnesium are expressed in equivalents per million:

$$SAR=\frac{Na^+}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}.$$

SALINITY AND SODIUM HAZARDS

An explanation of the classification of the sodium and the salinity hazard as shown in figure 4 is as follows (U.S. Salinity Laboratory Staff, 1954, p. 79–81):

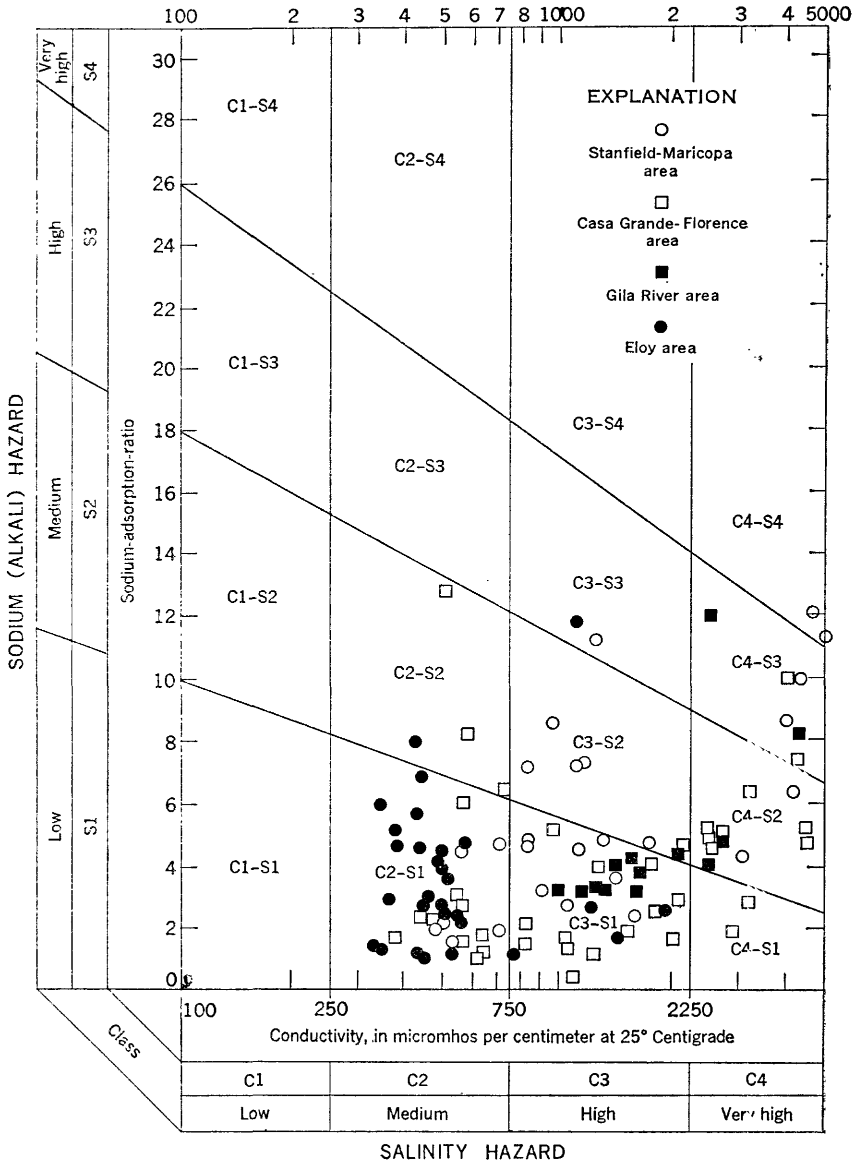

FIGURE 4.—Sodium and salinity hazard of ground water. Diagram adopted from U.S. Salinity Laboratory Staff (1954).

"Low-Salinity Water (C1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability."

"Medium-Salinity Water (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control."

"High-Salinity Water (C3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected."

"Very High Salinity Water (C4) is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected."

"Low-Sodium Water (S1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchaneable sodium. However, sodium-sensitive crops such as stone-fruit trees and avocadoes may accumulate injurious concentrations of sodium."

"Medium-Sodium Water (S2) will present an appreciable sodium hazard in fine-textured soils having high cation-exchange-capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability."

"High-Sodium Water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management—good drainage, high leaching, and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium, except that amendments may not be feasible with waters of very high salinity."

"Very High Sodium Water (S4) is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these waters feasible."

SIGNIFICANCE OF CARBONATE IN IRRIGATION WATER

The relation of calcium and magnesium to bicarbonate and carbonate in irrigation water is important in determining the probability of the formation of black alkali soils. If water contains a large amount of bicarbonate or carbonate, calcium and magnesium tend to precipitate as carbonate in the soil solution. Thus, the proportion of sodium in the water is increased. As calcium and magnesium are lost, the chance that sodium carbonate will form is greatly increased. Eaton (1950) calls this residual sodium carbonate and has defined it as the excess of carbonate over calcium plus magnesium expressed in milliequivalents per liter (meq per l). On the basis of experiments by personnel of the U.S. Salinity Laboratory (1954, p. 81–82),

it is concluded that waters with more than 2.5 meq per l "residual sodium carbonate" are not suitable for irrigation purposes. Waters containing 1.25 to 2.5 meq per l are marginal, and those containing less than 1.25 meq per l "residual sodium carbonate" are probably safe. It is believed that good management practices and proper use of amendments might make it possible to use successfully some of the marginal waters for irrigation. These conclusions are based on limited data and are, therefore, tentative.

Some irrigation water in western Pinal County is likely to contain residual sodium carbonate; however, the data show that most of the water may be classed as safe to marginal. Good management practices and proper use of soil amendments have apparently made the use of marginal-quality water for irrigation successful in western Pinal County.

FLUORIDE IN GROUND WATER

The concentration of fluoride in water is an important consideration in the evaluation of the suitability of water for domestic purposes. Optimum fluoride concentrations help reduce incidence of tooth decay; however, concentrations greater than the recommended upper limits tend to cause dental fluorosis (mottled enamel) in children. The optimum fluoride level depends on climatic conditions because the amount of water (and consequently the amount of fluoride) ingested by children is primarily influenced by air temperature (U.S. Public Health Service, 1962, p. 41). Aside from the physiological aspects of fluoride concentration in water, the amount of fluoride in water also may be important in relation to the geologic and lithologic environment. The following discussion is concerned mainly with the occurrence of fluoride in ground water in relation to the types of sediments in the drainage basin. The distribution of fluoride in ground water is shown on plate 2; the zones represent water containing less than 1.5 ppm and more than 1.5 ppm fluoride.

Fluoride-bearing minerals are usually common in igneous rocks and less abundant in sedimentary rocks. The fluoride ion (F^-) occurs frequently in mica (biotite and muscovite), amphibole (hornblende), and other minerals. Apatite is also an important mineral group containing fluoride, and according to Barth (1947), all the fluoride in basalt comes from apatite. The most abundant and widely distributed fluorine mineral is fluorite (CaF_2), which is found in veins or is associated with metallic ores; this mineral is also found in limestone, dolomite, and as an accessory mineral in igneous rocks and pegmatite.

The fluoride-bearing minerals generally are present in the alluvial sediments in the basins in southern Arizona and probably were enriched in the indurated sediments that form the bedrock. High concentrations of fluoride are possible in dilute water only if the concentration of calcium is very low. Such water is uncommon but may exist in an environment that contains fluorite but has the calcium removed from solution by ion-exchange reactions.

Where ground water in western Pinal County contains more than about 1.0–1.5 ppm fluoride, calcium concentration is low. Water containing more than 1.5 ppm fluoride has about the same distribution as the moderately and highly mineralized water shown on plate 1. Fluoride in excess of 1.5 ppm occurs near the edge of the mountains in the western part of the Stanfield-Maricopa area, near the Casa Grande ridge, in the Coolidge area, east of Maricopa, and north of the Gila River in T. 3 S., R. 6 E. (pl. 2). The ground water in the Eloy area contains less than 1.5 ppm fluoride with the exception of an anomalously high fluoride content found in a few deep wells. The position of these wells with respect to the bedrock is shown in cross section *A–A'* from Red Rock northwest to sec. 29, T. 7 S., R. 6 E. (fig. 5). In most places where the bedrock is tapped by a well, the water contains more than 1.5 ppm fluoride. Water from well (D–8–7)9add, which penetrates more than 300 feet of the bedrock, contains 5.3 ppm fluoride. This well is 2,100 feet deep and yields water from the 1,800- to the 2,100-foot level. Water from well (D–5–6)27ada, which is 1,480 feet deep, contains 9.0 ppm fluoride. This well penetrates more than 200 feet of the bedrock. Evidence collected recently from other parts of southern Arizona indicates that a unit similar to the bedrock of this report contains significantly large amounts of fluoride.

QUALITY OF WATER IN THE ELOY AREA

Hem states (in Turner and others, 1943, p. 74): "Ground water in the Eloy area is very uniform in chemical character. Generally water samples from this area were found to contain about 300 parts per million of dissolved solids, largely calcium bicarbonate. Waters encountered at various depths did not seem to differ appreciably in concentration." Deeper wells have been drilled since the 1941 data were obtained, and many more water samples have been analyzed; thus the volume of available data has increased. These new data show, however, that the quality of ground water in this area is virtually unchanged from that described 20 years ago.

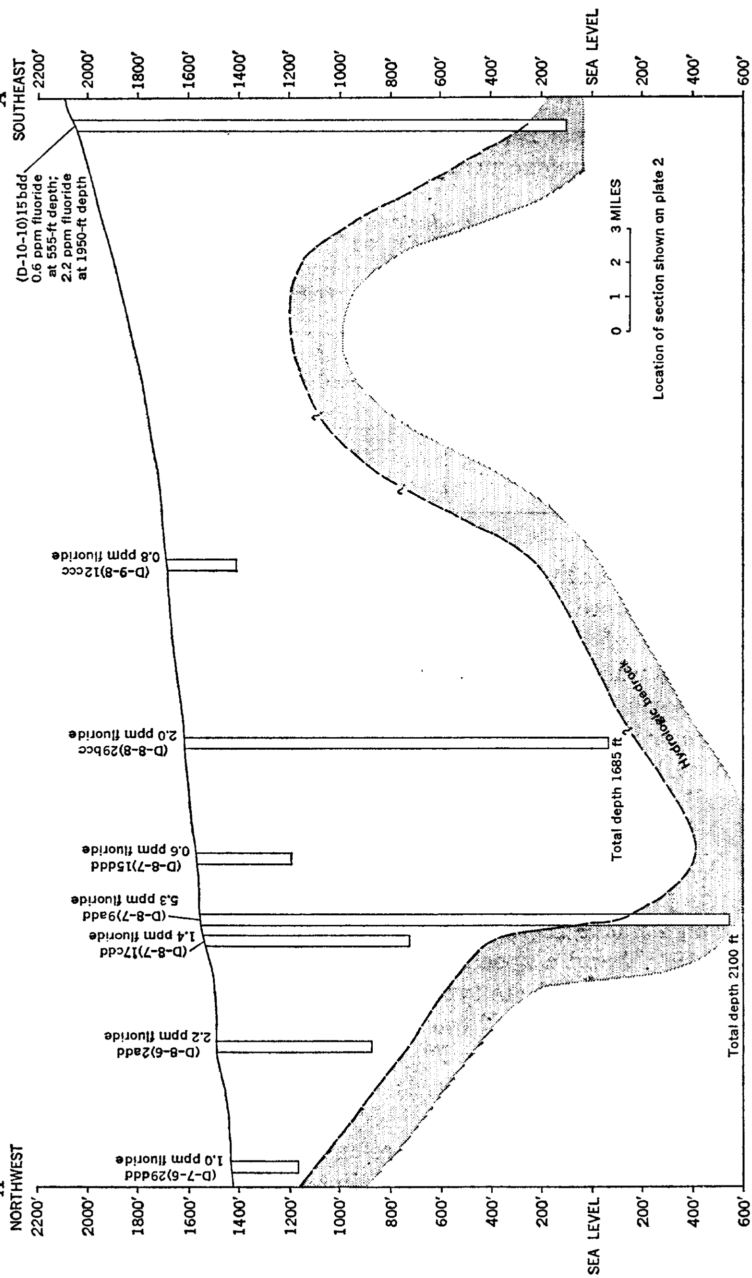

FIGURE 5.—Fluoride concentration of ground water in relation to bedrock.

The median specific conductance of 131 samples taken from 1941–48 was 467 micromhos. The median dissolved solids was calculated to be 304 ppm (table 2). The median specific conductance of 220 samples taken in 1960 was 460 micromhos, and the computed value for median dissolved solids was 299 ppm. There was no significant change in the dissolved-solids concentration of the ground water.

TABLE 2.—*Change in specific conductance and dissolved solids in ground water, 1941–48 and 1960*

Area	Median specific conductance		Median dissolved solids (calculated)	
	1941–48	1960	1941–48	1960
Eloy	467	460	304	299
Casa Grande–Florence	1, 120	880	728	572
Stanfield–Maricopa	600	810	390	526
Gila River	1, 650	1, 500	1, 070	975

Some of the samples taken during both periods showed a specific conductance of as much as 4,400 micromhos; however, unusually high conductances were shown generally by samples from wells in the northwestern part of the area. The conductance in almost 95 percent of the samples was less than 1,000 micromhos. The median conductance is given because it is affected less by the unusually high conductances in the upper limits of the sample distribution.

Two wells in sec. 9, T. 8 S., R. 7 E., yield water of different quality. One well is 418 feet deep and yields water having a temperature of 77°F and a specific conductance of 507 micromhos; the water is a calcium bicarbonate type. The second well is 2,100 feet deep, and the casing is perforated from 1,000 to 1,500 feet below the land surface and from 1,800 to 2,100 feet; the well yields water having a temperature of 125°F and a specific conductance of 3,300 micromhos. This water is a sodium sulfate type. The driller reported that most of the yield from the second well was from the 1,800- to 2,100-foot level.

Most of the water in the Eloy area is rated low in sodium hazard and medium in salinity hazard; however, water that has very high sodium and salinity hazards probably is present at depths greater than those reached by most of the present wells. Well (D–8–7)9add is 2,100 feet deep and yields water having a specific conductance of 3,300 micromhos and a sodium-adsorption-ratio of 38 (fig. 4). More water of this quality may be used in the future if the declining water table makes deeper wells necessary.

Although the fluoride concentration in the ground water is generally less than 1.5 ppm, there is evidence that fluoride concentration increases with depth. The water from well (D–10–10)15acc southeast of Red Rock contains 0.6 ppm fluoride at 555 feet below the land surface and 4.0 ppm at 1,950 feet. Water from the 1,800- to 2,100-foot level in well (D-8-7)9add, about 8 miles west of Eloy, contains 5.3 ppm fluoride. Well (D-8-6)2add is 600 feet deep and yields water containing 2.2 ppm fluoride.

QUALITY OF WATER IN THE CASA GRANDE-FLORENCE AREA

The quality of the ground water in the Casa Grand-Florence area is extremely variable. From 1941–48, the specific conductance of the water ranged from 385 to 7,040 micromhos; in 1960 the range was from 390 to 5,800 micromhos. The median specific conductance of 105 samples taken from 1941–48 was 1,120 micromhos; the median for 195 samples in 1960 was 880 micromhos (table 2). Differences in the areal distribution of the sampling for the two periods may be the explanation for the apparent improvement in the quality.

The sodium hazard is low to medium and the salinity hazard is medium to very high for most of the water in the area (fig. 4); however, water having very high sodium and salinity hazards is present, mainly in the area of highly mineralized water near Casa Grande (pl. 1). The most satisfactory ground water for irrigation is found between Casa Grande and Florence.

Some ground water near Coolidge contains more than 1.5 ppm fluoride. Well (D-5-9)30cbb is 350 feet deep and contains 6.0 ppm fluoride; the University of Arizona has reported 8.5 ppm fluoride in the water from a 444-foot-deep well at Coolidge.

QUALITY OF WATER IN THE STANFIELD-MARICOPA AREA

There has been a slight overall increase in the salinity of the ground water in the Stanfield-Maricopa area from the testing period of 1941–48 to that of 1960. The median specific conductance of the water from 1941–48 was 600 micromhos, and in 1960 it was 810 micromhos. Ground water that has a specific conductance of less than 1,000 micromhos is present in most of the area; however, in the southeastern part, highly mineralized water occurs near the Casa Grande ridge. Plate 1 shows that the highly mineralized water has moved several miles southward and westward since 1941, probably because heavy pumping has formed a depression in the water table west of Casa Grande and caused the migration of saline water in the aquifer.

The alluvium in the extreme western part of the area contains moderately mineralized water along the mountain slopes. Recharge to this area may pass through sedimentary rocks that contain some evaporite minerals. Some of the wells in this area yield water containing more than 1,000 ppm of dissovled solids. A driller reported salt water at 60 feet below the land surface and fresh water at a greater depth. When the salt-water section was sealed off, the well yielded potable water.

Wells in secs. 3–28, T. 5 S., R. 3 E., yield water that has a specific conductance of more than 1,000 micromhos (pl. 1). This area forms an "island" of moderately saline water that is surrounded by water of good quality. The island also conforms in shape and location to a ground-water "high." To the west, heavy pumping has formed a water-table depression, and wells yield water of good quality; it is possibile that moderately saline water existed at shallow depths prior to pumping and that subsequent development has dewatered the saline part of the aquifer.

The salinity hazard of the ground water in the area ranges from medium to very high (fig. 4). The very high salinity hazard water is near the Casa Grande ridge and also in the northwest part of the area. The sodium hazard of the water ranges from low to very high. Most of the wells in the area yield water that may be classed as having a low sodium and high salinity hazard; some of the wells have been abandoned because of the high salinity of the water.

Places in which the quantity of fluoride in the water is more than 1.5 ppm are limited to the western part of the area, near the Casa Grande ridge, and west of Maricopa (pl. 2).

QUALITY OF WATER IN THE GILA RIVER AREA

The quality of the ground water in the Gila River area is uniform in chemical composition, ranging in specific conductance from about 1,000 to 2,000 micromhos. The water is similar in composition to the Gila River water in that it is mainly of the sodium chloride type (pl. 1).

Only a small amount of quality-of-water data is available for wells in this area; the median specific conductance of 35 samples taken from 1941–48 was 1,650 micromhos, as compared to 1,500 micromhos for 38 samples taken in 1960 (table 2).

Water-quality changes occur with depth, as revealed in well (D–4–6)16adc. Data from this well show the specific conductance of the water to be 1,730 micromhos at 214 feet below the land surface and 480 micromhos at 460 feet. The water at the greater depth contains less calcium and magnesium.

The water of the Gila River area is rated mainly as high in salinity hazard and low in sodium hazard, which indicates that it can be used on almost all soils with little danger that exchangeable sodium will accumulate to harmful levels; however, if the water is used on soils with restricted drainage, special management for salinity control may be required.

Fluoride concentration in the water is generally less than 1.5 ppm, except in the area north of the Gila River close to the Santan Mountains where the observed fluoride concentration is as much as 2.0 ppm. Fluoride does not seem to be an important contaminant in the ground water from the Gila River area.

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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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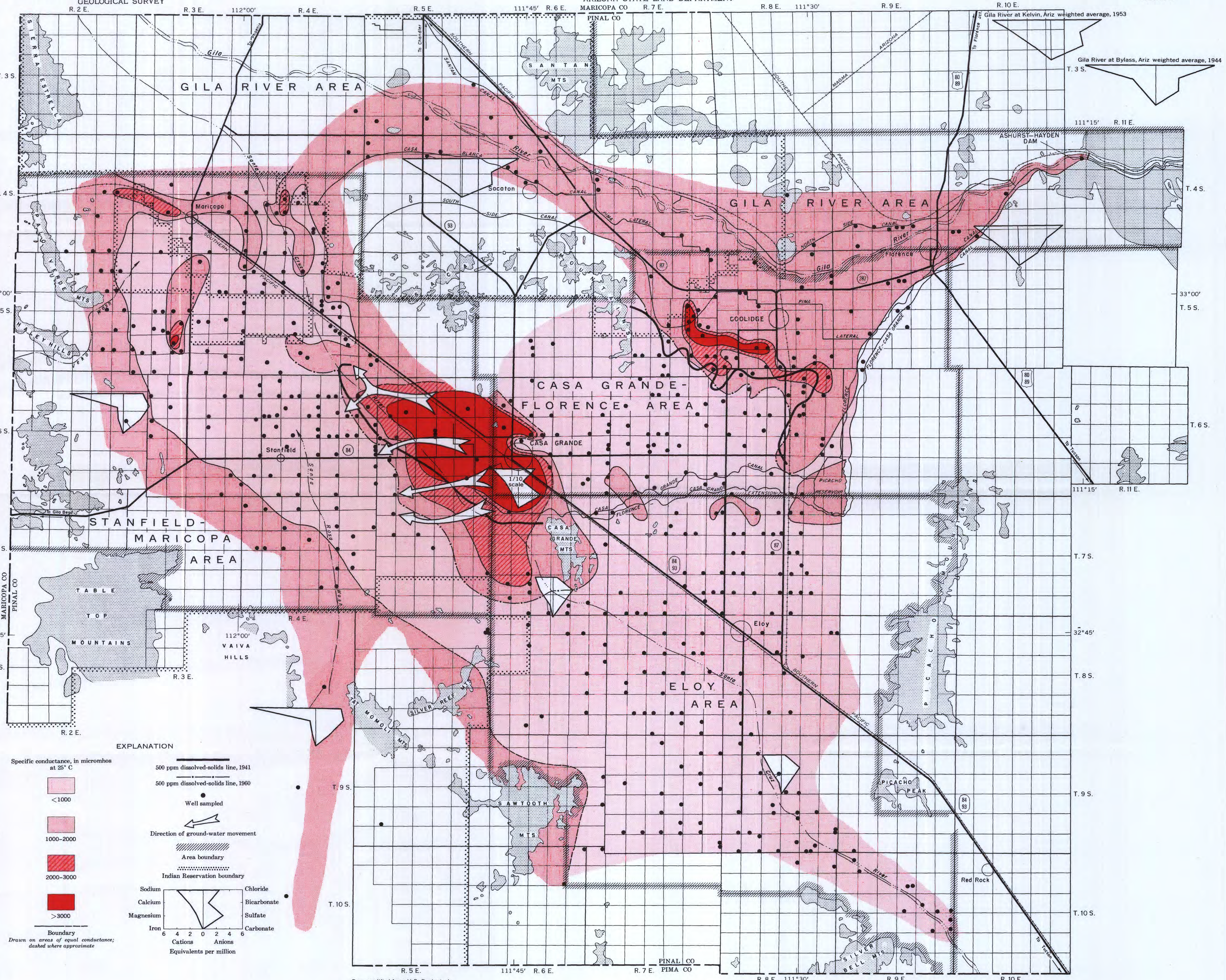
ARIZONA STATE LAND DEPARTMENT

WATER-SUPPLY PAPER 1819-E
PLATE 1



Base modified from U.S. Geological Survey topographic quadrangles

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1966—W65312

Water-quality data compiled by L. R. Kister, 1960

MAP SHOWING AREAS OF DIFFERENT WATER TYPE AND SPECIFIC CONDUCTANCE OF GROUND WATER, WESTERN PINAL COUNTY, ARIZONA

5 0 5 10 MILES

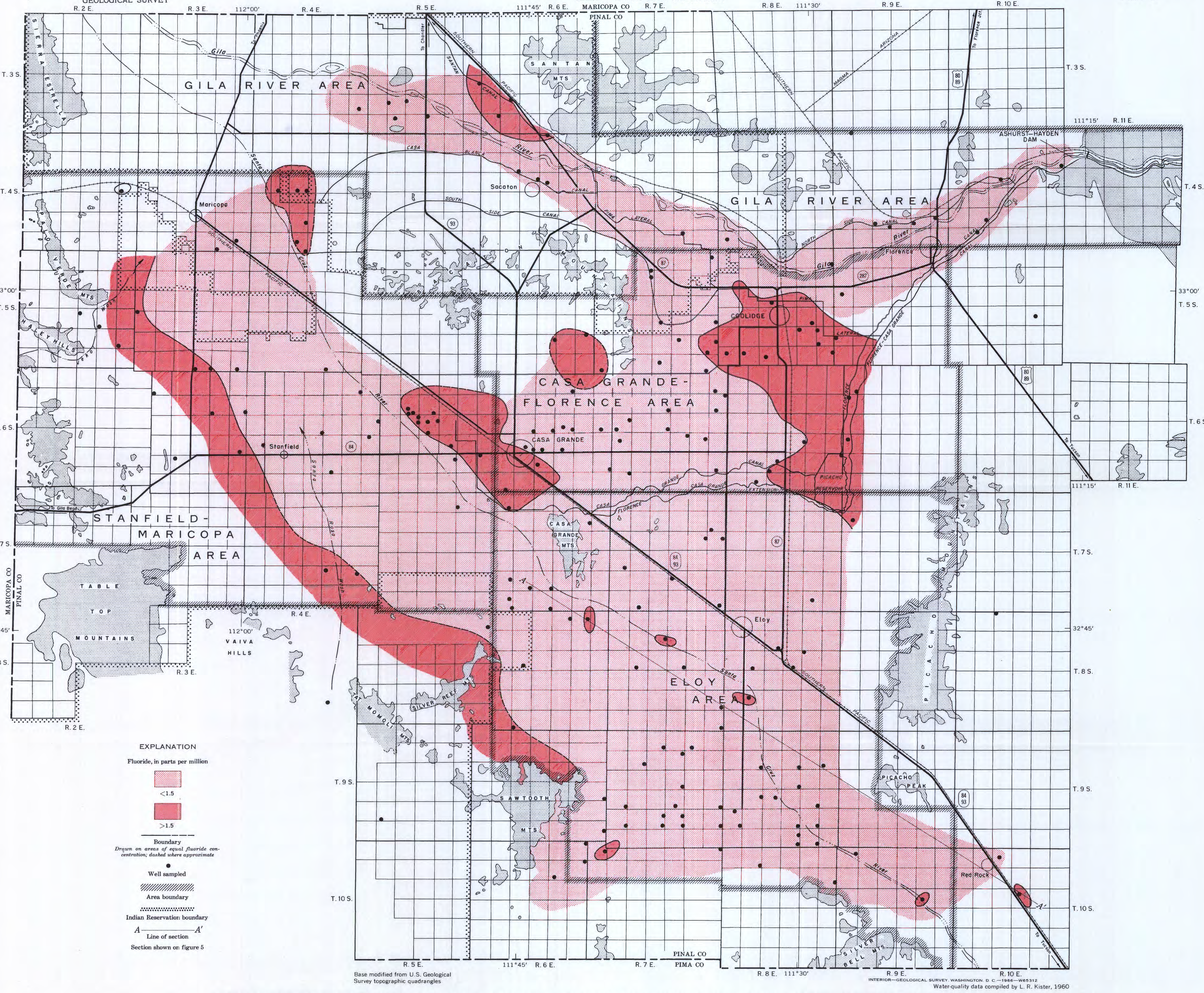
5 0 5 10 KILOMETERS

APPROXIMATE MEAN DECLINATION, 1966

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
ARIZONA STATE LAND DEPARTMENT

WATER-SUPPLY PAPER 1819-E
PLATE 2



MAP SHOWING DISTRIBUTION OF FLUORIDE IN GROUND WATER, WESTERN PINAL COUNTY, ARIZONA

5 0 5 10 MILES

5 0 5 10 KILOMETERS

APPROXIMATE MEAN DECLINATION, 1966