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SPRINGS IN THE VICINITY OF SOCORRO, NEW MEXICO

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INTRODUCTION

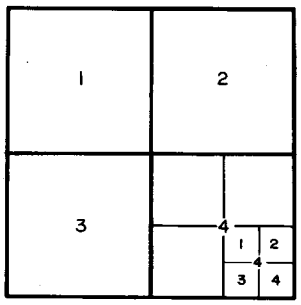
Purpose and Scope

The purpose of this paper is to present chemical, hydrological, and geological data and some interpretations for springs in the vicinity of Socorro, Socorro County, New Mexico (figure 1). Not every spring in the area covered by Figure 1 has been visited, but insofar as is known few major springs have been missed.

An attempt is made to relate yield and chemical content and temperature of the water with the character of the water-bearing formation and structural and topographical relationships. Some discussion is given to various types of classifications that might be useful. In addition, consideration is given to chemical equilibrium relationships in the systems $CaCO_3$-CO_2-H_2O and $CaCO_3$-CO_2-$CaSO_4$-H_2O.

Location and Numbering System

The area studied is in the central part of Socorro County, New Mexico, and is approximately centered around the city of Socorro (figure 1). The area covers about 1500 square miles extending from the Rio Salado on the north to the southern tip of the Magdalena Mountains on the south, and from the Magdalena and Bear mountains on the west to about 10 miles east of the Rio Grande on the east.



The numbering system for springs is the same as the well and spring location system used by the U.S. Geological Survey in New Mexico. The method of numbering is based on the public land survey system. A location number consists of four sets of digits and symbols connected by periods. The first set is for the township south (S) or north (N) of the principal base line, and the second set is for the range east (E) or west (W) of the principal meridian. The third set is the section number within the township, and the fourth set is the location within the section. The fourth set of numbers is obtained by subdividing a section as shown in the diagram.

The subdivision is based on the regular quarter section method; for example, the NW¼ of the section is shown by 1; the SE¼ of the NW¼ is shown by 14, and the SW¼ of the SE¼ of the NW¼ is shown by 143. A number such as 1S.2W.10.123 means that a spring is located in the SW¼ of the NE¼ of the NW¼ of section 10, Township 1 South, Range 2 West. Where the map coverage is inadequate or locations are doubtful, zeros will be used; for example, a final three digits of 340 means that the location is good only to the quarter-quarter section and 300 means good only to the quarter section.

Climate and Vegetation

The climate of the Socorro area is predominantly semiarid with hot, dry summers and cool, dry winters with most precipitation occurring during the summer. Relative humidity is low most of the time. The area generally has a period of strong winds during the late spring and early summer. Temperature extremes range from 10°F below zero or less during the winters to more than 100°F during the summers. The varied topographic relief has a pronounced influence on climate with a range of semiarid in the Rio Grande valley and lower areas up to nearly subhumid on top of the Magdalena Mountains.

The general climatic regime of the area is illustrated by data from weather stations at Socorro, Bosque del Apache, and Magdalena (U.S. Weather Bureau; *also see* Dorroh, 1946). The station at Socorro is at an elevation of 4600 feet above sea level and has records back to 1850, but the following statistics are based mainly on the period 1905-1961: average annual precipitation of 8.74 inches and average annual temperature of 58.5°F, with mean monthly ranging from about 37°F in January to about 79°F in July. Thomas (1962, p. 20) gives an average annual for Socorro of 10.12 inches for 1882-1943 and Dorroh (1946, p. 37) gives 10.12 inches for apparently the same period. The station at Bosque del Apache, located at the south edge of the area (figure 1), is at an elevation of about 4500 feet and has records

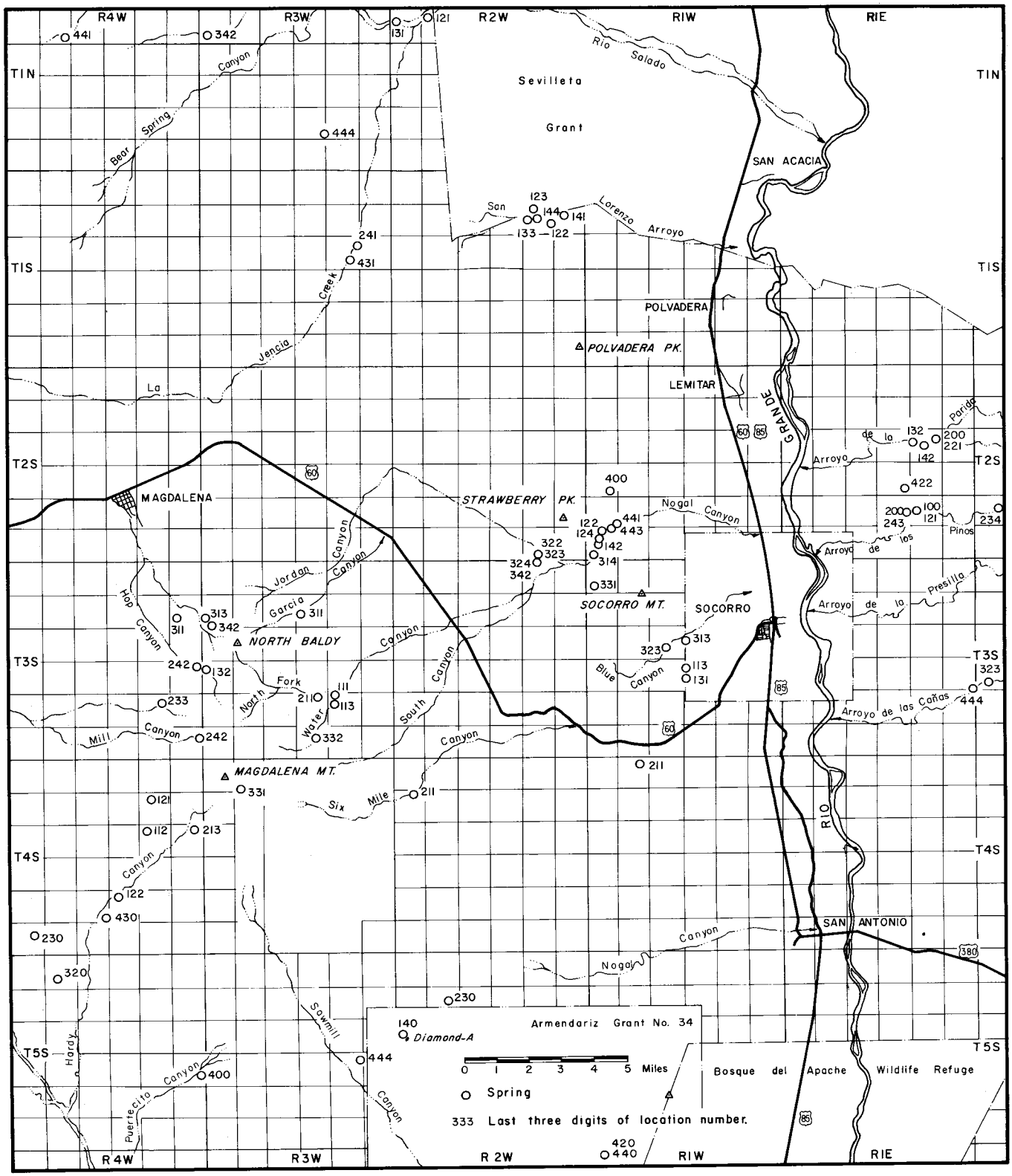


FIGURE 1

Spring locations in the Socorro region, New Mexico.

back to 1851, but the following statistics are based mainly on the period 1909-1961: average annual precipitation of 7.77 inches, average annual temperature of 58.1°F, with mean monthly ranging from about 38°F in January to about 78°F in July; Class A pan evaporation for 1947-1961 was about 100 inches a year with evaporation taking place every month. The station at Magdalena is at an elevation of about 6600 feet and has records back to 1889, but the following statistics are based primarily on the period 1906-1961: average annual precipitation of nearly 12 inches and average annual temperature of about 52°F, with mean monthly ranging from about 33°F in January to about 71°F in July. Average annual potential evapotranspiration for the period 1951-1954 has been computed to be 2.68 feet at Socorro and 2.70 feet at Bosque del Apache (Hantush, 1959, p. 24).

One climatic feature of particular interest is the drought in the Southwest during the period 1942-1956 (Thomas, 1962; Thomas et al., 1963). Precipitation at Socorro was considerably less than potential evapotranspiration during the period 1951-1954, and this is probably the case in most years. Therefore, from the viewpoint of a humid region, Socorro and vicinity could be said to be under practically permanent drought conditions. For a semiarid region, however, meteorologic records indicate alternating periods of some 10 to 15 years of above average and below average precipitation. A drought is then better considered to be an extended period of less than normal rainfall. A cumulative departure curve from average annual precipitation for 1905-1961 in Socorro indicates that such a period extended from 1942 to 1956, and a 5-year moving average curve for the same period indicates that a dry period occurred from 1943 to 1956. The rainfall for 1956-1962 was about or slightly below average.

The vegetation of the Socorro area is influenced by climate and topography. Away from streams at the lower elevations, the typical vegetation consists of creosote, sage, and cacti with grasses. At intermediate elevations, grasses are more prevalent and pinon and juniper become common; also scrub oak is present. In the mountainous areas, the vegetation trends increasingly toward conifers. Extensive groves of salt cedar and mesquite are found along the Rio Grande and for considerable distances up tributary streams and arroyos. Cottonwood and willows are found along the Rio Grande and other tributaries, and are often indicative of springs. Aspen groves are quite often characteristic of spring areas at elevations in excess of 7500 feet.

GENERAL GEOLOGY

The geology of the Socorro area is discussed in detail elsewhere in this guidebook (and see particularly DeBrine et al., 1963). The rocks in the vicinity of Socorro range in age from Precambrian to Recent and include a diversity of lithologic types. The area can be subdivided into three distinct north-south trending belts for the purposes of this paper: east of the Rio Grande, the Rio Grande Valley, and west of the Rio Grande. The Rio Grande Valley is filled with fluviatile and playa deposits of the Santa Fe group (late Tertiary age) and the volcanics and sediments of the Datil and Baca formations (Tertiary age). The valley also has a veneer of Recent alluvium along stream bottoms and gravels and dunes on the terraces.

East of the Rio Grande the rocks are mainly of Paleozoic age with the more important units being Pennsylvanian limestones and the Abo, Yeso, Glorieta, and San Andres formations of Permian age. Some Precambrian is found in the Joyita Hills east of San Acacia and in isolated patches to the south. Some undifferentiated Mesozoic sediments mainly of Triassic age are found in the Valle de la Parida northeast of Socorro. A thin belt of Datil and Baca formations is found along the boundary with the Rio Grande Valley. Recent alluvium covers the arroyo bottoms, and sand dunes are found at various elevations on the terraces.

West of the Rio Grande, the rocks are mainly of volcanic origin with most being considered to be Datil and Baca or their equivalents of Tertiary age. These rocks include flows, intrusives, and a considerable volume of interbedded sediments of volcanic origin. A few Permian rocks are found in the Magdalenas. Pennsylvanian limestones are found where the Rio Salado crosses the southern tip of the Ladron Mountains east of Riley, in the Lemitar and Socorro mountains, in the unnamed hills southwest of San Antonio, and in the Magdalena Mountains. Some Mississippian rocks are found in the Lemitars. Some Precambrian is found in the Ladrons west of Riley, in the Magdalenas, and west of San Antonio. Reddish gypsum-bearing silts and clays probably representing playa deposits are found along the Lemitar and Socorro mountains from the Rio Salado to south of Socorro. Near the Rio Salado, these deposits are called the Popotosa formation (Tertiary age), but correlation is not definite further south. West of the Magdalenas, sediments are found that are probably equivalent to the Santa Fe group but are usually referred to as the Gila conglomerate. Recent alluvium is found along arroyo bottoms.

The regional strike of the rocks in the Socorro area is approximately north-south with moderate dips in the younger rocks and steep dips to overturning in the older rocks. Faulting appears generally to be of the normal type with a dominant north-south trend and a lesser east-west trend.

DRAINAGE

The most important stream is the southward-flowing Rio Grande which crosses the east-central portion of the area (figure 1). All arroyos east of the Rio Grande drain directly into it, but none has perennial flow. West of the Rio Grande, all arroyos coming from the Lemitar and Socorro mountains and the Chupadera Hills drain directly into it, but none has perennial flow.

The area west of the Magdalena Mountains drains directly to the Rio Grande. The east side of the Magdalenas drains into the Snake Ranch Flats which is crossed by U.S. Highway 60 from about six miles west of Socorro to about four miles east of Magdalena. The southern portion of the Snake Ranch Flats has nearly closed surface drainage with groundwater drainage to the Rio Grande through arroyos such as Nogal north of Socorro Mountain. The northern part of the Snake Ranch Flats drains to the Rio Salado, a major tributary of the Rio Grande by way of La Jencia creek. Some ground water probably flows westward through San Lorenzo arroyo west of San Acacia.

PREVIOUS INVESTIGATIONS

The only previous investigation dealing directly with springs in the Socorro area is the work by Waldron (1956). Most of the springs described and sampled by Waldron have been relocated and sampled during the present study. Various authors have briefly mentioned springs in the Socorro area. Darton (1928) describes some springs east of the Rio Grande; data on ground water and chemistry of water collected during the Rio Grande Joint Investigation are given by Theis (1938) and Scofield (1938); the Socorro thermal spring has been mentioned by several authors (Stearns et al., 1937); the area north of the present area is described by Spiegel (1955; 1962). The distribution of soluble and exchangeable cations in soils near Socorro has been discussed by Hassan (1962).

ACKNOWLEDGEMENTS

This report is based on work performed during a continuing program of research in ground-water hydrology conducted by the Research and Development Division of the New Mexico Institute of Mining and Technology under the general supervision of Dr. E. J. Workman, president of NMIMT, and under the direction of Dr. Mahdi S. Hantush, chairman of the Department of Ground-water Hydrology.

Mr. F. X. Bushman, hydrologist with the Bureau of Mines and Mineral Resources, has been of considerable assistance in supplying background information about springs and in suggesting possible locations. Graduate students at NMIMT made some of the chemical analyses, did the drafting, and went into the field with the author. Particular thanks are owing to Bruce DeBrine, Dennis Williams, and Nathan Columbus. Dr. Zane Spiegel has been very helpful discussing various springs and by supplying data collected during his work in the area. Mrs. Priscilla Jones typed the tables.

METHODS OF CLASSIFICATION

CHEMICAL

A simple chemical method of classification is to give a spring a name based on chemical content. In the present study, a name is derived from the dominant ions in terms of percentages of equivalents per million (epm) as 100 per cent cations and 100 per cent anions. The criteria used for both cations and anions are as follows: (1) if one ion is greater than 50 per cent, then that name is used, and (2) if no ion is greater than 50 per cent, then the ions greater than 25 per cent are given in decreasing order from left to right with the cations coming first. For example, a calcium bicarbonate ($Ca\text{-}HCO_3$) water contains more than 50 per cent calcium and more than 50 per cent bicarbonate. A sodium calcium sulfate chloride ($Na\text{-}Ca\text{-}SO_4\text{-}Cl$) water contains less than 50 per cent of any cation or anion but sodium is greater than calcium and sulfate is greater than chloride, and all four are greater than 25 per cent. This system is used for the chemical classification given in Appendix A.

Various types of graphical methods can be used, but a trilinear graph seems suitable for the present study. The form of the graph shown in Figure 2 was developed by Piper (1944). Cations in per cent epm are plotted in the lower left triangle, anions are plotted in the lower right triangle, and the points are projected into the central diamond. All the chemical analyses tabulated in Appendix B are plotted in Figure 2.

Rather elaborate classifications can be based on trilinear graphs, but one easy and useful method is to assign each analysis a binomial or decimal number derived from the per cent calcium plus magnesium and the per cent carbonate plus bicarbonate. For

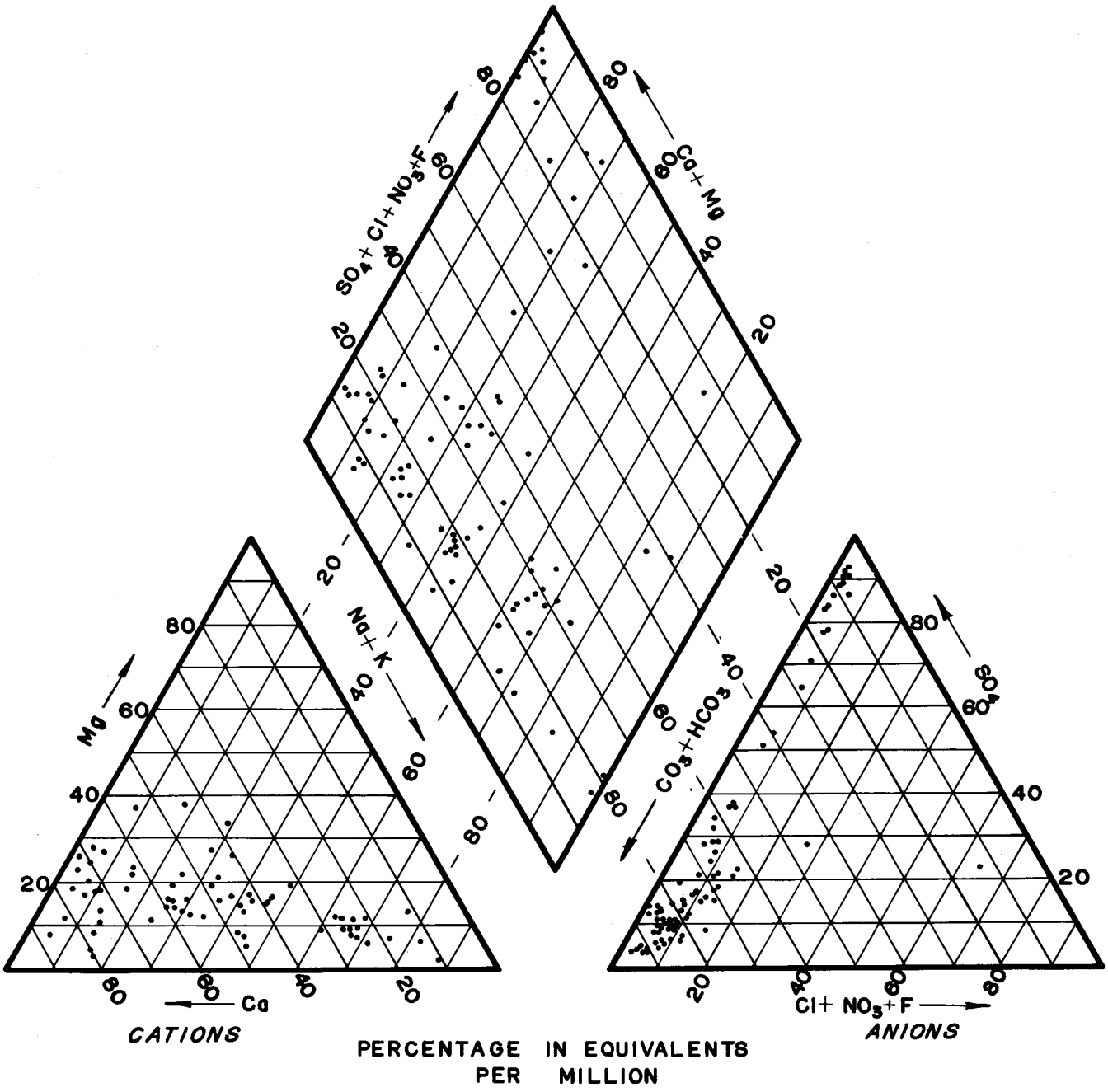


FIGURE 2
Water-analysis diagram for springs in the vicinity of Socorro, Socorro County, New Mexico.

example, 65.20 means that calcium plus magnesium equals 65 per cent of the cations and carbonate plus bicarbonate equals 20 per cent of the anions. This number has the advantage of locating the analysis in the central diamond. All analyses used in this report are assigned a number in Appendix A.

GEOLOGICAL AND TOPOGRAPHICAL

A rather obvious method of classification is one based on the lithologic character of the water-bearing formations. Designations such as *limestone springs* or *volcanic springs* are commonly used. Several problems arise in that an area may have a large number of

rock types, or else, because of surficial material or dense vegetation, that considerable difficulty may be encountered in precisely determining the water-bearing material. Therefore, in the present report, only generalized lithologic terms will be used. A variation would be to use the geologic ages or the formational names of the rocks, but this does not seem advisable here. A classification based on structural relationships can be most useful if the relationships can be determined. In the present paper, the major structural classification is fault line springs.

A topographical classification has the advantage of being descriptive without the genetic implications inherent in a lithological or structural classification. Obviously, any spring can be classified in all three categories. Topographical designations that have seemed useful for the present study are arroyo bottom, small arroyo bottom tributary to main arroyo, and hillside.

TEMPERATURE

The temperature of a spring water can be very useful for classification purposes if a suitable range is shown and if a large number of temperature measurements can be obtained. A general assumption made in temperature classification is that an ordinary or "normal" spring obtaining water close to the land surface should have a temperature close to the mean annual air temperature. Springs having temperatures appreciably above or below the mean annual air temperature require further study to determine the reasons for the anomalous temperatures.

The average annual air temperatures in the vicinity of Socorro range from about 58°F in the Rio Grande to 52°F at Magdalena to 50°F or less above 7500 feet. Therefore, as a general criterion, an anomaly of 10°F will be considered significant, and any spring with a temperature greater than 15° above average annual air temperature will be considered a thermal spring. Temperatures given in Appendixes B and C were usually measured with centigrade thermometers accurate to 0.1°C.

The biggest problem of a temperature classification is in obtaining the measurements. Ideally, a spring should have an appreciable, unimpeded flow and should be measured right at the point of issuance. In the vicinity of Socorro, a large number of springs have very small flows and may also be ponded, and as a result, temperature measurements are of doubtful accuracy. Also, springs flowing in stream beds or surface water runoff will tend toward the prevailing air temperature.

CHEMISTRY OF WATER

ANALYTICAL DATA

Most of the chemical analyses listed in Appendix B were made at the New Mexico Institute of Mining and Technology. Conductivity was measured with an Industrial Instruments Conductivity Bridge RC-16B2. Hydrogen ion activity as pH was measured with a Beckman pH Meter Model G. Calcium, magnesium, carbonate, bicarbonate, and chloride were determined by methods described in Betz Laboratories (1962), sulfate was determined by the visual thorin method (Rainwater and Thatcher, 1960, p. 279-281), nitrate was determined with a Hach "Portable Engineer's Laboratory," and with few exceptions sodium and potassium were obtained by difference. The analyses by the U.S. Geological Survey were made by methods described in Rainwater and Thatcher (1960). The few analyses from other sources are described in references noted in Appendix B.

EQUILIBRIUM CALCULATIONS

Equilibrium calculations have been made for the systems $CaCO_3$-CO_2-H_2O and $CaCO_3$-CO_2-$CaSO_4$-H_2O which are equivalent to water in equilibrium with calcite at the prevailing partial pressure of carbon dioxide (P_{CO_2}) and with calcite and gypsum at the prevailing P_{CO_2}. The calculations are helpful in testing assumptions regarding the nature of the water-bearing formation. Also, equilibrium or deviations therefrom can be used to develop hypotheses regarding time in contact with the aquifer, and chemical changes undergone while in transit through the rocks.

Calculations for the system $CaCO_3$-CO_2-H_2O are made by use of equations developed by a linear regression of data from Frear and Johnston (1929), according to methods outlined in Yaalon (1954).

$$pH + \log(Ca^{++}) + \log(HCO_3^-) = 11.39 + 1.76\sqrt{\mu} \quad (1)$$

$$2pH + \log(Ca^{++}) + \log P_{CO_2} = 14.43 + 1.76\sqrt{\mu} \quad (2)$$

where

Ca^{++} and HCO_3^- are in milligrams per liter (mg/l) and μ = ionic strength.

The equations are valid at 25°C in a P_{CO_2} range of 0.0003-1. The results of the calculations are given in Appendix A. The approach used was to calculate pH from measured calcium and bicarbonate by equation (1). Equilibrium was then decided on the agreement between measured and calculated pH as follows: in equilibrium, $\leq$ 0.05 pH unit; nearly in equilibrium, $\leq$ 0.10 pH unit; roughly in equilibrium, $\leq$

0.25 pH unit; not in equilibrium, > 0.25 pH unit. If the agreement was within 0.25 pH unit, then P_{CO_2} was obtained from equation (2) using calculated pH and measured calcium.

Calculations for equilibrium in the system $CaCO_3$-CO_2-$CaSO_4$-H_2O were made by use of an approximate method and equations developed by Hall (1963).

$$\log P_{CO_2} = 1.122 \log \frac{(HCO_3^-)^2}{(SO_4^=/2)} - 1.407 \quad (3)$$

$$\log S_{CH} = 0.425 \log P_{CO_2} + 1.187 \quad (4)$$

$$\log S_S = -0.0414 \log P_{CO_2} + 1.421 \quad (5)$$

where S_{CH} is the solubility of $CaCO_3$ in the presence of $CaSO_4$ expressed as HCO_3^- in epm; S_S is the solubility of $CaSO_4$ in the presence of $CaCO_3$ expressed as $SO_4^=$ in epm; and HCO_3^- and $SO_4^=$ are expressed in epm. The equations are valid at 25°C in the P_{CO_2} range of about 0.005 to 1. The results of the calculations are given in Appendix A. The procedure was to calculate P_{CO_2} from measured HCO_3^- and $SO_4^=$ by equation (3), and then to calculate HCO_3^- and $SO_4^=$ from equation (4) and (5) using calculated P_{CO_2}. Equilibrium was then based on agreement between measured and calculated HCO_3^- and $SO_4^=$ as follows: in equilibrium, agreement of both HCO_3^- and $SO_4^=$ within 10 per cent; approximate equilibrium if either HCO_3^- or $SO_4^=$ are within 10 per cent; not in equilibrium, HCO_3^- and $SO_4^=$ greater than 10 per cent.

The main justification for the rather loose use of the word *equilibrium* is that the degree of "lack" of equilibrium is of more value in a study like this than a rigid "in" or "not in" equilibrium. Also, the calculations for $CaCO_3$-CO_2-H_2O are in all instances based on pH and alkalinity determinations made in a laboratory at some time, often months, after collection. Therefore, adjustments may have occurred, and some doubt is cast upon the validity of the calculations. This problem is not so critical for the calculations in the system $CaCO_3$-CO_2-$CaSO_4$-H_2O, although HCO_3^- may be affected.

SOURCE OF CONSTITUENTS

Humans and animals make contributions to the dissolved solids content, and in places this can become sizeable. In the Socorro area, however, most springs have not been subject to much interference by man except for development work. The use of the water for stock does offer chances for additions of material, as in many instances cattle are allowed to walk all over the spring and immediate vicinity; therefore, at least some chloride and possibly sulfate and nitrate along with accompanying cations may be due to stock. Atmospheric precipitation has a normal content of a few parts per million of calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, chloride, and nitrate, usually totalling something like 5 to 20 ppm but generally less than 10 ppm. As a result, some chloride and sulfate in spring waters are probably from the atmosphere. A most important contribution from the atmosphere, however, is the CO_2 dissolved in the precipitation. Atmospheric P_{CO_2} is on the order of 0.0003, and this is sufficient to dissolve about 50 mg/l of calcite. Another source of constituents could be vapors or fluids from depth, say, rising from an igneous intrusion. The only likely place for this to occur would be in the thermal springs just west of Socorro; however, an appreciable contribution from depth does not seem too likely although no real evidence one way or the other is available at present.

An important source of constituents is the soil through which a large part of the precipitation passes. The precipitation is then either lost by evapotranspiration, held as soil moisture, passes through as recharge to the ground water, or moves into streams where it may again become recharge or else is lost from the area. In any event, a substantial amount of water issuing from springs has been in contact with soil. Soil is a source of material in at least three important ways: (1) it contains at least some slightly soluble salts such as carbonate and sulfates, (2) it promotes weathering of minerals, particularly sulfates, carbonates, and silicates such as feldspars, and (3) organic activity may substantially increase the P_{CO_2}, thereby increasing the amount of calcite that can be dissolved.

The final source of constituents to be considered is the water-bearing rocks themselves. Equilibrium calculations can give insight into what might be expected from the slightly soluble rocks such as limestone, gypsum, and limestone and gypsum together. The same principles hold for dolomite. More soluble materials such as halite do not appear to be present in the area of interest. Real problems arise in attempting to decide in a quantitative fashion what constituents might be expected from alluvium, shale, sandstone, and volcanics present in the vicinity. Not enough is known about the chemical composition of the rocks, let alone about solubilities of the minerals, to be much more than semiqualitative. Additional problems are added by lack of knowledge of chemical processes in the saturated rocks; for example, ion exchange and oxidation of sulfides. Some generalizations can be made. The volcanic rocks often contain enough calcite to maintain approximate equilibrium

but rarely contain much gypsum. Water from the more rhyolitic volcanic rocks tends to be higher in per cent sodium, that is softer, than water from the more andesitic volcanic rocks. Also, waters from volcanic rocks tend to be low in dissolved solids. In addition, the rhyolitic rocks and sediments derived from them appear to act as a cation exchange medium.

DISCUSSION OF SPRINGS

Before a discussion of the springs, a few remarks should be made about the source of recharge to the springs. With the possible exception of the thermal springs at Socorro, all springs receive their recharge either directly from precipitation or indirectly by way of stream flow or ground water. The same is probably true for the thermal springs, but this can not be definitely shown at present.

East of the Rio Grande

The springs east of the Rio Grande are found along main arroyos, although several are actually in small arroyos tributary to the larger ones. Most of the springs are in arroyo bottoms where the dominant control is one or more resistant beds crossing the arroyo. Ojo de las Cañas (3S.2E.10.323) is an excellent example. A prominant eastward-dipping sandstone bed in the Yeso formation crosses the arroyo nearly at right angles. The bed forces water to the surface and serves also as a water fall. Faulting may be the major control for springs at "Ojo de la Parida" (2S.1E.14.221) where springs are found in alluvium associated with undifferentiated Triassic rocks and the Baca formation. Quotation marks are used because what is apparently the actual or original Ojo de la Parida (2S.1E.12.300) seems to have been dry for quite some time. At least two other springs in arroyo bottoms, Ojo de Amado (2S.1E. 27.243) and Ojo del Coyote (2S.1E.22.422), appear to be controlled either by faults or by contacts between geologic units.

The springs east of the Rio Grande are characterized by high sulfate content and relatively high total dissolved solids with the exception of Ojo del Rancho de Lopez (2S.2E.20.234). Most of the springs are calcium sulfate waters with decimal numbers ranging from 60.30 to 100.05 (figure 2). Some of the springs, particularly in the vicinity of Ojo de la Parida and at Ojo de las Cañas, are in equilibrium with the system $CaCO_3$-CO_2-$CaSO_4$-H_2O. a few of the springs that are not in equilibrium are still fairly close. This equilibrium relationship is to be expected as the water-bearing formations contain both limestone and gypsum. Although some of the units may contain halite or similar evaporites, this is not reflected in the analyses. In fact, low chloride both in percentage and absolute amounts is a constant characteristic of these waters, with only one sample having more than 40 ppm, and that one has only 88 ppm.

None of the springs sampled is reported to have gone dry, although several were quite low when visited. The original Ojo de la Parida appears to have been dry and several other springs either shown on maps or else reported were dry when visited. Briefly then, the springs east of the Rio Grande are few and far between and tend to have rather small flows. Temperatures are about the mean annual air temperature. The chemical content of the waters fairly well reflects the type of water-bearing formation through which they have passed. The Spanish names and appearance of these springs indicate that they have been used for a long time.

West of the Rio Grande

The springs west of the Rio Grande show a much greater diversity than do those to the east. The thermal springs at Socorro will be discussed separately. The springs west of the Rio Grande do have some features in common, since with one exception they are low in chloride and generally are low in sulfate. They tend to be of either a calcium bicarbonate or a sodium bicarbonate type (figure 2). The yields of the springs are rather low, with the highest coming from fault line springs. A few of the springs go dry, and several on maps or reported have been dry for a long time. Some of the sampling locations are actually for stream flow, normally spring fed, or for underflow coming to the surface.

The sample from the spring in the "box" of the Rio Salado (1N.2W.7.131) is different from any other water in the area in that it is a sodium chloride water with high dissolved solids (figure 2, decimal 24.14). This spring is from an area characterized by water bubbling up through sand and gravel in the bed of the Rio Salado. The "box" is cut through steeply, dipping Pennsylvanian limestones, and the spring water probably comes by artesian flow from the limestone. This is shown also by a temperature of 70°F which is at least 10 degrees high for the area. The spring water is in equilibrium with calcite at a P_{CO_2} at .042, although it is rather high in sulfate.

San Lorenzo arroyo has some interesting springs where the occurrence of sodium bicarbonate waters suggests that the volcanic rocks are acting as cation exchangers. The arroyo is cut through a thick sequence of continental sediments and associated vol-

canics of Tertiary age equivalent to the Datil and Popotosa formations. The red gypsiferous clays and silts of the Popotosa are not present. Most of the springs are in the arroyo bottom and probably represent underflow from local sources and possibly the northern part of the Snake Ranch Flats, which is forced to the surface by channel constrictions. Exceptions to this are springs at 1S.2W.12.141 which is in a faulted or intruded zone and at 1S.2W.11.133a which issues from an orifice in a volcanic breccia bed. The latter is interesting in having almost no calcium and magnesium (figure 2, decimal 01.62) but in being surrounded by arroyo bottom seeps that are much higher in calcium and magnesium. All the springs farther down the arroyo seem to show natural softening.

Nogal Canyon just north of Socorro Mountain has a number of springs that represent underflow from the southern Snake Ranch Flats. Two of the springs, however, are not in the arroyo bottom and are controlled by faulting. The increase in sulfate down the canyon is from less than 40 ppm at the Snake Ranch at the head to 150 ppm or more at the mouth. The canyon is cut through a section of volcanics and sediments including red gypsiferous clay and silt.

Domingo Spring (3S.1W.6.331) in a small arroyo on the side of Socorro Mountain has a rather interesting chemical composition. The spring is in rhyolitic material and receives recharge only from precipitation, but chemically it is quite similar to the thermal springs to be described later. Apparently, a sodium bicarbonate content can be obtained in rhyolitic material either by solution, as in this case, or by cation exchange, as in San Lorenzo arroyo.

Chupadera Spring (4S.1W.5.211) south of U.S. Highway 60 is the only spring west of the Rio Grande, other than the one at the "box" at the Rio Salado, containing more than a few hundred ppm sulfate. The spring and several neighboring ones that are now dry occur at a contact, either intrusive or faulted, between red gypsiferous clay and volcanics. This spring is nearly dry now, but at one time the springs yielded considerably more water.

South and west of San Antonio, several groups of springs are found that appear to be controlled by faulting. A few temperature measurements indicate that these springs may be a little warm for the area. One set of springs lies along a fault trend and occurs mainly in Santa Fe group sediments faulted against volcanic rock. These are Torreon (5S.2W.8.230), Cienega (5S.2W.18.140), and Burro (5S.3W.14.444). The springs have similar chemical compositions and are low in dissolved solids. Torreon and Cienega springs are in equilibrium with calcite at a P_{CO_2} of .0014. Burro Spring is not in equilibrium with calcite and is a little higher in dissolved solids than the others, and possibly it has been concentrated by evaporation. Burro Spring now has a very low flow but Torreon and Cienega have total flows which, although they cannot be measured or even satisfactorily estimated, probably are in excess of 40 gpm. Geological and topographic relationships indicate that the water from these springs represents flow from the southern end of the Magdalena Mountains. The other set of springs that appears to be controlled by faults occurs in Datil volcanics at 6S.1W.6.420 and 6S.1W.6.440. Only the latter spring has appreciable flow at present. Their chemical composition is similar to the springs just described, except they are lower in calcium and magnesium. Several other reported springs in the vicinity either do not exist or have been dry for quite some time.

THERMAL SPRINGS AT SOCORRO

The thermal springs at Socorro are of interest for several reasons: (1) their temperatures are about 90° to 91°F which is significantly higher than the average annual air temperature of 58°F, (2) they are sodium bicarbonate waters with low dissolved solids, and (3) two of them supply a large part of water for the city of Socorro and apparently have done so since pre-Spanish days. The two large springs, Sedillo or Evergreen (3S.1W.22.131) and Socorro (3S.1W.22.113), have flows in excess of 200 gpm and lie on definite fault zones. The water-bearing formation is a rhyolitic breccia. Cook Spring (3S.1W.15.313) has a much smaller flow, and flows from an adit which was driven to intercept the water. The well in Blue Canyon (3S.1W.16.323) is included because it is drilled into the same breccia and yields the same type of water.

At present, NMIMT is conducting a study of the yield, temperature, chemical nature, and time in storage of water from the springs, with emphasis on the Socorro Spring. Samples have been taken for determination of tritium, and preliminary results indicate that the water has been out of contact with the atmosphere for about four years (Holmes, 1963). Temperature measurements by a recorder since September 1962 have ranged between 90° and 91°F with no sharp fluctuations. Flow in the spring has not varied since November 1962, when a recorder was installed. The channel has not been rated yet, but the flow is on the order of 220 to 250 gpm. Spot samples for specific conductance since September 1962 have plotted as a straight line for temperature

versus conductivity passing through 355 micromhos at 25°C. The variations in conductivity are about what would be expected from the accuracy of the instrument and cell used. Attempts to use a conductivity recorder have shown that the spring gives off CO_2 as it flows out of the rocks. Equilibrium calculations show that the thermal waters are in equilibrium with calcite at a P_{CO_2} of 0.0015-0.0017.

Three problems of scientific interest about the Socorro springs are (1) the source of heat, (2) the source of recharge, and (3) the reasons for the chemical composition. Only a brief discussion can be given, although all these points are now under study. Approximate temperature measurements in old mine workings indicate that Socorro Mountain is a geothermal high. The region around Socorro Mountain is active seismically (Sanford, 1963), and very likely this is related to the problem. Not much but speculation can be offered about the nature of the geothermal high, the source of heat, or the depth to which the water goes before returning to the surface.

The source of recharge can be accounted for in large part. The only unanswered question is whether or not a component comes from depth as magmatic water. Probably little or no water comes from this source, but this cannot be demonstrated yet. The major part of the recharge comes from the Magdalena Mountains by way of the Snake Ranch Flats. As mentioned by Holmes (1963), some local recharge probably occurs. Calculations by Zane Spiegel (personal communication, 1962) have indicated that Socorro Mountain does not have sufficient area to be the major source of recharge, whereas the Snake Ranch Flats and east slope of the Magdalenas do. Approximate water-level contours indicate that the water is coming from the general vicinity of Six Mile and South canyons, but probably not so far north as Water Canyon. The rhyolitic breccia from which the springs issue crops out along the margin between Socorro Mountain and the Snake Ranch Flats (DeBrine et al., 1963), and this is where the recharge presumably takes place.

The chemical composition of the thermal waters sets a definite limit on the source of recharge. That is, the recharge water has to have nearly the same composition and have less dissolved solids or else it has to have a chemical composition that can be changed to fit the spring water but again with less dissolved solids. The composition of the thermal spring waters indicates also that the water has not been in contact with the red gypsiferous clay that makes up the bulk of Socorro Mountain.

The chemical analyses from Water Canyon (Appendix B) approach the borderline of suitability, whereas well analyses from the Snake Ranch Flats, not given here, spring analyses from Snake Ranch, and an analysis from Box Spring in Six Mile Canyon do seem suitable. What is required, however, is that cation exchange takes place. The waters on the east side of the Magdalena Mountains and Snake Ranch Flats are a calcium bicarbonate type whereas the thermal springs are a sodium bicarbonate type. Presumably cation exchange takes place in the rhyolitic breccia after the water leaves the recharge area. One final question that can not yet be answered is why the thermal springs do not acquire considerable additional dissolved solids during the time the water is in contact with the rhyolitic breccia.

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APPENDIX A-CHEMICAL CLASSIFICATION AND EQUILIBRIUM RELATIONSHIPS

Classification: see text

Decimal: see text

System $CaCO_3$-CO_2-H_2O: Agreement between measured and calculated pH shown by I-agreement ≤0.05 pH units; N-agreement ≤0.10 pH units; R-agreement ≤0.25 pH units; X-agreement >0.25 pH units; ?-calculations could not be made

System $CaCO_3$-CO_2-$CaSO_4$-H_2O: Agreement between measured and calculated HCO_3^- and $SO_4^=$ in ppm shown by In-HCO_3^- and $SO_4^=$ within 10%; H-HCO_3^- within 10% but not $SO_4^=$; O-Neither HCO_3^- nor $SO_4^=$ within 10%

Location Number	Name	Classification	Decimal	$CaCO_3$-CO_2-H_2O			$CaCO_3$-CO_2-$CaSO_4$-H_2O			
				Equilibrium	Calculated pH	Calculated P_{CO_2}	Equilibrium	Calculated HCO_3^-	Calculated $SO_4^=$	Calculated P_{CO_2}
1N.2W.7.131	---	Na-Cl	24.14	R	7.00	.042	0	---	---	---
1N.2W.8.121	---	Na-HCO_3-SO_4-Cl	17.44	R	7.86	.0038	0	---	---	---
1N.3W.7.342	Carbon Spring	Ca-Na-Mg-HCO_3	67.69	N	7.49	.0017	0	---	---	---
1N.3W.27.444	---	Ca-Na-HCO_3	67.63	X	---	---	0	---	---	---
1N.4W.8.441	Baca Spring	Na-Ca-HCO_3	51.68	X	---	---	0	---	---	---
1S.2W.11.123	---	Na-HCO_3	17.84	X	---	---	0	---	---	---
1S.2W.11.133a	---	Na-HCO_3	00.73	X	---	---	0	---	---	---
1S.2W.11.133a	---	Na-HCO_3	01.62	X	---	---	0	---	---	---
1S.2W.11.133b	---	Na-Ca-HCO_3	58.82	X	---	---	0	---	---	---
1S.2W.11.133c	---	Ca-Na-HCO_3	63.83	X	---	---	0	---	---	---
1S.2W.11.133d	---	Na-Ca-HCO_3	54.85	X	---	---	0	---	---	---
1S.2W.11.144	San Lorenzo Spring	Na-HCO_3	32.78	X	---	---	0	---	---	---
1S.2W.11.422	---	Na-HCO_3	39.82	X	---	---	0	---	---	---
1S.2W.12.141	---	Na-HCO_3	25.68	X	---	---	0	---	---	---
1S.3W.14.241	La Jencia Creek	Ca-Na-HCO_3	64.61	I	7.84	.0022	0	---	---	---
1S.3W.14.431	La Jencia Creek	Ca-HCO_3	76.66	X	---	---	0	---	---	---
2S.1W.19.414	Ojitos Spring	Na-Ca-HCO_3	54.79	?	---	---	0	---	---	---
2S.1W.30.441	---	Ca-HCO_3	68.54	X	---	---	0	---	---	---
2S.1W.30.443	---	Ca-HCO_3	66.56	X	---	---	0	---	---	---
2S.1W.31.122	---	Na-Ca-HCO_3	53.56	X	---	---	0	---	---	---
2S.1W.31.124	---	Ca-HCO_3	71.64	X	---	---	0	---	---	---
2S.1W.31.142	---	Ca-Na-HCO_3	68.66	X	---	---	0	---	---	---
2S.1W.31.314	---	Ca-HCO_3	74.75	X	---	---	0	---	---	---
2S.2W.35.322	Snake Ranch	Ca-HCO_3	71.86	X	---	---	0	---	---	---
2S.2W.35.323	Snake Ranch	Ca-HCO_3	77.82	?	---	---	0	---	---	---
2S.2W.35.324	Snake Ranch Spring	Ca-HCO_3	76.84	?	---	---	0	---	---	---
2S.2W.35.342	Snake Ranch Spring	Ca-HCO_3	75.82	?	---	---	0	---	---	---
3S.1W.6.331	Domingo Spring	Na-HCO_3	34.64	X	---	---	0	---	---	---
3S.1W.15.313	Cook Spring	Na-HCO_3	30.68	?	---	---	0	---	---	---
3S.1W.15.313	Cook Spring	Na-HCO_3	31.67	X	---	---	0	---	---	---
3S.1W.16.323	Blue Canyon Well	Na-HCO_3	40.62	?	---	---	0	---	---	---
3S.1W.16.323	Blue Canyon Well	Na-HCO_3	35.73	I	8.03	.0017	0	---	---	---
3S.1W.22.113	Socorro Spring	Na-HCO_3	33.73	?	---	---	0	---	---	---
3S.1W.22.113	Socorro Spring	Na-HCO_3	34.71	X	---	---	0	---	---	---
3S.1W.22.113	Socorro Spring	Na-HCO_3	38.62	?	---	---	0	---	---	---

APPENDIX A-CHEMICAL CLASSIFICATION AND EQUILIBRIUM RELATIONSHIPS (continued)

Location Number	Name	Classification	Decimal	$CaCO_3$-CO_2-H_2O			$CaCO_3$-CO_2-$CaSO_4$-H_2O			
				Equilibrium	Calculated pH	Calculated P_{CO_2}	Equilibrium	Calculated HCO_3^-	Calculated $SO_4^=$	Calculated P_{CO_2}
3S.1W.22.113	Socorro Spring	Na-HCO_3	38.77	N	8.04	.0016	O	---	---	---
3S.1W.22.131	Sedillo (Evergreen) Spring	Na-HCO_3	34.70	?	---	---	O	---	---	---
3S.1W.22.131	Sedillo (Evergreen) Spring	Na-HCO_3	38.73	X	---	---	O	---	---	---
3S.3W.7.313	Patterson Tunnel	Ca-HCO_3	93.77	I	7.32	.011	O	---	---	---
3S.3W.7.342	---	Ca-HCO_3	96.86	R	7.05	.032	O	---	---	---
3S.3W.10.311	---	Ca-HCO_3	95.84	X	---	---	O	---	---	---
3S.3W.19.132	---	Ca-HCO_3	83.61	X	---	---	O	---	---	---
3S.3W.26.111	N. Fk., Water Canyon	Ca-HCO_3	84.77	X	---	---	O	---	---	---
3S.3W.26.113	Water Canyon	Ca-HCO_3	84.76	X	---	---	O	---	---	---
3S.3W.27.211	N. Fk., Water Canyon	Ca-HCO_3	97.86	X	---	---	O	---	---	---
3S.3W.34.332	Water Canyon	Ca-HCO_3	90.86	X	---	---	O	---	---	---
3S.4W.12.311	---	Na-HCO_3	29.90	X	---	---	O	---	---	---
3S.4W.24.242	---	Ca-HCO_3	87.74	X	---	---	O	---	---	---
3S.4W.26.233	Rock Springs Canyon	Ca-Na-HCO_3	53.87	X	---	---	O	---	---	---
3S.4W.36.242	Mill Canyon	Ca-HCO_3	87.93	R	7.92	.0015	O	---	---	---
4S.1W.5.211	Chupadera Spring	Na-SO_4-HCO_3	12.40	X	---	---	O	---	---	---
4S.2W.7.211	Box Spring	Ca-HCO_3	93.82	R	8.00	.0011	O	---	---	---
4S.3W.5.331	Baldy Spring	Ca-HCO_3	88.86	X	---	---	O	---	---	---
4S.4W.11.121	---	Ca-HCO_3	86.91	R	8.43	.00026	O	---	---	---
4S.4W.13.213	Hardy Springs	Ca-HCO_3	90.95	X	---	---	O	---	---	---
4S.4W.14.112	Buttercup Spring	Ca-HCO_3	77.88	X	---	---	O	---	---	---
4S.4W.27.122	---	Ca-HCO_3	85.91	X	---	---	O	---	---	---
4S.4W.28.430	---	Na-HCO_3	33.88	R	7.95	.0025	O	---	---	---
4S.4W.31.230	Alameda Spring	Ca-Na-HCO_3	57.91	X	---	---	O	---	---	---
5S.2W.8.230	Torreon Spring	Ca-HCO_3	76.84	I	7.96	.0014	O	---	---	---
5S.2W.18.140	Cienega Spring	Ca-HCO_3	68.91	I	7.99	.0014	O	---	---	---
5S.3W.14.444	Burro Spring	Ca-HCO_3	74.88	X	---	---	O	---	---	---
5S.4W.5.320	---	Ca-Na-HCO_3	59.81	N	7.83	.0027	O	---	---	---
5S.4W.24.400	Puertocito Gap	Ca-HCO_3	91.81	R	7.44	.0081	O	---	---	---
6S.1W.6.420	---	Ca-Na-HCO_3	56.82	X	---	---	O	---	---	---
6S.1W.6.440	---	Ca-Na-HCO_3	58.82	R	8.10	.00096	O	---	---	---
2S.1E.14.132	---	Ca-SO_4	98.08	X	---	---	H	159	1500	.015
2S.1E.14.142	---	Ca-SO_4	99.09	X	---	---	O	---	---	---
2S.1E.14.200	"Ojo de la Parida"	Ca-SO_4	94.10	X	---	---	In	201	1470	.026
2S.1E.14.221	"Ojo de la Parida"	Ca-SO_4	92.13	X	---	---	O	---	---	---
2S.1E.14.221	"Ojo de la Parida"	Ca-SO_4	100.15	X	---	---	O	---	---	---
2S.1E.14.221	"Ojo de la Parida"	Ca-SO_4	100.11	X	---	---	O	---	---	---
2S.1E.22.422	Ojo del Coyote	Ca-SO_4	76.10	X	---					

APPENDIX A-CHEMICAL CLASSIFICATION AND EQUILIBRIUM RELATIONSHIPS (continued)

Location Number	Name	Classification	Decimal	$CaCO_3$-CO_2-H_2O			$CaCO_3$-CO_2-$CaSO_4$-H_2O			
				Equilibrium	Calculated pH	Calculated P_{CO_2}	Equilibrium	Calculated HCO_3^-	Calculated SO_4^-	Calculated P_{CO_2}
2S.1E.27.200	Ojo de Amado	Ca-Mg-Na-SO_4	72.42	?	---	---	O	---	---	---
2S.1E.27.200	Ojo de Amado	Ca-Na-Mg-SO_4	64.22	?	---	---	O	---	---	---
2S.1E.27.243	Ojo de Amado	Ca-Mg-Na-SO_4	71.29	X	---	---	O	---	---	---
2S.2E.30.234	Ojo del Rancho de Lopez	Ca-HCO_3	91.76	X	---	---	O	---	---	---
3S.1E.24.444	---	Ca-SO_4	72.08	X	---	---	In	170	1500	.018
3S.2E.19.323	Ojo de las Cañas	Ca-SO_4	96.08	X	---	---	H	176	1489	.020
3S.2E.19.323	Ojo de las Cañas	Ca-SO_4	100.07	X	---	---	In	140	1523	.011

APPENDIX B - CHEMICAL ANALYSES OF SPRINGS IN THE VICINITY OF SOCORRO, SOCORRO COUNTY, NEW MEXICO

Analyst: all analyses by New Mexico Institute of Mining and Technology except those numbered as follows: 1 U.S. Geological Survey, 2 Waldron (1956), 3 Scofield (1939, p. 256)

Location Number	Name	Date Collected	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium plus Potassium (as Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Total Hardness as $CaCO_3$	Dissolved Solids	Specific Conductance (micromhos at 25°C)	pH	Remarks
1N.2W.7.131	---	3/14/63	70	---	---	171	32	792	383	0	492	1032	---	---	---	582	---	4610	7.2	---
1N.2W.8.121	---	3/14/63	61	---	---	23	6	175	251	0	128	88	---	---	---	84	---	1000	8.0	---
1N.3W.7.342	Carbon Spring	6/14/62	67	---	---	47	19	44	246	0	56	22	---	---	---	198	---	527	7.6	---
1N.3W.27.444	---	3/14/63	43	---	---	50	12	39	198	0	80	10	---	---	---	172	---	536	7.8	---
1N.4W.8.441	Baca Spring	6/14/62	---	---	---	58	22	105	383	0	124	24	---	---	---	236	---	715	8.0	---
1S.2W.11.123	---	3/21/63	49	---	---	19	4	143	383	0	32	14	---	11	---	66	---	744	8.6	---
1S.2W.11.133a	---	4/25/63	57	---	---	0.1	0.04	139	244	17	24	14	---	---	---	0.40	---	574	9.0	Ca, Mg & Na measured on flame spectrophotometer, K=.70 ppm, Mn=.01 ppm
1S.2W.11.133a[1]	---	4/8/63	61	21	---	1.4	0.1	133	222	31	30	16	1.2	4.8	---	4	348	586	9.3	---
1S.2W.11.133b	---	4/18/63	---	---	---	38	10	45	234	tr.	32	6	---	---	---	136	---	526	8.4	---
1S.2W.11.133c	---	4/18/63	---	---	---	46	10	42	251	tr.	32	6	---	---	---	154	---	535	8.5	---
1S.2W.11.133d	---	4/18/63	---	---	---	39	9	53	259	tr.	28	6	---	---	---	136	---	530	8.5	---
1S.2W.11.144	San Lorenzo Spring	3/21/63	57	---	---	30	5	94	285	tr.	36	14	---	13	---	96	---	612	8.5	---
1S.2W.11.422	---	3/28/63	57	---	---	37	7	84	300	tr.	28	12	---	9	---	118	---	613	8.6	---
1S.2W.12.141	---	3/21/63	---	---	---	19	11	127	305	tr.	80	24	---	2	---	94	---	789	8.6	---
1S.3W.14.241[1]	La Jencia Creek	7/24/60	---	---	---	35	6.9	30	136	0	41	10	.5	15	---	116	245	360	7.8	---
1S.3W.14.431	La Jencia Creek	7/26/62	77	---	---	57	9	26	190	0	64	10	---	---	---	180	---	474	8.0	---
2S.1W.19.400[2]	Ojitos Spring	?/ /62	---	---	---	50	12	67	308	0	38	20	---	---	---	174	---	---	---	---
2S.1W.30.441	---	5/3/62	55	---	---	90	12	58	264	0	150	20	---	---	---	274	---	746	8.1	---
2S.1W.30.443	---	5/3/62	66	---	---	89	11	62	268	0	136	20	---	---	---	256	---	727	7..	---
2S.1W.31.122	---	5/3/62	57	---	---	46	11	65	207	0	104	16	---	---	---	160	---	566	8.0	---
2S.1W.31.124	---	5/3/62	59	---	---	74	13	45	259	0	90	20	---	---	---	236	---	627	7.8	---
2S.1W.31.142	---	5/3/62	55	---	---	60	16	47	254	0	80	18	---	---	---	216	---	591	7.9	---
2S.1W.31.314	---	5/3/62	61	---	---	62	9	32	239	0	40	16	---	---	---	192	---	505	7.9	---
2S.2W.35.322	Snake Ranch	5/10/62	61	---	---	50	7	29	227	0	10	14	---	---	---	154	---	392	8.4	---
2S.1E.26.100[1]	Chupadero (Old Chavez) Spring	6/6/60	---	---	---	---	---	128	214	0	775	34	1.0	7.1	---	750	---	1740	7.5	Cu=.01 ppm, K=7.9 ppm; Zn=.01 ppm
2S.1E.26.121	Chupadero (Old Chavez) Spring	6/6/62	63	---	---	162	87	81	200	0	696	36	---	---	---	764	---	1790	7.8	---
2S.1E.27.200[3]	Ojo de Amado	4/24/36	---	---	---	89	33	66	259	0	251	20	---	1.2	---	359	---	876	---	K=8 ppm
2S.1E.27.200[1]	Ojo de Amado	6/6/60	---	14	---	---	---	12.1	205	0	506	35	.7	.0	---	475	---	1310	7.8	K=5.8 ppm, Cu=.03 ppm; Zn=.00 ppm
2S.1E.27.243	Ojo de Amado	6/6/62	64	---	---	114	56	97	256	0	444	38	---	---	---	516	---	1410	8.1	---
2S.2E.30.234	Ojo del Rancho de Lopez	6/6/62	---	---	---	72	31	14	315	0	28	36	---	---	---	306	---	710	7.7	---
3S.1E.24.444	---	3/15/63	61	---	---	408	58	228	171	0	1520	22	---	---	---	1260	---	2660	---	---
3S.2E.19.323	Ojo de las Cañas	6/13/62	---	---	---	552	141	38	193	0	1776	24	---	---	---	1960	---	3030	7.6	---
3S.2E.19.323	Ojo de las Cañas	3/15/63	---	---	---	488	141	---	142	0	1568	20	---	---	---	1800	---	2800	---	---

APPENDIX B - CHEMICAL ANALYSES OF SPRINGS IN THE VICINITY OF SOCORRO, SOCORRO COUNTY, NEW MEXICO (continued)

Location Number	Name	Date Collected	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium plus Potassium (as Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Total Hardness as $CaCO_3$	Dissolved Solids	Specific Conductance (micromhos at 25°C)	pH	Remarks
3S.3W.27.211	North Fork, Water Canyon	2/8/63	48	---	---	105	16	5	355	0	44	0	---	---	---	326	---	632	8.2	---
3S.3W.34.332	Water Canyon	2/8/63	45	---	---	65	10	10	237	0	10	15	---	---	---	202	---	430	7.8	---
3S.4W.12.311[1]	---	6/30/62	---	35	---	21	2.8	71	239	0	8.6	8.2	0.5	1.0	---	64	266	402	8.2	---
3S.4W.24.242[1]	---	6/30/62	---	19	---	46	3.2	9.0	129	0	21	9.6	0.2	0.8	---	128	174	285	6.9	K=4.6 ppm
3S.4W.26.233	Rock Springs Canyon	5/23/63	---	---	---	26	1	23	112	0	8	4	---	---	---	58	---	193	7.2	---
3S.4W.36.242	Mill Canyon	5/23/63	---	---	---	33	1	6	112	0	4	2	---	---	---	86	---	206	7.7	---
4S.1W.5.211	Chupadera Spring	5/17/62	63	---	---	39	3	372	444	0	476	42	---	---	---	110	---	1872	8.3	---
4S.2W.7.211	Box Spring	2/8/63	46	---	---	30	5	3	102	0	10	6	---	---	---	95	---	219	7.8	---
4S.3W.5.331	Mt. Baldy Spring	6/11/62	---	---	---	25	3	5	90	0	8	2	---	---	---	74	---	159	7.8	---
4S.4W.11.121	---	6/6/63	---	---	---	17	1.4	4	63	0	2	2	---	---	---	48	---	115	8.2	---
4S.4W.13.213	Hardy Springs	6/4/63	54	---	---	38	6	6	154	0	4	2	---	---	---	120	---	255	8.0	---
4S.4W.14.112	Buttercup Spring	6/6/63	---	---	---	34	7	16	159	0	12	4	---	---	---	116	---	288	8.1	---
4S.4W.27.122	---	6/6/63	---	---	---	38	9	11	173	0	8	4	---	---	---	134	---	313	8.3	---
4S.4W.28.430	---	6/4/63	---	---	---	18	4	58	200	0	8	10	---	---	---	62	---	382	7.8	---
4S.4W.31.230	Alameda Spring	6/4/63	---	---	---	30	5	33	185	0	4	8	---	---	---	96	---	334	7.4	---
5S.2W.8.230	Torreon Spring	5/17/62	65	---	---	29	3	13	115	0	12	4	---	---	---	84	---	210	8.0	---
5S.2W.18.140	Cienega Spring	5/17/62	69	---	---	26	2	16	120	0	4	4	---	---	---	74	---	215	8.0	---
5S.3W.14.444	Burro Spring	6/11/63	---	---	---	44	11	25	224	0	8	12	---	---	---	154	---	417	7.8	---
5S.4W.5.320	---	6/11/63	---	---	---	29	6	31	163	0	16	10	---	---	---	96	---	348	7.9	---
5S.4W.24.400	Puertecito Gap	6/11/63	---	---	---	60	9	8	202	0	16	16	---	---	---	178	---	426	7.6	---
6S.1W.6.420	---	6/18/63	---	---	---	22	2.4	23	115	0	12	6	---	0.4	---	66	---	246	7.2	Collected in a swampy environment
6S.1W.6.440	---	6/18/63	70	---	---	22	2.4	22	112	0	12	4	---	2.2	---	66	---	244	7.9	---
2S.1E.14.132	---	3/15/63	---	---	---	469	87	13	151	0	1360	12	---	---	---	153.2	---	2480	---	---
2S.1E.14.142	---	3/15/63	---	---	---	411	94	6	156	0	1232	12	---	---	---	1416	---	2320	---	---
2S.1E.14.200[1]	"Ojo de la Parida"	10/27/50	---	21	---	456	113	47	200	tr.	1460	15	---	.2	---	1600	---	2430	7.9	---
2S.1E.14.221[1]	"Ojo de la Parida"	6/6/60	---	25	---	---	---	51	227	0	1170	13	.7	.0	---	1300	---	2080	7.7	Cu=.01 ppm; K=3.1 ppm;
2S.1E.14.221	"Ojo de la Parida"	6/6/62	65	---	---	344	86	---	190	0	864	12	---	---	---	1214	---	2040	7.4	---
2S.1E.14.221	"Ojo de la Parida"	3/15/63	---	---	---	350	93	---	166	0	1056	10	---	---	---	1256	---	2050	---	---
2S.1E.22.422	Ojo del Coyote	6/6/62	---	---	---	638	109	302	317	0	2224	88	---	---	---	2044	---	4120	7.9	---
2S.2W.35.323[1]	Snake Ranch	6/25/60	---	29	---	---	---	21	196	0	20	8.2	.4	3.6	---	152	---	371	7.2	---
2S.2W.35.324	Snake Ranch Spring	5/10/62	61	---	---	---	---	26	237	0	20	12	---	---	---	176	---	414	8.2	---
2S.2W.35.342[1]	Snake Ranch Spring	6/25/60	---	31	---	---	---	23	201	0	12	15	.4	1.2	---	150	---	353	7.4	---
3S.1W.6.331	Domingo Spring	5/10/62	64	---	---	23	5	71	183	0	48	24	---	---	---	78	---	437	8.3	---
3S.1W.15.313[1]	Cook Spring	3/20/58	---	28	---	---	---	68	175	0	44	14	1.8	1.1	.08	62	---	393	8.2	K=3.0 ppm; Cu=.00 ppm; Zn=.00 ppm; Ba=.08 ppm
3S.1W.15.313	Cook Spring	3/23/62	---	---	---	17	5	63	163	5	40	12	---	---	---	62	---	412	8.8	---
3S.1W.16.323[1]	Blue Canyon Well	7/24/56	90	26	---	---	---	53	145	8	37	14	.6	1.0	.76	78	---	380	8.5	---
3S.1W.16.323	Blue Canyon Well	12/20/61	88	---	---	18	5	55	166	0	32	12	---	---	---	68	---	---	8.0	---
3S.1W.22.113[3]	Socorro Spring	2/17/36	---	---	---	19	4	58	168	0	30	14	---	1.2	---	63	---	340	---	K= 5 ppm

APPENDIX B - CHEMICAL ANALYSES OF SPRINGS IN THE VICINITY OF SOCORRO, SOCORRO COUNTY, NEW MEXICO (continued)

Location Number	Name	Date Collected	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium plus Potassium (as Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Total Hardness as $CaCO_3$	Dissolved Solids	Specific Conductance (micromhos at 25°C)	pH	Remarks
3S.1W.22.113[1]	Socorro Spring	1/24/57	90	27	0.00	18	3.9	54	154	0	28	15	.6	1.2	---	61	224	348	7.8	K=2.8 ppm; Mn=0.00 ppm; Al(total)=0.0 ppm; PO_4=0.15 ppm; beta-gamma activity <11 micro-micro curies per liter; Ra=0.2 micro-micro curies per liter; U = 1.8 micrograms per liter
3S.1W.22.113[1]	Socorro Spring	3/20/58	89	39	---	---	---	57	160	5	33	16	.7	1.1	.06	74	---	362	8.4	K=3.0 ppm; Cu=.00 ppm; Zn=.40 ppm; Ba=1.6 ppm
3S.1W.22.113	Socorro Spring	12/12/61	91	---	---	18	5	50	163	0	28	8	---	---	---	64	---	---	8.1	---
3S.1W.22.131[1]	Sedillo (or Evergreen) Spring	3/20/58	90	27	---	---	---	56	159	0	33	14	.8	1.3	.05	63	---	318	8.2	K=2.9 ppm; Cu=.00 ppm Zn=.04 ppm; Ba=0.0 ppm
3S.1W.22.131	Sedillo (or Evergreen) Spring	12/12/61	88	---	---	18	5	50	154	5	24	10	---	---	---	64	---	---	8.4	---
3S.3W.7.313[1]	Patterson Tunnel	7/1/62	---	17	---	76	6.4	7.8	217	0	43	3.6	1.1	0.1	---	216	262	426	7.3	K=1.2 ppm; Orange brown deposit in ditch
3S.3W.7.342[1]	---	7/1/62	---	12	---	105	5.8	5.5	305	0	35	2.0	0.3	0.5	---	286	316	534	7.3	K=1.0 ppm
3S.3W.10.311	---	7/26/62	63	---	---	106	23	9	388	0	48	8	---	---	---	358	---	705	7.8	---
3S.3W.19.132[1]	---	6/30/62	---	15	---	54	1.3	13	125	0	57	1.4	0.3	5.0	---	140	208	331	7.0	---
3S.3W.26.111	North Fork, Water Canyon	5/10/62	64	---	---	62	12	19	229	5	34	10	---	---	---	206	---	440	8.5	---
3S.3W.26.113	Water Canyon	5/10/62	73	---	---	54	9	15	188	10	20	8	---	---	---	170	---	358	8.7	---

APPENDIX C-RECORDS OF SPRINGS IN THE VICINITY OF SOCORRO, SOCORRO COUNTY, NEW MEXICO

Well location number: see text

Altitude: estimated from USGS topographic quadrangle maps

Geologic source: Qal--alluvium, mainly arroyo bottoms; QTg--Gila conglomerate or its equivalent; QTr--Volcanics associated with QTg; QTs--Santa Fe group or its equivalent; QTsv--volcanics associated with QTs; Td--Datil formation; Tds--Datil sediments; Tdv--Datil volcanics; Tpt--Popotosa formation; Tb--Baca formation; R--Triassic undifferentiated; Pg--Glorieta formation; Py--Yeso formation; Pa--Abo formation; P--Pennsylvanian limestone

Yield: ≈--approximately; NV--no visible flow; VS--very small (<<1 gpm); S--small (<1 gpm); <--less than; >--greater than

Use: PS--public supply; D--domestic; S--stock; I--irrigation

Location number	Owner	Name	Altitude (feet)	Type of Material	Geologic Source	Occurrence	Yield		Use	Temperature (°F)	Remarks
							Rate gpm	Date			
1N.2W.7.131	Gray & Ligon Ranch	---	5200	Sand	P(?)	Bubbling up through sand	15-20	3/14/63	S	70	Probably artesian flow from Pennsylvanian limestone
1N.2W.8.121	Gray & Ligon Ranc	---	5200	Sand and silt	Qal(?)	Seeping out of river bank	4	3/14/63	S	61	---
1N.3W.7.342	---	Carbon Spring	5720	Sandstone	QTs	Arroyo bottom; may be controlled by dike	≈1	6/14/62	S	67	---
1N.3W.27.1444	Gray & Ligon Ranch	---	5620	Sand and gravel	Qal	Shaft at edge of arroyo	---	---	S,D	43	---
1N.4W.8.441	Spears Ranch	Baca Spring	6200	Sandstone and shale	Tb or Td	Small arroyo bottom; may be controlled by dike	S	6/14/62	S,D	---	Near contact of Baca and Datil formations
1S.2W.11.123	---	---	5520	Sand and gravel	Qal or Tdv	Arroyo bottom seep	VS	3/21/63	S	49	Dried up 4/25/63
1S.2W.11.133a	---	---	5500	Volcanic breccia	Tds	Orifice in volcanic breccia in arroyo bottom	S	4/25/63	S	57	Spring is surrounded by seeps in arroyo bottom
1S.2W.11.133a	---	---	5500	Volcanic breccia	Tds	Orifice in volcanic breccia in arroyo bottom	S	4/8/63	S	61	Spring is surrounded by seeps in arroyo bottom
1S.2W.11.133b	---	---	5500	Sand	Qal or Td	Arroyo bottom; may be controlled by sedimentary bed	S	4/18/63	S	---	Near 1S.2W.11.133a
1S.2W.11.133c	---	---	5500	Sand	Qal or Td	Arroyo bottom; may be controlled by sedimentary bed	S	4/18/63	S	---	Near 1S.2W.11.133a
1S.2W.11.133d	---	---	5500	Sand	Qal or Td	Arroyo bottom; may be controlled by sedimentary bed	S	4/18/63	S	---	Near 1S.2W.11.133a
1S.2W.11.144	---	San Lorenzo Spring	5480	Sand and gravel	Qal or Td	Arroyo bottom	>10	3/21/63	S	57	Forced to surface by volcanic rocks
1S.2W.11.422	---	---	5360	Sand and gravel	Qal or Td	Arroyo bottom	≈10	3/28/63	S	57	Forced to surface by volcanic rocks
1S.2W.12.141	---	---	5280	Volcanics	Tdv	Small side arroyo	2	3/4/63	S	---	In faulted or intruded zone
1S.3W.14.241	Badger Cattle Co.	La Jencia Creek	5680	Sand	Qal or QTs	Arroyo bottom	15	7/24/60	S	---	Underflow coming to surface
1S.3W.14.431	Badger Cattle Co.	La Jencia Creek	5680	Sand	Qal or QTs	Arroyo bottom	>2	7/26/62	S	77	Underflow coming to surface
2S.1W.14.414	J. B. Kelley	Ojitos Spring	5300	Volcanic breccia	Td(?)	---	≈10	?/52	S	---	---
2S.1W.30.441	J. B. Kelley	---	5130	Sand	Qal or Td(?)	Arroyo bottom	4	5/3/62	S	55	---
2S.1W.30.443	J. B. Kelley	---	5140	Sand	Qal or Td(?)	Arroyo bottom	≈1	5/3/62	S	66	---
2S.1W.31.122	J. B. Kelley	---	5240	Sand and silt	Qal or Td(?)	Hillside above arroyo bottom	2	5/3/62	S	57	---
2S.1W.31.124	J. B. Kelley	---	5260	Sand	Qal or Td(?)	Arroyo bottom	2	5/3/62	S	59	---
2S-1W.31.142	J. B. Kelley	---	5350	Sand and silt	Qal or Td(?)	Hillside above arroyo bottom	1	5/3/62	S	55	---
2S.1W.31.314	J. B. Kelley	---	5440	Sand	Qal or Td(?)	Arroyo bottom	2	5/3/62	S	61	---
2S.2W.35.322	Pete Strozzi	Snake Ranch	5680	Sand	Qal or Ts	Arroyo bottom	NV	5/10/62	S	61	Ponded area
2S.2W.35.323	Pete Strozzi	Snake Ranch	5680	Sand	Qal or Ts	Arroyo bottom	NV	6/25/60	S	---	Ponded area
2S.2W.35.324	Pete Strozzi	Snake Ranch Spring	5680	Sand	QTs	Arroyo bottom	≈2	5/10/62	S	61	---
2S.2W.35.342	Pete Strozzi	Snake Ranch Spring	5680	Sand	QTs	Arroyo bottom	1 1/2	6/25/60	S	---	---

APPENDIX C-RECORDS OF SPRINGS IN THE VICINITY OF SOCORRO, SOCORRO COUNTY, NEW MEXICO (continued)

Location number	Owner	Name	Altitude (feet)	Type of Material	Geologic Source	Occurrence	Yield Rate gpm	Yield Date	Use	Temperature (°F)	Remarks
3S.1W.6.331	Pete Strozzi	Domingo Spring	5800	Rhyolite	Tdv(?)	Arroyo bottom	NV	5/10/62	S	64	Up on side of Socorro Mountain
3S.1W.15.313	---	Cook Spring	4900	Rhyolite breccia(?)	Tdv(?)	Hillside	10-15	3/20/58	I	---	Adit dug to intercept water
3S.1W.15.313	---	Cook Spring	4900	Rhyolite breccia(?)	Tdv(?)	Hillside	>1	3/23/62	I	---	Adit dug to intercept water
3S.1W.16.323	NMIMT	Blue Canyon well	5000	Rhyolite breccia	Tdv(?)	In Blue Canyon on Socorro Mountain	20	7/24/56	D,I	90	Well drilled into breccia
3S.1W.16.323	NMIMT	Blue Canyon well	5000	Rhyolite breccia	Tdv(?)	In Blue Canyon on Socorro Mountain	---	---	D,I	88	Well drilled into breccia
3S.1W.22.113	City of Socorro	Socorro Spring	4960	Rhyolite breccia	Tdv(?)	Hillside with breccia faulted against tuff	---	---	PS	---	Shaft and adit
3S.1W.22.113	City of Socorro	Socorro Spring	4960	Rhyolite breccia	Tdv(?)	Hillside with breccia faulted against tuff	353	1/24/57	PS	90	Shaft and adit
3S.1W.22.113	City of Socorro	Socorro Spring	4960	Rhyolite breccia	Tdv(?)	Hillside with breccia faulted against tuff	220	3/20/58	PS	89	Shaft and adit
3S.1W.22.113	City of Socorro	Socorro Spring	4960	Rhyolite breccia	Tdv(?)	Hillside with breccia faulted against tuff	---	---	PS	91	Shaft and adit
3S.1W.22.131	Sedillo and City of Socorro	Sedillo (or Evergreen) Spring	5000	Rhyolite breccia	Tdv(?)	Hillside with breccia in fault zone(?)	240	3/20/58	PS,I	90	Extensively developed
3S.1W.22.131	Sedillo and City of Socorro	Sedillo (or Evergreen) Spring	5000	Rhyolite breccia	Tdv(?)	Hillside with breccia in fault zone	---	---	PS,I	88	Extensively developed
3S.3W.7.313	New Jersey Zinc & Lead Co.	Patterson Tunnel	7825	Unknown	---	Flow from tunnel	40	7/1/62	S	---	Abo formation and igneous rocks in tailings
3S.3W.7.342	---	---	8080	Limestone	P	Fault contact of limestone and volcanics	1/4	7/1/62	S	---	---
3S.3W.10.311	Strozzi	Garcia Canyon	7080	Limestone	P	Arroyo bottom	>2	7/26/62	S	63	Control by limestone beds crossing arroyo
3S.3W.19.132	Dan Hutchison	---	8280	Purple Andesite	Tdv	Pool in tunnel	NV	6/30/62	D,S	---	---
3S.3W.26.111	Cibola Natl. Forest	N. Fork, Water Canyon	6800	Gravel	Qal or P(?)	Streambed	>40	5/10/62	S	64	---
3S.3W.26.113	Cibola Natl. Forest	Water Canyon	6800	Gravel	Qal or Tdv(?)	Streambed	20-30	5/10/62	S	73	---
3S.3W.27.211	Cibola Natl. Forest	N. Fork, Water Canyon	7000	Gravel	Qal or P(?)	Streambed	S	2/8/63	S	48	Area of permanent flow
3S.3W.34.332	Cibola Natl. Forest	Water Canyon	---	Gravel	Qal or Tdv(?)	Streambed	S	2/8/63	S	45	Area of permanent flow
3S.4W.12.311	Don Hutchison	---	7275	Andesite	Tdv(?)	---	0.01	6/30/62	S	---	---
3S.4W.24.242	Don Hutchison	---	8020	Sand and gravel	Qal(?)	Arroyo bottom	S	6/30/62	D,S	---	---
3S.4W.26.233	Cibola Natl. Forest	Rock Springs Canyon	7600	Soil	Tdv(?)	Hillside	S	5/23/63	D,S	---	---
3S.4W.36.242	Cibola Natl. Forest	Mill Canyon	8760	Soil	Tdv(?)	Hillside	>1	5/23/63	D	---	---
4S.1W.5.211	Sedillo	Chupadera Spring	5200	Soil or red silt	Tpt(?)	Hillside	S	5/17/62	S	63	---
4S.2W.7.211	Cibola Natl. Forest	Box Spring	----	Volcanics	Tdv(?)	Arroyo bottom	S	2/8/63	S	46	Dried up by 6/17/63
4S.3W.5.331	Cibola Natl. Forest	Baldy Spring	----	---	Tdv(?)		---	---	D,S	---	
4S.4W.11.121	Cibola Natl. Forest	---	----	Soil	Tdv(?)	Arroyo bottom	>3	6/6/63	D,S	---	---
4S.4W.13.213	Cibola Natl. Forest	Hardy Springs	----	Volcanics	Tdv	Hillside, from talus pile	3	6/4/63	S	54	---
4S.4W.14.112	Muleshoe Ranch	Buttercup Spring	----	Soil	Tdv(?)	Hillside	.05	6/6/63	S	---	---
4S.4W.27.122	Muleshoe Ranch	---	----	Conglomerate or volcanics	QTg or QTr	Arroyo bottom	.25	6/6/63	S	---	---
4S.4W.28.430	Weston Ranch	---	----	Soil	Tdv	Hillside	.17	6/4/63	S	---	---
4S.4W.31.230	Weston Ranch	Alameda Spring	----	Conglomerate or volcanics	QTg or QTr	In bottom of small side arroyo	±2	6/4/63	S	---	---
5S.2W.8.230	Bianchi-Strozzi-Gianera	Torreon Spring	----	Sediments or volcanics(?)	QTs or QTsv	Slight rise between two arroyos	>10	5/17/62	S	65	At fault contact between sediments and volcanics(?)
5S.2W.18.140	Diamond A Ranch	Cienega Spring	----	Conglomerate and sand	QTs	Arroyo bottom in fault zone	3	5/17/62	S	69	---
5S.3W.14.444	Burris Ranch	Burro Spring	----	Sediments or volcanics	QTs or QTsv	Arroyo bottom pond	S	6/11/63	S	---	At contact of sediments and volcanics

APPENDIX C-RECORDS OF SPRINGS IN THE VICINITY OF SOCORRO, SOCORRO COUNTY, NEW MEXICO (continued)

Location number	Owner	Name	Altitude (feet)	Type of Material	Geologic Source	Occurrence	Yield		Use	Temperature (°F)	Remarks
							Rate gpm	Date			
5S.4W.5.320	Weston Ranch	---	----	Soil or volcanics	Tdv	Hillside	1.5	6/11/63	D,S	---	Collected at overflow to stock tank
5S.4W.24.400	---	Puertecito Gap	----	Volcanics(?)	Tdv(?)	---	---	---	S	---	Windmill well
6S.1W.6.420	Diamond A Ranch	---	----	Soil	Tdv(?)	On top of stream bank	---	---	S	---	Probably controlled by fault
6S.1W.6.440	Diamond A Ranch	---	----	Volcanics	Tdv	Hillside in fault zone(?)	25	6/18/63	S	70	Spring may be a little warm
2S.1E.14.132	---	---	4990	Sand and gravel	Qal or Tdv	Arroyo bottom	>1	3/19/63	S	---	Lowermost spring area downstream from Ojo de la Parida
2S.1E.14.142	---	---	5000	Sand and gravel	Qal or Tb	Arroyo bottom	>2	3/15/63	S	---	Next to lowermost spring area downstream from Ojo de la Parida
2S.1E.14.200	---	"Ojo de la Parida"	5030	Sand and gravel	Qal or $\bar{R}$	Arroyo bottom	1/5	10/27/50	S	---	May be near fault contact (original Ojo de la Parida is dry)
2S.1E.14.221	---	"Ojo de la Parida"	5030	Sand and gravel	Qal or $\bar{R}$	Arroyo bottom	20	6/6/60	S	---	May be near fault contact (original Ojo de la Parida is dry)
2S.1E.14.221	---	"Ojo de la Parida"	5030	Sand and gravel	Qal or $\bar{R}$	Arroyo bank	VS	6/6/62	S	65	May be near fault contact (original Ojo de la Parida is dry)
2S.1E.14.221	---	"Ojo de la Parida"	5030	Sand and gravel	Qal or $\bar{R}$	Arroyo bottom	>2	3/15/63	S	---	May be near fault contact (original Ojo de la Parida is dry)
2S.1E.22.422	---	Ojo del Coyote	5010	Sandstone and volcanics	Pg or Td	Hillside	VS	6/6/62	S	---	At contact of Glorieta and Datil formations
2S.1E.26.100	---	Chupadero (Old Chavez) Spring	4910	Sandstone and shale	Pa	Small arroyo bottom	---	---	D,S	---	Controlled by sandstone bed
2S.1E.26.121	---	Chupadero (Old Chavez) Spring	4910	Sandstone and shale	Pa	Small arroyo bottom	3/4	6/6/62	S	63	Controlled by sandstone bed
2S.1E.27.200	---	Ojo de Amado	4990	Sand and gravel	$\bar{P}$ or Td	Pool in arroyo bottom	---	---	S	---	At contact of Pennsylvanian limestone and Datil
2S.1E.27.200	---	Ojo de Amado	4990	Sand and gravel	$\bar{P}$ or Td	Pool in arroyo bottom	---	---	S	---	At contact of Pennsylvanian limestone and Datil
2S.1E.27.243	---	Ojo de Amado	4990	Sand and gravel	$\bar{P}$ or Td	Pool in arroyo bottom	NV	6/6/62	S	64	At contact of Pennsylvanian limestone and Datil
2S.2E.30.234	---	Ojo del Rancho de Lopez	5210	Sand and gravel	Pa(?)	Arroyo bottom	VS	6/6/62	S	---	Controlled by sandstone bed
3S.1E.24.444	---	---	5020	Sand and silt	Qal	Bottom of small side arroyo	≈2	3/15/63	S	61	In or near a fault zone
3S.2E.19.323	---	Ojo de las Cañas	5040	Sand and gravel	Py	Arroyo bottom	>2	6/13/62	S	---	Controlled by sandstone bed
3S.2E.19.323	---	Ojo de las Cañas	5040	Sand and gravel	Py	Arroyo bottom	≈10	3/15/63	S	---	Controlled by sandstone bed