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GROUND-WATER RECONNAISSANCE IN THE WESTERN PART OF THE MOJAVE DESERT, CALIFORNIA, WITH PARTICULAR RESPECT TO THE BORON CONTENT OF WELL WATER

By

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standards and nomenclature of the
Geological Survey

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GROUND-WATER RECONNAISSANCE IN THE WESTERN PART OF THE MOJAVE DESERT, CALIFORNIA, WITH PARTICULAR RESPECT TO THE BORON CONTENT OF WELL WATER

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SUMMARY AND CONCLUSIONS

Reconnaissance geochemical studies of ground waters in the western part of the Mojave Desert indicate two areas that show a possibility of containing economic deposits of borates. These areas were determined by the abnormally high boron factors of the ground waters when compared to the boron factors of waters sampled throughout the area.

Ground water analyzed from well 30/37-12N1 in Red Rock Canyon showed a boron concentration of 33 ppm and a boron factor of 10. Detailed geochemical prospecting would be desirable in the large exposed section of the Tertiary rocks in Red Rock Canyon area to investigate the source of mineralization to the ground water.

Analyses of ground water from wells 11/6-20A1 and 17L1 about 7 miles east of the Kramer borate deposit show a boron concentration and factor as high as 35 ppm and 23, respectively. Colemanite has been reported from test holes drilled in this area. Well 11/6-20A1 was drilled to a depth of 712 feet, but an accurate log of the well was not available.

In general the boron concentrations and factors of ground and surface waters throughout this part of the western Mojave Desert area are less than 1.0 ppm and 1.0, respectively. A few factors were as high as 3.0, but this is not considered a significant factor for this area.

Caution should always be used in the geochemical interpretation of ground waters as a guide to the location of mineral deposits. Low concentrations or absence of the desired mineral constituent in ground water does not necessarily indicate the nonoccurrence of the mineral. Hydrologic conditions can be such that the mineral deposit does not affect to any appreciable degree the chemical character of the water tapped by a well. For example, above the Kramer borate deposit a small quantity of ground water of low boron concentration occurs as perched water. Therefore if water wells are not drilled to a great enough depth to tap the main ground-water body in which the unique mineral is concentrated, the analyses of the water may be valueless as a geochemical guide.

In those areas where concentrations of the desired mineral appear to be high, no valid conclusion can be made until the entire ground-water basin is hydrologically and geochemically studied to show that a unique water occurs which could possibly be accounted for by a unique mineral source.

INTRODUCTION

Location of the Area

The area of this reconnaissance investigation is in the western part of the Mojave Desert (pl. 1) between 117°00' and 118°30' west longitude and between 34°45' and 35°30' north latitude. It embraces parts of six topographic basins as defined by Thompson (1929), namely: Antelope, Fremont, Middle Mojave, Harper, Cuddeback (also known as Golden), and Superior Valleys. In general the area lies north of a line from Barstow, to Hodge, to Kramer, to Mojave; east and south of the Garlock-El Paso fault zone; and west of a line trending north from Barstow.

This area is shown on the following topographic quadrangle maps Searles Lake (scale 1:250,000); Barstow and Mojave (scale 1:125,000); Cross Mountain, Saltdale, Randsburg, Mojave, and Castle Butte (scale 1:62,500); and Mojave, Plano, Desert Butte, Castle Butte SE, Johannesburg SW, Kramer Borate District (scale 1:24,000), and Cuddeback Lake and Pilot Knob (preliminary, scale 1:38,000).

The outlines of the valleys investigated are shown on plate 1 and have been somewhat modified after Thompson (1929) on the basis of larger-scale topographic maps having contour intervals of 50 or 25 feet instead of the 100-foot interval of the Searles Lake quadrangle (scale 1:250,000) available to Thompson. In general it is convenient to consider these valleys as separate areas; although, as will be explained later, watersheds or topographic divides do not everywhere coincide with ground-water divides, and at some places ground water moves from one ground-water basin to another beneath topographic divides.

Antelope Valley, which is in the southwest corner of the Mojave Desert, is bordered on the west by the Tehachapi Mountains; on the north and east by a disconnected chain of irregular low hills; and on the south by the San Gabriel Mountains, which are outside the area studied and are not shown on plate 1. Although Thompson (1929) shows the northern boundary of the Antelope Valley a few miles north of Rogers Lake, which is a large playa in the lowest part of the valley, there is a large area bounded on the north by the Rand Mountains and to the west and east by relatively low hills, all of which drain~~s~~ into Rogers Lake and may thus be considered a part of the valley. The area north of U. S. Highway 466 is herein referred to as the Boron area and is the only part of Antelope Valley studied in the present investigation. The Kramer borate deposits lie in the southwestern part of the Boron area, and the ground-water study was begun in this area.

Fremont Valley, the northwesternmost valley studied, is bounded on the north by the El Paso Mountains, on the northwest by the southern end of the Sierra Nevada, on the east by the Rand Mountains, and on the south and southeast by Antelope Valley. The southern boundary of the area has been modified after Thompson (1929). Thompson included most of the Boron area in the Fremont Valley, whereas, in fact, the surface drainage in this area is a part of Antelope Valley.

The Middle Mojave Valley of this report includes that part of the Mojave River between Hodge and Barstow. Also included is the area south and southeast of the Kramer Hills and the area southeast of Lenwood. The reach of the Middle Mojave Valley of Thompson (1929) between Hodge and Victorville was not included in this study.

Harper Valley, which is about 15 miles west of Barstow, lies immediately east of the Boron area and is adjoined on the south by the Middle Mojave Valley. The south and southeast boundaries of the valley are not well defined, particularly in the vicinity of Hinkley where the boundary was drawn somewhat arbitrarily because, during periods of floods, the Mojave River has discharged into Harper Lake; also, ground water moves northward from the Middle Mojave Valley to Harper Valley.

Cuddeback Valley is a relatively small well-defined valley southeast of Randsburg, north of Harper Valley, and west of Superior Valley. This valley was termed Golden Valley by Thompson (1929) but current usage favors Cuddeback because of the same name applied to the dry lake in the central part of the valley.

Superior Valley lies immediately east of Cuddeback Valley, north and northeast of Harper Valley, and west of Coyote Valley (not shown on the maps). It is somewhat larger than Cuddeback Valley.

Purpose and Scope of the Investigation

In the autumn of 1952 the Mineral Deposits Branch of the United States Geological Survey, in connection with its work on the Mojave Desert project, requested the Ground Water Branch of the Geological Survey to undertake a reconnaissance ground-water investigation of the western part of the Mojave Desert. The principal purpose of the ground-water study was to determine, in areas of Tertiary deposits containing known or suspected borate ores, whether study of the chemical character of ground waters or other ground-water techniques could be used as a guide in the location of subsurface borate deposits.

Accordingly, the work was directed toward: (1) The collection of available chemical analyses from public agencies and other sources as well as the sampling of wells and springs in the field for chemical analysis. The data were plotted on maps and chemical diagrams, and were studied with particular respect to the boron concentration, as shown on plates 4, 5, 7, and 9 to 13; (2) the canvassing of most of the wells in the area not only to collect samples but also to determine the altitude of the ground-water levels, which were used to construct the water-level contours shown on plates 3 and 8 to provide information on the direction of ground-water movement through or within the several valleys. These water-level data also provided information on the existence of subsurface barriers, usually fault barriers, which impede ground-water movement; and (3) the collection of available well logs which were used to study the character of the water-bearing deposits in areas where ground waters contained above-average concentrations of boron. The water-bearing deposits as exposed at the surface had already been mapped by the Mineral Deposits Branch. The results of the geologic mapping, modified by the author, in the light of subsurface information, are shown on plates 3, 8, and 12.

The investigation was begun in January 1953 in the area of the known Kramer borate deposits near Boron, California, in order to determine the occurrence and chemical quality of ground waters where the occurrence and extent of commercial borate deposits were known in considerable detail. Subsequently, the study was expanded to include adjacent areas in the northern parts of Fremont and Antelope Valleys. This phase of the investigation was completed in July 1953, and a progress report was prepared for administrative use. Thereafter, the area of investigation was expanded to include additional areas in the Middle Mojave, Harper, Cuddeback, and Superior Valleys.

During the period April to July 1953, F. H. Olmsted, geologist, Ground Water Branch, was assigned to the project to direct the work and the preparation of the progress report mentioned. The author of the present report terminated his employment with the Geological Survey in December 1954, before completing the report. Fred Kunkel, geologist, Ground Water Branch, completed the report for public release..

The ground-water reconnaissance has been carried on by the Geological Survey, United States Department of the Interior, under the general supervision of J. F. Poland, district geologist of the Ground Water Branch in charge of ground-water investigations in California, and under the immediate supervision of G. F. Worts, Jr., geologist in charge of the Long Beach area office. Ward Smith, geologist in charge of the Mojave Desert project of the Mineral Deposits Branch, directed the broad phases of the work insofar as it is related to the overall program.

Field Methods

Inventory of Wells and Springs

The first step in this investigation was an inventory of water wells and springs in each of the six valleys (pl. 1) to obtain the following data: (1) Location of well or spring by odometer traverse or compass bearing; (2) physical description of well or spring; (3) determination of land-surface altitude at well or spring by barometer or interpolation from topographic map; (4) depth of well by measurement or owner's report; (5) depth to water by measurement or from owner's report, if measurement ~~were~~ was impossible; (6) rate of discharge of pumped well, flowing well, or spring; 2nd (7) driller's log, casing size and perforations, chemical analyses, previous water-level measurements, and other available data.

These data were listed on standard Geological Survey forms and are ~~will become~~ a part of the permanent file in the Long Beach office of the ~~Ground Water Branch~~ Geological Survey, where they ~~will be~~ are available for inspection. A total of about 570 wells were canvassed throughout the six areas, of which 160 wells were canvassed by personnel of the Long Beach office. There are about 270 wells in the Boron and Koehn Lake areas and about 300 wells in the Harper, Middle Mojave, Cuddeback, and Superior Valleys.

Collection of Water Samples for Chemical Analysis

Water samples were collected directly from pumped and flowing wells and springs, and bailed from unused wells. Approximately 50 samples were collected throughout the six basins to give a broad areal coverage. The collection of water samples, however, was unavoidably limited by the distribution of wells and springs and resulted in an incomplete areal coverage. Nevertheless, an effort was made to collect samples in those areas known or believed to be underlain by sediments and volcanics of Tertiary age.

Where possible, samples from pumped wells were collected directly from the end of the discharge pipe, thereby avoiding possible contamination and concentration which can occur in storage and reservoir tanks. The temperature of the water, an estimate of the flow in gallons per minute, and the length of time the well was pumped before sampling were recorded when a well was sampled. The temperature, flow, and type of discharge were also noted when sampling springs and flowing wells. In addition to these data, the depth of the well, perforated intervals, and logs were recorded whenever this information was available.

Samples were bailed from unused wells having open unobstructed casings or from wells which could be made accessible. On the bailing of water samples, the volume of water bailed, drawdown, and recovery rates of the water level were noted. This information was used to determine whether the well was plugged or if there was free access for water to move through the perforations.

The equipment used for bailing included a detachable steel tripod mounted on the front end of a jeep pickup, a 4-inch sheave affixed to the top of the tripod, and 600 feet of 2,000-pound-test aircraft cable mounted on the front winch of the jeep. Two bailers, one 8-inch O.D. by 5 feet and the other 4-inch O.D. by 5 feet, holding 12 and 3 gallons respectively, were constructed. The power for lowering and lifting the bailers was supplied by the jeep through the front power takeoff. It was estimated that from a well with an average depth to water of 200 feet, 100 to 120 gallons per hour could be bailed with the 8-inch bailer.

Collection of Basic Data

Considerable time was spent contacting public and private agencies to obtain copies of well logs, water-level records, and chemical analyses. Some data were obtained from the [illegible] Ground Water Branch office in Long Beach, Calif., which has been conducting a ground-water investigation in parts of Antelope and Fremont Valleys and canvassing wells in Harper Valley.

A total of approximately 2,000 logs of wells and chemical analyses were collected throughout the Mojave Desert and adjacent areas. Of these, about 200 oil- and water-well logs were collected for the six areas, and 80 have been field located. In addition, approximately 80 analyses of surface and ground waters were collected, and the field locations of 40 sampling points were established. Other agencies from which data were collected are as follows: California Division of Water Resources; California Division of Oil and Gas; San Bernardino County Flood Control District; U. S. Department of Agriculture, Salinity Laboratory, Riverside, California; U. S. Bureau of Reclamation, Boulder City, Nevada; Union Pacific Railroad; Atchison, Topeka, and Santa Fe Railroad; Los Angeles Metropolitan Water District; and U. S. Geological Survey, Surface Water Branch, San Bernardino, California. In addition, data were obtained from private land owners, well drillers, and power companies. Most of these data were collected by means of a portable microfilmer.

Acknowledgments

Max Bookman, Engineer in Charge of the Los Angeles office of the California Division of Water Resources, Glenn Brown, assistant engineering geologist, and other personnel made available well logs, chemical analyses, and other data in the Mojave Desert area. Lloyd Martin of the San Bernardino County Flood Control District made available chemical analyses for that part of the Mojave Desert within the boundaries of San Bernardino County. L. V. Wilcox, U. S. Department of Agriculture Salinity Laboratory, Riverside, Calif., supplied copies of analyses for Indian Wells Valley, Death Valley, and Amargosa River area and for other areas in Los Angeles, Kern, and San Bernardino Counties in the Mojave Desert area. Glenn Lang of the U. S. Geological Survey, San Bernardino, Calif., supplied information on water supplies in the Mojave River valley.

E. Harris of East Barstow, W. Scroggins of Helendale, and H. Ley of Oro Grande, well drillers, supplied well logs and other information on ground water in the western part of the Mojave Desert. J. Smith, California Electric and Power Co., Barstow, and the personnel of the Randsburg office furnished well and pump-test data.

Well-Numbering System

The well-numbering system used by the Geological Survey in California shows the location of wells and springs according to the rectangular system for the subdivision of public land. For example, in the number 30/37-24R3, which was assigned to a well near Cantil in the Koehn Lake area, the part of the number preceding the bar indicates the township (T. 30 S.), the part between the bar and the hyphen shows the range (R. 37 E.), the digits between the hyphen and the letter indicate the section (sec. 24), and the letter indicates the 40-acre subdivision of the section as shown in the accompanying diagram:

24

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Within each 40-acre tract, the wells and springs are numbered serially, as indicated by the final digit of the number. Thus, well 30/37-24R3 is the third well to be listed in the SE¼SE¼ sec. 24, T. 30 S., R. 37 E., Mount Diablo base and meridian lines.

Although that part of the area about north of the town of Mojave is covered by the Mt. Diablo base and meridian lines and that part to the south by the San Bernardino base and meridian lines, no duplication in township and range numbers results: The Mt. Diablo numbers are from T. 29 S. to T. 32 S. and from R. 36 E. to R. 47 E.; the San Bernardino numbers are from T. 8 N. to T. 12 N. and from R. 2 W. to R. 11 W.

As all of the wells are either in the northwest quadrant of the San Bernardino base and meridian lines or in the southeast quadrant of the Mt. Diablo base and meridian lines, the abbreviation of the township and range part of the numbers is sufficient.

The well-numbering system is commonly used as a shorthand means of describing locations of features other than wells and springs. For example, one of the adits of the Yellow Aster Mine near Randsburg can be described as being located in 30/40-2D. This would indicate a location within the NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 2, T. 30 S., R. 40 E., Mt. Diablo base and meridian lines. These locations are not indicated on the maps.

Special cases arise where the above described well-numbering system is altered. The following are examples of the altered well numbers used in this report:

A) A well located in the field where the section-net control is poor, is denoted by the letter X in place of the 40-acre tract letter. Well 10/5-32X1 is an example of this type of number, and the well would be plotted on a map as X1.

B) A well not located in the field but which has a reported location is denoted by a dash in place of the 40-acre tract letter. Wells 10/5-32-1 and 10/5-32-2 are examples of this type of number and they would be plotted on a map as -1 and -2, respectively.

NUMERICAL AND GRAPHIC EXPRESSION OF WATER ANALYSES

Because chemical analyses of waters commonly are expressed in parts per million (ppm), the purpose of this section is to set forth the information needed to convert analyses in parts per million to the form used for graphic plotting, with special reference to the trilinear water-analyses diagram described by Piper (1945). The material here presented is in part a duplication of information given by Piper, but has been done to present a step-by-step instruction on how to proceed from the analysis to the plotted graph.

Determined Constituents

In general, natural waters contain only a few dissolved constituents, most of them in the form of cations or anions, but some in the form of un-ionized compounds. The principal cations are calcium, magnesium, and sodium, potassium being minor; the principal anions are bicarbonate, sulfate, and chloride, carbonate (if present at all), nitrate, boron, and fluoride being present in minor amounts (table 2). Un-ionized silica usually is present in colloidal form, and iron usually is present but commonly in a concentration of less than 1 ppm. Additional minor and rarer constituents are listed by Piper (1953, p. 3).

The usual complete analysis made by the Geological Survey includes determination of all the constituents listed in the preceding paragraph and, in addition, dissolved solids, determined by evaporation to dryness, and specific conductance (micromhos at 25°C). Hardness is expressed as calcium carbonate and generally differentiated into carbonate and noncarbonate hardness.

In many analyses dissolved solids are not determined, and specific conductance may not be available. In these analyses, if the six principal ionized constituents have been determined analytically, a summation of these constituents usually gives an approximate value for the total dissolved solids. However, in the summation of these constituents, expressed in parts per million, the carbonate equivalent of the bicarbonate concentration is used. This procedure, as described by Collins (1923, p. 253), is followed to conform with the value obtained for dissolved solids by the evaporation process. In the process of evaporation of natural water to dryness bicarbonate decomposes to an equivalent amount of carbonate owing to the loss of carbon dioxide and water, in the ratio of 61 parts by weight of bicarbonate to 30 parts by weight of carbonate. The carbonate equivalent is obtained by dividing the bicarbonate concentration, expressed in parts per million, by 2.03. For example:

$$\frac{61 \text{ ppm } HCO_3}{2.03} = 30 \text{ ppm } CO_3$$

Extension of Partial Analyses

In many partial analyses the chloride, sulfate, and bicarbonate concentrations are determined by standard laboratory techniques. However, if sulfate is determined by the turbidity method and hardness by the soap method, their ~~respective~~ values should be considered approximate.

Often in partial analyses sodium is not determined, and calcium and magnesium are determined only as total hardness in parts per million as ~~of~~ calcium carbonate. In this type of partial analysis, if the principal anions were determined accurately, the approximate concentration of sodium, in equivalents per million (epm), can be determined by difference as follows:

$$\frac{\text{Total hardness}^{\cancel{1/}}}{50} = \text{sum of Ca + Mg (epm)}$$

$$\text{Approximate Na (epm)} = \text{Sum of anions (epm)} - \text{sum of Ca + Mg (epm)}$$

In some partial analyses total hardness is broken down into Ca and Mg hardness. In this case the equivalents per million of both Ca and Mg can be calculated by the same equation as follows:

$$\frac{\text{Ca hardness (ppm)}}{50} = \text{Ca (epm)}$$

$$\frac{\text{Mg hardness (ppm)}}{50} = \text{Mg (epm)}$$

~~1. Total hardness expressed in ppm of $CaCO_3$.~~

Unnecessary - already stated
CHVS

For plotting on the diamond field of the water-analysis diagram (pl. 2) discussed in the following sections, the minimum partial analysis required would include determination of total hardness, sodium, bicarbonate, and carbonate. For plotting on the cation and anion triangles as well, calcium would have to be determined in addition to hardness, which would give magnesium by difference, and either chloride or sulfate among the anions would have to be determined; or else five of the six principal ions would have to be determined directly. However, this method of analysis is only approximate and in some cases may lead to substantial error. It is recommended only where the more complete analyses are impractical.

Conversion of Parts Per Million to Percentage Reacting Values

The first step prior to plotting an analysis on the water-analysis diagram is to convert the constituents expressed as parts per million (ppm) to equivalents per million (epm), and then to determine the percentage reacting values (%RV) of the individual constituents.

The analysis as expressed in parts per million (ppm) gives a weight relationship (the number of unit weights of the constituent in a million unit weights of water) and does not demonstrate the proportions of the constituents. In order to obtain a more useful statement of the chemical character, the various constituents expressed as parts per million are converted to equivalents per million (epm). This conversion can be accomplished in two ways: First, by dividing the parts per million of the constituent by the equivalent weight[1] (combining weight) of the constituent; second, by obtaining the reciprocal of the equivalent weight of the constituent and multiplying this value by the reported parts per million of the constituent. These methods are shown in the following equations:

$$\frac{\text{Parts per million of constituent}}{\text{equivalent weight of constituent}} = \text{equivalents per million}$$

or

$$(\text{Parts per million}) \times \frac{1}{(\text{equivalent weight})} = \text{equivalents per million}$$

---

[1] The equivalent weight of an element or radical is that weight which will combine chemically with the hydrogen ion, whose valence and atomic weight are taken as a standard of one. In order to determine the equivalent weight, the atomic weight, if the constituent is an element such as sodium, or the molecular weight, if the constituent is a radical such as sulfate, is divided by the valence of the respective element or radical.

It can be seen from the above equations that, for analyses in which the constituents are reported as equivalents per million, a conversion to parts per million, if desired, can be readily accomplished as follows:

(Equivalents per million) x (equivalent weight) = parts per million

Table 1 shows the atomic and molecular weights, the equivalent weights, and the reciprocals of the equivalent weights of the common and some of the minor constituents of natural waters (the ions included in the usual Geological Survey complete analysis of the).

Table 1.- Factors for converting parts per million to equivalents per million

Constituent		Atomic or molecular weight	Equivalent weight	Reciprocal of equivalent weight
Cations				
Calcium	(Ca)	40.08	20.04	.0499
Magnesium	(Mg)	24.32	12.16	.0822
Sodium	(Na)	23.00	23.00	.0435
Potassium	(K)	39.10	39.10	.0256
Anions				
Carbonate	(CO_3)	60.02	30.01	.0333
Bicarbonate	(HCO_3)	61.02	61.02	.0164
Sulfate	(SO_4)	96.06	48.03	.0208
Chloride	(Cl)	35.46	35.46	.0282
Fluoride	(F)	19.00	19.00	.0526
Nitrate	(NO_3)	62.01	62.01	.0161
Boron	$(B)^3$	10.82	3.61	.2770

In a natural water the total equivalents of cations should equal the total of the anions. Therefore, the sum of the equivalents per million of cations and anions for an analysis affords a ready means of checking the accuracy of the analytical work, unless one of the ions has been calculated by difference. The Geological Survey ~~Quality of Water Branch~~ considers a 2-percent unbalance in sum of cations versus anions as the allowable limit of ~~limit of permissible~~ error in an analysis of natural water.

A third method of expressing the chemical analysis of a natural water is the percentage reacting value (%RV) of the various constituents. This value is calculated from the equivalents per million and is the ratio of the individual cation (or anion) to the sum of all the cations (or anions) expressed as a percentage. For example:

$$\frac{\text{Equivalents per million of Na}}{\underset{\Sigma}{\text{sum}}\text{ of equivalents per million of the cations}} \times 100 = \%\text{RV Na}$$

$$\frac{\text{equivalents per million of HCO}_3}{\underset{\Sigma}{\text{sum}}\text{ of equivalents per million of the anions}} \times 100 = \%\text{RV HCO}_3$$

The percentage reacting values so determined for each cation and anion are plotted on the water-analysis diagram.

Any unbalance in the analysis is adjusted automatically during the calculation of percentage reacting values by obtaining the percentage relationship of the individual cations or anions in equivalents per million to the sum of all the cations (or anions). By this means, the sum of percentage reacting values of the cations and anions each will equal 100 percent.

Plotting Analyses on the Water-Analysis Diagram

The mechanics of plotting the percentage reacting values on the water-analysis diagram are relatively simple and can be done in several ways. Table 2 shows four complete analyses in all three forms of expression. The percentage reacting values of the constituents in these analyses are plotted on plate 2, a water-analysis diagram. The diagram has three separate fields for plotting, two triangles at the lower left and lower right, respectively, and an intervening diamond-shaped field. The percentage scales in all three fields read from zero to 100 percent, ~~with~~ the fields being marked off in divisions of 10 ~~2~~ percent. redundant [illegible]

In plotting the percentage reacting values, the minor constituents are grouped with the major ions to which they are related. For example, potassium is grouped with sodium, carbonate (and boron, if present as tetraborate) with bicarbonate, and fluoride and nitrate with chloride.

The cations, calcium, magnesium, and sodium plus potassium, are plotted in the triangle to the lower left, and the anions, bicarbonate plus carbonate, sulfate, and chloride, are plotted in the triangle to the lower right. These plots show the relative proportions of the principal constituents of natural water on the basis of the percentage reacting values. The intervening diamond-shaped field shows the general chemical character of the water. The arrows along the sides of the three fields point to the direction of 100 percent of the cation or anion indicated by the chemical symbol accompanying the arrow. Thus, each of the vertices in the triangular fields is a 100-percent point for one of the respective cations or anions and the opposite side of the triangle is the zero base.

You showed capitals in text and I believe would continue them here.

Table 2.- Analyses of selected California waters

[Analyses by ~~Quality of Water Branch,~~ Geological Survey]

Analyses	1			2			3			4		
Constituents in	ppm	epm	%rv	ppm	epm	%rv	ppm	epm	%rv	ppm	epm	%rv
Ca	4.0	0.200	53.3	175	8.73	27.4	303	15.12	20.6	4.5	0.225	5.5
Mg	1.2	0.099	26.4	192	15.79	49.5	39	3.21	4.4	.5	.041	1.0
Na	1.4	0.061	16.3	168	7.31	22.9	1,260	54.8	74.6	87	3.783	92.4
K	0.6	0.015	4.0	2.8	0.07	0.2	13	0.33	0.4	1.7	.043	1.1
Total cations		0.375	100.0		31.90	100.0		73.46	100.0		4.092	100.1
CO_3	0	0.0		0						0		
HCO_3	19	0.311	79.3	212	3.47	10.7	126	2.06	2.7	200	3.278	78.6
SO_4	2.0	0.042	10.7	1,260	26.23	81.3	398	8.29	11.0	1.4	.029	0.7
Cl	1.2	0.034	8.7	58	1.64	5.1	2,310	65.2	86.2	29	.818	19.6
F	0.1	0.005	1.3	0			0.2	0.01	0.0	.5	.026	0.6
NO_3	0.0	0.000		59	0.95	2.9	5.4	0.09	0.1	1.4	.023	0.5
Total anions		0.392	100.0		32.29	100.0		75.65	100.0		4.174	100.0
SiO_2	8.4			46			54			19		
Fe	0.0									.04		
Boron	0.01			1.46			1.40					
Sum	28			2,070			4,450			224		
Spec. cond. micromhos at 25°C)	35.2			2,450			7,540					
Percent sodium	16			23			75			92		

1.
2. Give locations of samples?
3.
4.

Have no Idea

The percentage reacting values of the cations and anions can be plotted as a point in their respective triangles. This gives one point in each triangle. Projection of these points into the diamond-shaped field gives a point, at the intersection of the projections,. that characterizes the water as a whole. The independent plotting of a point in the diamond field gives a check on the accuracy of the triple plot, for if the intersection of projections drawn from the points in the triangular fields coincides with the independent point plot in the diamond field, the plot is correct.

The point plot on the water-analysis diagram does not indicate the concentration of dissolved solids. If it is desired to compare several waters for concentration as well as general character, the concentration may be indicated by drawing a circle centered at the proper point on the diamond field, having an area or a diameter in proportion, direct or logarithmic, to the concentration. In this report such a comparison has not been made.

For office-study purposes all analyses shown on plates 5, 7, 10, 11, and 13 were plotted on the cation and anion triangles as well as on the central diamond, which only is shown. The anion and cation plots did not indicate any peculiar characteristics and therefore were not included.

Utility of the Water-Analysis Diagram

The water-analysis diagram has proved to be a useful aid in the study of the chemical character of natural waters. Numerous natural chemical changes, which surface and especially ground waters undergo, can be visually and graphically demonstrated by means of this diagram. Ion ~~Base~~ exchange, ~~more accurately termed cation-exchange~~, sulfate reduction, and the impairment or improvement of water quality by the mixing of waters are some of the geochemical phenomena ~~which~~ that can be shown on the diagram. Generally, however, plots of natural waters, contaminated waters of increasing concentrations, and of possible contaminants do not of themselves demonstrate the source of contamination, chiefly because ~~cat~~ion exchange diverts the plot of contaminated waters from the "blend-lines" between plots of natural water and possible contaminants. The diamond-shaped field of the diagram (pl. 2) can be subdivided into several distinct fields in which waters of a particular chemical character fall (Piper and Garrett, 1953, p. 14). These fields (pl. 2) are as follows: (A) Alkalies and strong acids dominant, (primary salinity); (B) noncarbonate hardness; alkaline earths and strong acids dominant, (secondary salinity); (C) carbonate alkali; weak acids and alkalies dominant, (primary alkalinity); (D) carbonate hardness; alkaline earths and weak acids dominant, (secondary ~~salinity~~ alkalinity); (E) alkalinity or salinity not dominant.

One of the main purposes of the water-analysis diagram is to show the different types of water in an area, and this it does most successfully. However, many problems concerning the chemical character of water cannot be solved using the diagram, and any conclusions based on it should be carefully drawn ~~with sound demonstration of how they were reached~~.

In this report, terms describing the general chemical character of waters that are of primary or secondary salinity or of primary or secondary alkalinity are used in particular senses, as in the following examples: (1) "calcium chloride designates a water in which the calcium amounts to 50 percent or more of the bases and chloride to 50 percent or more of the acids, in chemical equivalents; (2) "sodium sulfate chloride" designates a water in which the sodium amounts to 50 percent or more of the bases in chemical equivalents, and the sulfate and chloride are the two major ~~acids~~ anions but neither one exceeds 50 percent in chemical equivalents. Waters that are not dominantly alkaline or saline (Piper and Garrett, 1953, p. 14) are not identified as a specific type. (See pl. 2)

Boron Factor

In studying the boron concentrations in the ground waters of the western part of the Mojave Desert, it was found that, when considering the economic concentrations of boron, the "boron factor" as used by J. A. Logan (personal communication, 1953) was more significant than the boron concentration alone. The boron factor is derived from the relation of boron in parts per million to an adjusted value of the specific conductance. The value of specific conductance in micromhos, which is $K \times 10^6$ at 25°C, is adjusted to $K \times 10^3$ at 25°C. Therefore, a water containing 1 ppm of boron and a specific conductance 1,000 micromhos would have an adjusted specific conductance of 1 and a boron factor of 1, as follows:

$$\text{Boron factor} = \frac{\text{Boron (ppm)}}{K \times 10^3} = \frac{1}{1} = 1$$

This relationship of the boron concentration to the adjusted specific conductance allows a more critical evaluation of the significance of the boron concentration when the economic potential is being considered. The majority of the samples collected in the areas studied show a boron factor of 1 or less. A considerable number range from 1 to 2.5 and a few show significant boron factors of 10 or higher.

The following comparison of several analyses is made in order to demonstrate the significance of the boron factor over the absolute concentration of boron in the ground water. A water from well 30/38-24F1 In the Koehn Lake area showed a boron concentration of ~~50~~ 51 ppm, which is approximately 50 times greater than the average boron concentration throughout the several areas. However, the specific conductance of this water is on the order of 20,000 micromhos, which is approximately

35 times greater than the average specific conductance. Thus, the boron factor for the water from this well is 2.5, which is not significantly higher than the boron factor of many of the ground waters throughout the area.

The ground water analyzed from wells 11/6-17L1 ~~17K1~~ and 20A1 near ~~17P1 in~~ the Boron area showed a specific conductance slightly higher than those throughout the area, being on the order of 1,500 ~~1,000~~ micromhos. The boron concentrations ranged from 20 to 35 ppm and the boron factor ranged from 13 to 24. The boron factor of this water averaged 18 times more than the average boron factor throughout the area.

These examples demonstrate the necessity of caution in interpreting the significance of the boron concentration in ground water. A high boron concentration can be achieved by the concentration of ground water by evaporation in local areas and does not necessarily indicate a unique mineral source which is being introduced into the ground water. Thus, the average concentrations of dissolved solids or the specific conductance and the average boron concentrations of all the ground waters throughout the area under investigation were used as a basis of comparison when it was suspected that a unique boron water was found. For example, if the average type of water in the Boron and Koehn Lake areas were concentrated 40 to 50 times, the water would be similar to the more concentrated waters in the vicinity of Koehn Lake, indicating no significance to an apparently high concentration in the naturally concentrated water.

Chemical Symbols Used on Maps

The chemical character of the ground waters also is summarized by use of symbols on plates 4, 9, and 12. A typical set of symbols and their meaning as they apply to a well or spring is as follows:

$$\frac{84.8 - 0.9}{1890} \quad 0.5$$

Cl (367)

The center of the geometric symbol () is at the location of the well or spring on the map, and the symbol indicates the character of the water (calcium chloride in this example) as shown on plate 2. The letter and number below the geometric symbol indicate the well number (Cl) as described in the well-numbering system. The number in parenthesis is the depth of the well in feet (367).

The number in the numerator of the fraction preceding the decimal point is the percent reacting value of the calcium and magnesium combined (84). The number to the right of the decimal point is the percentage reacting value of the carbonate and bicarbonate combined (8). The number to the right of the dash is the concentration of the boron, in parts per million (0.9). The denominator of the fraction is the specific conductance in micromhos at 25°C (1,890). The number to the right of the fraction is the boron factor (0.5).

DESCRIPTION OF GROUND-WATER AREAS

In all the areas canvassed water wells tap relatively thick sections of alluvium of Quaternary and possibly late Tertiary age. These deposits contain ground water, and yield water to wells at rates ranging from a few gallons per minute to several thousand gallons per minute. Unfortunately, most of the used wells were concentrated in local areas throughout most of the western part of the Mojave Desert, and for these there was inadequate information on casing, perforation, and well depth. ~~information.~~ As a result, the interpretation of the hydrologic and quality-of-water conditions was somewhat difficult. The water-level measurements made during the well canvass have been used to construct, where possible, water-level contours, which are shown on plates 3 and 8. In areas where wells are sparse no contours were drawn.

why [illegible]

Boron Area of Antelope Valley

Geology and Physiography

The Boron area of this report (pl. 1) is in the northeastern part of Antelope Valley, extending north from U. S. Highway 466 to the Rand Mountains. Most of the runoff from this area drains southward to the north end of Rogers Lake or to the numerous small playas several miles to the north.

Throughout most of the area (pl. 3) extensive granitic outcrops occur. In the southern part considerable ~~Tertiary~~ volcanic and clastic rocks of Tertiary age occur along with the crystalline rocks. Several major northwest-trending and a few east-trending faults traverse parts of the area. The Kramer borate deposit is about 3 miles northwest of the town of Boron and is associated with the Tertiary volcanics which crop out in the vicinity of the deposit.

Occurrence and Movement of Ground Water

Most of the ground water in Antelope Valley is derived from precipitation that falls on the higher parts of the San Gabriel and Tehachapi Mountains, south of the area covered by this report. In the Boron area, as shown by water-level contours (pl. 3), ground water moves generally southward, the gradient being approximately 10 feet to the mile from well 12/8-34A1, 9 miles northwest of Boron, to well 11/8-15C1, 6 miles northwest of Boron. Immediately south of well 11/8-15C1 a partly buried basalt ridge probably acts as a barrier impeding ground-water movement from the north. As the barrier, which is parallel to the north ends of secs. 14, 15, and 16, T. 11 N., R. 8 W., is crossed there is a displacement of water levels between wells 11/8-15C1 and 20H1 of about 70 feet in 2 miles. The basalt forming this ridge, which dips below the Kramer borate deposit, together with the clay bed, which overlies the borate deposit beneath the valley floor, effectively prevent ground water from coming in contact with the deposit.

Approximately 3 to 4 miles east of Boron there is a ground-water divide, east of which ground water moves eastward into Harper Valley, and west of which water moves westward. From the wide spacing of the contours (pl. 3), it would seem that westward movement is relatively slow and that only a small volume of ground water moves in that direction. The spacing of the contours suggests also that a somewhat greater volume of ground water moves into the valley west of Boron from the north.

Incomplete geophysical data, geologic mapping of the unconsolidated deposits ~~by the Ground-Water Branch~~, and well logs suggest that the ground water moving from the north is restricted to relatively narrow and thin deposits of older alluvium between the ridges of the basalt and tuff beds. Supply wells 11/8-2N1 and 2N2 of the Pacific Coast Borax Co. are located on the north side of the postulated ground-water barrier in 11/8-15. These wells tap relatively coarse sections of older alluvium that have a high percentage of basaltic sand and gravel.

The water-level contours on plate 3 show that ground-water discharge from the Boron area occurs through the alluvial deposits in a "narrows" between essentially non-water-bearing rocks, principally in secs. 17 and 18, T. 11 N., R. 9 W. This outlet is the only area of subsurface outflow not only for the Boron area but also for Antelope Valley as a whole. The ground water so discharged moves northwest into the Koehn Lake area (pl. 3).

Chemical Character of Ground Water

In the Boron area a special effort was made to determine whether useful geochemical guides to economic sources of boron could be developed. Efforts were made to collect as many water samples as possible in and around the borate ore body in order to determine the relation between the ground water and a known ore deposit. Thirteen water samples were collected and analyzed and three additional analyses were obtained from the Survey's files. With the exception of three samples, two taken immediately above the ore body during coring operations and one from well 11/8-22E1 of unknown depth on the western fringe of the ore body, no significantly large concentrations of boron were found in the samples analyzed.

In general the ground water of the Boron area can be classed as a sodium sulfate chloride water. (See pls. 2, 4, and 5.) Analyses of water from the Pacific Coast Borax Co. well 11/8-2N1, several miles north of the ore body, and well 31/41-31N1, 11 miles northeast of the ore body, showed rather similar compositions. The specific conductance of the water from each of the wells is on the order of 800, and the boron concentrations and factors are, respectively, 0.6 ppm and 0.7 for both wells. The bicarbonate and sulfate concentrations in well 11/8-2N1 are 205 and 93 ppm, respectively, and in well 31/41-31N1 are 128 and 154 ppm, respectively.

The blend of ground waters moving southwest from well 11/8-2N1 and west from well 11/8-24D1 is shown by the analysis of water from well 11/8-20H2 and in general suggests an overall increase in the percentage of calcium and magnesium. This increase could be accounted for by the leaching of Tertiary continental deposits which contain limy marl and limestone. However, the specific conductance and boron concentrations of waters to the southwest are comparable to the waters to the north. Water from well 11/8-24B1 does not show this increase of calcium, but it is reported that the well in part is drilled in consolidated basalt and does not tap water in the main part of the basin.

Analyses of waters from wells 11/8-26J1 and 10/7-3D1, which are respectively 1.5 miles south and 5 miles southeast of the ore body, show a greater concentration of dissolved solids and boron than that from well 11/8-2M1, which is north of the ore body; also the relative concentrations of sulfate and chloride ~~with respect~~ in comparison to the bicarbonate concentration ~~is~~ are higher. The specific conductances of the waters from wells 11/8-26J1 and 10/7-3D1 are, respectively, 1,351 and 2,070 and the boron concentration and factors are, respectively, 1.3 ppm and 1.1, and 4.5 ppm and 2.2. The reasons for these differences are not obvious. The presence of boron minerals has been reported from numerous test holes north and upgradient from these water wells. The leaching of these reported borates from the sediments could account for the increase of the boron and the increased concentration in the wells south and southeast of the ore body.

The samples collected ~~which~~ that showed significant boron factors were within the area of the borate deposits. The sample collected from well 11/8-22E1 on the western fringe of the ore body is similar in chemical character to the ground water sampled from neighboring wells. The specific conductance is 1,150, and the water remains a sodium sulfate chloride type. The concentration of boron is 14 ppm, and the boron factor is 12.2. This would seem to indicate that the ground water in this part of the area is in contact with borate-bearing deposits or is being contaminated by the ore body. ~~However,~~ the ground water in that part of the area where the ~~main~~ principal sodium borate~~s~~ deposits are found is perched above the ore body and is not believed to be contaminated by the ore. However, so far as could be determined very little water is perched above the ore body, and it is doubtful whether a significant amount of water moves downgradient from the ore body.

Analyses of perched water collected above the main ore body during the coring of test well 11/8-24D1 indicate that the water was contaminated by shale that immediately overlies the ore body. The specific conductance of this water is 1,990, and the concentration of boron is exceedingly high--314 ppm with a boron factor of 158. The sulfate and chloride concentrations of this water are comparable to those in the ground waters south and southeast of the ore body. Another interesting feature of this water is the unusually high concentration of carbonate, reported as 357 ppm, and is reported to be almost entirely sodium carbonate. The calcium, magnesium, and bicarbonate concentrations are only a few parts per million. In most natural ground and surface waters the concentration of the bicarbonate ion is much greater than that of the carbonate ion, which commonly is only a few parts per million. In all probability the green borate-rich shale is the source of the ~~high~~ sodium carbonate ~~concentration~~.

In speculating on the origin of the Kramer borate deposits and the relation of both ground and surface waters to the genesis of the deposit, the meager data are inconclusive. From the available geologic, hydrologic, and geophysical data it appears that the Kramer borate deposit is of local origin, probably related to the extrusion of the basalt flows of Tertiary age which underlie the borate deposit. The multiple-basin hypothesis for the formation of saline deposits (reference) does not seem applicable as an explanation for the origin of the deposit,

cite

and no evidence could be found to substantiate the Kramer basin as part of a series of basins. The Kramer deposit appears to have formed in an isolated fault basin which may have been ~~lowered~~ subsiding at the same time the borates were deposited. ~~contemporaneously with the deposition of the borates.~~

The relation of ground and surface waters to the formation of the deposit appears to be of only minor significance. The original boron source may have been a sodium bicarbonate water highly concentrated in boron, comparable to hot-spring waters locally found today in some parts of California. The high percentage of carbonate in the clays of the ore body would tend to indicate a bicarbonate water as the original source of mineralization. Ground or surface waters contemporaneously, or at a later time, appear to have altered somewhat the chemical character of the borates around the fringes of the ore body by supplying the necessary calcium for the formation of colemanite and ulexite. Because the geologic history and the hydrology of the ancestral basin are extremely complex and have not been resolved, the manner in which the mineralization occurred within the basin is not known.

Obviously, the hydrologic and geologic conditions which have existed since the formation of the ore body were favorable to the preservation of the Kramer borate deposits. The relatively arid conditions under which fanglomerate accumulated over the ore body reduced to a minimum the leaching and removal of the soluble borates. The underlying basalt, which crops out north of the ore body and probably forms a ~~the probable~~ ground-water barrier, may have prevented ground water from leaching the deposit to any great extent. It seems reasonable to conclude that if a substantial supply of ground water had saturated and moved past the ore body, a substantial part of the borates might have been removed and concentrated as salines in areas of evaporation downgradient from the ore body, such as the Koehn Lake area of recent times. However, no areas of concentrated borates were found in the groundwater drainage system as it exists today.

Koehn Lake Area of Fremont Valley

Geology and Physiography

The Koehn Lake area and the north part of the Chaffee ~~Basin~~ area are within the boundaries of Fremont Valley (pl. 1). For this investigation only the Koehn Lake area (pl. 3) was studied. The Koehn Lake area is bounded on the south by the Muroc fault, on the west and north by the Garlock-El Paso fault zone, and on the east and southeast by the consolidated rocks of the Rand Mountains.

The lowest part of the Koehn Lake area is occupied by a moist playa known as Koehn Lake (termed Kane or Cane Lake in some earlier reports) which has an altitude of about 1,900 feet--about 370 feet lower than Rogers Lake, which is the lowest part of Antelope Valley. There is no surface drainage between Antelope and Fremont Valleys, but Thompson (1929, p. 208) suggested the possibility that during a period of greater precipitation in the Pleistocene epoch a lake may have existed in Antelope Valley which may have overflowed to Koehn Lake through the now alluviated gap northwest of Rogers Lake in secs. 17 and 18, T. 11 N., R. 9 W.

The Koehn Lake area is of particular interest in the present investigation because it is the ultimate destination of ground water in both Antelope and Fremont Valleys and also because of the deposits of nearly pure sodium chloride and gypsum which occur along the northwestern margin of the lake. One borax test hole, 30/38-24F1, was drilled to a depth of 550 feet near the southern margin of Koehn Lake, but no borates were encountered. Ulexite has been reported in this vicinity by H. S. Gale (~~unpbl. rept.~~ personal communication, 1953). In addition, ulexite "cotton-balls" have been mined near the surface of the soil northwest of Koehn Lake in sec. 8, T. 30 S., R. 38 E.

[illegible] p. 33 [illegible]

Occurrence and Movement of Ground Water

Ground water in appreciable quantities occurs in the unconsolidated alluvial deposits of the Koehn Lake area. All of the ground water in the basin is derived from precipitation within the drainage basin ~~and~~ or from subsurface flow out of Antelope Valley. This water ~~and water from the sides of the valley~~ move toward the lowest part of the basin, where it discharges by evaporation from the moist surface of Koehn Lake, by transpiration from plants whose roots draw water from ground water, and by evaporation or the transpiration of water pumped for irrigation ~~and~~ or flowing from wells and springs. By far the greatest quantity of water comes from the southwest. Several miles south of Koehn Lake in an area of rather recent large-scale agricultural development, irrigation wells have been constructed that locally have reported yields of as much as 4,000 gpm (gallons per minute).

Part of the ground-water underflow is from Antelope Valley, which moves into the Koehn Lake area through an alluviated gap between Castle and Desert Buttes, and part is from the Chaffee ~~Basin~~ area across the Muroc fault. The Muroc fault, which is the southern boundary of the Koehn Lake area, is an effective, though not complete, ground-water barrier along its northwest extension. Water levels on the southwest side of the fault in Chaffee Basin are as much as 400 feet higher than those on the north~~west~~east side of the fault. However, water-level contours show that there is movement northward away from the fault, indicating leakage through or over this barrier. The southeast extension of the Muroc fault in the Boron area does not appear to act as a barrier to the movement of ground water. Wells 11/9-31D1 and 30Q1, which are on opposite sides of the possible southeast extension of the fault, do not show disparities in water level.

The water-level gradient (pl. 3) through the alluvial valley 3 to 5 miles west of Castle Butte is approximately 15 feet per mile westward, but it flattens considerably at about the west edge of R. 38 E. This profile is shown on plate 6. The cause of the apparent ground-water "nose" in the eastern part of T. 32 S., R. 37 E., is not known, but geophysical data suggest an undefined structural change in this part of the area.

The Garlock fault, which strikes along the northwest side of Koehn Lake, is a ground-water barrier as indicated by about a 190-foot displacement in water levels at the town of Garlock and by springs along the prominent escarpment about 2 miles to the southwest.

The steep hydraulic gradient in the area 9 miles south-southwest of Koehn Lake and the flat gradient in the area to the north strongly suggest the presence of a ground-water barrier near or along the abrupt change in gradient. If a barrier exists, it is probably related to the southwest-trending fault zone shown along the north side of the Rand Mountains.

Hydrologic conditions in the Koehn Lake area are complex, and it appears that in addition to unconfined water there are several zones of confined water as well as semiperched water. A detailed interpretation of these several water-bearing zones was beyond the scope of this investigation.

Chemical Character of Ground Water

As indicated by water analyses for wells 12/10-35P1, 32/37-24N2, and 32/38-32N1, the ground water that moves northward from Antelope Valley between Castle and Desert Buttes is of the sodium sulfate chloride type. (See pls. 4 and 7.) The specific conductance is on the order of 800 and the boron concentration and factor are, respectively, about 0.4 ppm and 0.4. The concentrations of bicarbonate, sulfate, and chloride average about 220, 100, and 80 ppm, respectively.

From this area northward to Koehn Lake a series of samples were collected from wells along a 12-mile reach. A progressive decrease in the percentage of sodium occurred from 83 in well 12/10-35P1, east of Desert Butte, to 47 in well 30/37-36C1, a few miles west of Koehn Lake. This decrease was enough to change the water from the sodium type to one in which no cation exceeded 50 percent. The specific conductance of the water averaged about 800, the boron concentration and factor, respectively, averaging about 1.0 ppm and 1.2. Possible recharge from the west together with the ground water crossing the Muroc fault and mixing with the water moving northward from Antelope Valley could account for the change in quality of water. The decrease from 83 to 47 percent sodium is not the normal direction for base exchange. Generally, base exchange involves the replacement of sodium ions, held in the sediment or soil, by the calcium and magnesium ions in the ground water, thereby increasing the concentration of sodium and decreasing the calcium and magnesium in the ground water. However, base exchange is reversible, so that under certain conditions an increase in the concentration of calcium and magnesium in the ground water and a proportionate decrease in the amount of sodium could occur.

Another significant change in the character of ground water moving north toward Koehn Lake is the increase in the bicarbonate concentration, with a corresponding decrease in the sulfate and chloride concentrations. The bicarbonate concentration averages about 300 ppm and the sulfate and chloride concentrations average about 130 and 25 ppm, respectively. The boron concentration and factor are usually less than 1 ppm and 1.0, respectively. Possible mixing of water moving from the vicinity of Jaw Bone Canyon to the west with that from the south could account for the change in chemical character.

Ground water moving from the north and northwest, principally from the area of Red Rock Canyon, is of the sodium sulfate type. Analysis of water from well 30/37-12N1 in the wash of Red Rock Canyon shows a specific conductance of 3,480, with sulfate, chloride, and bicarbonate concentrations of 934, 427, and 196 ppm, respectively. The sodium concentration is on the order of 800 ppm and the calcium and magnesium concentrations total less than 60 ppm. The boron concentration and factor are respectively 33 ppm and ~~10.0~~ 9.5. This relatively high boron factor is significant and suggests the possibility of borate mineralization in the large exposed section of Tertiary volcanics and clastics in the vicinity of Red Rock Canyon. This area has been mapped by Dibblee (1952) but no borate deposits were found. However, ulexite "cottonballs" have been found in the upper few feet of soil several miles southeast of the mouth of Red Rock Canyon. It is possible that the borates are disseminated throughout parts of the Tertiary section and that no distinct deposit occurs. It would seem reasonable to conclude that the source of the borates in the valley north of Koehn Lake is Red Rock Canyon.

Samples collected from springs along the El Paso and Garlock fault zones north of Koehn Lake have boron concentrations and factors, respectively, on the order of 1 ppm and 1.0.

Ground water moving toward Koehn Lake from the northeast is comparable to the sodium sulfate chloride water ~~type~~ that moves toward Koehn Lake from the south. The specific conductance is on the order of 1,100, and the boron concentration and factor are, respectively, somewhat higher than 1 ppm and 1.0.

The area in and around Koehn Lake exhibits the hydrologic and geochemical complexities which arise in many of the desert basins of interior drainage. Although the principal movement of ground water is from the south, some waters of diversified chemical character reach the lake area from the north, east, and west. The chemical analyses indicate six distinct types of ground water in and around Koehn Lake. They are: (1) sodium sulfate+chloride, (2) sodium sulfate, (3) sodium chloride, (4) calcium bicarbonate, (5) calcium chloride, and (6) waters in which alkalinity or salinity is ~~are~~ not dominant. (See pls. 2 and 7.)

The specific conductance of ground water in and around Koehn Lake ranges from about 700 to 20,000. The boron concentrations and factors range, respectively, from 0.4 to 51 ppm and from 0.2 to 10. Water from well 30/38-24F1, which has a depth of 500 feet, has a specific conductance on the order of 20,000 and a boron concentration and factor of 51 ppm and 2.5, respectively. The analysis shows that the ground waters southeast of Koehn Lake are highly concentrated, probably owing due to evaporation of ground water during the deposition of the deposits and to lack of ground-water movement through the area. Koehn Lake is the "sink" for all ground water in Fremont Valley.

[illegible]

Flowing well 30/38-8J1, on the western edge of Koehn Lake, has a specific conductance of 7,~~385~~ 390. The concentrations of chloride, sulfate, and bicarbonate are, respectively, 2,130, 535, and 263 ppm, the sodium concentration is 1,630 ppm, and the calcium and magnesium concentrations are only 59 and 14 ppm, respectively. This is a sodium chloride water and is radically different from the ground waters from other sources moving toward Koehn Lake. In addition, samples collected from wells on the southeastern edge and several miles east of the lake were sodium chloride ~~type~~ waters. Several miles south and southwest of Koehn Lake, wells 30/38-32D1 and 30/38-34C1 yielded a calcium chloride ~~type~~ water. The reasons for the diverse chemical character of ground waters around the lake are not understood fully, but in part probably are caused by base exchange and in part are known to result from the deposits through which the ground waters move to reach the lake.

The diversity of the ground waters closely parallels the diversity of the sedimentation and mineralization of the area. Within an area of a few square miles ulexite "cottonballs," sodium chloride, and calcium sulfate were mined at one time. The concentrations of ground waters, temperature~~s~~, humidity, solubilities, and base exchange are among the most prominent environmental factors in influencing the mineralization of saline playas. The reasons why sodium chloride is deposited at a certain time in one part of the area and calcium sulfate in another part are not apparent. Detailed geologic, hydrologic, and mineralogic studies of Koehn Lake might explain many of the phenomena that were ~~encountered~~ noted but not explained during this reconnaissance investigation.

Middle Mojave Valley

Geology and Physiography

That part of the Middle Mojave Valley (pl. 8) studied in this reconnaissance investigation adjoins Harper Valley on the north and extends from Hodge northeastward to Barstow. In the vicinity of Hodge the valley is restricted ~~with~~ by metamorphic and crystalline rocks cropping out on both sides of the river's flood plain. North of Hodge the valley broadens and extends northward to Harper Valley and eastward to the narrows at Barstow. In general~~,~~ the alluvial deposits are relatively thick, but locally in areas where isolated granitic rocks crop out in the valley, the deposits probably are relatively thin. Large areas of older alluvial deposits crop out in the southern part of the area.

One major fault, termed the Lockhart fault, trends southeast from Harper Valley into the Middle Mojave Valley. If the fault does continue through this part of the Middle Mojave Valley, it would pass approximately through the town of Hinkley. Inferences on its position and existence near Hinkley ~~is~~ are based on water-level data, as discussed in the next section of the report.

In the vicinity of Hinkley, at depths ~~from~~ of 120 to 150 feet below the land surface, ~~there occurs~~ is a relatively extensive and continuous bed of blue clay. The extent of this clay, which may ~~be~~ represent an old lake bed, is not known, but it probably is at least 10 square miles. This deposit probably was laid down when the Mojave River was dammed at the narrows at Barstow, possibly during Pleistocene time.

During infrequent large floods on the Mojave River, surface water overflows its banks and some water flows northward from the area east of Hinkley through a narrows to Harper Valley. It is believed that the Mojave River has intermittently discharged into Harper Valley ~~probably during and since~~ since late Pleistocene time.

Occurrence and Movement of Ground Water

Unless there are 6 individual sections

The principal area of ground-water development in the Middle Mojave Valley is in the vicinity of Hinkley. In this area at least 3,500 acres ~~six sections~~ of alfalfa ~~are~~ is irrigated by wells that pump between 1,500 to 2,000 gpm each. Most of the water in this area is pumped from permeable lenses of sand and gravel that overlie the blue clay ~~member~~. Where the blue clay is found, it seems to be the lower limit of good production ~~wells~~. Wells drilled through the clay have not shown any increase in production, according to local drillers and landowners.

Between Hodge and Lenwood there is a large reentrant in the hills ~~to the~~ southeast of the Mojave River. Wells in this area are pumped for domestic uses only. Along the Mojave River, particularly in secs. 14 and 15, T. 9 N., R. 3 W., alfalfa is irrigated from wells that pump as much as 2,000 gpm.

That part of the Middle Mojave Valley east of the Kramer Hills, south of U. S. Highway 466, and west of a north-south line through Wild was canvassed, but no used wells were found.

Ground water moves downstream toward Hodge from the southwest and the gradient at Hodge is approximately 10 feet to the mile (pl. 8). Downstream from Hodge ground water moves northward toward Hinkley and northeastward toward Barstow ~~with~~ under a gradient of ~~from~~ 10 to 20 feet to the mile.

About 2 miles southeast of Hinkley the gradient abruptly steepens to almost 70 feet per mile as ground water moves into a cone of depression created by a relatively large draft from wells for irrigation. However, the cone in part may be steepened or modified by the Lockhart fault, which enters the valley from the northwest. The fault may extend as far southeast as the cone of depression and there may act as a partial ground-water barrier.

Several miles east of the ground-water depression near Hinkley, the ground-water flow divides. Part of the movement is westward and northwestward toward the depression and Harper Valley, respectively, and part moves eastward downstream toward Barstow.

About 4 miles southeast of Lenwood, the altitude of the water surface in wells 9/2-34M1 and 34M2 is approximately 230 feet higher than that near the river. Although the water-level contours near these wells are poorly controlled, they indicate a ground-water contribution to the Middle Mojave Valley from the southeast.

Owing to the lack of wells in the western part of the Mojave River Valley east of the Kramer Hills, essentially nothing is known about the occurrence and movement of ground water. Presumably, a small amount of ground water is supplied to the valley from the hills. Some recharge to the broad valley area around the junction of Harper Lake Road and U. S. Highway 466 (pl. 8) may be supplied from the Mojave River through the gap ~~by~~ near well 9/4-33J1. ?

~~The~~ Chemical Character of Ground Water

Ground water ~~which~~ moving northward from Lenwood is a calcium bicarbonate water. (See pls. 9 and 10.) The specific conductance is on the order of 500 and the boron concentration is usually less than 0.2 ppm. As the water moves northward and northeastward, spreading out through the area, a change occurs. Southeast of Hinkley, the water tapped by wells is the type that is neither saline or alkaline (pls. 2 and 10) and the specific conductance increases to more than 1,500 with no appreciable change in the boron concentration. Through this part of the area the water has an abnormally high nitrate concentration--on the order of 15 ppm. In general, wells showing high nitrate concentrations penetrate the blue clay bed. The high nitrate conceivably could be caused by ~~the chemical reduction~~ reaction of organic matter in the blue clay ~~by~~ with calcium bicarbonate water such as the type that recharges the area from the south.

Nitrate is formed by oxidation not reduction, of organic matter. CPMS

It appears reasonable that the change in character of the waters must be due either to the reaction of the water with the water-bearing deposits or to the leaching of the deposits by returned irrigation waters. In either case the chemical change of the ground waters reflects the character of the soluble minerals in the deposits that have been taken into solution or replaced by minerals in solution, or both.

West and southwest of Hinkley wells 10/3-29M1, 10/3-30Q2, and 10/3-33C1 indicate that the ground water is predominant~~e~~ly a sodium sulfate bicarbonate water having ~~chloride type with a~~ specific conductance of 800, 968, and 532, respectively. The boron concentration is between 0.6 and 1.3 ppm, and the boron factors average about 1.4 ~~are on the order of 1.0.~~

Wells 10/3-2J1 and 2Q1, in the gap about 4 miles northeast of Hinkley through which ground water moves into Harper basin, tap an aquifer which yields a sodium sulfate//chloride water. These waters have a relatively high concentration indicated by a specific conductance of 3,610 for well 2J1 and 1,790 ~~micromh~~os for well 2Q1. The respective boron concentrations are 9.2 and 5.0 ppm; and the respective boron factors are 2.5 ~~2.6~~ and 2.8 ~~3.0~~. Both ~~of~~ these wells are less than 100 feet deep ~~in dept~~h and are perforated in all zones beneath the water table.

From Hodge to Barstow along the channel and flood plain of the Mojave River the ground water is of the calcium bicarbonate type previously discussed. However, south and southeast~~ward~~ of the river, the ground water that moves toward the river from the valley area about 3 miles southeast of Lenwood is of the sodium bicarbonate type. The specific conductance is on the order of 600 and the boron concentration about 0.4 ppm. The significant difference is the higher concentration of sodium as compared to that in the high-calcium ground waters beneath the ~~river~~ flood plain.

Harper Valley

Geology and Physiography

Harper Valley is a topographic depression whose lowest part is occupied by Harper Lake, which in large part is a dry-type playa, but along the eastern end is a moist-type playa. The northern limit of the valley is defined by Black Mountain, which is composed of basalt of Quaternary age and by an extensive series of continental deposits of Tertiary age. The eastern margin is marked by granitic and metamorphic rocks and the western margin is marked by isolated outcrops of granitic rocks. However, the southern limit, which adjoins the Mojave River Valley, is arbitrary, there being no surface divide between the two. As already explained, both surface drainage and ground-water movement occur from the Middle Mojave Valley to Harper Valley through the gap north of Hinkley.

Harper ~~The~~ valley is traversed by a series of northwest-trending faults. A series of prominent fault scarps can be observed along the foot of Black Mountain. The major faults are the Lockhart fault, which trends through the center of the valley a few miles south of Harper Lake, and the Gravel Hills fault, which trends in the same direction north of Harper Lake.

The Lockhart Ranch, which is the principal development in the area, is about 7 miles north of U. S. Highway 466 along Harper Lake Road.

Occurrence and Movement of Ground Water

The water-level contour map (pl. 9) indicates that ground water moves into the central part of Harper Valley from all directions. Possibly the largest quantity moving into the area is from the Middle Mojave Valley in the vicinity of Hinkley. Some ground-water recharge also may occur from Cuddeback Valley to the north, which is approximately 600 feet higher than Harper Valley. However, if such recharge ~~should~~ does occur, the quantity does not appear to be large. Probably only minor amounts of ground water enter Harper Valley from the east and west where the hills are low and presumably recharge is small. West of Hinkley some water may cross the Lockhart fault.

The Lockhart fault (extended) seems to form a barrier to ground-water movement north of wells 10/4-8P1, 10/4-24J1, 10/4-25A1, 10/5-3H1, and 11/5-35N1. Along the fault from northwest to southeast, the gradient between wells 10/5-3H1 and 11/5-35N1 and that north of the fault suggests a water-level displacement of 40 to 50 feet, ~~with~~ the level north of the fault being lower; the altitude of the water level in well 10/4-8P1, which was about 2,084 feet, is about 100 feet higher than that in well 10/4-~~3H1~~ 3Q1, north of the fault; and the altitudes of the levels in wells 10/4-24J1 and 25A1, which was about 2,150 feet, is more than 100 feet higher than that north of the fault if the gradient is projected southeast from 2,000-foot contour to sec. 18, T. 10 N., R. 3 W.

Owing to the heavy pumping ~~of~~ at the Lockhart Ranch, a ground-water depression has developed about 1 mile southwest of Harper Lake. The contours show that ground water is moving toward the center of this pumping depression from all sides. The ground water moving eastward toward the Lockhart Ranch from the vicinity of Hinkley has a gradient of approximately 10 to 20 feet per mile. About 3 miles east of the pumping depression the gradient starts to steepen and reaches a maximum of at least 50 feet per mile near the center of the depression.

Well 11/5-14R1, a mile east of the pumping depression, appears to tap a perched ground water. The water level in this well is 115 feet higher than that in the nearest well, which is half a mile to the east. Also, the ~~quality of~~ water from this shallow well is more concentrated than that ~~in~~ from other wells in this part of the valley. Well 11/3-30A1, 7 miles west of Lockhart Ranch, was flowing in 1954. The depth of the well was not measured but was reported to be 200 feet.

Chemical Character of Ground Water

Wells sampled in the eastern part of the Harper Valley yield water comparable in quality to the moderately concentrated intermediate-type water of the Middle Mojave Valley near Hinkley. The specific conductance is on the order of 500, the boron concentration and factor being about 1.0 ppm and 2.0, respectively.

Water from flowing well 11/3-30A1 is of the sodium bicarbonate type and has a boron concentration and factor of 3.4 ppm and ~~5.1~~ 5.2, respectively, which are abnormally high. The fact that this well draws water from a relatively deep confined aquifer whereas nearby wells draw from a shallower aquifer may account for its different character.

Ground water sampled in the vicinity of the Lockhart Ranch, between the Lockhart fault to the southwest and Harper Lake to the northwest, shows a rather uniform composition. The specific conductance is about 1,300, the boron concentrations and factors never exceeding 1.5 ppm and 1.0, respectively. The waters are of the sodium chloride sulfate type and the percentage reacting value of the sodium (percent sodium) is generally 50 percent or more.

One well, 11/5-14R1, yielded a water of the sodium chloride sulfate type having the same general percentage reacting values as other nearby wells. However, the specific conductance was 7,300 and the boron concentration and factor were 8.7 ppm and 1.2, respectively. This water appears to be from a perched or semiperched water body, because the water level in the well is more than 100 feet higher in a well 0.6 mile to the east and there is no evidence of a ground-water barrier between them.

Southwest of the Lockhart fault wells 11/6-17K1 and 11/6-20A1 yield ground water with significant boron concentration, and factors. They are, respectively, 20 ppm and ~~12~~ 13 for well 11/6-~~17K1~~ 17L1 and 35 ppm and 24 for well 11/6-20A1. The specific conductances are ~~1,565~~ 1,570 and 1,~~455~~ 460, respectively. The composition of this water and the proportion of constituents is comparable to those of the ground water in the western part of the Harper ~~basin~~ Valley. The main difference between the two is the increased boron concentration without a corresponding increase in concentration of the other constituents. It is also of significance that colemanite, which is a calcium borate mineral, had been reported in test holes drilled in this vicinity.

Cuddeback Valley

Cuddeback Valley (pl. 12), also known as Golden Valley (Thompson, 1929), is a well-defined basin of interior drainage. Its lowest part is occupied by Cuddeback Lake, a dry-type playa. There is a low divide at the southern end of the valley, and it appears as though surface water once flowed southward to Harper Lake through an eroded gap which had developed along the contact of the granitic rocks of Fremont Peak and continental deposits of Tertiary age immediately east of Fremont Peak. However, faulting along the Tertiary section and deposition of alluvial fans have caused the drainage to be interrupted.

North and northwest of the center of the valley are extensive outcrops of volcanic rocks of Tertiary age, whereas the western border and most of the southern~~,~~ and eastern borders of the valley ~~generally consist of~~ are formed by granitic rocks. Extensive alluvial fans and pediments have developed along the western and particularly the eastern part~~s~~ of the valley.

During the investigation, only 18 wells were located of which ~~two~~ 2, wells 29/41-22R1 and 34K1, are in the mountains east of Johannesburg.

Owing to insufficient water-level data, water-level contours were not constructed in this valley. However, the existing data indicate that there is no ground-water recharge from adjoining valleys and that all the water in Cuddeback Valley is derived from precipitation that falls within the boundaries of the drainage area. On the other hand, there appears to be possible southeastward drainage of ground water from Cuddeback Valley to Harper Valley.

Water samples collected in Cuddeback Valley show no significant boron concentrations. Water from wells 30/41-36G1 and 30/42-24F1 on the west and east sides of the valley, respectively, are of similar compositions. (See pls. 12 and 13.) They are a sodium bicarbonate-chloride water ~~which~~ such as is ~~also~~ characteristic also in the Boron area and part of the Koehn Lake area. The specific conductance is on the order of 600 and the concentration of boron is 0.5 ppm or less. The water from well 30/42-20K1, near the center of the basin, is more typical of the highly concentrated ground water found in evaporite-type playas. It is a sodium chloride water containing relatively minor concentrations of bicarbonate and sulfate. Specific conductance is 6,880, but the boron concentration is only 1.5 ppm.

Superior Valley

Superior Valley, like Cuddeback Valley to the west, is a well-defined topographic basin of interior drainage. The lowest part of the valley (pl. 12) contains four separate small dry-type playas which are aligned nearly east-west across the valley. There appears to have been an outlet for surface water through the southwest corner of the valley into Black Canyon, which leads to Harper Valley. However, uplift along the Blackwater fault, which trends northwest along the southwestern border of the valley, and local deposition of alluvial-fan deposits has blocked the surface outlet.

The western margin and parts of the southern and eastern margins of the valley are ~~composed~~ formed by of granitic ~~type~~ rocks. The Black Mountain basalt of Quaternary age underlies the southwestern flank of the valley. The northern part of the area is ~~composed~~ underlain almost entirely by ~~of Tertiary~~ continental deposits of Tertiary age

Two major northwest-trending faults traverse the valley area. One is the Blackwater fault along the west side and the other is an unnamed fault along the east side, which probably extends farther northwest than shown on plate 12 and which probably forms a barrier to ground-water movement.

A total of 11 wells were inventoried in the valley, which, when visited, was uninhabited. The northern part of the valley is used as a gunnery range.

The depth to water beneath the central part of the area is between 87 and 110 feet. This depth to water is too great to permit discharge in the playa areas. Because the gradients are nearly flat, it is difficult to determine where ground-water discharge from the valley occurs.

However, the movement may be to the east toward Coyote Valley across the northwest-trending fault along the east side of Superior Valley. The difference in water-level altitudes in 1953-54 between wells 31/46-12P1 and 31/47-5R1, which are west and east of the fault barrier, respectively, was 57 feet, the level being lower east of the fault.

A water sample was taken from test well 31/46-16J1 in 1953 by the Bureau of Land Management. This analysis shows a sodium chloride water having a specific conductance of 2,520 and a boron concentration of 0.9 ppm. The main constituents are 672 ppm of chloride and 300 ppm of sodium.

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Table 3.- Description of water wells in part of the western Mojave Desert, Calif.

Table 3 presents selected data for wells shown on maps and described in the text. The wells are listed by the areas shown on page 1. In addition to these wells, the well index contains those wells for which basic data were collected although the wells were not inventoried in the field.

Well number.--The U. S. Geological Survey well-numbering system designates the well location according to the General Land Office rectangular land survey, as explained in the introduction.

Altitude.--The altitude given is the land-surface altitude or datum at the well in feet above mean sea level. The letter a preceding this figure indicates an approximate altitude estimated from a topographic map having a contour interval of 25 feet or more. Altitudes not preceded by the letter a were determined either by barometer or by interpolation from the 5-foot contour interval for wells on topographic map of the Kramer borate district, which has a scale of 1:24,000.

Depth.--The depth of the well is in feet below land-surface datum. Depths in feet and tenths were measured by the Geological Survey; depths given in whole feet are reported.

Depth to water.--The standing or nonpumping water levels in wells are in feet below land-surface datum. Depths in feet and tenths of feet, tenths, and hundredths are measurements by the Geological Survey. Depths given in whole feet are reported.

Chemical quality.--The chemical quality is indicated by specific conductance in micromhos at 25°C ($K \times 10^6$) of a sample of water pumped or bailed from the well. Also shown is the boron content of the water sample in parts per million and the boron factors as explained in the text. Analyses are by the laboratory of the Geochemistry and Petrology Branch of the Geological Survey in Claremont, except as indicated by footnotes.

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Antelope Valley

(Measurements from March 1951 through April 1953)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
10/7- 3D1	-	-	-	2,070	4.5	2.2
5A1	-	-	-	1,810	2.2	1.2
11/7-13R1	2,577	404	270.2	-	-	-
30G1	a2,475	675	310	1,190	1.3	1.1
32G1	2,463	-	-	-	-	-
32G2	2,459	210	-	-	-	-
32G3	2,457	300	170	-	-	-
11/7-32M1	2,445	410	201.2	-	-	-
32N1	2,456	300	-	1,530	2.7	1.8
32N2	2,458	454	225	-	-	-
32N3	2,463	400	-	-	-	-
11/8- 2N1	2,480	400	178.0	b 805	.6	.7
11/8- 2N2	2,489	336	188.0	871	.6	.7
11D2	2,476	514	168	789	.5	.6
12R1	2,537	-	224.1	-	-	-
15C1	2,436	-	140.7	-	-	-
19K1	2,354	355.8	142.90	-	-	-
11/8-20H1	2,380	300	166.4	-	-	-
20H2	2,384	500	170.8	671	1.0	1.5
20R1	2,370	152.0	dry	-	-	-
22E1	2,398	-	-	b1,150	14	12.2
24D1	-	315	-	1,990	314	158
11/8-24D2	-	-	-	2,160	250	116
26E1	2,388	175	160.4	-	-	-
26J1	2,415	400	-	1,350	1.3	1.0
28A1	2,384	176.1	172.3	-	-	-
32G1	2,341	156.0	130.66	-	-	-
11/9- 7M1	2,335	165.0	155.0	-	-	-
12L1	a2,385	200+	168.64	-	-	-
13R1	a2,350	188.0	134.38	-	-	-
14B1	a2,370	157.0	156.78	-	-	-
17M1	a2,326	200.0	130.05	-	-	-

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b. Analysis from Quality of Water Branch, Geological Survey, Sacramento, Calif.

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Antelope Valley--Continued

(Measurements from March 1951 through April 1953)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
11/9-17M2	-	-	134	-	-	-
19A1	2,318	-	124.50	-	-	-
22Q1	a2,320	-	106.77	b896	1.2	1.3
23B1	a2,370	200	143	964	.3	.3
24B1	a2,335	155.0	131.29	-	-	-
11/9-30Q1	a2,315	169.1	99.99	-	-	-
31D1	a2,330	200	115.14	b1,300	.3	.2
32B1	a2,290	87.0	dry	-	-	-
32C1	a2,290	79.3	dry	-	-	-
34A1	2,303	193.5	93.11	-	-	-
11/9-34K1	2,300	147	80.75	-	-	-
36P1	2,311	191	95	-	-	-
11/10-36B1	a2,345	300±	-	-	-	-
31/40-32F1	2,802	256.3	253.7	-	-	-
35N1	2,750	217.0	195.95	-	-	-
31/41-31N1	2,775	340	219.8	806	.6	.7
32/39- 4K1	-	-	-	-	-	-
4L1	a2,725	237.0	208.3	1,700	3.3	1.9
30J1	2,485	253.0	229.3	-	-	-

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b. Analysis from Quality of Water Branch, Geological Survey, Sacramento, Calif.

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Fremont Valley

(Measurements from Sept. 1951 through May 1953)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
11/11- 2N1	a2,510	81.1	dry	-	-	-
6D1	a2,720	256.3	-	-	-	-
8D1	a2,640	204	200.3	-	-	-
18D1	a2,670	220+	213.5	-	-	-
20Q1	a2,600	76.2	dry	-	-	-
11/11-30K1	a2,575	-	124.8	-	-	-
32N1	a2,600	112.8	-	-	-	-
34M1	a2,550	282.3	78.8	-	-	-
11/12-12D1	a2,750	261	dry	-	-	-
12M1	a2,725	40	dry	-	-	-
11/12-14D1	2,722	263	dry	-	-	-
26J1	a2,605	225	154.5	-	-	-
26J2	a2,605	361	158	-	-	-
12/8-34A1	2,527	-	216.55	-	-	-
12/10-35P1	2,365	271.8	195.47	738	0.1	0.1
29/38-27R1	a2,250	-	spring	882	0.8	0.9
34P1	1,934	22.5	dry	-	-	-
29/39-20Q1	-	-	spring	1,710	.9	.5
22D1	a2,165	56.4	49.31	-	-	-
27K1	2,143	125.0	dry	-	-	-
29/39-28J1	2,098	-	173.09	-	-	-
30J1	1,984	265	72	1,130	1.3	1.2
31A1	1,980	165	65	-	-	-
32C1	1,980	238	79.3	-	-	-
35H1	2,293	-	325	-	-	-
29/40-21A1	a2,800	-	408	-	-	-
30/37-12N1	a2,190	160	105.30	3,480	33	9.5
13E1	-	2,900	-	-	-	-
13E2	-	2,910	-	-	-	-
13F1	-	1,859	-	-	-	-

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Fremont Valley--Continued

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
30/37-22A1	a2,170	-	180	3,500	1.8	0.5
23J1	2,015	-	56.74	-	-	-
24G1	1,990	-	48.01	-	-	-
24J1	1,967	211	19	871	2.8	3.2
24N1	1,985	-	32.64	-	-	-
30/37-24R1	1,950	13	spring	796	1.0	1.3
24R2	1,950	200	0.5	-	-	-
24R3	1,941	160	flowing	-	-	-
24R4	1,945	-	spring	-	-	-
24R5	1,941	-	spring	-	-	-
30/37-25M1	1,984	-	29.82	-	-	-
26D1	a2,040	-	78.15	-	-	-
26E1	a2,030	-	-	798	.6	.8
26M2	a2,025	100	65	-	-	-
26M3	a2,025	640	65	-	-	-
30/37-27H1	a2,050	220	87	-	-	-
28G1	-	-	-	906	.4	.4
34B1	a2,040	-	79.3	-	-	-
34H1	a2,025	-	55.2	-	-	-
35P1	a2,015	-	63.42	-	-	-
30/37-36C1	a1,990	-	-	762	.7	.9
36G1	1,970	-	29.32	-	-	-
36K1	a2,005	-	62.82	-	-	-
36N1	a2,025	840	53.9	856	1.0	1.2
30/38- 3B1	1,928	16.1	dry	-	-	-
30/38- 3E1	1,943	30.0	dry	-	-	-
3K1	1,902	-	2.20	-	-	-
4D1	2,000	-	117.05	3,750	20	5.3
4N1	1,914	-	14.82	-	-	-
8G1	1,932	12.8	2.38	-	-	-
30/38- 8G2	1,932	-	-	-	-	-
8J1	1,901	-	flowing	7,390	2.6	.4
17D1	1,950	-	22.89	-	-	-
19A1	1,949	900	-	-	-	-
19F1	1,960	3,000	-	-	-	-

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Fremont Valley--Continued

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
30/38-19L1	--	845	2	-	-	-
19M1	1,964	1,190	9	728	0.4	0.5
19P1	1,937	5,100	-	-	-	-
20B1	1,912	180	flowing	790	1.1	1.4
20B2	1,918	80	flowing	796	.8	1.0
30/38-21D1	1,898	-	flowing	738	.2	.3
21E1	1,898	-	spring	-	-	-
24F1	1,929	550	13.19	20,000	51	2.5
28D1	1,905	152	flowing	-	-	-
30B1	1,930	-	flowing	-	-	-
30/38-30C1	1,932	-	spring	-	-	-
30E1	1,943	260	3.31	-	-	-
30P1	1,956	-	-	-	-	-
30Q1	1,956	-	-	-	-	-
30R1	1,943	80±	16.10	-	-	-
30/38-30R2	1,943	37.5	6.46	-	-	-
31F1	-	-	-	-	-	-
31G1	-	-	-	-	-	-
32D2	-	40	-	7,900	3.0	.4
32D2	-	167	-	-	-	-
30/38-32E1	1,972	-	25.14	-	-	-
32G1	-	-	-	-	-	-
34C1	1,934	367	flowing	1,900	.8	.4
34C2	1,925	52	8.9	-	-	-
30/39- 3E1	a2,165	225.0	dry	-	-	-
30/39- 5A1	2,005	84.5	84.4(?)	-	-	-
5R1	2,053	259.0	136.64	3,080	4.6	1.5
6G1	-	-	24.28	-	-	-
6Q1	-	11.0	dry	-	-	-
31/37- 1H1	a2,030	-	61.6	-	-	-
31/37-10A1	a2,120	320	120	-	-	-
12N1	a2,140	-	80.56	-	-	-
13A1	a2,130	-	-	-	-	-
13B1	a2,140	-	156.84	-	-	-
14L1	a2,185	-	197.10	783	.8	1.0
22Q1	a2,360	-	257.72	-	-	-

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Fremont Valley--Continued

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
31/37-34A1	a2,285	-	201.54	-	-	-
35N1	a2,320	-	231.29	1,010	1.0	1.0
31/38-18P1	a2,225	-	147.42	-	-	-
31C1	a2,320	-	200.4	-	-	-
32/36-21Q1	a2,810	805	372.0	-	-	-
32/36-22B1	a2,720	829	605	-	-	-
22B2	a2,710	534	dry	-	-	-
22N1	a2,790	370	300	-	-	-
23Q1	a2,660	1,000	570.6	-	-	-
32/37- 1N1	a2,330	-	232.6	-	-	-
32/37- 2E1	a2,325	446	238.41	-	-	-
4D1	a2,390	-	302.06	-	-	-
4P1	a2,405	-	307.89	-	-	-
4Q1	a2,400	-	302.98	-	-	-
11N1	a2,375	-	269.09	-	-	-
32/37-14N1	a2,400	-	-	808	1.3	1.6
24N1	a2,385	-	263.33	-	-	-
24N2	a2,385	-	-	935	1.2	1.3
26G1	a2,405	-	-	-	-	-
26G2	a2,405	-	301.12	-	-	-
32/37-26N1	a2,420	-	365.8	-	-	-
32N1	a2,555	-	419.9	-	-	-
34D1	a2,475	-	-	-	-	-
32/38-10P1	a2,475	200.0	177.54	1,720	.5	.3
30B1	a2,360	-	222.14	-	-	-
32/38-32N1	a2,375	-	225.05	957	.6	.6

Table 3.- Description of water wells in part of the western Mojave desert, Calif.--Continued

Middle Mojave Valley

(Measurements from May 1953 through August 1954)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
8/3- 4H1	2,272	29	11.00	c980	0.3	0.3
8/4-10-1	-	30	16	d2,500	1.5	.6
10-2	-	-	-	d4,480	2.5	.6
10-3	-	-	-	d3,430	1.9	.6
10-4	-	30	-	d2,340	1.2	.5
8/4-10-5	-	30	12	d3,570	1.2	.3
11-1	-	45	-	d3,360	1.4	.4
11-2	-	28	-	d3,190	1.2	.4
12-1	-	30	14	d916	.2	.2
12-2	-	-	-	d920	.2	.2
8/4-12-3	-	15	5	d556	.1	.2
15-1	-	30	-	d470	0	0
15-2	-	30	-	d425	.1	.2
16-1	-	96	84	-	-	-
16-2	-	26	25	d1,890	1.3	.7
3/4-16-3	-	30	25	d1,480	.5	.3
16-4	-	20	12	d2,220	1.3	.6
19-1	-	20	9	d1,120	.3	.3
19-2	-	-	-	d1,240	.4	.3
20-1	-	-	-	d1,350	.5	.4
8/4-21-1	-	50	20	d779	.2	.3
30-1	-	400	100	d3,180	.6	.2
8/5-19C1	-	-	dry	-	-	-
25-1	-	-	-	d1,190	.3	.3
8/6-14Q1	2,760	300	191.78	-	-	-
8/6-15G1	-	-	-	-	-	-
9/2- 1-1	-	80	-	c1,692	.3	.2
4D1	2,176	-	27.14	-	-	-
5N1	2,193	-	27.25	-	-	-
6E1	2,191	-	29.23	-	-	-

c. Analysis from California Division of Water Resources.

d. Analysis from San Bernardino County Flood Control District.

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Middle Mojave Valley--Continued

(Measurements from May 1953 through August 1954)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
9/2-11C1	-	-	98.85	-	-	-
17C1	2,245	-	68.70	-	-	-
17E1	2,250	-	73.50	c691	0.6	0.9
18J1	2,239	131	68	-	-	-
19B1	2,255	-	71.04	-	-	-
9/2-19R1	2,313	-	128.30	c638	.4	.6
34E1	-	-	-	e604	.5	.8
34M1	2,495	230.0	153.45	-	-	-
34M2	2,506	226.0	159.50	-	-	-
9/3- 1D1	2,206	146	55.70	d460	.1	.2
9/3- 1J1	-	-	-	d290	.05	-
1R1	2,197	200	32.35	-	-	-
2A1	-	108	f63	-	-	-
2C1	2,226	129	53.60	-	-	-
3E1	2,238	125	92.50	-	-	-
9/3- 3J1	2,243	-	dry	-	-	-
3-1	-	-	-	d510	.1	.2
4-1	-	-	80	e1,350	.9	.7
10P1	2,292	-	102.60	-	-	-
10R1	2,209	-	26.30	-	-	-
9/3-11E1	-	28	-	d580	.2	.3
13R1	2,236	212	60.60	c619	.1	.2
13R2	2,226	-	44.62	-	-	-
14D1	2,211	54	29.80	e592	.2	.3
14D2	2,211	46	28.20	-	-	-
9/3-15J1	2,227	-	16.36	-	-	-
15Q1	2,234	134	17.61	-	-	-
15Q2	2,234	100	35	d522	.1	.2
24J1	2,300	-	135.10	c569	.4	.7
26H1	2,332	202	153.70	c619	.6	1.0

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c. Analysis from California Division of Water Resources.

d. Analysis from San Bernardino County Flood Control District.

e. Analysis from Salinity Laboratory, U. S. Department of Agriculture, Riverside, Calif.

f. Record from owner.

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Middle Mojave Valley--Continued

(Measurements from May 1953 through August 1954)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
9/3-27A1	2,240	-	19.95	-	-	-
27A2	2,235	-	23.50	-	-	-
28A1	2,250	-	27.78	d690	0.04	0.06
28K1	-	-	dry	-	-	-
28R1	2,267	-	15.20	521	0	0
9/3-34C1	2,310	104	61.40	c1,320	.5	.4
34E1	2,302	-	dry	-	-	-
34N1	-	-	-	1,020	1.1	1.1
9/4-33J1	2,490	253.0	249.52	-	-	-
9/6-34B1	2,750	106.5	91.55	1,600	1.0	.6
9/6-34R1	2,725	-	-	-	-	-
10/2-19P1	2,217	-	73.30	-	-	-
24-1	-	130	34	e671	.1	.1
30N1	2,178	135	-	-	-	-
30N2	-	-	-	c542	.2	.4
10/2-30Q1	2,181	110	17.30	d310	.1	.3
30R1	2,177	-	25.04	d530	.04	.08
31D1	2,183	120	35.34	-	-	-
31R1	2,183	-	28.05	-	-	-
32B1	2,171	135	23.78	e376	.1	.3
10/2-32K1	2,172	-	25.50	-	-	-
32Q1	-	-	-	d310	.1	.3
33D1	2,179	-	22.66	-	-	-
33J1	2,158	45	22.30	-	-	-
33Q1	-	115	-	d715	.1	.1
10/2-34N1	2,157	-	19.67	-	-	-
34R1	2,148	-	19.86	-	-	-
35R1	2,128	-	15.21	c634	.2	.3
10/3- 2J1	-	80	-	3,610	9.2	2.5
2J2	2,158	115	56.22	-	-	-

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c. Analysis from California Division of Water Resources.

d. Analysis from San Bernardino County Flood Control District.

e. Analysis from Salinity Laboratory, U. S. Department of Agriculture, Riverside, Calif.

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Middle Mojave Valley--Continued

(Measurements from May 1953 through August 1954)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 23°C)	Boron (ppm)	Boron factor
10/3- 2Q1	2,138	68	39.57	1,792	5.0	2.8
9H1	2,154	-	72.11	-	-	-
10R1	2,138	-	45.42	-	-	-
11M1	2,135	-	42.50	-	-	-
14D1	-	-	-	d500	0	0
10/3-15H1	2,144	75	52.60	e567	.2	.4
15J1	2,149	-	-	-	-	-
15Q1	2,156	80±	46.70	-	-	-
15Q2	2,152	-	47.09	-	-	-
21R1	2,160	-	33.97	-	-	-
10/3-21R2	-	80	-	-	-	-
22E1	2,163	-	47.90	-	-	-
22N1	-	108	30	-	-	-
23M1	2,164	-	54.25	-	-	-
23N1	2,165	178	-	-	-	-
10/3-23Q1	2,170	130	35	-	-	-
23R1	2,171	-	48.40	-	-	-
24E1	2,164	-	48.57	-	-	-
24N1	-	-	-	c518	.1	.2
26B1	2,170	-	-	-	-	-
10/3-26F1	2,175	-	-	-	-	-
26N1	2,186	-	-	-	-	-
26P1	2,181	-	86.40	-	-	-
26R1	2,183	200	68.97	-	-	-
27D1	-	121	29	d550	.1	.2
10/3-27J1	2,180	149	85.23	-	-	-
27M1	-	118	50	-	-	-
27N1	2,187	-	69.18	-	-	-
27N2	2,191	-	83.00	-	-	-
27P1	2,189	-	-	-	-	-

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c. Analysis from California Division of Water Resources.

d. Analysis from San Bernardino County Flood Control District.

e. Analysis from Salinity Laboratory, U. S. Department of Agriculture, Riverside, Calif.

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Middle Mojave Valley--Continued

(Measurements from May 1953 through August 1954)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
10/3-27Q1	2,186	-	83.00	-	-	-
27R1	2,186	280	100.10	-	-	-
27R2	-	126	-	c1,500	0.3	0.2
27-3	-	43	-	e551	.2	.4
28A1	-	75	36	1,280	1.5	1.2
28A2	-	-	-	-	-	-
28B1	-	-	-	2,540	2.2	.9
28C1	2,165	60	41.72	-	-	-
28C2	2,165	-	42.66	-	-	-
28F1	2,169	-	48.40	536	.5	.9
10/3-28H1	-	250	-	-	-	-
28H2	2,174	-	-	-	-	-
28H3	2,167	184	45.25	-	-	-
28L1	2,175	-	49.32	-	-	-
28L2	-	-	-	-	-	-
10/3-29M1	2,204	100		d800	.6	.8
30P1	-	121	63	-	-	-
30Q1	2,222	90	-	-	-	-
30Q2	2,219	104	60.80	968	1.3	1.3
30R1	2,220	80	62.05	-	-	-
10/3-32C1	2,219	-	65.24	-	-	-
33A1	-	108	-	-	-	-
33C1	2,199	94	63.10	532	1.1	2.1
33H1	-	108	60	-	-	-
34E1	2,214	155	70	-	-	-
10/3-34H1	2,207	-	-	-	-	-
35C1	-	216	55	d1,890	.5	.3
35E1	2,203	-	92.40	-	-	-
35F1	2,197	154	-	d830	.2	.2
35G1	-	130	76	d1,240	.4	.3

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c. Analysis from California Division of Water Resources.

d. Analysis from San Bernardino County Flood Control District.

e. Analysis from Salinity Laboratory, U. S. Department of Agriculture, Riverside, Calif.

Table 3.-- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Middle Mojave Valley--Continued

(Measurements from May 1953 through August 1954)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
10/3-35H1	2,190	-	-	-	-	-
35P1	2,228	-	75.90	-	-	-
35R1	2,196	-	-	-	-	-
35-1	-	-	-	c634	0.2	0.3
35-2	-	-	-	e457	.1	.2
10/3-36C1	2,181	154	56.00	-	-	-
36P1	-	-	31	-	-	-
10/4-24J1	2,201	102.0	57.10	-	-	-
25A1	2,194	54.0	47.25	-	-	-

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c. Analysis from California Division of Water Resources.

e. Analysis from Salinity Laboratory, U. S. Department of Agriculture, Riverside, Calif.

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Harper Valley

(Measurements from October 1952 through June 1954)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
10/3- 4H1	2,100	-	46.20	-	-	-
6B1	2,044	-	dry	e504	0.2	0.4
10/4- 3F1	2,129	-	150.73	-	-	-
3Q1	2,134	-	153.20	-	-	-
8P1	2,194	790	110	c1,470	.9	.6
10/5- 3H1	2,254	350.0	223.18	-	-	-
3J1	-	-	-	-	-	-
10/6- 3F1	2,455	-	213.00	-	-	-
5E1	2,475	300	-	-	-	-
5E2	2,475	340	-	-	-	-
10/6- 5E3	2,472	440	-	2,120	2.9	1.4
5E4	2,472	262	195.00	-	-	-
5E5	2,475	285	175.23	-	-	-
5F1	2,475	234	195	-	f.3	
6L1	2,500	-	192.00	-	-	-
11/3- 7D1	2,082	123.1	55.55	-	-	-
21R1	2,063	-	55.94	-	-	-
28R1	2,073	60	28.50	e548	.6	1.1
28R3	2,074	-	26.00	-	-	-
30A1	2,031	200	flowing	d660	3.4	5.2
11/3-30A2	2,033	-	flowing	-	-	-
32P1	2,050	35	9	-	.4	-
32P2	2,050	50	11.40	-	-	-
32R1	-	38	16±	-	-	-
33H1	-	206	-	464	.6	1.3
11/3-34F1	2,087	-	36.73	-	-	-
11/4- 4R1	2,036	-	35.07	-	-	-
5-1	-	-	28	e1,880	6.5	3.5
6M1	2,051	-	47.55	-	-	-
13-1	-	768	38	e1,450	1.2	.8

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c. Analysis from California Division of Water Resources.

d. Analysis from San Bernardino County Flood Control District.

e. Analysis from Salinity Laboratory, U. S. Department of Agriculture, Riverside, Calif.

f. Record from owner.

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Harper Valley--Continued

(Measurements from October 1952 through June 1954)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
11/4-18C1	2,030	-	81.30	-	-	-
19E1	2,060	500	178.70	c3,580	1.0	0.3
19H1	2,039	210	108.60	-	1.4	-
19L1	2,066	350	144.60	-	-	-
19R1	2,046	-	125.00	-	-	-
11/4-29R1	2,052	500	97.70	-	-	-
29-1	-	253	38	e1,240	1.17	1.0
30C1	-	180	149.30	-	-	-
30E1	-	588	-	f1,578	-	-
30N1	-	500	-	f1,677	-	-
11/4-30N2	2,113	500	159.20	c1,567	1.3	.8
30P1	-	-	147.20	-	-	-
30R1	-	-	134.10	-	-	-
31A1	2,076	300	128.10	d1,500	.9	.6
32F1	-	225	124.80	-	-	-
11/4-32L1	-	272	131.70	c983	.6	.6
33G1	-	310	--	c1,470	1.0	.7
33Q1	-	350	-	-	-	-
35G1	-	-	30.68	-	-	-
11/5- 2B1	2,110	158.0	99.65	-	-	-
11/5- 2B2	2,110	-	98.82	-	-	-
2D1	2,145	-	132.10	-	-	-
13H1	2,034	-	84.60	-	-	-
13Q1	2,058	285	135.82	-	-	-
14R1	2,062	153	25.10	7,300	8.7	1.2
11/5-24A1	-	300	-	-	-	-
24A2	-	250	-	-	-	-
24E1	-	250	160±	-	-	-
24G1	-	250	-	c1,280	.9	.7
24G2	-	475	-	-	-	-

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c. Analysis from California Division of Water Resources.

d. Analysis from San Bernardino County Flood Control District.

e. Analysis from Salinity Laboratory, U. S. Department of Agriculture, Riverside, Calif.

f. Record from owner.

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Harper Valley--Continued

(Measurements from October 1952 through June 1954)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
11/5-24P1	-	444	-	f1,610	-	-
24R1	-	-	-	f1,507	-	-
35N1	2,212	288.0	194.10	-	-	-
11/6-17L1	2,576	618	330.3	1,570	20	13
17P1	2,577	-	317.5	-	-	-
11/6-20A1	2,572	712	247.7	1,460	35	24
12/4-34C1	2,131	375.0	136.55	-	-	-
32/41-15J1	2,775	300	203.50	992	1.4	1.4
32/43-28L1	2,196	-	spring	c1,040	.7	.7

c. Analysis from California Division of Water Resources.
f. Record from owner.

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Cuddeback Valley
(Measurements from February 1953 through August 1954)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality		
				Specific conductance (micromhos at 25°C)	Boron (ppm)	Boron factor
29/41-34K1	3,475	180	38.25	-	-	-
30/41-36G1	2,747	319.2	235.30	548	0.5	0.9
30/42- 4E1	2,615	210.0	107.32	-	-	-
5K1	2,650	-	122.38	-	-	-
5P1	2,650	125.4	123.02	-	-	-
30/42-10L1	2,590	130	70.54	-	-	-
12F1	2,695	-	182.30	-	-	-
18R1	2,635	-	99.43	-	-	-
20D1	2,630	-	91.25	-	-	-
20K1	-	-	-	6,881	1.5	.2
30/42-24F1	-	-	141.10	673	0	-
30/43- 2D1	-	-	17.85	631	0	-
31/42- 5R1	2,554	-	51.82	-	-	-

Table 3.- Description of water wells in part of the western Mojave Desert, Calif.--Continued

Superior Valley

(Measurements from August 1953 through February 1954)

Well number	Altitude of land surface (ft above sea level)	Depth of well (ft below lsd)	Depth to water (ft below lsd)	Chemical quality: Specific conductance (micromhos at 25°C)	Chemical quality: Boron (ppm)	Chemical quality: Boron factor
30/45-35P1	3,062	-	145.00	-	-	-
31/45- 1C1	-	-	121.20	-	-	-
15X	3,034	-	107.60	-	-	-
24R1	3,026	-	106.63	-	-	-
31/46- 2M1	3,020	-	101.70	-	-	-
31/46-12P1	3,004	-	87.00	-	-	-
16J1	3,011	265	93.20	g2,519	0.9	0.4
21M1	-	-	107.90	-	-	-
31/47- 5R1	3,113	-	253.00	-	-	-

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g. Analysis from U. S. Bureau of Land Management.

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert

(For source of analyses see table 3)

Antelope Valley

Well number	10/7-3D1	10/7-5A1	11/7-30G1
Constituents (parts per million)			
Silica (SiO_2)	22	44	15
Calcium (Ca)	67	48	49
Magnesium (Mg)	19	7	11
Sodium (Na)	400	330	215
Potassium (K)	7.0	6.0	6.0
Bicarbonate (HCO_3)	240	162	192
Carbonate (CO_3)	-	17	-
Sulfate (SO_4)	360	271	223
Chloride (Cl)	373	302	180
Nitrate (NO_3)	10	5.0	5
Boron (B)	4.5	2.2	1.3
Fluoride (F)	1.2	.8	1.6
Dissolved solids (Dis. sol.)	1,549	-	840
Hardness as $CaCO_3$ (Hardness)	-	-	-
Specific conductance (Sp. C.) (micromhos at 25°C; $K \times 10^6$)	2,070	1,810	1,190
Percent sodium (% Na)	78	82	74
pH	7.7	8.4	7.8
Boron factor $\left(\frac{\text{ppm B}}{\text{E.C.} \times 10^3}\right)$	2.2	1.2	1.1
Water temperature (°F)	-	-	-
Well depth in feet (Depth)	240	-	675
Date of collection (Date)	4-22-53	-	4-22-53

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Antelope Valley--Continued

Well No.	11/7-32N4	11/8-2N1	11/8-2N2	11/8-11D2	11/8-20H2	11/8-22E1
Constituents (ppm)						
SiO_2	58	72	60	66	61	25
Ca	54	30	38	35	40	29
Mg	8.0	8.5	10	9.8	15	8.9
Na	280	125	128			
K	9.0	6.4	5.0	10.0	11	6.2
HCO_3	235	201	205	193	185	207
CO_3	-	-	-	-	-	-
SO_4	256	87	93	93	95	148
Cl	231	83	90	89	63	167
NO_3	20	24	-	-	-	1.3
B	2.7	.6	.6	.5	1.0	14
F	1.2	.9	-	-	-	.6
Dis. sol.	1,060	536	590	568	513	709
Hardness	-	110	-	-	-	109
Sp. C.	1,530	805	871	789	671	1,150
% Na	79	70	68	69	54	79
pH	7.8	8.2	8.1	8.0	7.7	8.0
B. factor	1.8	.7	.7	.6	1.5	12.2
°F	72	72	71	75	69	70
Depth	300	400	336	514	500	-
Date	4-22-53	4-2-53	2-24-53	2-24-53	2-24-53	4-2-52

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Antelope Valley--Continued

Well No.	11/8-24D1	11/8-26J1	11/9-22Q1	11/9-23B1	11/9-31D1	31/41-31N1
Constituents (ppm)						
SiO_2	8.0	25	58	8.4	36	17
Ca	32	54	38	7.6	76	30
Mg	5.0	12	36	2.6	13	5.2
Na	457	216	82	205	175	134
K	8	9.0	1.3	6.0	7.7	6.5
HCO_3	15	198	166	226	198	128
CO_3	357	-	-	10.4	-	-
SO_4	162	231	139	176	111	154
Cl	239	192	87	68	245	76
NO_3	3.5	-	14	-	3.6	-
B	314	1.3	1.2	0.3	.3	.6
F	1.2	-	.3	-	.3	-
Dis. sol.	2,500	874	537	598	765	509
Hardness	-	-	243	-	243	-
Sp. C.	1,990	1,350	896	964	1,300	806
% Na	91	73	42	94	60	76
pH	8.8	7.7	7.9	8.8	7.7	8.0
B. factor	158	1.0	1.3	.3	.2	.7
°F	-	68.5	69	66.5	68	71
Depth	315	400	-	200	200	340
Date	4-6-53	2-25-53	4-2-52	2-24-53	4-5-52	2-17-53

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Antelope Valley--Continued

Well No.	32/39-4L1
Constituents (ppm)	
SiO_2	50
Ca	11
Mg	-
Na	393
K	7.5
HCO_3	606
CO_3	12
SO_4	256
Cl	90
NO_3	2.5
B	3.3
F	4.0
Dis. sol.	-
Hardness	-
Sp. C.	1,700
% Na	96
pH	8.3
B. factor	1.9
°F	-
Depth	237.0
Date	5-7-53

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Fremont Valley

Well No.	12/10-35P1	29/38-27R1	29/39-20Q1	29/39-30J1	30/37-12N1	30/37-22A
Constituents (ppm)						
SiO_2	25	-	34	4.0	54	30
Ca	19	23	95	50	53	164
Mg	4.0	7.0	96	37	3.2	4.0
Na	143	166	160	141	734	602
K	3.0	3.0	4	9	6.0	4.0
HCO_3	210	207	298	227	196	102
CO_3	-	-	-	-	-	-
SO_4	99	144	698	138	934	999
Cl	70	87	24	187	427	480
NO_3	2.5	5.0	1.0	5.0	2.0	.7
B	.1	.8	.9	1.3	33	1.8
F	1.6	.8	.5	.8	8.0	4.0
Dis. sol.	-	506	-	714	-	-
Hardness	-	-	-	-	-	-
Sp. C.	738	882	1,710	1,130	3,480	3,500
% Na	82	81	36	53	97	76
pH	7.5		8.2	7.7	8.2	7.5
B factor	.1	.9	.5	1.2	9.5	.5
°F	-	-	72	75.5	-	70
Depth	271.8	spring	spring	265	160	
Date	5-7-53	4-23-53	3-12-53	4-23-53	8-19-53	3-11-53

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Fremont Valley--Continued

Well No.	30/37-24J1	30/37-24R1	30/37-26E1	30/37-36C1	30/37-36N1	30/38-4D1
Constituents (ppm)						
SiO_2	50	40	26	40	31	65
Ca	64	66	67	57	58	148
Mg	7.2	19	21	16	15	30
Na	113	80	78	82	89	653
K	3.5	2.6	3	4.0	5	10
HCO_3	275	294	315	176	156	123
CO_3	-	-	-	-	-	-
SO_4	174	135	109	121	128	1,100
Cl	48	32	26	80	103	501
NO_3	2.0	2.5	3.7	.6	3.5	1.5
B	2.8	1.0	.6	.7	1.0	20
F	1.6	1.6	.7	.4	.2	2.4
Dis. sol.	-	-	-	-	-	-
Hardness	-	-	-	-	-	-
Sp. C.	871	796	798	762	856	3,750
% Na	54	41	41	47	49	90
pH	7.7	7.5	7.6	7.7	7.7	7.8
B factor	3.2	1.3	.8	.9	1.2	5.3
°F	-	-	66.5	75	81.5	-
Depth	211	13	-	-	840	-
Date	5-7-53	5-7-53	3-17-53	3-11-53	3-11-53	8-19-53

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Fremont Valley--Continued

Well No.	30/38-8J1	30/38-19M1	30/38-20B1	30/38-21D1	30/38-24F1	30/38-32D1
Constituents (ppm)						
SiO_2	75	40	39	75	trace	30
Ca	59	68	69	73	1,670	837
Mg	14	14	13	17	36	370
Na	1,630	77	84	70	3,220	589
K	14	2	6	6.7	36	10
HCO_3	263	284	300	253	61	155
CO_3	-	-	-	-	-	-
SO_4	535	122	122	134	852	1,660
Cl	2,130	26	33	33	7,320	2,120
NO_3	5.0	1.3	.7	1.5	5.0	5.0
B	2.6	.4	1.1	.2	51	3.0
F	1.6	1.6	.8	1.6	3.2	.4
Dis. sol.	-	-	-	-	-	-
Hardness	-	-	-	-	-	-
Sp. C.	7,380	728	790	738	20,000	7,900
%Na	94	42	44	38	62	26
pH	7.6	7.7	7.9	7.6	7.9	7.3
B factor	.4	.5	1.4	.3	2.5	.4
°F	82.5	71	-	67	-	-
Depth	-	1,190	180	-	550	40
Date	5-6-53	5-13-53	3-12-53	5-6-53	5-6-53	5-6-53

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Fremont Valley--Continued

Well No.	30/38-34C1	30/39-5R1	31/37-14L1	31/37-35N1	32/37-14N1	32/37-24N2
Constituents (ppm)						
SiO_2	20	2.5	28	30	26	27
Ca	355	145	62	62	29	44
Mg	9.8	36	14	14	7	15
Na	73	452	79	112	125	136
K	4.0	13	4	3	4	2
HCO_3	107	151	164	123	218	218
CO_3	-	-	-	-	-	-
SO_4	866	303	119	129	93	113
Cl	92	778	88	158	79	114
NO_3	3.0	5.0	1.0	2.9	1.0	2.0
B	.8	4.6	.8	1.0	1.3	1.2
F	.4	.4	.1	.3	.9	.7
Dis. sol.	-	-	-	-	-	-
Hardness	-	-	-	-	-	-
Sp. C.	1,900	3,080	783	1,010	808	935
% Na	15	66	44	54	72	63
pH	7.6	7.6	7.6	7.9	7.9	7.8
B factor	.4	1.5	1.0	1.0	1.6	1.3
°F	82	-	72.4	78	-	80.5
Depth	367	259	-	-	-	-
Date	5-6-53	5-6-53	3-10-53	3-10-53	3-10-53	3-10-27

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Fremont Valley--Continued

Well No.	32/38-10P1	32/38-32N1
Constituents (ppm)		
SiO_2	20	28
Ca	27	21
Mg	13	8
Na	256	178
K	38	2
HCO_3	971	258
CO_3	-	12
SO_4	15	104
Cl	74	93
NO_3	.5	.8
B	.5	.6
F	.4	1.8
Dis. sol.	-	-
Hardness	-	-
Sp. C.	1,720	957
% Na	78	81
pH	7.7	8.6
B factor	.3	.6
°F	-	-
Depth	200	-
Date	5-7-53	3-10-53

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Middle Mojave Valley

Well No.	8/3-4H1	9/2-17E1	9/2-19R1	9/3-1D1	9/3-11E1	9/3-13R1
Constituents (ppm)						
SiO_2	-	-	-	20.8	27	-
Ca	84	28	11	47	46	45
Mg	19	7	4	7	9	8
Na	120	115	135	50	56	90
K	3.5	3.7	2.6	-	-	3.0
HCO_3	273	229	224	220	205	212
CO_3	-	-	-	-	-	-
SO_4	166	101	85	35	41	78
Cl	111	43	41	34	47	62
NO_3	7.9	2.0	2.5	6.6	5.0	0
B	.3	.6	.4	.1	.2	.1
F	.9	4.0	2.0	.7	.6	1.2
Dis. sol.	668	450	402	-	-	402
Hardness	-	-	-	-	-	-
Sp. C.	980	691	638	460	580	619
% Na	48	70	97	43	45	58
pH	7.9	8.0	8.0	8.2	7.9	7.7
B factor	.3	.9	.6	.2	.3	.2
°F	-	-	-	-	-	-
Depth	29	-	-	146	28	212
Date	4-20-54	5-6-54	4-20-54	3-27-52	2-3-52	4-20-54

Table 4.-- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Middle Mojave Valley--Continued

Well No.	9/3-24J1	9/3-26H1	9/3-28R1	9/3-34C1	9/3-34N1	9/6-34B1
Constituents (ppm)						
SiO_2	-	-	29	-	37	-
Ca	19	20	40	111	70	22
Mg	3	6	10	19	19	5.5
Na	115	123	60	147	125	312
K	3.7	4.1	1.9	2.5	2.4	5.6
HCO_3	215	203	173	292	268	138
CO_3	-	-	-	-	-	-
SO_4	72	117	67	256	153	316
Cl	40	40	39	127	95	244
NO_3	0	6.0	3.4	4.4	2.6	1.0
B	.4	.6	0	.5	1.1	1.0
F	2.0	2.2	.4	.7	.8	.4
Dis. sol.	373	420	-	782	-	-
Hardness	-	-	-	-	-	-
Sp. C.	569	619	521	1,320	1,020	1,600
% Na	81	79	50	47	52	89
pH	7.9	8.0	7.4	7.5	7.5	7.3
B factor	.7	1.0	0	.4	1.1	.6
°F	-	-	-	-	69	-
Depth	-	202	-	104	-	106.5
Date	4-20-54	4-20-54	5-26-54	4-13-54	5-7-54	5-15-53

Table 4.-- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Middle Mojave Valley--Continued

Well No.	10/2-30Q1	10/2-33Q1	10/2-35R1	10/3-2J1	10/3-2Q1	10/3-14D1
Constituents (ppm)						
SiO_2	17	-	-	29	18	31
Ca	28	50	56	47	27	34
Mg	3.0	16	9	22	2.1	8.4
Na	36	84	68	823	364	60
K	-	3.1	-	3.2	2.2	-
HCO_3	154	298	201	223	124	187
CO_3	-	-	-	-	-	-
SO_4	17	66	141	602	265	37
Cl	23	39	28	807	321	44
NO_3	2.5	16	1.5	.3	0	3.5
B	.1	.1	.2	9.2	5.0	0
F	.6	1.0	.3	4.0	8.0	.6
Dis. sol.	-	-	398	-	-	-
Hardness	-	-	-	-	-	-
Sp. C.	310	715	634	3,610	1,790	500
% Na	49	59	46	90	92	52
pH	7.6	7.4	7.7	7.4	8.0	8.0
B factor	.3	.1	.3	2.5	2.8	0
°F	-	-	-	-	-	-
Depth	110	115	-	80	68	-
Date	3-13-52	6-53	12-15-51	12-14-53	12-14-53	2-6-52

Table 4.-- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Middle Mojave Valley--Continued

Well No.	10/3-24N1	10/3-27D1	10/3-27R2	10/3-28A1	10/3-29M1	10/3-30Q2
Constituents (ppm)						
SiO_2	-	27	-	46	50	35
Ca	47	37	173	117	19	18
Mg	3.7	9.5	26	27	12	6.4
Na	62	68	103	124	132	182
K	1.0	-	3.9	3.9	-	2.9
HCO_3	168	196	280	186	179	196
CO_3	-	-	-	-	-	-
SO_4	59	52	271	301	111	179
Cl	52	48	185	142	72	90
NO_3	2.5	2.0	11	3.6	2.0	0
B	.1	.1	.3	1.5	.6	1.3
F	.5	.7	.3	0	.9	1.2
Dis. sol.	305	-	1,180	-	-	-
Hardness	-	-	-	-	-	-
Sp. C.	518	550	1,500	1,280	800	968
% Na	50	54	30	41	75	85
pH	7.4	8.0	7.4	7.3	8.1	7.3
B factor	.2	.2	.2	1.2	.8	1.3
°F	-	-	-	69	-	70.5
Depth	-	121	126	75	100	104
Date	4-13-54	2-6-52	4-13-54	5-25-54	2-6-52	4-22-54

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Middle Mojave Valley--Continued

Well No.	10/3-33C1	10/3-35C1
Constituents (ppm)		
SiO_2	57	22
Ca	27	246
Mg	8.5	38
Na	71	170
K	3.3	5.4
HCO_3	159	371
CO_3	-	-
SO_4	63	427
Cl	47	253
NO_3	0	17
B	1.1	.5
F	.4	.5
Dis. sol.	-	-
Hardness	-	-
Sp. C.	532	1,890
% Na	62	33
pH	7.3	7.4
B factor	2.1	.3
°F	71.5	-
Depth	94	216
Date	4-22-54	3-4-52

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Harper Valley

Well No.	10/4-8P1	10/6-5E3	11/3-30A1	11/3-32P1	11/3-33H1	11/4-19H1
Constituents (ppm)						
SiO_2	-	57	36.4	35	34.8	35.2
Ca	19	43	1.72	47	22.8	155
Mg	4	13	.52	14	5.68	30
Na	310	426	143	91	72.2	616
K	5.9	3	1.40	.9	.90	11
HCO_3	134	304	219	224	167	262
CO_3	-	11	39.0	-	-	-
SO_4	173	318	36.7	77	49.0	248
Cl	305	335	32.0	73	33.0	982
NO_3	6.3	20	3.97	1.20	0	9.8
B	.9	2.9	3.4	.4	.6	1.4
F	1.0	1.6	1.60	.4	1.2	0
Dis. sol.	860	1,360	426	53	-	-
Hardness	-	-	-	-	-	-
Sp. C.	1,470	2,120	660	-	464	-
% Na	90	85	97	54	68	72
pH	8.0	7.8	9.2	7.6	7.5	7.8
B factor	.6	1.4	5.2	-	1.3	-
°F	-	-	64	73	69.5	71
Depth	790	440	200	35	206	210
Date	6-15-53	4-17-53	2-6-52	6-54	5-5-54	6-29-54

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Harper Valley--Continued

Well No.	11/4-30N2	11/4-31A1	11/4-32L1	11/4-33G1	11/5-14R1	11/5-24G1
Constituents (ppm)						
SiO_2	-	78	-	-	66	-
Ca	66	46	36	40	170	18
Mg	12	7.4	10	5	56	4
Na	290	260	180	290	1,510	290
K	5.9	-	4.6	5.9	3.6	3.8
HCO_3	220	173	166	141	486	237
CO_3	-	-	-	-	-	-
SO_4	246	240	155	207	1,220	129
Cl	280	235	151	275	1,590	243
NO_3	10.9	7.9	9.4	11	10.2	13
B	1.3	.9	.6	1.0	8.7	.9
F	.8	.8	1.0	1.2	.8	1.2
Dis. sol.	1,080	952	688	905	-	875
Hardness	-	-	.6	.8	-	-
Sp. C.	1,570	1,500	983	1,470	7,300	1,280
% Na	74	80	69	90	84	91
pH	7.3	7.8	7.5	8.4	7.4	7.7
B factor	.8	.6	.6	.7	1.2	.7
°F	73	-	-	77	-	74
Depth	500	300	272	310	153	250
Date	6-12-53	2-6-52	6-12-53	6-23-53	6-16-54	6-12-53

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Harper Valley--Continued

Well No.	11/6-17L1	11/6-20A1	32/41-15J1	32/43-28L1
Constituents (ppm)				
SiO_2	22	19	31	-
Ca	27	19	35	41
Mg	7.0	10	8	7
Na	269	259	162	188
K	-	-	2	4.8
HCO_3	-	-	210	122
CO_3	-	-	-	-
SO_4	138	178	138	301
Cl	184	240	95	99
NO_3	-	-	9.7	2.4
B	20	35	1.4	.7
F	.8	0	1.0	2.6
Dis. sol.	1,020	946	-	745
Hardness	95	90	-	-
Sp. C.	1,570	1,460	992	1,040
% Na	-	-	75	75
pH	8.2	7.8	7.7	7.8
B factor	13	24	1.4	.7
°F	-	-	-	-
Depth	618	712	300	spring
Date	1950	1950	3-1-53	1-11-54

Table 4.- Selected chemical analyses of waters from the western part of the Mojave Desert--Continued

(For source of analyses see table 3)

Cuddeback and Superior Valleys

Well No.	30/41-36G1	30/42-20K1	30/42-24F1	30/43-2D1	31/46-16J1
Constituents (ppm)					
SiO_2	13	-	7.3	22	-
Ca	23	464	12	49	141
Mg	5.6	85	.6	5.6	52
Na	100	866	128	78	300
K	3.0	15	12	2.0	13
HCO_3	151	88	157	261	120
CO_3	10	-	15	-	-
SO_4	64	56	20	17	156
Cl	61	2,310	104	61	672
NO_3	-	5.0	.3	.3	13
B	.5	1.5	0	0	9
F	-	.8	.8	.8	2.0
Dis. sol.	381	-	-	-	1,720
Hardness	-	-	-	-	-
Sp. C.	548	6,880	673	631	2,520
% Na	72	55	83	53	56
pH	8.4	8.0	8.6	7.9	7.2
B factor	.9	.2	0	0	.4
°F	72	70	-	-	-
Depth	319.2	-	-	-	265
Date	2-17-53	4-29-53	8-19-53	8-19-53	1-12-54