OT-8

GROUND WATER IN THE VICINITY OF McGREGOR RANGE CAMP SITE, OTERO COUNTY, N. MEX.

By

James W. Hood

OFR: 58-49

ALBUQUERQUE DISTRICT
P. O. BOX 1538
ALBUQUERQUE, NEW MEXICO

NO. SWKGA-2

7 OCT 1958

SUBJECT: Release to Open File - McGregor and Holloman Ground-Water Reports

TO: U. S. Geological Survey
Ground Water Branch
P. O. Box 4217
Albuquerque, New Mexico

OT. 8
S.W. Hood

Gentlemen:

Reference is made to your letter on the above subject, dated 24 September 1958.

The Albuquerque District has no objection to the requested release of the two reports entitled "Ground-Water in the Vicinity of McGregor Range, Otero County, New Mexico", and "Ground-Water Resources and Related Geology in the vicinity of Holloman Air Force Base, Otero County, New Mexico."

Sincerely yours,

Charles S. Rogers, Jr.
for R. C. WOODSON
Chief, Engineering Division

OCT 8 1958

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United States
Department of the Interior
Geological Survey

GROUND WATER IN THE VICINITY OF McGREGOR RANGE CAMP SITE, OTERO COUNTY, NEW MEXICO

By

James W. Hood

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Prepared for
U. S. Army, Corps of Engineers

OPEN FILE

U.S.G.S.
P.O. Box 26659
Albuq NM 87125

March 1956

Not Reviewed for Conformance with Stratigraphic Nomenclature or
Editorial Standards of the U. S. Geological Survey

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GROUND WATER IN THE VICINITY OF SOUTH McGREGOR RANGE CAMP SITE, OTERO COUNTY, N. MEX.

By

James W. Hood

U. S. Geological Survey

March 1956

INTRODUCTION

McGregor Range is a part of the training facilities of Fort Bliss, Texas, and is a broad expanse of semidesert land, formerly part of the McGregor Ranch. A camp to accommodate 1,000 men is to be constructed at the northeast corner of sec. 1, T. 26 S., R. 7 E., Otero County, New Mexico, to provide housing for troops engaged in training activities on the range. The principal water requirements of the camp will be potable water for drinking, cooking, cooling, and sanitary purposes. A minimum of 10,000 gallons per day of water is needed, but it is desirable to have as much as 70,000 gallons per day.

The area of about 400 square miles discussed in this memorandum (see fig. 1) is partly in the southwestern corner of Otero County, N. Mex., and partly in adjoining El Paso County, Texas. The size and location of the area are such that conditions in several ground-water provinces may bear upon the development of ground-water supplies at the South McGregor Range camp site. Approximately three days were spent in the field in January 1956, in order to obtain data to supplement data from previous investigations. Information herein is presented primarily as a matter of record, to support recommendations made as to sites of test drilling, and is not exhaustive.

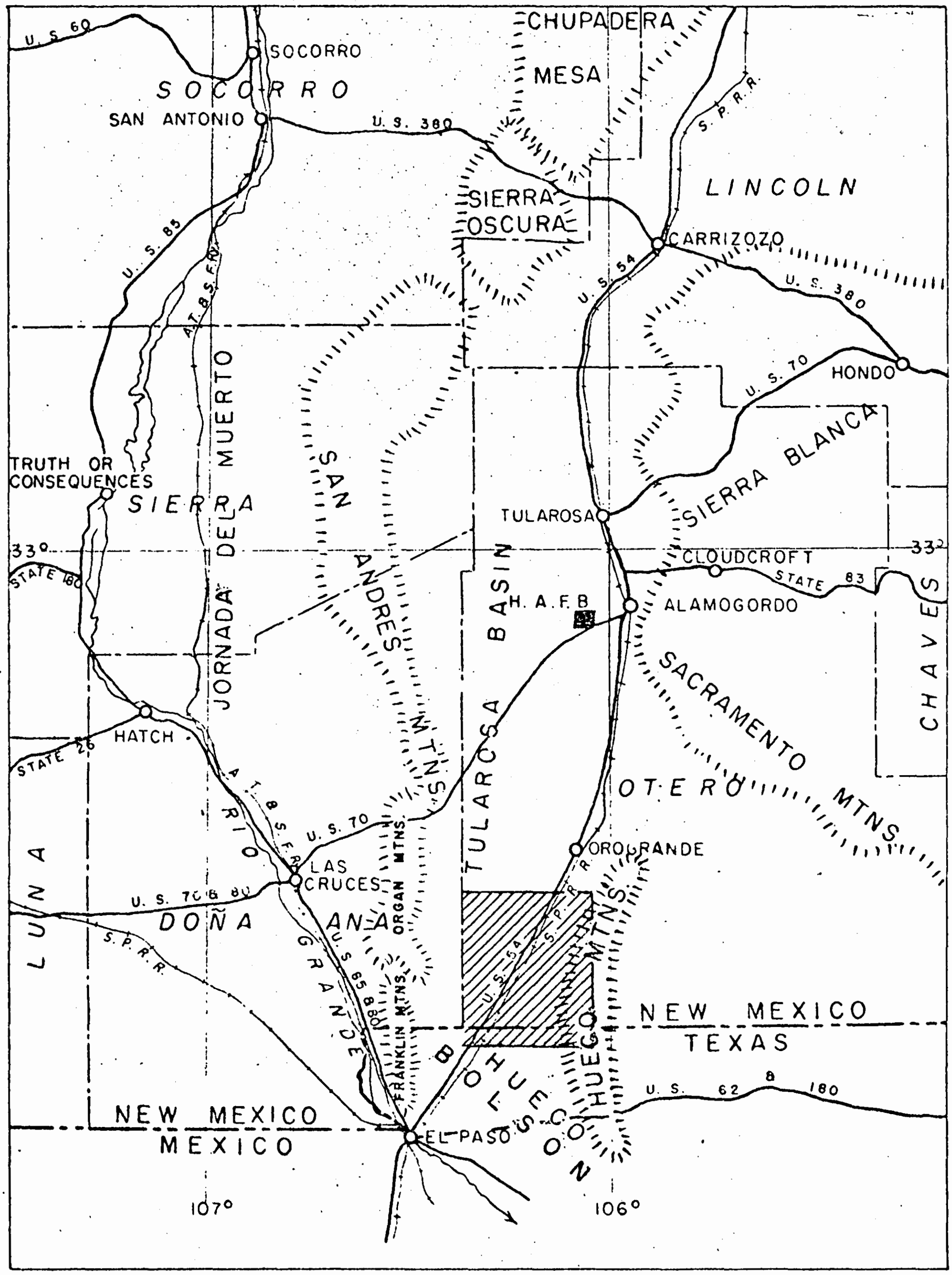

Fig. 1.--Map of south-central New Mexico and western Texas showing area discussed in this report.

Sayre and Livingston (1945) studied the Hueco Bolson during the period 1935 to 1939, and published some data on the area discussed in this report. A continuing investigation of the El Paso area has been carried on by the U. S. Geological Survey in cooperation with the City of El Paso, which has resulted in several publications containing data on the area covered by this report (Scalapino, 1949; Follett, 1954; and Smith, 1956). In addition to these reports, a large amount of available data, largely unpublished, was obtained during 1953 from a test-drilling program carried on cooperatively by the U. S. Geological Survey, the City of El Paso, the U. S. Army, and the U. S. Air Force.

Basic data for the area are given in tables 2, 3, 4, 5, and 6. In the tables, wells are listed in the numerical order of their location numbers. The method used by the U. S. Geological Survey in numbering water wells in New Mexico is shown in figure 2. The location number is a description of the geographic location of the well, based on the public land survey system, and indicates the location of the well to the nearest 10-acre tract. The location number consists of a series of numbers separated by decimal points. The first three parts of the location number indicate the township south, range east, and section, respectively. The last part of the number consists of three digits which indicate the 160-, 40-, and 10-acre tracts respectively. For example, the number 22.4.24.222 indicates a location in the NE¼, NE¼, NE¼, sec. 24, T. 22 S., R. 4 E. The quarter-section or any subdivision thereof is numbered in the order shown in figure 2. If a well location is known only to the nearest 40-acre tract the last digit in the series of three is zero; likewise, if known only to the nearest 160-acre tract, the last two digits are zeros. However, if the well can be located only to the section the last segment of the well number is omitted. If more than one well is in a 10-acre tract, the first well is numbered with the location number only, and all other wells in the tract are assigned the location number with the suffix a, b, --- in the order of their construction, or discovery by the Survey.

For the purposes of this memorandum only, wells in the part of El Paso County, Texas, shown in plate 1 are numbered in accordance with the New Mexico well-numbering system. It should be noted that in the Texas portion of plate 1 the term "Block" replaces the term "Range east", used in the New Mexico portion. Otherwise, the method of location designation is the same in both states.

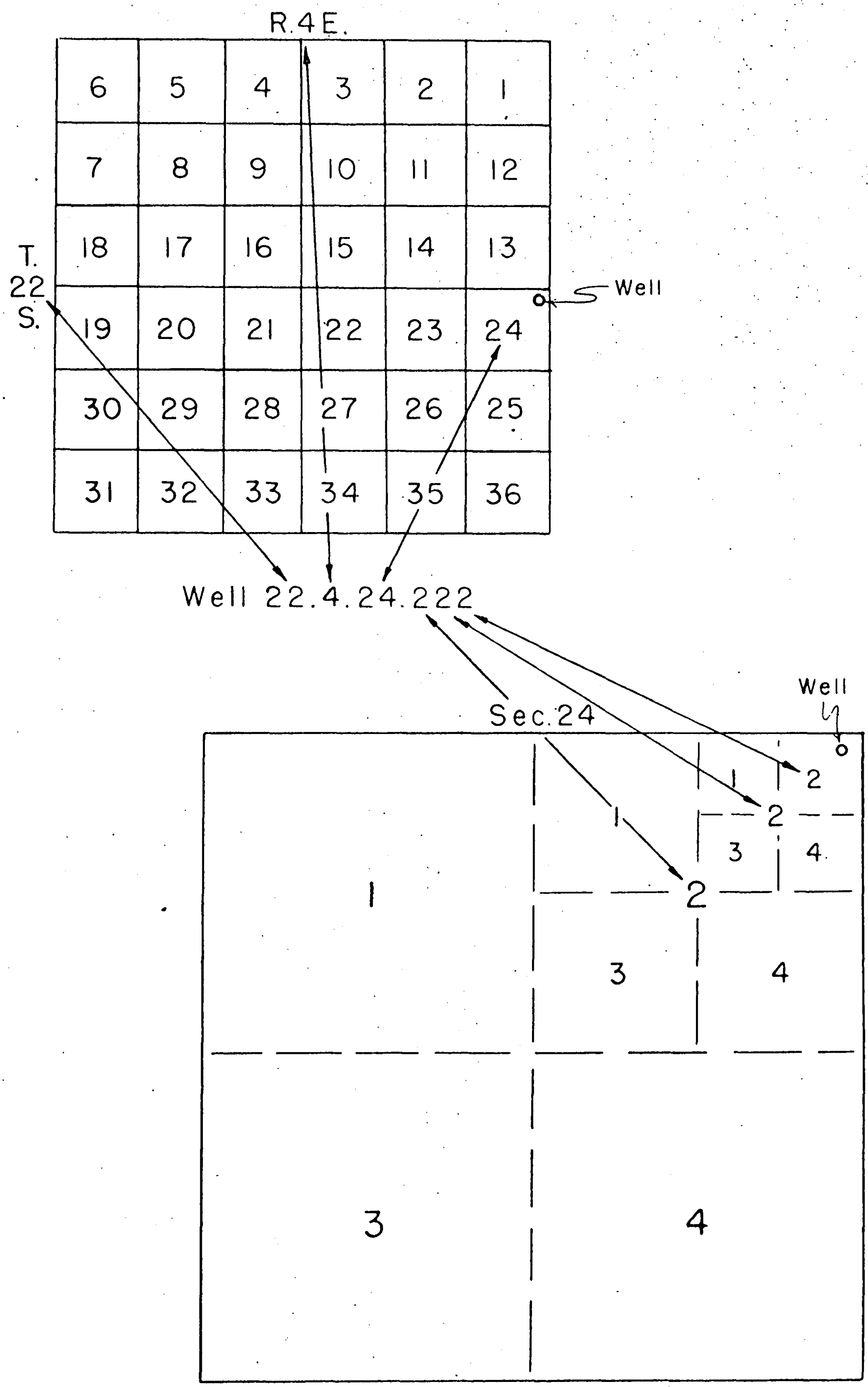

Figure 2--Plat illustrating method of numbering wells in New Mexico

PHYSIOGRAPHY AND CLIMATE

McGregor Range is at the east edge of the Tularosa-Hueco depression, an intermontane basin. The Tularosa Basin and Hueco Bolson are topographic subdivisions of the larger basin and are separated by a low divide which extends from the Franklin Mountains near the State line north-eastward toward the Jarilla Mountains at Orogrande, New Mexico. Topographically the area discussed in this memorandum is mostly in the Hueco Bolson, but is partly in the Tularosa Basin. The divide between the two topographic subdivisions is in the northwestern quarter of the area shown in plate 1. The proposed McGregor Range camp site is in the Hueco Bolson.

The area discussed herein, the Tularosa-Hueco depression, is adjoined on the east by the Hueco Mountains, a dry, barren range composed mostly of sedimentary rocks. The mountains average about 1,000 feet in height above the basin floor, but Cerro Alto, the highest peak in the range, rises 2,500 feet above the basin floor and has an altitude of 6,717 feet. The mountain range becomes lower and more rounded in appearance to the north. In the western Hueco Mountains, alluvial debris slopes steeply downward to the west, from the principal part of the mountains to the edge of the basin floor. The outlying foothills of the mountains pierce both the alluvial slope and the basin floor at the east edge of the basin.

The floor of the Tularosa Basin and Hueco Bolson is nearly flat, and slopes downward very gently toward the Franklin Mountains on the west side of the bolson. The altitude of the bolson surface ranges from about 4,350 to about 4,100 feet. In the northern part of the area shown in plate 1, the surface of the bolson is broken by numerous depressions which apparently occur in a random pattern. Elsewhere, in the central and western parts of the Hueco Bolson, the surface contains a number of asymetrical troughs which are as much as 75 feet deep and which trend northward, parallel to the trends of the mountain ranges. The surface of the bolson is covered with sand dunes from 5 to 15 feet high. Some of the dunes are moderately active and drifting, but most are stabilized by mesquite growth and many are separated by wind-swept corridors paved with clay and caliche.

Both the Tularosa Basin and the Hueco Bolson are areas of interior surface drainage. Although the Rio Grande cuts across the surface of the Hueco Bolson, surface drainage into the Rio Grande is poorly developed except near the edges of the Rio Grande flood plain. In the Tularosa-Hueco basin, all streams are ephemeral. Stream courses are developed only at the edges of the basin. Most tributary drainage basins in the Hueco Mountains are small. As a result of the small drainage areas and the low precipitation in the area the amount of runoff from individual canyons is small, and the alluvial fans at the mouths of the canyons also are small. However, one exception may have an important bearing upon ground-water conditions in the McGregor Range area. East-northeast of Davis Dome is a large alluvial fan which is at the mouth of a drainage basin having an area of about 76 square miles. The broad mouth of the canyon contains several arroyos or dry stream courses, and the size of the fan, which is a natural water-spreading ground, is several times that of other nearby fans. The size of the drainage basin above the fan indicates that relatively large amounts of water may be available for recharge to the ground water body beneath the fan.

The climate of the McGregor Range is similar to that of El Paso, Texas. At El Paso Airport, altitude 3,920 feet, the average annual precipitation is 7.83 inches, although precipitation in 1953 was only 4.42 inches. The Hueco Mountains undoubtedly receive somewhat more precipitation, owing to their greater altitude. The amount of precipitation in the vicinity of McGregor Range may be comparable to that at Orogrande, New Mexico, altitude 4,200 feet, which has an average annual precipitation of 9.60 inches. Precipitation in the general area is greatest during the summer and early fall, and occurs principally as local, intense falls of short duration from thunderstorms.

At El Paso the average annual temperature is 63.3°F. The highest average monthly temperature of 81.3°F. occurs in July and the lowest average monthly temperature of 43.4°F. occurs in January. The potential evaporation from a free water surface as represented by an evaporation pan is from 8 to 10 feet per year.

GEOLOGY

Character of the Rocks

Rocks exposed in the vicinity of the McGregor Range camp site are Pennsylvanian, Permian, and Tertiary to Recent in age. A section of rocks ranging in age from Precambrian to Pennsylvanian occurs beneath the surface. According to King (1945) both the Pennsylvanian and the Permian rocks consist of limestone, shale, marl, and conglomerate. King refers the Pennsylvanian rocks to the Magdalena limestone and separates them into three divisions: a lower division of thick-bedded, coralline limestone; a middle division of marl, shale, and some limestone; and an upper division of limestone and interbedded marl with some conglomerate and reef limestone. King refers the Permian rocks to the Hueco limestone, of Wolfcamp age, which he separates into three divisions: a lower division of a locally developed basal conglomerate (Powwow conglomerate) and an overlying thick-bedded limestone; a middle division of thin-bedded limestone and interbedded marl; and an upper division of thick-bedded limestone containing the Deer Mountain red shale member. A pronounced angular and erosional unconformity separates the Magdalena limestone from the Hueco limestone. The Permian rocks appear to be restricted largely to the area south of the State line, as erosion has removed most of the Permian rocks north of the line, near the camp site.

Mesozoic rocks are not exposed in the vicinity of McGregor Range, and it appears, on the basis of data from oil-test wells 25.7.25.444 and 25.8.23.310, that Mesozoic rocks are not present beneath the basin surface.

Of the unconsolidated rocks, those of Tertiary age are thickest and most extensive. Nearly all the bolson fill in the Tularosa Basin and Hueco Bolson probably is of Tertiary age. The fill consists of clay, silt, sand, gravel, pebbles, and boulders laid down by streams and lakes, and caliche in thin beds and disseminated grains. The source of the fill is debris eroded from the nearby mountains. Pleistocene sediments in the basin proper are probably less than 100 feet in thickness, and in many places appear to be only about 15 to 30 feet thick, based on the depth to the base of thick caliche beds which persist over most of the area and which are assumed to be Pleistocene. However, Pleistocene deposits are probably several hundred feet thick at the bases of the mountains, where they form alluvial fans or similar deposits which are some of the principal intake intake areas for recharge to the ground water stored beneath the basin. Recent sediments are but a thin veneer of sand and soil in the basin.

The bolson fill appears to be thickest near the center of the Hueco Bolson. In the central part of the basin, several miles south of Newman, an oil test is reported to have penetrated nearly 5,000 feet of fill. Another oil test in the same area, cited by Sayre and Livingston (1945), is reported to have penetrated 4,010 feet of sediments believed to be entirely bolson fill. The Ernest no. 1 oil test, well 25.7.20.444, is reported to have entered Pennsylvanian rocks at 2,130 feet. El Paso test hole T-30, well 24.7.34.144, was drilled to 1,209 feet entirely in bolson fill, but El Paso test hole T-31, well 24.8.32.344, entered limestone at about 900 feet. Well 25.8.23.310 is reported to have entered Pennsylvanian rock at 480 feet. Well 1.1.6.340 was reported by the driller on location to have entered consolidated rock at 468 feet. El Paso test hole T-8, well 26.8.32.111, did not penetrate consolidated rocks; however, a coarse-grained conglomerate was penetrated from 600 feet to the bottom of the hole at 824 feet. The conglomerate is believed to be indicative that consolidated rock was a short distance below the bottom of the hole.

Taking into account interpretations of geologic structure in the area, it appears that the bolson fill may be divided as to thickness into at least three areal units: 1) between the base of the Hueco Mountains proper and the trend of consolidated rock outcrops such as Davis Dome and the three buttes east of Alvarado, the fill is probably 400 to 600 feet thick; 2) from Davis Dome westward to approximately the west side of R. 7 E., the fill is probably from 900 to 2,200 feet thick; and 3) west of R. 7 E., the fill may exceed 2,200 feet in thickness over a considerable area.

Igneous rocks in the area consist of syenite porphyry and trachyte, which according to King (1945) are Tertiary (?) in age. A number of stocks, laccoliths, and sills cut and distort the upper Paleozoic rocks in the Hueco Mountains near the State line.

Water-Bearing Characteristics of the Rocks

Throughout most of the Hueco Mountains, there are few wells and springs and it is believed that the consolidated sedimentary rocks are essentially impermeable. However, along the east edge of the Hueco Bolson, in the vicinity of the McGregor Range camp site, some evidence shows that the limestones beneath the bolson fill are porous and can yield water. Well 25.8.23.310, which is reported to have entered Pennsylvanian rock at 130 feet, is reported to have entered a very porous zone at 610 feet. The zone was reported to be so porous as to interfere with cementing operations. Well 25.8.32.220, a well formerly used for watering stock, is reported to be 785 feet deep and therefore probably penetrated water-bearing consolidated rocks. Unused well 25.8.1.220 is 775 feet deep and therefore is probably similar to well 25.8.32.220. However, no specific data are available concerning yields of these wells.

The bolson fill is treated herein as a unit with regard to water-bearing characteristics. Throughout most of the Hueco Bolson and unconsolidated fill contains a large amount of sand and gravel. The most permeable sections are along the bases of the Organ and Franklin Mountains. The amount of sand is less near the Hueco Mountains; moreover, the grain-size diminishes markedly with distance from the mountains toward the center of the bolson. However, on the basis of sample and drillers' logs of wells and test holes, throughout the area already explored the amount of sand or predominantly sand-bearing beds is not less than 40 percent of the fill penetrated by the bit, with one notable exception. In the area north and east of Alvarado siding on the Southern Pacific Railroad, virtually all the fill was clay, as shown in the logs of wells 24.7.34.100 and 24.8.32.344. In general, reasonably large quantities of ground water can be obtained from the bolson fill; and the chief problem is whether the quality will be acceptable.

Igneous rocks in the McGregor Range area are impermeable for the most part and therefore yield no water. The presence of igneous rock in the area may account for the reports of hot water from several wells.

Structure

The Tularosa Basin and Hueco Bolson are essentially parts of the same large trough-shaped depression, in which the bedrock formations beneath the basin floor have been faulted down relative to the adjacent mountains. The relative movement was accomplished by large-scale faulting, as along the base of the Franklin and Organ Mountains, and probably along the west edge of the Hueco Mountains. In this overall structural pattern, however there are many complex details.

According to King (1945), the principal structural feature in the Hueco Mountains is an arch; the axis of the arch is somewhat west of the present crest of the range, and trends northward. Most of the visible faults cutting consolidated rocks in the western Hueco Mountains are minor, and King believes that they are comparatively recent in age. In the mountains a number of domes are superimposed on the arch. The abundance of igneous stocks in the area, and an inferred laccolith to the east, suggest that domes which have not been unroofed by erosion are probably underlain by laccolithic intrusions. Inasmuch as no major faults were mapped by King in the Hueco Mountains near the State line, it is inferred that, if a major fault exists in the area, it is probably west of the westernmost outliers of the mountains and is concealed by bolson fill. At well 26.8.32.111 and in another test hole approximately 12½ miles south, consolidated rock is 900 to 1,000 feet below the surface of the fill. Both holes were about 2 miles west of the mountains. Although the difference in altitude of the consolidated rock beneath the test hole locations and in the mountains may be due to erosion, in view of structural conditions existing elsewhere in the Tularosa-Hueco depression, it is more likely that the difference is due to faulting.

During early Pleistocene time (Sayre and Livingston, 1945), additional movement along older fault planes, developed in Tertiary time, produced the gentle westward tilt of the bolson surface. In addition, it appears that the bolson fill was faulted not only along the west side but also out in the bolson proper. Sayre and Livingston called attention to the several north-trending asymmetrical troughs in the bolson surface. These troughs are of moderate depth and are closed and thus were not produced by erosion by water. Wind erosion is not the probable cause, because large amounts of windblown materials are not found downwind from the depressions, and the troughs are not oriented with the prevailing winds. From the shapes of the troughs, their orientation with regional structural trends, and the fact that the steeper sides are not all on the same side, east or west, it is inferred that the troughs are the surface reflection of faulting. It is believed that the troughs are instrumental in providing part of the recharge to ground water stored in the bolson fill (see p. 81.). Examples of the troughs are shown on plate 1, in the vicinity of Newman; also, one of special interest extends northwestward along the east side of Davis Dome. The latter trough may be instrumental in recharge of ground water in the vicinity of the proposed McGregor Range camp site.

HYDROLOGY

Occurrence of Ground Water

For purposes of discussion the McGregor Range area is divided into two parts, one encompassing most of the area underlain by the bolson fill, and the other, farther east, including the outlying foothills and extending to the main mass of the Hueco Mountains. The latter area includes the three buttes east of Alvarado, Davis dome, and the vicinity of Nation's Hot Well (26.[illegible].33.120a).

In the western area, underlain by thick sections of bolson fill, ground water occurs generally under water-table conditions. Transient artesian conditions, noted in pumping tests of several wells in the Hueco Bolson, are attributed to clay lenses of limited extent in the aquifer. In the McGregor Range the water table in the fill slopes generally southward at a rate of about 4 feet per mile. Depths to water in the area range from about 270 feet below the land surface at Hueco Camp to about 365 feet below the land surface in well 1.78.18.130. The differences in depth to water are due mainly to the general eastward rise of the basin surface, at an average gradient of about 5 feet per mile.

In the eastern area, adjacent to the Hueco Mountains, ground-water conditions are not so well known. However, on the basis of data from several wells and inferences drawn from the geologic structure in the area, the following conditions appear to exist. East of Davis Dome and Nation's Hot Well (26.8.33.120a) consolidated rocks are known to underlie the bolson fill at depths of 400 to 600 feet. Most water wells in the area have been drilled to depths of 700 to 800 feet, as contrasted to depths of 400 to 450 feet for wells drilled in the bolson fill farther west. It is inferred that in the area where consolidated rock lies at these relatively shallow depths, the principal aquifers are the limestones underlying the fill. The water table in the limestone appears to be nearly level. In plate 2 it can be seen that, in wells 25.8.1.220 and 26.8.33.120a, the altitude of the water table differs by only 4 feet over a distance of 12 miles. The nearly level water table indicates either that the cavernous limestones in the area are much more permeable than the fill, or that not much water is moving through the limestone; the latter possibility would seem to call for the presence of a barrier of low permeability between the limestone and the permeable bolson fill to the west. Some evidence of high permeability of the limestone aquifer may be afforded by the rather abrupt drop in the altitude of the water table from the bolson fill eastward into the limestone area. In wells 26.7.35.230, 26.8.32.111, and 26.8.33.120, the altitudes of the water table are 3,712; 3,647; and 3,639 feet respectively, indicating a rather steep downward slope eastward toward the Hueco Mountains. On the basis of unpublished data obtained by the Geological Survey in Texas this same sort of east-west change in water level appears to prevail for a north-south distance of 30 miles or more along the west face of the Hueco Mountains in both New Mexico and Texas. The apparent water-table slope from the bolson fill to the limestone area indicates, on the assumption that no impermeable barrier is present, that water in the bolson fill is discharging into the limestone. The permeability of the limestone doubtless is due to solution by ground water in an area where the rocks have been distorted and jointed by arching and doming, and shattered by faulting. The ultimate destination of water moving through the limestone is not known, but it is believed that the water is probably discharged southward into the fill again, and eventually into the Rio Grande in Texas some distance to the south of the McGregor Range area.

In the west edge of the Hueco Mountains where the limestone is water-bearing and at the east edge of the basin floor where water levels in the bolson fill, are relatively deep it is inferred that a perched water table may be present in the fill. This inference is drawn from the occurrence of such a condition in the shallow well (26.8.33.120) near Nation's Hot Well (26.8.33.120a). Although El Paso test hole T-8 (26.8.32.111) and Nation's Hot Well have water levels about 450 feet below land surface, the depth to water in the shallow well is only 162 feet below land surface. The bottom of the shallow well is 300 feet below land surface, or about 150 feet above the apparent regional water table. The electric log of El Paso test hole T-8 indicates that the perched water may have been encountered in the test hole, but not detected owing to the hydraulic-rotary method of drilling used. The perched water, as pumped from well 26.8.33.120, is of considerably better quality than water from the deeper aquifer, and should be taken into consideration as a possible producing zone.

Recharge and Discharge of Ground Water

Water in the bolson fill was derived from several sources. The bolson-fill aquifer in the Tularosa Basin appears to be continuous with that in the Hueco Bolson. Ground water in the Tularosa Basin not discharged by evaporation and transpiration within that basin, or by movement into limestones to the east, moves southward into the Hueco Bolson. It is believed that, owing to the fine grain of most of the bolson-fill sediments, the amount of ground water moving from the Tularosa Basin to the Hueco Bolson is not great. Precipitation in most of the adjacent mountains and subsequent runoff, yield appreciable quantities of recharge to the Hueco Bolson, particularly from the Organ and Franklin Mountains. In addition to the above sources of water, it is believed that a significant part of the potable water in the McGregor Range area is the result of local precipitation directly on the bolson surface. Although the surficial dunes readily absorb and transmit the water downward, the movement is stopped or impeded in most places by persistent beds of caliche beneath the dunes. However, where the caliche has been fractured by faulting, or where solution pipes (Sayre and Livingston, 1945, pl. 3) have been developed, water can pass through the caliche and move downward to the water table. Recharge to ground water from local precipitation is probably greatest in the vicinity of the trough-shaped depressions and the small sinks in the basin surface. It is not known whether precipitation and subsequent runoff in the Hueco Mountains contributes materially to recharge to the bolson-fill aquifer, because it is possible that most of the recharge water from that source may enter the limestone aquifer directly.

Ground water in the bolson fill is discharged directly into the flood-plain deposits of the Rio Grande and, it is believed, into the limestones along the west edge of the Hueco Mountains.

The mechanism of recharge to and discharge from the limestone aquifer has been discussed above. It appears that, in addition to recharge from the fill, the limestone aquifer may receive some recharge from precipitation in the Hueco Mountains. The relative amounts of recharge from the bolson fill and from precipitation in the Hueco Mountains are not known, but it is believed that the large fan east of Davis Dome may absorb and transmit appreciable quantities of water to the ground-water body in that area.

Availability of Ground Water

In the Hueco Bolson, most water wells now in use are outside the Fort Bliss ranges, between the State line and El Paso. Nearly all the large-capacity wells are in areas where relatively large amounts of potable water are available. Within the area shown on plate 1, the yields of only three wells are known. Two of the wells are at Hueco Camp; of these, Hueco Camp well 2 is reported to have yielded 100 gallons per minute with a draw-down of 11 feet, indicating a specific capacity of about 9 gpm per foot of drawdown. Hueco Camp well 3 is reported to have had a drawdown of 35 feet while pumping 250 gallons per minute, indicating a specific capacity of about 7 gpm per foot of drawdown. The third well is the "Alvarado Well" (25.7.16.122) which is equipped with a cylinder pump and pump jack. The well has been pumped at an estimated rate of about 15 gpm. Most of the remaining wells in the area are unused stock wells or test holes, and no data on yields or aquifer hydraulic characteristics are available.

Wells yielding 100 gpm or more probably can be constructed almost anywhere in the McGregor Range with the probable exception of the area east and northeast of Alvarado. In the latter area, it appears that nearly all the bolson fill is clay and is, therefore, relatively impermeable. With respect to potable water, the practical rate of pumping from a well would depend on the thickness of the zone of potable water, the permeability of the sediments, and the degree of isolation of the potable water from the saline water that underlies or is adjacent to potable water almost everywhere in the Tularosa-Hueco basin.

CHEMICAL QUALITY OF GROUND WATER

Ground waters in the Tularosa-Hueco depression range from potable waters, containing only small quantities of dissolved minerals, to brines. The largest supplies of potable water are along the bases of the Organ and Franklin Mountains, where sediments in both the intake area and the aquifer are very permeable and relatively insoluble. Throughout the Hueco Bolson, potable waters are underlain by saline waters. The zone containing potable water is thickest near the Franklin Mountains and becomes thinner toward the east and northeast. In the immediate vicinity of McGregor Range, the thickness of the potable-water zone appears to range from less than 50 feet to 200 feet, but the exact thickness is difficult to ascertain, owing to the lack of adequate data concerning quality of water in the zone immediately below the water table.

Chemical analyses of water from wells and test holes in the McGregor Range area are given in table 6. Of the 15 different locations shown in the table, 9 were of exploratory test wells, in which water samples were taken from specific zones isolated from the hole above by means of a packer sealed against the wall of the hole. The water samples were obtained by air-lift pumping through the packer and supporting drill stem, which extended to the surface. Air-lift pumping requires that the apparatus extend some distance beneath the water level in order to function, and therefore the shallowest part of the aquifer could not be sampled. Of the 9 test holes, 3 were cased to be used as observation wells, and samples were bailed from these. Samples from the remaining 6 locations listed in the table were pumped from existing wells.

Study of the chemical analyses of ground water obtained by drill-stem test reveals that, in the Hueco bolson westward from the vicinity of Newman, the increase in salinity of ground water is mainly due to an increase of chloride, sodium, and potassium. The concentrations of most other chemical constituents remain at a relatively low level. Eastward from the vicinity of Newman chloride and sulfate concentrations in the shallower parts of the aquifer are more nearly equal and increases in salinity represent increases in both sulfate and chloride. Analyses of drill-stem samples from well 25.7.32.122 show that the two types of water interfinger in the center of the bolson. However, analyses of samples from the deeper strata in the eastern part of the bolson are similar in relative concentration of constituents to the analyses of samples from the western part of the bolson.

Potable water as used in this memorandum is defined as water containing 1,000 ppm or less of dissolved solids or having a specific conductance of 1,400 micromhos or less at 25°C, and usually containing no more than 250 ppm each of chloride and sulfate. The following table gives the estimated thickness of the potable-water zone in several wells and test holes shown on plate 1. The estimates are based not only on the chemical analyses of water samples, water levels in the wells, and depths of wells, but also on electric logs of the test holes, which are not included in this memorandum. It should be noted that the thicknesses shown do not represent water-bearing material only, but the entire saturated sections.

Table 1.--Estimated thickness of potable-water zone in wells and test holes in vicinity of McGregor Range.

Well number	Known thickness (feet)	Probable maximum thickness (feet)
25.6.20.334a	-	100
25.6.34.111	-	70
25.7.16.122	-	70
26.6.34.130	49	-
26.7.32.120	-	40
26.7.35.230	36	-
26.8.32.111	-	30
26.8.33.120	138*	-
1.80.1.111	49	130
1.80.4.222	-	60
1.80.24.333	241	-

* Perched water

Although water of fair quality may be found in some wells below the zones shown in table 1, the mineralization of the ground water usually increases rapidly with depth. Data shown in the table imply that a well drilled at the site of the South McGregor Range camp site will penetrate a potable-water zone about 50 feet or less in thickness.

No recorded data regarding the limestone aquifer east of the camp site are available. However, if the limestone receives water from the bolson fill, as seems probable, the water in the limestone should be similar to that in the fill - saline in most places. If there is potable water anywhere in the limestone aquifer, the source is most probably recharge from precipitation and runoff in the Hueco Mountains. Any potable water present in the limestone aquifer probably floats upon saline water, and the largest quantities of potable water are probably stored near the largest sources of recharge, ie. the largest canyons.

DEVELOPMENT OF GROUND-WATER SUPPLIES

Requirements

According to the Corps of Engineers, the South McGregor Range camp will house about 1,000 persons. Temporary water-storage facilities will be installed at the camp for use during the first phase of construction. However, the camp ultimately will have a permanent elevated storage tank of 45,000-gallon capacity.

The Corps of Engineers has stated that the desired amount of potable water for drinking, cooking, sanitary purposes, and air conditioning is 70 gallons per day per capita, or about 70,000 gallons per day for 1,000 persons. The amount of potable water available to the camp should be not less than 10,000 gpd. The desired amount of potable water, 70,000 gallons per day, could be supplied by a well yielding 146 gallons per minute for 8 hours or 73 gallons per minute for 16 hours.

In addition to water required for domestic purposes, some water will be required for ordinary fire protection, and for safety showers and other protection in connection with the operation of the range. Safety showers and other range operations are considered to be standby needs and probably will not require much water on the average. Water requirements for fire protection are stated to be the combined flow from 12 hoses, each 2½ inches in diameter, at a minimum pressure of 50 psi, for 45 seconds. It is assumed herein that the pressure of 50 psi is at the hydrant. According to a pump-company manual, 100 feet of rubber-lined fire hose, with a hydrant pressure of 50 psi, will discharge 116 gpm through a ¾-inch nozzle, 186 gpm through a 1-inch nozzle, and about 300 gpm through a 1-3/8-inch nozzle. If it is assumed that 1-inch nozzles are used, 12 hoses of the given size will discharge about 1,675 gallons in 45 seconds. This is a small fraction of the proposed 45,000-gallon storage facility, and can be drawn from the potable-water system without seriously depleting the supply.

If potable water must be hauled to the camp site, saline water may be used for firefighting and safety showers.

Existing Supplies

There are no existing water supplies of suitable quality in the McGregor Range. The nearest troop-supply well is at Hueco Camp, about 12 miles distant by road. The nearest municipal source of potable water is at El Paso, more than 25 miles distant by road. The nearest privately owned source of potable water is at Newman, about 12 miles distant by road.

Exploratory Drilling in the Area

On the basis of data given in preceding sections, the following ground-water conditions are believed to exist in the McGregor Range area. At the west side of the area, in the vicinity of Hueco Camp and Newman, the potable-water zone is relatively thick, 50 to 100 feet, and supplies of 50 to 100 gpm per well may be obtained. In the southern and central parts of McGregor Range, in the vicinity of the South McGregor Range camp site, west of Davis Dome, relatively large amounts of highly mineralized water can be obtained from wells, but the potable-water zone is thin or absent. In the eastern part of McGregor Range, between Davis Dome and the main part of the Hueco Mountains, most of the ground water may be in a limestone aquifer. The quality of water in the limestone is unknown. In this latter area and at the east edge of the area, described previously it is possible that adequate supplies of potable water might be developed in a perched zone, above the regional water table. To test these conclusions, the following program of exploratory drilling is proposed.

Proposed test hole locations are shown on plate 1, and are numbered T-1 through T-5, in the suggested order of drilling. However, test holes T-3 and T-4 should be considered as alternate locations, one location or the other to be chosen as a result of the findings at location T-2. Test hole T-1 is intended to determine whether a perched-water zone is present and to determine the thickness of the potable-water zone, if any, in the regional saturated section. Test holes T-2, T-3, and T-4 are intended to determine whether a perched-water zone is present above the limestone aquifer, and to determine the quantity and quality of water available from the limestone aquifer. Test hole T-5 is intended to determine whether the relatively thick potable-water zone at Newman extends northward. Test hole locations T-2a and T-3a are given as alternate locations, should locations of firing points on the new range facilities imperil a possible production well at the locations of T-2 and T-3.

Test holes should be drilled by the cable-tool method. The use of a cable-tool drilling rig will permit the obtaining of water samples quickly and easily at specific intervals, the determination of the exact depth at which water is encountered (this is especially important in the detection of a perched water body), and drilling in porous limestone, if encountered.

The diameter of the test holes should be adequate to accommodate casing of a size that will permit the completion of a test hole as a production well, if such completion is desired. It is suggested that provision be made for at least two sizes of casing, because in drilling by the cable-tool method it frequently becomes impossible to drive casing, and it is then necessary either to reduce the size of the hole or to use an under-reamer. Casing will be necessary because, in the use of the cable-tool method, the walls of the hole must be supported.

The following depths of test holes are suggested: T-1 and T-5, 500 feet; T-2 and T-3, 800 feet; and T-4, 850 feet. It is believed that, at the locations of T-1 and T-5, a normal section of bolson fill will be encountered, and that the stated depths will permit testing the thickness of any potable-water zone that may be present. At the locations of T-2, T-3, and T-4, the stated depths will permit the testing of any possible perched-water zone and an adequate section of the consolidated rocks. It is estimated that consolidated rocks underlie the fill at depths of about 500 feet at T-2 and T-3, and at about 550 feet at T-4.

It is suggested that 10-inch blank casing be run to the top of consolidated rock or to the water table. If the hole is started with 10-inch casing, the hole into consolidated rock or the saturated section of fill should be of a size adequate to accommodate 8-inch screen. It is suggested that the 8-inch screen be suspended from 3-inch casing extending to the land surface, to permit easy handling when running screen behind the bit.

In order to determine the location of the interface between saline and potable water, it is suggested that, after the water table has been reached, water samples be bailed from the test hole after each 10 feet is drilled. The relatively small sampling interval will permit the immediate detection of saline waters when they are encountered and the planning for plugging part of the well if necessary.

Special consideration should be given in the proposed drilling program to provide for plugging back the hole if saline water is encountered, and the stopping of drilling: 1) if igneous rock is encountered; 2) if highly saline water is encountered; and 3) if on the basis of drill cuttings and bailing of the test hole, it is believed that sufficient permeable material has been penetrated to yield the desired quantity of water. Although it is not probable, it is possible that igneous rock will be encountered. Some igneous rock is exposed in the area, and a driller reported that igneous rock was encountered at 650 feet in well 25.8.23.340. If highly saline water is encountered, the test hole should be plugged back to about 10 feet above the depth at which such water was first encountered, for it is very unlikely that potable-water sands will be encountered beneath the saline-water-bearing zone.

The following data should be obtained from each test hole:

(1) Driller's log and drilling-time log, showing the depth, thickness, color, and character of each stratum penetrated, and the time required to penetrate each stratum. Individual intervals logged should not exceed 5 feet in thickness.

(2) Drill-cutting samples from intervals of 5 feet, or less if beds of lesser thickness can be detected. If consolidated rock is encountered, each stratum should be sampled, irrespective of thickness, but at intervals not to exceed 5 feet. The samples should be taken from the bailer and should be composites of the entire interval, but not of a single point within the sampling zone. Samples should be sacked and labeled with the test-hole number and the depth range of the zone represented by the sample.

(3) Driller's record of casing and screen placed in the test hole.

(4) Driller's record of development procedure.

(5) Driller's record of measurements obtained while test pumping the hole.

The driller's log should contain a record of:

(1) the depth at which water was first encountered,

(2) the depth to which the water rose when first encountered, and

(3) any subsequent changes in depth to water during drilling.

When the well has been completed, or when it is believed that enough permeable material has been penetrated to yield the desired quantity of water, the screen should be run to the bottom of the hole. The screened zones should then be developed and subsequently test pumped. Development should consist of:

(1) surging with a surge block and subsequently bailing out the materials passed through the screen, surging to be continued until the amount of material removed by the bailer measurably diminishes;

(2) treatment with development chemicals of the sodium hexametaphosphate type in the case of wells screened in bolson fill, the chemicals to be mixed thoroughly in the well and allowed to remain for a period of about 8 hours, during which the test pump can be installed;

(3) surging and pumping with the test pump for a period of about 8 hours, or until the sand content of the pumped water declines to a satisfactory amount.

After development is completed, the water level in the well should be allowed to recover for at least 8 hours before the test pumping period begins. Test pumping should consist of at least 12 hours of pumping at various rates - for example, a 3-step pumping test consisting of three 4-hour steps at rates of 50, 100, and 150 gpm. A preliminary determination of the maximum yield of the well should be made during the third period of development. If the anticipated maximum yield of the well should be less than 150 gpm, the rate of pumping during each step should be smaller. If upon completion of development the well yields 50 gpm or less, the tested zone may be deemed an inadequate source, in which case the well should be deepened, or the rig moved to the next location. The test pumping period should be followed by at least 8 hours of water-level measurements to determine the rate of recovery. The test pump used should be one that can pump 150 gpm from a depth of 700 feet, in order to test holes in an area where the depth to water is great and drawdowns large.

SUMMARY

The South McGregor Range camp site is on the east side of the Tularosa-Hueco depression, a bolson or structural trough filled with clay, sand, and gravel. Most of the bolson fill is of Tertiary age and has been slightly deformed by tilting and faulting. In the eastern part of the McGregor Range area the Hueco Mountains rise above the bolson floor; they contain rocks of Pennsylvanian, Permian, and Tertiary(?) age. Structural features of the mountains include arching and minor doming of the consolidated rocks, and faulting of minor proportions. Major faulting has occurred along the edges of and in the bolson near the Hueco Mountains. Structural conditions in the McGregor Range area have produced at least two types of ground-water occurrence, and have some influence on the recharge to ground water stored in the area.

In the main part of the bolson, the fill ranges in known thickness from about 1,000 to more than 4,000 feet. The fill contains ground water under essentially water-table conditions. The water table slopes generally southward at a rate of about 4 feet per mile. Logs of test holes in the area indicate that 40 percent or more of the fill is sand, or beds composed principally of sand. The amount of sand indicates that properly constructed wells in the fill should produce 100 gpm or more. In the vicinity of the McGregor Range camp site only a relatively thin zone at the top of the saturated fill is believed to contain potable water. Water in the bolson fill receives recharge from rainfall both in the mountains and locally on the bolson surface. Water in the fill discharges into the Rio Grande, but apparently a part first discharges into the adjacent limestone aquifer on the east.

Along the west base of the Hueco Mountains, the bolson fill appears to be 400 to 600 feet thick. Limestone underlying the fill appears to have become cavernous as a result of circulation of ground water through rocks distorted by faulting and arching. The water table is in the limestone aquifer and is lower in altitude than the water table in the adjacent bolson fill to the west. The water table in the limestone is nearly level, sloping gently southward. Information on the quantity or quality of ground water from the limestone aquifer is meager.

A saturated zone perched above the regional zone of saturation may exist in the area along the east edge of the bolson fill and the west edge of the limestone aquifer. On the basis of an analysis of water from one well, the water in the perched zone is believed of good chemical quality.

In order to develop a supply of potable ground water for the South McGregor Range Camp, the proposed locations shown on plate 1 have been selected to test potable-water sections in the bolson fill at the camp site, in a possible perched-water zone and in the limestone aquifer east of the camp site, and in the Newman area. Data from the test holes can provide the basis not only for constructing wells to provide the immediate requirements of the camp but also for the construction of any necessary pipeline, and for wells to provide for possible future increase of requirements.

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Table 2.--Records of wells and test holes in the vicinity of McGregor Range, Otero County, New Mexico, and El Paso County, Texas

Location number	Owner	Driller	Date drilled	Depth of well (feet)	Diameter of well (inches)	Altitude of land surface (feet) 1/
		Otero County, N. Mex.				
23.6.35.100	U. S. Government	B. and W. Drilling Co.	1953	650	-	4,080.7
24.7.34.144	do.	do.	1953	1,209	-	4,070.5
24.8.1.233	-	-	Old	410	-	4,220E
24.8.32.344	State of New Mexico	B. and W. Drilling Co.	1953	945	-	4,080E
25.6.4.110	U. S. Government	do.	1953	1,208	-	4,060E
25.6.20.334	do.	Layne-Texas Co.	1943	439	10,8,4	-
25.6.20.334a	do.	do.	1944	440	12,10	4,029.4
25.6.34.111	do.	B. and W. Drilling Co.	1953	737	-	3,998.7

Table 2.--Records of wells and test holes in the vicinity of McGregor Range, Otero County, N. Mex., and El Paso County, Tex. - Continued

Location number	Water level: Below land surface (feet) 2/	Water level: Date of measurement	Method of lift 3/	Use of water 3/	Remarks
					Otero County, New Mexico - Continued
23.6.35.100	287.5	Mar.29, 1953	N	N	El Paso test hole T-22. Analyses of two drill stem tests given in table 6. See sample log.
24.7.34.144	312.7	July 14,1953	N	N	El Paso test hole T-30. Analysis of one drill stem test given in table 6. See sample log.
24.8.1.233	365R	-	C,W	N	Known as both Mott well and as South well.
?24.8.32.344?, 25.18.6.200	-	-	N	N	El Paso test hole T-31. No water encountered in (N-1) hole. Limestone at about 900 ft. See sample log.
25.5.4.110	300.0	1953	N	N	El Paso test hole T-28. Analysis of one drill stem test given in table 6. See sample log.
25.6.20.334	300R	1943	T,G	TS	Hueco Camp well 2. Casing: 10-inch blank to 333 ft; 8-inch perforated from 333 to 355 ft: 4-inch perforated from 355 to 436 ft. Reported drawdown in 1945 11 ft. while pumping 100 gpm. Gravel-walled well.
25.6.20.334a	293.02	Mar. 10, 1954	T,G	TS	Hueco Camp well 3. Casing: steel 10-inch blank to 320 ft.,12-inch blank from 320 to 401 ft; 12-inch Armco no. [illegible] shutter screen from 401 to 440 feet. Reported drawdown in 1944 35 feet while pumping 250 gpm. Gravel-walled well. Pump set at 400 ft.
25.6.34.111	270.0	Apr.17, 1953	N	N	El Paso test hole T-36. Analyses of six drill stem tests given in table 6. See sample log.

Table 2.--Records of wells and test holes in the vicinity of McGregor Range, Otero County, N. Mex., and El Paso County, Tex. - Continued

Location number	Owner	Driller	Date drilled	Depth of well (feet)	Diameter of well (inches)	Altitude of land surface (feet) 1/
		Otero County, N. Mex. - Continued				
25.7.16.122	State of New Mexico	-	-	441	8	4,101.4
25.7.20.444	-	-	Old	-	-	4,098E
25.7.24.410	State of New Mexico	-	Old	404	6	4,115E
25.8.1.220	do.	-	Old	775	-	4,150E
25.8.23.310	do.	Al Parker	-	1,000	8	4,205E
25.8.23.340	do.	do.	-	700	-	4,220E
25.8.32.220	do.	-	Old	785	-	4,100E
25.8.34.410	-	B. and W. Drilling Co.	1953	100-	-	4,195E
25.9.30.340	State of New Mexico	-	-	210+	12,8	4,405E
26.6.23.113	-	-	-	-	-	3,970.5
26.6.34.130	Southern Pacific Lines	-	1902	332	6	-
26.6.34.130a	do.	-	1917	400	18	3,998.2
26.7.22.122	C. J. Mapel	-	1930	450	-	4,072E

Table 2.--Records of wells and test holes in the vicinity of McGregor Range, Otero County, N. Mex., and El Paso County, Tex. - Continued

Location number	Water level		Method of lift 3/	Use of water 3/	Remarks
	Below land surface (feet) 2/	Date of measurement			
	Otero County, New Mexico - Continued				
25.7.16.122	355.45 354.79	July 6, 1953 Mar. 23, 1954	C,G	TS	"Alvarado well." Drilled to 900 feet (?). Estimated yield: 15 gpm.
25.7.20.444	-	-	N	N	Ernest No. 1. Ernest Oil test. Reported to have entered Pennsylvanian rock at 2,130 feet.
25.7.24.410	-	-	N	N	Unused stock well.
25.8.1.220	506.70	Jan.12,1956	C,N	N	Unused stock well. "Borrego tank well."
25.8.23.310	-	-	N	N	Oil test. Driller reports well entered Pennsylvanian rock at 480 feet. Very porous limestone at 510 feet.
25.8.23.340	-	-	N	N	Oil test. Driller reports igneous rock encountered at 650 feet.
25.8.32.220	-	-	N	N	"Pit tank well." Found in January 1956 to be filled to 151 feet below land surface.
25.8.34.410	-	-	N	N	El Paso test hole T-38. Hole abandoned at less than 100 feet owing to loss of circulation, and caving.
25.9.30.340	-	-	N	N	Well appears to be an old oil test. Double casing at land surface in pit which may be old drilling "cellar". Hole dry and caved at 210 feet, January 1956.
26.6.23.113	-	-	C,W	S	
26.6.34.130	-	-	C,G	RR	Well 141 in Water Supply Paper 919.
26.6.34.130a	283.27 283.4	July 11,1938 Jan. 7, 1954	C,G	RR	Well 140 in Water Supply Paper 919. See log.
26.7.22.122	325.59	June 23,1937	C,N	N	Well 152 in Water Supply Paper 919. Unused stock and domestic well.

Table 2.--Records of wells and test holes in the vicinity of McGregor Range, Otero County, N. Mex., and El Paso County, Tex. - Continued

Location number	Owner	Driller	Date drilled	Depth of well (feet)	Diameter of well (inches)	Altitude of land surface (feet) 1/
		Otero County, N. Mex. - Continued				
26.7.32.122	State of New Mexico	B. and W. Drilling Co.	1953	435	3	4,061.2
26.7.35.230	do.	-	Old	400	5	4,077E
26.8.8.133	do.	-	Old	450	8	4,102E
26.8.32.111	-	B. and W. Drilling Co.	1953	824	-	4,094.6
26.8.33.120	Navar Bros.	-	Old	300	-	4,095.3
26.8.33.120a	do.	-	Old	-	-	4,095.3
		El Paso County, Texas				
1.1.6.340	Navar Bros.	Payne and Ballard	1956	514+	8	4,175E
1.1.6.430	do.	-	1952	500+	6	4,180E
1.78.18.130	-	-	-	-	-	4,073.4
1.79.16.340	-	-	-	-	-	4,043.3
1.80.1.111	U. S. Government	B. and W. Drilling Co.	1953	801	-	3,994.7

Table 2.--Records of wells and test holes in the vicinity of McGregor Range, Otero County, N. Mex., and El Paso County, Tex. - Continued

Location number	Water level: Below land surface (feet) 2/	Water level: Date of measurement	Method of lift 3/	Use of water 3/	Remarks
					Otero County, New Mexico - Continued
26.7.32.122	347.92	Jan. 6, 1954	N	N	El Paso test hole T-6. Drilled to 1,200 feet. Casing: 3-inch to 435 feet, perforated from 425 to 435 feet. Analyses of four drill stem tests given in table 6. Well completed for use as observation well. See sample log.
26.7.35.230	363.70	July 19, 1938	N	N	"Joint well." Unused stock well. Well 153 in Water Supply Paper 919.
26.8.8.133	-	-	N	N	"Hot well". Unused stock well.
26.8.32.111	447.3	June 21, 1953	N	N	El Paso test hole T-8. Analyses of two drill stem tests given in table 6. See sample log.
26.8.33.120	162.0	Apr. 9, 1954	C,W	S	Well 154 in Water Supply Paper 919.
26.8.33.120a	452.90	July 19, 1938	N	N	"Nation's Hot Well." Well 154a in Water Supply Paper 919. Water from this well is reported to be hot and highly mineralized.
					El Paso County, Texas
1.1.6.340	-	-	-	-	Well visited while drilling in progress. Projected depth 600 feet. See partial log.
1.1.6.430	500+	1952	N	N	Well found in January 1956 to be filled.
1.78.18.130	365.95	Apr. 14, 1954	N	N	"New Joint well". Unused stock well.
1.79.16.340	337.54	Apr. 14, 1954	N	N	"Camel well." Unused stock well.
1.80.1.111	270.0	Mar. 21, 1953	N	N	El Paso test hole T-4. Analyses of two drill stem tests given in table 6.

Table 2.--Records of wells and test holes in the vicinity of McGregor Range, Otero County, N. Mex., and El Paso County, Tex. - Continued

Location number	Owner	Driller	Date drilled	Depth of well (feet)	Diameter of well (inches)	Altitude of land surface (feet) 1/
		El Paso County, Tex. - Continued				
1.80.4.222	-	B. and W. Drilling Co.	1953	520	3	4,045E
1.80.23.444	U. S. Government	-	Old	-	-	3,975.1
1.80.24.333	do.	B. and W. Drilling Co.	1953	450	3	3,973.1

Table 2.--Records of wells and test holes in the vicinity of McGregor Range, Otero County, N. Mex., and El Paso County, Tex. - Continued

Location number	Water level: Below land surface (feet) 2/	Water level: Date of measurement	Method of lift 3/	Use of water 3/	Remarks
		El Paso County, Texas - Continued			
1.80.4.222	334.0	1953	N	N	El Paso test hole T-3. Drilled to 825 feet. Casing: 3-inch to 520 feet, perforated from 500 to 520 feet. Analyses of five drill stem tests given in table 6. Well completed for use as observation well.
1.80.23.444	268.22 268.9	July 6,1937 Jan. 6,1954	N	N	"McElroy Cow Camp well." Drilled as oil test. Unused stock well. Well 138 in Water Supply Paper 919.
1.80.24.333	266.81	Jan. 6,1954	N	N	El Paso test hole T-11a. Drilled to 1,005 feet. Casing: 3-inch to 450 feet, perforated from 430 to 450 feet. Analyses of four drill stem tests given in table 6. Well completed for use as observation well.

1/ E - estimated from topographic maps, otherwise by instrumental leveling.

2/ R - reported, otherwise measured.

3/ Abbreviations:

C - Cylinder pump
G - Gasoline
N - None
RR - Railroad
S - Stock
T - Turbine pump
TS - Troop supply
W - Windmill

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, New Mexico

23.6.35.100 U. S. Government

(El Paso Test Hole 22, 1953)

Material	Thickness (feet)	Depth (feet)
Sand and caliche	10	10
Medium-grained, red sand	10	20
Fine to coarse-grained red sand	10	30
Fine to medium-grained red sand	10	40
Fine-grained, red sand, and some caliche	20	60
Very fine-grained, red sand, and some caliche	10	70
Sand and gravel	10	80
Clay and some sand	10	90
Clay and gravel	10	100
Sand and gravel	40	140
Fine-grained sand, and clay	10	150
Fine-grained sand	10	160
Fine-grained sand, and gravel	20	180
Fine to coarse-grained sand	13	193
Fine-grained sand, and clay	16	209
Fine to coarse-grained sand	38	247
(Sample missing)	3	250
Fine-grained sand	10	260
Fine-grained sand, and clay	10	270

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

23.6.35.100 U. S. Government
(El Paso Test Hole 22, 1953)
-Continued

Material	Thickness (feet)	Depth (feet)
Fine-grained sand, and clay and gravel	19	289
Medium-grained sand	7	296
Fine to medium-grained sand, and clay	4	300
Fine to medium-grained sand; clay and gravel	20	320
Fine to medium-grained sand	26	346
Sand and gravel	34	380
Sand, gravel and clay	10	390
Fine-grained sand and gravel	5	395
Very fine to fine-grained sand	19	414
Sand, gravel, and clay	6	420
Fine to medium-grained sand	15	435
Fine to coarse-grained sand	15	450
Fine to medium-grained sand	18	468
Clay and fine-grained sand	12	480
Fine-grained sand, and some gravel	10	490
Fine-grained sand, some gravel and clay	11	501
Fine-grained sand, and clay	9	510
Sandy clay	10	520
Clay	10	530
Clay and some gravel	8	538

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

23.6.35.100 U. S. Government
(El Paso Test Hole 22, 1953)
-Continued

Material	Thickness (feet)	Depth (feet)
Sand, some gravel and clay	2	540
Clay and some sand	20	560
Fine to medium-grained sand	12	572
Medium-grained sand, and clay	8	580
Clay	5	585
Medium-grained sand, and some clay	15	600
Fine to coarse-grained sand	10	610
Sand and clay	20	630
Medium to coarse-grained sand	10	640
Clay and sand	10	650

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

24.7.34.100 U. S. Government

(El Paso test hole 30,1953)

Material	Thickness (feet)	Depth (feet)
Sand, some gravel and caliche	10	10
Fine to medium-grained sand	20	30
Very fine to medium-grained sand, and some clay	10	40
Very fine to medium-grained sand, and some gravel	10	50
Fine to coarse-grained sand, and some caliche	30	80
Fine to coarse-grained sand, some caliche and clay	40	120
Clayey sand to sandy clay and some caliche	100	220
Silty to sandy clay and some caliche	40	260
Silty, plastic, dark-brown clay, some sand and caliche	50	310
Mottled, reddish-brown, and gray clay and some caliche	90	400
Silty, medium-brown clay, some sand and caliche	90	490
Light to medium-brown clay and some caliche	130	620
Reddish-brown clay, mottled with gray clay; and some caliche	280	900
Silty, medium-brown clay and some caliche	309	1,209

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

24.8.32.344 State of New Mexico

(El Paso test hole 31, 1953)

Material	Thickness (feet)	Depth (feet)
Buff sand, clay and caliche	10	10
Sandy, light-red clay, and caliche	10	20
Red clay	10	30
Light-brown clay	10	40
Sandy, light-brown clay, and caliche	14	54
Reddish, fine-grained sand	10	64
Sandy, light-brown clay, and caliche	10	74
Buff, clayey sand, and caliche	18	92
Gray, fine-grained, clayey sand	10	102
Gray, fine-grained sand, and caliche pebbles	22	124
Light-red to buff clay	20	144
Hard, red clay	10	154
Heavy, waxy, red clay, and caliche	40	194
Sandy, light-red clay	10	204
Hard, waxy, light-red clay, and caliche	60	264
Very hard, light-red clay, 264-267 (Sample missing)	10	274
Light-red clay, and caliche	10	284
Slightly sandy, light-red clay, and caliche	10	304
Hard, light-red clay, and caliche	10	314
Light-red clay, and caliche	10	324

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N.Mex. - Continued

24.8.32.344 State of New Mexico

(El Paso test hole 31,1953) -Continued

Material	Thickness (feet)	Depth (feet)
Buff clay	30	354
Light-red clay, and caliche	20	374
Dark-red clay, and caliche	10	384
Shaly, red clay, and caliche	20	404
Red clay, and caliche	10	414
Hard, red clay	50	464
Slightly sandy, hard, red clay	8	472
Hard, red clay	32	504
Slightly sandy, red clay	6	510
Sandy, light-red clay, and caliche	10	520
Light-red clay, very fine-grained sandstone, and caliche	10	530
Sandy, light-red clay, and caliche	10	540
Slightly sandy, calcareous, light-red clay	40	580
Sandy, calcareous, light-red and gray clay	24	604
Slightly sandy, light-red clay	34	638
Buff to reddish-brown clay	132	770
Reddish-brown clay	120	890
(Sample missing - electric log indicates limestone was penetrated from about 892 to 910 feet)	40	930
Clay and limestone cuttings	15	945

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

25.6.4.100 U. S. Government
(El Paso test hole 28, 1953)

Material	Thickness (feet)	Depth (feet)
Fine-grained sand	20	20
Very fine-grained sand, and clay	20	40
Fine-grained sand; gravel and caliche	10	50
Sandy, buff clay	10	60
Buff clay	40	100
Buff clay, and sandstone	40	140
Sandy, buff clay	10	150
Buff clay, and coarse gravel	12	162
Fine-grained sand	8	170
Buff clay	39	209
Fine-grained sand	19	228
Buff clay	12	240
Medium-grained sand	10	250
Buff clay	1	251
Medium-grained sand	10	261
Medium to very coarse-grained sand	10	271
Fine-grained sand	20	291
Very fine-grained sand	10	301
Very fine-grained sand, and gravel	20	321
Very sandy clay	10	331
Very coarse-grained sand, and clay	10	341

Table 5.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

25.6.4.100 U. S. Government

(El Paso Test hole 26, 1955)

- Continued

Material	Thickness (feet)	Depth (feet)
Sandy clay and angular gravel	12	353
Sandy clay	3	356
Buff clay	15	371
Clay and sand	10	381
Sand and some clay	10	391
Fine-grained sand	10	401
Medium-grained sand	10	411
Medium-grained sand, and clay	10	421
Medium-grained sand	10	431
Fine to medium-grained sand	10	441
Fine to medium-grained sand, and clay	20	461
Medium-grained sand	10	471
Sandy clay	14	485
Brown clay and angular gravel	10	495
Coarse-grained, angular gravel; sand and clay	10	505
Coarse-grained sand; clay and gravel	10	515
Sandy clay	16	531
Sandy clay, and very coarse-grained gravel	10	541
Fine to medium-grained sand, and some clay	10	551
Sandy, buff clay	10	561
Sandy clay and gray clay	10	571
Sandy, buff clay	10	581

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

25.6.4.100 U. S. Government

(El Paso test hole 28, 1953)

-Continued

Material	Thickness (feet)	Depth (feet)
Sandy, buff clay, and caliche pebbles	10	591
Buff clay and some very fine-grained sand	10	601
Very fine to medium-grained sand, and clay	10	611
Very fine to medium-grained sand, and gravel	5	616
Buff clay, and sand	20	636
Buff clay; sand and gravel	10	646
Buff clay, and sand	20	666
Medium-grained sand; gravel and much clay	10	676
Buff clay, and sand	13	689
Buff clay, and bentonite (?)	10	699
Sandy, buff clay	10	709
Buff clay, and medium-grained sand	10	719
Very fine-grained sand, and clay	10	729
Fine to coarse-grained sand, and clay	10	739
Very fine-grained sand, and clay	20	759
Very fine to coarse-grained sand, and much clay	4	763
Sandy, buff clay	10	773
Very fine-grained sand, and clay	10	783
Buff clay and some sand	25	808

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

25.6.4.100 U. S. Government

(El Paso test hole 28, 1953) - Continued

Material	Thickness (feet)	Depth (feet)
Buff clay	20	828
Buff clay and some fine-grained sand	20	848
Medium-grained sand, and clay	10	858
Buff clay	10	868
Buff clay, and medium-grained sand	20	888
Fine to medium-grained sand, and clay	10	898
Fine-grained sand, and clay	10	908
Very fine to medium-grained sand; clay and gravel	10	918
Sandy, buff clay	10	928
Very fine-grained sand, and clay	10	938
Very fine-grained sand	10	948
Very fine-grained sand, and clay	10	958
Clay and very fine-grained sand	10	968
Very fine-grained sand, and clay	20	988
Clay and very fine-grained sand	40	1,028
Clay, very fine to coarse-grained sand, and gravel	10	1,038
Brown clay	10	1,048
Brown clay, and fine-grained gravel	38	1,086
Buff clay, and fine-grained sand	10	1,096
Brown clay, fine-grained sand and gravel	9	1,105

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

25.6.4.100 U. S. Government

(El Paso test hole 28, 1953)

- Continued

Material	Thickness (feet)	Depth (feet)
Very fine-grained sand; gravel and clay	11	1,116
Sandy, buff clay	20	1,136
Buff clay and fine-grained sand	20	1,156
Buff clay	10	1,166
Very fine-grained sand, and clay	10	1,176
Medium-grained sand, and clay	10	1,186
Very fine-grained sandstone	10	1,196
Buff clay	9	1,205

From 0' - 988 - 53% clay

~~bottom~~ 988-1205 80% clay

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N Mex. - Continued

25.6.34.111 U. S. Government

(El Paso test hole 36, 1953)

Material	Thickness (feet)	Depth (feet)
Fine to medium-grained sand, and caliche	20	20
Fine to very coarse-grained sand; gravel and caliche	10	30
Gravel, pebbles and caliche	20	50
Very coarse-grained, quartz sand, and gravel	20	70
Fine to very coarse-grained sand, and gravel	10	80
Brown clay, and gravel	10	90
Fine to coarse-grained sand, and gravel	10	100
Brown clay, and gravel	10	110
Very fine to very coarse-grained sand, and gravel	20	130
Very fine to medium-grained sand	30	160
Very fine to medium-grained sand; gravel and clay	10	170
Brown clay	10	180
Brown clay, and caliche pebbles	6	186
Sandy, buff clay	4	190
Buff clay, and pebbles	10	200
Brown clay, and gravel	6	206
Coarse-grained sand, and some clay	4	210
Medium to coarse-grained sand, and gravel	5	215
Brown clay; sand and gravel	2	217
Very fine to coarse-grained sand	3	220

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

25.6.34.111 U. S. Government

(El Paso test hole 36, 1953) - Continued

Material	Thickness (feet)	Depth (feet)
Fine to very coarse-grained sand, and gravel	10	230
Fine to coarse-grained sand; gravel and clay	10	240
Buff clay, and coarse-grained gravel	14	254
Coarse to very coarse-grained sand, and clay	6	260
Buff clay, and pebbles	10	270
Coarse to very coarse-grained sand, and some clay	10	280
Sharp or angular gravel, and caliche	10	290
Sandy, buff clay	10	300
Angular gravel, and some clay	10	310
Very fine to medium-grained buff sand, and clay	6	316
Buff clay	4	320
Brown to buff clays, and caliche	10	330
Fine to coarse-grained sand	6	336
Buff clay	4	340
Buff clay, and gravel	6	346
Fine-grained sand	7	353
Buff clay	3	356
Medium-grained sand	4	360
Buff clay, and coarse-grained gravel	10	370
Buff clay	20	390

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

25.6.34.111 U. S. Government

(El Paso test hole 30, 1953)

- Continued

Material	Thickness (feet)	Depth (feet)
Medium-grained sand	10	400
Very fine to fine-grained sand	10	410
Fine-grained sand; gravel and caliche	11	421
Fine to medium-grained sand, and caliche	19	440
Very fine to fine-grained sand	11	451
Sandy, buff clay, and caliche	9	460
Sandy, buff clay; gravel, and caliche	10	470
Very fine to fine-grained sand, and clay	10	480
Sandy, buff clay, and caliche gravel	10	490
Buff clay, coarse-grained sand, and gravel	10	500
Very coarse-grained sand; gravel and caliche	20	520
Very fine to fine-grained sand	10	530
Medium to coarse-grained sand; gravel, and caliche	12	542
Fine to coarse-grained sand; and caliche gravel	18	560
Medium to coarse-grained sand; gravel, caliche, and clay	10	570
Sandy, buff clay; gravel, and caliche gravel	10	580
Clay, coarse-grained sand, and gravel	5	585
Fine to coarse-grained sand, and gravel	10	595
Very sandy clay, and gravel	10	605

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

25.6.34.111 U. S. Government

(El Paso test hole 36, 1953) - Continued

Material	Thickness (feet)	Depth (feet)
Sandy clay and much caliche	3	608
Sandy clay, gravel and caliche	7	615
Buff clay	10	625
Very fine-grained sand	20	645
Medium to coarse-grained sand, and caliche gravel	20	665
Very coarse-grained sand, and gravel	12	677
Sandy clay, and caliche gravel	13	690
Medium to coarse-grained sand, and clay	10	700
Medium-grained sand, and clay	10	710
Medium-grained sand, and gravel	10	720
Medium to coarse-grained sand, and gravel	10	730
Medium to coarse-grained sand; gravel and caliche	5	735

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

26.7.32.122 State of New Mexico

(El Paso test hole 6, 1953)

Material	Thickness (feet)	Depth (feet)
Caliche	20	20
Coarse-grained gravel, red clay and caliche	30	50
Coarse-grained angular gravel, and caliche	10	60
Brown clay, and caliche	10	70
Sandy, brown clay, and caliche	10	80
Brown clay; sand and caliche	20	100
Very coarse-grained, angular gravel	20	120
Fine-grained red sand	2	122
Coarse-grained sand; clay, and caliche pebbles	8	130
Caliche	10	140
Coarse to very coarse-grained sand	10	150
Brown clay, and caliche	10	160
Very fine to very coarse-grained sand and coarse-grained, angular gravel	30	190
Very fine to coarse-grained sand, coarse-grained angular gravel, and caliche	10	200
Sandy, buff clay	20	220
Sandy, brown clay, and caliche pebbles	10	230
Buff clay and fine-grained, angular gravel	10	240
Very coarse-grained sand; angular gravel, and brown clay	10	250
Fine to coarse-grained, angular gravel	10	260

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

26.7.32.122 State of New Mexico

(El Paso test hole 6, 1953) - Continued

Material	Thickness (feet)	Depth (feet)
Fine to coarse-grained sand	10	270
Coarse-grained sand, and angular gravel	10	280
Fine to coarse-grained sand	10	290
Sandy, buff clay	10	300
Fine to coarse-grained sand	10	310
Coarse-grained sand, some gravel and pink clay	10	320
Sandy, brown clay	10	330
Brown clay, coarse-grained sand, and gravel	10	340
Very fine-grained sand	8	348
Buff clay and coarse-grained sand	2	350
Brown clay and very fine-grained sandstone	20	370
Angular gravel and very fine-grained sand	10	380
Very fine to fine-grained sand	10	390
Sandy, buff clay	7	397
Brown clay and bentonite (?)	3	400
Pink clay and coarse-grained sand	10	410
Sandy, pink clay	4	414
Sand and clay	6	420
Fine to medium-grained sand	10	430
Fine to medium-grained sand, and clay	10	440

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

26.7.32.122 State of New Mexico
(El Paso test hole 6, 1953)
- Continued

Material	Thickness (feet)	Depth (feet)
Sandy, pink clay	20	460
Medium-grained sand, and clay	10	470
Fine to medium-grained sand	10	480
Fine to medium-grained sand, and clay	10	490
Pink clay and some sand	20	510
Sandy, pink clay	10	520
Pink clay	24	544
Clay and sand	6	550
Medium-grained sand and much clay	10	560
Pink clay	20	580
Fine to medium-grained sand	4	584
Sandy, pink clay	6	590
Fine to medium-grained sand	10	600
Sandy, pink clay	10	610
Very fine to medium-grained sand, and clay	10	620
Sharp, quartz gravel; sand and clay	4	624
Fine to medium-grained sand	6	630
Well-sorted, medium-grained sand	5	635
Red clay, and coarse-grained sand	5	640
Fine-grained sandstone and sand	10	650
Coarse-grained sand; gravel and clay	10	660

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

26.7.32.122 State of New Mexico

(El Paso test hole 6, 1953) - Continued

Material	Thickness (feet)	Depth (feet)
Sandy, brown clay	10	670
Medium to coarse-grained sand	5	675
Brown clay	17	690
Sandy, brown clay, and caliche pebbles	10	700
Brown clay, and sandstone	10	710
Fine to medium-grained sand	8	718
Medium-grained sand, sandstone, and clay	2	720
Medium to coarse-grained sand	10	730
Medium to coarse-grained sand, and gravel	10	740
Very fine to fine-grained sand	10	750
Fine to medium-grained sand	5	755
Brown clay and bentonite (?)	5	760
Sandy clay, and bentonite (?)	9	769
Fine to medium-grained sand	5	774
Brown clay	3	777
Medium-grained sand	3	780
Very fine to medium-grained sand	13	793
Brown and gray clay	7	800
Sandy, brown clay	10	810
Medium-grained sand, and clay	12	822
Brown clay, and very fine-grained sandstone	18	840

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

26.7.32.122 State of New Mexico

(El Paso test hole 6, 1953) - Continued

Material	Thickness (feet)	Depth (feet)
Sandy, brown clay	4	844
Very fine to fine-grained sand	5	849
Brown clay	11	860
Very fine-grained sandstone, and brown clay	10	870
Very fine-grained sandstone and medium-grained sand	10	880

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

26.8.32.111

(El Paso test hole 8, 1953)

Material	Thickness (feet)	Depth (feet)
Medium to coarse-grained sand, and caliche	30	30
Medium to coarse-grained sand	20	50
Very fine to fine-grained sand	40	90
Very fine to medium-grained sand	10	100
Fine to coarse-grained sand	10	110
Very fine to medium-grained sand	60	170
Very fine to very coarse-grained sand	30	200
Very fine to coarse-grained sand and some clay	30	230
Very fine-grained sand, silt and some clay	20	250
Very fine to medium-grained sand. Little clay	10	260
Very fine to medium-grained sand, and clay	10	270
Brown clay and very fine-grained sand	10	280
Brown clay	10	290
Brown clay and some very fine-grained sand	10	300
Red clay, some silt and fine-grained sand	10	310
Red clay and some fine-grained sand	30	340
Red clay, very fine-grained sand and gray silt	30	370
Red clay, and medium to coarse-grained sand	10	380
Red clay and medium to very coarse-grained sand	10	390

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

26.8.32.111

(El Paso test hole 8, 1953) -Continued

Material	Thickness (feet)	Depth (feet)
Medium to very coarse-grained sand, clay and some gravel	10	400
Medium to very coarse-grained sand and red clay	10	410
Red clay, very coarse-grained sand and some gravel	20	430
Red clay and very fine to coarse-grained sand	10	440
Red clay, gray silt and some gravel	10	450
Red clay and silt	10	460
Red clay, silt, very coarse-grained sand and some gravel	30	490
Red clay and silt	10	500
Red clay, silt and thin strata of caliche	10	510
Red clay, silt, fine caliche gravel and some coarse-grained sand	10	520
Red clay, silt and some caliche	20	540
Red clay, medium to coarse-grained sand, silt and some gravel	10	550
Brown clay, silt, and medium to coarse-grained sand	20	570
Brown clay, very fine to medium-grained sand and some gravel	20	590
Brown clay, very fine to coarse-grained sand, and gravel	10	600
Red and brown silty clay, very fine to medium-grained sand, and gravel	20	620
Brown clay, very fine to medium-grained sand, and gravel	10	630

Table 3.--Sample logs of wells and test holes in vicinity of McGregor Range, Otero County, N. Mex. - Continued

26.8.32.111

(El Paso test hole 8, 1953) - Continued

Material	Thickness (feet)	Depth (feet)
Brown clay, very fine to coarse-grained sand, gravel and pebbles	10	640
Very fine to very coarse-grained sand, clay, gravel and pebbles	10	650
Brown clay, very fine to very coarse-grained sand and gravel	20	670
Brown clay, very fine-grained sand, gravel and pebbles	10	680
Gravel, pebbles, thin strata of caliche, some fine to medium-grained sand and little clay	5	685
Gravel and pebbles	5	690
Gravel, pebbles, red clay and some very fine to medium-grained sand	10	700
Conglomerate consisting of gravel, thin strata of caliche and fine-grained sand	30	730
Conglomerate of gravel, pebbles, and fine-grained sand	10	740
Conglomerate of gravel and pebbles	40	780
Conglomerate of gravel, pebbles, some red clay and very fine-grained sand	30	810
Conglomerate of gravel, pebbles and very fine to coarse-grained sand	10	820

Table 4.--Driller's log of well in vicinity of McGregor Range, Otero County, New Mexico

26.6.34.130a Southern Pacific Lines (Well 3)

(Well 140 in Water Supply Paper 919)

Material	Thickness (feet)	Depth (feet)
Sand	10	10
Caliche	5	15
Sand	135	150
Clay	5	155
Sand	20	175
Clay	4	179
Sand	8	187
Clay	3	190
Sand	43	233
Clay	4	237
Sand	7	244
Rock	1	245
Sand	55	300
Clay	4	304
Sand	4	308
Clay	4	312
Sand, water	38	350
Clay	10	360
Sandstone	20	380

Table 4.--Driller's log of well in vicinity of McGregor Range, Otero County, New Mexico - Continued

26.6.34.130a Southern Pacific Lines (Well 3)

(Well 140 in Water Supply Paper 919)

Material	Thickness (feet)	Depth (feet)
Sand, water	17	397
Clay	2	399
White rock	1	400

Table 5.--Driller's log of well in vicinity of McGregor Range, El Paso County, Texas

1.1.6.340 Navar Bros.

(Partial log)

Material	Thickness (feet)	Depth (feet)
Clay and sand streaks; very little sand	400	400
Conglomerate and yellow shale	35	435
Conglomerate	24	459
Hard quartzite: drilling rate, 1 foot per hour	9	468
Black shale, and lime	12	480
Lime	5	485
Lime and shale streaks	17	502
Soft, black shale	12	514

Well to be drilled to 600 feet.

Table 6.--Chemical analyses [illegible] water from [illegible] and test hole[illegible] in the vicinity of McGregor R[illegible]e, Otero County, N. Mex., and El Paso County, Tex.

(Analyses by U. S. Geological Survey, in parts per million except percent sodium, specific conductance, and pH)

Location number	Depth of well or interval sampled (feet)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
		Otero County, N. Mex.					
23.6.35.100	423-450	Mar. 30, 1953	-	-	-		
	534-610	do.	-	-	-		
24.7.34.144	400-447	July 13, 1953	14	22	2.8	336	3.7
25.6.4.110	439-514	Mar. 31, 1953	24	1,250	282	314	
25.6.20.334a	440	-	39	132	33	131	
25.6.34.111	339-421	Apr. 17, 1953	35	298	106	461	24
	438-470	Apr. 18, 1953	20	314	92	417	23
	500-542	Apr. 19, 1953	30	394	110	409	24
	563-585	do.	12	214	56	316	17
	603-645	Apr. 20, 1953	24	452	109	488	24
	672-710	Apr. 28, 1953	26	760	163	435	
25.7.16.122	441	-	11	27	2.4	390	
26.6.34.130	332	Sept. 23, 1935	-	70	17	133	
26.7.32.122	435	May 1, 1953	-	-	-		
	435	May 3, 1953	21	160	52	645	12
	585-610	Mar. 19, 1953	5.3	113	26	534	9.4
	715-740	Mar 20, 1953	14	34	5.7	336	4.5
	852-880	Mar. 22, 1953	21	90	5.5	541	5.6
26.7.35.230	400	Aug. 10, 1935	-	-	-		
26.8.32.111	645-690	June 21, 1953	3.7	119	17	889	9.3
	775-820	June 22, 1953	17	534	61	2,850	
26.8.33.120	300	-	34	50	12	83	

Table 6.--Chemical analyses of water from wells and test holes in the vicinity of McGregor Range, Otero County, N. Mex., and El Paso County, Tex. Continued

(Analyses by U. S. Geological Survey, in parts per million except percent sodium, specific conductance, and pH)

Location number	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$ Total	Hardness as $CaCO_3$ Noncarbonate	Percent sodium (% Na)	Specific conductance (micromhos at 25°C)	pH
					Otero County, New Mexico							
23.6.35.100	41	1,410	6,710	-	-	-	-	7,950	-	-	19,000	6.5
	35	1,460	8,010	-	-	-	-	8,950	-	-	22,500	6.6
24.7.34.144	96	387	232	1.1	0.5	0.34	1,050	66	0	91	1,800	7.7
25.6.4.110	36	1,210	3,390	.0	-	-	7,000	4,280	4,250	30	11,000	6.7
25.6.20.334a	91	50	438	.4	6.3	-	875	465	390	-	1,640	7.5
25.6.34.111	92	779	940	.4	4.2	.25	2,690	1,180	1,100	45	4,150	7.5
	96	571	1,020	.4	3.5	.28	2,510	1,160	1,080	43	4,130	7.4
	53	663	1,120	.6	2.0	.15	2,770	1,410	1,370	38	4,470	7.3
	69	410	720	.2	.2	.26	1,780	764	708	47	3,280	7.2
	49	212	1,720	.0	1.0	.28	3,050	1,580	1,540	40	5,490	7.1
	35	211	2,700	0	-	-	4,560	2,570	2,540	37	5,360	7.1
25.7.16.122	76	310	380	.9	2.0	-	1,160	78	15	-	2,350	7.6
26.6.34.130	98	38	290	-	5.2	-	602	245	-	-	-	-
26.7.32.122	118	-	720	-	-	-	-	580	-	-	3,870	7.6
	86	901	710	.5	1.0	.24	2,550	613	542	69	3,890	7.6
	59	622	610	.3	.0	.22	1,950	389	340	74	3,210	7.3
	81	70	505	.7	.0	.35	1,010	108	42	86	1,930	7.4
	47	44	950	1.0	.0	.36	1,6[illegible]0	247	208	82	3,220	7.3
26.7.35.230	176	-	91	-	-	-	-	33	-	-	-	-
26.8.32.111	53	163	1,450	.9	.5	.33	2,670	367	324	83	4,860	7.4
	62	611	5,030	.3	-	-	9,130	1,530	1,530	80	15,100	7.3
26.8.33.120	134	136	41	.6	54	-	435	174	64	-	715	8.1

Table 6.--Chemical analyses of water from wells and test holes in the vicinity of McGregor Range, Otero County, N. Mex., and El Paso County, Tex.--Continued

(Analyses by U. S. Geological Survey, in parts per million except percent sodium, specific conductance, and pH)

Location number	Depth of well or interval sampled (feet)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
		El Paso County, Texas					
1.80.1.111	506-525	Mar. 4, 1953	22	149	37	212	15
	707-732	Mar. 6, 1953	2.2	344	78	609	
1.80.4.222	457-500	May 18, 1953	16	108	20	207	12
	520	June 10, 1953	33	133	27	330	11
	542-586	May 18, 1953	18	222	51	638	18
	679-725	May 20, 1953	19	218	65	1,690	
	752-798	do.	26	242	59	2,040	
1.80.23.444	-	Apr. 3, 1936	-	35	8.8	116	
1.80.24.333	450	1953	32	27	7.4	91	6.4
	461-507	1953	25	36	8.3	124	7.8
	648-694	1953	26	162	51	508	
	927-973	1953	25	148	47	1,170	

Table 6.--Chemical analyses of water from wells and test holes in the vicinity of McGregor Range, Otero County, N. Mex., and El Paso County, Tex. Continued

(Analyses by U. S. Geological Survey, in parts per million except percent sodium, specific conductance, and pH)

Location number	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$		Percent sodium (% Na)	Specific conductance (micromhos at 25°C)	pH
								Total	Noncarbonate			
					El Paso County, Texas							
.80.1.111	72	70	612	0.5	4.0	0.36	1,160	524	465	46	2,180	7.5
	37	72	1,700	-	.5	-	2,820	1,180	1,150	53	5,160	7.2
.80.4.222	91	36	492	.3	5.9	.16	943	352	277	55	1,850	7.2
	60	11	795	.0	5.4	.09	1,380	443	394	61	2,700	7.5
	64	25	1,510	.0	3.0	.09	2,520	764	711	64	4,350	7.3
	94	233	2,950	.7	-	-	5,220	812	734	82	9,260	7.0
	163	617	3,2[illegible]0	.6	-	-	6,260	846	713	84	10,500	7.0
.80.23.444	146	54	139	-	5.0	-	430	124	-	-	-	-
.80.24.333	151	53	89	.5	5.0	.16	386	93	0	-	641	7.6
	133	67	158	.6	4.5	.25	498	124	15	-	885	7.9
	57	48	1,150	.2	.0	-	1,970	614	567	-	3,760	7.2
	96	137	2,040	.6	-	-	3,610	563	484	-	6,560	7.1