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GROUND-WATER GEOLOGY OF THE ALPINE AREA, BREWSTER, JEFF DAVIS, AND PRESIDIO COUNTIES, TEXAS

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ABSTRACT

The Alpine area is in the arid and semiarid Trans-Pecos region of Texas. The area described in this report is about 340 square miles and is largely in northern Brewster County but includes also parts of Jeff Davis and Presidio Counties. The Alpine area occupies part of the erosional remnant of the once vast Davis Mountains volcanic field. The rocks of the volcanic field are largely extrusives which overspread the area early in the Tertiary period. Most of the extrusive rocks and all the associated intrusive rocks in general are poor aquifers and contain only small supplies of unconfined ground water. The extrusive section consists of silicic, intermediate, and basic rocks having an aggregate thickness of about 3,400 feet. The section is deeply eroded, and throughout much of the Alpine area the rocks lie above the water table.

Extrusive rocks consisting of basalt locally have moderate permeability and yield as much as 240 gallons per minute to properly constructed wells. The high permeability associated with solidified flows of basalt in many other places is not present in the Alpine area, owing to alteration and secondary mineralization. The results of pumping tests at four wells completed in the basalt showed a range in coefficient of transmissibility from about 5,100 to 17,000 gallons per day per foot. In areas of recent faulting the basalt aquifers are relatively permeable and are capable of supplying the municipal needs of Alpine, the only town in the area. Alluvial deposits on the Alpine plain have a maximum thickness of 130 feet. The deposits are poorly sorted, contain interstitial caliche, and have low permeability. They supply stock and domestic wells.

The chemical quality of the water in the volcanic rocks is suitable for most uses. The fluoride content in some of the wells, however, is slightly in excess of 1.5 parts per million--the maximum recommended concentration for municipal supply.

The surface streams in the Alpine area are ephemeral.

Only small to moderate quantities of ground water are available from most domestic wells, and a continuing program of ground-water exploration is suggested in order to meet the increased demands of stock and domestic users. The four areas that appear most favorable for ground-water development are discussed in order of their apparent potential. They are: (1) Sunny Glen, (2) Stocking Canyon Divide, (3) Musquiz Canyon, and (4) immediate vicinity of Alpine.

INTRODUCTION

Purpose and Scope of Investigation

Despite some 35 years of ground-water exploration, Alpine, the seat of Brewster County, Tex., is plagued by recurrent municipal water shortages. About 32 wells have been drilled since 1921 to meet increasing municipal demand, but the present supply is inadequate, particularly during periods of drought.

In recent years, many residents of Alpine drilled domestic wells to obtain adequate individual supplies. The yield of these domestic wells is less than 10 gpm(gallons per minute) each. In the aggregate, however, a substantial quantity of ground water is pumped, and the water table in the immediate vicinity of Alpine has declined steadily.

The indications of diminishing ground-water supplies, the prospects of continued municipal growth, and the increasing need for more reliable water supplies throughout the area led to an investigation of the Alpine area by the United States Geological Survey in cooperation with the Texas Board of Water Engineers and the Commissioners' Court of Brewster County. The Alpine area, which lies in the Trans-Pecos region of Texas, consists of 340 square miles, chiefly in northwestern Brewster County but including small parts of Jeff Davis and Presidio Counties (fig. 1).

The investigation was made under the general supervision of A. N. Sayre, Chief of the Ground Water Branch, U. S. Geological Survey, and under the direct supervision of R. W. Sundstrom, district engineer in charge of the ground-water investigations in Texas.

Previous Investigations

Prior field investigations of the ground-water resources of the Alpine area were limited in scope. Available reports (Baker, 1939; Lang, 1949; McAnulty, 1950; and Classen, 1950) contain insufficient detailed information about volcanic geology in relation to the occurrence of ground water upon which to base a program of ground-water exploration.

A reconnaissance inspection of the geology of the area and its relation to the possible occurrence of artesian water was made by Baker in June and July 1939. His informal report led to the drilling of a deep test hole during the period 1939-42 to obtain ground water from limestone of Early Cretaceous age. Reportedly, the test hole was 2,700 feet deep, but reliable information is available only to 925 feet.

In November 1947 Lang made a brief field inspection of ground-water conditions at Alpine. A manuscript report summarizing his observations stressed many inconsistencies in reported and recorded hydrologic data and also pointed out the complicated nature of local geologic factors that influence ground-water development.

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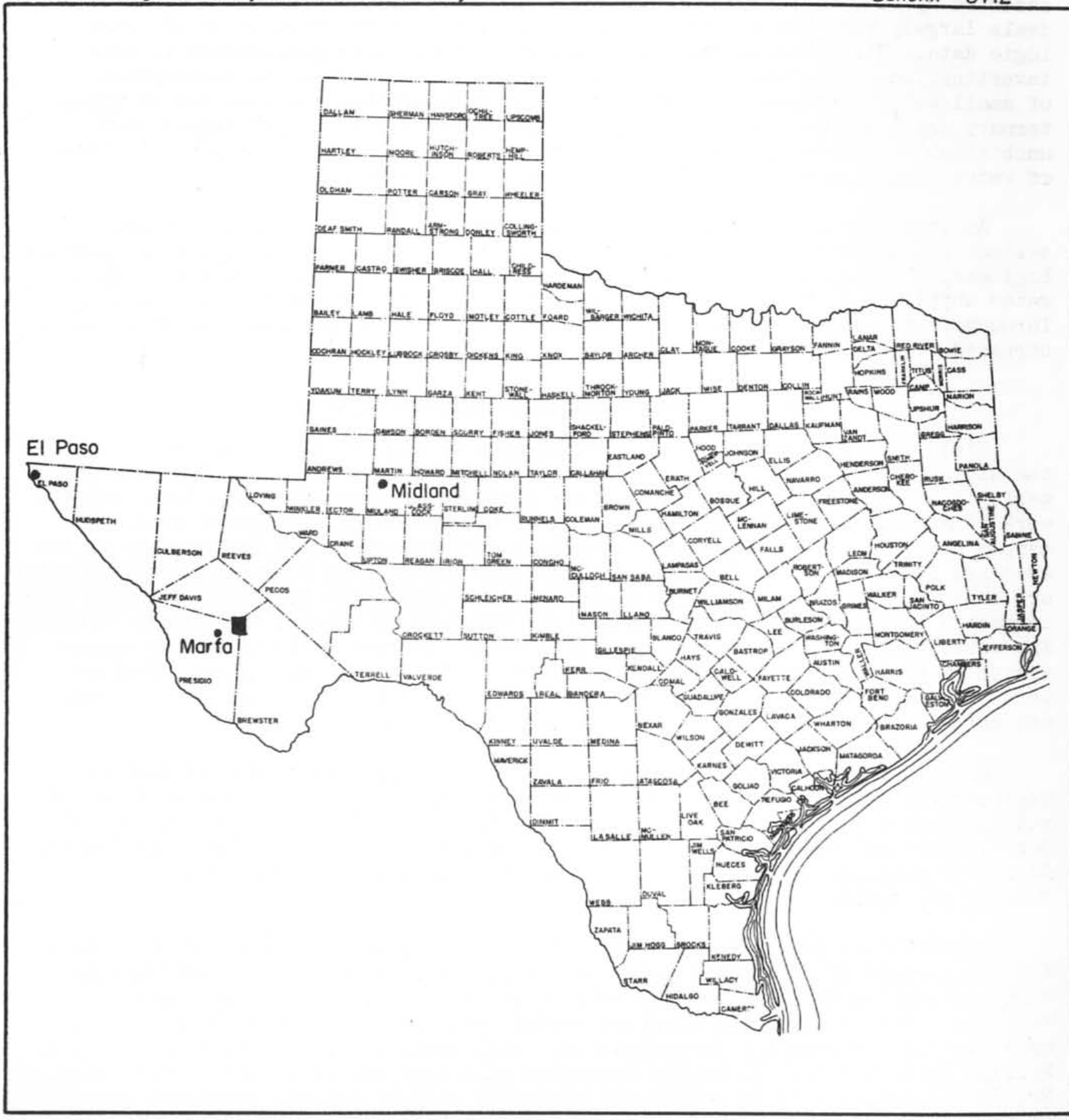

FIGURE 1.- Map of Texas showing area covered by this report.

McAnulty mapped the Alpine 15-minute quadrangle in April and May 1950, assisted by four senior geology students from Sul Ross College. His report deals largely with the geology but also includes a brief compilation of hydrologic data. His astute appraisal of the geology has wide application to this investigation. The report cites areas that appear favorable for development of small water supplies in volcanic rocks of Tertiary age and alluvium of Quaternary age and concludes that if sufficient water for municipal supply were unobtainable in these rocks, it would be necessary to explore the possibilities of water supply in marine sedimentary strata at considerable depth.

An engineering report on the municipal water and the sanitary sewerage systems was submitted to the city in September 1950 by Ashley G. Classen, Sanitary Engineer, El Paso, Tex. Classen recommended that the city develop a municipal water supply of 1,750,000 to 2,000,000 gallons per day in the next 15 years. Throughout the report the need for application of sound hydrologic studies was stressed.

Methods of Investigation and Acknowledgments

Field studies were made in the first part of 1955 in 340 square miles in the Alpine area, chiefly in northwestern Brewster County (pl. 1). Reconnaissance geologic mapping of 230 square miles was modified or taken directly from original work of McAnulty (1955), and the geology of the remaining 110 square miles was mapped using aerial photographs. Data collected for 206 wells and springs in the area are shown in tables 6 and 9, and periodic water-level measurements in 19 wells are shown in table 8. About 300 domestic wells within the Alpine city limits were canvassed but insufficient information was obtained to warrant tabulation. Pumping tests were made at selected municipal wells and test wells under the supervision of E. A. Moulder, hydraulic engineer, U. S. Geological Survey. Samples were obtained for an aggregate of 1,844 feet of test holes drilled in the area, and sample logs for the test holes are included in table 7.

Altitudes were established for 170 wells and 4 springs by Samuel Samson, engineer for Ashley G. Classen and Associates. Examinations of thin sections of volcanic rocks were made in 1955 by Charles Milton, geologist, U. S. Geological Survey (personal communication, July 20, 1955), and by Peter T. Flawn, geologist, Bureau of Economic Geology, University of Texas (personal communication, October 26, 1955).

Appreciation is expressed to the ranchers who permitted entry on their land for the purpose of scheduling wells and mapping geology and spent considerable time acquainting the writers with well locations and significant geologic features. Public officials supplied useful information and made equipment and maps available during the investigation. Well drillers P. W. Gooden, Anton Hess, Nolland Shuler, and C. N. Watson furnished well logs and many other useful data. Mr. John Stovell, city secretary and engineer, city of Alpine, furnished records of wells, pumpage, and past ground-water exploration. Mr. W. N. McAnulty, geologist, Dow Chemical Co., and Mr. Harry Neilsen, geologist, Gulf Oil Corp., briefed the writers on significant geologic features and gave helpful advice on subsurface correlations.

Well-Numbering System

The wells are numbered according to their locations within a county. Each county is divided into 10-minute quadrangles which are lettered A through Z, and if necessary AA through ZZ, beginning in the northwest corner of the county. Wells within a quadrangle are numbered consecutively beginning in the northwest corner of the quadrangle. For example, well H-1 is in the northwest corner of quadrangle H.

GEOGRAPHY

Physical Subdivisions and Landforms

The Alpine area contains three physical subdivisions (fig. 2): (1) the Alpine plain, (2) the Davis Mountains, and (3) the Marfa plateau. Their physiographic setting is in or borders the Davis Mountains volcanic field, which occupies parts of Brewster, Jeff Davis, and Presidio Counties. Only physiographic features in the Alpine plain and Davis Mountains influence the ground-water supply at Alpine.

The Alpine plain has an extent of approximately 150 square miles (fig. 2) and is bordered on the south, west, and north by escarpments 450 to 950 feet high formed largely by silicic volcanic rocks of the Duff formation of Goldich and Seward (1948) but partly by intruded syenite masses. The surface of the plain, which lies between altitudes of 4,750 and 4,000 feet above sea level, is formed by a shallow apron of debris which was spread eastward from the Davis Mountains by ephemeral drainage. Two hills formed by intrusive syenitic rocks and uplifted volcanic strata rise sharply above the plain at Alpine. The city lies between the hills, whose several names include Alpine or South Hill and Sul Ross or Hancock Hill. The eastern part of the plain is characterized by low, rolling hills of solidified lava flows which are exposed through the debris apron.

According to McAnulty (1955, p. 535), the name Davis Mountains defines a rugged erosional remnant of a once vast field of largely extrusive volcanic rocks. The present mountains are 5 to 28 miles in width, their linear trend being north-northwest from west-central Brewster County to northern Jeff Davis County. They occupy most of the western part of the Alpine area, forming irregular borders of the Alpine plain and the Marfa plateau.

Intrusive rocks, which locally form peaks, are exposed prominently as dikes, plugs, and other irregular masses. Notable peaks include McIntyre, Ranger, Twin, Haystack, Paisano, and three Mitre peaks, which form the backbone of the mountains between altitudes of about 5,500 and 6,750 feet. The intrusive rocks that form the mountain range are relatively impermeable and constitute a hydrologic barrier along which an irregular ground-water divide is discernible. This geologic feature bears directly upon the problems of ground-water recharge and movement in the Alpine area.

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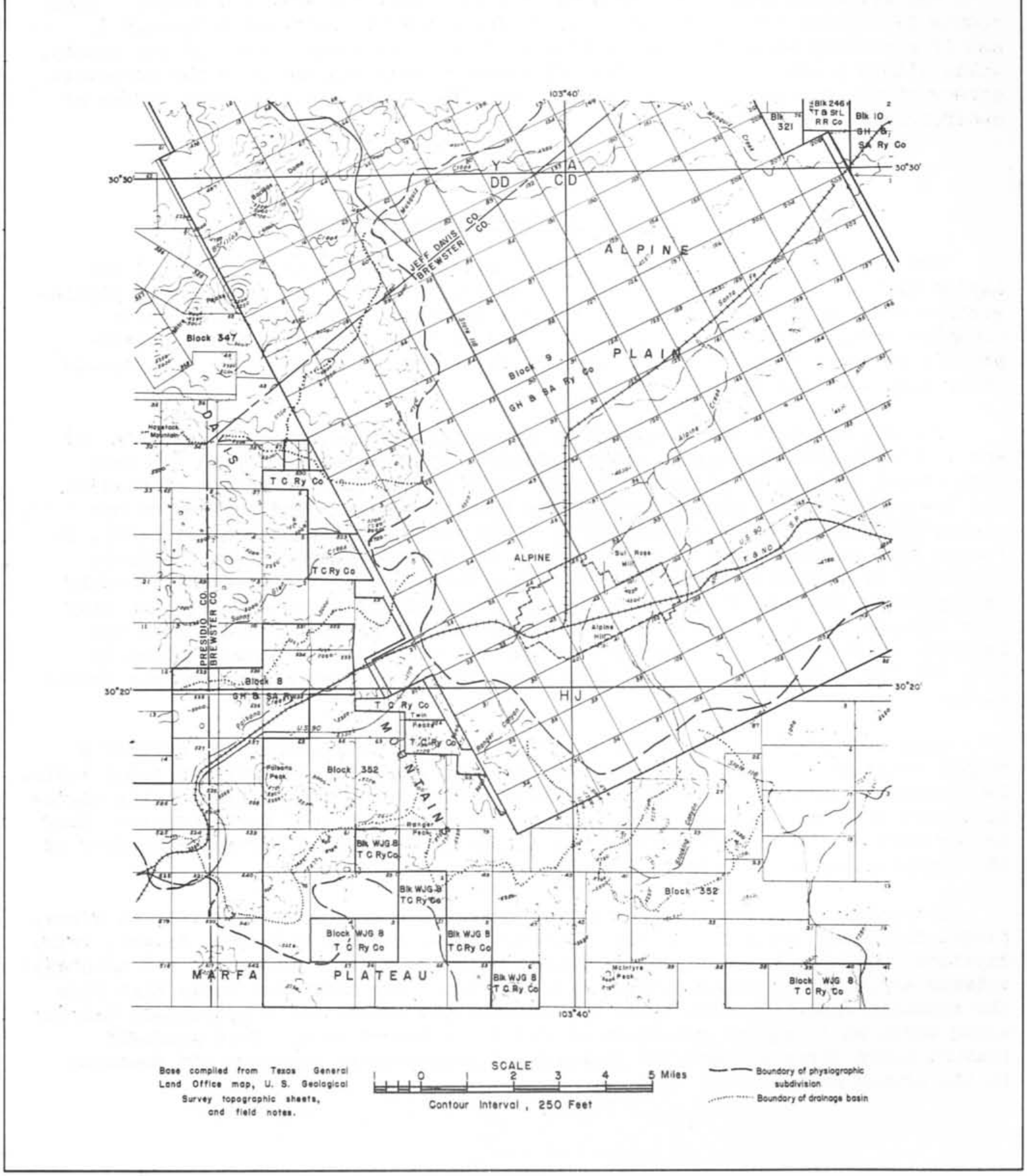

FIGURE 2.- Map of physiographic subdivisions, generalized topographic features, and primary land net in the Alpine area, Brewster, Jeff Davis, and Presidio Counties, Tex.

The eastern fringe of the Marfa plateau is in the Alpine area. The plateau is a desert about 5,250 feet high that extends unbroken across northern Presidio County to a low drainage divide about 15 miles west of the town of Marfa. Bolson deposits, consisting of extensive sheets of clay, silt, sand, and gravel, form the surface of most of the plateau and lie with angular discordance on volcanic and consolidated sedimentary rocks. The bolson deposits have buried the west and south slopes of the Davis Mountains. The Marfa plateau appears to be an important ground-water province, but development has been confined to relatively small municipal supplies at Marfa and industrial supplies at Tinaja, a siding on the Santa Fe Railroad. Ground-water conditions in the whole of the plateau are beyond the scope of this investigation, but a study of ground-water conditions of the entire plateau in the near future seems advisable.

Drainage

Drainage of the Alpine area is by large ephemeral streams which carry flood runoff. These streams occupy canyons in the Davis Mountains, but only shallow gullies on the Alpine plain. Information about the principal local drainage basins is given in table 1.

Table 1. Drainage basins in the Alpine area, Texas.

Basin	Drainage area (sq. mi.)	Topography
Stocking Canyon	5.4	Steep canyon with broken slopes.
Ranger Canyon	8.5	Steep, narrow canyon; steep northeast slope of Ranger Peak.
Paisano Canyon	28.7	Steep, broken escarpments, rolling plain; slopes of Paisano Peak.
Sunny Glen Canyon	29.8	Steep slopes of prominent peaks, rolling to broken terrain, and short, narrow canyons.
Musquiz Canyon	98.6 1/	Broad-bottomed valleys, steep-sided tributary canyons, and rolling to broken mountainous terrain.

1/ Part of drainage area lies north and west of map area.

Flood runoff from the canyons in the mountains discharges through narrow throats and spreads onto the Alpine plain. All the streams listed in table 1, with the exception of Musquiz Creek, join at various points on the Alpine plain to form Alpine Creek, an ephemeral stream. Musquiz Creek and its principal tributary, Barillos Creek, are perennial in reaches a few miles above the discharge throat in sections 10, 15, and 64, block 9, GH & SA Railway Company Survey. In this area, the water table in the alluvium is at or near the land surface.

Climate

The climate of the Trans-Pecos region of Texas ranges from arid to semiarid. The mountainous areas receive more precipitation than the intervening plateaus or intermontane deserts. The Alpine area has a semiarid climate and an average annual precipitation of 15.48 inches (figs. 3 and 4), most of which falls during the summer, largely in torrential rainstorms of irregular areal distribution. Records of the United States Weather Bureau show a wide range in the amount of annual precipitation (fig. 4). Local areas may receive several heavy showers within a year while nearby areas receive no showers. In some years widespread rains over a period of several days or a week may effectively restore soil moisture and recharge ground-water reservoirs. Snowstorms are infrequent.

The Alpine area has a delightfully cool summer climate for the latitude (30°20' N). The average temperature at Alpine, according to records of the U. S. Weather Bureau for the period 1930-54, is about 63°F. The highest recorded temperature is 106°F and the lowest is -2°F. Daytime temperatures commonly reach 100°F, but the nights are cool. The U. S. Weather Bureau determined the average length of the growing season to be 222 days. The average dates for the first and last killing frosts are November 11 and April 2.

Economy

Alpine was incorporated in 1917 coincident with legislative authorization for the establishment of Sul Ross College. The principal source of present wealth is the livestock industry, but city officials seek to build a more diversified economy.

According to the U. S. Bureau of the Census, the population of Alpine in 1920 was 931. By 1950 Alpine had a population of 5,246 (exclusive of a student population at Sul Ross College of 1,024). Further municipal growth is anticipated because: (1) The city is the principal retail and distribution center for a large area in the Trans-Pecos region of Texas; (2) the presence of Sul Ross College has instilled a high degree of civic pride, demanded constant civic improvement, and brought recognition to the city as a cultural center of the Trans-Pecos area; (3) in 1955 the Southern Pacific Railroad Company designated Alpine as its freight division point between El Paso and Del Rio; and (4) the development of nearby recreational areas, notably Big Bend National Park, has considerably increased tourist travel in the Alpine area.

The cattle industry began in the Alpine area in the early 1880's with the completion of the Southern Pacific Railroad through the Trans-Pecos region. Herds were shipped by rail to Brewster County from overcrowded ranges east of the Pecos River. Sheep and goats were brought into the region soon thereafter to graze rugged parts of the range. Early ranch headquarters were established near springs and perennial reaches of streams, and it was these areas that were first overgrazed. The construction of earthen tanks, wells, and pipelines later permitted permanent grazing operations to spread over vast areas.

The occurrence of periods of drought has caused wide fluctuations in the numbers of livestock on the range because ranchers are forced to decrease their herds during successive years of below-average rainfall. The U. S. Census of Agriculture reported 36,220 head of cattle in Brewster County in 1950 and 18,900 in 1954. The numbers of sheep and lambs reported were 210,162 in 1950 and 87,441 in 1954. The decrease can be correlated directly with the 4-year period of below-average rainfall from 1951 to 1954 (fig. 4).

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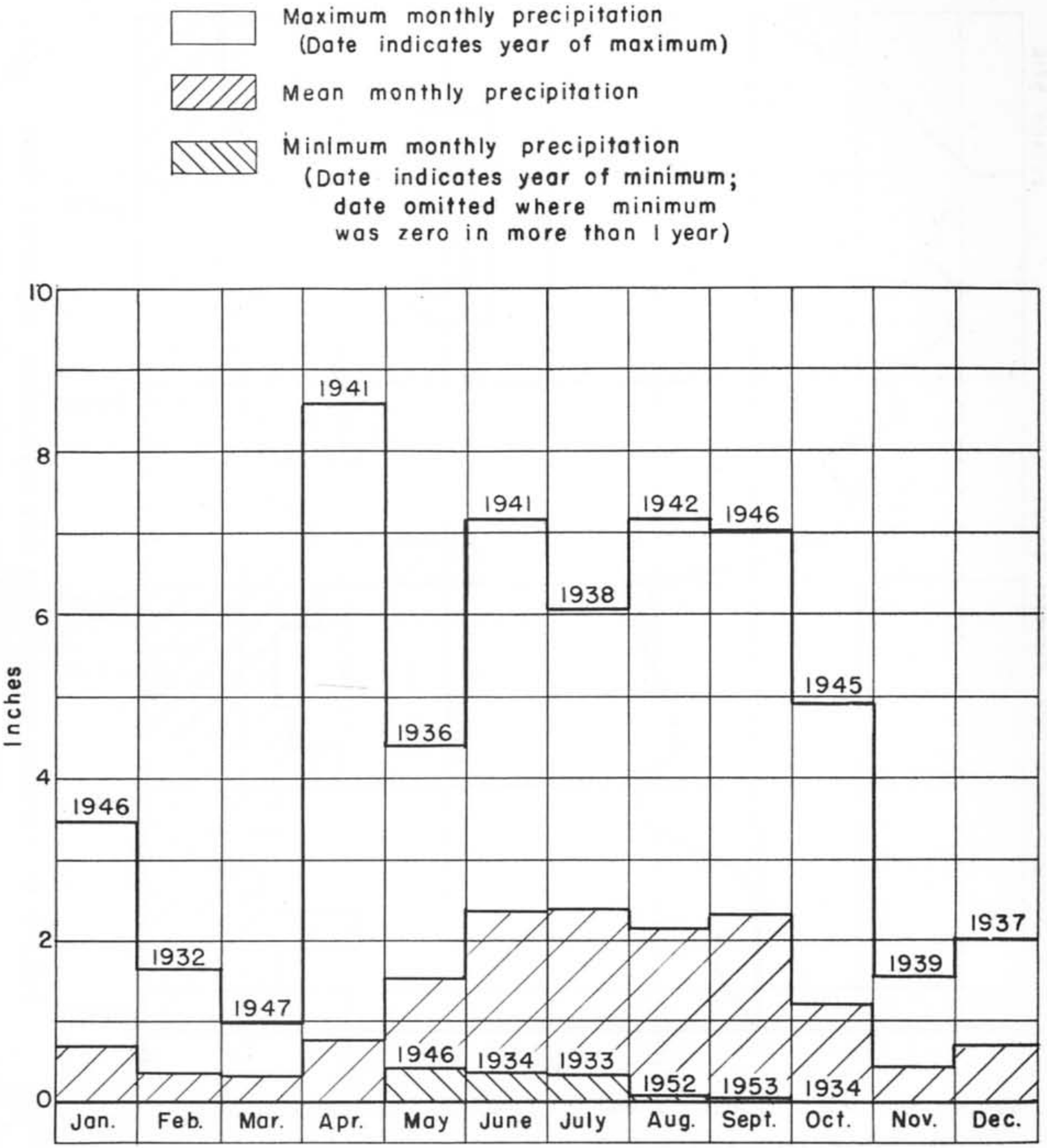

FIGURE 3.-Monthly precipitation at Alpine, Brewster County, Tex., 1930-54. (From records of U. S. Weather Bureau.)

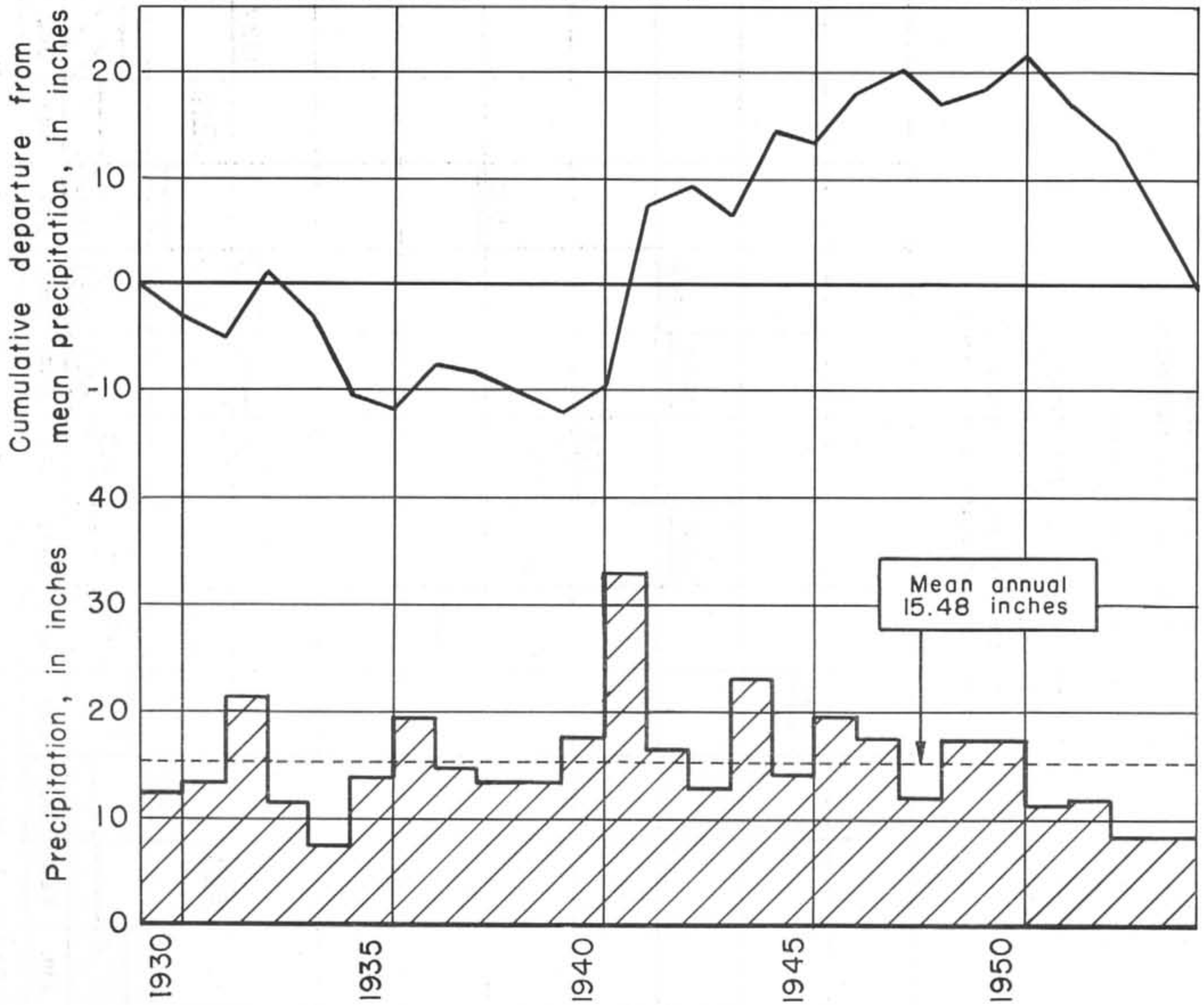

FIGURE 4 .- Annual precipitation and cumulative departure from mean precipitation at Alpine, Brewster County, Tex. (From records of U. S. Weather Bureau.)

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING CHARACTERISTICS

The occurrence and development of ground water depend largely upon geologic factors. Accordingly, pertinent areal and subsurface geologic factors and their influence on the occurrence and development of ground water are described on subsequent pages. The physical properties of exposed rock units and their water-bearing characteristics are summarized in table 2.

Intrusive and extrusive igneous rocks of Tertiary age crop out in the Alpine area. The extrusive rock section has a maximum thickness of about 3,400 feet and is made up of solidified lava flows and interflow beds of explosive debris (pyroclastics). These igneous rocks are an erosional remnant of the Davis Mountains volcanic field.

Moderately permeable basalt layers are the important water-bearing rocks in the Alpine area. Original permeability was created by numerous interconnecting primary openings, such as cavities between flows, shrinkage cracks, gas vesicles, lava tubes, and tunnels, which formed as the lava cooled. The original permeability of the basalt, however, was diminished substantially by alteration and secondary mineralization. In areas of recent faulting additional cracks have been produced by mechanical forces. Basaltic pyroclastic rocks consisting of ash, pumice, cinders, agglomerate, and vent breccia may have been highly permeable prior to consolidation, alteration, or devitrification, but now they compose relatively impermeable interflow beds.

Silicic and intermediate volcanic rocks form extensive flows or blankets of welded tuff(?) whose principal secondary structures are crude columnar joints interconnected to varying degrees. Regional faulting of considerable magnitude locally may create high permeability, but in general these rocks are relatively impermeable. Silicic and intermediate pyroclastic materials are products of highly explosive volcanism and seem to be widespread but not continuous.

Rocks of the volcanic field rest unconformably on an eroded, structurally complex sedimentary terrane comprised of marine stratigraphic units of Paleozoic and Cretaceous age. Surface exposures and subsurface records of marine sedimentary rocks in the Alpine area are meager; therefore the discussion of the marine stratigraphic section is highly generalized. Little is known of the occurrence of ground water in marine sedimentary rocks in the Alpine area.

Marine Sedimentary Rocks

Stratified shale and limestone and subordinate amounts of sandstone belonging to the Permian and Cretaceous systems crop out extensively south and southeast of the Alpine area. Undifferentiated rocks of Cretaceous age that probably belong to the Eagle Ford shale crop out in a small area in the southeastern part of the Alpine area (pl. 1). Marine sedimentary strata do not crop out elsewhere in the Alpine area, and their occurrence in the subsurface cannot be correlated or predicted from available data. McAnulty (1955) determined a stratigraphic section in the Cathedral Mountain quadrangle which locally might be partly or entirely present in the subsurface of the Alpine area. No complete record of this subsurface section was obtained in this investigation.

Table 2.- Rocks exposed in the Alpine area, Texas

System	Epoch or series	Formation	Thickness (feet)	Physical characteristics	Water-bearing characteristics
Quaternary	Recent and Pleistocene	Alluvium	0-130	Boulders, cobbles, gravel, sand, silt, and clay derived from nearby extrusive and intrusive igneous rocks. The coarse-grained materials are widespread on the Alpine plain and at the mouths of canyons. Materials in the upper reaches of streams are fine-grained, predominantly sand, silt, and clay. Bedded and interstitial caliche up to 30 ft thick underlie the Alpine plain.	Contains unconfined ground water in flood plain of Musquiz Canyon and in the debris apron of the Alpine plain. Generally of low permeability but supplies many stock and domestic wells.
Tertiary	Oligocene	Intrusive rocks	-	Dikes, plugs, apophyses, and sills; largely of syenite.	Yields small quantities of water from fractures for stock and domestic use.
		Duff formation of Goldich and Seward (1948)	0-1,390	Chiefly silicic rocks including rhyolite porphyry, trachyte porphyry, and tuff, and beds of tuffaceous sand, silt and clay; contains solidified flows of weathered basalt in upper part.	Lies above water table and is not an aquifer in most of the Alpine area.
		Sheep Canyon basalt of Goldich and Seward (1948), and Cottonwood Springs basalt of Goldich and Seward (1948)	0-1,228	Altered basalt and basalt porphyry; vesicles at the top and bottom of individual flows locally are filled with calcite and silica. Numerous interflow beds of vari-colored tuff and tuffaceous sediments, locally altered to bentonite and bentonitic clay.	Contains unconfined ground water. Principal aquifers are basalt layers in the upper part of the sequence capable of yields up to 240 gpm in areas where there is faulting. Undisturbed basalt in the lower part yields up to 75 gpm. Measured ranges in coefficient of transmissibility are from 5,100 to 17,000 gpd per ft.
	Eocene	Crossen trachyte of Goldich and Seward (1948)	70-230	Gray trachyte and trachyte porphyry; weathers reddish-brown.	Supplies stock wells in southeastern part of the area.
		Pruett formation of Goldich and Seward (1948)	260-555	Tuff, locally calcareous, tuffaceous clay and silt, sandstone and some conglomerate, and fresh-water limestone.	Yields very little water. Some wells reported to be dry or to yield insufficient water for stock. Small yields might be obtainable from sandstones and conglomerate.
	Unconformity				
Cretaceous		Sedimentary rocks	-	Shale and limestone.	Water-bearing characteristics in this area not known.

Shale and limestone of Early Cretaceous age were identified in well D-18 from 703 to 950 feet by R. V. Hollingsworth (1955) of Midland, Tex. on the basis of the following fossil fragments:

Miliolid Foraminifera---------------------------------- 730-735 feet

Charophyta--- 941-943 feet

Hollingsworth also identified limestone and limy shale of Permian age by the following fossils:

Bryozoan fragments at 1,020-1,026, 1,061-1,063, 1,070-1,077, and 1,095-1,104 feet

Brachiopod fragments at 1,055-1,058, 1,061-1,063, 1,070-1,077, and 1,095-1,104 feet

Ostracods (nondescript, smooth) at 1,104-1,109, 1,168-1,172, and 1,181-1,185 feet

The Pure Oil Co. drilled an oil test (No. 1 Massie West) 13 miles southwest of Alpine, encountering rocks of Cretaceous age (Edwards limestone) at 3,370 feet, rocks of Permian age (Guadalupe series (?)) at 3,614 feet, Ordovician rocks (Ellenburger group) at 4,796 feet, and Precambrian granite wash at 5,545 feet. The total thickness of the pre-Tertiary marine section at this location is 2,175 feet.

Extrusive Igneous Rocks

Extrusive rocks consist of lava and pyroclastics which are erupted from volcanoes and deposited on the earth's surface.

Pruett Formation of Goldich and Seward (1948)

The Pruett formation of Goldich and Seward (1948) of Eocene age crops out along the eastern border of the Alpine area and at Barillos dome (pl. 1). A small exposure is in fault contact with the Cottonwood Springs basalt of Goldich and Seward (1948) on the east side of McIntyre Peak in section 39, block 352. The formation, which is the basal member of the extrusive section, lies unconformably on Lower Cretaceous sedimentary rocks. It consists predominantly of indurated ash or tuff, interbedded with lenticular varicolored calcareous, tuffaceous clay and silt, with local lensing of sand and conglomerate. The beds of clay and silt are predominantly pink or light tan. The tuff locally contains one to three lenticular beds of fresh-water limestone.

The thickness of the formation ranges widely owing to the irregularity of the surface on which it was deposited and subsequent erosion of its upper surface before being overspread by flows of the Crossen trachyte of Goldich and Seward (1948). McAnulty measured thicknesses in the outcrop ranging from 260 to 489 feet. Well D-18 encountered 554 feet of tuff.

The Pruett formation is the basal member of the Buck Hill volcanic series of Goldich and Seward (1948). Goldich and Elms (1949, p. 1144) determined from exposures in the Buck Hill quadrangle, south of Alpine in west-central Brewster County, that this volcanic series comprised a rather complete section of extrusive rocks of early Tertiary age. McAnulty (1955, p. 545) found fossils of Eocene age in the Pruett formation and traced the formation into the Alpine area. Vertebrate fossil evidence was used (McAnulty, 1955, p. 556-557) to correlate the tuff with a thick sequence of basal Tertiary tuff and fine-grained tuffaceous sedimentary rocks that crop out in the Tierra Vieja Mountains in northwest Presidio County. The Pruett formation has not been correlated throughout the Trans-Pecos region, but its wide distribution is suspected.

The tuff beds generally have low permeability in the Alpine area; hence, the formation is a poor aquifer, yielding insufficient water even for stock use. Locally some sandy tuff, sandstone, and conglomerate may be more permeable, but the distribution of these beds is erratic and cannot be predicted in the subsurface.

Crossen Trachyte of Goldich and Seward (1948)

The Crossen trachyte of Goldich and Seward (1948) crops out in the eastern part of the Alpine area in a series of broken to rolling hills. A small exposure in fault contact with younger rocks lies just east of McIntyre Peak. The trachyte, which generally is unconformable on the Pruett formation, in places is missing in the section. It consists of extensive, successive flows of solidified trachytic lava with a few thin interflow beds of tuff. The solidified trachyte is typically fine-grained and dense; locally it is sparsely porphyritic, containing phenocrysts of glassy feldspar. The rock is gray in fresh exposures but weathers rusty brown--the color of extensive outcrops in the area. Outcrop thicknesses ranging from 71 to 275 feet were measured by McAnulty, and 78 feet of the trachyte was encountered in well D-18 and about 33 feet in well H-5. The trachyte thins northward, and its entire thickness is penetrated by wells within a few feet of the surface in the northeastern part of the area.

The Crossen trachyte was described and named by Goldich and Seward (1948, p. 19) from a massive porphyritic trachyte that caps Crossen Mesa in the north part of the Buck Hill quadrangle. Correlation between the type area and exposures in the Alpine area was established by McAnulty (1950, p. 13).

The water-bearing characteristics of the Crossen trachyte are poorly known in the Alpine area. Stock wells penetrated trachyte layers in the northeastern part of the area but encountered no water because the formation lay above the water table. Where the formation lies beneath the water table, as at well H-5, sufficient water for stock can be obtained from wells.

Sheep Canyon Basalt of Goldich and Seward (1948) and Cottonwood Springs Basalt of Goldich and Seward (1948)

In the Cathedral Mountain quadrangle, which includes the southern edge of the Alpine area, McAnulty (1955) mapped three distinct stratigraphic units which had been named and described by Goldich and Seward (1948). They are, in ascending order, the Sheep Canyon basalt, the Potato Hill andesite, and the Cottonwood Springs basalt. Because the Potato Hill andesite of Goldich and Seward could not be recognized north of the Cathedral Mountain quadrangle, McAnulty (1950) mapped the entire sequence in the Alpine quadrangle as a single rock unit. McAnulty (1955, p. 557) considered the basalt sequence to be of Oligocene age because of the pronounced erosional unconformity between the basalt and the underlying Crossen trachyte.

The Sheep Canyon and the Cottonwood Springs basalt are undifferentiated in the Alpine area. They consist of a sequence of predominantly basic solidified lava containing numerous lenticular interflow beds of tuff and tuffaceous sediment, which crops out in the southeastern part of the Alpine area and in small isolated hills along the west side of the Alpine plain. The distribution of lava flows that compose the lower part of the sequence was controlled by a well-developed northward-trending drainage. An erosional unconformity of considerable relief exists between this basalt sequence and the underlying Crossen trachyte, and locally the basalt sequence directly overlies the Pruett formation.

The Sheep Canyon basalt and Cottonwood Springs basalt consist of basalt and minor amounts of trachy-basalt, trachy-andesite, and andesite. Individual layers are predominantly pahoehoe basalt. In general, the basalt is highly altered and decomposed and easily broken, except well within the interior of the individual solidified flows. Owing to the degree of alteration, vesicular zones in the basalt are difficult to determine and thus are poor criteria for finding the tops and bottoms of individual flows. Many of these zones contain amygdules (vesicle fillings) of quartz, chalcedony, jasper, chlorite, and calcite, all products of secondary mineralization.

The basalt generally is medium to fine textured but locally is porphyritic, containing large phenocrysts of altered feldspar. The basalt in the lower part of the sequence is greenish-black and contains considerable olivine, whereas in the upper part of the sequence it is gray and dark gray. Dense phases weather dark brown and vesicular phases weather reddish-brown. The most highly altered basalt exhibits a subparallel arrangement of plagioclase feldspar crystals that imparts a speckled schistose appearance to the rock. Drill cuttings of this altered rock are difficult to distinguish from some of the fine-textured intrusive rocks in the Alpine area. Lenticular interflow beds consist of tuff or indurated ash, locally devitrified to bentonite or reworked in beds of tuffaceous clay and silt. Their predominant color is brick red; however, the bentonite beds are red, green, brown, or white.

The thickness of the Sheep Canyon basalt and Cottonwood Springs basalt ranges between wide limits. They are thickest where they occupy old drainage-ways. McAnulty (1950) measured a complete section of 1,228 feet extending from the southeast quarter of section 37, block 9, GH&SA Railroad Company to the west side of section 27, block 352. He suggested a thickness of 410 feet at well D-55 from an inspection of the driller's log, but it seems likely that only a part of the section was present or recognized by the driller. The sequence was not completely penetrated in any of the test holes in this investigation, but the writers infer from all available data an average thickness between 900 and 1,000 feet. The thickness of individual basalt layers ranges from a few feet to about 50 feet, whereas the thickness of the interflow beds ranges from a few feet to 200 feet.

The water-bearing properties of the basalts vary with rock type. The basalt layers, which are the only rocks in the area that are capable of supplying enough water for municipal demands, have a wide range in permeability. Interflow beds of tuff, tuffaceous clay, and silt are lenticular and less permeable than the basalt layers. Successful drilling sites are difficult to predict because potential aquifers are lenticular.

Basalt layers in the lower part of the sequence have generally low permeability and in most places yield less than 75 gpm to wells. Many wells produce less than 15 gpm. Well D-51, however, is an exception, producing a reported 200 gpm with considerable drawdown. The well produces from basalt in which the permeability has been increased locally by fractures associated with the Alpine Hill intrusion. Numerous wells, including municipal wells, in and around Alpine produce from the lower part of the Sheep Canyon basalt and the Cottonwood Springs basalt. The wells are of small diameter and are largely uncased. Initial yields seemingly decline with continued pumping, probably because of well caving.

The most prolific aquifers in the basalt sequence are the upper basalt layers, which originated as aa lava flows and contain brecciated zones whose moderately high permeability is due to faulting. Well C-28, which produces from upper basalt layers, has the highest specific capacity (discharge in relation to drawdown) of any well in the Alpine area.

Duff Formation of Goldich and Seward (1948)

The Duff formation of Goldich and Seward (1948) crops out extensively in the western half of the Alpine area (pl. 1). It forms most of the rugged erosional surface of the Davis Mountains and this is well exposed in cliffs. Extrusive volcanic rocks younger than the Duff formation crop out in the southwestern part of section 6, block WJG8, TC Railroad Survey. These rocks belong to the Tascatol formation of Goldich and Seward (1948) and the Rawls basalt of Goldich and Seward (1948)(McAnulty, 1955, p. 555-556). Owing to their scant occurrence in the area and their hydrologic unimportance, they are included with the Duff formation in this report.

The lower part of the Duff formation consists of widespread layers of silicic tuff in various stages of alteration. Intercalated in the predominantly tuffaceous section are small flood-plain deposits of tuffaceous clay, silt, sandstone, and boulder conglomerate. The tuff and tuffaceous sediments are gray, tan, pink, and red. The formation is capped extensively by columnar-jointed porphyritic solidified flows which range in mineral composition from that of rhyolite to trachyte and generally may be classified as felsite porphyry. The rocks are brecciated near centers of extrusion and intrusion in the vicinity of Paisano and Twin Peaks and Barillos dome (Lewis, 1949). The felsite porphyry contains many large phenocrysts of feldspar. The felsite is predominantly various shades of gray when freshly broken; however, greenish-black felsite crops out in the southwestern part of the Alpine area. Extensive outcrops weather to a light brown.

McAnulty (1950) measured thicknesses of the Duff formation in outcrops in the Alpine area ranging from 425 to 1,390 feet. He mapped and described the formation in the Cathedral Mountain quadrangle (McAnulty, 1955) in detail and made minor modifications of the original descriptions by Goldich and Seward (1948) in the Buck Hill quadrangle.

The Duff formation lies above the water table in most of the Alpine area, and records were obtained of only two stock wells (DD-22 and DD-24) which obtain water from the formation. Little is known of the water-bearing properties of the formation.

Intrusive Igneous Rocks

Intrusive rocks are formed by the solidification of molten matter beneath the surface of the earth. Most of the intrusive rocks in the Alpine area were formed in vents and fissures and in many places have been exposed by erosion. Owing to their resistance the intrusive rocks comprise the core or backbone of the Davis Mountains and form Alpine and Sul Ross Hills. Also, irregular sills and apophyses were emplaced laterally in and between rock units of the volcanic rocks and marine sedimentary rocks and do not crop out.

McAnulty (1950, p. 19) assigned an age of Oligocene or younger to the intrusive rocks because the youngest extrusive formation in the Alpine area is contorted and displaced at the margins of the intrusive masses. The effects of intrusion are widespread in the Alpine area and include alteration and secondary mineralization in volcanic and marine sedimentary rocks.

There is some uncertainty about the rock type or types that characterize the intrusive masses. Rosenbusch and Osann (1923) used the name paisanite for the rocks that crop out at the base of Paisano Peak. These rocks are grouped as rhyolites by Grout (1932), as alkali aplites by Rosenbusch and Osann (1923), and as micrograinite or keratophyre by Holmes (1920).

In general the intrusive rocks have low permeability, and wells penetrating fractures in the rocks produce only enough water for stock and domestic use. The relatively impermeable intrusive rocks retard the movement of ground water and cause a change in the gradient of the water table. The intrusive rocks also force ground water in alluvial valley fill to come to the surface and create short perennial reaches in Musquiz Canyon, at the confluence of Barillos and Musquiz Creeks.

Alluvium

Alluvial deposits of Quaternary age crop out extensively on the Alpine plain, the Marfa plateau, and the flood plains of the principal streams in the Davis Mountain (pl. 1). The materials are largely unconsolidated and range in texture from clay to boulder gravel. The alluvium consists of subrounded and angular fragments of all the volcanic-rock types of the Davis Mountains volcanic field, whence it was derived. Zones of lime caliche ranging up to 30 feet in thickness are present in thin beds or interstitially in the upper part of the gravel, forming a shallow hardpan throughout much of the Alpine plain. The coarse alluvial materials form at the edges of the Alpine plain owing to reduced gradients and carrying power of the streams. They are poorly sorted, having been transported only short distances.

The Alpine plain thus is largely a debris apron ranging in thickness from a featheredge to 130 feet. The range in thickness is caused largely by relief developed on an erosional surface of the Sheep Canyon basalt of Goldich and Seward (1948) and the Cottonwood Springs basalt of Goldich and Seward (1948). The alluvium generally is thinner in the valleys in the Davis Mountains. Test drilling in Musquiz Canyon showed alluvial thicknesses ranging from 24 to 71 feet.

The alluvial deposits have an overall low permeability owing to the poor degree of sorting and the presence locally of a hardpan formed by bedded and interstitial caliche. Well C-31 penetrated 64 feet of saturated gravel but yielded only about 15 gpm. Many domestic and stock wells in the Alpine area tap saturated alluvial deposits. The domestic wells in Alpine produce less than 10 gpm, but the low yield results in part from the small diameter of the wells. Two test wells in the alluvial deposits at Musquiz Canyon produced less than 45 gpm by bailer. Well DD-3 penetrated about 49 feet of saturated gravel, but produced only about 43 gpm with an estimated drawdown of about 49 feet. The alluvial deposits at the mouth of Musquiz Canyon contain little caliche and the apparent low permeability is due primarily to poor sorting.

GEOLOGIC STRUCTURE

Geologic structure applies to the physical attitudes of rock formations, their physical relationship to each other, and the displacement of formations along faults. The structural features thus formed are exposed on the surface or are inferred from subsurface data, and they are evaluated as to their possible effect upon the occurrence of ground water.

Regional and Local Dip of Beds

The intrusive core of the Davis Mountains is, more or less throughout its linear extent, a structural barrier between the stratified rocks of the Del Norte region to the southeast, and those in the subsurface of the Marfa basin. McAnulty (1955, p. 563) has shown a significant reversal of regional dip at the east margin of McIntyre Peak and a syncline lying to the east. The igneous core thus forms the west margin of the north-trending assymetrical syncline which has complex interior features, including uplifted marine sediments locally intruded and isolated by igneous sills and apophyses. The regional dip of sedimentary beds of Permian and Cretaceous age was determined by McAnulty (1955, p. 562-563) from outcrops in the Del Norte Mountains southeast of the Alpine area. He measured west regional dips that range from 5 to 10 degrees and local dips as high as 35 degrees.

The regional dip of the volcanic rocks is west and northwest from the eastern part of the Alpine area toward the Marfa basin. In the eastern part of the Alpine area, the dip is about 4 to 6 degrees, and in the western part it is about 2 to 3 degrees. The regional dip is steeply reversed or deflected at the margins of intrusive masses. In general this structural effect is local, and only a few hundred feet beyond the margin of the intrusive there is no apparent change in regional dip. Some intrusions seemingly tilted the beds on one or two sides but merely pierced the beds on other sides, forming a "trap door" (McAnulty, 1950, p. 50) structural feature.

Unconformities

A major unconformity in the Alpine area separates the volcanic-rock sequence of Tertiary age from marine sedimentary rocks of Cretaceous age and older. It has considerable relief in places owing to the complex structural history of the sedimentary sequence, including its invasion by intrusives and extensive erosion of the composite surface before burial by volcanic rocks. The Pruett formation of Goldich and Seward (1948) commonly forms the upper unit of the unconformity, and the lower unit may be one of several formations of Permian or Cretaceous age. Locally the unconformable contact may be occupied by an igneous sill or apophysis.

Unconformities separate all the volcanic formations and have considerable relief where periods of erosion intervened between periods of volcanic activity. Within individual formations there are numerous unconformities--for example, solidified basalt flows are unconformable on beds of tuff, tuffaceous silt, or clay. Lithologic units are apt to be of small areal extent, therefore, and uniform ground-water conditions and well yields cannot be expected over a wide area.

Faults

The volcanic rocks are broken by normal faults caused by crustal adjustment during and after the period of volcanic activity. Only a few of the faults are traceable on the surface, and most are inferred from abrupt lithologic changes. The faults are commonly near centers of extrusion. The Alpine fault, which predates the Tertiary volcanism, is the largest fault known in the Alpine area. It trends between Alpine and Sul Ross Hills, thence north and northeast along Alpine Creek. Its location on plate 1 is approximate, however, because it is covered by Recent alluvium. The log of well D-18 suggests that limestones of Permian and Cretaceous age were dragged upward by a laccolithic intrusion encountered at 1,282 feet.

Faults that displace basaltic rocks apparently are responsible for the above-average yield that was obtained from wells C-22 and C-28 in the Sunny Glen area. Additional test wells should be located along the fault trends in this area.

GROUND WATER

Ground water in the Alpine area occurs in both confined and unconfined aquifers. When an unconfined aquifer is tapped by a well, the water in the well will stand at the same level at which it was encountered in the formation. The water table is defined as the level at which unconfined water stands in nonpumped wells. A confined aquifer is one in which ground water is confined between relatively impermeable materials. When a confined aquifer is tapped by a well, the water in the well will rise above the level at which the water is encountered in the formation.

The most important ground-water supply in the Alpine area is unconfined in the volcanic rocks and locally in alluvial deposits. Confined ground water occurs in marine sedimentary rocks that lie at unknown depths beneath the volcanic rocks. The depth and extent cannot be predicted with any reasonable degree of certainty from available information, owing to complexities wrought by volcanic intrusion. It would be very costly to determine the depth to and extent and water-bearing characteristics of the marine sediments. Therefore, the investigation for this report was concerned primarily with the source, details of occurrence, and chemical quality of the unconfined ground water.

Hydraulic Characteristics

To evaluate the ground-water resources of an area, it is necessary to determine the hydraulic characteristics of the saturated rocks, or aquifers as they are called. Brown and Stallman (Knowles, 1952) call this the application of the theory of ground-water hydraulics, which they define for practical purposes as "the process of combining observed field data on water levels, their fluctuations, natural or artificial discharges, etc., with suitable equations or computing methods to find the hydraulic characteristics of aquifers." If the hydraulic characteristics are evaluated in accordance with geologic conditions, it is possible to establish the design of well fields, determine optimum well yields, and predict water-level trends in response to pumping. The most significant hydraulic characteristics of an aquifer are (1) its ability to store water, expressed as the coefficient of storage, and (2) its ability to transmit water, expressed as the coefficient of transmissibility. Both coefficients have numerical values that can be determined by field methods.

The coefficient of transmissibility is the number of gallons of water, at the prevailing temperature, that will flow in 1 day through a vertical strip of the aquifer 1 foot wide and of a height equal to the full thickness of the aquifer, under a hydraulic gradient of 1 foot per foot. The unit is gallons per day (gpd) per foot. It is directly proportional to the ability of the formation to yield water to wells, if all other conditions are equal. The coefficient of storage of an aquifer is defined as the volume of water it releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

Pumping tests were made on four wells (figs. 5, 6, 7, and 8) to determine the hydraulic characteristics of the Sheep Canyon basalt and the Cottonwood Springs basalt. Water-level data were collected from the pumping wells during drawdown and recovery tests and the coefficients of transmissibility were computed (table 3) by the nonequilibrium method of Theis (1935) modified by Cooper and Jacob (1946), and by the recovery method of Theis (Wenzel, 1942). It was not possible to compute the coefficient of storage because observation wells were not available during the tests.

Table 3. Coefficients of transmissibility in the Alpine area, Texas.

Well no.	Coefficient of transmissibility (gpd/ft)	Type of test
D-13	8,200	Drawdown
D-22	5,100	Drawdown
C-22	16,000	Recovery
C-28	17,000	Drawdown

Pumpage and water-level records from other wells tapping the Sheep Canyon basalt and the Cottonwood Springs basalt in the Alpine area indicate that the average coefficient of transmissibility of the formation may be much lower than even the lowest figure reported above, and apparently varies directly with the thickness of saturated basalt penetrated. The highest coefficient of transmissibility obtained in the basalts was at well C-28 in Sunny Glen, which was drilled along a fault trend and penetrated about 264 feet of saturated basalt. The importance of faults is reflected in figure 8, where data obtained toward the end of the test on well C-28 plot below the straight line which represents the trend of water levels in an aquifer of infinite areal extent. The apparent cause for the departure is a sharp decrease in transmissibility laterally from the well. Well logs, pumping records, and water-level data indicate that the basalt is less permeable south and east of well C-28.

The maximum potential yield in the less permeable parts of the aquifer can be realized by the construction of large-diameter wells that are properly screened and gravel packed.

Ground-Water Recharge

Precipitation, the source of all natural ground-water recharge, either enters the soil, runs off in streams, or is evaporated. Part of the water that enters the soil is retained there and subsequently is consumed by evapotranspiration. Excess water percolates below the belt of soil moisture to the water table and thus recharges ground-water reservoirs.

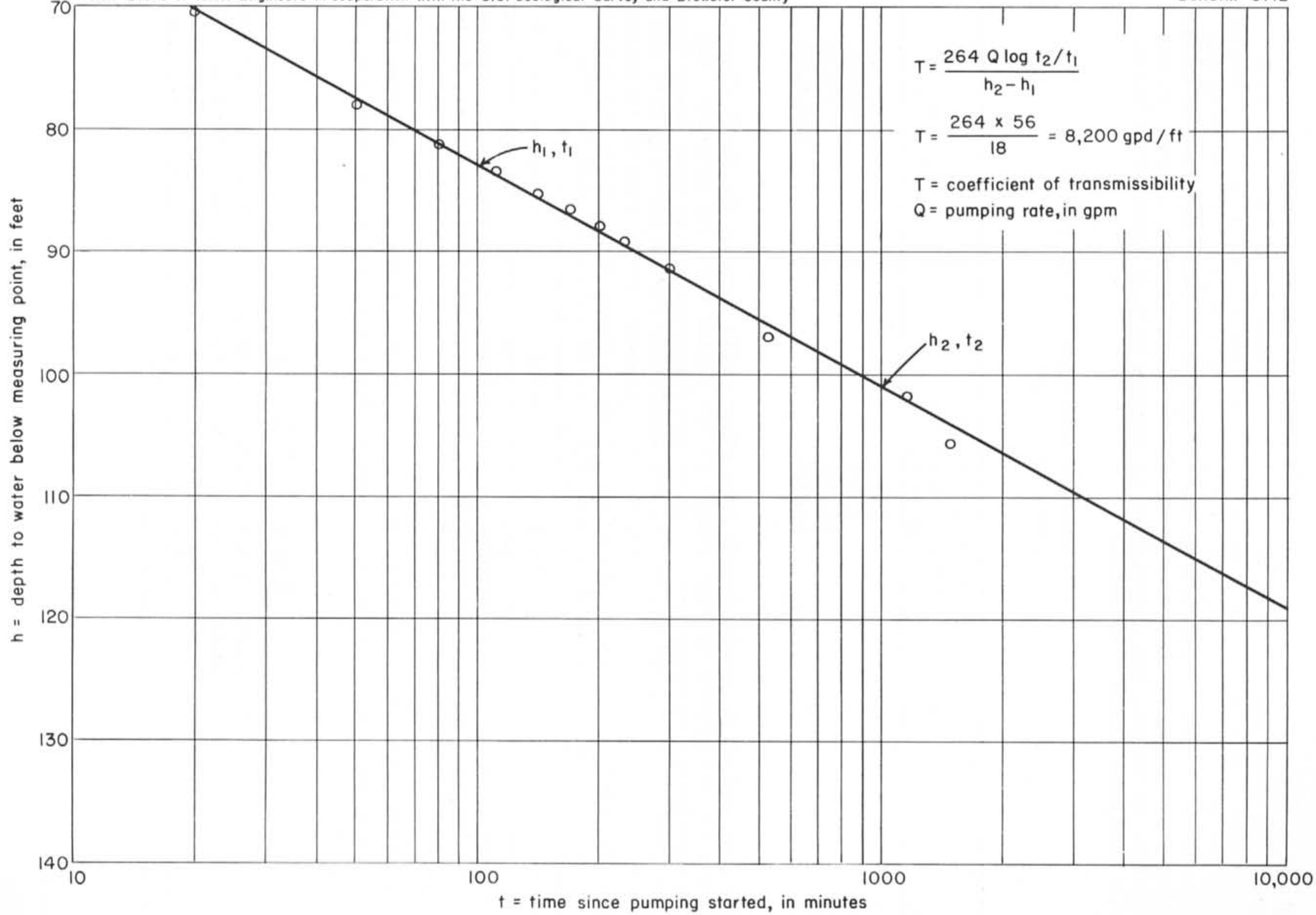

FIGURE 5. - Drawdown of water level in well D-13, March 8, 1955.

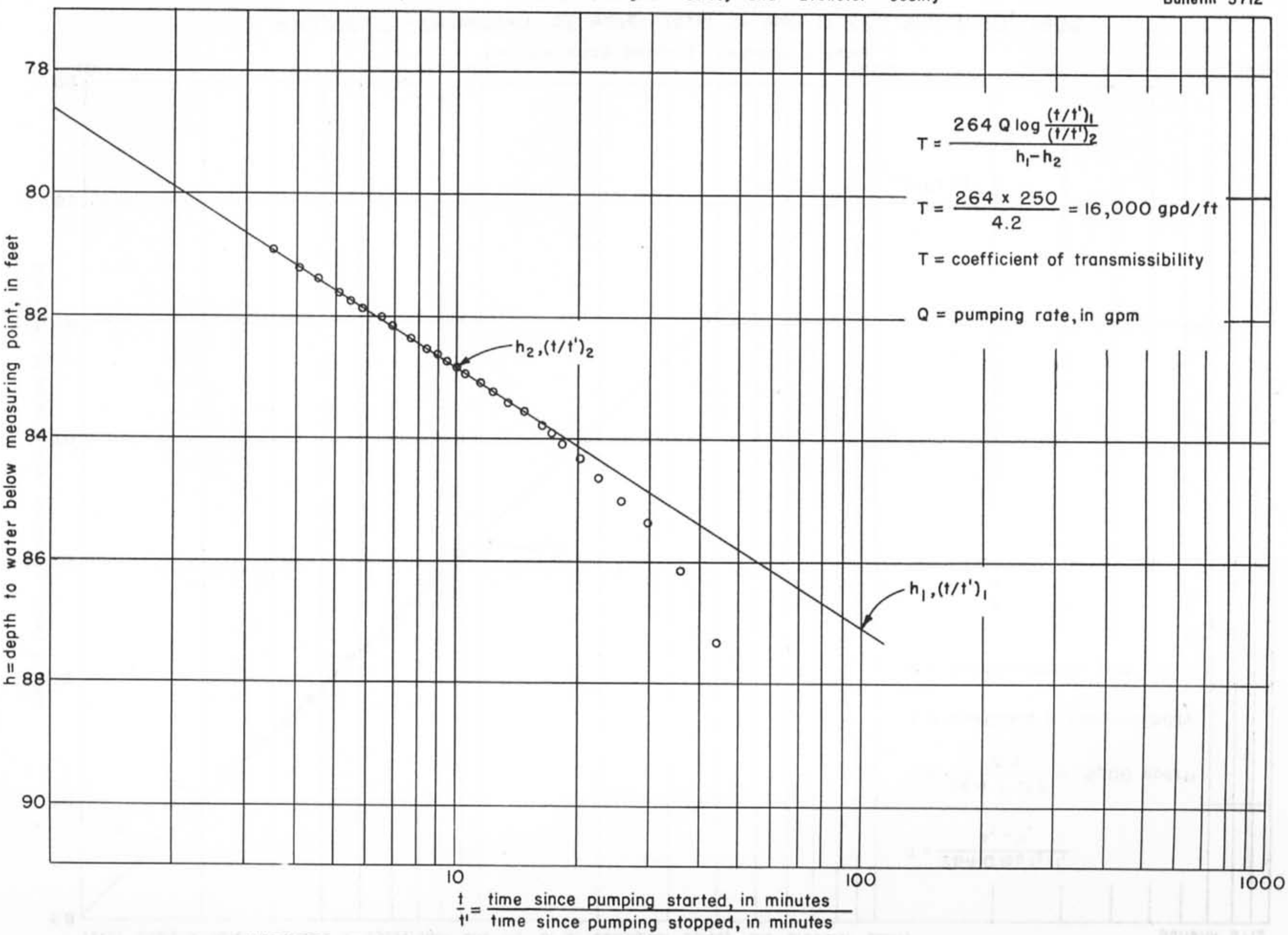

FIGURE 6 - Recovery of water level in well C-22, March 9, 1955.

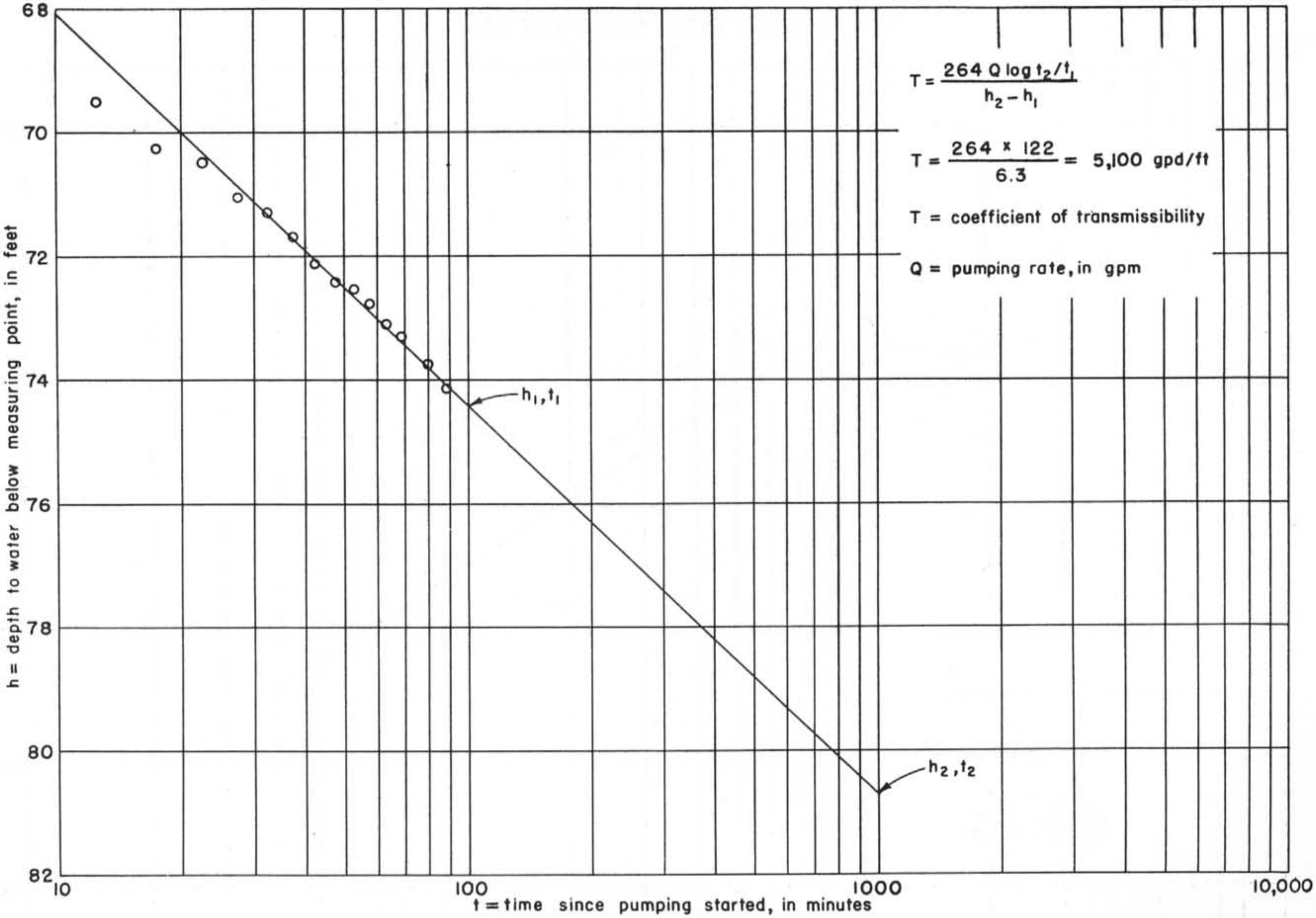

FIGURE 7. - Drawdown of water level in well D-22, March 10, 1955

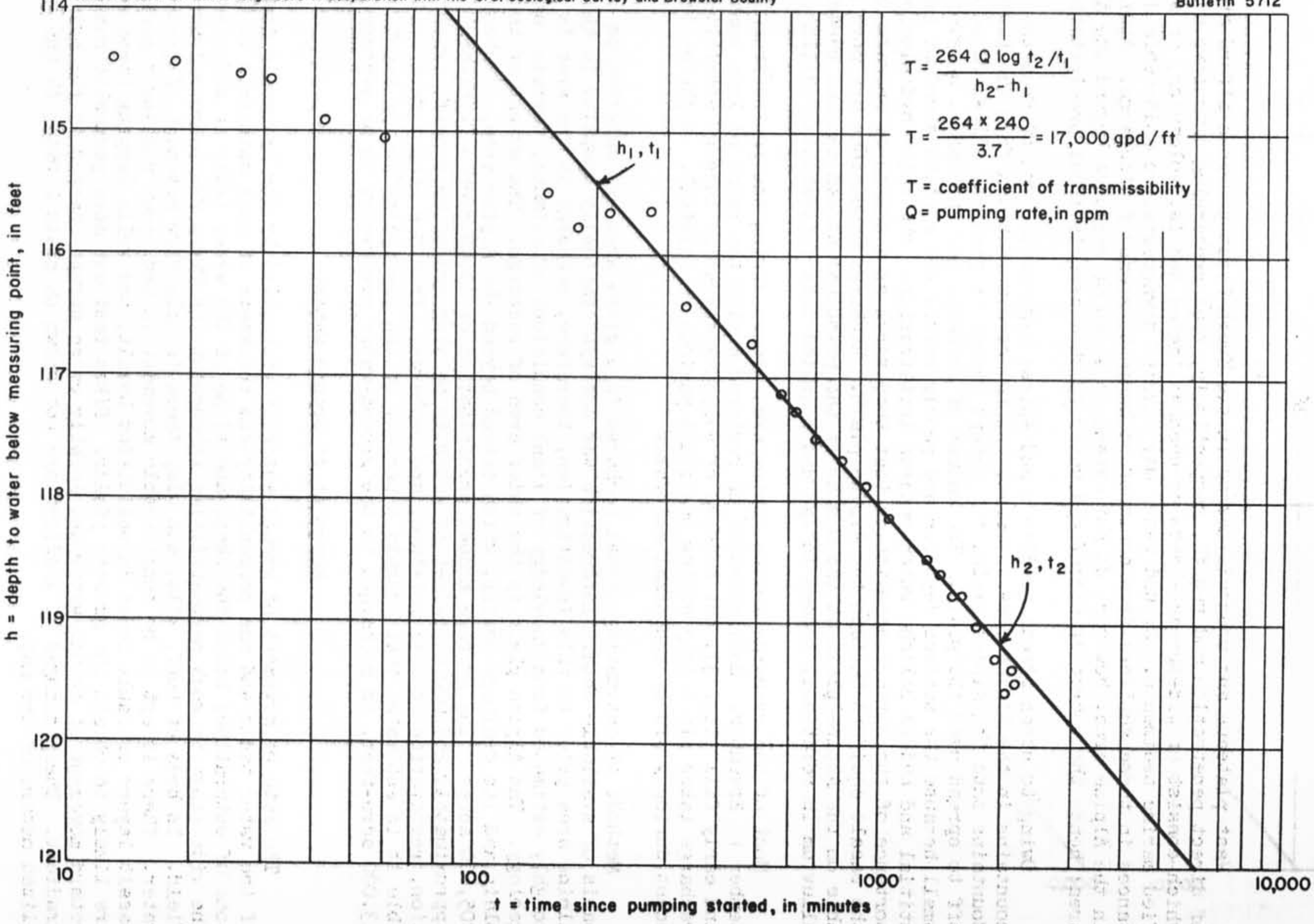

FIGURE 8. - Drawdown of water level in well C-28, August 8, 1955

Vast plateaus and mountain masses in the Trans-Pecos province afford areas of direct penetration and runoff, respectively, thus recharging extensive aquifers which consist of widespread sheets of unconsolidated debris, volcanics, or stratified marine sediments. Ground water may migrate downgradient considerable distances in these aquifers from areas of recharge to areas of discharge. Aquifers in the Alpine area, however, do not extend to areas of recharge beyond the Alpine area; hence the source of unconfined water in this area is local precipitation.

Owing to steep stream gradients and sparse vegetation, runoff from the mountains in the Alpine area is rapid. As the streams debouch from the Davis Mountains onto the Alpine plain, the abrupt change in gradient allows flood runoff to spread over the plain. The amount of recharge per unit area, however, is small because the surface deposits are poorly sorted and contain abundant interstitial and bedded caliche which retards infiltration. The chief hydrologic importance of the surface deposits is that they serve as a source of recharge to the basalt aquifers beneath the Alpine plain. Recharge conditions are more favorable on the Alpine plain at the mouths of the principal stream canyons because the alluvium is relatively recent in age and contains less interstitial caliche.

Most of the recharge in the Alpine area occurs during the period from September to November. Soil moisture is restored during the rains of late summer and early fall (fig. 3), but because of evapotranspiration losses, effective recharge takes place only during sustained periods of rainfall. Recharge is scant during years of subnormal rainfall.

Methods of estimating annual recharge in a given area are selected on the basis of available data. Information was not systematically compiled in the Alpine area prior to this investigation; therefore, recharge in the area is roughly estimated from knowledge of local conditions of climate, terrain, and geology. The Alpine plain is the chief area of recharge. The extent of the plain and its drainage basins, which extend beyond the Alpine area, is about 205,400 acres. The average annual precipitation of 15.48 inches furnishes approximately 265,000 acre-feet of water to be disposed of by runoff, evaporation, restoration of soil moisture, and recharge. From the meager data available it is estimated that roughly 5 percent of the precipitation, or about 13,000 acre-feet, is recharged to the ground-water reservoirs in an average year.

Movement of Ground Water

The rate of movement of ground water is controlled by the hydraulic gradient of the water table and the permeability and thickness of rock materials in the zone of saturation; hence the shape and slope of the water table is affected by the wide range in rock permeabilities throughout the Davis Mountains volcanic field. In beds of tuff, silt, and clay there is only slow movement of ground water. There is apt to be considerable movement in the upper and lower parts of basalt layers or fault zones in solidified basalt, and wells tapping these zones are likely to obtain the greater yields. Dikes that cut more permeable rocks retard movement of ground water and locally cause abrupt changes in the hydraulic gradient. These changes of gradient are not shown on plate 2 owing to the generalized nature of the map.

Ground water moves from areas of recharge to areas of discharge. In the Alpine area movement is in the direction of major surface drainage; thus it is generally eastward and northward from ground-water divides in the Davis Mountains (pl. 2). The movement of ground water in the broad Sunny Glen Canyon extends down the hydraulic gradient toward the Alpine plain from an inferred ground-water divide at the east edge of the Marfa plateau. The intrusive core of the Davis Mountains is an effective hydrologic barrier between the two physiographic provinces.

Ground-water movement is toward the general vicinity of Alpine from the west and south. Prior to accelerated ground-water development at Alpine and the sustained drought beginning in 1950, the natural discharge point for much of the ground water was Kokernot Springs, which in 1947 had an estimated discharge of 400 gpm but in 1955 were dry.

Ground-Water Discharge

In the Alpine area ground water is discharged largely from wells. Minor amounts are discharged from springs, and a very small amount is discharged by evapotranspiration.

Available records show that for the period April 1954 through September 1955 the average rate of discharge from 11 municipal wells at Alpine (table 6) was 523,000 gpd. About 288,000 gpd of the total average discharge has been supplied from well C-22 since July 1955. Consequently, production from well C-22 made possible the retirement or standby status of all old municipal wells except well D-51, whose initial reported yield has been sustained.

Within the city limits there are 300 to 400 domestic wells, production from which has alleviated the problem of municipal supply and distribution. They are equipped with submersible turbine or cylinder pumps, powered by electricity or wind. Individual wells produce less than 10 gpm, but the aggregate discharge is substantial. Although pumping from these domestic wells has caused a decline of the water table, the water is used beneficially and no longer flows from Kokernot Springs, a beautiful but highly impractical feature in this arid region.

Discharge by municipal and domestic wells in conjunction with sustained drought thus is responsible for the decline of the water table in the immediate vicinity of Alpine. The aggregate discharge has not met peak summer demands (estimated at about 800,000 gpd), and by 1955 the water-supply situation at Alpine had reached a critical stage.

QUALITY OF GROUND WATER

The quality of the ground water in the Alpine area, in general, is excellent for domestic, municipal, industrial, and irrigation use.

Laboratory analyses (table 9) indicate that the water characteristically contains rather low concentrations of dissolved solids, ranges widely in hardness, and contains beneficial to somewhat undesirable amounts of fluoride. Analyses of water samples from 18 wells and springs are given in table 9; the analyses are summarized in table 4 and are illustrated graphically in figure 9.

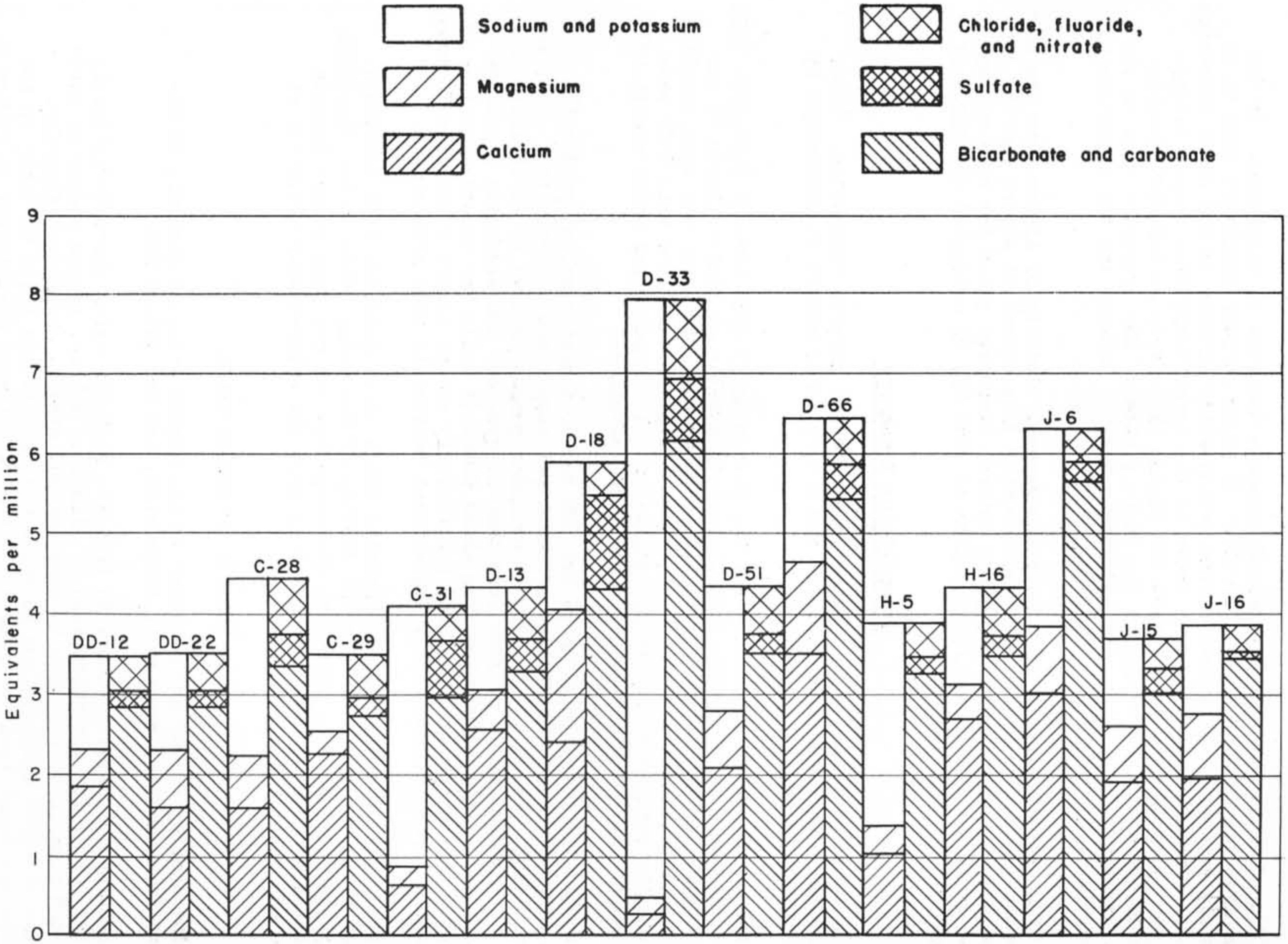

FIGURE 9. - Graphic representation of analyses of ground water in the Alpine area, Texas.

Suitability of Water for Municipal Use

Standards of quality for drinking water used on interstate carriers have been established by the United States Public Health Service (1946). The dissolved solids, sulfate, and chloride content of the ground water in the Alpine area (table 9) are within the recommended maximum concentration limits.

The fluoride content of water from 15 representative wells ranged from 0.8 to 2.4 ppm. Samples from three city wells contained 1.6, 1.6, and 2.0 ppm of fluoride. The sample from well C-28 in the Sunny Glen area contained 2.4 ppm of fluoride. Drinking water in which fluoride exceeds 1.5 ppm may cause permanent mottling of the enamel of human teeth if the water is used habitually during the calcification and formative stage of the teeth (Dean, 1936); however, fluoride in concentrations of about 1.0 ppm tends to reduce tooth decay.

The hardness of the ground water ranged from 22 to 232 ppm. The hardness is largely carbonate hardness, however, and thus the water can be readily softened by employing the lime process of treatment.

The silica concentration in the ground water ranged from 20 to 61 ppm--somewhat greater than is generally found in ground water. This chemical characteristic reflects the environment of silicic and intermediate volcanic rocks. Silica is important especially in waters used for certain industrial purposes because it contributes to the formation of boiler scale.

Table 4. Range in concentration of chemical constituents in ground water in the Alpine area, Texas.
(Mineral constituents in parts per million)

Constituent or property	Maximum	Minimum
Silica (SiO_2)	61	20
Calcium (Ca)	70	12
Magnesium (Mg)	20	2.2
Sodium and potassium (Na+K)	75	8.8
Bicarbonate (HCO_3)	345	72
Sulfate (SO_4)	57	4.8
Chloride (Cl)	24	6.2
Fluoride (F)	2.4	.8
Nitrate (NO_3)	8.5	.2
Dissolved solids	389	123
Hardness as $CaCO_3$	232	42
Percent sodium	80	23
Specific conductance (micromhos at 25°C)	588	158
pH	8.5	7.5

GROUND-WATER EXPLORATION

Municipal Water-Supply Development

Municipal test wells (table 5) drilled during the period 1923 to 1954 inclusive are within an area of about 2 square miles. (See pl. 1.) Records indicate that 32 wells were drilled with a total reported footage of about 15,625 feet. In early 1955, 11 of the wells were being pumped intermittently. Their combined yield is less than 15,000,000 gallons per month, which is insufficient for municipal demand during the summer.

Ground-water exploration for a municipal supply at Alpine began in 1921, and the first well (D-48) was completed in 1923. By 1929, 5 wells had been drilled but of these only 2 (D-50 and D-51) are currently in use. During the next 10 years only 2 wells were drilled, and they were not used because of insufficient yield. Interest in municipal ground-water development was revived in 1939 owing to the sustained drought of the 1930's and the increasing demand for water caused by the expanding population. Upon geological advice (Baker, 1939), a deep test (D-55) was begun in 1939 and abandoned in 1942 at a reported depth of 2,700 feet. During 1942-43, 4 wells were completed, but none had yields considered sufficient for municipal use.

Municipal pumping increased sharply after World War II. During the period 1949-51, inclusive, 9 wells were drilled, 6 of which were equipped with pumps. The program of exploration included a reconnaissance study of the geology of the Alpine area by W. N. McAnulty. Municipal demand remained unsatisfied, however, and during 1953-54 eight wells were drilled. Only 2 of the wells (C-42 and D-13) were considered successful. In July 1955 water for municipal use was obtained from well C-22, a privately drilled well, and in February 1956 the city bought well C-28, which was a test hole drilled during this investigation.

As of October 1956, six wells (C-22, C-28, D-12, D-42, D-47, and D-51) were in use or on a standby basis. During October 1956 the average production was about 516,000 gpd.

The preceding record of ground-water exploration substantiates the conclusion that only small yields can be expected from the extrusive rocks that underlie Alpine (Lang, 1949). It appears that the maximum potential of the aquifer at Alpine can be obtained by means of large-diameter wells that are gravel packed and properly screened. The yield of any well probably will not exceed 100 gpm and may be as low as 50 gpm. However, artificially gravel-packed wells would obtain the most dependable production from the altered basaltic materials of the aquifer.

Table 5. Municipal wells drilled at Alpine, Brewster County, Tex. (1923-54, inclusive)

Well		Year completed	Reported depth
City no.	Report no.		
1	D-48	1923	300
2	D-49	1924	173
3	D-50	1924	443
East Well 7	D-42	1927	700
7a	Destroyed	1927(?)	585
4	D-51	1929	700
Scout well	D-52	1936	601
23	D-15	1937	293
6a	Destroyed	1939	580
College well	D-35	1940	1,400(?)
Baker test	D-55	1942	2,700
20	Destroyed	1942	350
5	Destroyed	1943	287
5a	Destroyed	1943(?)	--
Henderson test	D-8	1949	1,050
Funk well	C-36	1949	500
Parker well	D-9	1949	300
Moss well	D-53	1950	650
Ball park well	D-16	1950	300
Golf course well	D-22	1950	300
Micou well	D-47	1951	300
Santa Fe well	C-51	1951	400
Lane test	Destroyed	1951	300
Cowell well	C-42	1953	356
East no. 1	D-43	1953	200
East no. 2	D-45	1953	202
East no. 3	Destroyed	1953	200
East no. 4	Destroyed	1953	200
Kokernot no. 1	D-13	1954	280
Kokernot no. 2	D-12	1954	250
Kokernot no. 3	D-11	1954	325
Kokernot no. 4	D-14	1954	350
Daugherty no. 1	C-22	1953	361
Terry no. 1	C-28	1955	592

County Test-Drilling Program

In 1955 Brewster County financed 1,844 feet of test drilling for geologic and hydrologic information. (See wells DD-2, DD-3, DD-9, DD-10, DD-13, C-28, C-31, and H-5 in table 7.) The drilling was under the administrative supervision of Ashley G. Classen and Associates of El Paso, Tex. The writers selected localities suitable for test drilling, logged cuttings taken at 5-foot intervals, and determined the depths of individual holes. Test holes were drilled with cable-tool rigs to insure adequate sampling of the geologic materials. All the test holes required some casing before completion, and the casing was slotted opposite water-bearing zones according to specifications by Classen and Associates.

The thickness of the alluvium was determined at the mouth of Musquiz Canyon, and bailing tests at wells DD-2 and DD-3 indicated that the permeability of the alluvium was low. The depth to basalt was determined in the Sunny Glen area, and pumping tests at wells C-28 and C-31 indicated that along fault trends the basalt was moderately permeable.

Well D-18

At the request of officials of the city of Alpine, the writers examined cuttings and prepared a geologic log to 1,794 feet (table 7) for well D-18, which was drilled to test the theory of the occurrence of potable water of supposed primary origin. The writers had no other connection with the drilling of well D-18. The test site was located by Stephen Reiss of Simi, Calif., at the request of city officials. Mr. Reiss believed that the geology of the Alpine area was favorable for reasonably shallow occurrence of "primary" water. Drilling commenced in April 1955 and was stopped in May 1956 at a depth of 2,002 feet. The hole was drilled with cable tools, and drill cuttings were obtained at intervals ranging from 1 to 26 feet.

The well penetrated 703 feet of volcanic rocks of probable Eocene age, the lower 73 feet of which was a sill of microsyenite. Stratified marine rocks of Early Cretaceous age were topped at 703 feet, and of Permian age at about 950 feet. The ages of the strata were established on the basis of fossil fragments in the cuttings (Hollingsworth, 1955). At 1,282 feet an intrusive mass of rhyolite porphyry was encountered, but because of advanced alteration the precise lithology of the mass could not be identified until lesser degrees of alteration were encountered at about 1,512 feet. Thin sections of the intrusive rocks between 1,292 and 1,508 were studied by Flawn (personal communication, Oct. 26, 1955), who stated:

> The rock is a fine-grained rhyolite porphyry and consists of anorthoclase phenocrysts in a very fine-grained trachyoid groundmass composed mostly of alkali feldspar and microlites in sub-parallel arrangement and interstitial quartz. There are sporadic irregular patches of opaque iron oxide in the groundmass which in habit resemble the occurrence of sodic amphiboles in similar rocks in this region. Possibly these patches of iron oxide are the result of alteration of an original ferromagnesian mineral; the presence of minor chlorite in association with them supports this interpretation. A few euhedral zircons are present as accessory minerals. The grain size of the phenocrysts ranges from 0.1 to 1.0 mm; the groundmass is about 0.05 mm. In the upper part of the interval the rock is in an advanced stage of alteration. Phenocrysts are commonly partly or wholly replaced by calcite and the groundmass is partly kaolinized and stained with iron oxide.

The test encountered only a small seep of water at 125 feet, the approximate position of the water table. The water level in the well declined progressively with drilling depth and on May 25, 1956, was measured by Dowell Inc. of McCamey, Tex., at 1,183 feet below the land surface. The chemical quality of the water is similar to the water in volcanic rocks throughout the Alpine area (table 9).

AREAS OF POSSIBLE ADDITIONAL DEVELOPMENT

Thorough prospecting for the development of a substantial water supply should be done in areas having a considerable thickness of the upper part of the Sheep Canyon basalt and the Cottonwood Springs basalt below the water table. Geologic mapping must be done to locate primary and secondary structural features of the type that create permeability in basaltic rocks in the Alpine area. Saturated basalt layers are the best aquifers, although it is evident that their original permeability has been considerably diminished by alteration and secondary mineralization. Solidified flows of aa (scoriaceous, broken) basalt retain moderate permeability, and where their thickness and extent are adequate they are capable of supplying the municipal needs of Alpine. The occurrence and source vents of the aa flows are largely hidden in the subsurface or obscured by later volcanism; hence, carefully supervised test drilling should be included in any program of ground-water exploration. Deeply weathered pahoehoe basalt flows have low permeability, but it may become necessary to develop their maximum potential yield by construction of large-diameter gravel-packed wells.

Sunny Glen area

An area about 2 to 5 miles northwest of Alpine at the mouth of Sunny Glen Canyon appears favorable for municipal water-supply development. All available data indicate that an area of about 5 square miles is underlain by at least 532 feet of the Sheep Canyon basalt and Cottonwood Springs basalt. The original permeability in the solidified basalt flows apparently is affected somewhat by rock alteration and probably some secondary mineralization, but locally the rocks are moderately to highly permeable because of faulting. Wells C-22 and C-28 lie along fault trends and their relatively high specific capacities are attributed to permeability caused by faulting.

Detailed geologic mapping should disclose more complete information about the faults in the Sunny Glen area. Additional test drilling should be done along the faults and the rock formations in each test hole carefully sampled. All test holes should be electrically logged and pumping tests made prior to final well construction.

Stocking Canyon Divide

Volcanic rocks occupy an asymmetrical syncline in marine sedimentary rocks in the vicinity of the Stocking Canyon divide 7 miles south of Alpine. Layers of basalt and beds of tuff and sandy tuff belonging to the Sheep Canyon basalt and the Cottonwood Springs basalt crop out at the surface. The exact thickness of the volcanic rocks is not known; however, rocks described as lava were encountered at a depth of 700 feet in well J-14. A partial driller's log of well J-14 obtained from the files of Pure Oil Co., Midland, Tex., indicates that the rocks were saturated with ground water to a depth of about 1,100 feet. Stories of the amount of water encountered in well J-14 vary widely among longtime residents. None of the stories could be confirmed, but as little opportunity exists for ground-water recharge, the area appears favorable for only limited water-supply development. Because of possible limited perennial supply and distance from Alpine, development of municipal water supply in the area of Stocking Canyon divide obviously should be preceded by thorough test drilling.

Musquiz Canyon Area

Ground water is contained in alluvial deposits at the mouth of Musquiz Canyon about 10 miles north-northeast of Alpine. Test drilling indicated that the alluvial deposits are poorly sorted and range in thickness from 24 to 71 feet. From information obtained from bailing tests it seems likely that properly constructed large-diameter shallow wells would yield up to 50 gpm. Areas underlain by the thickest saturated alluvial deposits would be the most likely place to develop new wells. The alluvium also serves as a source of recharge to the underlying basalt which forms the bedrock in the area. Further test drilling would be necessary to determine whether large yields could be obtained from the bedrock.

Immediate Vicinity of Alpine

The immediate vicinity of Alpine is underlain by about 800 feet of the Sheep Canyon and Cottonwood Springs basalts. Overlying the basalt is a relatively thin mantle of alluvium most of which is above the water table. Many of the privately owned wells in the city produce water from the alluvium; however, the yields are small--generally less than 10 gpm. Larger yields are obtained from wells tapping the basalt; the yields of the municipal wells range from less than 50 to about 200 gpm.

Additional development of ground water in the immediate vicinity of Alpine appears feasible. Yields of at least 50 gpm and as much as 100 gpm might be expected from large-diameter, gravel-packed wells. The effect of additional development on water levels in the area cannot be predicted from the available data. The program of observation of water levels in wells should be continued in order to observe the effects of continued pumping on storage in the ground-water reservoir, and additional pumping tests should be made to provide data for the determination of proper well spacing.

LIST OF REFERENCES

Published

COOPER, H. H., JR., and JACOB, C. E., 1946, A generalized graphical method of evaluating formation constants and summarizing well-field history: Am. Geophys. Union Trans., v. 27, p. 526-534.

DEAN, H. T., 1936, Chronic endemic dental fluorosis: Am. Med. Assoc. Jour., v. 107, p. 1269-1272.

GOLDICH, S. S., and SEWARD, C. L., 1948, Green Valley-Paradise Valley field trip: West Texas Geol. Soc. Fall Field Trip, p. 11-23.

GOLDICH, S. S., and ELMS, M. A., 1949, Stratigraphy and petrology of Buck Hill quadrangle, Texas: Geol. Soc. America Bull., v. 60, no. 7, p. 1133-1182.

GROUT, F. F., 1932, Petrography and petrology: New York and London, McGraw-Hill Book Co., Inc.

HOLMES, ARTHUR, 1920, The nomenclature of petrology: London, Thomas Murtry & Co.

KING, P. B., 1937, Geology of the Marathon region, Texas: U. S. Geol. Survey Prof. Paper 187, p. 118-119.

MCANULTY, W. N., 1955, Geology of the Cathedral Mountain quadrangle, Brewster County, Tex.: Geol. Soc. America Bull., v. 66, p. 531-578.

ROSENBUSCH and OSANN, 1923, Elemente die Gesteinslehre: Stuttgart, E. Schweizerbart.

THEIS, C. V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Am. Geophys. Union Trans., p. 519-524.

UNITED STATES PUBLIC HEALTH SERVICE, 1946, Drinking water standards: Public Health Repts., v. 61, no. 11, p. 371-384.

WENZEL, L. K., 1942, Methods for determining permeability of water-bearing materials, with special reference to discharging-well methods: U. S. Geol. Survey Water-Supply Paper 887.

Unpublished

BAKER, C. L., and BACON, C. S., 1939, Report on underground water prospects in the vicinity of Alpine, Tex.: Files of the city of Alpine, mimeographed report.

LIST OF REFERENCES

Unpublished--continued

CLASSEN, A. G., 1950, Survey, investigation, and study of the municipal water works and sanitary sewerage systems of the city of Alpine, Texas: Consultant's report by Ashley G. Classen & Associates, El Paso, Tex.

HOLLINGSWORTH, R. V., 1955, Paleontological report on city of Alpine, Reiss water well: Letter to city of Alpine, July 11, 1955.

KNOWLES, D. B., 1952, Ground-water hydraulics, pt. 1, Theory: U. S. Geol. Survey open-file report (Ground Water Note 28), 105 p.

LANG, J. W., 1949, Ground water in the Alpine area and adjacent territory, Brewster County, Texas: U. S. Geol. Survey open-file report, 24 p. (typewritten).

LEWIS, JEAN, 1949, Geology of Barillos dome, Jeff Davis County, Trans-Pecos, Tex.: Univ. Texas Master of Arts thesis, 92 p.

MCANULTY, W. N., 1950, Geology and ground-water resources of Alpine and adjacent territory, Brewster County, Texas: Typewritten report in files of the city of Alpine, 84 p.

Table 6.- Records of wells and springs in the Alpine area, Texas

All wells are drilled unless otherwise noted in remarks column.

Water level : Reported water levels given in feet; measured water levels given in feet and tenths.

Method of lift and type of power: C, cylinder; E, electric; G, gasoline or butane; J, jet; N, none; T, turbine; W, windmill. Number indicates horsepower.

Use of water : D, domestic; N, none; P, public supply; S, stock.

Well	Location: Section	Location: Block	Location: Survey	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
A-1	150	9	G.H.& S.A. Ry. Co.	H. L. Kokernot, Jr	--	--	Spring	--	Sheep Canyon and Cottonwood Springs basalt	--	+	Feb. 17, 1955	Flows	D,S	
C-1	85	9	do	W. G. Henderson	--	--	--	6	--	4412.34	52.0	Feb. 22, 1955	C,W	S	
C-2	128	9	do	do	George Lines	1946	86	6	Alluvium	4275.40	48.4 48.8	Feb. 17, 1955 Aug. 30, 1955	C,G	S	Cased to 8 ft.
C-3	58	9	do	Meriwether & Kokernot	--	1920	200	--	do	4473.90	88.9	Feb. 16, 1955	C,W	S	
C-4	57	9	do	G. C. Meriwether	-- McSpadden	1953	252	8	--	4588.99	--	--	T,E	D,S	Cased to 10 ft.
C-5	55	9	do	Mrs. Flora Daugherty	C. N. Watson	1955	160	10	--	4590.02	78.0	Mar. 22, 1955	C,W	S	Dug to 90 ft. Cased to 90 ft. See log.
C-6	54	9	do	do	--	1925	70	72	Alluvium	--	53.5	do	N	N	Dug.
C-7	52	9	do	H. L. Kokernot, Jr.	--	--	--	--	do	4521.27	13.4	Feb. 9, 1955	C,W	S	Do.
C-8	22	9	do	Perry Cartwright	Anton Hess	1954	325	8	do	4611.06	128.7	Jan. 25, 1955	C,W	S	Cased to 100 ft. See log.
C-9	50	9	do	W. N. Gourley	--	--	120	6	do	4471.26	26.5	Feb. 16, 1955	C,W	S	
C-10	93	9	do	do	--	--	100	--	do	4416.41	--	--	C,W	S	Dug and drilled.
C-11	6	347	--	Dutch Arthur	--	--	175	6	--	4779.27	59.4	Mar. 30, 1955	C,W	S	
C-12	830	347	--	do	--	--	50	--	Alluvium	4688.51	33.3	do	C,W	S	Dug.
C-13	3	9	G.H.& S.A. Ry. Co.	Mrs. Nell Tipelcek	P. W. Gooden	1953	212	8	--	4617.17	a/88.8 90.3	Jan. 27, 1955 Sept. 1, 1955	N	--	Observation well.
C-14	51	9	do	Mrs. Flora Daugherty	--	--	--	6	Alluvium	4499.87	34.9	Jan. 27, 1955	C,W	S	
C-15	94	9	do	Perry Cartwright	--	--	60	--	do	4422.71	51.6	Jan. 25, 1955	C,W	S	Dug.
C-16	94	9	do	do	--	--	60	--	do	4423.65	50.4	do	C,W	S	Do.
C-17	3	347	--	Gage Holland	E. E. Doyle	1951	210	6	--	4904.33	127.9	Mar. 29, 1955	C,W	S	Cased to 25 ft.
C-18	3	9	G.H.& S.A. Ry. Co.	Mrs. Oscar Roberts	--	--	--	--	Alluvium	4639.48	14.0 8.2	Mar. 30, 1955 Aug. 30, 1955	N	N	Dug.
C-19	3	9	do	Mrs. Nell Tipelcek	-- Miles	1925	212	--	--	4603.14	18.6 76.2	Aug. 2, 1948 Feb. 10, 1955	T,G	S	

a/ See table 8 for water level measurements.
* See table 9 for chemical analyses of water from wells and springs.

Table 6.- Records of wells and springs in the Alpine area--Continued

Well	Location			Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Altitude of land surface (ft.)	Water level		Method of lift	Use of water	Remarks
	Section	Block	Survey								Below land-surface datum (ft.)	Date of measurement			
•C-20	3	9	G.H.& S.A. Ry. Co.	Mrs. Oscar Roberts	--	1935	300	5	Sheep Canyon and Cottonwood Springs basalt	4615.76	58.3	Mar. 1, 1955	C,W	S	Reported strong supply. Formerly used to irrigate 40 acres of land.
C-21	22	9	do	Perry Cartwright	-- Wooley	1946	190	6	--	4576.39	a/71.8 77.5	Jan. 25, 1955 Jan. 2, 1956	C,W	S	
C-22	23	9	do	Mrs. Flora Daugherty	P. W. Gooden	1953	361	10, 8, 7	Sheep Canyon and Cottonwood Springs basalt	4553.29	a/71.3 90.8	Feb. 9, 1955 Aug. 23, 1955	T,G	P	Casing: 10-in. to 31 ft; 8-in. to 300 ft; and 7-in. to 361 ft. Supplies city of Alpine.
C-23	49	9	do	Perry Cartwright	--	1950	100	6	Alluvium	4446.52	66.7	Jan. 27, 1955	C,W	S	Cased to 100 ft. Dug and drilled.
C-24	829	347	--	Gage Holland	--	--	190	6	--	4691.82	--	--	C,W	S	
C-25	2	347	--	do	--	--	275	--	--	4752.19	27.0	Mar. 29, 1955	C,W	D,S	
C-26	2	9	G.H.& S.A. Ry. Co.	Mrs. Nancy Caldwell	--	--	130	--	--	4710.09	--	--	C,W	S	Dug and drilled.
C-27	2	9	do	do	--	1930	160	--	Sheep Canyon and Cottonwood Springs basalt	4659.73	122.7 123.7	Jan. 21, 1955 Aug. 9, 1955	C,W	S	
•C-28	24	9	do	W. H. Terry, Jr.	Nolland Schuler	1955	592	8	do	4573.41	a/112.6 113.7	July 14, 1955 Aug. 2, 1955	T,G	P	Cased to 307 ft. Drawdown 17 ft after pumping 36 hours at 240 gpm. Supplies city of Alpine. See log.
•C-29	23	9	do	Mrs. Flora Daugherty	--	1914	50	--	Alluvium	4509.15	a/46.4 51.8	Jan. 25, 1955 Mar. 4, 1956	C,W	S	Dug.
C-30	48	9	do	Perry Cartwright	Nolland Schuler	1950	100	5	do	4490.69	40.2 38.4	Jan. 27, 1955 Sept.16, 1955	C,W	S	Cased to 100 ft.
•C-31	48	9	do	do	do	1955	503	--	Sheep Canyon and Cottonwood Springs basalt	4509.69	a/65.6 66.2	Aug. 22, 1955 Mar. 4, 1956	N	N	Test hole, observation well. See log.
C-32	48	9	do	do	Anton Hess	1954	240	8	Alluvium	4482.63	68.8 100.9	Jan. 27, 1955 Sept.16, 1955	C,W	S	Cased to 92 ft. See log.
C-33	46	9	do	Mrs. Margaret Smith	--	--	70	--	do	4460.44	63.1	Feb. 15, 1955	C,W	D	Dug.
C-34	3	347	--	Gage Holland	--	--	--	--	--	4857.18	87.3	Mar. 29, 1955	C,W	S	
C-35	47	9	G.H.& S.A. Ry. Co.	Perry Cartwright	T. M. Schuler	1949	187	8	Alluvium	--	46.1	Jan. 27, 1955	C,W	S	Cased to 168 ft. See log.
C-36	46	9	do	City of Alpine	C. N. Watson	1949	500	12, 10, 8	do	4464.95	--	--	T,E, 30	P	Casing: 12-in. to 71 ft; 10-in. to 297 ft; 8-in. to 368 ft. Weak supply. See log.

Table 6.- Records of wells and springs in the Alpine area--Continued

Well	Location: Section	Location: Block	Location: Survey	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
C-37	532	8	G.H.& S.A. Ry. Co.	Gage Holland	George Hargas	1952	400	6	Alluvium	4888.54	196.4	Mar. 29, 1955	C,W	S	Cased to 20 ft. Weak supply.
C-38	24	9	do	W. H. Terry, Jr.	Nolland Schuler	1954	540	8	Sheep Canyon and Cottonwood Springs basalt	4629.00	a/81.9 85.6	Jan. 19, 1955 Jan. 2, 1956	N	N	Cased to 528 ft. Observation well. See log.
C-39	24	9	do	do	do	--	131	5	Alluvium	4612.43	98.5	Jan. 19, 1955	T,E	D,S	Cased to 128 ft.
C-40	24	9	do	do	C. N. Watson	1946	200	6	do	4612.80	98.8 31.9	Jan. 19, 1955 Aug. 29, 1955	N	N	Cased to 188 ft.
C-41	25	9	do	S. Stapp	--	--	--	--	do	4623.31	41.7 40.3	Jan. 20, 1955 Aug. 29, 1955	C,W	S	Dug.
C-42	45	9	do	City of Alpine	P. W. Gooden	1953	356	10, 8	do	--	--	--	N	--	
C-43	534	8	do	Gage Holland	George Hargas	1952	350	6	do	4875.23	38.6 31.5	Mar. 28, 1955 Aug. 30, 1955	N	N	Cased to 20 ft. Weak supply.
C-44	533	8	do	do	E. E. Doyle	1951	50	8	do	4723.86	37.0	Mar. 28, 1955	C,W	S	Cased to 20 ft.
C-45	27	9	do	Southern Pacific Lines	J. S. McSpadden	1921	236	8	do	--	--	--	N	N	Weak supply. See log.
C-46	25	9	do	Lewis Lewenthal	E. E. Doyle	1947	320	--	Sheep Canyon and Cottonwood Springs basalt	4659.91	a/141.4 141.9	Aug. 16, 1948 Mar. 4, 1956	C,E, 3	S	
C-47	25	9	do	V. G. Heil	--	--	150	--	Alluvium	4580.00	115.9 116.1	Jan. 20, 1955 Aug. 30, 1955	C,W	D	
C-48	44	9	do	James Featherstone	-- Wooley	1941	120	6	do	4538.56	52.2 51.9	Feb. 7, 1955 Aug. 29, 1955	C,W	D	Cased to 62 ft.
C-49	45	9	do	Perry Cartwright	--	1944	73	6	do	--	52.3	Feb. 7, 1955	N	N	Dug and drilled. Cased to 25 ft.
C-50	45	9	do	Anton Hess	Anton Hess	1942	70	10	do	--	43.8	Aug. 16, 1948	C,W	D,S	Cased to 38 ft.
C-51	45	9	do	City of Alpine	C. N. Watson	1951	400	12, 10, 8, 6	Sheep Canyon and Cottonwood Springs basalt	4477.80	--	--	T,E, 5	P	Cased to 400 ft. Abandoned in 1955. See log.
C-52	45	9	do	Perry Cartwright	--	1925	65	--	Alluvium	--	38.9	Feb. 7, 1955	C,W	D	Dug and drilled.
C-53	27	9	do	Catto Gage Ranch	--	--	--	6	do	4749.31	57.6 59.3	May 10, 1955 Aug. 30, 1955	C,W	S	
C-54	25	9	do	--	--	1947	240	8	--	4589.18	85.8 90.2 93.0	July 31, 1948 Feb. 22, 1955 Aug. 30, 1955	C,W	S	
C-55	29	9	do	S. R. Chamberlin	--	1954	150	6	Alluvium	4633.36	--	--	T,E, ¾	D	
C-56	29	9	do	Percy Davis	Anton Hess	1953	350	8	Sheep Canyon and Cottonwood Springs basalt	4620.59	--	--	C,W	D,P	See log.

Table 6.- Records of wells and springs in the Alpine area--Continued

Well	Location: Section	Location: Block	Location: Survey	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
C-57	25	9	G.H.& S.A. Ry. Co.	Lewis Lewenthal	McSpadden Bros.	--	210	6	--	4590.56	127.9	May 12, 1955	C,W	D,S	
C-58	44	9	do	Guss Lines	Fritz Graft	1935	254	--	Alluvium	4564.17	77.4 74.1	Feb. 20, 1955 Aug. 29, 1955	C,W	D	
C-59	44	9	do	Edward Oliver	--	--	47	--	do	4516.07	39.7	Mar. 7, 1955	C,W	D	Dug.
C-60	43	9	do	M. T. McClure	R. C. Gooden	1954	190	6	do	4531.35	--	--	C,E	D	Cased to 100 ft.
C-61	43	9	do	L. W. Roark	--	--	--	--	do	4569.94	--	--	C,W	D,S	
C-62	43	9	do	K. L. Killion	-- Stewart	1950	99	6	do	4533.73	73.3	Mar. 1, 1955	C,W	D	Cased to 99 ft.
C-63	43	9	do	Kenneth Clouse	E. C. Scarber	1950	76	6	do	4530.92	72.1	do	C,W	N	
C-64	43	9	do	Margaret Smith	-- Wooley	--	240	5	Sheep Canyon and Cottonwood Springs basalt	4531.71	29.9 75.2	Aug. 17, 1948 Mar. 1, 1955	J,E, 1/3	D	
C-65	43	9	do	Pete Gallego	--	--	--	5	Alluvium	4532.96	56.9	Mar. 2, 1955	J,E, 1/3	D	
C-66	43	9	do	Chas. Ives	Anton Hess	--	165	5	do	4532.10	56.6	do	J,E	D	Cased to 165 ft.
C-67	43	9	do	do	--	--	--	6	do	4534.89	58.5	do	N	N	Weak supply.
C-68	29	9	do	Mrs. Catherine Mosley	P. W. Gooden	--	170	8	do	4571.87	76.2	Feb. 22, 1955	C,W	S	
C-69	43	9	do	Mrs. John Cowell	--	--	--	--	do	4576.96	52.0	Feb. 24, 1955	C,W	D	
C-70	29	9	do	Ray Smith	P. W. Gooden	1952	60	8	do	4592.85	49.3	Feb. 22, 1955	C,W	D	
C-71	30	9	do	John Lane	--	1925	150	6	do	4609.54	39.5 56.7	Aug. 17, 1948 May 12, 1955	C,W	S	
D-1	123	9	do	Perry Cartwright	-- Sublet	1940	320	6	--	4279.17	--	--	C,W	S	Cased to 200 ft.
D-2	92	9	do	do	--	--	--	8	--	4331.34	107.1	Feb. 22, 1955	N	N	Cased to 50 ft. Weak supply.
D-3	94	9	do	do	P. W. Gooden	1951	425	8	--	4395.43	64.2	Feb. 7, 1955	N	N	Reported dry hole.
D-4	94	9	do	do	C. N. Watson	1955	100	7	Crossen trachyte	--	60.9	Sept.15, 1955	C,W	S	Cased to 12 ft. See log.
D-5	95	9	do	do	--	1925	--	--	Alluvium	4340.12	58.8	Jan. 25, 1955	C,W	S	Dug.
D-6	186	9	do	Mrs. G. A. Morris	--	Old	500	6	--	4340.95	298.5	May 11, 1955	C,W	S	Cased to 300 ft.
D-7	97	9	do	H. L. Kokernot, Jr.	--	1954	125	8	--	4389.14	40.9	Feb. 8, 1955	J,E	D	Cased to 85 ft.
D-8	46	9	do	Rex Ivey	T. W. Huffman	1950	1,032	6	Sheep Canyon and Cottonwood Springs basalt	--	--	--	N	N	Insufficient supply for city. See log.

Table 6.- Records of wells and springs in the Alpine area--Continued

Well	Location			Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Altitude of land surface (ft.)	Water level		Method of lift	Use of water	Remarks
	Section	Block	Survey								Below land-surface datum (ft.)	Date of measurement			
D-9	45	9	G.H.& S.A. Ry. Co.	City of Alpine	C. N. Watson	1949	300	12, 10, 8	Sheep Canyon and Cottonwood Springs basalt	4446.62	191.5	Feb. 14, 1955	T,E, 15	P	Casing: 12-in. to 57 ft; 10-in. to 138 ft; 8-in. to 300 ft. Weak supply. See log.
D-10	98	9	do	H. D. Carpenter	R. C. Gooden	1954	212	8	--	4436.67	a/41.1 38.3	Feb. 14, 1955 Oct. 1, 1955	N	--	Cased to 120 ft. Observation well.
D-11	98	9	do	City of Alpine	P. W. Gooden	1954	325	12, 10, 8	Sheep Canyon and Cottonwood Springs basalt	4412.05	a/39.4 23.8	Feb. 14, 1955 Jan. 2, 1956	N	N	Cased to 325 ft. Weak supply. See log.
D-12	98	9	do	do	do	1954	250	8	--	4405.89	a/47.4 20.4	Feb. 14, 1955 Jan. 2, 1956	T,E, 7½	P	Cased to 159 ft. Weak supply.
*D-13	98	9	do	do	do	1954	276	12	Sheep Canyon and Cottonwood Springs basalt	4401.89	a/113.7 18.4	Feb. 15, 1955 Mar. 3, 1956	T,E, 15	P	Cased to 276 ft. See log.
D-14	98	9	do	do	R. C. Gooden	1954	350	10, 8	Alluvium	4393.81	a/32.1 21.7	Feb. 14, 1955 Jan. 2, 1956	N	N	Casing: 10-in. to 63 ft; 8-in. to 290 ft. Weak supply. See log.
D-15	45	9	do	do	--	1938	293	6	--	--	23.0 85.4	July 31, 1948 Feb. 8, 1955	N	N	Weak supply.
D-16	98	9	do	do	G. W. Huffman	1950	550	12, 10	Sheep Canyon and Cottonwood Springs basalt	4442.47	--	--	T,E, 60	P	Cased to 550 ft. Weak supply. See log.
D-17	45	9	do	Mrs. V. E. Miller	--	1947	92	6	Alluvium	--	--	--	J,E, 1	D	Cased to 92 ft.
*D-18	98	9	do	City of Alpine	P. W. Gooden	1955	2,002	8	Pruett formation and intrusive rocks of Tertiary age	4539.52	116.5	Sept. 5, 1955	N	N	Test well. See log.
D-19	45	9	do	J. W. Stone	do	1953	110	6	--	--	35.0	Feb. 24, 1955	J,E, ¾	D	Cased to 80 ft.
D-20	45	9	do	H. E. LaBeff	do	1955	115	6	--	--	31.7	Feb. 23, 1955	J,E	D	Cased to 115 ft. Dug and drilled.
D-21	45	9	do	Chalmers Broadfoot	Nolland Schuler	1950	100	9	--	--	33.1	do	J,E, 1	D	Cased to 60 ft.
D-22	98	9	do	City of Alpine	P. W. Gooden	1950	350	10	Sheep Canyon and Cottonwood Springs basalt	4553.81	70.5	Jan. 6, 1955	T,E, 25	P	Cased to 350 ft. See log.
D-23	45	9	do	Miss Lutie Britt	-- Stuart	1948	100	6	--	--	36.7	Feb. 23, 1955	J,E, ½	D	Cased to 100 ft.
D-24	45	9	do	L. H. Lockhart	--	1954	110	6	--	--	38.1	do	C,W	D	Cased to 40 ft.
D-25	45	9	do	W. H. Perryman	Anton Hess	1954	167	6	--	--	52.5	do	T,E, ¾	D	Cased to 85 ft. See log.

Table 6.- Records of wells and springs in the Alpine area--Continued

Well	Location: Section	Location: Block	Location: Survey	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
D-26	98	9	G.H.& S.A. Ry. Co.	Wm. Sohl	C. N. Watson	1950	311	8	--	--	88.8	Mar. 31, 1955	T,E, 1	D	Cased to 20 ft. Weak supply.
D-27	98	9	do	do	Nolland Schuler	1951	250	8	--	--	--	--	N	N	Weak supply.
D-28	98	9	do	do	do	1952	331	8	--	--	118.2	Mar. 31, 1955	N	N	Cased to 20 ft. Weak supply.
D-29	100	9	do	Gene Benson	--	--	--	10	--	4507.81	117.0	do	C,W	D	
D-30	115	9	do	H. L. Kokernot, Jr.	--	--	--	--	--	4412.70	70.6	Feb. 22, 1955	C,W	S	
D-31	42	9	do	E. A. McMillan	P. W. Gooden	1955	142	7	--	--	51.3	Mar. 10, 1955	--	D	Cased to 140 ft.
D-32	42	9	do	Chas. Stringfellow	--	--	35	--	Alluvium	--	23.8	Mar. 17, 1955	J,E, ½	D	Dug.
D-33	101	9	do	Z. M. Decie	C. N. Watson	1955	275	6	Sheep Canyon and Cottonwood Springs basalt	--	--	--	T,E	D	Cased to 60 ft. See log.
D-34	101	9	do	John W. Gillett	do	--	200	6	--	4577.85	a/137.4	Feb. 2, 1955	N	--	Observation well.
D-35	101	9	do	City of Alpine	--	1940	1,400	--	--	4562.64	--	--	T,E, 15	P	Cased to 500 ft. Weak supply.
D-36	100	9	do	Gene Benson	Nolland Schuler	--	--	8	--	4452.81	59.6	Feb. 8, 1955	N	N	
D-37	100	9	do	do	-- Sublet	--	--	8	--	4453.12	60.1	Jan. 31, 1955	J,E	D	
D-38	100	9	do	Sul Ross College	--	--	--	6	--	4426.74	30.5	Feb. 22, 1955	C,W	S	
D-39	101	9	do	Southern Pacific Lines	Emmet Harrel and Scott Foster	1944	323	8	Sheep Canyon and Cottonwood Springs basalt	--	--	--	T,E, 7½	P	See log.
D-40	101	9	do	do	--	1923	320	9, 7	--	--	77.0	Feb. 3, 1955	T,E	N	Cased to 211 ft. Weak supply.
D-41	101	9	do	--	--	1923	320	9, 7	--	--	75.3	do	T,E	N	Do.
D-42	101	9	do	City of Alpine	--	1927	580	--	--	4498.26	--	--	T,E, 30	P	Weak supply.
D-43	101	9	do	do	P. W. Gooden	1953	200	8	--	--	91.6	Jan. 19, 1955	T,E	P	Cased to 200 ft.
D-44	100	9	do	Sul Ross College	--	--	--	8	--	4449.76	53.4	Feb. 22, 1955	C,W	S	
D-45	100	9	do	City of Alpine	R. C. Gooden	1953	202	7	Alluvium	4459.91	a/26.0 26.9	Feb. 8, 1955 Mar. 4, 1956	N	N	Cased to 122 ft. Weak supply. See log.
D-46	101	9	do	Willie Uranga	P. W. Gooden	1953	363	5	--	--	78.0	Feb. 23, 1955	N	N	Cased to 363 ft.
D-47	42	9	do	City of Alpine	C. W. Watson	1951	300	12, 10	Alluvium and Sheep Canyon and Cottonwood Springs basalt	4511.64	--	--	T,E, 10	P	Cased to 260 ft. Weak supply. See log.

Table 6.- Records of wells and springs in the Alpine area--Continued

Well	Location: Section	Location: Block	Location: Survey	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
D-48	42	9	G.H.& S.A. Ry. Co.	City of Alpine	Anton Hess	1921	300	10	--	--	--	--	N	N	Weak supply. See log.
D-49	42	9	do	do	--	1924	173	--	--	--	--	--	N	N	
•D-50	42	9	do	do	Anton Hess	1924	443	10, 8, 6	--	4567.45	--	--	T,E, --	P	Cased to 443 ft. Used as alternate well.
•D-51	42	9	do	do	--	1929	700	10	--	4583.51	--	--	T,E, 50	P	Cased to 325 ft. Strong supply.
D-52	42	9	do	do	Anton Hess	1936	601	--	Sheep Canyon and Cottonwood Springs basalt	--	216.5	Mar. 14, 1955	N	N	Weak supply.
D-53	102	9	do	do	C. N. Watson	1950	600	8	--	4550.64	--	--	T,E, 15	P	Weak supply. See log.
D-54	102	9	do	Joe Moss	--	--	130	--	Alluvium	4516.64	--	--	C,W	N	Reported yield, 106 gpm.
D-55	101	9	do	City of Alpine	Anton Hess & C. Rixford	1940	2,400	12	--	--	--	--	C,W	D	See log.
D-56	103	9	do	Elm Grove Cemetery	--	--	98	--	--	4509.09	30.9	Feb. 21, 1955	J,E	D	
D-57	103	9	do	do	Anton Hess	1955	140	6	--	4498.00	34.6	May 2, 1955	N	N	
D-58	103	9	do	do	C. N. Watson	1948	153	8	--	4508.11	--	--	J,E	D	Cased to 153 ft.
D-59	113	9	do	Mrs. G. A. Morris	--	--	--	9	--	4634.58	59.9	Feb. 21, 1955	N	N	
D-60	43	9	do	John Lane	R. W. Gooden	1951	179	6	--	4528.00	82.1	May 12, 1955	C,W	S	Cased to 179 ft.
D-61	103	9	do	Mrs. G. A. Morris	--	--	--	--	--	4544.30	29.1	Feb. 17, 1955	N	N	
D-62	102	9	do	Joseph Moss	--	--	--	--	Alluvium	4572.58	21.2	Feb. 21, 1955	C,W	S	Dug.
D-63	105	9	do	do	--	--	--	--	do	4580.95	a/21.8 21.7	Feb. 17, 1955 Mar. 4, 1956	N	N	Do.
D-64	104	9	do	Mrs. G. A. Morris	--	--	--	--	do	4573.51	14.4	Feb. 17, 1955	C,W	S	Do.
D-65	104	9	do	do	--	--	--	--	do	4570.12	12.3	do	C,W	S	Do.
•D-66	104	9	do	do	C. N. Watson	1955	97	8	do	--	11.8	Aug. 16, 1955	C,W	S	Cased to 80 ft. See log.
H-1	535	8	do	Frank Lane	--	1920	35	--	do	4790.52	27.1 15.0	May 9, 1955 Aug. 30, 1955	C,W	D,S	Dug.
H-2	823	352	W. J. Mitchell	Catto Gage Ranch	--	1949	80	--	--	4811.01	--	--	J,E	D	
H-3	30	9	G.H.& S.A. Ry. Co.	John Lane	--	--	30	--	Alluvium	4639.79	--	--	C,W	S	Dug.
H-4	535	8	do	Gage Holland	--	--	---	--	--	4820.80	--	--	C,W	S	

Table 6.- Records of wells and springs in the Alpine area--Continued

Well	Location			Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Altitude of land surface (ft.)	Water level		Method of lift	Use of water	Remarks
	Section	Block	Survey								Below land-surface datum (ft.)	Date of measurement			
*H-5	33	9	G.H.& S.A. Ry. Co.	John Lane	Anton Hess	1955	370	8	Sheep Canyon and Cottonwood Springs basalt	4701.79	72.0	Aug. 23, 1955	N	N	Cased to 156 ft. Test well. See log.
H-6	67	352	W. J. Mitchell	Vernon McIntyre	--	--	--	5	--	4907.10	67.9 67.9	Mar. 28, 1955 Aug. 30, 1955	C,W	S	
H-7	69	352	do	do	--	--	--	--	Alluvium	4900.14	17.3 14.0	Mar. 28, 1955 Aug. 30, 1955	C,W	D	Dug.
H-8	527	8	G.H.& S.A. Ry. Co.	Gage Holland	--	--	--	--	do	4942.55	38.4 35.9	Mar. 29, 1955 Aug. 30, 1955	N	N	Do.
H-9	527	8	do	do	--	--	--	--	--	4926.30	31.4 38.6	Mar. 7, 1955 Aug. 30, 1955	C,W	S	
H-10	527	8	do	Frank Lane	--	--	--	6	--	4964.98	69.7	Mar. 7, 1955	C,W	D	
*H-11	93	352	W. J. Mitchell	John Lane	--	--	Spring	--	--	4875.20	--	--	--	D,S	Temp. 68°F.
H-12	527	8	G.H.& S.A. Ry. Co.	Gage Holland	--	--	--	--	Alluvium	4966.45	20.2	Mar. 7, 1955	C,W	S	Dug.
H-13	34	9	do	Z. M. Decie	R. C. Gooden	1951	311	6	--	5225.42	228.9	Mar. 22, 1955	C,W	S	Cased to 30 ft.
H-14	525	8	do	Vernon McIntyre	--	--	--	--	--	4979.91	27.3	Mar. 7, 1955	C,W	S	Dug and drilled.
H-15	539	8	do	Paisano Baptist Assembly, Inc.	--	--	140	7	Intrusive rocks of Tertiary age	5131.35	75.1	do	C,E	D,P	
*H-16	539	8	do	do	--	1942	196	5	do	5171.88	--	--	C,E, 5	D,P	Cased to 190 ft.
H-17	540	8	do	Vernon McIntyre	McSpadden Bros.	--	550	6	--	5207.00	257.9 260.0	Mar. 7, 1955 Aug. 16, 1955	C,W	S	Cased to 420 ft.
H-18	75	352	W. J. Mitchell	do	--	--	--	--	--	--	169.8	May 16, 1955	C,W	S	
H-19	59	352	do	do	--	1934	--	6	--	5274.32	37.6	May 15, 1955	C,W	S	
H-20	--	--	--	--	McPhail-Kemster	--	--	--	--	--	--	--	--	--	
H-21	93	352	W. J. Mitchell	Z. M. Decie	George McSpadden	1952	601	6	--	5403.67	--	--	C,W	S	Cased to 12 ft.
H-22	93	352	do	do	R. C. Gooden	1949	130	7	--	5419.17	42.3	Mar. 24, 1955	N	N	Cased to 60 ft. Weak supply.
H-23	45	352	do	do	--	1910	400	7	--	5181.41	--	--	C,W	S	
J-1	107	9	G.H.& S.A. Ry. Co.	Mrs. G. A. Morris	George Hargas	--	95	7	--	4701.86	69.6	Feb. 17, 1955	C,W	S	
J-2	39	9	do	John Lane	--	Old	61	4	--	4710.45	29.0 30.1	Apr. 21, 1955 Aug. 2, 1955	N	N	Cased to 35 ft.
J-3	106	9	do	do	--	--	7	--	--	4720.73	32.4	Aug. 31, 1955	C,W	S	
J-4	35	9	do	do	R. C. Gooden	1953	348	--	--	4784.86	147.5	Mar. 5, 1955	T,E, 1½	D	Cased to 18 ft.

Table 6.- Records of wells and springs in the Alpine area--Continued

Well	Location: Section	Location: Block	Location: Survey	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
J-5	36	9	G.H.& S.A. Ry. Co.	John Lane	--	1910	82	--	Alluvium	4776.49	52.0	Mar. 5, 1955	N	--	Dug.
•J-6	25	352	W. J. Mitchell	Z. M. Decie	McSpadden Bros.	--	--	6	Crossen trachyte	4955.29	120.4 106.9	Feb. 22, 1955 Aug. 31, 1955	C,W	S	
J-7	27	352	do	do	George Harris	1955	60	4	Alluvium	4913.47	18.6	Apr. 29, 1955	C,W	S	
J-8	17	352	do	Mrs. G. A. Morris	-- Richardson	--	15?	72	do	--	5.7	May 11, 1955	C,W	S	Dug.
J-9	17	352	do	do	Nolland Schuler	--	82	6	--	5113.59	21.6 22.2	Feb. 21, 1955 Aug. 31, 1955	C,W	S	Cased to 82 ft.
J-10	15	352	do	G. C. Meriwether	--	--	--	--	--	5149.62	41.6	Feb. 22, 1955	C,W	S	Dug and drilled.
J-11	29	352	do	Z. M. Decie	Dave Schuler	1951	104	6	--	5001.21	57.0	Mar. 25, 1955	C,W	S	Cased to 30 ft.
J-12	31	352	do	do	--	--	Spring	--	Sheep Canyon and Cottonwood Springs basalt	--	--	--	--	S	
J-13	23	352	do	G. C. Meriwether	--	--	--	6	--	5264.71	48.7 48.9	Mar. 25, 1955 Aug. 31, 1955	C,W	S	
J-14	31	352	do	Z. M. Decie	C. M. Joiner	1932	2,140	8	Sheep Canyon and Cottonwood Springs basalt	5236.86	--	--	N	N	Oil test. Cased to 1,400 ft. See log.
•J-15	33	352	do	do	--	--	Spring	--	do	--	--	--	--	S	
•J-16	33	352	do	do	Art Gard	1948	104	5	do	5174.75	37.2 15.9	Mar. 22, 1955 Aug. 31, 1955	C,W	S	Cased to 104 ft.
J-17	45	352	do	do	Nolland Schuler	1954	160	6	--	5124.92	139.0	Mar. 22, 1955	C,W	S	Cased to 30 ft. Temp. 71°F.
J-18	39	352	do	do	Art Gard	1948	108	6	Sheep Canyon and Cottonwood Springs basalt	5185.62	85.0	Mar. 25, 1955	C,W	S	Cased to 30 ft.
J-19	38	WJG 8	T.C. Ry. Co.	do	--	--	35	--	Alluvium	5074.47	10.7	do	C,W	D,S	Dug.
Y-1	137	9	G.H.& S.A. Ry. Co.	W. G. Henderson	--	1943	80	6	--	4608.58	32.3	Feb. 21, 1955	C,W	S	Cased to 10 ft.
Y-2	146	9	do	H. L. Kokernot, Jr.	Plymouth Oil Co.	--	130	8	--	4534.87	a/41.5 42.3	Feb. 21, 1955 Jan. 2, 1956	N	N	Seismograph shot hole.
Y-3	78	9	do	Ed Davidson	--	--	Spring	--	Duff formation	--	+	Jan. 7, 1955	Flows	D,S	
DD-1	65	9	do	H. L. Kokernot, Jr.	--	--	--	--	--	--	32.4	Jan. 28, 1955	C,W	S	
DD-2	81	9	do	Ed Davidson	Anton Hess	1955	71	--	Alluvium	4640.16	a/23.4 21.1	July 28, 1955 Mar. 3, 1956	N	N	Test hole. Abandoned. See log.
DD-3	81	9	do	do	do	1955	131	8	do	4642.01	19.7 17.4	July 21, 1955 Sept. 1, 1955	N	N	Cased to 47 ft. Test hole. See log.

Table 6.- Records of wells and springs in the Alpine area--Continued

Well	Location			Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Altitude of land surface (ft.)	Water level		Method of lift	Use of water	Remarks
	Section	Block	Survey								Below land-surface datum (ft.)	Date of measurement			
DD-4	80	9	G.H.& S.A. Ry. Co.	W. G. Henderson	--	--	Spring	--	Sheep Canyon and Cottonwood Springs basalt	4565.36	+	Feb. 21, 1955	Flows	S	
DD-5	132	9	do	do	--	--	40	--	Alluvium	4567.13	13.2 13.1	Feb. 4, 1955 Feb. 21, 1955	C,W	D,S	Dug. Two wells 10 ft apart.
DD-6	51	347	--	Pete Kennedy	George McSpadden	1951	260	--	--	4873.40	72.1	Apr. 25, 1955	C,W	S	Reported yield 10 gpm.
DD-7	10	9	G.H.& S.A. Ry. Co.	Mrs. A. J. Tippet	--	--	Spring	--	Duff formation	4863.50	+	Mar. 2, 1955	Flows	D,S	Reported yield, 150 gpm.
DD-8	10	9	do	Permian Basin Girl Scouts	P. W. Gooden	1953	224	8	--	4808.20	17.3	Feb. 6, 1955	T,E	P	Cased to 224 ft. Reported strong supply. See log.
DD-9	62	9	do	H. L. Kokernot, Jr.	Anton Hess	1955	53	--	Alluvium	4666.64	12.7 10.2	July 11, 1955 Sept. 1, 1955	N	N	Test hole. See log.
DD-10	62	9	do	do	do	1955	53	--	do	4675.65	a/17.6 19.0	Aug. 1, 1955 Mar. 3, 1956	N	N	See log.
DD-11	62	9	do	do	--	1924	--	29	do	4655.82	15.9	Jan. 5, 1955	C,W	S	Dug. Reported strong supply.
*DD-12	81	9	do	Ed Davidson	Nolland Schuler	1953	148	6	do	4649.78	25.1	Feb. 18, 1955	C,W	S	
DD-13	81	9	do	do	Anton Hess	1955	70	--	do	4645.40	21.9	Aug. 3, 1955	N	N	Test hole. See log.
DD-14	81	9	do	do	George Lines	1944	96	6	do	4616.23	--	--	C,W	S	Cased to 20 ft.
DD-15	386	347	--	Pete Kennedy	--	1941	155	6	--	--	--	--	C,W	D,S	
DD-16	386	347	--	do	--	1948	120	6	--	--	--	--	C,W	D,S	Well 100 ft east of well DD-15.
DD-17	385	347	--	do	--	--	260	5	--	4926.24	52.4	Apr. 25, 1955	C,W	S	Cased to 30 ft.
DD-18	16	9	G.H.& S.A. Ry. Co.	Mrs. A. J. Tippet	C. N. Watson	1935	154	6	--	4850.38	97.1 96.4	Feb. 16, 1955 Aug. 30, 1955	C,W	S	Cased to 40 ft.
DD-19	15	9	do	do	--	--	30	--	Alluvium	4734.45	14.2 13.5	Feb. 16, 1955 Aug. 30, 1955	C,W	S	Dug.
DD-20	357	347	--	Pete Kennedy	George McSpadden	1952	280	10	--	4966.53	13.2	Apr. 25, 1955	C,W	S	
DD-21	8	9	G.H.& S.A. Ry. Co.	Mrs. A. J. Tippet	--	--	300	6	--	4967.18	243.5	May 9, 1955	C,W	S	Cased to 30 ft.
*DD-22	358	347	--	G. C. Meriwether	--	--	200	5	Duff formation	5145.17	166.7 166.6	Apr. 4, 1955 Aug. 17, 1955	C,W	S	
DD-23	53	347	--	do	--	--	Spring	--	Sheep Canyon and Cottonwood Springs basalt	--	+	--	Flows	S	
DD-24	45	347	--	do	--	--	325	5	Duff formation	5189.51	243.5 243.6	Apr. 25, 1955 Aug. 30, 1955	C,W	S	Cased to 315 ft.

a/ See table 8 for water level measurements.
* See table 9 for chemical analyses of water from wells and springs.

Table 7.- Logs of wells in the Alpine area, Texas
(All logs are drillers' logs unless stated otherwise)

	Thickness (feet)	Depth (feet)
Well C-5		
Owner: Mrs. Flora Daugherty. Driller: C. N. Watson.		
Sample log by R. T. Littleton and G. L. Audsley.		
No record	110	110
Syenite (?), weathered, gray, tuff, ashy, argillaceous, plastic, brick-red, contains some silica and calcite	50	160

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well C-8					
Owner: Perry Cartwright. Driller: Anton Hess.					
Gravel and boulders (water)	100	100	Rock, hard, red-violet, (water)	125	325
Rock, hard, yellow	100	200			

	Thickness (feet)	Depth (feet)
Well C-28		
Owner: W. H. Terry, Jr. Driller: Nolland Schuler.		
Sample log by R. T. Littleton and G. L. Audsley.		
Alluvium of Quaternary age		
Gravel and caliche	60	60
Sheep Canyon basalt and Cottonwood Springs basalt		
Basalt, altered, vesicular, reddish-brown	15	75
Basalt, dense, crystalline, reddish-brown; basalt schistose appearing, gray to brown, 75 to 95 feet; clay, soft, globular, orange, 95 to 100 feet	30	105
Basalt, containing muscovite, biotite and feldspar, vesicular, gray to brown; traces of soft clay, white; calcite present	20	125
No record	5	130
Basalt, highly altered, abundant biotite and feldspar, banding evident, gray, brown, reddish-brown alternating with a yellowish-brown to red	26	156

(continued on next page)

Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well C-28--continued		
Basalt as above, 15 percent; basalt, highly altered, microcrystalline, platy feldspars, some crystals brown with copper luster, veined with calcite; dark green	9	165
Basalt, gray-brown to gray-lavender, banding 50 percent; basalt, green-black, as above, 50 percent	15	180
Basalt, vesicular, vesicles contain siliceous material, brittle, brick red	5	185
Tuff, locally basaltic, soft, clayey, sticky when wet, pink, brick red, maroon	5	190
No sample	5	195
Tuff, clayey to ashy, brick red	20	215
Tuff, fine textured, brecciated, locally soft, compact, bentonitic, dull green	20	235
Bentonite, locally pure, white; cavings of red tuff and green bentonite	15	250
No sample	10	260
Tuff, bentonitic, with streaks of almost pure bentonite, varicolored; sample contains abundant free glass(?) and quartz	15	275
Tuff, basaltic, soft, brown; sample contains varicolored tuff, as above	5	280
Bentonite, white and gray	5	285
Tuff and basaltic tuff, red and lavender, 65 percent; basalt, black and lavender, weathered, vesicular 35 percent	5	290
Basalt, amygdaloidal with green chlorite(?); gray, dark gray, purple, cavings of tuff	5	295
Tuff, basaltic, streaked with white bentonite, dark gray	10	305
Basalt, holocrystalline, contains glassy feldspar and olivine, black and dark gray	5	310
Olivine basalt, holocrystalline, partly weathered or altered, hard to moderately hard, greenish-black	5	315
Basalt, altered, fine to coarse textured, becoming finely vesicular, showing considerable secondary alteration at 330-340 feet, gray to dark gray, locally reddish	40	355
Basalt, finely vesicular, platy feldspar, green and clear silica, some calcite, gray violet, locally red-	25	380

(continued on next page)

Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well C-28--continued		
Basalt, very hard, platy feldspar, some olivine, maroon-black, samples contain some tuff, altered grayish-white and green----------------------------------	10	390
Basalt, amygdaloidal with calcite and chalcedony, grayish-violet, reddish-black, and brick red; tuff and tuffaceous clay at 395-400 and 415-420 feet------	30	420
Basalt, altered locally vesicular, vesicles contain calcite, red-brown, black----------------------------	20	440
Basalt, hard, altered, dark greenish-black------------	20	460
Basalt, altered, moderately hard, dense, silt coating on basalt grains, green----------------------------	12	472
Clay, tuffaceous, bentonitic, brick red, some red basaltic tuff--	8	480
Basalt, contains abundant platy feldspars, gray to reddish-gray--	25	505
Basalt, holocrystalline, dense, locally vesicular, reddish-brown, brown, gray, 75 percent; clay, ashy, red, 25 percent-------------------------------------	7	512
Basalt, amygdaloidal with clay and calcite, black, gray, maroon--	9	521
Tuff, ashey, ferruginous appears to be porphyritic, greenish-gray--	8	529
Basalt, vesicular to amygdaloidal, maroon-------------	21	550
Basalt, porphyritic and amygdaloidal, gray------------	15	565
Basalt, altered, contains abundant secondary calcite, light gray--	10	575
Tuff, basaltic, greenish-gray, (green bentonite at 584-585 feet)--	17	592
Well C-31		
Owner: Perry Cartwright. Driller: Nolland Schuler.		
Sample log by R. T. Littleton and G. L. Audsley.		
Alluvium of Quaternary age		
Gravel and caliche, poorly sorted, some sand and gravel of rhyolite (?) tuff, basalt and silicic flow rocks--	130	130
Sheep Canyon basalt and Cottonwood Springs basalt		
Tuff, red-brown, soft to shaley and hard--------------	35	165
Tuff, basaltic, hard, dense, finely vesicular, microcrystalline, red to red-brown, 55 percent; tuff, soft, shaley to clayey, red to tan, 45 percent-------	5	170

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well C-31--continued		
Basaltic tuff, as above, 90 percent; tuff, varicolored 10 percent	4	174
Basaltic tuff, 75 percent; tuff, 25 percent	4	178
Tuff, clayey to shaley, some vesicular, red, 70 percent; basaltic tuff, 30 percent	5	183
Tuff, clayey to shaley, hard, somewhat vesicular, red-brown to brown, 90 percent; tuff, white, clayey, 10 percent	12	195
Tuff, red-brown to brown, as above, 75 percent; tuff, soft argillaceous, red and white	10	205
Tuff, soft, shaley, red-brown to brown 70 percent; basalt, hard, brown and pink, some white clay showing, 30 percent	20	225
Tuff, hard, shaley, rust to brown, 50-80 percent; tuff, soft, argillaceous, white, 20-30 percent; much quartz sand	10	235
Tuff, argillaceous, white, tan, pink, 40-80 percent; basaltic tuff, 10-30 percent; tuff, hard maroon, 0-30 percent; much sand	22	257
Tuff, soft to brittle, ashy, somewhat clayey, rust to pink, 65 percent; tuff, soft, clayey, white 35 percent	8	265
Basalt, highly altered, crumbly, vesicular, maroon-gray	30	295
Basalt, as above 50 percent; tuff, ashy, argillaceous, rust colored, 50 percent	5	300
Tuff, argillaceous, brittle, somewhat vesicular, rust to red-brown 65 percent; basalt, as above 30 percent; tuff, white, 5 percent	5	305
Tuff, rust, as above, 50 percent; tuff, clayey to brittle, green-black, 35 percent; basalt, scoriaceous, ashy, vesicular, maroon, 15 percent	10	315
Tuff, locally basaltic, scoriaceous, gray and brick red, (sample badly contaminated)	5	320
Basaltic tuff and scoria, altered, considerable secondary mineralization involving devitrification of ash to bentonite and bentonitic clay, gray and brick red	5	325
Clay, tuffaceous to silty, from reworked and devitrified volcanic ash and hematite-impregnated fine grained tuffaceous sediment, clay is micaceous, platy, some fragments with slickensides	5	330

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well C-31--continued		
Basaltic tuff, altered and weathered, moderately soft, gray and dark gray, 55-75 percent; clay, as above, bentonitic, with some white bentonite, 25-45 percent-	20	350
Basalt, altered, shows considerable secondary mineralization including chlorite (?) and vein calcite, greenish-gray and lavender----------------------------	5	355
Basalt, altered, gray to greenish-gray----------------	5	360
Basalt, 60 percent; basalt, coarse textured moderately altered, dark gray and dark greenish-gray, 40 percent	5	365
Basalt, as above 95-100 percent; occasionally clay, red, tuffaceous------------------------------------	30	395
Basalt, 65 percent; basalt, as above, 20 percent; clay, tuffaceous, red, 15 percent--------------------	5	400
Basalt, 50 percent; clay, as above, 5 percent----------	5	405
Basalt, moderately altered, black to dark gray, 80 percent; clay as above, 20 percent----------------	5	410
No sample--	5	415
Clay, tuffaceous, silty, soft, red--------------------	2	417
Clay, slightly silty, brick red to maroon--------------	8	425
Basalt, altered, black and brown, 60 percent; clay, as above, 40 percent----------------------------------	5	430
Basalt, hard, black and brown, 80 percent; clay bentonitic, red, 20 percent-------------------------	5	435
Basalt, highly altered, shows considerable secondary mineralization, black, gray speckled, also lavender--	4	439
Basalt, as above, and red to brown basaltic tuff-------	6	445
Basalt, soft, altered, contains abundant secondary crystalline calcite and some green chlorite(?), black and greenish-gray------------------------------	30	475
Basalt, vesicular, altered with abundant secondary crystalline calcite, black and maroon-black 80 percent; basalt, ashy, scoriaceous, vesicular, brick red, 20 percent------------------------------------	15	490
Basalt, medium hard, vesicular, vesicles filled with green chlorite and needle-like silica, maroon-black---	13	503

Table 7.- Logs of wells in the Alpine area--Continued

Well C-32

Owner: Perry Cartwright. Driller: Anton Hess.

	Thickness (feet)	Depth (feet)
Gravel, boulders----------	20	20
Soapstone, soft, gray, green, white------------	70	90
Rock, fractured, red (water at 130 feet)------------	40	130
No sample (water)--------	50	180
Rock, hard, red, green, blue------------------	15	195
Rock, hard, purple-------	10	205
Shale, crumbly, red------	35	240

Well C-35

Owner: Perry Cartwright. Driller: T. M. Schuler.

Sample log by W. N. McAnulty.

	Thickness (feet)	Depth (feet)
No samples--	95	95
Basalt, mixed with alluvium and various igneous rock; contains calcite, chalcedony, greenish----------------	5	100
Basalt, fine-grained, black, stained with iron oxide-----	40	140
Basalt, amygdaloidal, dull green------------------------	5	145
Basalt, weathered, considerable calcite and chalcedony, amygdaloidal, red-brown-------------------------------	10	155
Basalt, considerable chalcedony, resinous, red-brown-----	15	170
Basalt, weathered, sandy, with fine sandy coating--------	5	175
Basalt, weathered, and red fine, sandy tuff-------------	5	180
Basalt, red-gray with chalcedony, some amygdaloidal------	7	187

Well C-36

Owner: City of Alpine. Driller: C. N. Watson.

	Thickness (feet)	Depth (feet)
Alluvium, gravel, clay-----	60	60
Gravel (water)-------------	11	71
Conglomerate, black (water)	114	185
Soapstone-----------------	10	195
Clay, blue----------------	10	205
Conglomerate rock, black-	92	297
Rock, black--------------	23	320
Rock, fractured, red-----	120	440
Limestone, deteriorated--	60	500

Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well C-38					
Owner: W. H. Terry, Jr. Driller: Nolland Schuler.					
Gravel	116	116	Rock, black	25	320
No sample	30	146	Tuff, sandy, red	25	345
Tuff and gravel	84	230	Rock, gray	45	390
Rock and gravel	65	295	Shale, blue and green	150	540
Well C-45					
Owner: Southern Pacific Lines. Driller: J. S. McSpadden.					
Soil and gravel	17	17	Clay	41	181
Rock, soft, white, (water at 65 feet)	48	65	Rock, hard	16	197
Rock, white	38	103	Rock, soft, green	12	209
Rock, red, with clay	37	140	Rock	27	236
Well C-51					
Owner: City of Alpine. Driller: C. N. Watson.					
Alluvium	68	68	Tuff	20	298
Basalt	44	112	Basalt	11	309
Tuff	11	123	Rock, hard, red	25	334
Basalt (water)	37	160	Basalt	13	347
Basalt, broken and solid	107	267	Tuff	3	350
Soapstone	11	278	Not reported	50	400
Well C-56					
Owner: Percy Davis. Driller: Anton Hess.					
Gravel, caliche, boulders	100	100	Sandstone, soft, red	6	336
Basalt, hard, green, black, purple, red, some clay	120	220	Clay, red	14	350
Clay, red and red rock (water at 330 feet)	110	330			

Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-4		
Owner: Perry Cartwright. Driller: C. N. Watson.		
Sample log by R. T. Littleton and G. L. Audsley.		
No sample	15	15
Gravel and caliche	5	20
Basalt, altered, hard, fine-textured, black, locally brown 90 percent; cavings 10 percent	40	60
Basalt, as above, 40 percent; trachy-basalt, hard, altered irregular color streaks, containing feldspar and biotite, brown, gray, 60 percent	10	70
Trachyte, hard, micro-crystalline, some biotite and quartz, red-brown to cream	15	85
Tuff, hard to soft, containing feldspar and small amount of biotite and quartz, red and green	5	90
Tuff, soft, argillaceous, pink to cream	10	100
Well D-8		
Owner: Rex Ivey. Driller: T. W. Huffman.		
Sample log by W. N. McAnulty.		
Alluvial fill and outwash, basalt, gravel, and sand (encountered first water at 58 feet)	74	74
Basalt, fine-textured, black, contains some chalcedony, calcite, and a resinous reddish-brown material	32	106
Tuff, fine-grained, slightly calcareous, contains feldspar crystals, red	6	112
Basalt, altered, brown, contains chalcedony and calcite	6	118
Tuff, fine-grained, bentonite, slightly gritty, greenish-gray	13	131
Basalt, altered, highly calcareous, red-brown; contains considerable chalcedony, calcite, and light green feldspar	23	154
Tuff, fine-grained; bentonite, gray	5	159
Basalt, altered at top, black, contains chalcedony, calcite, feldspar, and red weathered tuff	31	190
Tuff, fine-grained, red and gray	4	194
Basalt, black	6	200

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-8--continued		
Tuff, weathered, sandy to fine grained, red, brown and gray	13	213
Basalt, highly altered, dull gray, contains considerable chalcedony, and calcite; shows iron oxide staining	9	222
Basalt, fresh, black, with much chalcedony, calcite, glassy feldspar	8	230
Basalt, mixed with red and gray tuff	10	240
Basalt, contains feldspar and olivine	28	268
Basalt, highly altered to fresh, mixed with brownish-gray tuff, and containing feldspar and some chalcedony	22	290
Tuff, weathered, sandy, brown	9	299
Basalt, altered, contains considerable calcite and feldspar	8	307
Tuff, weathered, sandy, brown	8	315
Tuff, fine sand, calcareous, greenish-gray; felsite toward base, red (at 320-325 feet, obtained 5 bailers of water in 40 minutes)	35	350
Andesite (?), rock, fine grained, brownish-gray, (at 420 feet, water stood within 180 feet of surface)	75	425
Tuff, fine-grained, greenish, gray	9	434
Andesite (?), vitreous appearance, brownish-gray	6	440
Tuff, fine-grained, greenish-gray, (at 443 feet, bailed 7 bailers full in 5 minutes)	10	450
Andesite (?), fine-grained, brownish-gray, considerable iron oxide staining	40	490
Tuff, sandy, reddish brown	16	506
Tuff, brown, with slender crystals of iron sulphate ($FeSO_4$), has an alum taste	4	510
Basalt, weathered, reddish-brown	6	516
Basalt and fine-grained, green tuff	9	525
No samples (at 549 feet, bailed 60 bailers full in 60 minutes, lowered water level to 340 feet in 10 minutes; next test, 23 bailers in 23 minutes, lowered water level to 348 feet; then 30 bailers in 30 minutes, lowered water level to 357 feet.)	25	550
Basalt, has considerable iron oxide staining and contains grains of feldspar	80	630
Tuff, bentonite with some rounded sand grains of igneous rock material, greenish-gray	42	672
Basalt and tuff (tuff probably caving)	73	745

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-8--continued		
Tuff, fine-grained, greenish, gray	38	783
Basalt, brownish-black	22	805
Tuff, fine-grained, greenish-gray	9	814
Trachyte, mostly fine-grained, contains glassy feldspar, reddish-brown	61	875
Tuff, white, gray, and greenish-gray, with considerable admixture of gray limestone	25	900
Limestone, gray	5	905
Tuff, sandy and fine-grained, gray, interbedded with limestone	127	1,032

Well D-9

Owner: City of Alpine. Driller: C. N. Watson.

	Thickness (feet)	Depth (feet)
Soil (?)	8	8
Gravel and clay	48	56
Rock, black	50	106
Clay, red	3	109
Soapstone, bentonitic	24	133
Rock, black, water at 185 feet	57	190
Clay, red	8	198
Conglomerate	67	265
Rock, red	29	294
Clay, red	6	300

Well D-11

Owner: City of Alpine. Driller P. W. Gooden.

Sample log by R. T. Littleton and G. L. Audsley.

	Thickness (feet)	Depth (feet)
Alluvium of Quaternary age		
No sample	50	50
Gravel and clay; clay pink and green, plastic, some biotite; gravel, trachyte and tuff, some free quartz	20	70

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-11--continued		
Basalt, black, contains platy feldspar, olivine, 40 percent; gravel and clay, as above, 60 percent----	10	80
Sheep Canyon basalt and Cottonwood Springs basalt		
Basalt, black, veined with calcite and platy feldspar, 70 percent; tuff, argillaceous, pink and brown, some feldspar and mica, 30 percent------------------	5	85
Basalt, black, 25 percent; tuff, ashy, brick-red to pink, with biotite and feldspar, 70 percent; tuff, argillaceous, yellow-green, 5 percent----------------	6	91
Basalt and basaltic tuff, highly altered, containing feldspar and biotite, black to dark maroon, much free calcite--	9	100
Basalt, amygdaloidal, amygdules of calcite, green clay, highly altered, deep maroon, 50 percent; tuff, ashy, soft, calcareous, brick-red, 50 percent--	6	106
Bentonite, argillaceous, plastic, containing a few crystals of feldspar, yellow-green------------------	4	110
Bentonite and red, soft tuff; a few cuttings of altered basalt--------------------------------------	3	113
Tuff, soft, bentonitic, red, green, purple, 95 percent; basalt, black, 5 percent----------------------------	22	135
Tuff, as above, 60 percent; basalt, black and basaltic tuff, medium hard, red, some quartz, 40 percent------	8	143
No sample--	37	180
Tuff, soft, ashy, brick-red, gray, 60 percent; basalt, black and maroon, 40 percent------------------------	15	195
Tuff, soft, contains some mica, pink, green, gray, 65 percent; basalt, reddish-brown to black, 35 percent--	35	230
Tuff, containing much mica, feldspar and amphibole, brittle, weathered, light pink, 60 percent; basalt, dense, reddish-brown, 30 percent; tuff, argillaceous, light green, 10 percent----------------------------	10	240
Tuff, light pink, as above----------------------------	18	258
No sample--	2	260
Tuff, as above, becoming more ashy and unconsolidated--	12	272
Tuff, sugary texture, soft, argillaceous, containing shards of volcanic glass, light green, 75 percent; tuff, light pink, as above, 20 percent; basalt, reddish-brown, 5 percent----------------------------	4	276
No sample--	49	325
Total depth--		325

Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well D-13					
Owner: City of Alpine. Driller: P. W. Gooden.					
Alluvium	34	34	Basalt	38	106
Clay, yellow	6	40	Shale, blue-green	40	146
Volcanic ash	6	46	Basalt, black	104	250
Gravel, some clay, water	22	68	Sand	23	273
			Lime, pink	3	276
Well D-14					
Owner: City of Alpine. Driller: R. C. Gooden.					
Sand and gravel (much water, 65-75 feet)	75	75	Basalt, hard	150	310
Basalt	15	90	Shale and tuff	36	346
Shale, red, blue, green	70	160	Tuff rock, red	4	350
Well D-16					
Owner: City of Alpine. Driller: G. W. Huffman.					
Soil (?)	10	10	Rock, red	100	405
Gravel	34	44	Basalt with interflow beds of blue clay	25	430
Rock, red, sandy at 60-67 feet	31	75	Clay, blue (possibly more water at 490-495 feet)	70	500
Rock, red and black	45	120	Rock, sandy, red	50	550
Conglomerate	55	175			
Rock, black with interflow beds of blue clay	130	305			

	Thickness (feet)	Depth (feet)
Well D-18		
Owner: City of Alpine. Driller: P. W. Gooden.		
Sample log by R. T. Littleton and G. L. Audsley.		
Crossen trachyte		
Clay and soil; trachyte-fragments, fresh to highly altered, brown to dark brown	10	10

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Clay, bentonitic, yellow, 80 percent; trachyte fragments, vesicular, angular, 15 percent; bentonite, white, 5 percent	15	25
Clay; hard to soft, brittle, yellow and tan; may be alteration product of trachyte; trachyte fragments sparse	10	35
Trachyte, hard, very fine-textured, altered, bluish-green, lavender and brown; 95 percent; clay, tan, 5 percent	15	50
Trachyte, fine-textured, sparsely veined with silica, some crystalline quartz, rock partly altered, moderately hard to soft, lavender, 55-80 percent; bentonite, white, green, 20-45 percent; clay, bentonitic, tan	10	60
Trachyte, fine-textured, hard, lavender, some fragments have manganese stain, sparsely veined with quartz	15	75
Trachyte, gray and lavender, gray is highly altered, sparsely vesicular; the vesicles are filled or lined with silica; the rock is veined and dotted with silica and locally considerably iron stained, 70 percent; clay, bentonitic, light green to tan, 30 percent	3	78
Pruett formation		
Bentonite, soft, light green, 95 percent; clay, bentonitic, tan, 5 percent	5	83
Bentonite, gray	3	86
Limestone, hard, partly silicified but largely veined with calcite; rock breaks with subconchoidal fracture, yellowish-tan (driller reports crevice at 87 feet; lost water temporarily)	9	95
Clay, calcareous, shaley, soft, dark gray	5	100
Limestone, brittle veined with calcite, light to dark gray	8	108
Limestone, brittle, crystalline, minutely veined with calcite, light tan	6	114
Limestone, soft, crystalline, tuffaceous, light gray, 90 percent; tuff, calcareous, 10 percent	6	120
Limestone, soft, crystalline, light to dark gray, 60 percent; tuff, soft, weakly calcareous, grayish-green, 40 percent; sample contains numerous small calcite crystals	5	125

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Tuff, soft, weakly to noncalcareous, somewhat bentonitic, grayish-green and dark green------------	3	128
Tuff, soft, bentonitic, clayey, noncalcareous, dark green, 55 percent; limestone, tuffaceous, clayey, light grayish-tan, 45 percent-----------------------	4	132
Limestone, crystalline, slightly tuffaceous, abundantly veined with calcite, light grayish-tan (sample contains considerable clear free crystalline calcite, some of which is stained green)--------------------	8	140
Limestone, soft, tuffaceous, sparsely crystalline with calcite, light grayish-tan with thin streaks of green---	19	159
Limestone, crystalline, partly tuffaceous, soft, light greenish-gray and tan------------------------------	5	164
Tuff, soft, clayey, weakly to strongly calcareous, drab green and light purple------------------------	4	168
Tuff, soft to hard, brittle, clayey, green and purple (green is very weakly calcareous, purple is noncalcareous)--	15	183
Limestone, soft, tuffaceous, light greenish-gray and gray---	4	187
Tuff, soft, weakly to moderately calcareous, green, 70 to 100 percent----------------------------------	8	195
Limestone, tuffaceous, clayey, soft, grayish-brown-----	5	200
Limestone, crystalline containing abundant calcite, gray and brown, 90 percent; tuff, soft, highly calcareous, green, 10 percent-----------------------	8	208
Tuff, highly calcareous, gray and green---------------	3	211
Limestone, crystalline, hard, veined with calcite, light grayish-tan-----------------------------------	6	217
Limestone, soft, compact, light gray, 60 percent; tuff, soft, calcareous, light green, 35 percent; trachyte cavings, 5 percent---------------------------------	3	220
Limestone, as above, 80 percent; tuff, as above, 20 percent---	10	230
Shale, highly (coated or veined sparsely with asphaltum) calcareous, hard, veined with calcite, pyrite, black, 55 percent; limestone, containing pyrite, soft, gray, 40 percent; tuff, soft, calcareous, green, 5 percent--	3	233

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Limestone, hard, contains veins of pyrite, gray, 45 percent; limestone very soft, calcareous, lavender, green, 45 percent; shale, hard calcareous, brittle, veined with pyrite, black, 10 percent	3	236
Limestone, gray, hard to soft, calcareous, green, 75 percent; clay, plastic, calcareous, green, 20 percent; tuff, soft, non-calcareous, yellow, 5 percent	4	240
Shale, veined with calcite, calcareous, asphaltic, black, 65 percent; limestone, soft, veined with pyrite, gray, 30 percent; tuff, soft, calcareous, blue-green, 5 percent	3	243
Tuff, soft, calcareous, bentonitic, blue-green, 60 percent; limestone, soft, veined with pyrite, gray, 30 percent; shale, calcareous, black, 10 percent	3	246
Tuff, blue-green, as above, 60 percent; limestone, as above, 30 percent; tuff, soft, noncalcareous, yellow, 5 percent; tuff, hard, silty, noncalcareous, light green, 5 percent	4	250
Tuff, soft, calcareous, bentonitic, blue-green, 65 percent; limestone, soft, veined with calcite, gray, 30 percent; shale, calcareous, black 5 percent	4	254
Limestone, containing small crystals of pyrite, grayish-white, 60 percent; tuff, soft, contains pyrite, light green, 30 percent; tuff, silty, calcareous, contains cinder and ash particles, also has sparse crystals of pyrite, gray, 10 percent	17	271
Limestone, white-gray, 70 percent; tuff, soft, noncalcareous, green, 25 percent; tuff, hard, noncalcareous, brown, red and yellow, 5 percent	4	275
Limestone, white to gray, 80 percent; tuff, soft, green, 20 percent	4	279
Limestone, white to gray, 40 percent; tuff, soft, green, 55 percent; tuff, noncalcareous, brown, pink, 5 percent	4	283
Tuff, soft, noncalcareous, green, 45 percent; limestone, gray, 35 percent; tuff, brittle, composed of silty particles in a calcareous binder, white, 15 percent; tuff, brown and yellow, 5 percent	4	287

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Tuff, soft, noncalcareous, blue and green, 50 percent; tuff, argillaceous, noncalcareous, plastic, light green, 30 percent; limestone, white, 15 percent; tuff, soft, noncalcareous, brown, 5 percent----------	5	292
Tuff, soft, noncalcareous, green and blue, 65 percent; tuff particles in a calcareous matrix, 70 percent; limestone, white-gray, 15 percent-------------------	2	294
Tuff, soft, noncalcareous, some pyrite crystals present, green, 60 percent; limestone, compact to crystalline, hard, 20 percent; tuff, noncalcareous, argillaceous, plastic, green, 15 percent; tuff, brown, white, blue, 5 percent-----------------------	11	305
Tuff, argillaceous, plastic, noncalcareous, green, 70 percent; tuff, noncalcareous, soft, green, blue, 15 percent; limestone, brown and white, 15 percent---	5	310
Tuff, noncalcareous, soft, green, 65 percent; limestone, brown and white, 15 percent; tuffaceous clay, 10 percent; tuff, blue, brown, pink, 10 percent---	5	315
Tuff, soft, noncalcareous, green, 70 percent; limestone, brown, 15 percent; buff, argillaceous, plastic, green, 15 percent--------------------------	10	325
Tuff, soft, noncalcareous, green, 55 percent; tuff, argillaceous, plastic, noncalcareous, green, 30 percent; limestone, brown, 15 percent-------------	5	330
Tuff, brecciated, calcareous gray, 50 percent; tuff, noncalcareous, containing some pyrite, soft, blue and green, 40 percent; limestone, gray, brown, 10 percent---	7	337
Tuff, soft, veined with small seams of calcite, blue, 30 percent; limestone, gray and brown, 30 percent; tuff, agglomeritic, calcareous, gray, 25 percent; tuff, green, pink, 15 percent-----------------------	8	345
Limestone, granular, gray, 25 percent; tuff, veined with small seams of calcite, soft, light, green, 30 percent; tuff, brecciated, calcareous, gray, 30 percent; tuff, granular, containing some biotite, soft, gray, 10 percent; limestone, soft, brown, 5 percent-------------------------------------	5	350

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Limestone, compact to crystalline, containing some pyrite, brown, 55 percent; tuff, soft, containing some pyrite in seams, noncalcareous, blue and green, 35 percent; tuff, brecciated, calcareous, gray, 5 percent; tuff, violet, yellow, calcite, 5 percent--	9	359
Clay, soft, somewhat shaley, noncalcareous, blue-green, 70 percent; limestone, brown, white, 25 percent; tuff, green, violet, yellow, 5 percent--------------------	4	363
Limestone, contains some biotite, white-gray, 60 percent; tuff, granules, calcareous, white, 25 percent; tuff, soft, green, 10 percent; clay, soft, blue-green, 5 percent------------------------------------	18	381
Limestone, gray, containing much blue and white glassy material, 70 percent; tuff, soft, noncalcareous, green, 30 percent------------------------------------	14	395
Limestone, containing glassy material and having a porphyritic appearance, gray and brown, 65 percent; tuff, calcareous, soft, having bright deep, green spots of argillaceous tuff, light green, 35 percent--	20	415
Limestone, hard, brittle, crystalline, veined with calcite, gray, tan, and brown-----------------------	23	438
Limestone, somewhat softer than above, grayish, tan, 70 percent; shale, hard, brittle, weakly calcareous to noncalcareous, gray with brown stain, 25 percent; limonite, clay, 5 percent---------------------------	4	442
Tuff, noncalcareous, hard, brittle, light gray and light brown, has considerable limonite stain, 55 to 70 percent; rock appears to be altered due to mineralization, limonite and limonitic clay, 30 to 45 percent--	8	450
Limonite and limonitic tuff, noncalcareous, appears highly mineralized, yellow, brown, white, and pink, some red veining resembling cinnabar----------------	16	466
Tuff, limonitic, soft, noncalcareous, yellow and light yellow, white and light green, 75 percent; clay, soft, noncalcareous, blue, 20 percent; limestone, soft, violet, 5 percent; tuff, white and light green, 5 percent------------------------------	10	476
Tuff, limonitic, soft, noncalcareous, yellow, 35 percent; tuff, calcareous, medium hard, gray, containing light blue and black glassy material, 50 percent; limestone, violet, 10 percent; clay, soft, blue, 5 percent--------------------------------	5	481

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Tuff, limonitic as above, 80 percent; (decrease of gray tuff), clay and tuffaceous clay, noncalcareous, blue, 20 percent	25	506
Clay, shaley, soft, noncalcareous, blue, 70 percent; limestone and calcareous tuffs, 30 percent	7	513
Tuff, soft, noncalcareous, limonitic, yellow, 70 percent; tuffs and shales, soft, blue, 20 percent; bentonite, soft, green, 10 percent	9	522
Tuff, soft, noncalcareous, red-brown, 80 percent; bentonite, soft, green, 10 percent; clay, soft, blue, 10 percent	5	527
Tuff, rhyolitic (?), noncalcareous, hard, brown, 40 percent; tuff, red-brown, 35 percent; tuff, soft, limonitic, yellow, 15 percent; bentonite, soft, green, 10 percent	18	545
Tuff, rhyolitic (?), noncalcareous, light brown, 90 percent; bentonite, 10 percent	52	597
Tuff, hard, brittle, calcareous to weakly calcareous, gray	11	608
Tuff, noncalcareous, altered, devitrified, light gray and greenish-gray	6	614
Tuff, soft, noncalcareous, gray, 95 percent; tuff, yellow, green, 5 percent; some bentonite	7	621
Tuff, soft to hard, noncalcareous, gray, 65 percent; clay, bentonitic, soft, green, 15 percent; tuff, soft, yellow, 20 percent	7	628
Tuff, gray, and bentonite, green, 50 percent; felsite, noncalcareous, somewhat granular, possibly a weathered or metamorphosed zone, light tan, 50 percent (the felsite could possibly be a rhyolite at the top of a sill)	7	635
Intrusive rocks of Tertiary age		
Microsyenite, 80 percent; bentonite clay, soft, green, 20 percent	5	640
Microsyenite, very fine texture, glassy, light gray, some red and black stains	63	703
Rocks of Cretaceous age, undifferentiated		
Clay and shale, soft, noncalcareous, tuffaceous, some showing of pyrite and bentonite, blue	9	712
Shale and clay, soft, noncalcareous, tuffaceous, blue, some bentonite	6	718

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Limestone, dense, associated with blue shale in proportions from 25-60 percent dark brown; shale and clay, soft, noncalcareous, blue, 40-75 percent; bentonite, soft, green, 10 percent-------------------	12	730
Shale and clay, soft, noncalcareous, containing some pyrite, blue, 60 percent; limestone, medium soft, compact in places, interbedded with shale, light brown, 35 percent; clay, bentonitic, containing some pyrite, soft, green, 5 percent-----------------	3	733
(Driller reports entering a very hard formation.) Limestone crystalline, containing pyrite, calcite veins, brown, 40 percent; clay, shaley, pyritized abundantly, gray and bluish-gray, 40 percent; bentonite, talcose, weakly calcareous, green, 20 percent--	2	735
Clay, gray, talcose, may be alteration product (?), 65 percent; limestone, impure to crystalline, brown, 25 percent; serpentine (?), talcose, slick, greasy, green to light green, 10 percent; (material from 712-737 caved badly)---------------------------	7	742
Clay, soft, noncalcareous, containing some pyrite, blue, 50 percent; limestone, compact, contains some pyrite, brown to light tan, 40 percent; tuffaceous clays, soft, green and brown, 10 percent------------	18	760
Limestone, hard, whitish-gray, 85 percent; clay, soft, noncalcareous, blue, 10 percent---------------------	6	766
Limestone, crystalline, contains abundant free calcite, hard, brittle, white and light gray, 75 percent; clay, noncalcareous, containing abundant crystals of pyrite, whitish-blue, 25 percent-----------------	10	776
Limestone, locally carboniferous (?) and shaley, moderately hard, brittle, crystalline but containing very little free calcite, gray and dark gray, 90 percent; clay, as above, 10 percent; some fragments are slickensided, drilling very hard-------	11	787
Limestone, hard, brittle, moderately calcareous, veined with quartz, gray and brownish-gray, 90 percent; clay, calcareous, hard, brittle, light blue, 10 percent---	8	795
Limestone, hard, sample very finely powdered, light gray, 100 percent (limestone may be cherty)----------	11	806

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Limestone, slatey, moderately hard to hard, crystalline, containing abundant calcite, gray and brownish-gray to brown--	21	827
Limestone, crystalline, hard, contains abundant calcite, gray to dark gray with brown specks---------	20	847
Limestone, as above, except may also be cherty---------	8	855
Sample badly contaminated; consists of cavings of blue pyritized clay and brown crystalline limestone in about equal proportions; material drilled was reported hard limestone and was so finely powdered that no cuttings were obtained---------------------	9	864
Limestone, cherty, very hard, light tan---------------	10	874
Limestone, hard, cherty, siliceous, light gray to grayish-tan; (driller reported increase in water at 892 feet)---------------------------------------	30	904
Limestone, crystalline, hard, gray to dark gray, possibly streaked with paper-thin calcareous black shale--	11	915
Limestone, shaley to crystalline, hardness about 3 but cherty and shaley in streaks, dark gray and black----	4	919
Limestone, cherty and shaley, gray to dark gray--------	3	922
Limestone, crystalline, hard, cherty; streaks of black, limy, carbonaceous, shale, soft; sparse amount of massive pyrite, dark gray and black; shale contains unidentified fossil imprint-------------------	8	930
Shale, limy, contains abundant pyrite, black to dark gray, 50 percent; limestone, crystalline to shaley, fossiliferous, brownish-gray, 50 percent-------------	9	939
Limestone, crystalline to shaley, streaked with thin beds of black limy shale, fossiliferous, medium hard to hard, brownish-gray--------------------------	4	943
Shale, soft, clayey, noncalcareous, pyritized, fossiliferous, bluish-gray---------------------------------	8	951
Shale, as above, 50 percent; siltstone, moderately calcareous, reduces to silty residue in hydrochloric acid, locally appears to be a limy mudstone, tan, streaked with light tan, 50 percent-----------------	5	956
Rocks of Permian age, undifferentiated		
Limestone, cherty, impure, moderately calcareous, hard, light gray, 45 percent; siltstone, weakly calcareous, tan, 30 percent; shale, black to dark bluish-gray, black is calcareous, gray is non-calcareous, 25 percent------------------------------	5	961

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Limestone, silty, cherty, weakly calcareous, tan, drab-	7	968
Limestone, very hard, cherty, moderate to weakly calcareous, containing considerable pyrite, tan to gray--	7	975
Limestone, becoming highly siliceous and pyritized, moderately calcareous, gray------------------------	5	980
Clay, brittle, moderately hard, noncalcareous, shaley, bluish-gray, some pyrite--------------------------------	3	983
No sample--	2	985
Limestone, siliceous or cherty, moderately calcareous, gray, contains chalcedony in lower part--------------	10	995
Limestone, slightly calcareous, siliceous, some chalcedony, pyrite, and free calcite, gray--------------	19	1,014
Limestone, moderately calcareous, crystalline, tan to gray; clay, bentonitic, soft, weakly calcareous, bluish-black--	12	1,026
Clay, soft, weakly calcareous, bentonitic, blue-green, 50 percent; limestone, crystalline, and pyrite, lower 4 feet is brownish-black, 50 percent----------------	8	1,034
Rock, hard, noncalcareous, appears possibly to be an altered syenite (?), brownish-black, 55 percent; clay, soft bentonitic, green and lavender, 25 percent; limestone, gray, 20 percent; also showing is a white and black rock, hard, noncalcareous, which may be syenitic (?)---------------------------------	6	1,040
Clay, noncalcareous, soft, possibly in the zone of alteration, brown, 50 percent; limestone, gray, 20 percent; clay, soft, bentonitic; 25 percent; limonite, botryoidal, hard, metallic luster, weakly magnetic, associated with limonite, black, glossy, 5 percent-----------------------------------	6	1,046
Clay, bentonitic, soft, noncalcareous, 50 percent; limonite, botryoidal, noncalcareous, metallic luster, 20 percent; limestone, fossiliferous, tan and gray, 15 percent; chalcopyrite, and free calcite, 5 percent---	4	1,050
(Zone from 1,026 to 1,050 contains altered rocks with considerable iron mineralization, possibly a fault zone or contact zone. From 1,050 feet pyrite and a yellowish marl is present in all samples.)		

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Limestone, fossiliferous, highly calcareous, brittle, pink to light tan, 45-65 percent; limestone, fossiliferous, gray, 20 percent; (hole caving)----------	8	1,058
Limestone, highly fossiliferous, light gray to black, 90 percent--	5	1,063
Siltstone, carbonaceous, calcareous binder, black, 75 percent; limestone, as above, 20 percent----------	4	1,067
Limestone, dark gray, 60 percent; siltstone, as above, 20 percent; traces of yellowish marl and pyrite------	3	1,070
Limestone, highly fossiliferous, containing some pyrite, dark gray and green, 90 percent; cavings, 10 percent (fossil fragments of bryozoa or coral (?))-----------	17	1,087
Clay, bentonitic, light blue-gray, 60 percent; limestone, fossiliferous, unidentified brachypods, dark gray, 35 percent; cavings, 5 percent----------------	8	1,095
Limestone, gray, 50 percent; clay, soft, noncalcareous, green, 50 percent-----------------------------------	9	1,104
Limestone, few fossil fragments, dark gray, some free calcite showing--------------------------------------	5	1,109
Limestone, as above, 90 percent; marl, yellow, 10 percent---	5	1,114
Limestone, gray, 50 percent; clay, soft, noncalcareous, light blue, 50 percent------------------------------	3	1,117
Limestone, nonfossiliferous, containing some pyrite, light brown--	8	1,125
Limestone, light brown, 80 percent; limestone, black, carbonaceous, 20 percent----------------------------	5	1,130
Limestone, nonfossiliferous, gray---------------------	10	1,140
Limestone, dark gray to light gray, some pyrite--------	20	1,160
Sandstone, clean, rounded grains, frosted, poorly cemented, 60 percent; limestone, dark gray, 40 percent--	8	1,168
Shale, noncalcareous, nonfossiliferous, breaks with conchoidal fracture, black, 55-65 percent; limestone, gray, 35-45 percent---------------------------	4	1,172
Limestone, nonfossiliferous, dark gray----------------	9	1,181
Limestone, fossiliferous, containing some pyrite, gray to light tan, 55-65 percent; clay, soft, calcareous, blue, 35-45 percent--------------------------------	4	1,185
Limestone, soft, highly calcareous, containing pyrite, fossiliferous, grayish-black------------------------	10	1,195

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Limestone, as above; shale, calcareous, light green----	6	1,201
Shale, brittle, arenaceous, calcareous, fossiliferous, green, 95 percent; limestone, nonfossiliferous, dark gray, 5 percent------------------------------------	11	1,212
Limestone, crystalline, with abundant free calcite, contains streaks of sandy limestone, gray and light gray---	10	1,222
Limestone, shaley limestone and marl locally streaked with silt, soft, calcareous------------------------	5	1,227
Limestone, crystalline, soft, fossiliferous, to abundantly fossiliferous, considerable free calcite, gray to light gray----------------------------------	28	1,255
Limestone, finely crystalline, soft, contains abundant pyrite, streaked sparsely with black shaley limestone, contains fossil fragments of coral (?) or bryozoa (?), gray------------------------------------	8	1,263
Clay, bentonitic, soft, gray, 85 percent; limestone and shaley limestone, gray and dark gray, 15 percent-----	5	1,268
Limestone, finely crystalline, soft, has a slight sugary texture, gray and light gray-----------------	5	1,273
Shale, hard, siliceous, very finely sandy to silty, streaked with fine-grained, shaley, sandstone, gray--	9	1,282
Intrusive rocks of Tertiary age		
Felsite, hard, siliceous, clayey, streaked with silty sandstone, light gray------------------------------	10	1,292
Felsite, hard, clayey, streaked with dark gray shaley pyritized clay; also light gray siliceous shale contains streaks of ferruginous clay-------------------	4	1,296
Felsite, altered, siliceous, cherty, weakly calcareous, when powdered in cold dilute acid, very light gray---	12	1,308
Felsite, altered, siliceous, cherty, ferruginous, calcareous in powdered form, streaked sparsely with black shale, weakly calcareous, very light gray, and brownish-yellow----------------------------	7	1,315
Felsite, altered, siliceous, cherty, ferruginous, light gray, pinkish-gray and yellowish-brown---------	17	1,332
Felsite, altered, very fine-grained, with angular grains of quartz in a slightly calcareous matrix, gray and tan, clay, ferruginous--------------------	8	1,340
Felsite, fine to very fine-grained, consists of angular quartz grains embedded in a matrix of gray clay, locally yellow and ferruginous, gray and tan; cavings of black shale, 5 percent--------------------------	4	1,344

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
Felsite, soft to hard in streaks, locally ferruginous, gray and tan, (bands of amorphous silica)------------	13	1,357
Felsite, highly siliceous, altered, soft, with hard streaks, gray and tan--------------------------------	22	1,379
Felsite, as above, with streaks of very fine-grained sandstone (?), highly siliceous---------------------	3	1,382
Felsite, and very fine-grained sandstone (?), siliceous, consists of angular quartz grains, gray and tan------	6	1,388
Felsite, highly siliceous, gray and tan---------------	25	1,413
Felsite, fine to very fine-grained, quartzitic in appearance, siliceous, containing black stains (possibly manganese oxides), gray to tan-------------	95	1,508
Felsite, porphyry, texture felsitic to very finely granular to aplitic; contains minute, square crystals of glassy feldspar (sanadine ?), and clusters of minute dark fragments of riebeckite (?), gray to light gray, locally stained light brown and black with iron or manganese-------------------------	29	1,537
As above with somewhat less staining, rock appearance considerably fresher than above-----------------	25	1,562
As above, cuttings have a dust coating which is very weakly calcareous; sample contains gray granular fragments that are weakly calcareous; decrease in the amount of riebeckite (?)-------------------------	8	1,570
As above, becoming weakly but persistently calcareous along minute fractures and around the edges of feldspar crystals------------------------------------	65	1,635
As above, except locally much brown coloration---------	2	1,637
As above, except no brown colorations------------------	3	1,640
As above, except much red-orange and brown local staining (driller encountered hard drilling and had trouble keeping straight hole at 1,640 feet)-----	5	1,645
As above, except some small bands of soft maroon material (manganese oxide) showing the blue-gray felsite porphyry, no stains-------------------------	5	1,650
As above, except no banding and brown stains increasing--	30	1,680
As above, except felsite porphyry now light gray, small minute clusters of black specks, brown staining predominant-------------------------------------	61	1,741
As above, except some maroon coloration and a black coating having a flat, slick appearance, as biotite--	7	1,748

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-18--continued		
As above, except no maroon coloration	5	1,753
As above, except an increase in a brown-black mica; still calcareous along minute fractures and sides of feldspar crystals (driller reports extremely hard drilling)	3	1,756
As above, except formation softer (driller believes more water encountered at 1,760 feet), also decrease in mica	38	1,794
No record	208	2,002
Well D-22		
Owner: City of Alpine. Driller: P. W. Gooden.		
Sample log by W. N. McAnulty.		
No sample	46	46
Sand and gravel contains fragments of weathered basalt	4	50
Andesite (?), reddish	15	65
Basalt, fine-textured, numerous phenocrysts of feldspar, olivine, black and greenish-black	17	82
Tuff, intercalated with greenish-gray fine-textured basalt	8	90
Basalt, fresh, fine-textured, black	27	117
Tuff, fine-grained, containing weathered basalt, greenish-gray	57	174
Basalt, black, fresh	26	200
Shale, tuffaceous, argillaceous, black	40	240
Basalt	18	258
Tuff with intercalated basalt, weathered	72	330
No sample	20	350

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well D-25					
Owner: W. H. Perryman. Driller: Anton Hess.					
Gravel	30	30	Conglomerate, soft, seamy, blue, purple, green, white calcite	57	167
Shale and rock, red, (water at 52 and 90 feet)	80	110			

Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-33		
Owner: Z. M. Decie. Driller: C. N. Watson.		
Sample log by R. T. Littleton and G. L. Audsley.		
Gravel, consisting predominately of fragments of trachyte and caliche	14	14
Felsite, porphyry, contains numerous feldspar crystals, some amphibole, reddish-black, sample contains caliche	48	62
Obsidian, glassy, conchoidal, fractured, brittle, black	14	76
Tuff, soft, bentonitic, locally vesicular, veined with calcite, varicolored	20	96
Basalt, weathered, contains much platy feldspar giving it a micaceous appearance, contains some altered olivine, in part vesicular, dark greenish-black and red	16	112
Basalt, vesicular in upper part, weathered, locally contains intercalated beds of tuff and tuffaceous clay, gray, blue, and red	54	166
Clay, bentonitic, plastic, light green to gray, sample contains large feldspar crystals	22	188
Basalt, olivine, dark green containing much platy feldspar, locally intercalated beds of tuff and tuffaceous clay	87	275

Well D-39

Owner: Southern Pacific Lines. Driller: Emmet Harrel and Scott Foster.

	Thickness (feet)	Depth (feet)
Soil and clay	20	20
Caliche	40	60
Lava, red (water at 90 feet)	35	95
Lava, black	25	120
Shale, ash, lava, red	20	140
Lava, broken and black, water at 180-195 feet	140	280
Lava, red and black	43	323

Table 7.- Logs of wells in the Alpine area--Continued

Well D-45

Owner: City of Alpine. Driller: R. C. Gooden.

	Thickness (feet)	Depth (feet)
Soil	4	4
Gravel (water at 35 and 50 feet)	46	50
Clay	10	60
Rock	5	65
Clay	15	80
Rock	18	98
Clay	10	108
Rock	94	202

Well D-47

Owner: City of Alpine. Driller: C. W. Watson.

	Thickness (feet)	Depth (feet)
Fill	82	82
Gravel, water	15	97
Rock, hard, black	23	120
Gravel and clay, (water)	31	151
Rock, black	19	170
Rock, hard, red	50	220
Rock, black and tuff	40	260
Conglomerate (water)	10	270
Tuff, sandy	30	300

Well D-48

Owner: City of Alpine. Driller: Anton Hess.

	Thickness (feet)	Depth (feet)
Soil and dirt, soft, brown	5	5
Gravel and clay (water at 33 feet)	35	40
Rock, hard, brown	20	60
Clay, brown and yellow, and soapstone	10	70
Shale, pink	5	75
Rock, hard, red, blue-black	40	115
Shale, soft, brown	5	120
Rock, hard, black	5	125
Shale, chocolate colored	10	135
Rock, hard, fractured, blue-black (water at 135-150 feet)	25	160
Clay and gravel, red and brown	5	165
Rock, hard, blue and black	45	210
Clay, soft, red and pink	15	225
Shale, sandy, blue-black with red rock	75	300

Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well D-53		
Owner: City of Alpine. Driller: C. N. Watson.		
Sample log by W. N. McAnulty.		
Microsyenite (fine-grained intrusive syenite)	135	135
Tuff, sandy, brownish-gray	30	165
Microsyenite	20	185
Basalt, fine-grained, with considerable calcium carbonate, shiny black	55	240
Microsyenite	96	336
Basalt, shiny black, with appreciable reddish-brown mineral, olivine, and some calcium carbonate	84	420
Tuff, fine-grained, red and gray	8	428
Basalt, porphyritic, with phenocrysts of greenish glassy feldspar, considerable resinous reddish-brown material	22	450
Microsyenite	33	483
Basalt, very similar to that between 428 and 450 feet, contains some chalcedony, calcite, glassy feldspar, and olivine	107	590
Tuff, fine-grained, slightly sandy, red	5	595
Basalt, as above	5	600

Well D-55

Owner: City of Alpine. Driller: Anton Hess and C. Rixford.

	Thickness (feet)	Depth (feet)
Clay, caliche	50	50
Rock, hard, red	30	80
Shale, sandy, blue-gray	25	105
Shale, red	5	110
Rock, black	40	150
Shale, gray	10	160
Rock, hard, red-brown and blue-black	55	215
Shale, red	5	220
Rock, blue-black	23	243
Shale, red	9	252
Rock, hard	6	258
Lime, blue	42	300
Rock, very hard, black	55	355
Shale, red	5	360
Rock, black	27	387
Shale, dark red	13	400
Rock, black	50	450
Rock, red, with green crystals	25	475
Rock, gray, green	15	490
Rock, hard, black and gray	35	525

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Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well D-55--continued					
The following 525-925 feet is a partial log from samples examined by Dr. C. L. Baker, Texas Agricultural & Mechanical College.			Shale, sand, gray-green--	80	1,005
			Rock, hard, red, brown---	22	1,027
Volcanic ash (tuff)--------	55	580	Clay, gray-green, alternating with ash and bentonite--------------	233	1,260
Andesite (weathered zone from 638-642 feet, water-bearing)-----------	155	735	Sandstone, gray, red, green-----------------	30	1,290
Volcanic ash---------------	20	755	Shale, gray, some sand---	104	1,394
Basalt lava flow-----------	14	769	Shale, gray, shells------	20	1,414
Volcanic ash, cemented-----	58	827	Lime, hard, some chert, gray-------------------	38	1,452
Volcanic ash---------------	33	860	Shale, gray--------------	35	1,487
Trachyte-------------------	65	925	No record----------------	913	2,400

	Thickness (feet)	Depth (feet)
Well D-66		
Owner: Mrs. G. A. Morris. Driller: C. N. Watson.		
Sample log by R. T. Littleton and G. L. Audsley.		
Alluvium of Quaternary age		
No sample (driller reports gravel and sand, coarse)----	40	40
Crossen trachyte		
Clay, tuffaceous, contains embedded angular sand and gravel, tan-------------------------------------	20	60
Trachyte, weathered, soft, red, pink and brown---------	12	72
Trachyte, holocrystalline, locally veined with silica, becoming harder in lower part, lavender-------------	25	97
Well H-5		
Owner: John Lane. Driller: Anton Hess.		
Sample log by R. T. Littleton and G. L. Audsley.		
Gravel and caliche-------------------------------------	15	15
Trachyte, vitreous, with quartz and feldspar, maroon-black, 75-80 percent; tuff, porphyritic, argillaceous, varicolored, 20-25 percent----------------------------	35	50

(continued on next page)

Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well H-5--continued		
Tuff, brittle to argillaceous, containing biotite and feldspar, light green with red-brown stains------------	10	60
Tuff, as above; tuff, ashy, hard red-brown, some calcite-	10	70
Tuff, brittle, ashy, light green and red-brown----------	15	85
Tuff, as above, 50 percent; tuff; argillaceous to conglomeratic, rounded sand to pebble size aggregate, noncalcareous, blue-green, 50 percent-----------------	10	95
Tuff, blue-green, as above, 70 percent; tuff, red-brown, 30 percent; some calcite------------------------------	15	110
Tuff, silty, ashy, poorly consolidated, veinlets of calcite, blue-green; felsite, microcrystalline, veined by calcite, maroon-----------------------------	10	120
Tuff, argillaceous noncalcareous, sea-green, some calcite	25	145
Tuff, green, much calcite, as above, 80 percent; basalt, weathered, dense, black, 20 percent------------------	5	150
Basalt, as above---	10	160
Basalt, as above, 60 percent; tuff, argillaceous, shaly to hard, red-brown to tan, 40 percent-----------------	5	165
Basalt, hard, brittle, vesicular, vesicles filled with silica, platy feldspar, red-brown---------------------	5	170
Basalt, as above, 95 percent; tuff, argillaceous, white and green, 5 percent; considerable quartz and calcite--	25	195
Basalt, as above, 50 percent; tuff, as above, 45 percent; calcite, 5 percent--------------------------------	10	205
Tuff, soft, argillaceous, plastic, tan, white, green, 70 percent; basalt, as above, 25 percent; calcite, 5 percent; some sand----------------------------------	15	220
Tuff, argillaceous, green and brown, 80-95 percent; basalt, vesicular, hard, brittle, maroon, 5-20 percent; some free calcite-------------------------------	15	235
Basalt, as above, altered--------------------------------	20	255
Basalt, vesicular, vesicles filled with calcite, some platy feldspar, weathered, maroon, some sand----------	5	260
Tuff, conglomeritic, noncalcareous, argillaceous, sand to pebble size basalt aggregate and feldspar contained in a matrix of bentonitic clay, pink, 15 percent; basalt, as above, 85 percent-------------------	5	265
Basalt, highly altered, brittle to altered, containing olivine, feldspar, vesicles of calcite and silica, gray, and maroon-gray, some sand----------------------	35	300
Basalt, as above, 50 percent; basalt, scoriaceous, cindery, highly fractured and vesicular, brittle, brick-red, 50 percent; some quartz--------------------	10	310

(continued on next page)

Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well H-5--continued		
Trachyte, hard, microcrystalline, containing large crystals of quartz, some vesicular stages, much metallic blue-black globules and stains, maroon, maroon-gray, maroon-brown----------------------------------	20	330
Trachyte, as above, except showing of a green-black secondary alteration tuff; considerable quartz and calcite--	10	340
Trachyte, 50 percent; tuff, argillaceous, plastic, conglomeratic, rust, 25 percent; quartz, clear to orange, 25 percent---------------------------------------	5	345
Tuff, soft, argillaceous, cream, tan, orange, rust, 85 percent; quartz, 15 percent-------------------------	5	350
Tuff, argillaceous, soft, cream, tan, some quartz--------	5	355
Tuff, cream and tan as above, 65 percent; tuff, soft, argillaceous, containing large quartz crystals and fragments of weathered red trachyte, orange and cream, 35 percent--------------------------------------	15	370

Well J-14

Owner: Z. M. Decie. Driller: C. M. Joiner.

	Thickness (feet)	Depth (feet)
Drilling lava (hole full of fresh water)----------	220	220
Same as above--------------	170	390
Volcanic ash (prolific water entered hole, shut it off with 978 sacks of cement; cement job by Haliburton)--	155	545
Volcanic ash (bailed 3 bailers of fresh water per hour)----------------	75	620
Lava (700 feet of water in the hole)-----------	80	700
Able to shut off water at 1,100 feet when at a depth of 750-----------	750	1,450
Gas show-----------------	350	1,800
Total depth--------------	340	2,140

Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well DD-2		
Owner: Ed Davidson. Driller: Anton Hess.		
Sample log by R. T. Littleton and G. L. Audsley.		
Alluvium of Quaternary age		
Soil, sandy	5	5
Gravel, alluvial, bouldery, poorly sorted, with clay and sand	40	45
Sheep Canyon basalt and Cottonwood Springs basalt		
Basalt, highly altered, gray to rust	26	71
Well DD-3		
Owner: Ed Davidson. Driller: Anton Hess.		
Sample log by R. T. Littleton and G. L. Audsley.		
Alluvium of Quaternary age		
Soil and sand	15	15
Gravel, volcanic origin, angular, poorly sorted, with sand and free quartz	55	70
Sheep Canyon basalt and Cottonwood Springs basalt		
Basalt, coarse textured, crumbly, altered, contains considerable free quartz	60	130
Clay, tuffaceous, white	1	131

Well DD-8

Owner: Permian Basin Girl Scouts. Driller: P. W. Gooden.

	Thickness (feet)	Depth (feet)
Soil	10	10
Gravel and sand	20	30
Gravel, dirty, poorly sorted	70	100
Shale, white and red	40	140
Lime and jasper, white and red	35	175
Shale, sandy, white	46	221
Sand, white (water)	3	224

Table 7.- Logs of wells in the Alpine area--Continued

	Thickness (feet)	Depth (feet)
Well DD-9		
Owner: H. L. Kokernot, Jr. Driller: Anton Hess.		
Sample log by R. T. Littleton and G. L. Audsley.		
Alluvium of Quaternary age		
Gravel and sand	24	24
Sheep Canyon basalt and Cottonwood Springs basalt		
Basalt, highly altered, brown to gray	29	53
Well DD-10		
Owner: H. L. Kokernot, Jr. Driller: Anton Hess.		
Sample log by R. T. Littleton and G. L. Audsley.		
Alluvium of Quaternary age		
Soil, sandy, silty	5	5
Gravel, of silicic volcanic flow rocks, containing sand and silt	20	25
Gravel, coarse-grained, bouldery	7	32
Sheep Canyon basalt and Cottonwood Springs basalt		
Basalt, gray to reddish, contains abundant finely disseminated biotite	21	53
Well DD-13		
Owner: Ed Davidson. Driller: Anton Hess.		
Sample log by R. T. Littleton and G. L. Audsley.		
Alluvium of Quaternary age		
Gravel and sand	10	10
Sand, gravel, and quartz, contains fragments of silicic flow rocks	30	40
Sheep Canyon basalt and Cottonwood Springs basalt		
Basalt, gray, mottled with platy feldspar	30	70

Table 8.- Water levels in wells in the Alpine area, Texas

Date	Water level	Date	Water level	Date	Water level
		Well C-13			
Owner: Mrs. Nell Tipelcek.					
Apr. 10, 1955	88.68	Aug. 10, 1955	89.31	Dec. 10, 1955	89.92
Apr. 20	88.66	Aug. 20	89.18	Dec. 20	90.18
Apr. 30	88.84	Aug. 31	89.36	Dec. 31	90.13
May 10	88.89	Sept.10	89.37	Jan. 10, 1956	90.33
May 20	88.85	Sept.20	89.37	Jan. 20	89.93
May 31	88.95	Sept.30	89.46	Jan. 31	89.99
June 10	88.92	Oct. 10	89.58	Feb. 10	90.08
June 20	88.90	Oct. 20	89.70	Feb. 20	90.14
June 30	88.87	Oct. 29	89.69	Feb. 29	90.21
July 10	88.89	Nov. 10	89.54	Mar. 10	90.21
July 20	88.95	Nov. 20	89.81		
July 31	89.02	Nov. 30	89.84		
		Well C-21			
Owner: Perry Cartwright.					
Jan. 25, 1955	71.84	Mar. 21, 1955	71.98	Sept. 1, 1955	75.25
Feb. 15	a86.59	Mar. 28	71.54	Oct. 3	75.64
Feb. 23	70.80	Apr. 4	71.25	Nov. 1	76.13
Feb. 24	71.07	Apr. 11	72.32	Dec. 1	76.80
Feb. 25	71.19	June 20	72.10	Jan. 2, 1956	77.50
Mar. 14	71.70	Aug. 1	74.07		
a Pumping.					
		Well C-22			
Owner: Mrs. Flora Daugherty.					
Feb. 9, 1955	71.32	July 6, 1955	73.83	Aug. 2, 1955	a156.98
Feb. 15	73.26	July 27	a150.8	Aug. 2	a157.16
Feb. 18	72.87	July 28	a150.51	Aug. 2	a156.84
Mar. 28	75.58	July 28	a153.6	Aug. 15	a157.8
Apr. 4	73.25	July 29	a153.9	Aug. 23	90.8
June 20	73.93	July 30	a151.4		
June 29	71.42	Aug. 2	a157.20		
a Pumping.					

Table 8.- Water levels in wells in the Alpine area--Continued

Date	Water level	Date	Water level	Date	Water level
		Well C-28			
Owner: W. H. Terry, Jr.					
Aug. 10, 1955	116.68	Oct. 10, 1955	113.35	Dec. 10, 1955	112.88
Aug. 20	115.31	Oct. 20	112.92	Dec. 20	113.45
Aug. 31	114.72	Oct. 31	112.54	Dec. 31	113.85
Sept.10	114.49	Nov. 10	112.25	Jan. 10, 1956	114.18
Sept.20	114.34	Nov. 20	112.27	Jan. 20	113.79
Sept.30	113.77	Nov. 29	112.44		
		Well C-29			
Owner: Mrs. Flora Daugherty.					
Jan. 25, 1955	46.36	Feb. 27, 1955	49.43	Sept.15, 1955	46.93
Feb. 23	48.16	Feb. 28	48.80	Sept.16	46.75
Feb. 24	48.62	Mar. 1	47.90	Oct. 3	44.93
Feb. 25	48.98	Mar. 2	47.95	Nov. 1	44.33
Feb. 27	47.74	Mar. 4	47.95	Dec. 1	46.95
Feb. 27	47.76	Mar. 7	49.20	Mar. 4, 1956	51.80
Feb. 27	47.62	Apr. 4	48.40		
Feb. 27	48.73	Aug. 8	49.72		
		Well C-31			
Owner: Perry Cartwright.					
Aug. 22, 1955	65.55	Nov. 1, 1955	61.68	Jan. 2, 1956	64.15
Aug. 30	64.72	Nov. 30	61.89	Mar. 4	66.16
		Well C-38			
Owner: W. H. Terry, Jr.					
Jan. 16, 1955	81.89	Oct. 3, 1955	86.33	Feb. 29, 1956	84.96
July 17	82.08	Nov. 1	86.15	Mar. 10	85.12
July 25	82.33	Jan. 24, 1956	85.05	Mar. 20	85.17
July 30	82.20	Jan. 31	85.05	Mar. 24	85.25
Aug. 10	82.29	Feb. 10	84.79		
Sept. 1	86.50	Feb. 20	84.83		

Table 8.- Water levels in wells in the Alpine area--Continued

Date	Water level	Date	Water level	Date	Water level
		Well C-46			
Owner: Lewis Lewenthal.					
Aug. 16, 1948	141.40	Nov. 1, 1955	141.05	Mar. 4, 1956	141.94
Aug. 30, 1955	142.35	Dec. 1	141.15		
Oct. 3	141.31	Jan. 2, 1956	141.47		
		Well D-10			
Owner: H. D. Carpenter.					
Apr. 16, 1955	41.46	Aug. 10, 1955	39.15	Dec. 20, 1955	38.94
Apr. 20	41.47	Aug. 20	39.19	Dec. 31	38.97
Apr. 30	41.66	Aug. 31	38.57	Jan. 10, 1956	39.21
May 10	41.62	Sept.10	38.52	Jan. 31	39.30
May 20	41.73	Sept.20	38.42	Feb. 10	39.48
May 31	41.69	Sept.30	38.21	Feb. 20	39.73
June 10	41.65	Oct. 10	38.15	Feb. 29	39.62
June 20	41.62	Oct. 20	38.36	Mar. 10	39.66
June 30	41.51	Oct. 30	38.17	Mar. 20	39.62
July 10	40.96	Nov. 10	39.12	Mar. 24	40.01
July 20	40.84	Nov. 20	39.65		
July 31	39.52	Dec. 13	38.75		
		Well D-11			
Owner: City of Alpine.					
Feb. 14, 1955	39.36	Mar. 8, 1955	35.16	Mar. 30, 1955	38.30
Feb. 15	39.20	Mar. 9	35.04	Apr. 4	38.93
Feb. 16	39.14	Mar. 10	35.10	Apr. 11	39.54
Feb. 20	38.24	Mar. 11	35.25	May 2	41.16
Feb. 23	37.58	Mar. 12	35.49	May 27	41.25
Feb. 24	37.59	Mar. 14	36.80	June 20	45.62
Feb. 25	37.09	Mar. 16	36.27	Aug. 1	29.78
Feb. 26	36.84	Mar. 17	36.35	Sept. 1	24.65
Feb. 28	36.34	Mar. 19	36.62	Oct. 3	21.17
Mar. 2	35.96	Mar. 21	37.12	Nov. 1	22.59
Mar. 4	35.65	Mar. 23	37.40	Nov. 30	23.90
Mar. 6	35.42	Mar. 25	37.64	Jan. 2, 1956	23.84
Mar. 7	35.26	Mar. 28	38.07		

Table 8.- Water levels in wells in the Alpine area--Continued

Date	Water level	Date	Water level	Date	Water level
		Well D-12			
Owner: City of Alpine.					
Feb. 14, 1955	47.42	Feb. 28, 1955	39.65	June 20, 1955	79.68
Feb. 14	50.02	Mar. 2	38.63	Aug. 1	30.52
Feb. 15	47.25	Mar. 4	37.68	Sept. 1	22.20
Feb. 16	47.04	Mar. 6	36.93	Oct. 3	18.06
Feb. 20	44.54	Mar. 7	36.48	Nov. 1	19.19
Feb. 23	42.81	Apr. 4	45.10	Nov. 30	20.51
Feb. 24	42.22	Apr. 11	46.60	Jan. 2, 1956	20.43
Feb. 25	41.49	May 2	49.03		
Feb. 26	40.81	May 27	47.45		
		Well D-13			
Owner: City of Alpine.					
Feb. 15, 1955	113.73	Feb. 28, 1955	42.03	Sept. 1, 1955	29.33
Feb. 15	112.49	Mar. 2	40.96	Oct. 3	23.08
Feb. 16	83.72	Mar. 4	40.10	Nov. 1	22.68
Feb. 20	49.62	Mar. 6	39.47	Nov. 30	22.50
Feb. 23	45.70	Mar. 7	39.10	Jan. 2, 1956	22.14
Feb. 24	44.83	Mar. 27	53.60	Mar. 3	18.44
Feb. 25	43.94	June 20	84.89		
Feb. 26	43.23	Aug. 1	38.66		
		Well D-14			
Owner: City of Alpine.					
Feb. 14, 1955	32.11	Mar. 4, 1955	30.53	Apr. 11, 1955	33.70
Feb. 15	32.10	Mar. 6	30.40	May 2	34.63
Feb. 16	32.18	Mar. 7	30.24	May 27	34.82
Feb. 20	31.82	Mar. 19	31.86	June 20	34.66
Feb. 23	31.56	Mar. 21	32.37	Aug. 1	27.62
Feb. 24	31.58	Mar. 23	32.42	Sept. 1	24.40
Feb. 25	31.30	Mar. 25	32.58	Oct. 3	20.65
Feb. 26	31.21	Mar. 28	32.87	Nov. 1	22.20
Feb. 28	30.93	Mar. 30	32.96	Nov. 30	22.14
Mar. 2	30.72	Apr. 4	33.35	Jan. 2, 1956	21.72

Table 8.- Water levels in wells in the Alpine area--Continued

Date	Water level	Date	Water level	Date	Water level
		Well D-34			
Owner: John W. Gillett.					
Apr. 15, 1955	137.61	May 20, 1955	137.81	June 30, 1955	138.32
Apr. 20	137.63	May 31	137.97	July 10	138.45
Apr. 30	137.71	June 10	137.99		
May 10	137.77	June 20	138.20		
		Well D-45			
Owner: City of Alpine.					
Feb. 8, 1955	26.03	Mar. 28, 1955	27.20	Oct. 3, 1955	24.34
Feb. 21	26.35	Apr. 4	27.38	Nov. 1	24.93
Feb. 28	26.54	Apr. 11	27.54	Nov. 30	25.91
Mar. 7	26.71	June 20	28.11	Jan. 2, 1956	26.47
Mar. 14	26.87	Aug. 1	24.46	Mar. 4	26.91
Mar. 21	27.02	Sept. 1	24.02		
		Well D-63			
Owner: Joseph Moss.					
Feb. 17, 1955	21.80	Mar. 28, 1955	22.20	Oct. 3, 1955	22.22
Feb. 21	21.80	Apr. 4	22.21	Nov. 1	22.50
Feb. 28	21.84	Apr. 11	22.25	Nov. 30	21.86
Mar. 7	21.91	June 20	23.21	Jan. 2, 1956	21.21
Mar. 14	21.99	Aug. 1	21.66	Mar. 4	21.70
Mar. 21	22.04	Sept. 1	21.73		
		Well Y-2			
Owner: H. L. Kokernot, Jr.					
Feb. 21, 1955	41.47	Mar. 21, 1955	41.29	Oct. 3, 1955	41.94
Feb. 28	41.38	June 17	41.33	Nov. 1	42.12
Mar. 7	41.39	July 7	41.22	Nov. 30	42.22
Mar. 14	41.32	Aug. 1	41.45	Jan. 2, 1956	42.28

Table 8.- Water levels in wells in the Alpine area--Continued

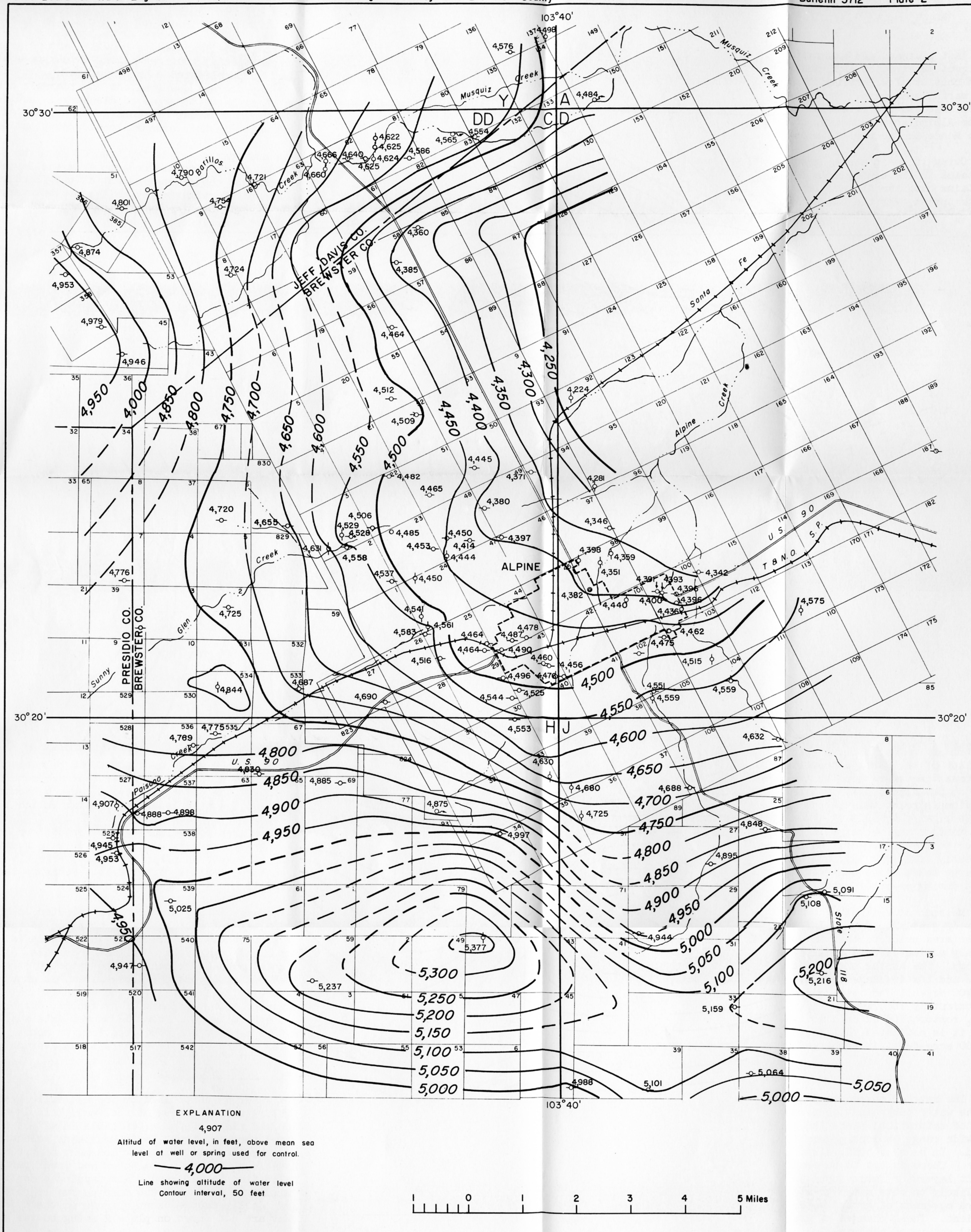
Date	Water level	Date	Water level	Date	Water level
		Well DD-2			
Owner: Ed Davidson.					
July 28, 1955	23.35	Oct. 3, 1955	19.35	Jan. 2, 1956	21.10
Aug. 1	19.98	Nov. 1	19.65	Mar. 3	21.09
Sept. 1	19.02	Nov. 30	20.50		
		Well DD-10			
Owner: H. L. Kokernot, Jr.					
Aug. 1, 1955	17.60	Nov. 1, 1955	19.70	Mar. 3, 1956	18.99
Sept. 1	15.93	Nov. 30	18.73		
Oct. 3	17.65	Jan. 2, 1956	19.98		

Table 9- Analyses of water from wells and springs in the Alpine area, Texas

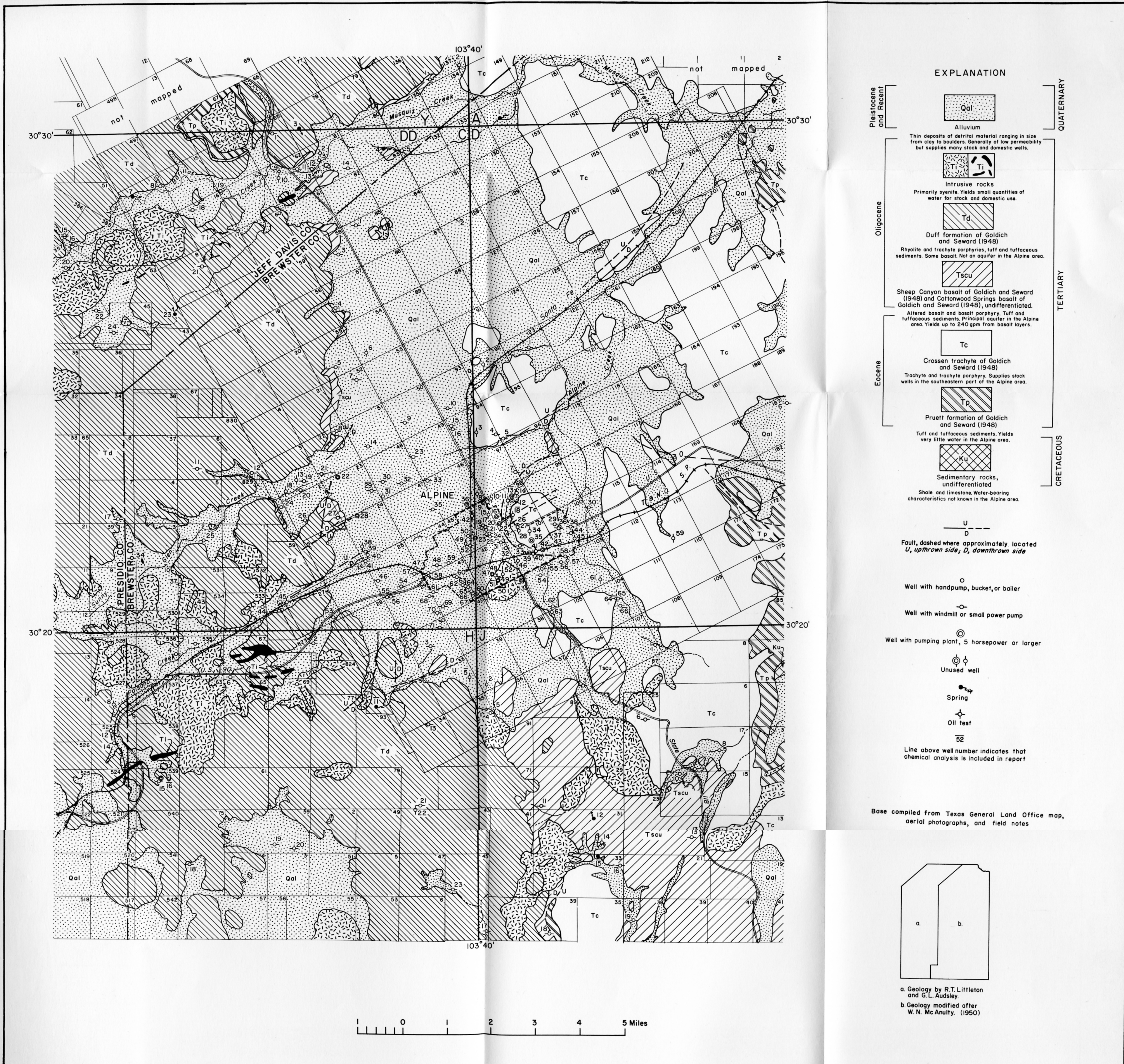
Analyses were made in the laboratory of the Geological Survey at Austin, Texas, under the direction of Burdge Irelan, District Chemist
(Analyses are in parts per million except specific conductance, pH, and percent sodium)

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
C-20	Mrs. Oscar Roberts	300	Aug. 3, 1948	34	19	3.6	8.8	72	8	8	-	3.2	123	62	23	158	-
C-22	Mrs. Flora Daugherty	361	Mar. 12, 1954	44	28	2.2	20	125	6.6	6.2	1.5	1.0	173	79	33	239	7.5
C-28	W. H. Terry, Jr.	592	Aug. 8, 1955	48	31	7.9	51	204	19	18	2.4	3.5	286	111	50	427	7.9
C-29	Mrs. Flora Daugherty	50	Aug. 15, 1955	60	45	3.6	22	167	11	12	1.6	6.0	243	127	27	327	7.7
C-31	Perry Cartwright	503	Sept. 16, 1955	20	12	2.9	75	181	33	12	1.8	.5	266	42	80	396	7.9
D-13	City of Alpine	276	Aug. 19, 1955	49	51	6.0	30	199	20	18	1.6	4.2	286	152	30	417	8.0
D-18	do	2,002	Sept. 2, 1955	35	48	20	42	262	57	10	2.0	.5	356	202	31	552	7.7
D-50	do	443	Jan. 4, 1955	55	51	11	39	226	19	24	2.0	8.5	318	172	30	484	7.7
D-51	do	700	Aug. 19, 1955	54	41	8.9	35	213	12	16	1.6	3.2	277	140	35	406	7.8
D-66	Mrs. G. A. Morris	97	do	60	70	14	41	330	21	16	1.2	3.8	389	232	28	588	7.7
H-5	John Lane	370	Aug. 29, 1955	39	20	4.4	58	198	9.9	12	1.6	.2	259	68	65	364	7.7
H-11	do	Spring	Aug. 16, 1948	45	50	6.7	23	210	11	12	-	1.8	256	152	25	388	-
H-16	Paisano Baptist Assembly, Inc.	196	Aug. 16, 1955	52	54	5.2	28	211	13	16	2.0	3.2	277	156	28	407	7.7
J-6	Z. M. Decie	-	do	44	61	9.6	57	345	12	12	1.6	.8	368	192	39	570	7.7
J-15	do	Spring	do	55	38	8.5	25	188	11	9.8	1.2	2.5	243	130	30	340	8.3
J-16	do	104	Oct. 16, 1955	61	39	10	25	209	4.8	7.8	.8	4.8	256	139	28	354	7.9
DD-12	Ed Davidson	148	Aug. 17, 1955	46	37	5.7	26	174	9.4	9.0	1.2	6.1	231	116	33	330	8.0
DD-22	G. C. Meriwether	200	do	34	32	8.8	28	a/172	10	14	2.0	1.0	218	116	35	331	8.5

a/ Includes equivalents of 6 parts per million carbonate (CO_3).



GENERALIZED MAP OF THE WATER TABLE IN THE ALPINE AREA, BREWSTER, JEFF DAVIS AND PRESIDIO COUNTIES, TEXAS, 1955.



RECONNAISSANCE GEOLOGIC MAP SHOWING LOCATIONS OF WELLS AND SPRINGS, ALPINE AREA, BREWSTER, JEFF DAVIS, AND PRESIDIO COUNTIES, TEXAS.