STATE OF WASHINGTON
Daniel J. Evans, Governor

DEPARTMENT OF WATER RESOURCES
H. MAURICE AHLQUIST, Director

Water-Supply Bulletin No. 31

GROUND-WATER WITHDRAWAL IN THE ODESSA AREA, ADAMS, GRANT, AND LINCOLN COUNTIES WASHINGTON

By
A. A. GARRETT

Prepared in cooperation with
UNITED STATES GEOLOGICAL SURVEY
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GROUND-WATER WITHDRAWAL IN THE ODESSA AREA,

ADAMS, GRANT, AND LINCOLN COUNTIES, WASHINGTON

By

A. A. Garrett

ABSTRACT

Before 1960, in the 670-square-mile project area near Odessa, Washington, ground water was used only for public supply and for individual farmsteads. Since 1960, irrigation of wheat with ground water has become common and withdrawals have greatly increased. In 1963, 66 irrigation wells pumped a total of about 11,400 acre-feet of water. In 1965, 94 wells pumped about 22,000 acre-feet. More irrigation wells are being drilled and still others are planned in the near future.

Ground-water supplies are being developed nonuniformly within the project area and, as a result of intensive localized development, ground-water levels are declining in some areas. The withdrawal of more than 4,000 acre-feet of water from the north-central part of the area in 1965 caused a 2- to 20-foot decline in water level throughout one area of about 45 square miles. On the other hand, the withdrawal during 1965 of a few thousand acre-feet of water from the east-central part of the study area resulted in a slight decline in level only locally. Withdrawal of more than 4,100 acre-feet from the southern part of the area reportedly did not affect water levels.

Most wells in the area are pumped nearly continuously during 7 months of the year and are idle during the other 5. Some of the wells are not idle long enough for water levels to recover completely before the next pumping season begins. This cyclic pumping pattern could produce successive yearly increments of residual drawdown.

In many parts of the project area, water levels in shallow aquifers (those less than about 300 feet below land surface) are different in altitude from those in the deeper aquifers tapped by many large-yield irrigation wells. Nonetheless, pumping of some of the deeper irrigation wells produces water-level declines in shallow wells. Simultaneous pumping of several wells has resulted in declines of as much as a foot in shallow wells as far as 3 miles distant.

NATURE OF THE PROBLEM

Since the 1880's, when the Odessa area was being settled, wheat has been the most important crop in that area. Dry farming was practiced exclusively until about 1960, when wheat growers found that markedly greater crop yields could be obtained by applying supplemental water through the use of sprinkler systems. Because surface water is not available in most of the area, the growers turned to wells as a source of irrigation water. Most of the supply is obtained from wells that tap basalt aquifers as much as several hundred feet below land surface. The pumps that are being installed on some of the wells are so large that 200 horsepower motors are required to operate them. At some places, however, as in the Crab Creek coulee, large amounts of water are pumped from dug wells that tap the alluvium immediately underlying the coulee floor.

The increasing rate at which deep irrigation wells have been drilled since 1960 has caused the Washington State Department of Water Resources to consider the possibility that the area's ground-water resource may become depleted within a very short time.

This report shows (1) the amount of ground water pumped from the Odessa area during 1963-65, (2) the parts of the area where the pumping is taking place, (3) the effects of that pumping as of year-end 1965, and (4) the possible future trends.

Ground-water withdrawal from individual wells was computed from electrical-energy data furnished by the power companies that distribute electricity in the project area. Instantaneous values of water discharged and rate of electrical energy consumed were obtained for most of the irrigation wells being operated during the summer of 1965. Equating the relationship between these to the kilowatts used at each well for each pumping season allowed the computation of pumpage for the season. (For a complete description of the method of computation used, see Cardwell and Jenkins, 1963, p. 90.) It should be noted that the accuracy of the pumpage data is dependent largely on the extent to which the power company records, as obtained, represent each year's energy consumption.

The effects of pumping during the 1965 irrigation season (from April into October for most irrigators) were determined from water-level measurements in wells. During the year, monthly measurements were made in about 60 wells, and random measurements were made in numerous additional wells.

Efforts to determine the effects of pumping were applied intensively in the central part of the area, between Crab Creek coulee on the north and Bowers Coulee on the south. Although pumpage was determined outside this area, only random water-level measurements were collected from only a few wells.

The area where both pumpage data and recurrent water-level measurements were obtained is outlined on figure 1. About 60 percent of the project area was intensively investigated.

DESCRIPTION OF THE AREA

The project area occupies 670 square miles in the east-central part of the state. It covers the northern two-thirds of T. 18 N., Rs. 30-33E., and all of Tps. 19-22 N., Rs. 30-33E. These land subdivisions, together with numerous other features are shown on figure 1.

TOPOGRAPHY AND DRAINAGE

The Odessa area is a part of the Columbia Plateau. Although dissected by several west- to southwest-trending coulees, the surface of the study area is generally flat, and slopes downward from about 2,000 feet altitude in the northeast to about 1,100 feet in the southwest. The major coulees are Crab Creek, Rocky, Farrier, Weber and Bowers. All but Weber Coulee head in the inter-coulee surface east of the study area. Erosion of these coulees has provided striking local relief; for example, the south valley wall of the Crab Creek coulee at Odessa is about 230 feet high.

The project area drains to the west and southwest through the major coulees. Because of the direction of regional land slope, only the extreme northern part of the area drains to Crab Creek. Most of the area drains to the other four major coulees or to their tributaries.

No perennial streams cross the area. Crab Creek becomes perennial a short distance upstream from Irby, about 14 miles from the west boundary of the project (fig. 1). At Irby, the 22-year average annual streamflow is about 62,000 acre-feet. At Odessa, where the stream is dry during part of most years, the flow decreased to zero about in June 1965 and the stream-bed remained dry during that summer.

The amount of water that flows in the other coulees in the project area is generally not known. A gaging station installed in Farrier Coulee in March 1963, at a point 3¼ miles upstream from its confluence with Bowers Coulee, recorded a peak flow of 191 cfs (cubic feet per second) on January 29, 1964, during a single storm.

CLIMATE

The average annual precipitation and air temperature at Odessa are about 10 inches and 49°F. To the north and east, the climate becomes wetter and cooler. The range in annual precipitation at Odessa during the 63-year period of record is from 4 inches in 1929 to 18 inches in 1940, as shown in figure 2. The curve showing cumulative departure from average precipitation indicates the overall cyclic nature of the precipitation excess and deficit. From about 1915 to 1940 the precipitation generally was less than average. From 1940 to 1961 it was greater than average and into 1965 the precipitation again was deficient.

On the average, July, August, and September are the dryest months; only about half an inch of rain falls during each of these months. January is the

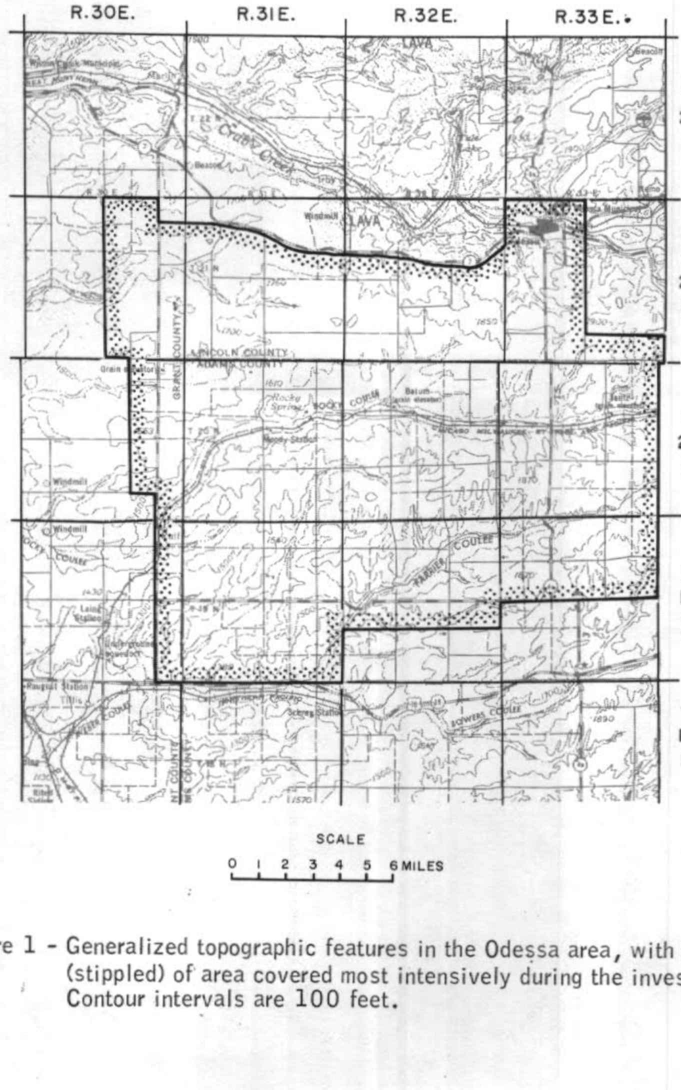


Figure 1 - Generalized topographic features in the Odessa area, with outline (stippled) of area covered most intensively during the investigation. Contour intervals are 100 feet.

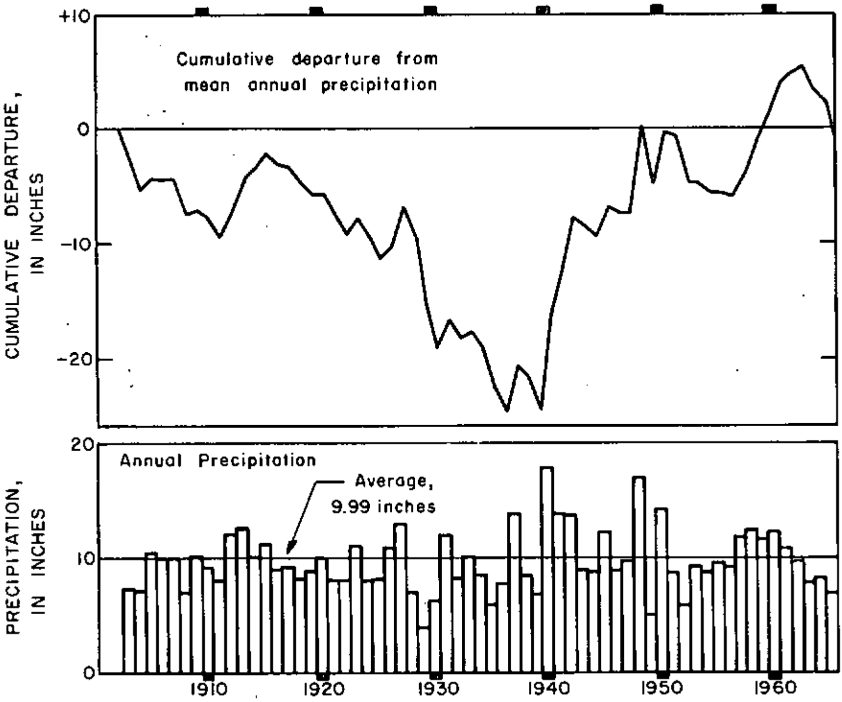


Figure 2 - Graphs showing annual precipitation at Odessa and cumulative departure from average annual precipitation for the period 1903-65

wettest month, the precipitation being nearly 1½ inches. May and June are comparatively wet because of the thunderstorms that commonly occur then.

GEOLOGIC SETTING

The Odessa area is underlain to unknown depth by basalts of the Columbia River Group of Tertiary age. The thick lava sequence consists of an undetermined number of flows which in places are separated by sedimentary interbeds. The surface of the generally flat-lying basalt has been dissected into numerous minor depressions and several major coulees all of which were produced by glacial melt water flooding during Pleistocene time.

Nearly everywhere, the basalt is overlain by surficial sediments of varying thickness. The intercoulee uplands have a veneer of soil and other fine materials, derived from weathered basalt and eolian silt and fine sand. The coulee floors are underlain to depths of as much as 85 feet or more by stream-laid sediments ranging in size from sand and gravel to boulders. In general, the basalt is buried more deeply beneath the coulees than beneath the uplands where it is generally less than 30 feet below land surface.

The character of the basalt is known only from drillers' logs; the few outcrops have not been mapped as of 1965. Most of these logs are meager and subject to variations in terminology among drillers. The descriptions of the basalt as recorded in these logs are restricted almost completely to color (brown, gray, black), or to degree of induration (broken, soft, hard, dense). Drillers' logs of many of the wells in the Odessa area are shown in table 4. The locations of these wells and of others for which information is included in this report are shown in plate 1 (in pocket). The total thickness of the basalt beneath the project area, although in most places virtually unknown, is nearly 4,500 feet at well 21/31-10M1, about 11 miles west of Odessa (table 4). This 4,682-foot oil-test well penetrates basalt to a depth of 4,465 feet.

Some logs record unconsolidated interflow deposits that vary considerably in character, from broken basalt to clay and shale. The Vantage Sandstone member of the Yakima Basalt (Bingham and Grolier, 1966, p. 6), which is the lowermost of the named sedimentary interbeds beneath the Columbia Basin Irrigation Project area to the west, probably extends beneath the Odessa area. The Vantage may be represented at well 18/31-23D1 by the silt, gravel, and broken rock from 492 to 515 feet, at well 19/30-1L1 by stiff blue clay from 443 to 451 feet, and at well 19/32-31G1 by blue shale and gravel from 402 to 437 feet.

REGIONAL GROUND-WATER CONDITIONS

GROUND-WATER OCCURRENCE

Most of the ground water available for use in the project area is stored in basalt aquifers. The aquifers consist chiefly of zones along the tops and bottoms of most basalt flows. The flow centers are generally dense, and very little ground water is stored in this impermeable rock. The flow tops are usually permeable because they are either highly fractured, vesicular, or cavernous, or they contain cinders and rubble. The basal part of the flows can be permeable where pillow structures or gas pockets were formed or where openings were left between flows. In well drillers' logs, water is reported to be obtained from zones in the basalt that are porous, broken, honeycombed, or "soft". These terms are descriptive of the tops or bottoms of flows, and they confirm, to a degree, the premise that the water occurs chiefly in these zones.

Where a flow with pillows at its base immediately overlies a flow whose top is fractured and vesicular, the resulting aquifer is highly productive. Where two flows are separated by a fine-grained sedimentary deposit, that material is likely to act hydrologically as a barrier that slows the vertical circulation of water, producing differing water levels below and above. Where the interbedded sediments occur in the Odessa area, drillers seem not to attach special significance to them as sources of water. In only a few logs (see table 4) do they note that water can be obtained from these interflow deposits.

Individual aquifers may be extensive over many square miles in the Odessa area. However, their permeability varies markedly from place to place, as indicated by differences in the specific capacity of wells throughout the area. No evidence was obtained during this study suggesting that the deeper aquifers, the lowermost ones tapped by many of the new irrigation wells, are more permeable than those nearer the surface. Irrigation wells are being drilled to depths of 1,000 feet or more primarily to take advantage of the aggregate yield of a large number of aquifers rather than to reach a given aquifer whose permeability is exceptionally high.

The data obtained during this study suggest that the basalt aquifers underlying the Odessa area are in hydraulic continuity with each other, to the extent that they may form, in the aggregate, one ground-water system or reservoir. Perhaps the best evidence suggesting vertical hydraulic relationship from aquifer to aquifer is the similarity of water levels in shallow and deep wells that are within a few hundred feet of each other. For example, the altitude of water level in 285-foot well 20/33-8J1 was about the same as that in the newly drilled 662-foot well 20/33-8J2 in November 1964, before the deeper well was placed in service. Similarly, the water levels in wells 19/30-10P1 and 10P2 reportedly are identical to the nearest foot. Yet the two wells, which are 15 feet apart, are 251 and 615 feet deep, respectively. Further evidence to show vertical hydraulic continuity is that the pumping of deep irrigation wells has affected the water levels in shallow, observation wells as much as 4 miles away.

The foregoing evidence must be tempered, however, by the possibility that the cited examples of common water levels in shallow and deep wells could represent the exception rather than the rule. The evidence must also be tempered by reports from some well owners and drillers who state that when some wells are deepened their water levels have declined. For example, when well 21/30-3E1 was deepened from 451 to 628 feet in April 1965 and when well 19/30-28M1 was deepened from 540 feet, levels in both declined (table 3). The water-level data are not diagnostic however, because part or all of the water-level decline attributed to deepening may have been normal decline during the irrigation season. At most, the decline reportedly due to deepening is about 20 feet for both wells.

Generally, present evidence indicates that the vertical permeability from aquifer to aquifer ranges from low to moderate. The writer therefore concludes, for the Odessa area in general, that if direct precipitation were available for recharge it would eventually find its way to even the deepest water-yielding parts of the basalt sequence.

Locally in coulee bottoms, and especially in the Crab Creek valley, large yields are obtained from sand and gravel aquifers that are only a few feet below land surface. In Crab Creek valley these aquifers undoubtedly are in hydraulic continuity with the creek. Neither the areal extent of these aquifers nor their hydraulic relationship to the underlying basalt aquifers was determined during the present study.

DIRECTION OF GROUND-WATER MOVEMENT

Water levels in the Odessa area range from 1,600 feet above sea level about 7 miles south of Odessa to about 1,050 feet in the extreme southwestern part. Hence, the regional piezometric surface roughly parallels the land-surface gradient from northeast to southwest. The slope of the piezometric surface is not uniform throughout this 24-mile segment of the project area. For a distance of

8 miles, from sec. 8, T. 20 N., R. 33 E. (the most northeasterly part of the area for which land-surface altitude is approximately known) to the vicinity of sec. 5, T. 19 N., R. 32 E., the slope is about 13 feet per mile. In the 5-mile distance from sec. 5 to sec. 22, T. 19 N., R. 31 E., the slope increases to about 60 feet per mile. Through the remainder of the 24-mile reach, the slope is nearly flat, probably less than 5 feet per mile. Generalized piezometric contours are shown in figure 3. The contours were interpreted chiefly from water levels in wells deeper than 175 feet. Although the levels in some shallow wells may be different from those in nearby deep wells, the directions of ground-water movement in the shallow and deeper aquifers seem much the same.

The reasons for the steepening and flattening of gradients described have not been explored. The steepening gradient may result from one or more of the following factors: (1) a thinning of the basalt aquifers, (2) a decrease in their permeability, or (3) faulting that has offset some or all the aquifers into positions abutting less permeable parts of the basalt sequence.

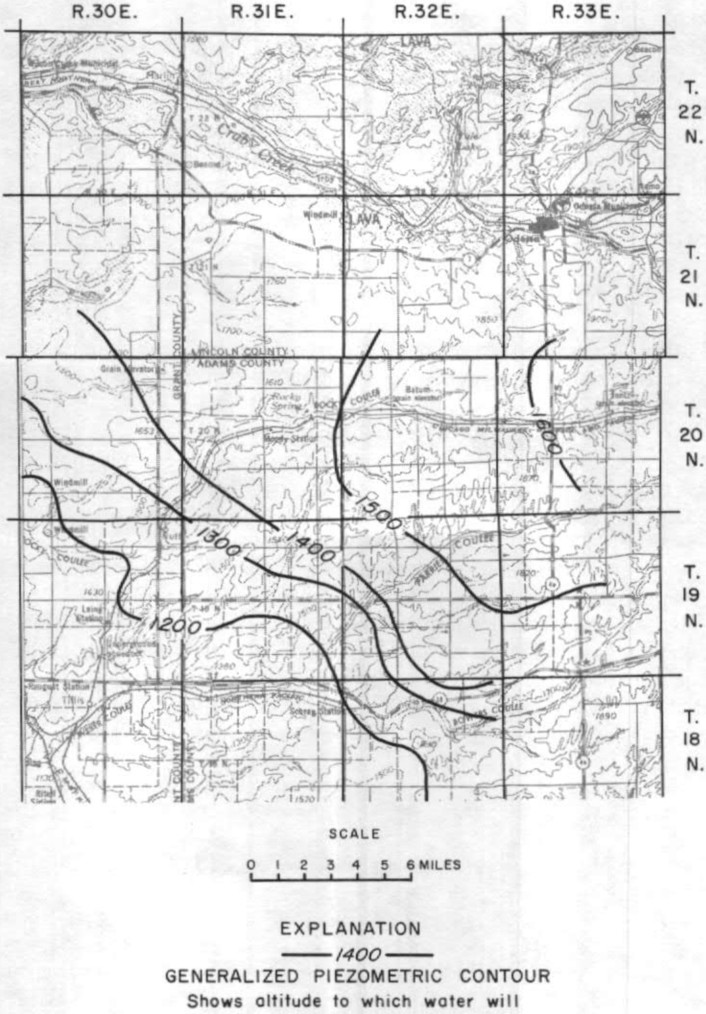
The configuration of the piezometric contours in the northeastern part of the project area suggests that some ground water may move toward Crab Creek from the upland south of Odessa. Water levels in the upland are above the level of the adjacent valley floor. If hydraulic continuity existed between the aquifers underlying the upland and those underlying Crab Creek valley, basalt wells in the valley should flow. However, they do not flow; in fact, water levels in the valley near Odessa are as much as 100 feet or more below land surface.

An explanation of this apparent lack of continuity includes the following possibilities: (1) the basalt aquifers beneath the upland are not hydraulically connected with the basalt aquifers beneath the valley, or (2) the amount of ground water moving downvalley is so great (because of the relatively high permeability of the basalt aquifers beneath the valley) that a steep gradient must exist between the aquifers beneath the upland and those beneath the valley in order to maintain a balance between inflow and outflow.

The configuration of the contours where they cross Farrier Coulee (fig. 3) suggests an effluent condition whereby ground-water head is dissipated as a result of underflow down the coulee and into Bowers Coulee. This possibility was not confirmed.

SOURCES OF RECHARGE

The ground-water recharge needed to maintain the observed water-level gradient across the study area from northeast to southwest (fig. 4) must come almost entirely from hydraulically related aquifers east of the area. Available evidence indicates that some recharge may also occur, locally by effluent seepage of surface streams to underlying gravels and thence into deeper basalt aquifers. In the southwestern part of the study area, some artificial recharge occurs as a result of leakage from the East Low Canal and percolation from irrigated lands in the Columbia Basin Irrigation Project area. The recharge to the ground-water reservoir from direct precipitation appears to be small or nonexistent.



SCALE

0 1 2 3 4 5 6 MILES

EXPLANATION

—— 1400 ——

GENERALIZED PIEZOMETRIC CONTOUR

Shows altitude to which water will rise in tightly cased wells. Contour interval 100 feet. Datum is mean sea level

Figure 3 - Generalized piezometric surface. Based mostly on water-level measurements in wells deeper than 175 feet.

Aside from the major source of ground-water recharge from aquifers outside the study are, effluent seepage from surface streams is probably the next in importance, although probably on a localized extent beneath coulee floors. Crab Creek contributes recharge to the underlying shallow gravel aquifers; these shallow aquifers may, in turn, partly supply some recharge to deeper basalt aquifers. The high permeability of the gravels is shown by the large capacities of several wells located in the coulee. The amount of recharge to the underlying basalt has not been determined; the levels in basalt wells 21/33-4Q1 and 21/33-7H1 are 53 and over 100 feet respectively, below the coulee bottom, which suggests that the hydraulic continuity with the gravel aquifers may be restricted. Similar conditions exist in Bowers Coulee; water levels in basalt wells are 50 or more feet below land surface.

Aquifers underlying the extreme southwestern part of the study area are being recharged by irrigation return and canal seepage in the adjacent Columbia Basin Irrigation Project area. Water levels in nearly all the wells that tap basalt aquifers southwest of, and immediately northwest of, the East Low Canal have been affected. Levels in wells southwest of the canal have risen an average of about 40 feet; a few levels have risen more than 80 feet. The level in well 18/31-20D1, just east of the canal rose 36 feet during the period 1950-58 (Walters and Grolier, 1960, p. 152). Hydrographs of wells 18/30-8C1 and 18/30-34M1 show the nature of the water-level rise from 1951 through 1965 (fig. 4). In both wells, the levels appear to have nearly stabilized since about 1960. The graph for 34M1 before 1954 shows the typically flat water-level pattern for other wells in the central and western parts of the study area.

The only effect in the study area of the aforementioned recharge may be one of ultimately reshaping slightly the water-level gradient northeastward. As water levels rise in the area beneath the East Low Canal and adjacent lands, the upgradient profile must be adjusted to the new base level.

The rather flat water-level gradient through the southwestern part of the study area may represent an adjustment in hydraulic gradient to the new base level at the canal.

Recharge of the ground-water reservoir by direct precipitation on the land surface appears to be small or nonexistent. Where the soil profile is several feet thick the rain or snowfall supplies little more than the basic soil-moisture requirement. For example, silt loam can retain about 2½ inches of water per vertical foot of soil profile; only during the coldest months, when evapotranspiration is low, would the precipitation be able to penetrate below the first 2 or 3 feet of soil profile. During the remainder of the year, evaporation and water consumption by plants would exceed the ability of precipitation to replace soil moisture. Doubtless, under certain specialized conditions, such as rapid melting of snow, or storms of unusual duration, enough water may collect in coulees and other low places to ultimately provide a small amount of local recharge. If precipitation on the project area were significant to ground-water recharge, a long-term relation would be expected between water-level fluctuations and precipitation quantities. Yet, no such long-term relation is obvious. Figure 2 shows that a period of above-normal precipitation occurred in the early 40's. Hydrographs for a few wells in the central and western parts of the study area

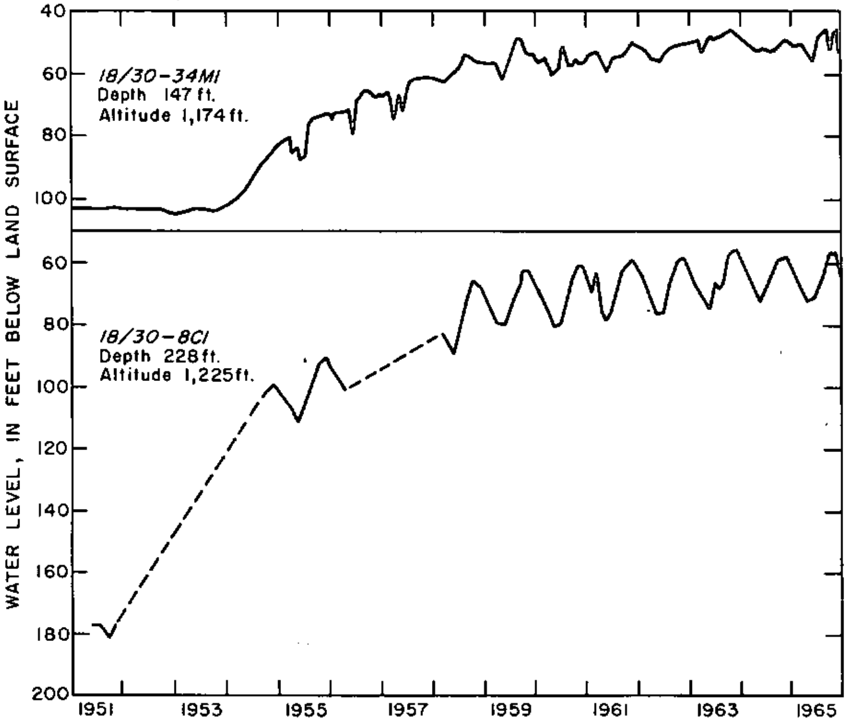


Figure 4 - Water-level fluctuations in unused basalt wells affected by recharge from Columbia Basin Irrigation Project area.

(Walters and Grolier, 1960, figs. 1, 5, and 19) show no response to this excess of precipitation. If, in spite of evidence to the contrary, precipitation in the area does recharge underlying basalt aquifers, the rate must be so slow and the path so devious that the relation between recharge and discharge is virtually constant.

NATURAL GROUND-WATER DISCHARGE

Natural loss of ground water from the study area occurs both by underflow through alluvium that underlies the coulee floors, and by movement through basalt aquifers hydraulically continuous downgradient to the west and southwest.

Ground-water discharge renders Crab Creek perennial downstream from near Irby. Upstream, the creek is dry from July to December during most years. Of the discharge of Crab Creek at the Irby gaging station, probably as much as 7,000 acre-feet is contributed to the stream channel by effluent ground water. The remainder flows through the study area from tributary areas to the east. The amount of water that leaves the area as underflow in the gravel beneath the Crab Creek coulee is not known, but is probably small.

Discharge of ground water from the study area by underflow through at least the upper part of the basalt sequence could be computed if the slope, or gradient, of the water surface and the transmissibility of the aquifer materials were known. Information shown in figure 3 and cited on page 18 were used to estimate the water-level gradients that occur in the westernmost and southwesternmost parts of the study area; the gradient in these marginal segments controls the amount of water leaving the study area as underflow. This amount is largely independent of variations of gradient that occur within the project area.

Available information allows the assumption that in the segment from Crab Creek southward about to the center of T. 21 the underflow moves generally westward out of the study area, and in the segment from about the center of T. 21 southeast to the southeast edge of the study area, the movement is southwestward. The first segment is about 8 miles long and across it the gradient is an estimated 15 feet per mile. The second segment is about 30 miles long and across it the gradient may average as much as 40 feet per mile.

Yield and drawdown data for numerous wells in the Odessa area suggest that a transmissibility of about 45,000 gallons per day per foot characterizes the upper 750 feet of saturated basalt. On the basis of the foregoing values of transmissibility, gradient, and lengths of sections the flow through the basalt is estimated at 65,000 acre-feet per year. This quantity should be considered only as an estimate of a possible order of magnitude. This estimate may be low because some values of transmissibility determined for the region are greater than 100,000 gallons per day per foot.

GROUND-WATER DEVELOPMENT AND USE

Development of ground water in the Odessa area occurred in two phases, initially for domestic and stock use, and more recently for irrigation of large farms.

When the Odessa area was settled, many wells were drilled to meet farmstead domestic needs. Most of these wells are 6 inches in diameter and are cased only through the unconsolidated materials overlying the basalt. The depth of penetration into basalt depended on the depth to water: in the coulees, wells that penetrated only a few feet of basalt yielded enough water for all needs; in the higher parts of the area, wells were drilled to depths ranging about from 100 to 300 feet. Locally in Crab Creek valley, the saturated alluvium is sufficiently permeable and shallow dug wells were adequate for all purposes.

All these domestic wells were fitted with windmill-powered plunger pumps installed directly atop the casings, or bolted to concrete or plank foundations. At the time of well inventories by the U. S. Geological Survey in 1942 and 1950, many of the windmill-powered pumps were still in operation. Some pumps had been adapted to operate also from electric motors or gasoline engines. By late 1964, however, when field work for the present project began, nearly all windmills had been abandoned or destroyed. The old plunger pumps in most of the wells had been converted to electric power, and some of them had been replaced by submersible versions. Because most of these submersible pumps yield more water than the old plunger types, drawdowns in the wells commonly are greater, and some of the wells are incapable of supporting the increased demand for water. Of the wells not being used in 1965 a few still contain the original plunger pumps, while many others remain with open casings. Water-level measurements in these wells were used in part to evaluate the effect of operation of the new large-yield irrigation wells.

Ground water was first used for the irrigation of wheat in about 1960. Since then, and because of the large quantity of water needed for this purpose, wells with diameters as great as 16 inches are being drilled to depths ranging generally from 200 to 700 feet. Normally the casings for these extend only through the unconsolidated materials above the basalt. Pumps for these wells are powered by electric motors with name-plate capacities as great as 200 horsepower. Seasonal yields of as much as 500 acre-feet from individual wells are common.

In this report, largely for convenience, the older domestic wells are referred to as "shallow wells," whereas, the large-capacity irrigation wells are referred to as "deep wells." However, large yields are obtained from relatively shallow depths in some places, so that irrigation wells locally may be no deeper than adjacent domestic wells.

During the period 1963-65, for which withdrawals from irrigation wells in the Odessa area were computed, the annual increase in production has been great. Table 1 lists the ground-water withdrawals for each township in the project area during each of the 3 years. During 1963, the total was more than 11,000 acre-feet, from 66 irrigation wells; this withdrawal averages only about 12,300 gpm (gallons per minute) for a 7-month pumping season. This would represent about 0.3 inch of water over the entire 670-square-mile area if applied uniformly.

By 1965, the pumped quantity had doubled, even though the number of wells (94) had increased only 40 percent. The records show that the disproportionate increase in pumped quantity occurred because the newer wells were being pumped at considerably greater rates. If existing trends continue, pump motors with horsepowers of 200 or more will become common. In general, however, the size of a pumping plant is determined by well depth, so that motor ratings larger than about 400 horsepower will be rare until such time as wells are commonly drilled to depths considerably greater than 1,500 feet.

As shown in table 1, the withdrawal of ground water is not uniform over the project area. In some townships, ground-water development has been rapid, whereas in others, virtually no development has occurred as of 1966. The distribution of areas where annual ground-water withdrawal is substantial is shown in figure 5.

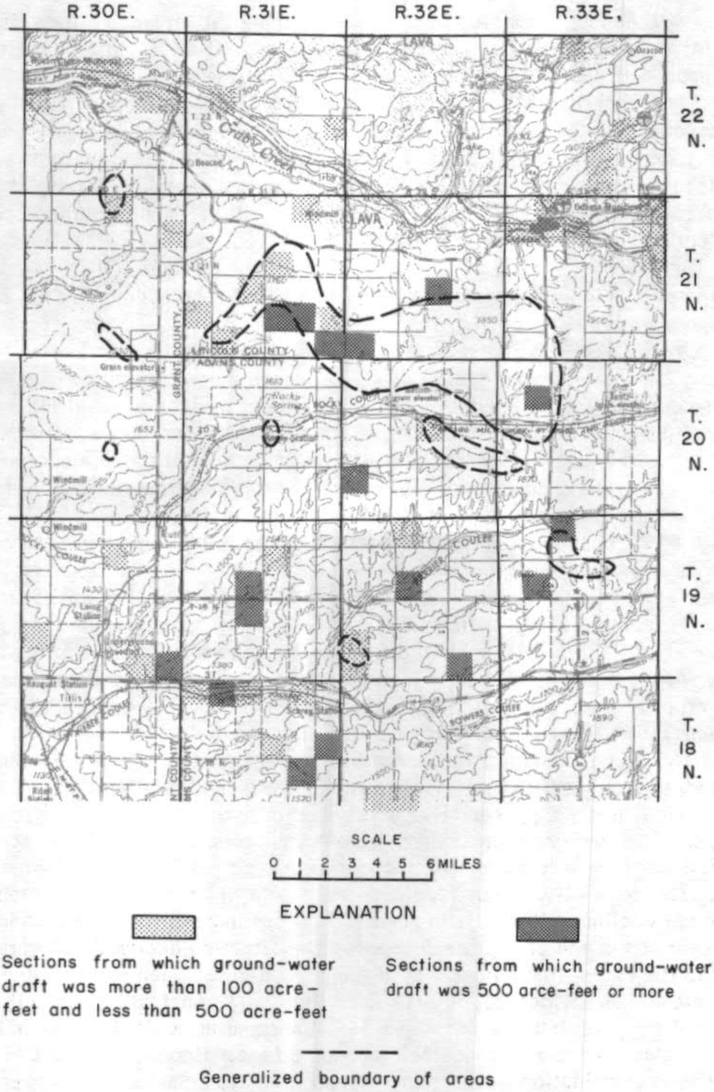
The amount of ground water used for rural domestic requirements is insignificant in comparison to that used for irrigation. As of 1965, the total quantity used from an estimated 220 wells may be about 250 acre-feet per year.

THE EFFECTS OF GROUND-WATER WITHDRAWAL

Water-level measurements were made in many wells in the western and central parts of the Odessa area as early as 1950. As part of the present study, recurrent measurements were made in wells in the more heavily pumped parts of the project area, beginning in October 1964 and continuing into December 1965 (table 3). These measurements were made in unused wells, in domestic wells pumped only intermittently, and in irrigation wells pumped heavily during a part of the year and not at all during the remaining time. A comparison of the December 1965 levels with those of the previous year shows that in parts of the project area, water levels declined during 1965. The declines ranged from slight to nearly 20 feet.

Figure 5 shows one major and a few minor areas where these declines occurred. The major area, in the north-central part of the study area, is about 45 square miles in extent. The declines there doubtless resulted in large part from heavy pumping in the south half of T. 21 N., R. 31 E., and in the SW¼ of T. 21 N., R. 32 E. In all, the draft from these centers of heavy pumping was more than 4,000 acre-feet in 1965. Local pumping elsewhere produced the minor areas of drawdown shown in figure 5. The area farthest to the southeast resulted from the withdrawal of about 2,200 acre-feet.

The boundaries of the areas shown in figure 6 were interpreted in part from water-level declines in shallow observation wells. Many of the wells are less than half as deep as some of the irrigation wells whose pumping effects were being investigated. The shape of the cone of pressure relief that surrounds an irrigation well pumping from basalt aquifers can be defined accurately from nearby observation wells only when the latter are open to the same aquifers that yield water to the irrigation well. If the observation wells are appreciably shallower than the pumping irrigation well--to the extent that they are open only to some of the aquifers that are yielding to the irrigation well--the drawdowns in the observation wells may be small. The effect on water level at a given distance from the



EXPLANATION

Sections from which ground-water draft was more than 100 acre-feet and less than 500 acre-feet

Sections from which ground-water draft was 500 arce-feet or more

Generalized boundary of areas where water level declined 2 feet or more

Figure 5 - Sections where ground-water draft was 100 acre-feet or more, and areas where water levels declined 2 feet or more, during 1965.

pumping well might, therefore, be considered insignificant when, in reality, it is rather large. For that reason, the boundaries shown (fig. 5) must be considered approximate and only very general.

Most of the wells in the Odessa area that supply water for irrigation are pumped nearly continuously for 7 months and are idle for the remaining 5 months of each year. This pumping pattern results in a cyclic decline and recovery of water level in the pumped wells, as shown by the hydrograph of two wells in figure 6. Of these two wells, 21/32-31C1 is within the major area of water-level decline shown in figure 5. The other well, 21/31-27K1, is outside this area. The hydrograph for 31C1 shows a net decline of about 10 feet in 1965 and a decline of undetermined amount the previous year. The hydrograph for 27K1 shows an overall net gain rather than a decline.

When a well is pumped on an intermittent basis, with intervening periods of recovery, any year-to-year decline in level caused by the pumping generally will decrease during each succeeding year. The amount of decline resulting from each season of pumping can be computed from the nonequilibrium flow equations for an infinitely broad aquifer. The decline in level at the end of a given number of pumping seasons is a function of rate of withdrawal, transmissibility, number of pumping seasons, and the ratio of length of the pumping seasons, and the ratio of length of the pumping season to the length of the intervening period of recovery.

To show that the major declines in level that occurred in some wells in the Odessa area cannot continue indefinitely, the hypothetical residual drawdown in level at the end of each year from 1965 to 1974 has been computed for well 21/32-31C1. This 744-foot well yielded an average of about 830 gpm during 1965. At the end of the intervening recovery period, the water level had not recovered fully when pumping started again in 1966. Assuming that the pumping pattern of 1966 is similar to that of 1965, the cumulative decline at the start of the 1967 season will have included the original decline plus the residue from the 1966 season, and so on. Application of the nonequilibrium flow equations to this situation, under a conservatively assumed transmissibility of 7,000 gallons per day per foot and under an assumption of constant seasonal withdrawal, gives the annual decline in level for 10 successive pumping seasons, beginning with 1965. The cumulative annual declines are shown in figure 7. The graph shows that the net decline will double in about 1970 but increase by only an additional 50 percent at the end of another 5 years. The situation depicted in figure 7 is invalid to the extent that withdrawal of ground water has been increasing each year (table 1). Nonetheless, it does show that, at a constant season-to-season withdrawal equal to that now being pumped, the cumulative decline probably would lessen, but at a greater distance below land surface. Because well 21/32-31C1, like many other irrigation wells in the project area, is deep enough to accommodate additional declines of considerable magnitude, continued pumping probably will not be harmful. Problems will arise only if the decline increases markedly beyond that projected, as more large-yield wells are drilled. As water levels decline, however, the cost of the electricity to pump the water will increase. Also, costs will be incurred in lowering pump intakes or in installing larger pumps.

The water-level decline in shallow domestic wells may be of greater local concern. Most of these wells were drilled to supply only a few gallons per minute

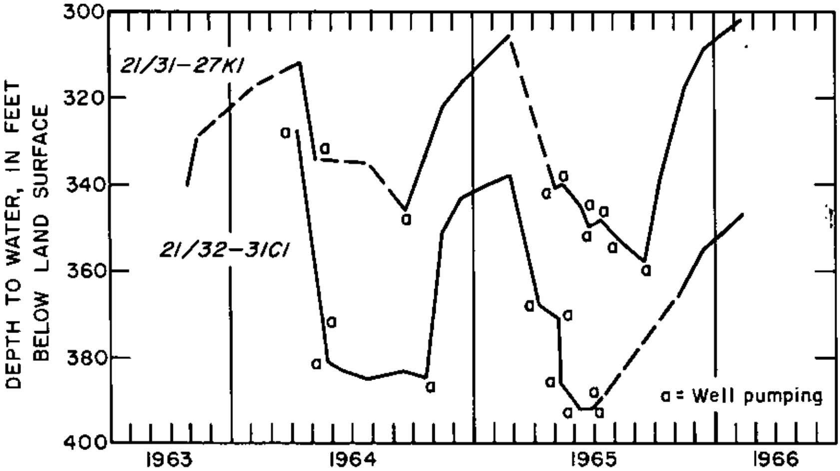


Figure 6 - Hydrographs showing seasonal pattern of pumping and water-level fluctuations in wells 21/31-27K1 and 21/32-31C1

intermittently, and a decline in level of only a few feet will cause some wells either to go dry or to decrease substantially in yield. Declines in level of several feet have occurred where these wells are within a few hundred feet of deeper pumped wells. Declines of a foot or two have been noted in domestic wells as much as several miles from centers of heavy pumping. For example, the levels in shallow wells 21/33-20L1 and 29K1 probably are being affected by the withdrawal of several thousand gallons a minute in the southern part of T. 21 N., Rs. 31 and 32 E. That the level in these two shallow wells, roughly 8 miles east (plate 1), probably are affected by irrigation pumping is suggested by the increasing declines in observation wells closer to the heavily pumped area. A comparison, largely interpolated, of water-level measurements in January 1966 with those of January 1965 shows that the levels in wells 20L1 and 29K1 were about 1 and 2 feet, respectively, lower in January 1966; the levels in well 21/32-26J1, 2½ miles west, and in well 21/32-27R1, 1 mile farther west, were about 3 feet lower, and in well 21/32-21P1, 1½ miles still farther west, the level was about 4 feet lower. Conversely, in well 21/33-22D1, about 1½ miles east of 20L1, and almost 10 miles distant from the center of pumping the water level was slightly higher in January 1966 than in 1965.

The hydrographs of eight selected observation wells are shown in figure 8. Although most of these wells are not as deep as the irrigation wells whose pumping effects were being investigated, the effect of pumping seemed readily transmitted to most of them. All of these wells are less than 400 feet deep; the depth of well 19/33-10E1, although unknown, is presumed to be less than 400 feet.

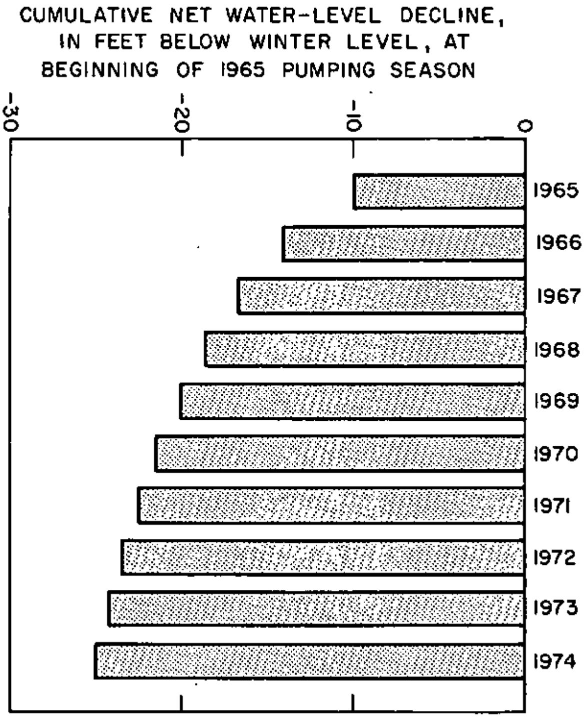


Figure 7 - Graph showing hypothetical cumulative decline of water level in well 21/32-31C1, for the period 1965-74

Of the eight wells, 21/32-21P1 and 26J1 are nearest to the center of heavy withdrawal and show the greatest declines. Wells 19/33-9K1 and 10E1 are less than a mile distant from irrigation well 19/33-4Q1, which pumped at a rate of more than 1,000 gpm during the 1965 pumping season. Wells 20/33-26B1 and 30A1 are 3 to 4 miles distant from irrigation wells 19/33-4Q1 and 20/33-8J2, whose aggregate yield probably is more than 2,200 gpm. The two remaining wells, 21/30-26R1 and 21/33-22D1, are far removed from areas of heavy pumping. The hydrographs for these two confirm the belief that if no major pumping were taking place in the area, water levels would tend to maintain roughly a constant altitude.

In contrast to the areas described above, in which water-level declines occurred in response to pumping for irrigation, no decline has occurred as of 1965 in the area adjacent to the center of pumping in the north half of T. 18 N., R. 31E., and the SW¼ T. 19 N., R. 32 E. Here, the aggregate pumpage in 1965 was at least 4,100 acre-feet, yet the data--even though fragmentary--suggest no adverse effect in water levels has occurred.

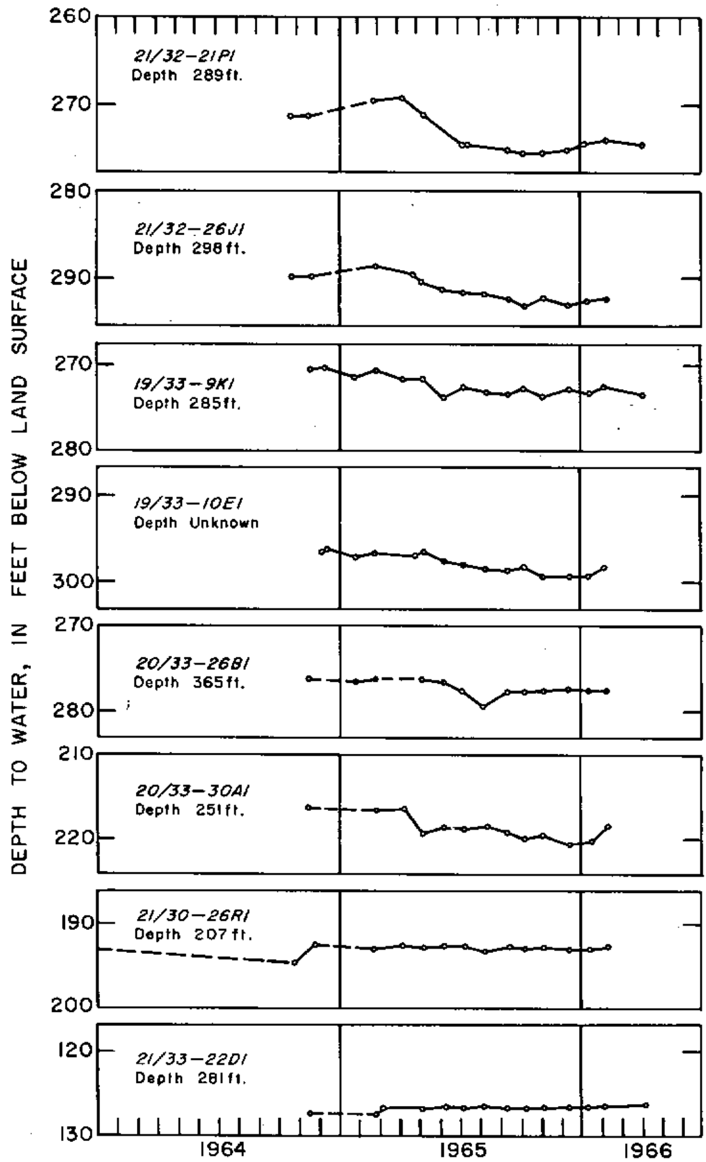


Figure 8 - Hydrographs of selected wells shallower than 400 feet. (Group 1, wells in area of extensive water-level decline; group 2, wells in eastern area of moderate water-level decline; group 3, wells in area where water levels have not been affected by pumping.)

SUMMARY

In the Odessa area, recharge to basalt aquifers by direct precipitation is small. Most of the recharge originates, presumably, from basalt aquifers to the east that are hydraulically continuous with those in the project area. In the southeastern part of the area, within and adjacent to the Columbia Basin Project, basalt aquifers receive recharge from irrigation water and from canal seepage.

The water-level gradient in much of the project area is toward the southwest, and ranges widely, from 60 feet per mile in the south-central part of the area to 5 feet per mile in the extreme southwestern part. The steep gradient in the south central part suggests the existence of a structural feature that reduces the horizontal permeability of the basalt aquifers.

Little is known of the vertical permeability of the basalt sequence. The permeability apparently is high enough that pumping of deep wells produces declines in water levels of some nearby shallow wells. However, the permeability is low enough that water levels are not everywhere the same in shallow and deep wells. This indicates that, at least since the beginning of intensive ground-water development, levels of water in the several aquifers have not had an opportunity to equilibrate.

Except for shallow gravel aquifers in a small part of Crab Creek coulee, deeper basalt aquifers supply nearly all ground water for both domestic and irrigation use. Nearly all of the domestic wells are less than 300 feet deep, whereas most irrigation wells range in depth from 200 to 700 feet. Generally, when basalt wells are constructed, only the sedimentary materials that overlie the basalt are cased off. For that reason, the deep wells tap the same aquifers that the shallow ones do, in addition to those below.

In 1965, about 22,000 acre-feet of ground water was pumped for irrigation in the Odessa area. This pumpage represents an increase of about 100 percent beyond that in 1963.

The area from which the largest amount of ground water was withdrawn in 1965 is T. 21 N., R. 31 E. The withdrawal of water here resulted in at least a 2-foot lowering of water levels over an area of 45 square miles. There, levels declined an average of about 5 feet in irrigation wells while a decreasing effect was noted in shallow observation wells at increasing distances from heavily pumped wells or groups of wells. Another heavily pumped area is T. 18 N., R. 31 E. The effect of the withdrawal on water levels there is not definitely known; however, fragmentary field data in that township suggest little effect during the 1965 irrigation season.

Most irrigation wells are deep enough to permit a decline several times that of 1965. The major effect will be an increase in the cost of electricity and other costs related to lowering or modifying the pump intakes. Further, the annual decline in level for a given rate of withdrawal should decrease and ultimately reach equilibrium. However, the continual increase in numbers of wells and in yields will preclude attainment of actual equilibrium.

Only a few feet of water remain in some of the shallow wells whose levels are affected by pumping of nearby irrigation wells. In these shallow wells, a continued decline in level can result in either a major decrease in yield or a complete loss of water.

In those parts of the Odessa area not as yet affected by pumping of irrigation wells, water levels appear to fluctuate little during the pumping season. However, the data obtained are not detailed enough to show possible long-term trends either of decline or recovery.

REFERENCES

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APPENDIX

WELL-NUMBERING SYSTEM

Well numbers used in this report show the location of wells according to the rectangular system for subdivision of public land. For example, in the well number 18/30-33A1, the two numbers preceding the hyphen indicate the township and range (T. 18 N., R. 30 E.) north and east of the Willamette base line and meridian. The first number following the hyphen indicates the section (sec. 33) and the letter (A) gives the 40-acre subdivision of the section, as follows:

Section 33

D	C	B	A	← A1
E	F	G	H	
M	L	K	J	
N	P	Q	R	

The last number (1) is the serial number of the well in that particular 40-acre tract. Thus, the first well recorded in the NE¼NE¼ sec. 33, T. 18 N., R. 30 E., would have the number 18/30-33A1, and the second well would have the number 18/30-33A2.

GROUND-WATER DATA

All the basic data collected as part of this study are included with this report, and are listed in tables 1-4. Table 1 is on page   of the text and lists the major pumpage from the study area for 1963-65. Tables 2, 3, and 4 are included in the appendix and are described below. The locations of all wells cited in the text are listed in these tables and are shown on figure 3.

Table 2: Records of wells. An inventory of all wells canvassed within the study area. Because part of the Odessa area is within the Columbia Basin Irrigation Project area covered by an earlier investigation (Walters and Grolier, 1960), the table includes some wells for which records have been previously published but which supply source material for the current project.

Table 3: Water levels of wells. Includes measurements in both observation wells and those measured only once or twice.

Table 4: Drillers' logs. Copied from original records except where some interpretation of the entries has been made to clarify or condense lithologic descriptions.

Table 1 - Ground-water withdrawal in the Odessa area for the years 1963-65. Water is used chiefly for irrigation[a]

Township	Number of wells each year			Withdrawal in acre-feet		
	1963	1964	1965	1963	1964	1965
18 N, 30 E	4	4	5	90	190	155
18 N, 31 E	3	6	8	1,650	2,630	3,220
18 N, 32 E	2	2	3	665	1,300	660
19 N, 30 E	6	6	8	1,150	1,380	1,410
19 N, 31 E	4	5	6	1,050	1,110	1,460
19 N, 32 E	5	7	8	1,420	1,980	2,310
19 N, 33 E	1	1	3	35	40	2,235
20 N, 30 E	1	1	1	0	35	0
20 N, 31 E	1	3	4	20	60	65
20 N, 32 E	0	0	2	0	0	975
20 N, 33 E	1	2	3	15	8	530
21 N, 30 E	2	2	2	215	255	295
21 N, 31 E	6	8	10	1,250	2,900	3,590
21 N, 32 E	1	2	2	590	1,670	1,415
21 N, 33 E	12	12	13	[a]1,090	[a]1,490	[a]1,360
22 N, 30 E	11	11	10	1,030	1,270	1,070
22 N, 31 E	2	2	2	380	740	705
22 N, 33 E	4	4	4	770	935	950
Totals	66	78	94	11,420	17,993	22,405

[a]Most of the water withdrawn from T. 21 N., R. 33 E. is used by Odessa for public supply.

Table 2 - Records of wells

Well no.	Owner or tenant	Date drilled	Land-surface altitude (feet)	Depth (feet)	Diameter (inches)	Rating when drilled: Yield (gpm)	Rating when drilled: Drawdown (feet)	Use	Pump type, horsepower	Production rate (gpm)	Remarks
T. 18 N., R. 30 E.											
2C1	Ireton & Quinn	1950	1,152	100	6	--	--	N	N	--	W.
2C2	Ireton & Quinn	1964	1,154	94	14-12	150	--	I	T, 5	--	L, W.
3A2	F. M. Cooper	1951	1,140	266	10-8	185	74	D	T, 25	--	W, (440).
4P1	Schmalz	--	1,142	140	6	65	--	DS	J, 10	--	W.
8C1	Unknown	--	1,225	228	8	--	--	DS	N	--	
11G1	R. V. Rennick	1907	1,268	433	10	94	--	DS	T, 25	--	Deepened from 280 ft in 1951. W, (441).
33A1	Robert Kinder	1950	1,152	150	8	59	50	D	T, 20	--	W, (442).
34M1	Andrew Cruden	--	1,174	147	6	--	--	DS	J, 1	--	
T. 18 N., R. 31 E.											
2A1	Hutterian Brethren	1953	1,220	405	12-8	1,350	21	I	T, 75	900	W, (443).
4G1	Jake Kagele	1957	1,190	293	12	1,000	90	I	T, 100	700	W, (443).
5A3	J. A. Weber	1952	1,183	201	10	620	113	DIS	T, 60	--	W, (443).

6F1	Robert Allen	1951	1,167	254	15	1,000	31	I	T, 75	415	W, (443)
6H2	P. D. Lyman	1950	1,172	370	16	1,050	79	I	T, 50	650	W, (443).
13R2	R. A. Franz	1953	1,462	911	12	1,000	--	I	T, 150	1,000	Deepened from 613 ft in 1959. W, (444).
15J1	W. E. Franz	1964	1,370	697	16	452	240	I	S, 75	--	L, W.
23D1	W. E. Franz	1965	1,368	663	16-12	1,800	85	I	S, 200	--	Combined production of 15J1 and 23D1 is 2,050 gpm. L, W.
T. 18 N., R. 32 E.											
6A1	Victor Franz	1950	1,320	410	8	300	204	I	S, 20	114	W, (444).
21J1	Henry Franz	1965	1,547	640	16	1,200	6	I	S, 200	--	W.
28C1	Leonard & Henry Franz	1959	1,484	616	16-12	1,000	4	I	T, 150	--	L, W.
29R1	Leonard & Henry Franz	1965	1,512	630	16	1,800	Slight	I	S, 200	--	L, W.
T. 19 N., R. 30 E.											
1L1	A. L. Ramm	1965	1,422	523	12	1,200	22	I	T, 125	--	L, W.
4H1	Frank Hinkhouse	--	1,449	294	6	--	--	N	P	--	W.
10P1	Henry Schell	1910	1,395	251	6	--	--	N	N	--	W.
10P2	Henry Schell	1962	1,394	615	10	490	2	I	T, 60	400	L, W.
12P1	Harry Masto	1966	1,465	646	16-12	1,500	5	I	T, 200	--	L, W.

*(See page 38 for explanation of Table 2 abbreviations).

Table 2 - Records of wells

Well no.	Owner or tenant	Date drilled	Land-surface altitude (feet)	Depth (feet)	Diameter (inches)	Rating when drilled		Use	Pump type, horsepower	Production rate (gpm)	Remarks
						Yield (gpm)	Drawdown (feet)				
T. 19 N., R. 30 E. - Cont.											
12Q1	Harry Masto	1966	1,464	656	15	1,500	58	I	T, 200	--	L.
16H1	Frank Hinkhouse	--	1,438	317	6	--	--	D	P	--	W.
19J1	Page Weston	--	1,419	500	6	--	--	N	P	--	W.
28D1	Ted Jeske	--	1,392	360	6	--	--	DI	T, 10	--	W.
28D2	Ted Jeske	1949	1,392	360	8	--	--	DI	S, 5	100	Combined production of 28D1 and 28D2 is 79 gpm.
28M1	C. W. Hinkhouse	--	1,376	--	--	--	--	N			Deepened from 540 ft in 1965. W, (472)
30L2	Paul Shafer	1949	1,340	675	10	1,000	75	I	T, 100	470	L, W.
35K1	Robert Allen	1949	1,170	360	12-8	1,000	10	I	T, 75	825	W, (473).
36A1	Leavitt	1951	1,190	366	12-8	1,000	--	I	T, 75	--	L, W.
36H1	Leavitt	1951	1,178	285	12	400	140	I	T, 50	500	Deepened from 209 ft in 1951. W.
36M1	Leavitt	1949	1,180	260	12	820	80	I	T, 75	--	W.

T. 19 N., R. 31 E.											
2N1	George Hilzer	--	1,370	92	6	--	--	DS	P, 1	3	W.
10Q1	James Kagele	1965	1,373	662	16	1,400	107	I	T, 200	--	L, W.
13P2	Carl Melcher	1962	1,537	328	8	55	50	DS	S, 3	--	L, W.
16H1	Jake Kagele, Jr.	1954	1,414	565	12	930	12	I	T, 150	--	W, (473).
16R1	Jake Kagele, Jr.	1950	1,290	287	16	818	12	I	T, 75	454	W, (473).
19B1	J. W. Phillips	--	1,454	218	6	--	--	N	N	--	
21R1	Jake Kagele, Jr.	1950	1,330	1,000	12-8	--	--	I	T, 100	637	W.
22D2	Richard Kagele	1964	1,270	279	8	50	50	D	S, 10	--	L, W.
35R1	Leonard & Henry Franz	1961	1,253	331	12	--	--	IS	T, 50	144	W.
35R2	Leonard & Henry Franz	1964	--	430	12	600	73	I	T, 50	--	L.
T. 19 N., R. 32 E.											
4H1	Jacob Greenwalt	1959	1,610	296	12	1,040	31	I	T, 100	--	L, W.
16F1	Forrest Hardt	1964	1,430	442	16	1,300	5	I	T, 150	--	L, W.
19N1	Norman Kagele	1953	1,290	411	12-8	800	237	IS	S, 20	350	W, (474).
22C1	Walt Waltner	--	1,658	278	6	--	--	D	P	--	W.
23M1	R. A. Gering	--	1,555	62	4	--	--	N	P	--	W.

Table 2 - Records of wells

Well no.	Owner or tenant	Date drilled	Land-surface altitude (feet)	Depth (feet)	Diameter (inches)	Rating when drilled		Use	Pump type, horsepower	Production rate (gpm)	Remarks
						Yield (gpm)	Drawdown (feet)				
T. 19 N., R. 32 E. - Cont.											
26P1	P. Schrag	1905	1,594	156	6	--	--	D	S, 3/4	--	W.
27D1	Unknown	--	1,517	104	6	--	--	N	P	--	W.
30N1	Norman Kagele	1958	1,405	447	16-12	900	65	I	T, 75	550	L, W.
30R1	Henry Gering	1955	1,522	130	6	87	10	DIS	T, 7 1/2	--	W.
31C1	Henry Gering	1955	1,469	520	12-8	260	238	I	T, 50	280	W, (474).
31G1	Howard Gering	1958	1,438	707	18-12-10-8	960	234	I	T, 125	800	Deepened from 445 ft in 1965. Yield measured when depth was 445 ft. L, W.
32N1	Henry Gering	1920	1,479	140	6	--	--	N	N	--	W.
33N1	J. J. Schrag	--	1,500	89	6	--	--	N	P	--	W.
35A1	Sam Graber	1958	1,657	643	12-8	1,050	61	I	T, 150	--	L, W.

T. 19 N., R. 33 E.											
4Q1	H. C. Hoefel	1965	--	666	15	1,800	6	I	T, 200	--	L. W.
6M1	A. C. Schlimmer	1964	--	273	--	35	Slight	DI	S, 5	--	L. W.
8J1	P. F. Hoefel	1902	--	295	6	84	1	DI	T, 7 1/2	41	W.
9G1	H. C. Hoefel	--	--	290	6	--	--	N	N	--	W.
9K1	Frank Marshall	--	--	285	6	--	--	N	N	--	W.
10E1	Unknown	--	--	--	6	--	--	D	P	--	W.
10M1	David Salo	--	--	304	6	--	--	D	S, 2	--	W.
11L1	Unknown	--	--	--	6	--	--	D	N	--	W.
17R1	P. F. Hoefel	1965	--	692	15	1,550	32	I	T, 200	1,430	L, W.
22C1	Unknown	--	--	205	6	--	--	N	N	--	W.
T. 20 N., R. 30 E.											
3J1	Sam Tschritter	--	1,521	471	6	--	--	DS	S, 1	--	W.
5D1	Unknown	--	1,436	150	6	--	--	S	P, 3	--	
6H1	Edward Tschritter	--	1,402	84	6	--	--	S	P	--	
11H1	Edwin Jasman	--	1,568	285	6	60	0	DIS	S, 5	55	W.

Table 2 - Records of wells

Well no.	Owner or tenant	Date drilled	Land-surface altitude (feet)	Depth (feet)	Diameter (inches)	Rating when drilled		Use	Pump type, horsepower	Production rate (gpm)	Remarks
						Yield (gpm)	Drawdown (feet)				
T. 20 N., R. 30 E. - Cont.											
14C1	Harvey Schell	--	1,578	385	6	--	--	N	N	--	
21H1	Evelan Claassen	--	1,578	401	6	--	--	DS	S, 5	--	W.
25E1	Henry Phillips	1905	1,612	284	6	--	--	N	N	--	W.
27J3	Joseph Jantz	1966	--	589	16	1,050	117	I	--	--	L.
34C1	J. C. Jantz	--	1,568	280	6	--	--	N	P	--	W.
T. 20 N., R. 31 E.											
4R1	Alvin Iltz	--	1,650	144	6	--	--	DIS	S, 5	40	
5C1	J. F. Kissler	--	1,647	178	6	115	--	DIS	S, 5	18	
6J1	Jacob Frick	--	1,599	148	6	--	--	N	P	--	W.
7A1	Anna Franz	--	1,576	120	8	--	--	N	N	--	W.
11C1	Reuben Scheller	--	1,699	270	8	100	--	DI	S, 3	35	W.
12D2	Walter Scheller	1958	1,679	166	6	120	--	DI	S, 5	25	W.

14A1	M. H. Miller	1962	1,504	195	10	280	7	DIS	T, 7 1/2	280	L, W.
15E1	Stanley Wraspir, Jr.	1950	1,446	397	12-8	--	--	DI	T, 30	94	W.
22D1	Walter Haase	--	1,575	214	6	--	--	N	N	--	W.
28J1	L. J. Bonney	--	1,600	222	6	--	--	N	P	--	W.
32A1	J. J. Phillips	--	1,581	341	6	--	--	N	N	--	W.
T. 20 N., R. 32 E.											
4C1	Els brothers	1902	1,714	189	6	--	--	D	P, 3/4	--	W.
6N2	Reuben Heimbigner	1965	1,723	600	10-8	400	60	DI	T	--	L, W.
9D1	Robert Melcher	--	1,626	160	--	--	--	N	P	--	W.
11L1	Len Lobe	1910	1,663	119	6	--	--	N	N	--	W.
15Q1	W. C. Raugust	1964	1,675	740	16-8	1,100	118	I	T, 150	--	L, W.
16J1	Els brothers	--	1,685	203	6	--	--	N	N	--	W.
25C2	Weldon Walter	1962	1,791	706	8	--	--	D	S, 5	40	L, W.
26B1	Henry Michelson	1900	1,780	243	6	--	--	N	N	--	W.
30C1	Joe Herman	1903	1,690	126	6	--	--	D	S, 3/4	--	W.
30M1	H. P. Wacker	1964	1,710	570	15	1,600	83	I	T, 200	1,350	L, W.

Table 2 - Records of wells

Well no.	Owner or tenant	Date drilled	Land-surface altitude (feet)	Depth (feet)	Diameter (inches)	Rating when drilled: Yield (gpm)	Rating when drilled: Drawdown (feet)	Use	Pump type, horsepower	Production rate (gpm)	Remarks
T. 20 N., R. 33 E.											
8J1	R. E. Hemmerling	--	--	285	6	--	--	DS	S, 1	--	W.
8J2	R. E. Hemmerling	1964	--	662	16	1,200	116	I	T, 100	--	L, W.
13A1	Otto Schoonover	--	--	65	--	--	--	I	S, 7 1/2	--	W.
13A2	Otto Schoonover	--	--	65	96	--	--	I	C, 10	--	W.
22P1	Harold Derr	--	--	260	--	--	--	D	P, 1	--	W.
26B1	Dan Gettman	--	--	365	6	--	--	D	P	--	W.
30A1	Robert Hemmerling	--	--	251	6	--	--	N	N	--	W.
34B1	Floyd Derr	--	--	--	6	--	--	N	P	--	W.
T. 21 N., R. 30 E.											
1G1	R. S. Beck	--	1,701	236	6	--	--	N	N	--	W.
3E1	Archie Zickler	1956	1,684	628	12	525	87	I	T, 75	525	Deepened from 451 ft in 1965. W, (503).
9P1	John Erickson	--	1,648	376	6	--	--	N	N	--	

12C1	R. S. Beck	1956	1,593	802	--	360	67	I	T, 60	--	Deepened from 667 ft in 1956. L, W.
13R1	L. M. Kissler	--	1,604	113	6	--	--	N	P	--	W.
26R1	Helena Ewert	--	1,648	207	6	--	--	N	N	--	W.
33A1	Fred Tschritter	--	1,555	297	6	--	--	N	P	--	W.
36M1	M. F. Peterson	--	1,665	280	6	--	--	N	N	--	W.
T. 21 N., R. 31 E.											
2Q1	Lewis Kagele	1964	--	407	16-14	1,200	80	I	T, 125	835	L, W.
10M1	C & D Mineral Development Co.	1961	1,612	4682	10	--	--	N	N	--	L, W.
13R1	Bill Frederick	--	--	88	6	--	--	S	P	--	W.
14J1	Bill Frederick	--	--	15	36	--	--	S	P	--	W.
15B1	Graedel brothers	1954	1,648	157	8	500	9	DI	T, 75	900	L, W.
15N1	Graedel brothers	--	1,762	262	6	--	--	DS	S, 1 1/2	--	W.
19A1	J. F. Kissler	--	1,580	134	6	--	--	DIS	T, 7 1/2	68	
21B1	Don Bates	1952	1,742	470	10	340	Slight	DIS	T, 100	446	L, W.
25B1	Lewis Kagele	1962	1,780	532	12	1,400	8	I	T, 150	724	L, W.
26K1	D. W. Jantz	1964	1,763	540	13	1,000	31	DIS	T, 150	1,065	L, W.

Table 2 - Records of wells

Well no.	Owner or tenant	Date drilled	Land-surface altitude (feet)	Depth (feet)	Diameter (inches)	Rating when drilled		Use	Pump type, horsepower	Production rate (gpm)	Remarks
						Yield (gpm)	Drawdown (feet)				
T. 21 N., R. 31 E. - Cont.											
27K1	Marvin Fink	1958	1,756	512	12	720	Slight	I	T, 150	880	Deepened from 480 ft in 1964. Yield measured when depth was 480 ft. L. W.
30L1	Fred Kissler	1954	1,679	482	12-8	600	40	I	T, 60	110	L.
31R1	Don Wacker	--	--	198	6	--	--	D	S, 1 1/2	17	W.
32D1	Fred Kissler	1960	1,669	708	12-8	668	60	I	T, 50	233	L, W.
36G1	Henry Schibel	1965	1,770	551	15-12	1,600	8	I	T, 150	--	L, W.
T. 21 N., R. 32 E.											
21P1	Henry Schafer	1900	1,804	289	6	--	--	D	P, 1	--	W.
22P2	Jerry Schafer	1962	1,832	630	12	800	20	I	T, 150	995	L, W.
26J1	Ivan Walter	--	1,831	298	6	--	--	N	P	--	W.
27R1	Roloff	--	1,782	266	--	--	--	N	P	--	W.
29H1	Mrs. Leoffelbein	--	1,794	278	--	--	--	DS	S, 1 1/2	--	W.

31C1	Alvin Fink	1964	1,811	744	15	1,000	50	I	T, 150	829	L, W.
32B1	Sam Weber	--	1,760	252	--	--	--	N	P	--	W.
T. 21 N., R. 33 E.											
1F1	Ben Walter	1949	--	235	8	300	12	I	T, 60	251	L.
2P1	John Scrupps	1956	--	200	12	750	6	I	T, 50	235	L, W.
4Q1	C. H. Scrupps	--	--	--	14	--	--	I	T	--	W.
5L1	J. A. Reihs	1962	--	250	8	--	--	I	S, 15	101	L, W.
5Q1	City of Odessa (well 2)	1937	--	302	10	--	--	P	S, 40	--	
7A1	Wayne Braun	1961	--	257	10	800	2	I	T, 25	450	L.
7D1	Sol Walter	1953	--	234	12	300	78	I	T, 30	187	L.
7H1	Odessa Community Golf Club	1965	--	290	12	1200	Slight	I	T, 75	--	L, W.
8B1	City of Odessa (well 1)	--	--	240	10	--	--	P	T, 40	--	
8E1	Odessa School Dist.	--	--	102	6	--	--	N	P	--	W.
8K1	City of Odessa	1965	--	--	18	--	--	P	N	--	
9L1	B. J. Lyons	1956	--	425	12-8	620	127	I	T, 75	335	Basalt at 3 ft below land surface. W.
10J1	John Scrupps	--	--	--	--	--	--	I	T, 50	--	W.
12P1	King brothers	--	--	--	--	--	--	I	T, 30	305	
12H1	Ed. Heimbugner	--	--	16	6	--	--	IS	C, 20	--	

Table 2 - Records of wells

Well no.	Owner or tenant	Date drilled	Land-surface altitude (feet)	Depth (feet)	Diameter (inches)	Rating when drilled		Use	Pump type, horsepower	Production rate (gpm)	Remarks
						Yield (gpm)	Drawdown (feet)				
T. 21 N., R. 33 E. - Cont.											
13P1	King brothers	1953	--	180	12	1,300	81	I	T, 100	558	L.
20L1	Art Jeske	1904	--	--	--	--	--	D	S, 1/2	--	W.
22D1	Unknown	--	--	281	--	--	--	N	P	--	W.
24B1	John Scrupps	1955	--	120	6	120	1	D	T, 5	120	Basalt at 12 ft below land surface.
29K1	Sol Walter	--	--	300	6	--	--	D	S, 5	10	W.
31D1	Herbert Walter	1953	--	344	6	--	--	D	S, 5	--	W.
T. 22 N., R. 30 E.											
8N1	Arnold Nestegard	--	--	30	--	--	--	I	C, 7 1/2	150	
8P1	W. R. Seig	--	1,286	16	36	--	--	I	C, 10	200	
9F1	C. F. Mordhorst	1949	1,275	20	48	400	1	I	C, 30	750	(516).
10J1	Chris Larsen	1963	1,280	157	12	1,450	138	I	T, 100	750	L.
10R1	Chris Larsen	1959	1,310	184	--	--	--	DI	T, 25	225	

13F1	George Starkel	1954	--	228	12	1,475	30	I	T, 30	--	(516).
14C1	Roger James	1951	1,330	145	12-10	720	9	I	T, 25	350	(516).
18B1	Larsen brothers	--	--	22	48	100	Slight	DIS	C, 7 1/2	--	Casing perforated 17-20 ft in gravel.
18C1	Larsen brothers	--	--	16	60	60	1/2	I	C, 25	500	
26P1	Unknown	--	1,720	228	6	--	--	N	N	--	W.
33J1	B. C. James	--	1,610	172	6	--	--	N	N	--	
34N1	Archie Zickler	--	1,670	183	6	--	--	DS	S	--	W.
T. 22 N., R. 31 E.											
17F1	Richard Kuch	1963	--	21	36	1,000	1/2	DI	C, 75	518	Casing perforated 16-21 ft in rocks and "hardpan" W.
24G1	L. M. Wraspir	1959	--	700	12	900	3	I	T, 100	510	L, W.
36H1	Jacob Ott	--	--	--	6	--	--	D	J,P,P, ½,½,½,	--	W.
T. 22 N., R. 33 E.											
2K1	August Sackman	1964	--	167	8	--	--	DIS	S, 5	--	W.
4L1	L. J. Bonney	1956	--	246	12-8	--	--	I	S, 7 1/2	357	Well reported to flow 150 gpm. L, W.

Table 2 - Records of wells

Well no.	Owner or tenant	Date drilled	Land-surface altitude (feet)	Depth (feet)	Diameter (inches)	Rating when drilled		Use	Pump type, horsepower	Production rate (gpm)	Remarks
						Yield (gpm)	Drawdown (feet)				
T. 22 N., R. 33 E. - Cont.											
19C1	Harvey Haase	1964	--	367	8-6	60	--	D	S, 5	--	L, W.
23P1	Ben Smith	1955	--	614	12	600	117	I	T, 75	374	Deepened from 200 ft in 1956-57 and from 345 ft in 1966. Yield rate measured when depth was 200 ft; production rate measured when depth was 345 ft. L, W.
27E1	Wilbert Shott	1952	--	300	12-10	--	--	I	T, 75	700	L, W.
34D1	Martin Kramer	1953	--	367	12	640	213	I	T, 75	257	L, W.

*Rating when drilled -- Initial test yield and drawdown as reported by driller or owner.

Use -- D, domestic; I, irrigation; N, not used; P, public supply; S, stock.

Pump type -- C, centrifugal; J, jet; P, plunger; S, submersible; T, turbine.

Production rate -- Discharge rate into irrigation system, estimated by Geological Survey.

Remarks -- L, well log in table 4; W, water-level measurement in table 3. Numeral in parenthesis is number of page on which well log is listed in Walters and Grolier (1960); these logs are not repeated in the present report.

Table 3 - Water levels in wells

Water levels are reported as depth below land surface and altitude above mean sea level, in feet. Depths reported to tenths or hundredths of a foot were measured by Geological Survey personnel, using steel tape or electric sounding cable; measurements recorded to nearest foot were reported by owner, tenant, or driller, or are airline measurements which may be in error by 10 feet or more.

Date	Water level	
	Depth	Altitude
18/30-2C1		
8-15-50	59.44	1,095
5-10-65b	27.00	1,127
18/30-2C2		
7-15-64	11	1,143
18/30-3A2		
10-12-51	105	1,035
18/31-4G1		
5- -57	48	1,142
18/30-4P1		
5- 6-42	90	1,052
1948	71	1,071
18/30-11G1		
5-22-42	190	1,078
8- 4-50	239	1,029
9-28-50	245	1,023
11- 2-51	268	1,000
18/30-33A1		
1-18-51	84	1,068
18/31-2A1		
5-27-53	33	1,187
3-12-58	41.07	1,179
5-10-58a	62.20	1,158
6-20-62a	87.62	1,132
18/31-5A3		
9- -52	54	1,129
11- 4-52	55	1,128
18/31-6F1		
5- 2-51	27	1,140
18/31-6H2		
5-15-50	34	1,138
8-31-50	33	1,139
5-10-58	41.49	1,131
18/31-13R2		
10- -53	334	1,128
1955	318	1,144
11- -59	309	1,153
18/31-15J1		
10-24-64	229	1,141
3- 2-65a	444	926
5-11-65a	462	908

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
18/31-23D1		
1-25-65	226	1,142
5-11-65a	326	1,042
18/32-6A1		
3- -50	76	1,244
6-29-65a	348	972
18/32-21J1		
1- 9-66	414	1,133
18/32-28C1		
11- 9-59	344	1,140
18/32-29R1		
6-29-65	367.8	1,144
9-29-65	370	1,142
19/30-1L1		
6-11-65	283	1,139
19/30-4H1		
5-21-42	139.03	1,310
7-26-50	147.75	1,301
5- 7-58	133.40	1,316
3-21-63	125.71	1,323
11-18-65	125.14	1,324
19/30-10P1		
10-24-61	247.37	1,148
3-21-63	240.49	1,155
11-18-65	247.99	1,147
19/30-10P2		
5- -62	248	1,146
19/30-12P1		
8-23-65	340	1,125
19/30-16H1		
5- 6-42	275	1,163
7-27-50	273.77	1,164
5- 7-58	281.94	1,156
3-21-63	291.10	1,147
11-18-65	296.98	1,141
19/30-19J1		
7-26-50	272.24	1,147
5- 7-58	270.80	1,148
3-22-63	265.97	1,153
10-21-64	263.41	1,156
12- 7-64	262.84	1,156
2-28-65	262.28	1,157
4- 8-65	262.70	1,156
5- 5-65	261.96	1,157
6-10-65	262.13	1,157
7- 7-65	261.88	1,157
8-11-65	262.30	1,157
9-15-65	262.35	1,157
10- 8-65	262.38	1,157
11- 2-65	261.98	1,157
12-16-65	261.66	1,157

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
19/30-28D1		
7-28-50	230	1,162
5- 7-58	239	1,153
19/30-28M1		
7-28-50	228.58	1,147
10-20-64	237.85	1,138
2-28-65	228.67	1,147
4- 8-65	235.87	1,140
5- 5-65	238.23	1,138
6-10-65	237.75	1,138
7- 7-65	239.37	1,137
8-11-65	239.61	1,136
9-15-65	273.23	1,103
10- 8-65	310.15	1,066
11- 2-65	270.20	1,106
12-16-65	260.56	1,115
19/30-30L2		
12- -49	305	1,035
19/30-35K1		
11-17-49	36.80	1,133
19/30-36A1		
5-12-65	86.70	1,103
19/30-36H1		
5-18-50	60	1,118
5-12-65	70.08	1,108
19/30-36M1		
6- 3-49	45	1,135

Date	Water level	
	Depth	Altitude
19/31-2N1		
6-23-42	71.85	1,298
11- 9-50	71.35	1,299
5-12-58	71.66	1,298
4- 8-63	72.80	1,297
11-17-65	72.05	1,298
19/31-10Q1		
9-18-65	67	1,306
11-17-65	73.35	1,300
19/31-13P2		
5- 7-65	242.79	1,294
6- 9-65	242.75	1,294
7- 7-65	244.00	1,293
8-12-65	245.15	1,292
9-15-65a	275.48	1,280
10- 7-65a	257.98	1,279
11- 2-65	245.03	1,292
12-16-65	239.03	1,298
19/31-16H1		
7-19-54	240	1,174
19/31-16R1		
7-27-50	35	1,255
11- 9-50	32.65	1,257
19/31-21R1		
11- 9-50	169.05	1,161
9-11-58	181.95	1,148
19/31-22D2		
3- 2-65	106.31	1,164

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
19/31-35R1		
--	95	1,258
19/32-4H1		
3-27-63	79.64	1,530
3- 2-65	84.95	1,525
4- 5-65	93.15	1,517
5- 7-65a	133.36	1,477
6- 9-65a	150+	1,460-
7- 7-65a	134.64	1,475
8-12-65	103.52	1,506
9-16-65a	142.48	1,468
10- 7-65	104.98	1,505
11- 3-65	101.79	1,508
12-16-65	90.80	1,519
19/32-16F1		
11- -64	209	1,221
1965 a	223	1,207
°19/32-19N1		
9-11-58	52.6	1,237
4- 9-63	43.47	1,247
3- 2-65	55.42	1,235
19/32-22C1		
3- 2-65	191.24	1,467
4- 5-65	195.41	1,463
5- 6-65	191.66	1,466
6- 9-65	191.64	1,466
7- 7-65a	193.46	1,465
8-12-65	192.17	1,466
9-15-65	191.99	1,466
10- 7-65	194.79	1,463
11- 1-65	195.28	1,463
12-16-65	192.70	1,465
19/32-23M1		
10-25-61	60.59	1,494
3-27-63	62.30	1,493
11-18-65	58.31	1,497
19/32-26P1		
3-24-62	138.60	1,455
3-27-63	142.14	1,452
3- 2-65	143.03	1,451
4- 5-65	141.92	1,452
5- 5-65	142.45	1,452
6- 9-65	143.13	1,451
7- 7-65	143.35	1,451
8-12-65	143.45	1,451
9-16-65	143.64	1,450
10- 7-65	143.78	1,450
11- 1-65	143.54	1,450
12-16-65	144.04	1,450
19/32-27D1		
10-25-61	80.20	1,437
6-20-62	85.40	1,432
3-27-63	88.31	1,429
3- 2-65	94.43	1,423
4- 5-65	88.22	1,429
5- 5-65	87.96	1,429
6- 9-65	89.08	1,428
7- 7-65	90.46	1,427
8-12-65	92.41	1,425
9-16-65	93.03	1,424
10- 7-65	93.41	1,424
11- 1-65	93.39	1,424
12-16-65	93.23	1,424
19/32-30N1		
12- -58	240	1,165
5- 7-65a	366	1,039
19/32-30R1		
6- 9-55	114	1,408

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
19/32-31C1		
9-11-58	321	1,148
10-22-64	324	1,145
3- 1-65	315	1,154
4- 8-65	349	1,120
6-22-65a	348	1,121
7- 6-65a	343	1,126
8-12-65a	340	1,129
9-15-65a	338	1,131
10- 7-65a	342	1,127
11- 2-65	343	1,126
12-16-65	339	1,130
19/32-31G1		
3-21-59	111	1,327
3- 2-65	110	1,328
5-11-65	156.81	1,281
19/32-32N1		
10-26-61	94.19	1,385
3-27-63	96.80	1,382
19/32-33N1		
6-29-42	88.95	1,411
5-10-58	88.89	1,411
3-27-63	90.20	1,410
19/32-35A1		
3- 6-59	197	1,460
19/33-4Q1		
12- 8-64	251.12	--
12-11-64	251.79	--
1-29-65	252.85	--
2-27-65	252.38	--

Date	Water level	
	Depth	Altitude
1933/4Q1 - Cont.		
4- 6-65	252.99	--
5- 5-65a	261.48	--
6- 9-65a	275	--
7- 6-65a	263.79	--
8-12-65	263	--
9-13-65	255.12	--
10- 6-65	254.97	--
10- 7-65a	264.42	--
11- 1-65a	264.29	--
12-16-65	255.11	--
19/33-6M1		
5- -64	77	--
12-11-64	77.68	--
11-18-65	79.14	--
19/33-8J1		
11-17-64a	269.6	--
19/33-9G1		
12-11-64	272.25	--
19/33-9K1		
11-18-64	270.78	--
12-10-64	270.75	--
1-29-65	271.39	--
2-27-65	270.85	--
4- 6-65	271.84	--
5- 5-65	271.74	--
6- 9-65	273.80	--
7- 6-65	272.71	--
8-12-65	273.05	--
9-13-65	273.35	--
10- 6-65	272.72	--
11- 1-65	273.70	--
12-16-65	272.99	--
1-12-66	273.27	--

Table 3 - Water levels in wells

Date	Water level: Depth	Water level: Altitude
19/33-9K1-Cont.		
2- 9-66	272.58	--
4- 4-66	273.35	--
6- 6-66	274.15	--
19/33-10E1		
12-10-64	296.60	--
12-11-64	296.31	--
12-12-64	296.38	--
1-29-65	297.08	--
2-27-65	296.85	--
4-26-65	297.00	--
5- 5-65	296.51	--
6- 9-65	297.87	--
7- 6-65	298.00	--
8-12-65	298.61	--
9-13-65	298.95	--
10- 5-65	298.40	--
11- 1-65	299.44	--
12-16-65	299.14	--
1-12-66	299.17	--
2- 9-66	298.41	--
19/33-10M1		
10- 5-65	294.26	--
19/33-11L1		
11-18-64	235.28	--
2-26-65	235.25	--
4- 6-65	232.86	--
5- 6-65	236.80	--
6- 9-65	237.33	--
7- 6-65	237.36	--
8-12-65	237.64	--
9-13-65	237.77	--
10- 5-65	236.99	--
11- 1-65	237.79	--
12-16-65	237.59	--

Date	Water level: Depth	Water level: Altitude
19/33-17R1		
2-11-65	313	--
5-10-65a	368	--
19/33-22C1		
11-18-64	192.24	--
20/30-3J1		
7-24-50	118.80	1,402
5- 9-58	116.14	1,405
4- 5-63	120.53	1,400
10-23-64	123.09	1,398
11-19-64	119.59	1,401
2-28-65	119.75	1,401
4- 8-65	119.72	1,401
5- 5-65	119.95	1,401
6-10-65	120.57	1,400
7- 9-65	119.96	1,401
8-11-65	120.37	1,401
9-15-65	120.22	1,401
10- 8-65	120.41	1,401
11- 3-65	120.24	1,401
12-17-65	120.64	1,400
20/30-11H1		
5- 8-64	170	1,398
5-13-65	167.00	1,401
20/30-21H1		
1961	219	1,359
10-21-64	220.39	1,358
11-17-64	219.12	1,359
2-28-65	215.62	1,362
4- 8-65	215.25	1,363
5- 5-65a	241.36	1,337
6-10-65	226.17	1,352

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
20/30-21H1 - Cont.		
7- 7-65	226.25	1,352
8-11-65	224.52	1,353
9-15-65a	242.07	1,336
10- 8-65	226.93	1,351
11- 3-65	225.15	1,353
12-16-65	222.46	1,356
20/30-25E1		
10-23-61	267.53	1,344
3-21-63	279.23	1,333
11-17-65	267.37	1,345
20/30-34C1		
10-20-64	232.36	1,336
11-19-64	232.39	1,336
2-28-65	231.59	1,336
4- 8-65	231.02	1,337
5- 5-65	231.33	1,337
6-10-65	231.46	1,337
7-10-65	231.54	1,336
8-11-65	231.82	1,336
9-14-65	231.81	1,336
10- 8-65	232.35	1,336
11- 3-65	232.04	1,336
12-16-65	232.07	1,336
20/31-6J1		
10-20-61	126.19	1,473
10-21-64	127.46	1,472
3- 1-65	127.90	1,471
4- 8-65	127.54	1,471
5- 5-65	127.90	1,471
6-10-65	127.76	1,471
7- 8-65	127.88	1,471
8-11-65	127.96	1,471
9-16-65	128.03	1,471
10- 6-65	127.96	1,471
11- 3-65	127.80	1,471
12-15-65	128.35	1,471

Date	Water level	
	Depth	Altitude
20/31-7A1		
5-10-58	117.13	1,459
4- 8-63	111.58	1,464
6-24-64	112.24	1,464
7-25-64	112.31	1,464
8-26-64	112.25	1,464
9-25-64	112.27	1,464
8-11-65	113.13	1,463
20/31-11C1		
4-17-64	159.60	1,539
10-23-64	163.41	1,536
11-20-64	163.49	1,536
3- 1-65	163.63	1,535
4- 8-65	163.63	1,535
5- 5-65	163.58	1,535
6-10-65	159.79	1,539
7- 8-65	163.97	1,535
8-11-65	164.24	1,535
9-15-65	164.47	1,535
10- 6-65	164.64	1,534
11- 2-65	164.59	1,534
12-17-65	165.20	1,534
20/31-12D2		
4-17-64a	143.80	1,535
5-13-65a	145.78	1,533
20/31-14A1		
4-20-64	12.39	1,492
5-13-65	16.5	1,487
20/31-15E1		
4-20-64	12.81	1,433
10-21-64a	27.95	1,418
11-20-64	19.80	1,426
3- 1-65	9.87	1,436
4- 8-65	9.78	1,436

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
20/31-15E1 - Cont.		
5- 5-65	26.54	1,419
6- 9-65	30.42	1,416
7- 8-65	30.14	1,416
8-11-65	40.03	1,406
9-15-65	40.71	1,405
9-15-65a	58.47	1,388
10- 6-65	36.78	1,409
11- 2-65	28.65	1,417
12-17-65	17.83	1,428
20/31-22D1		
6-23-42	145.80	1,429
11- 8-50	142.5	1,432
5-10-58	141.34	1,434
4- 8-63	144.79	1,430
10-23-64	155.02	1,420
11-20-64	152.43	1,423
3- 1-65	141.75	1,433
4- 8-65	141.16	1,434
5- 5-65	150.04	1,425
6- 9-65	159.91	1,415
7- 8-65	162.12	1,413
8-11-65	166.54	1,408
9-15-65	169.75	1,405
10- 6-65	168.75	1,406
11- 2-65	162.41	1,413
12-17-65	151.44	1,424
20/31-28J1		
6-23-42	132.30	1,468
11- 8-50	130.9	1,469
5-10-58	129.7	1,470
4- 8-63	127.56	1,472
10-23-64	128.39	1,472
11-20-64	128.82	1,471
3- 1-65	129.3	1,471
4- 8-65	128.09	1,472
5- 5-65	128.60	1,471
6- 9-65	128.55	1,471
7- 8-65	128.36	1,472
8-11-65	128.60	1,471
9-15-65	128.65	1,471
10- 6-65	128.71	1,471
11- 2-65	128.44	1,472
12-17-65	129.21	1,471

Date	Water level	
	Depth	Altitude
20/31-32A1		
10-20-61	265.9	1,315
4- 8-63	273.4	1,308
11-17-65	279.10	1,302
20/32-4C1		
12-14-64	176.06	1,538
11-17-65	179.57	1,534
20/32-6N2		
5-25-65	300.00	1,423
6- 4-65	310	1,413
20/32-9D1		
10-30-62	84.03	1,542
4- 9-63	83.90	1,542
11-17-65	82.49	1,544
20/32-11L1		
10-30-62	113.69	1,549
2-27-63	114.65	1,548
5- 1-63	114.70	1,548
5-31-63	116.44	1,547
6-29-63	117.16	1,546
7-27-63	117.53	1,545
8-23-63	118.58	1,544
9-29-63	118.27	1,545
10-26-63	119.28	1,544
11-23-63	120.31	1,543
12-18-63	120.56	1,542
2-26-64	116.62	1,546
3-19-64	116.76	1,546
4-21-64	116.89	1,546
5-25-64	116.91	1,546
6-24-64	117.63	1,545
7-25-64	117.91	1,545
8-26-64	118.12	1,545
9-26-64	117.20	1,546
6- 8-65	117.36	1,546

Table 3 - Water levels in wells

Date	Water level Depth	Water level Altitude
20/32-15Q1		
3-13-65	122	1,553
6-28-65a	303	1,372
20/32-16J1		
10-31-62	130.66	1,554
2-26-64	130.01	1,555
3-19-64	130.50	1,554
4-21-64	130.62	1,554
5- 2-64	130.98	1,554
6-24-64	131.57	1,553
7-25-64	131.81	1,553
8-26-64	132.01	1,553
9-26-64	132.22	1,553
6- 8-65	134.89	1,550
20/32-25C2		
4- 9-63	270	1,521
10-21-64	253.1	1,538
11-20-64	251.97	1,539
2-27-65	251.55	1,539
4- 5-65	251.93	1,539
5- 6-65	253.55	1,537
6- 8-65a	255.35	1,536
7- 6-65	255.17	1,536
8-12-65	255.57	1,535
9-15-65	256.09	1,535
10- 6-65	256.66	1,534
11- 1-65	256.56	1,534
12-16-65	256.95	1,534
20/32-26B1		
10-27-62	234.55	1,545
2-26-64	231.36	1,549
3-19-64	231.28	1,549
4-21-64	231.40	1,549
5-25-64	231.79	1,548
6-26-64	233.31	1,547
9-26-64	232.71	1,547
6- 8-65	234.21	1,546
20/32-30C1		
10-29-62	87.63	1,602
4- 9-63	87.02	1,603
2-26-64	87.11	1,603
6-24-64	89.58	1,600
6-28-65	88.49	1,602
8-12-65	91.28	1,598
20/32-30M1		
1-12-65	202	--
20/33-8J1		
11-17-64	171.64	--
1-29-65	172.45	--
2-26-65	172.08	--
4- 5-65	180.40	--
5- 4-65	198.19	--
5-27-65	212.35	--
6- 8-65	209.33	--
7- 6-65	210.15	--
8-12-65	214.75	--
9-15-65	209.65	--
10- 7-65	190.02	--
11- 1-65	186.79	--
12-16-65	185.36	--
20/33-8J2		
11-14-64	189	--
11-17-64	188.35	--
1-29-65	188.84	--
2-26-65	188.53	--
4- 6-65	198.38	--
5- 4-65a	304.62	--
5-27-65a	318.08	--
6- 8-65a	316	--
7- 6-65a	311	--
8-12-65a	313	--
9-15-65a	268	--
10- 7-65	214	--
11- 1-65	205	--
12-16-65	201.45	--

Table 3 - Water levels in wells

Date	Water level Depth	Water level Altitude
20/33-13A1		
5-11-65	19.83	--
20/33-13A2		
5-11-65	13.77	--
20/33-22P1		
11-19-64	265.36	--
20/33-26B1		
11-19-64	276.07	--
1-29-65	276.63	--
2-26-65	276.10	--
5- 6-65	276.35	--
6- 8-65	276.87	--
7- 6-65	277.70	--
8- 9-65	279.79	--
9-13-65	277.76	--
10- 5-65	277.85	--
11- 1-65	277.77	--
12-15-65	277.37	--
1-12-66	277.66	--
2-10-66	277.65	--
20/33-30A1		
11-18-64	216.47	--
2-26-65	216.72	--
4- 5-65	216.44	--
5- 6-65	219.19	--
6- 8-65	218.37	--
7- 6-65	218.90	--
8-12-65	218.52	--
9-13-65	219.18	--
10- 6-65	220.00	--
11- 1-65	219.44	--
12-16-65	220.80	--
1-12-66	220.33	--
2-10-66	218.57	--

Date	Water level Depth	Water level Altitude
20/33-34B1		
11-18-64	285.02	--
2-26-65	283.23	--
4- 6-65	283.97	--
5- 5-65	284.40	--
6- 8-65	281.93	--
7- 6-65	283.75	--
8- 9-65	285.34	--
9-13-65	285.60	--
21/30-1G1		
5- 8-64	173.51	1,527
11-18-65	178.90	1,522
21/30-3E1		
4- 7-56	198	1,486
5- 1-58	205	1,479
11- 6-63	231	1,453
10-20-64	218.57	1,465
11-20-64	217.17	1,467
2-28-65	214.53	1,469
4- 7-65	235.92	1,448
5- 5-65	236.15	1,448
6-10-65a	386	1,298
7- 8-65a	395	1,289
8-10-65	370	1,314
8-11-65	367	1,317
9-14-65a	392	1,292
10- 8-65	382	1,302
11- 3-65	372	1,312
12-15-65	360	1,324
21/30-12C1		
1956	240	1,353
11- 5-63	262	1,331
5- 7-64a	296	1,297
5- 9-64a	299	1,294
5-22-64a	302	1,291
10-20-64	280	1,313
11-19-64	276	1,317
2-28-65	268	1,325
4- 7-65	258	1,335

Table 3 - Water levels in wells

Date	Water level Depth	Water level Altitude
21/31-10M1 - Cont.		
5-25-64	194.45	1,418
6-24-64	198.30	1,414
7-25-64	197.75	1,414
7-30-64	198.3	1,414
8-26-64	201.60	1,410
9-25-64	199.70	1,412
10-21-64	197.11	1,415
11-19-64	189.52	1,422
11-20-64	189.40	1,423
12-14-64	186.38	1,426
1-30-65	182.90	1,429
2-28-65	182.25	1,430
4-19-65	191.1	1,421
5- 7-65	197.3	1,415
6- 9-65	201.88	1,410
6-23-65	204.32	1,408
7- 8-65	202.12	1,410
8-10-65	204.72	1,407
9-14-65	208.02	1,404
10- 8-65	201.32	1,411
11- 3-65	193.17	1,419
12-15-65	185.69	1,426
21/31-13R1		
4-20-64	55.44	--
10-22-64	52.39	--
11-20-64	52.73	--
2-28-65	52.53	--
4- 6-65	52.26	--
5- 5-65	52.16	--
6- 7-65	52.09	--
7- 8-65	52.74	--
8-10-65	52.44	--
9-14-65	53.38	--
10- 7-65	52.60	--
11- 2-65	52.75	--
12-14-65	52.48	--
21/31-14J1		
6- 7-65	6.42	--

Date	Water level Depth	Water level Altitude
21/31-15B1		
1954	105	1,543
11- 7-63	112.7	1,535
4-15-64	125	1,523
11-18-65	126.53	1,521
21/31-15N1		
6- -63	225	1,537
4-15-64	222.17	1,540
10-23-64	231.02	1,531
11-20-64	228.82	1,533
2-28-65	228.11	1,534
4- 7-65	227.95	1,534
5- 7-65	232.90	1,529
6-10-65	234.77	1,527
7- 8-65	234.61	1,527
8-10-65	237.67	1,524
9-15-65	239.16	1,523
10- 6-65	239.20	1,523
11- 3-65	237.22	1,525
12-15-65	235.87	1,526
21/31-21B1		
5- 3-63	206	1,536
11- 5-63	207	1,535
4-16-64	196.41	1,546
10-21-64	221	1,521
11-19-64	217	1,525
2-28-65	217	1,525
4- 7-65	217	1,525
6-25-65	224	1,518
7- 8-65	222	1,520
8-10-65a	250	1,492
9-14-65a	250	1,492
10- 6-65	224	1,518
11- 3-65	223	1,519
12-15-65	223	1,519
21/31-25B1		
2-15-62	327	1,453
11-27-62	330	1,450

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
21/30-12C1 - Cont.		
5- 5-65	267	1,326
5- 8-65a	281	1,312
6-10-65a	296	1,297
7- 8-65	294	1,299
8-10-65	278	1,315
9-14-65	294	1,299
10- 8-65	293	1,300
11- 3-65	280	1,313
12-15-65	270	1,323
21/30-13R1		
4-17-64	104.29	1,500
10-23-64	105.14	1,499
11-20-64	105.38	1,499
2-28-65	105.73	1,498
4- 7-65	105.26	1,499
5- 5-65	105.20	1,499
6-10-65	105.04	1,499
7- 7-65	104.77	1,499
8-10-65	104.85	1,499
9-14-65	105.06	1,499
10- 8-65	105.21	1,499
11- 3-65	105.07	1,499
12- 5-65	105.30	1,499
21/30-26R1		
1902	206	1,442
5-28-42	192.10	1,456
7-24-50	191.93	1,456
5-10-58	191.04	1,457
4- 5-63	191.78	1,456
10-23-64	194.60	1,453
11-20-64	192.49	1,456
2-28-65	192.88	1,455
4- 7-65	192.42	1,456
5- 5-65	192.74	1,455
6-10-65	192.67	1,455
7- 9-65	192.58	1,455
8-10-65	193.17	1,455
9-16-65	192.76	1,455
10- 8-65	192.91	1,455
11- 3-65	192.77	1,455
12-15-65	192.84	1,455
1-11-66	192.84	1,455
2- 8-66	192.74	1,455

Date	Water level	
	Depth	Altitude
21/30-33A1		
7-21-50	229.8	1,325
5-10-58	215.5	1,340
4- 5-63	216	1,339
10-23-64	222.48	1,333
11-20-64	222.19	1,333
2-28-65	222.14	1,333
4- 7-65	220.64	1,334
5- 5-65	223.23	1,332
6-10-65	223.09	1,332
7- 9-65	223.73	1,331
8-11-65	223.58	1,331
9-16-65	230.87	1,324
10- 8-65	231.62	1,323
11- 3-65	231.03	1,324
12-15-65	230.65	1,324
21/30-36M1		
10-23-64	206.98	--
11-20-64	207.20	--
2-28-65	207.47	--
4- 7-65	206.89	--
5- 5-65	207.15	--
6-10-65	206.97	--
7- 9-65	207.02	--
8-11-65	207.22	--
9-16-65	207.09	--
10- 8-65	207.23	--
11- 3-65	207.19	--
12-15-65	207.08	--
21/31-2Q1		
11-19-64	142.55	--
11-17-65	169.10	--
21/31-10M1		
11-27-62	185	1,427
11- 5-63	190	1,422
3-19-64	180.85	1,431
4-21-64	187.25	1,425
5- 7-64	191.7	1,420

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
21/31-25B1 - Cont.		
11- 7-63	344	1,436
4- -64	359	1,421
10-21-64	351	1,429
11-19-64	341	1,439
4- 6-65a	339	1,441
5- 5-65a	343	1,437
5- 7-65a	349	1,431
6- 7-65a	355	1,425
6-24-65a	357	1,423
7- 8-65	356	1,424
10- 8-65	352	1,428
11- 2-65	340	1,440
12-14-65	335	1,445
21/31-26K1		
2-24-64a	251	1,512
10-21-64	276	1,487
11-19-64	233	1,530
2-28-65	233	1,530
4- 6-65	292	1,471
5- 5-65a	287	1,476
5- 7-65a	281	1,482
6- 7-65a	283	1,480
7- 8-65a	288	1,475
8-10-65a	284	1,479
9-14-65a	290	1,473
10- 6-65a	291	1,472
11- 2-65	241	1,522
12-14-65	239	1,524
21/31-27K1		
1- 9-58	322	1,434
11-27-62	322	1,434
10-29-63	340	1,416
11- 5-63	330	1,426
2- 5-64	318	1,438
4-15-64	312	1,444
5- 6-64a	334	1,422
7-30-64	335	1,421
9-25-64a	346	1,410
10-21-64	333	1,423
11-19-64	322	1,434
12-14-64	316	1,440
2-28-65	306	1,450

Date	Water level	
	Depth	Altitude
21/31-27K1 - Cont.		
5- 5-65a	341	1,415
5- 7-65a	340	1,416
6- 7-65a	345	1,411
6-24-65a	350	1,406
7- 8-65a	348	1,408
8-10-65a	353	1,403
9-14-65a	358	1,398
10- 6-65	339	1,417
11- 2-65	322	1,434
11-17-65	317	1,439
12-14-65	309	1,447
21/31-31R1		
6-10-65	181.45	--
7- 9-65a	187.19	--
8-11-65a	187.53	--
9-16-65a	187.77	--
10- 6-65a	188.26	--
11- 3-65a	188.25	--
12-17-65	180.13	--
21/31-32D1		
4-16-64	295	1,374
10-21-64a	367	1,302
11-20-64	317	1,352
2-28-65	256	1,413
4- 8-65a	338	1,331
11-17-65	335	1,334
21/31-36G1		
2-24-65	318	1,452
4- -65	327	1,443
6- 7-65a	363	1,407
7- 8-65	350	1,420
8-10-65a	371	1,399
21/32-21P1		
10-22-64	271.39	1,533
11- -64	271.29	1,533

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
21/32-21P1 - Cont.		
2-27-65	269.68	1,534
4- 7-65	269.08	1,535
5- 7-65	271.32	1,533
7- 8-65	274.74	1,529
7-10-65	274.89	1,529
9-14-65	275.33	1,529
10- 6-65	275.79	1,528
11- 2-65	275.79	1,528
12-14-65	275.27	1,529
1-10-66	274.82	1,529
2- 7-66	274.11	1,530
4- 5-66	274.95	1,529
6- 7-66	277.25	1,527
21/32-22P2		
7- -62	275	--
4-20-64	295	--
1-30-65	304	--
2-27-65	304	--
21/32-26J1		
10-22-64	290.0	1,541
11-20-64	290.0	1,541
2-27-65	288.96	1,542
4-26-65	289.69	1,541
5- 6-65	290.64	1,540
6- 9-65	291.10	1,540
7- 6-65	291.78	1,539
8-10-65	292.00	1,539
9-14-65	292.37	1,539
10- 7-65	293.29	1,538
11- 2-65	292.29	1,539
12-14-65	293.01	1,538
1-10-66	292.86	1,538
2- 7-66	292.48	1,538
21/32-27R1		
10-23-64	251.6	1,530
11-19-64	251.31	1,531
2-27-65	249.86	1,532
4- 6-65	250.00	1,532

Date	Water level	
	Depth	Altitude
21/32-27R1 - Cont.		
5- 6-65	251.14	1,531
6- 9-65	253.04	1,529
7- 6-65	253.51	1,528
8-10-65	254.29	1,528
9-14-65	254.39	1,528
10- 7-65	255.21	1,527
11- 2-65	255.45	1,527
12-14-65	254.44	1,528
1-10-66	253.90	1,528
2- 7-66	253.71	1,528
21/32-29H1		
7-31-64	259.5	1,534
11-17-65	268.15	1,526
21/32-31C1		
3-14-64	270	1,541
4-21-64a	327	1,484
5- 7-64a	372	1,439
5- 7-64a	374	1,437
5- 7-64	321	1,490
5- 7-64	310	1,501
5- 8-64	305	1,506
5-25-64a	381	1,430
6-24-64	383	1,428
7-25-64	383	1,428
8-26-64	383	1,428
9-25-64	385	1,426
10-20-64a	384	1,427
10-22-64a	384	1,427
11-19-64	351	1,460
12-14-64	343	1,468
1-30-65	340	1,471
2-27-65	337	1,474
4- 6-65a	368	1,443
5- 5-65a	371	1,440
5- 7-65a	386	1,425
6- 7-65a	392	1,419
6-24-65a	392	1,419
7- 8-65a	390	1,421
11- 2-65	366	1,445
12-14-65	355	1,456

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
21/32-32B1		
5- 7-65	228.52	1,531
6-10-65	229.57	1,530
7- 7-65	230.72	1,529
8-10-65	231.00	1,529
9-14-65	231.90	1,528
10- 6-65	232.76	1,527
11- 2-65	233.09	1,527
12-14-65	232.26	1,528
21/33-2P1		
6-21-65	103	--
21/33-4Q1		
6-21-65	52.80	--
21/33-5L1		
12-13-64	184.87	--
21/33-7H1		
5-27-65	110	--
6-28-65	106.4	--
10- 7-65	114	--
21/33-8E1		
10- 7-65	25.30	--
21/33-9L1		
5-14-65a	241	--

Date	Water level	
	Depth	Altitude
21/33-10J1		
5-14-65	59	--
21/33-20L1		
11-17-64	295.27	--
1-29-65	289.52	--
2-26-65	287.80	--
4- 5-65	290.28	--
5- 4-65	290.70	--
6- 9-65	297.63	--
7- 6-65	298.30	--
8-12-65	298.63	--
9-14-65	298.00	--
10- 7-65a	340.03	--
10- 7-65	300.86	--
11- 1-65	302.24	--
12-14-65	294.53	--
1-10-66	292.22	--
21/33-22D1		
11-18-64	127.06	--
2-26-65	127.13	--
3- 5-65	126.99	--
5- 4-65	126.90	--
6- 8-65	126.83	--
7- 6-65	126.74	--
8- 9-65	126.61	--
9-13-65	126.68	--
10- 7-65	126.78	--
11- 1-65	126.49	--
12-14-65	126.63	--
1-10-66	126.47	--
2- 7-66	126.37	--
4- 4-66	126.22	--
21/33-29K1		
11-17-64	227.97	--
1-29-65	228.44	--
2-26-65	228.06	--
4- 5-65	227.68	--

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
21/33-29K1 - Cont.		
5- 4-65	227.39	--
6- 9-65	227.26	--
7- 6-65	228.03	--
8-12-65a	266.73	--
9-14-65	229.51	--
10- 7-65	230.20	--
11- 1-65	230.17	--
12-14-65	230.51	--
1-10-66	230.43	--
2- 7-66	230.39	--
21/33-31D1		
11-17-65	295.94	--
22/30-26P1		
5-14-42	196.90	1,523
5-10-58	195.60	1,524
3-21-63	198.03	1,522
11-18-65	201.19	1,519
22/30-34N1		
10- -42	176	1,494
7-19-50	176.98	1,493
10-21-64	177.88	1,492
11-20-64	183.77	1,486
4- 7-65	184.15	1,486
5- 5-65	187.04	1,483
6-10-65	184.48	1,486
7- 8-65	184.59	1,485
8-10-65	184.85	1,485
9-14-65	185.24	1,485
10- 8-65	185.36	1,485
11- 3-65	185.31	1,485
12-15-65	185.89	1,484
22/31-17F1		
5-20-63	8	--

Date	Water level	
	Depth	Altitude
22/31-24G1		
8- -59	380	--
22/31-36H1		
4-21-64	10.42	--
11-16-65	7.55	--
22/33-2K1		
12-10-64	66.01	--
22/33-4L1		
12- 8-64	Flowing	--
22/33-19C1		
12-10-64	250.39	--
11-17-65	239.54	--
22/33-23P1		
7- -55	58	--
12-10-64	53.21	--
11-16-65	53.99	--
22/33-27E1		
9-15-56a	104.34	--
10-16-56	36.28	--
11-10-56	30.10	--
12-15-56	27.74	--
1-12-57	25.50	--
2-16-57	26.13	--
3-16-57	22.67	--
4-13-57	15.79	--
5-11-57a	101.45	--
6-15-57	18.89	--

Table 3 - Water levels in wells

Date	Water level	
	Depth	Altitude
22/33-27E1 - Cont.		
7-14-57	33.37	--
8-17-57a	177	--
9-14-57a	156	--
10-16-57a	140.66	--
11-16-57	31.22	--
12-14-57	31.28	--
2-15-58	12.18	--
4-16-58	5.18	--
22/33-34D1		
9-13-55	65.52	--
10-11-55	47.56	--
11-28-55	34.98	--
12-22-55	29.20	--
1-18-56	22.83	--
3-22-56	16.94	--
4-14-56	16.51	--
5-19-56a	128.08	--
6-16-56	23.78	--
7-14-56a	126.56	--
8-18-56	130	--
9-13-56	46.48	--
9-15-56	47.02	--
10-16-56a	126.53	--
11-10-56	44.81	--
12-15-56	43.06	--
1-12-57	41.15	--
2-16-57	41.63	--
10-22-59	38.96	--
12-15-60	42.05	--
3- 8-61	25.62	--
9-21-61	50.37	--
3-23-62	29.13	--
9-26-61	57.62	--
10- 1-63	60.38	--
3-20-64	30.00	--

Date	Water level	
	Depth	Altitude

a/ Well being pumped.

b/ Nearby well being pumped.

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
18/30-2C2. Ireton & Quinn. Altitude 1,154 ft. Drilled by Frear Drilling Co. Cased to 48 ft.		
Surficial deposits	43	43
Basalt, black	9	52
Clay, sandy, red	10	62
Basalt, black	29	91
Basalt, gray	3	94
18/31-15J1. W. E. Franz. Altitude 1,370 ft. Drilled by Barnett Pump & Irrigation, Inc. Cased to 33 ft.		
Sand and silt	27	27
Basalt, black	23	50
Basalt, brown, broken	37	87
Basalt, gray	83	170
Basalt, black	52	222
Basalt, brown, water-bearing	18	240
Basalt, black	47	287
Basalt, gray	48	335
Basalt, black	17	352
Shale and gray basalt	43	395
Basalt, gray	55	450
Basalt, black, hard	95	545
Basalt, gray	33	578
Basalt, brown, porous, water-bearing	92	670
Basalt, gray	15	685
Basalt, black, soft, porous, water-bearing	12	697
18/31-23D1. W. E. Franz. Altitude 1,368 ft. Drilled by Barnett Pump & Irrigation, Inc. Cased to 26 ft.		
Surficial deposits	20	20
Basalt, brown, broken	100	120
Basalt, gray	30	150
Basalt, black, broken, water-bearing	15	165
Basalt, gray	213	378
Basalt, brown, broken	42	420
Basalt, black	72	492
Silt, gravel, and broken basalt, water-bearing	23	515
Basalt, brown, broken	45	560
Basalt, gray, broken	20	580
Basalt, red, broken, water-bearing	75	655
Basalt, black	8	663

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
18/32-28C1. Leonard & Henry Franz. Altitude 1,484 ft. Drilled by Barnett Pump & Irrigation, Inc. Cased to 55 ft.		
Surficial deposits	55	55
Basalt, gray, hard	23	78
Basalt, medium-hard	22	100
Basalt, blue-gray, hard	6	106
Basalt, medium-soft	8	114
Basalt, brown, soft, and silty ash	30	144
Basalt, medium-hard	5	149
Basalt, soft, water-bearing	9	158
Basalt, black, medium-soft	20	178
Basalt, blue, medium-hard	16	194
Basalt, soft	4	198
Crevice	2	200
Basalt, medium-hard	13	213
Basalt, hard	8	221
Basalt, medium-soft and hard	44	265
Basalt, black, broken, water-bearing	43	308
Basalt, black, hard, broken	17	325
Basalt, black, medium-hard	65	390
Basalt, brown and black, soft	12	402
Basalt, black, medium-hard	23	425
Basalt, black, soft, broken	12	437
Basalt, blue, hard	13	450
Basalt, black, soft, broken	60	510
Shale, blue-gray	10	520
Basalt, black, honeycombed	20	540
Basalt, black and brown, honeycombed	12	552
Shale, gray, and black basalt	36	588
Basalt, red, honeycombed, water-bearing	8	596
Basalt, red and black, honeycombed	20	616
18/32-29R1. Leonard & Henry Franz. Altitude 1,512 ft. Drilled by Jasper Jones Well Drilling Co. Cased to 97 ft.		
Surficial deposits	12	12
Basalt, broken	56	68
Basalt, black, dense	24	92
Basalt, gray, hard	45	137
Basalt, black, hard	59	196
Basalt, black, broken, water-bearing	44	240
Basalt, gray, hard	20	260
Basalt, black, very porous	44	304
Basalt, broken	30	334
Basalt, gray	31	365

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
18/32-29R1 - Continued		
Basalt, gray, broken	29	394
Basalt, gray, medium-hard	53	447
Basalt, black, hard	49	496
Basalt, porous, broken, water-bearing	45	541
Basalt, black, broken	49	590
Basalt, gray, hard	20	610
Basalt, very porous, water-bearing	20	630
19/30-1L1. A. L. Ramm. Altitude 1,422 ft. Drilled by James E. Haney Co. Cased to 37 ft.		
Topsoil	11	11
Hardpan	2	13
Sand, black	24	37
Basalt, dark-gray, porous	28	65
Basalt, brown, porous	25	90
Basalt, dark-gray, solid	80	170
Basalt, dark-gray, porous; water-bearing at 220 ft, water level rose to 155 ft	90	260
Basalt, dark-gray, solid	95	355
Basalt, dark-gray, porous	88	443
Clay, blue, stiff	8	451
Basalt, red-brown, porous	67	518
Basalt, dark-gray, solid	5	523
19/30-10P2. Henry Schell. Altitude 1,394 ft. Drilled by Frear Drilling Co. Cased to 17 ft.		
Topsoil	4	4
Basalt, broken	13	17
Basalt, black	54	71
Basalt, brown, broken	70	141
Basalt, black, hard	106	247
Basalt, water-bearing	4	251
Basalt, gray, hard	261	512
Basalt, black	58	570
Basalt, black, broken, water-bearing	40	610
Basalt, black	5	615
19/30-12P1. Harry Masto. Altitude 1,465 ft. Drilled by Charles Jungmann Drilling Co. Cased to 308 ft.		
Topsoil	6	6
Clay	19	25

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
19/30-12P1 - Continued		
Basalt, broken	70	95
Basalt, black	163	258
Basalt, red	2	260
Basalt, black	24	284
Basalt, gray	24	308
Basalt, black	31	339
Basalt, gray	42	381
Basalt, black	76	457
Basalt, gray	16	473
Basalt, black	41	514
Basalt, gray	13	527
Shale, dark, soft	12	539
Basalt, broken	43	582
Basalt, dark	64	646
19/30-12Q1. Harry Masto. Altitude 1,464 ft. Drilled by Frear Drilling Co. Cased to 24 ft.		
Topsoil	7	7
Caliche	2	9
Basalt, black, broken	27	36
Basalt, black	90	126
Basalt, gray	46	172
Basalt, black	28	200
Basalt, gray, water-bearing at 226 ft	61	261
Basalt, black, water-bearing at 268 ft	25	286
Basalt, gray	71	357
Basalt, black	6	363
Basalt, gray, hard	156	519
Basalt, black, water-bearing at 559 ft	47	566
Basalt, gray	51	617
Basalt, black; water-bearing, 635-649 ft	39	656
19/30-30L2. Paul Shafer. Altitude 1,340 ft. Drilled by Frank Zimmerman. Cased to 34 ft.		
Topsoil	6	6
Caliche	3	9
Loam, sandy	25	34
Basalt, brown	64	98
Basalt, blue, hard	202	300
Basalt, porous, water-bearing	37	337
Basalt, blue, hard	98	435
Basalt, blue, porous, water-bearing	25	460

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
19/30-30L2 - Continued		
Basalt, gray	65	525
Basalt, porous, water-bearing	30	555
Basalt, gray, hard	85	640
Basalt, porous, water-bearing	35	675
19/30-36A1. Leavitt. Altitude 1,190 ft. Drilled by Basin Drilling Co. Cased to about 6 ft.		
Topsoil	4	4
Basalt, broken	8	12
Basalt, black	57	69
Basalt, blue, hard	52	121
Basalt, broken, water-bearing	14	135
Basalt, blue	25	160
Basalt, gray	52	212
Basalt, black	18	230
Basalt, broken, water-bearing	10	240
Basalt, blue	75	315
Basalt, gray	34	349
Basalt, broken, water-bearing	17	366
19/31-10Q1. James Kagele. Altitude 1,373 ft. Drilled by John W. Davisson. Cased to 27 ft.		
Surficial deposits	18	18
Basalt, gray, hard	20	38
Basalt, green, hard	34	72
Basalt, brown, soft, water-bearing	8	80
Sand, brown	6	86
Gravel	5	91
Sand, coarse	12	103
Sand, brown, firm	17	120
Sand, coarse, red	5	125
Sand, brown, firm	2	127
Basalt, green and red, soft	35	162
Basalt, red, hard	10	172
Basalt, gray, hard	53	225
Basalt, red, soft	12	237
Sand	10	247
Basalt, gray, hard	6	253
Basalt, gray, medium-hard	127	380
Basalt, red, medium-hard, water-bearing	50	430
Basalt, gray	20	450
Sand, water-bearing	18	468
Basalt, gray, hard	76	544

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
19/31-10Q1 - Continued		
Basalt, green, hard	23	567
Basalt, gray, hard	88	655
Sand	7	662
19/31-13P2. Carl Melcher. Altitude 1,537 ft. Drilled by Dewey Fox. Cased to 13 ft.		
Topsoil	8	8
Caliche	2	10
Basalt	50	60
Basalt, broken	20	80
Basalt, blue	160	240
Basalt, broken	5	245
Basalt, black and blue	70	315
Basalt, broken, water-bearing	13	328
19/31-22D2. Richard Kagele. Altitude 1,270 ft. Drilled by Frear Drilling Co. Cased to 48 ft.		
Surficial deposits	25	25
Basalt, black	31	56
Basalt, gray	11	67
Basalt, black and brown, water-bearing	20	87
Basalt, black	18	105
Basalt, gray	28	133
Basalt, black, water-bearing	19	152
Basalt, gray	22	174
Basalt, black and brown, water-bearing	18	192
Basalt, gray	11	203
Basalt, black	17	220
Basalt, gray	39	259
Basalt, black, water-bearing	18	277
Basalt, gray	2	279
19/31-35R2. Leonard & Henry Franz. Drilled by Barnett Pump & Irrigation, Inc. Cased to 47 ft.		
Surficial deposits	47	47
Basalt, broken	26	73
Basalt	50	123
Basalt, brown, broken, water-bearing	8	131
Basalt	109	240

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
19/31-35R2 - Continued		
Basalt, broken, water-bearing	17	257
Basalt, gray	80	337
Basalt, brown, broken	5	342
Basalt, gray	56	398
Basalt, porous, water-bearing	32	430
19/32-4H1. Jacob Greenwalt. Altitude 1,610 ft. Drilled by John W. Davisson. Cased to 29 ft.		
Topsoil	5	5
Clay and gravel	21	26
Basalt	1	27
Basalt, shelly	16	43
Basalt, hard	2	45
Basalt, broken	35	80
Basalt, hard	3	83
Basalt, broken	9	92
Basalt, hard	30	122
Basalt, soft, porous, water-bearing	29	151
Basalt, hard	46	197
Basalt, broken	6	203
Basalt, soft	11	214
Basalt, hard	7	221
Basalt, soft	25	246
Basalt, hard	50	296
19/32-16F1. Forrest Hardt. Altitude 1,430 ft. Drilled by John W. Davisson. Cased to 32 ft.		
Gravel	30	30
Basalt, gray, hard	72	102
Basalt, green, hard	27	129
Basalt, gray, hard	21	150
Basalt, brown, hard	5	155
Basalt, brown, soft, water-bearing	2	157
Basalt, gray, hard	31	188
Basalt, brown, soft, water-bearing	25	213
Basalt, gray, hard	5	218
Basalt, brown, soft	14	232
Basalt, gray, hard	11	243
Basalt, gray, soft	18	261
Basalt, gray, hard	58	319
Clay, blue	5	324
Basalt, green, soft, water-bearing	24	348
Basalt, gray, hard	18	366

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
19/32-16F1 - Continued		
Basalt, gray, soft	11	377
Basalt, gray, hard	18	395
Basalt, dark, soft	20	415
Basalt, black, soft, water-bearing	21	436
Basalt, gray, hard	6	442
19/32-30N1. Norman Kagele. Altitude 1,405 ft. Drilled by Barnett Pump & Irrigation, Inc. Cased to 16 ft.		
Topsoil	8	8
Boulders and gravel	8	16
Gravel, cemented, and boulders	54	70
Basalt, black	45	115
Basalt, honeycombed, water-bearing	5	120
Basalt, black	15	135
Basalt, broken	15	150
Basalt, black	26	176
Basalt, honeycombed, broken, water-bearing	72	248
Basalt	92	340
Basalt, honeycombed, broken	57	397
Shale and clay	50	447
19/32-31G1. Howard Gering. Altitude 1,438 ft. Drilled by Barnett Pump & Irrigation, Inc. Cased to 32 ft.		
Topsoil	18	18
Gravel and boulders	30	48
Basalt	87	135
Basalt, honeycombed, water-bearing	5	140
Basalt, black	45	185
Basalt, honeycombed, and some blue shale	25	210
Basalt, broken	15	225
Basalt, black	73	298
Basalt, broken, water-bearing (water level rose 2 ft)	7	305
Basalt	97	402
Shale, blue	28	430
Gravel, small, and blue shale, water-bearing	7	437
Basalt	8	445
Basalt, black, broken	20	465
Shale, blue, and broken basalt; water-bearing	15	480
Basalt, black	95	575
Basalt, black, broken	40	615

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
19/32-31G1 - Continued		
Basalt, decomposed, water-bearing (water level rose 67 ft)	33	648
Basalt, black	29	677
Shale, blue, water-bearing (water level rose 2 ft)	13	690
Basalt, black	15	705
Basalt, broken, and black sand	2	707
19/32-35A1. Sam Graber. Altitude 1,657 ft. Drilled by Frear Drilling Co. Cased to 75 ft.		
Topsoil	24	24
Caliche	14	38
Clay	10	48
Basalt, broken	27	75
Basalt, hard and soft, with clay seams	120	195
Basalt, gray	27	222
Basalt, broken, with clay seams	4	226
Basalt, brown, porous, water-bearing	4	230
Basalt, black	29	259
Basalt, gray	51	310
Shale, gray	15	325
Basalt, gray	76	401
Basalt, black	27	428
Basalt, gray	16	444
Basalt, black	62	506
Basalt, black and brown, porous	137	643
19/33-4Q1. H. C. Hoefel. Drilled by Jasper Jones Well Drilling Co. Cased to 132 ft.		
Topsoil	9	9
Clay	31	40
Caliche	35	75
Basalt, broken, with clay and gravel	5	80
Gravel and clay	7	87
Gravel, basaltic, loose, caving	13	100
Gravel, basaltic, and clay	7	107
Basalt, broken	8	115
Basalt	9	124
Basalt, dense	31	155
Basalt, dense, and gravel	18	173
Basalt, broken, and clay	27	200
Basalt, broken, and gravel	11	211
Basalt, dense	29	240
Gravel, basaltic	5	245
Basalt, dense	5	250

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
19/33-4Q1 - Continued		
Basalt, broken, and clay	17	267
Basalt, broken, with gravel and black sand	15	282
Basalt, sand, and gravel	28	310
Basalt, broken	7	317
Basalt, dense	23	340
Basalt, broken	3	343
Basalt, dense	5	348
Basalt, broken	17	365
Basalt, soft, and clay	15	380
Basalt, hard	25	405
Basalt, soft	1	406
Basalt, red, soft	10	416
Basalt, broken	14	430
Basalt, broken, and clay	25	455
Basalt, broken	21	476
Basalt, black, hard	36	512
Basalt, black, broken	9	521
Basalt, gray, hard	27	548
Basalt, black	2	550
Basalt, honeycombed	14	564
Basalt, black, broken	26	590
Basalt, hard	10	600
Basalt, broken	37	637
Basalt, black, hard	10	647
Basalt, red, broken	6	653
Basalt, black, broken	10	663
Basalt, black, hard	3	666
19/33-6M1. A. C. Schlimmer. Drilled by Frear Drilling Co. Cased to 42 ft.		
Clay	40	40
Basalt, black, with clay seams	45	85
Basalt, gray, very hard	81	166
Basalt, gray	89	255
Clay, sandy, red	18	273
19/33-17R1. P. F. Hoefel. Drilled by Jasper Jones Well Drilling Co. Cased to 98 ft.		
Topsoil, clay, and some gravel	60	60
Basalt, broken, and clay	28	88
Basalt, gravel, and clay	122	210
Gravel and clay	25	235

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
19/33-17R1 - Continued		
Basalt, black	5	240
Basalt, broken	6	246
Basalt, gray	49	295
Basalt, broken	17	312
Basalt, gray	36	348
Basalt, broken, and clay	22	370
Basalt, gray and black	54	424
Basalt and red clay	31	455
Basalt, gray and black	66	521
Basalt, porous, broken	14	535
Basalt, black	36	571
Basalt, broken	49	620
Basalt, black, broken in places	72	692
20/30-27J3. Joseph Jantz. Drilled by John W. Davisson. Cased to 58 ft.		
Surficial deposits	53	53
Basalt, brown, soft	142	195
Basalt, green, hard	94	289
Basalt, gray, hard	11	300
Basalt, gray, very hard	29	329
Basalt, black, medium-soft	34	363
Basalt, gray, very hard	28	391
Basalt, black, soft, water-bearing	31	422
Basalt, gray, hard	8	430
Basalt, gray, very hard	91	521
Clay, blue	4	525
Basalt, gray, soft	6	531
Basalt, gray, hard	22	553
Basalt, black, soft, water-bearing	33	586
Sand	3	589
20/31-14A1. M. H. Miller. Altitude 1,504 ft. Drilled by John W. Davisson. Cased to 38 ft.		
Topsoil	4	4
Gravel and clay	11	15
Gravel and broken basalt	13	28
Basalt, hard	12	40
Basalt, soft, water-bearing	33	73
Basalt, hard	7	80
Basalt, soft	12	92
Basalt, hard	10	102

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
20/31-14A1 - Continued		
Basalt, soft	5	107
Basalt, hard	48	155
Basalt, soft, water-bearing	13	168
Basalt, hard	3	171
Basalt, soft, water-bearing	20	191
Basalt, hard	4	195
20/32-6N2. Reuben Heimbigner. Altitude 1,723 ft. Drilled by Basin Drilling Co. Cased to 76 ft.		
Surficial deposits	30	30
Basalt, medium-hard	50	80
Basalt, hard	50	130
Basalt, soft	25	155
Basalt, hard	15	170
Basalt, soft, broken, water-bearing	55	225
Basalt, gray, hard	205	430
Basalt, red, soft	45	475
Basalt, soft, broken, water-bearing	10	485
Basalt, blue, hard	105	590
Basalt, broken, water-bearing	5	595
Basalt, hard	5	600
20/32-15Q1. W. C. Raugust. Altitude 1,675 ft. Drilled by Frank Zimmerman. Cased to 695 ft.		
Topsoil	7	7
Basalt, broken, and clay	39	46
Basalt, black, medium-hard	134	180
Basalt, hard	160	340
Basalt, broken, and clay; water-bearing	40	380
Basalt, gray, hard	295	675
Basalt, broken, and clay	10	685
Basalt, gray, hard	50	735
Basalt, broken, water-bearing	5	740
20/32-25C2. Weldon Walter. Altitude 1,791 ft. Drilled by Barnett Pump & Irrigation, Inc.		
Surficial deposits	65	65
Basalt, soft, broken	6	71
Basalt, hard	54	125
Basalt, soft, porous	20	145

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
20/32-25C2 - Continued		
Basalt, hard	25	170
Basalt, water-bearing at 190, 243, and 343 ft.	263	433
Basalt, red, porous	30	463
Basalt and interflow sediments	243	706
20/32-30M1. H. P. Wacker. Altitude 1,710 ft. Drilled by John W. Davison. Cased to 67 ft.		
Topsoil	54	54
Gravel	5	59
Basalt, brown, soft	8	67
Basalt, gray, hard	89	156
Basalt, brown, soft	12	168
Basalt, gray, hard	7	175
Basalt, green, hard	20	195
Basalt, gray, soft, water-bearing	5	200
Basalt, gray, hard	12	212
Basalt, gray, soft, water-bearing	46	258
Basalt, gray, hard	27	285
Basalt, gray, soft, water-bearing	10	295
Basalt, gray, hard	53	348
Basalt, brown, soft	22	370
Sand, red	6	376
Basalt, gray, hard	4	380
Sand, black	7	387
Basalt, red, hard	8	395
Basalt, gray, hard	42	437
Basalt, brown, soft, water-bearing	21	458
Basalt, gray	9	467
Basalt, green, hard	35	502
Basalt, red, soft, water-bearing	60	562
Basalt, hard	8	570
20/33-8J2. R. E. Hemmerling. Drilled by Jasper Jones Well Drilling Co. Cased to 72 ft.		
Topsoil	20	20
Gravel	25	45
Gravel and clay	5	50
Clay and broken basalt	15	65
Basalt	20	85
Basalt, broken	5	90
Basalt	30	120
Basalt, gray	15	135
Basalt, broken	55	190

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
20/33-8J2 - Continued		
Basalt, gray, hard	30	220
Basalt, gray, caving	10	230
Basalt, gray, hard	60	290
Basalt, broken, and clay	15	305
Gravel	10	315
Basalt, gray	10	325
Basalt, black	5	330
Gravel and broken basalt	4	334
Basalt, black	2	336
Basalt, gray	30	366
Basalt, broken, and clay	10	376
Basalt, black	34	410
Basalt, gray	8	418
Basalt, black	38	456
Basalt, broken, and clay	60	516
Basalt, black	19	535
Basalt, honeycombed	1	536
Basalt, gray	74	610
Basalt, black	35	645
Basalt, broken	10	655
Basalt, black	7	662
21/30-12C1. R. S. Beck. Altitude 1,593 ft. Drilled by Morrison & Morrison. Cased to 40 ft.		
Topsoil	30	30
Gravel, sandy	7	37
Basalt, dense	18	55
Basalt, porous, water-bearing at 75 ft	45	100
Basalt, gray, dense, water-bearing at 149 ft	165	265
Basalt, porous	15	280
Basalt, gray, dense	30	310
Basalt, porous, and rounded pebbles	10	320
Basalt, porous	25	345
Unknown	10	355
Basalt, gray, dense	10	365
Basalt, porous	10	375
Basalt, gray, dense	55	430
Basalt, black, porous	80	510
Basalt, black, dense	20	530
Basalt, porous, water-bearing at 549 ft	20	550
Basalt, dense	10	560
Basalt, gray, dense	30	590
Basalt, black and gray, dense	30	620
Basalt, blue, porous	15	635
Basalt, porous	30	665

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/30-12C1 - Continued		
Basalt, dense	2	667
Basalt, hard	99	766
Basalt, black, coarse, water-bearing	14	780
Basalt, black, coarse; water level dropped 16 ft to 109 ft	5	785
Basalt, medium-hard	4	789
Basalt, broken, water level at 240 ft	13	802
21/31-2Q1. Lewis Kagele. Drilled by John W. Davisson. Cased to 202 ft.		
Gravel	16	16
Hardpan	28	44
Basalt, green, hard	5	49
Basalt, gray, hard	118	167
Basalt, brown, soft, water-bearing	20	187
Sand, red	13	200
Basalt, brown, hard	60	260
Basalt, gray, hard	3	263
Basalt, soft, water-bearing	30	293
Basalt, gray, hard	5	298
Basalt, brown, soft	80	378
Basalt, black, hard	7	385
Basalt, brown, soft, water-bearing	17	402
Basalt, hard	5	407
21/31-10M1. C & D Mineral Development Co. Altitude 1,612 ft. Drilled by Morrison-Knudson. Cased to 98 ft.		
Basalt	100	100
Basalt, dark-green	10	110
Basalt, green, vesicular	20	130
Basalt, black and rust-colored	20	150
Basalt	80	230
Unknown	15	245
Basalt, greenish-black	10	255
Unknown	10	265
Basalt, gray-black	10	275
Unknown	25	300
Basalt, dark-gray	110	410
Unknown	10	420
Basalt, dark-gray	50	470
Basalt, black, dense, with 15 percent vesicular dense rust-colored basalt	50	520
Basalt, gray, dense	30	550

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/31-10M1 - Continued		
Basalt, rust-colored, dense, vesicular; and dense dark-green basalt	10	560
Basalt, rust to red, very vesicular; and dark-green and gray basalt	30	590
Serpentine, green to yellowish	30	620
Basalt, red, dark-brown; and dark-green, slightly vesicular	10	630
Basalt, dark-brown	50	680
Basalt, very fine-grained, medium- to dark-gray, hard	30	710
Basalt, dark-gray, brown- and rust-colored, dense, vesicular	40	750
Basalt, very fine-grained, gray-green, very vesicular	20	770
Basalt, very fine-grained, dark- and medium-gray, dense	310	1,080
Basalt, medium-gray with greenish tint	50	1,130
Basalt, medium-gray with brown tint	10	1,140
Basalt, medium-gray, dense	180	1,320
Basalt, dark-gray, dense	15	1,335
Basalt, medium red-brown	55	1,390
Basalt, very fine-grained, medium- to dark-gray	490	1,880
Basalt, dark- to medium-gray, dense	30	1,910
Basalt, very fine-grained, medium-gray to rust-colored, dense	280	2,190
Basalt, very fine-grained, light- to medium-gray, dense	100	2,290
Basalt, dark-gray, dense	30	2,320
Basalt, fine- to very fine-grained, medium- to dark-gray	780	3,100
Basalt, gray to dark-gray, and red basalt	40	3,140
Basalt, very fine-grained, medium- to dark-gray, brittle, dense	660	3,800
Basalt, medium- to light-gray, dense, with very soft, medium-brown and pale-green siltstone	30	3,830
Basalt, medium- to dark-gray, dense	150	3,980
Basalt, dark-gray, dense, with rust-colored basalt and vitreous olivine or glass	60	4,040
Basalt, medium- to dark-gray, dense, with occasional trace of rust-colored basalt	90	4,130
Basalt, medium- to dark-gray, dense	30	4,160
Unknown	5	4,165
Basalt	5	4,170
Basalt, with diatomite	5	4,175
Basalt, dark-gray, dense, and clay	25	4,200
Basalt, dark-gray, dense	70	4,270
Basalt, dark- to medium-gray	70	4,340
Basalt, dark- to medium-gray, and shale	20	4,360
Shale	10	4,370
Basalt, dark-gray, dense, and sand	40	4,410
Basalt, fine-grained, brown, and thin dark-gray shale	20	4,430
Basalt, dark- to medium-gray	35	4,465
Sand, coarse, subangular, unconsolidated	30	4,495
Sand, coarse, white, and shale	4	4,499
Shale, clayey, rusty- to mottled-green	14	4,513
Shale, rusty- to medium-brown	52	4,565
Shale, sandy	10	4,575

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/31-10M1 - Continued		
Sand, coarse to medium, subangular, quartzose	25	4,600
Sand, medium-grained	40	4,640
Sand, coarse to medium	10	4,650
Sand	17	4,667
Granite, fine-grained, medium-gray	15	4,682
21/31-15B1. Graedel Brothers. Altitude 1,648 ft. Drilled by Joy Drilling Co. Cased to 33 ft.		
Topsoil	1	1
Basalt, broken	41	42
Basalt, black, firm	24	66
Basalt, hard	2	68
Basalt, gray	22	90
Basalt	15	105
Basalt, gray, hard	41	146
Basalt, broken	11	157
21/31-21B1. Don Bates. Altitude 1,742 ft. Drilled by Frank Zimmerman. Cased to 21 ft.		
Topsoil	3	3
Hardpan	21	24
Basalt	14	38
Clay, brown	6	44
Basalt	1	45
Basalt, medium	28	73
Basalt, hard	12	85
Basalt, medium	22	107
Basalt, hard	3	110
Basalt, medium	25	135
Basalt, soft	40	175
Basalt, medium	12	187
Basalt, hard	7	194
Basalt, medium	40	234
Basalt, hard	11	245
Basalt, red, broken	23	268
Basalt, hard	13	281
Basalt, medium	11	292
Basalt, hard	52	344
Basalt, broken	24	368
Basalt, medium	18	386
Basalt, broken, and clay	40	426
Basalt, red, porous	20	446
Basalt, broken	24	470

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/31-25B1. Lewis Kagele. Altitude 1,780 ft. Drilled by John W. Davisson. Cased to 67 ft.		
Topsoil	5	5
Hardpan	49	54
Basalt, brown, hard	6	60
Basalt, gray, hard	41	101
Basalt, brown, soft, water-bearing	13	114
Basalt, green, soft, water-bearing	19	133
Basalt, blue, hard	14	147
Basalt, brown, medium	12	159
Basalt, gray, hard	12	171
Basalt, brown, soft	8	179
Basalt, gray, hard	7	186
Basalt, brown, soft	49	235
Sand, brown, water-bearing	13	248
Basalt, gray, hard	37	285
Basalt, brown, medium	19	304
Basalt, black, hard	82	386
Basalt, medium	32	418
Basalt, gray, hard	16	434
Basalt, black, soft, water-bearing	54	488
Basalt, gray, hard	10	498
Basalt, red, soft	22	520
Basalt, gray, hard	12	532
21/31-26K1. D. W. Jantz. Altitude 1,763 ft. Drilled by John W. Davisson. Cased to 71 ft.		
Topsoil	26	26
Clay	39	65
Basalt, hard	135	200
Basalt, brown, soft	18	218
Basalt, hard	20	238
Basalt, soft, water-bearing	3	241
Basalt, gray, hard	26	267
Sand	4	271
Basalt, gray, hard	2	273
Basalt, brown, soft	17	290
Sand and gravel	10	300
Basalt, hard	7	307
Sand	4	311
Basalt, brown, hard	28	339
Basalt, gray, hard	24	363
Shale, green	17	380
Basalt, gray, hard	42	422
Basalt, brown, soft	12	434
Basalt, brown, hard	83	517

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/31-26K1 - Continued		
Basalt, red, soft, water-bearing	18	535
Sand	4	539
Basalt, hard	1	540
21/31-27K1. Marvin Fink. Altitude 1,756 ft. Drilled by Zimmerman and Davisson. Cased to 53 ft; 8-inch liner, 408-448 ft.		
Topsoil, clayey	5	5
Hardpan and clay	23	28
Clay	1	29
Caliche	19	48
Basalt, broken	32	80
Basalt, medium-hard, broken	16	96
Clay	5	101
Basalt, medium-hard	14	115
Basalt, broken	15	130
Basalt, medium-hard	5	135
Basalt, broken	20	155
Basalt, medium	15	170
Basalt, brown, and clay	10	180
Basalt, medium	25	205
Basalt, black, medium, and clay	2	207
Basalt, medium	15	222
Basalt, medium to hard	3	225
Basalt, medium	1	226
Basalt, soft, water-bearing	2	228
Basalt, medium	26	254
Basalt, with crevices	3	257
Basalt, very hard	18	275
Basalt, broken, and clay	21	296
Basalt, medium, hole caving	4	300
Basalt, hard	22	322
Basalt, black, medium	10	332
Basalt, hard	36	368
Basalt, broken, and clay	9	377
Basalt, broken	4	381
Basalt, medium	9	390
Basalt, hard	33	423
Basalt, caving	12	435
Basalt	20	455
Basalt, firm, water-bearing	25	480
Sand	32	512

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/31-30L1. Fred Kissler. Altitude 1,679 ft. Drilled by Frear Drilling Co. Cased to 35 ft.		
Surficial deposits	30	30
Basalt	10	40
Basalt, gray	25	65
Basalt	40	105
"Rock", red	7	112
"Rock", brown	34	146
Basalt, gray	10	156
Basalt, blue	36	192
Basalt, black	25	217
Basalt, gray, hard	12	229
Basalt, gray	11	240
Basalt, red and black	35	275
Basalt, gray	50	325
Basalt, black and gray	22	347
Basalt, gray, hard	14	361
Basalt, gray	73	434
Basalt, black and gray	17	451
Basalt, gray, hard	6	457
Shale	20	477
Basalt, black	5	482
21/31-32D1. Fred Kissler. Altitude 1,669 ft. Drilled by Ted Joy.		
Topsoil	6	6
Caliche	6	12
Clay	3	15
Caliche	11	26
Clay	4	30
Basalt, black	31	61
Basalt, black, broken, with clay seams	61	122
Basalt	8	130
Basalt, broken	5	135
Basalt, black, medium	10	145
Basalt, gray, hard	6	151
Basalt, broken	4	155
Basalt, hard	2	157
Basalt, broken	24	181
Basalt, hard	8	189
Basalt, broken, water-bearing	10	199
Basalt, hard	7	206
Basalt, broken, water-bearing at 215 ft	19	225
Basalt	5	230
Basalt, black	18	248
Basalt, black, hard	13	261
Basalt, broken	13	274

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/31-32D1 - Continued		
Basalt	3	277
Basalt, hard	38	315
Basalt, broken, water-bearing at 318 ft	28	343
Basalt, medium	4	347
Basalt, hard	5	352
Basalt, gray, hard, water-bearing (150 gpm)	36	388
Basalt, hard	3	391
Basalt, water-bearing	9	400
Basalt, black	10	410
Basalt, black, medium	12	422
Basalt, hard	3	425
Basalt	7	432
Basalt, gray, hard	10	442
Basalt, gray, broken	8	450
Basalt	6	456
Basalt, black, soft	8	464
Basalt, hard	4	468
Basalt, soft	9	477
Basalt, hard, with crevices	1	478
Basalt	5	483
Basalt, hard	8	491
Basalt, black, broken	58	549
Basalt, gray, hard	75	624
Basalt, gray	1	625
Basalt, gray, hard	83	708
21/31-36G1. Henry Schibel. Altitude 1,770 ft. Drilled by Jasper Jones Well Drilling Co.		
Surficial deposits	35	35
Basalt, broken	36	71
Basalt, hard	1	72
Basalt, black, hard	16	88
Basalt, gray, hard	19	107
Basalt, soft, broken	8	115
Basalt, broken	4	119
Basalt, gray, hard; water-bearing, 130-132 ft	13	132
Basalt, hard	21	153
Basalt, gray, hard	20	173
Basalt, broken	2	175
Basalt, hard	16	191
Mud and cinders	4	195
Basalt, broken	15	210
Basalt, medium	17	227
Basalt, medium, hard	4	231

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/31-36G1 - Continued		
Basalt, gray, hard	12	243
Basalt, broken	2	245
Basalt, gray, hard	5	250
Basalt, gray, very hard	7	257
Basalt, gray, hard	5	262
Basalt, gray, very hard	5	267
Basalt, gray, hard	19	286
Basalt, black, very hard	8	294
Basalt, black, medium-hard	2	296
Gravel, fine, water-bearing	2	298
Basalt, medium-hard, broken	6	304
Basalt, black, medium-hard	10	314
Basalt, hard	3	317
Basalt, black, medium-hard	19	336
Basalt, medium-black, water-bearing	4	340
Basalt, gray, hard	11	351
Basalt, gray, with crevices	1	352
Basalt, medium-hard, broken	3	355
Basalt, medium-hard	1	356
Basalt, very hard	5	361
Basalt, hard	18	379
Basalt, broken	8	387
Basalt, black	3	390
Basalt, with crevices	1	391
Basalt, black	15	406
Basalt, hard	7	413
Basalt, black	7	420
Basalt, gray, hard	5	425
Basalt, gray, with crevices	2	427
Crevice	1	428
Basalt, hard	8	436
Basalt, black	9	445
Crevice	1	446
Basalt, black	15	461
Basalt, hard	13	474
Basalt, black, water-bearing (red-colored)	16	490
Basalt, black, broken	15	505
Basalt	6	511
Basalt, black	3	514
Basalt, black, water-bearing	17	531
Basalt, black	10	541
Basalt, black, harder	5	546
Basalt, porous, caving	5	551

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/32-22P2. Jerry Schafer. Altitude 1,832 ft. Drilled by John W. Davisson. Cased to 70 ft.		
Topsoil	6	6
Hardpan	53	59
Basalt, brown, hard	24	83
Basalt, gray, hard	14	97
Basalt, brown, soft	34	131
Basalt, green, hard	31	162
Basalt, brown, soft	48	210
Basalt, red, soft	49	259
Basalt, gray, hard	9	268
Basalt, black, soft, water-bearing	11	279
Basalt, gray, hard	6	285
Sand, brown	13	298
Sand, red	56	354
Sand, brown	14	368
Basalt, soft	12	380
Sand	6	386
Basalt, green, hard	11	397
Basalt, soft	98	495
Basalt, hard	15	510
Basalt, soft, water-bearing	25	535
Basalt, hard	6	541
Basalt, soft, water-bearing	30	571
Basalt, hard	27	598
Basalt, soft, water-bearing	29	627
Basalt, hard	3	630
21/32-31C1. Alvin Fink. Altitude 1,811 ft. Drilled by John W. Davisson. Cased to 86 ft.		
Topsoil	14	14
Hardpan	64	78
Basalt, brown, soft	45	123
Clay	2	125
Basalt, brown, soft	54	179
Basalt, gray, hard	16	195
Basalt, brown, soft	17	212
Basalt, gray, hard	14	226
Basalt, gray, soft	51	277
Basalt, green, hard	22	299
Basalt, red, soft, water-bearing	28	327
Sand	15	342
Basalt, gray, hard	61	403
Basalt, black, soft	25	428
Basalt, gray, hard	36	464
Basalt, gray, soft	22	486

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/32-31C1 - Continued		
Basalt, gray, hard	10	496
Basalt, black and red, soft	64	560
Basalt, gray, hard	115	675
Basalt, gray, soft, water-bearing	13	688
Basalt, green, hard	33	721
Sand, black, water-bearing	4	725
Basalt, gray, hard	19	744
21/33-1F1. Ben Walter. Drilled by Morrison & Morrison. Cased to 8 ft.		
Topsoil	3	3
Basalt, black	32	35
Basalt, gray, water-bearing	87	122
Basalt, black	24	146
Basalt, gray	46	192
Basalt, black, water-bearing	43	235
21/33-2P1. John Scrupps. Drilled by Basin Drilling Co. Cased to 19 ft.		
Topsoil and sand	9	9
Gravel	10	19
Basalt, blue, hard, water-bearing at 90 ft	73	92
Basalt, broken	8	100
Basalt, blue, hard, water-bearing at 101 and 135 ft	49	149
Basalt, broken	21	170
Basalt, blue, hard	30	200
21/33-5L1. J. A. Reihs. Drilled by Basin Drilling Co.		
Topsoil	2	2
Boulders, large	12	14
Basalt, black	55	69
Basalt, blue	51	120
Basalt, gray	21	141
Basalt, broken	19	160
Basalt, blue	80	240
Basalt, broken, water-bearing	10	250

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/33-7A1. Wayne Braun. Drilled by Basin Drilling Co. Cased to 35 ft.		
Topsoil	9	9
Sand	7	16
Gravel	17	33
Basalt	77	110
Basalt, blue, hard	16	126
Shale, green	13	139
Basalt, black	8	147
Basalt, broken	10	157
Basalt, blue	43	200
Basalt, broken	22	222
Basalt, blue, hard	30	252
Basalt, broken	5	257
21/33-7D1. Sol Walter. Drilled by Morrison & Morrison. Cased to 76 ft.		
Topsoil	10	10
Gravel, water-bearing	10	20
Boulders and gravel	12	32
Gravel and broken basalt, water-bearing	7	39
Basalt, broken	5	44
Gravel	16	60
Gravel and broken basalt	18	78
Basalt, gray	77	155
Basalt, broken, decomposed, water-bearing	5	160
Basalt, black and gray	39	199
Basalt, gray	33	232
Basalt, black, and sand; water-bearing	2	234
21/33-7H1. Odessa Community Golf Club. Drilled by Jasper Jones Drilling Co. Cased to 85 ft.		
Topsoil	10	10
Boulders, basaltic	9	19
Gravel, basaltic	66	85
Basalt	29	114
Basalt, broken	7	121
Basalt, broken, and green clay	9	130
Basalt	20	150
Basalt, broken	23	173
Basalt	6	179
Basalt, reddish, broken	6	185
Basalt, black, broken	7	192
Basalt, broken, mixed with red clay	30	222

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
21/33-7H1 - Continued		
Basalt	10	232
Basalt, black, broken	3	235
Basalt	10	245
Basalt, gray	3	248
Basalt	20	268
Basalt, gray	22	290
21/33-13P1. King brothers. Drilled by Frank Zimmerman. Cased to 20 ft; 10-inch liner, 117-157 ft.		
Topsoil	2	2
Gravel, medium-grained	10	12
Gravel and clay	8	20
Basalt, gray	30	50
Basalt, blue, hard	65	115
Clay, blue	10	125
Basalt, broken, water-bearing	32	157
Basalt, gray	23	180
22/30-10J1. Chris Larsen. Altitude 1,280 ft. Drilled by Frear Drilling Co. Cased to 3 ft.		
Topsoil	2	2
Basalt, black	29	31
Basalt, broken, water-bearing	5	36
Basalt, black, water-bearing	79	115
Basalt, gray, hard	30	145
Basalt, broken, water-bearing	11	156
Basalt, gray, hard	1	157
22/31-24G1. L. M. Wraspir. Drilled by Frear Drilling Co. Cased to 10 ft.		
Surficial deposits	4	4
Basalt, gray	172	176
Basalt, brown and black, water-bearing	54	230
Basalt, gray	47	277
Basalt, black, with shale streaks; water-bearing	73	350
Basalt, gray	14	364
Basalt, red and black, water-bearing	42	406
Basalt, gray	38	444
Basalt, black, water-bearing	49	493
Basalt, gray	45	538

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
22/31-24G1 - Continued		
Basalt, red and black, water-bearing	16	554
Basalt, gray	69	623
Basalt, black	16	639
Basalt, gray	61	700
22/33-4L1. L. J. Bonney. Drilled by Joy Drilling Co. Cased to 20 ft.		
Sand and clay	18	18
Basalt, black	9	27
Basalt, blue	68	95
Basalt, broken, water-bearing	5	100
Basalt, black	39	139
Basalt, blue	56	195
Shale	11	206
Basalt, blue	35	241
Basalt, broken, water-bearing	5	246
22/33-19C1. Harvey Haase. Drilled by John W. Davisson. 8-inch casing to 24 ft; 6-inch casing to 129 ft.		
Clay and weathered basalt	12	12
Basalt, gray, hard	40	52
Basalt, gray, soft, water-bearing	13	65
Basalt, gray, hard	87	152
Basalt, green, soft, water-bearing	13	165
Basalt, gray, soft, water-bearing	50	215
Basalt, gray, hard	60	275
Basalt, green, soft, water-bearing	43	318
Basalt, red, soft	12	330
Basalt, black, hard	5	335
Basalt, brown, soft, water-bearing	30	365
Basalt, gray, hard	2	367
22/33-23P1. Ben Smith. Drilled by Basin Drilling Co; deepened by R. L. Sewall and others. Cased to 50 ft.		
Topsoil	10	10
Sand and gravel	38	48
Basalt, water-bearing	102	150
Basalt, black	15	165
Basalt, water-bearing at 170 ft	5	170
Basalt, medium-hard	10	180

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
22/33-23P1 - Continued		
Basalt, water-bearing at 190 and 197 ft	20	200
Basalt, blue	40	240
Basalt, black	25	265
Basalt, blue	65	330
Basalt, broken, water-bearing	10	340
Basalt, blue	5	345
Basalt, gray	17	362
Basalt, broken	14	376
Basalt, black	18	394
Basalt, broken	36	430
Basalt, black	12	442
Basalt, gray	137	579
Basalt, broken	1	580
Basalt, gray	5	585
Basalt, broken	1	586
Basalt, gray	28	614
22/33-27E1. Wilbert Shott.		
Topsoil	2	2
Hardpan	2	4
Basalt, broken, water-bearing at 17 ft	13	17
Basalt, black	16	33
Basalt, gray	67	100
Basalt, broken, water-bearing at 100 ft	29	129
Basalt	6	135
Basalt, brown, broken	5	140
Basalt, black	39	179
Basalt, gray	46	225
Clay, blue	6	231
Basalt, soft, broken	4	235
Basalt, gray	5	240
Basalt, hard	1	241
Basalt, soft, broken	6	247
Basalt, hard	10	257
Basalt, broken	5	262
Basalt, hard	7	269
Basalt, black, hard and soft layers; well started to flow at 300 ft	31	300

Table 4 - Drillers' logs of representative wells

Materials	Thickness (feet)	Depth (feet)
22/33-34D1. Martin Kramer. Drilled by J. D. Lee.		
"Rock"	95	95
"Lime", gray	6	101
"Rock", brown	34	135
"Lime", broken	14	149
"Rock", brown, broken	47	196
"Lime", broken	90	286
Sand, water-bearing	4	290
"Sand rock"	12	302
Basalt, black	15	317
Sand, water-bearing	26	343
Basalt, black	24	367