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GEOLOGY AND GROUND-WATER RESOURCES OF THE MATANUSKA VALLEY AGRICULTURAL AREA, ALASKA

By Frank W. Trainer

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ABSTRACT

This report describes the geology and ground-water resources of an area of present and potential agricultural development in southcentral Alaska. The agricultural area, which covers about 350 square miles, is in a wide valley flanked by rugged mountains. The valley floor is underlain nearly everywhere by glacial drift whose total thickness is known at relatively few places. Bedrock in the valley floor is exposed or known to be near the surface in only a small part of the entire area. Nonglacial unconsolidated deposits include windblown material distributed generally over the agricultural area and slope deposits along the valley walls.

The youngest drift, which forms the valley floor throughout the area, is thought to be of late Wisconsin (Mankato) age. Exposures and well logs record at least one older drift sheet in several localities, and two older

drifts are known to be present at one place in the agricultural area. These older deposits have no topographic expression in the valley floor.

The drift includes till, outwash sand and gravel, and estuarine and lake(?) deposits. ~~Landforms composed of~~ physiographic features formed by these deposits in or adjacent to the agricultural area include an end moraine, lateral moraines, and ground moraine; eskers, crevasse fillings, and other pitted features, river terraces, and outwash flood plains; and an extensive estuarine flat. Stagnation of the ice was an important phase of the deglaciation ~~in~~ of this area. The topographic form of the valley floor is due chiefly to ~~glacial~~ deposition by glacial ice and melt water, ~~outwash-stream deposition~~, ice-block pitting, and terracing by meltwater streams.

The till, known locally as "hardpan", is characteristically silty or clayey, tough, and relatively impermeable. The youngest till, which is the best known, forms ground moraine in part of the area and a buried deposit in much of the remainder of it. Available data are not sufficient to show whether the buried till is a single sheet, but it appears to be ~~more or less~~ nearly if not entirely continuous in the relatively small parts of the area where wells are closely spaced. This till commonly ranges in thickness from about 10 feet to about 60 or 70 feet ~~thick~~; several wells penetrate till 100 feet or more thick (one section appears to exceed 400 feet), but it is thought that the thicker sections include two or more till units. The chief hydrologic significance of the till is that it forms a confining layer for artesian aquifers. The till is generally not water bearing except where it contains layers of sand or gravel, and these are commonly thin and yield only small quantities of water.

The outwash deposits are chiefly sand and sandy gravel. Boulder gravel is present in some places, especially in former drainage courses that were probably near the melting ice. Where well sorted these materials are relatively permeable and transmit water readily. Outwash deposits of silty sand and poorly sorted silty gravel are much less permeable. Individual sandy and gravelly beds in the outwash deposits are commonly thin and interlayered. However, a number of wells have penetrated thick deposits of sand; much of this sand becomes unstable under the differences in hydrostatic head commonly produced during drilling or pumping, and flows into the wells as "quicksand."

Sheetlike outwash deposits just beneath the land surface in much of the area range in thickness from a few feet to more than 100 feet. Ground water in these deposits is unconfined. In some places perched or semiperched ground water is present above till, bedrock, or what may be layers of stream-laid silt.

Other outwash deposits are buried beneath till. They are known to be as much as 50 to 60 feet thick, and probably are considerably thicker in some places. They commonly contain confined or artesian ground water. Well logs and hydrologic data suggest that buried outwash deposits form a continuous or fairly continuous layer in an area of more than 10 square miles near the community of Palmer. Buried deposits are also known to be present in several other parts of the agricultural area.

This area was overridden by two large valley glaciers that joined here to form a piedmont ice lobe. The repeated advance and recession of the ice, the effects of meltwater streams, and possibly the formation of temporary lakes, contributed to the complex stratigraphy of the drift which makes prediction of the presence and character of aquifers difficult.

Ground water occurs in the mantle of wind-blown material (loess and sand) only under special conditions, but the mantle is important hydrologically because it absorbs precipitation readily, providing soil moisture, leading to ground-water recharge, and preventing surface runoff.

The bedrock, chiefly sandstone, shale, and greenstone of Cretaceous and Tertiary age, is not an important water-bearing material.

Most wells in the agricultural area tap sand and gravel of the outwash deposits, and household and farm wells finished in suitable material generally provide dependable supplies. Only a few larger-capacity wells have been constructed. Two wells belonging to the City of Palmer have produced an average of about 100,000 gallons per day since late 1953, and water-level records suggest that equilibrium of recharge to and discharge from the aquifer has been attained near these wells for this rate of withdrawal. Data provided by test pumping ~~of~~ two wells in other parts of the agricultural area suggest that properly constructed wells, penetrating a sufficient thickness of favorable ~~aquifer~~ water-bearing material, may produce as much as 100 to 200 gallons per minute or more. However, no information is available regarding the effect of irregularities of the drift stratigraphy near those wells on the maintenance of sustained yields over long periods. Except for the relatively heavy pumping of the two municipal wells, ground-water withdrawal in the agricultural area has been on such a small scale and so widely dispersed that it probably has had a negligible effect on ground-water levels except near the wells.

The chief problems in the development of ground-water supplies in this area that cannot be solved by improved well construction are thought to be due to the apparent absence of suitable water-bearing material in ~~a few~~ places, ~~such as~~ where ~~the material is unstable and forms quicksand or where there is~~ sand becomes "quick" during the drilling or where little or no permeable material ~~in extensive deposits.~~ is penetrated.

Replenishment of the ground water is chiefly from precipitation. Probably only a small proportion of the annual precipitation (which ~~is, on the~~ average, about 15 inches) reaches the ground-water body, however, and very dry seasons are accompanied or followed by a marked decline of water levels in ~~the~~ some ~~deep~~ wells. In a few places water-table aquifers are recharged by water from streams. Natural discharge is by seeps and springs into streams and lakes, by evaporation, and by transpiration by plants.

Ground water in the agricultural area, characteristically a moderately hard calcium-magnesium bicarbonate water, is ~~in general~~ suitable for domestic use ~~chemically for human consumption~~. A few wells have obtained salty water or water that has objectionable hardness, iron content or other characteristics. The salt water is thought to have been trapped in the bedrock since a time when marine or estuarine water lay over this part of the region.

The area is divided into six physiographic units to facilitate description of the occurrence of ground water.

~~Tabulated~~ data in the report include records of 391 wells, whose locations are shown on the geologic map, the logs of 41 of the wells, and ~~data from~~ chemical analyses of 27 ground-water samples.

INTRODUCTION

Location and Extent of Area

The Matanuska Valley is a part of the lowland lying north of the Chugach Mountains ~~Range~~ in south-central Alaska (fig. ~~1~~ 2 and pl. 1). The valley of the Matanuska River and the lowland extending westward from it to the Susitna River are in the Matanuska and Wasilla districts as defined by P. S. Smith (1939, pl. 3).✓ The area described in ~~by~~ the

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✓ See list of references at end of report.

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present report (fig. 2), hereafter termed the Matanuska Valley agricultural area, is best known as ~~including~~ the site of agricultural colonization undertaken by the Federal Government in 1935. ~~It lies between the Talkeetna Mountains on the north and the Chugach Mountains Range on the south (fig. 2). It is bounded on the north by~~ It lies between the Talkeetna Mountains and the Little Susitna River on the north and ~~and on the south by~~ the Knik River and Knik Arm on the south, and extends from ~~It lies between~~ Eska Creek on the northeast to ~~and~~ Goose Bay on the southwest. As thus defined, the area lies approximately between 148°55' and 149°50' west longitude and between 61°25' and 61°45' north latitude; it covers about 350 square miles.

Figure 1 - Index map showing the location of the Matanuska Valley agricultural area.

(in pocket)

Purpose and Scope of Investigation

The field study on which this report is based was made by the writer during the period 1949-55, as part of the investigation of the ground-water resources of Alaska begun by the U. S. Geological Survey in 1947. The purpose of the investigation in this area was to map the water-bearing materials and to determine the occurrence, availability, and quality of ground water in the area. The need for the compilation and interpretation of geologic and hydrologic data became important with colonization in 1935, and this need has increased during the postwar period of continuing development. Most of the inhabitants depend upon wells for their water supply, and those taking up new land in undeveloped areas have lacked information on the availability of ground water. More extensive utilization of ground water, possibly including irrigation, undoubtedly will come in the future.

Geologic features were mapped on aerial photographs and the data later transferred to a base map. The base used was taken from parts of the Sutton, Matanuska, Eklutna, Houston, and Knik sheets, Army Map Service, U. S. Army. Some mapping was also done on the more recent Anchorage B-8, C-6, C-7, and C-8 quadrangles, U. S. Geological Survey. An inventory of wells was made, and a series of periodic observations of water levels in selected wells was continued throughout the field study. Seven test wells were drilled by the Geological Survey, using the jet-percussion and cable-tool methods.

Four quantitative tests of aquifer characteristics were made by pumping wells under controlled conditions. Cuttings from wells and samples of unconsolidated sediment from outcrops were examined to determine their texture and composition. The permeability of several small undisturbed samples was determined in the field with a variable-head permeameter (Wenzel, 1942, p. 64). Samples of water were collected from representative wells for chemical analysis.

Data from ~~representing~~ 391 wells are listed ~~tabulated~~ in table 5; the locations of the wells are shown on plate 1. In addition, drillers' logs of 41 wells are listed in table 4, and ~~data obtained by~~ chemical analyses of 27 water samples are listed in table 3.

The ~~This ground-water~~ investigation was made under the supervision of D. J. Cederstrom, district geologist ~~of the Ground Water Branch~~ for Alaska. M. J. Slaughter, and R. M. Waller and G. W. Whetstone of the assisted in certain phases of ~~Water Resources Division did much to facilitate~~ the field work. Leonard Reynolds, George Ramsey, and Glenn Ramsey drilled the test wells constructed as part of the investigation. E. C. Casey, D. A. Morris, D. C. Phillips, Clifford Shaw, M. J. Slaughter, R. M. Waller, and G. W. Whetstone made many water-level measurements and Mr. Waller determined the altitudes of several wells by instrumental levelling.

Previous Investigations

The geology of the Matanuska Valley agricultural area or of parts of it has been described in several reports. Capps (1940) discussed the geology of ~~this~~ the general region. Martin and Katz (1912) described that part of the area near Moose and Eska Creeks, and Landes (1927) the district between the Knik and Matanuska Rivers. T. N. V. Karlstrom (~~1950~~) included the area discussed in the present report in ~~a~~ an unpublished map showing the landforms of the larger area bordering the head of Cook Inlet. Rockie (1946) described the physical geography of the agricultural area in a report on soils and land conditions. The writer (1953) has given a preliminary description of ~~the~~ the geology and ground-water resources. Other papers, including those by Black (1951), Karlstrom (1953, 1955), ~~(1955),~~ Kellogg and Nygard (1951), Martin (1942), Péwé and others (1953, p. 12-13), Rockie (1942), Stump and others (1955, 1956), Stump and Roy (1956), ~~et al (1955),~~ and Tuck (1938), have been devoted to special problems relating to the geology of the area.

Acknowledgments

For many courtesies the writer is indebted to Mr. C. W. Wilson and his staff, of the Soil Conservation Service, ~~at~~ Palmer, Alaska; to D. L. Irwin, A. H. Mick, and staff, Alaska Agricultural Experiment Station, Palmer; and to officials of the City of Palmer. The Alaska

Road Commission permitted access to highway right of way for test drilling. R. T. Mathews, Alaska Public Works, Anchorage, made available facilities of the Palmer water system, then under construction, for pumping tests. James Hurley gave the writer copies of well logs from the files of the Alaska Rural Rehabilitation Corporation. The Matanuska Valley Fair Association permitted the use of storage space.

Special thanks are due the late Kirk Bryan and H. C. Stetson, and M. P. Billings ~~and~~ K. F. Mather, and J. P. Miller, of Harvard University, and C. E. Stearns of Tufts University, for their discussion of many suggestions regarding the writer's work.

Without exception, residents of the area permitted access to wells on their property or provided information regarding them. Samuel Cotten, James and Albert Frey, Henry LaRose, A. R. Moffitt, and Thomas Moffitt, who have drilled many wells in the agricultural area, described their experience and gave the writer much valuable information. The cooperation of Glen Woods, Henry Liebing, and Loren McKechnie facilitated the construction and testing of test wells. The owners of the observation wells listed ~~in the well records~~ permitted use of their wells ~~for this purpose~~, and J. C. Baldwin, Ted Buzby, Henry LaRose, F. B. Linn, Loren McKechnie, G. E. Murphy, Oscar Tryck, Noel Woods, and personnel of the Alaska Agricultural Experiment Station made many periodic water-level measurements.

GEOGRAPHY

Climate

The climate of the eastern part of the Cook Inlet lowland, which includes the Matanuska Valley agricultural area, is the result of a combination of marine and continental influences. Near the ocean but separated from it by the Chugach Mountains, the lowland lacks both the high precipitation of areas bordering the Gulf of Alaska and the temperature extremes of the interior of the Territory. Dale (1956) has described the climate of the Matanuska Valley.

Climatological data have been collected at several localities in the agricultural area in recent years. The longest record is that for the Alaska Agricultural Experiment Station near Matanuska. Selected data for this locality are presented in table 1. For some years of record the total precipitation in the Matanuska Valley has been as much as one-third greater or less than the mean. The mean total seasonal snowfall is nearly 4 feet, but the annual departure from the mean may be as great as half this amount. In most years the winter and spring are relatively dry, and about two-thirds of the annual precipitation occurs during the 5-month period June-October.

Wide departures from the mean temperature are well illustrated by variations in the length of the growing season. The last spring frost commonly occurs in late May, and the earliest autumn frost in late August or September. During a total of 35 years for which records are available the length of the growing season averaged 106 days but ranged from 59 to 140 days.

Table 1. - Climatological data for Alaska Agricultural Experiment Station, near Matanuska, Alaska, for period 1921-52 [1]

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Precipitation in inches:													
Mean	0.99	0.68	0.52	0.42	0.66	1.34	1.97	2.92	2.70	1.80	0.97	0.99	15.96
Maximum	2.89	3.16	1.42	1.64	2.31	4.62	3.75	6.37	7.55	4.61	3.71	3.81	
Minimum	.26	.10	.00	.00	T [2]	.16	.55	.45	.51	.39	.04	.04	
Temperature in degrees Fahrenheit:													
Mean monthly	13.1	18.1	25.0	36.5	46.9	55.2	57.6	55.5	47.8	36.6	23.4	14.3	35.8
Maximum monthly	21.4	27.3	33.6	45.5	57.8	66.4	67.7	64.9	56.7	44.0	30.0	21.5	
Minimum monthly	3.7	9.3	15.1	26.9	35.7	43.7	47.4	45.9	38.5	28.5	15.0	5.5	

1/ Data from U. S. Weather Bureau.

2/ Trace, less than 0.1 inch.

Midsummer temperatures in the agricultural area commonly range from 45° to 70° F; temperatures as high as 80° F are unusual. The winters are moderately cold, but periods during which the temperature reaches -20° to -30°F are usually short. The autumn "freeze-up" comes in October or November, and seasonal frost commonly reaches depths of 6 feet or more. The ground begins to thaw in April or May, but seasonal frost may persist beneath the surface in protected spots as late as July.

Appreciable microclimatic variation occurs within the agricultural area, perhaps because of differences in topography or because of other influences. The geographic distribution of light summer showers, and geographic variations in the occurrence of frosts in spring and autumn are particularly noticeable. For example, the average length of the growing season at Weather Bureau station Palmer 1N, at Palmer (about 6 miles northeast of the Experiment Station) was 26 days longer than that at the Experiment Station during the period 1942-55.

The seasonal distribution of rainfall (there being little rain early in the growing season), the wide departure from the mean precipitation during many seasons, and the late spring and early autumn frosts during many years are responsible for a measure of uncertainty in crop yields in the agricultural area.

The dominant wind of this region, known locally as the "Matanuska wind," is from the northeast. It is an autumn and winter wind and sometimes blows almost continuously for several days or longer. Weather Bureau records indicate that gusts reaching 50 miles per hour or more occur during the more severe storms. The "Knik wind," produced by the flow of oceanic air from the Gulf of Alaska moving down the Knik Valley, is relatively warm. During late winter and spring it brings mild weather and, in many years, removes much of the snow cover from the agricultural area before the ground begins to thaw.

Topography and Drainage

The Matanuska Valley agricultural area lies in a wide, flat-floored valley formed by the merging of the Matanuska and Knik valleys at the eastern end of Knik Arm (fig. 2). The valley is bounded by rugged mountains which rise abruptly above its floor. In the Chugach Mountains, at the southern edge of the valley, Pioneer Peak rises to an altitude greater than 6,300 feet; several other peaks surpass 4,000 feet, and altitudes of 3,000 feet are common. Along the northern edge of the valley, peaks in the Talkeetna Mountains reach altitudes of 3,000 to 5,000 feet.

Figure 2. - Physiographic units in the Matanuska Valley agricultural area.

(in pocket)

Although the altitude of the valley floor ranges from tide level at Knik Arm to 1,000 feet at the base of Wishbone Hill, the local relief is commonly not more than 100 to 200 feet. (See figure 2 for the locations of geographic features named.) Bodenburg Butte, which is almost 800 feet higher than the surrounding lowland, and other similar hills of rock provide greater relief. The bluffs along the Matanuska River north of Palmer rise 200 to 300 feet above the river flood plain.

Most of the valley floor is a gently rolling surface crossed by narrow, flat-floored stream courses. The hills and intervening valleys commonly trend southwestward; this characteristic is shown most conspicuously by two linear series of lakes near Wasilla, but it is repeated by many smaller features. Exceptions to this general orientation of topographic features include southward-trending, parallel hills and valleys in the northwestern part of the area; irregular hills and swales and winding ridges near Moose Creek and between Palmer and the Agricultural Experiment Station; and a series of benches and wide flats near the Matanuska and Knik Rivers and along the north side of Knik Arm.

Most of the area drains into the Matanuska and Knik Rivers, although the Little Susitna River drains part of the northern section of the area and several small streams flow directly into Knik Arm. Drainage is poor in many interstream tracts; there are large areas of swampy ground, and shallow lakes occupy many of the depressions.

The Knik River floods annually in July or August when

Lake George, impounded by Knik Glacier, drains as a result of its overflow and the resulting erosion of the ice along one edge of the glacier.

Vegetation

In its natural state most of the area discussed in this report was forested. White spruce, cottonwood, aspen, and birch are characteristic of the well drained soils. Willow grows on many types of deposits. Black spruce is common in some bogs. Alder grows both in moist spots on the lowland and, with willows, on the mountain slopes bordering the valley. The altitude of the tree line is commonly 1500 feet or less but is higher in many ravines. Trees in this area are shallow-rooted and easily blown down, and windfalls are common in forests composed of older trees. Fire, largely accompanying settlement and railroad construction, has burned over many parts of the valley floor. Extensive burned areas are now

A The Knik and Matanuska Rivers are braided glacial-outwash streams having wide, bare flood plains. Both streams have their highest flow during the summer. The Knik River floods annually in July or August when Lake George, impounded by Knik Glacier, overflows, erodes the ice along the valley wall, and drains.

covered by second-growth forest. Other burns, especially near tree line, have not become reforested but are covered by fireweed and grasses. Mosses, sedges, and grasses are common in poorly drained tracts throughout the agricultural area, and also form the ground cover in much of the forested land.

The flats along Knik Arm are, or recently have been, subject to tidal flooding; over most of their area they bear only small salt-tolerant plants. The wide flood plains of the Matanuska and Knik Rivers are practically bare of vegetation because at some time during every season or two the gravel bars either are submerged or are removed and rebuilt during the shifting of braided channels. The middle slopes of the mountains flanking the valley bear a cover of moss and low prostrate shrubs; near the summits there is no vegetative cover.

Culture

As a result of the finding of gold in the Talkeetna Mountains, the settlement at Knik was established in 1898 on the site of an Indian Village and Russian mission. In 1916 the Alaska Railroad was extended through the Matanuska Valley, and where it crossed the trail between Knik and the Talkeetna Mountains the community of

Wasilla was established. Matanuska grew at the junction of the main line and a spur line leading to the Matanuska Valley coal fields. After the establishment of the agricultural colony in 1935 the center of population of the valley shifted toward the community of Palmer.

The population of Palmer is about 1,000. Wasilla is much smaller, and only a few families remain in Matanuska and Knik. There are now more than 300 full-time and part-time farms operating in the Matanuska Valley (Mick and Johnson, 1954, p. 238). The rural population, which ~~is~~ probably exceeds ~~greater than~~ 2,000, is concentrated in the eastern part of the area. ~~distributed chiefly around Palmer and, to a lesser extent, around Wasilla and to the west and south.~~

The agricultural area is traversed by the main line of the Alaska Railroad, which passes through Matanuska and Wasilla northward to Fairbanks. A branch of the railroad extends from Matanuska through Palmer to Jonesville, on Eska Creek. The Glenn Highway begins at Anchorage, about 50 miles southwest of Palmer; it extends through Palmer and into the interior of Alaska by way of the upper Matanuska Valley. ~~Daily bus service links Wasilla, Palmer, and Anchorage.~~ All the settled sections of the valley lie on a road net maintained by the Alaska Road Commission. Air travel has long been popular in this area, as elsewhere in Alaska; several small local fields have been used, and a new airport was completed at Palmer in 1950.

Development of agriculture in the area has continued since establishment of the agricultural colony; dairy products, potatoes, and truck crops are the most important farm products. Stone (1950) has described the history of the agricultural colony.

GEOLOGY

Consolidated Rocks

The bedrock ~~exposed~~ adjacent to the agricultural area has been described in several reports, including those by Martin and Katz (1912), Landes (1927), Capps (1940), and Barnes (1953). The Talkeetna Mountains, to the north, are composed mainly of igneous rocks, chiefly granitic intrusive rocks (Mesozoic?) ~~and lesser amounts~~ with subordinate ~~of~~ lavas and tuffs; Cretaceous and Tertiary sedimentary rocks form the south flank of the mountains. Mesozoic rocks in the Chugach Mountains, to the south, include granitic intrusive rocks, metamorphosed sedimentary rocks (chiefly slate, argillite, and graywacke), and greenstone. Martin and Katz (1912, p. 72-75, pls. 15, 16) ~~describe~~ believe that part of the straight front of the Talkeetna Mountains ~~as representing a zone of faulting; they believe~~ has developed along a fault zone and that the course of the Little Susitna River is approximately along the fault zone downstream from the point where the stream emerges from the mountains. More recent work by the Geological Survey shows the presence of coal-bearing rocks of Tertiary age north of the Little Susitna River (Barnes, 1953, p. 4); these rocks, with other evidence, indicate that the mountain front rather than the stream course marks the western extension of the fault for at least 10 miles west of the mouth of the Little Susitna River canyon (Barnes, F. F., personal communication, 1956). Martin and Katz (1912, p. 74)

Contour configuration of the bedrock

Figure 3. - ~~Map showing~~ surface ~~of bedrock~~ near Palmer.

(in pocket)

suggest also that the relatively straight front of the Chugach Mountains, to the south, may be due to faulting, but they do not find enough evidence to form a definite conclusion.

Cretaceous sedimentary rocks, chiefly sandstone and shale, extend down the Matanuska Valley to Moose Creek. ~~they are sandstone and shale.~~ Conglomerate and sandstone exposed in small hills south of Palmer may be the southwestward extension of these rocks. Conglomerate, sandstone, shale, and coal of Tertiary age are exposed in the Eska Creek-Wishbone Hill-Moose Creek area. Coal has been mined there, and at Houston at the northwestern corner of the agricultural area. ~~Wishbone Hill, at the northeastern corner of the agricultural area, is a synclinal hill held up by the Tertiary Eska conglomerate.~~ Exposures along the Matanuska River and Moose and Wolverine Creeks show that in the northeastern part of the agricultural area the sedimentary rocks ~~commonly strike northeast~~ and are folded and faulted, and commonly strike northeast. The available data are ~~considered insufficient~~ too few to permit conclusions regarding the composition and structure of the sedimentary rocks beneath the wide valley floor ~~farther~~ west of Palmer or their depth of burial beneath the overlying unconsolidated deposits.

Figure 3 shows the configuration ~~topography of the surface~~ of the bedrock surface beneath ~~in~~ a relatively small area near Palmer. The west- and southwest-trending ridges at Palmer and at Bodenburg Butte and the deep valley between them are conspicuous features of the bedrock surface. Glacial erosion and perhaps preglacial stream erosion are responsible for these features, but it seems likely that their position and form have been controlled by other factors such as lithology, the strike of the beds, or the presence of fault zones. Any or all of these factors may have been important, but it is thought that faulting was probably the most significant. ~~As was noted in a preceding paragraph~~, Martin and Katz suggested that faulting has occurred along what is now the front of the Chugach Mountains; and recent mapping by R. G. Gastil (535 Eng. Det. (Terrain), Army Map Service, U. S. Army, personal communication, 1956) suggests the presence of fault zones.

Unconsolidated Deposits

Quaternary unconsolidated deposits, chiefly glacial drift, cover the bedrock in most of the agricultural area. The drift consists of (1) deposits laid down over the valley floor generally when the ice lay in or near this area; and (2) modern outwash-stream and estuarine deposits laid down far from the existing glaciers. The nonglacial deposits include wind-blown material, alluvial fans, talus, and frost-disturbed materials.

It has not been shown whether the existing Matanuska and Knik Glaciers are remnants of the more extensive glaciers which once extended across the agricultural area or whether those large glaciers melted completely and were later succeeded by the modern ones. Distinction ~~of~~ Pleistocene and Recent deposits in this area is therefore not attempted, and in this report all the unconsolidated deposits are designated simply Quaternary deposits.

The geologic map (pl. 1) shows the distribution of bedrock exposures, and of unconsolidated deposits exclusive of swamp deposits and the mantle of windblown material.

Glacial Drift

Glacial drift includes all materials deposited by glacial ice and its melt water: till, outwash-stream deposits, and deposits formed in standing water. Deposits of all these types are present in this area.

Till ("hardpan")

Till is a fragmental unconsolidated material deposited by or from glacial ice with little or no modification by running water. It is characteristically unsorted, consisting of rock fragments that range in size from clay to boulders. However, melt water is active in many places where till is deposited beneath and at the margins of the ice, and the deposit may therefore contain, be associated with, or grade into stream and pond sediments. Some glacial drift has been imperfectly washed and may be called arbitrarily either till or poorly sorted gravel. In addition, some till probably contains sorted sediment from older deposits eroded by the ice. Till is best considered one end member of a continuous series of materials; the other end member is well-sorted drift such as gravel or sand (Flint, 1947, p. 103).

The till in this area is commonly gray. It is composed chiefly of subangular to rounded rock fragments in a matrix of mixed sand, silt, and clay. The rock fragments range in size from granules to boulders and consist chiefly of the rocks characteristic of the adjacent mountains, and to a lesser extent of the sedimentary rocks exposed in the Matanuska Valley. Except where very sandy the till is massive, compact, and tough. It is difficult to excavate and is known locally as "hardpan".

The massive till locally includes (1) thin layers of well-sorted sand or sandy gravel (sample 7, fig. 4); (2) irregular streaks of poorly sorted bouldery, sandy, or silty material; and (3) a mantle of bouldery, sandy silt that covers the till on some hilltops and slopes. The layers of sand and gravel, commonly a few inches to a few feet thick, seem to be similar to lenses and stringers of sorted material found in till in the United States to the south (Meinzer, 1923, p. 285). They were probably deposited by small subglacial streams that flowed temporarily upon till beneath ice before being covered by additional till. The irregular streaks differ less markedly from the enclosing till than do the sandy layers; they are attributed to local variations in deposition. The mantle of poorly sorted material, commonly 1 to 2 feet thick, is thought to be superglacial drift, part of the ablation moraine that covered the glacier surface during melting of the ice. The sandy layers have been found in several outcrops and many wells in this area. The available evidence suggests that they are of limited and irregular extent, but there may be large numbers of them in the till. The irregular streaks and the mantle are probably widely distributed also, but there are relatively few exposures and these features have therefore been observed in only a few places.

The till of the Matanuska Valley agricultural area is relatively impermeable. It appears generally to be saturated, and is sensibly ~~It is~~ wet in some places, especially where ~~it is~~ sandy (See log of well 596a). As a rule, however, only the layers of sand or gravel yield water freely, and these, because of limited extent, in only small quantities.

Two points regarding the identification of till should be emphasized: (1) till is defined on the basis of mode of deposition but in areas of past glaciation this origin ~~can~~ must ~~only~~ be inferred from lithologic and other data; and (2) the only tests of the correctness of this inference are the consistency of the data used and the agreement of the inference with the known or inferred regional history. Because of its wide range in character and its similarity to several other sedimentary materials, till is difficult to identify in many exposures. But till encountered in drilling is even more difficult to identify, particularly because the buried materials are seldom seen in the undisturbed state. The distribution, thickness, and character of the buried till are inferred from information provided chiefly by well logs, and it is therefore pertinent to mention the evidence on which the interpretation is based.

Till similar to ~~such as~~ that exposed at the surface in some places was identified in several wells by means of chunks of undisturbed material recovered with the cuttings, or by correlation with beds exposed nearby on the basis of sequence of deposits and depth below the land surface. ~~This~~ The buried till is characterized by compact zones that stand open for several feet or more below the casing during cable-tool drilling, and that consist of a tough matrix of mixed clay, silt, and sand with embedded stones. In some places these zones alternate with softer material that caves (see logs of wells 445a and 445c, table 4). Mud formed from this till by drilling commonly contains sand and broken pebbles, and intervals shown in drillers' logs as "mud with gravel" or "mud with gravel and boulders" are thought generally to be till. These several characteristics — the way in which much of the material stands open ahead of the casing during drilling, the common presence of only thin relatively permeable zones in the material, and the character of the drill cuttings — serve to suggest that a subsurface formation is till even where undisturbed samples are not obtained.

Till is the chief or important component of the conspicuous end moraine which marks the farthest extent of the ice west of Goose Bay and Big Lake, just beyond the agricultural area. The lateral moraines which mark the upper edges of the ice along the valley walls of the mountain slopes flanking the valley, and the ground moraine which forms the landsurface in much of the western part of the agricultural area, also are composed of till. The ground moraine was deposited by the ice, and its surface probably has been little modified except by the deposition of a thin mantle of gravelly material upon it and by local melt-water erosion. Only a few wells have passed completely through the ground moraine. In four wells near Wasilla (596a, 597, 599, and 621a) the thickness of the deposit averages 70 feet. However, the ground moraine is 10 to 20 feet thick in the bluff at Goose Bay, to the southwest, and probably is considerably thinner than 70 feet over much of the western part of the agricultural area, where the glacier was wider than to the east.

surface in much of the western part of the agricultural area. ~~The surface of much of the ground moraine (pl. 1) is~~ one of glacial deposition, probably little modified except for the deposition of a thin mantle of gravelly material upon it ~~or~~ ~~for~~ and by local meltwater erosion. Only a few wells have passed completely through the ground moraine. In four wells near Wasilla (596a, 597, 599, and 621a) the thickness of the deposit averages 70 feet. However, the ground moraine is 10 to 20 feet thick in the bluff at Goose Bay, to the southwest, and probably is considerably thinner than 70 feet over much of the western part of the agricultural area, where the ~~ice~~ glacier was wider than to the east.

Over much of the agricultural area east of Wasilla, and west and north of the Matanuska River, till that is considered the eastward extension of the ground moraine is covered by outwash sand and gravel. Where wells have passed through the till ~~it~~ its thickness commonly ~~ranges~~ from about 10 feet to about 60 or 70 feet ~~thick~~. Several wells penetrate till 100 feet or more thick, and a few well logs record much thicker sections.

A large number of well logs and several exposures show older drift beneath the surface or near-surface till. Many of the data are summarized by plate 2 and figure 6, and detailed information is tabulated in the well records and well logs. An abandoned well near well 305 (see log, table 4) penetrated "blue mud" and "blue mud and shalerock" beneath outwash gravel that in turn lies beneath till; the blue mud is thought to be an older till that contains shale fragments near its base. Wells 442 (Kneff), 448 (Linn), and 496 (Valley Christian Childrens Home) are thought also to have encountered two tills. Two wells (445a and 445c) at the Agricultural Experiment Station passed through two layers of till and reached a third. It is inferred from the logs that these three tills are separate sedimentary units; this conclusion is confirmed for the upper two layers by ~~hydrologic data (see discussion of artesian conditions near the Experiment Station),~~ which show that ~~they~~ are continuous laterally near the wells.

Several thick sections of till penetrated by wells are thought to represent two or more till units. Well 4 (Lazy Mountain Childrens Home) penetrates till from the surface to a depth of at least 308 feet, with the exception of sand and gravel in the interval from 260 to 280 feet. ~~Hydrologic evidence (see discussion of ground water in till) shows that~~ this body of sand and gravel is of limited extent; it is considerably thicker than the layers of sorted material commonly found in till in the agricultural area, however, and the writer believes that it may be a remnant of an outwash deposit, eroded and later covered by till. If this interpretation is valid the aquifer separates two tills. Moreover, the 260-foot section of till above the sand and gravel is several times thicker than most known sections of till west of the river near here, and it seems likely that this thick upper till also represents more than one depositional unit.

What appears to be a 412-foot section of till, with a possible stratigraphic break at a depth of 307 feet, is recorded by the log of well 257 (Wallace). Wells 256 (Mayr), to the south, and 258 (Diedrick), to the north, penetrated till 140(?) and 168 feet thick, respectively. The disparity in thickness seems greater than would be expected in a single till deposit, even considering the differences in altitude of the wells and the irregularity that characterizes drift stratigraphy. The ~~differences in altitude of the~~ water levels in wells 256, 257 and 258—which have altitudes of 539, 450, and 645 feet, respectively—and the lack of consistent change from one well to the others show that the aquifers are not freely interconnected. All these facts, ~~together with~~ and the character of the aquifer materials (interlayered gravel, sand, and clay, apparently not similar to the sandy layers found in the till elsewhere in the agricultural area), suggest that ~~the~~ this thick till ~~in this tract re- presents~~ includes several separate ~~till~~ units.

Boulder pavements in till exposed in the bluff at Goose Bay may indicate unconformities in the section there, but the field evidence is not conclusive. Evidence for the age of the drift (see discussion of late Quaternary history) is consistent with the interpretation of the presence of more than one till sheet at Goose Bay, however.

Outwash-~~Sand and Gravel~~ stream Deposits

~~The~~ These outwash deposits, ~~that~~ which cover much of the Matanuska Valley agricultural area, include both drift laid down near the ice that once covered the area and deposits like those of the modern Matanuska and Knik Rivers, formed some distance from the ice. All these deposits are predominantly sand, pebbly sand, and sandy gravel, with lesser proportions of gravel, silty sand, and silt. According to usage common among local inhabitants and drillers, a gravel is any sandy sediment containing stones. This local usage is of necessity followed in most of the well records and logs in this report because detailed descriptions of the materials could not be obtained. A small part of the ~~drift~~ gravel is so poorly sorted that it resembles till. The other extreme of sorting, represented by porous gravel composed of pebbles and cobbles ~~without~~ and lacking sand, is also present locally. Figure 4 illustrates the particle-size composition of outwash sand; the absence of large proportions of silt and clay is well shown by these graphs.

Boulder gravel is commonest in the northeastern part of the agricultural area, in terraces near Palmer and in the rough ground near Moose and Eska Creeks. The occurrence of boulders there is attributed to short distance of transport from the ice. Boulder gravel has also been found in several other parts of the agricultural area, particularly in drainage courses that led from the melting ice.

Many wells have pentrated relatively clean sand or silty sand in layers that range from a few feet to perhaps as much as 223 feet in thickness (although the very thick sections are thought to include lake deposits as well as those of outwash streams). Some logs record no difficulty in well construction, but in many wells the sand became "quick" (loose saturated sand in which the grains are suspended in the water) during the drilling. In a few wells even pebbly sand heaved into the casing.

It is generally recognized that quicksand is formed from ordinary saturated sand by unbalanced hydrostatic pressure that keeps it suspended in the water. As soon as the balance of pressure is restored the suspended material settles and assumes its former firm condition. This is true of both surface deposits (as in a stream bed) and buried deposits. Silt and fine sand become "quick" more readily than coarser materials, presumably because a lesser head difference is required to suspend these finer materials. This mechanism is thought to explain the occurrence of most of the quicksand reported in the logs of wells drilled in the agricultural area. It has been suggested, however, that for some quicksand this temporarily unbalanced condition may be due to properties of the material itself (see, for example, Terzaghi and Peck, 1948, p. 100). This instability of the material may be due to the presence of clay or fine silt, the particles of which are bonded by oriented water molecules (Grim, 1951, p. 11); movement is thought to be produced by the application of stress or by a slight increase in the amount of water, which changes the orientation of the water molecules and breaks the bonds. The quicksand recorded above the water table in wells 160 (Bauer) and 182 (Rebarchek) may have been ~~a result of~~ disturbed by the drilling, ~~after the material near the well~~ as sand that had been saturated by the drilling water. Perhaps the presence of silt and a small amount of clay facilitates the formation of quicksand in other places where the material is disturbed below the water table.

Exposures show that bedding is well or moderately well developed in the sand and gravel. Extensive exposures generally show, however, that individual beds in a section pinch and thin out laterally. Crossbedding and channel-and-fill structures are common. Layers of silt are included in the sand and gravel in many places. Other materials, such as till, peat, and fine-grained sediments deposited in ponds, are present locally.

The surficial outwash-stream deposits of the area have been mapped (pl. 1) as a number of distinct units. However, as is pointed out in the ~~legend~~ explanation of the map, some are gradational ~~with~~ into one another. All these deposits were laid down by glacial meltwater, many of them on or against the ice; melting of the ice during and after deposition led to slumping and pitting of the adjacent deposits. This drift is therefore designated on the map as outwash-stream deposits, ~~with additional distinction as~~ areas of pitted deposits, eskers, and crevasse fillings are differentiated. The modern deposits of the Knik and Matanuska Rivers are shown as separate units; they differ from most of the older deposits in ~~having been~~ laid down farther from the ice, and seem to be on the average somewhat finer grained.

being, on the average, somewhat finer grained, probably because they were laid down farther from the ice.

The landforms and history of the outwash deposits are discussed in other reports (Trainer 1953) and another report in preparation). Pitting of the deposits, as a result of the melting of buried ice, and terracing by meltwater streams are considered among the most important processes in the development of the landscape in the agricultural area. The areal distribution of pits can be estimated from plate 1. Only a few of the more prominent terraces are shown on that map but nearly all of the area mapped as outwash deposits has been terraced.

Many stream terraces near Palmer are underlain by till that has a gravel cover commonly less than 20 to 30 feet thick (see, for example, records of wells 1, 2, 340, 343, 364, 370, 371, 372, 375, table 5). In addition, well records (623, 630?), a few outcrops of till (pl. 1), and poor surface drainage on terraces along the north side of Knik Arm in the western part of the agricultural area suggest that gravel lying on the till there is also thin. Probably the cover of gravel on each of these terraces is merely the load that was in transit along the flood plain. Where the surface of one of these terraces is poorly drained one may infer with some assurance that till lies beneath it at shallow depth; where the surface is well drained the thickness of the gravel cover must be determined from other evidence.

Near the Matanuska River north of Palmer the terrace on which Palmer stands is underlain by till that has a gravel cover locally not more than ~~five~~ 5 to ~~ten~~ 10 feet thick. At least half the well logs available for the wide terrace south of Palmer record a layer of coarser material ("boulders", "boulders and gravel", "coarse gravel"), commonly 30 to 50 feet thick, that lies just beneath the surface (see, for example, records or logs of wells 142, 143, 154, 160, 162, 165, 176, 182, 187, 189, and 195). Beneath this coarse material is finer alluvium ("sand" or "gravel and sand") or locally what may be till. Stump and others (1956, p. 70) note that the broad surface south of Palmer, and ~~together with~~ other surfaces at Bodenburg Butte and farther east, are remnants of a fan built southward by the Matanuska River. The near-surface layer of coarse gravel ~~is the material~~ composing the fan.

The preceding paragraphs describe outwash-stream deposits at or just beneath the land surface. In a large part of the agricultural area older glacial drift, buried by the surface or near-surface till, includes similar sand and gravel. Tables 4 and 5 record the available data regarding the distribution and character of these older deposits, and part of this information is summarized in plate 2. In general both the surficial and the older, buried outwash-stream deposits are relatively permeable. The surficial deposits are commonly well drained except in places where they are underlain by till at shallow depths. ~~Because of their significance as aquifers all these outwash-stream deposits are considered in detail in the discussion of ground water, in another section of this report.~~

Deposits Formed in Standing Water

Estuarine Deposits.- Glacial clay, silt, and sand are carried into Knik Arm by the Matanuska and Knik Rivers. Most of this new sediment is reworked by tidal currents, and probably much of it is carried into Cook Inlet. Extensive bars that appear to be fairly stable may be seen in the estuary at low tide, ~~however~~, and it is possible that they are being built at present. Wide bench-like features or flats underlain by tough, impermeable clay and silt border the head of Knik Arm near Matanuska (pl. 1) on the north side of the estuary and near Eklutna, outside the agricultural area, on the south side. These flats, which stand 20 to 30 feet above mean sea level, are partly flooded by very high tides; they are thought to owe their smooth upper surfaces to continuing slow tidal deposition upon older bars. Where silt and clay are at the land surface, as south and southwest of Matanuska, the ground is marshy. Stream-laid sand is at the surface in the intervening better-drained areas, but the estuarine clay and silt probably extend beneath this sand. A 200-foot hole drilled at Matanuska by the Alaska Railroad is reported (Bruce Cannon, Alaska Railroad, personal communication, 1955) to have ppenetrated clay and silt throughout its entire depth, except for sand near the surface.

On the assumption that the flats west of Matanuska and near Eklutna are modified bars similar to those that now stand slightly above low-tide level in the estuary, the writer believes they were formed chiefly at a time when the sea was several feet higher, relative to the land surface, than it is at present. They may have been built higher by the deposits of very high tides at any time since they were formed.

Lake(?) Deposits.- Sandy or silty ~~finer-grained~~ sediments in the subsurface in two parts of the agricultural area are thought to have been deposited in lakes. These deposits, which are known only from logs, ~~subsurface data,~~ underlie an area ~~are~~ near the Agricultural Experiment Station and an area south of Palmer.

The subsurface deposits near the Experiment Station are ~~is~~ described as "mud" in the older well logs. Comparison of these logs with data obtained from drilling observed by the writer (wells 445a and 445c) suggests that the deposits consist predominantly of fine silty sand with clay and some coarser material; they are ~~it is~~ generally saturated, and at many places form "quicksand" during drilling. The material ~~deposit~~ is more than 100 feet thick in some places. It is widely distributed in the subsurface in the area near the Experiment Station (typical logs are listed in remarks that accompany the log of well 437). The thickness of the deposits, the predominance of fine-grained materials, the presence of silt-clay laminae in the sand, and the scarcity of gravel beds suggest deposition in a lake or estuary ~~standing water~~. The materials are not predominantly sand and ~~clayey,~~ silt rather than clay. ~~so it is thought that deposition was not in an estuary~~. An appreciable part of any ~~the~~ clay carried into a ~~the~~ body of water probably would have been flocculated and deposited if the water had been saline or brackish. The relatively small proportion of clay present suggests that the sediment was deposited in fresh water; the body of water is thought to have been a lake but it may conceivably have been an estuary freshened at its upper end by the inflow of fresh water.

It seems likely that lakes would have formed here during glacial episodes, and that the relations between ice movement and the formation and destruction of the lakes would have been complex. This part of the valley floor must have been overridden repeatedly by the Knik Glacier and perhaps by the Matanuska Glacier. Many complex effects may result from combinations of glacial erosion and deposition, melt-water erosion and deposition, lake deposition, and the deformation of deposits by moving ice. It is to be expected, therefore, that the stratigraphy of the drift in this part of the valley is more complex than that in other parts. The sandy and silty deposits recorded by the logs represent several different depositional units.

Fine sand that becomes quick when disturbed has been encountered by many wells in the terrace south of Palmer. Detailed information is provided by the log of well 195, which records what appears to be a single deposit of sand from 77 to 240(?) feet below the surface. Alternating layers of stable sand and of sand that heaved into the casing were penetrated during drilling. It is thought that much of the stable sand remained stable only because of the long column of water kept in the casing during the drilling. Some of the sand, however (such as that at 110 feet), was found to be stable under pumping. Several wells near 195 (154, Mohan; 160, Bauer; 176, Crowther; table 4; 213, Dodds, table 5; and others) also encountered quicksand. Although details are not given by the logs, this sand probably is predominantly fine grained. Well 210

(Webb) is reported to have penetrated 89 feet of coarse sand before being completed. It seems likely that this sand was in part quicksand, otherwise the well presumably would have been completed at a shallower depth. It is interesting to note that the thick sand in the subsurface south of Palmer lies in or over the buried bedrock valley (fig. 3). The deposits that include this sand appear to be older than and unrelated to the near-surface gravel in the terrace. Because they are thick and are predominantly sand and silty sand, unlike the alternating thin beds of sand and gravel characteristic of the outwash-stream sediments in the agricultural area, the writer concludes that these deposits were probably laid down in a pond or lake. It is possible that they are deltaic (sandy) deposits formed in an estuary, although the common absence of clay layers seems to argue against this interpretation. Part of the lake(?) deposits in the subsurface near the Experiment Station may be the southwestward extension of this sand, but there is insufficient evidence to demonstrate such a relation. The deposits that underlie the area near the Experiment Station are of several different ages; those in the subsurface near Palmer appear to represent one depositional unit which may be older than the till shown by a few well logs in the terrace south of Palmer.

These deposits are the parent material of the soil in most of the agricultural area.

There has been little Water erosion of the loess mantle ~~is unimportant~~. The high permeability of the material, the presence of the vegetative cover, and the low rainfall intensity make surface runoff negligible. Wind erosion, except on bare alluvial flats, was insignificant prior to the introduction of agriculture in this area. At present wind erosion is a serious problem in some cleared agricultural land, particularly in the path of winter storms moving down the Matanuska Valley.

<u>Other deposits</u>

Several other types of deposits--alluvial fans, talus, and accumulations of frost-disturbed material--are present along the mountain walls of the valley. They are of relatively small areal extent but they are permeable and permit ready infiltration of water from rain and snow. ~~have some importance in regulating the movement of water down the mountain slopes.~~ Peat is being deposited in lakes and marshy tracts throughout the agricultural area. Deposits of calcareous marl occur in and beside some of the lakes (moxham and Eckhart, 1956). Deposits of reworked gravel, sand, and silt are present along the channels of nonglacial streams on the valley floor. Beaver dams, and lake ramparts--ridges of sand and gravel built by ice-push, may be seen at many of the lakes in the agricultural area.

Perennially Frozen Ground (Permafrost)

Perennially frozen ground has been found in several places in the agricultural area. Three of these localities, all in bogs, are shown on plate 1 as follows: 2½ miles southeast of Wasilla, 2-3/4 miles east-southeast of Wasilla, and 2¼ miles west of the Experiment Station. Dachnowski-Stokes (1941) describes another locality, in a bog three-quarters of a mile south of Palmer. N o doubt perennially frozen ground is present in many other poorly drained tracts in this area. So far as the writer is aware, however, it has never been found here in well drained ground. The presence of these restricted bodies of perennially frozen ground in this region, where they could not form now because the mean annual air temperature is several degrees above freezing, is considered due to their preservation, since a colder episode, in places where they are well insulated or otherwise protected from thawing. Similar bodies of perennially frozen ground have been found in the Anchorage area, (R. M. Waller, U. S. Geological Survey, personal communication, 1957), south of Knik Arm, and in the Kenai Lowland (Karlstrom, 1955a, p. 133-134), south of Cook Inlet.

The writer found no evidence suggesting that perennially frozen ground has been widespread in this area, or that in bogs such as those cited it has extended very far beyond the present borders of the bogs.

Late Quaternary History

The Cook Inlet Basin, of which this area is a part, has been an area of subsidence and deposition during Quaternary and perhaps part of Tertiary time, while the adjacent higher regions have been uplifted and eroded (Payne, 1955). The chief mountains and valleys of the region surrounding the Matanuska Valley agricultural area were probably formed under the control of lithology and regional structure, and must have been the dominant features of the preglacial topography. However, glaciation produced important changes in topographic details, so that the present topography is considerably different from that of preglacial time. The walls of the main valley and of its tributaries have been steepened, and the valleys widened, by glacial erosion. Deposition by ice and by streams and in standing water has partly filled the valleys and given them relativelysmooth floors.

Two tills are present at Goose Bay, one in the bluff and one under the beach below high-tide level; they are separated by gravel (one or more units) that contains a peat bed ~~two~~ 2 to ~~four~~ 4 feet thick.

Deposition by ice and by streams and in standing water has partly filled the valleys and given them relatively smooth floors.

Lateral moraines on the mountain walls of the main valley and of some of its tributaries, and ~~rounded stones~~ glacial erratics in deposits at higher levels, are evidence of two or more glacial advances. ~~The bluffs at Goose Bay expose two tills separated by gravel.~~ and What is believed to be a third, older drift sheet is exposed ~~farther west~~ along Knik Arm, west of Goose Bay ~~and~~ two ~~drifts~~ sheets are exposed south of Knik Arm in the valley of Eklutna Creek (T. N. V. Karlstrom, U. S. Geological Survey, personal communication, 1955). Subsurface ~~geologic and hydrologic~~ data presented in this report show that there are three buried tills at the Agricultural Experiment Station and suggest that two or more buried till sheets are present at several other places in the agricultural area. Several glaciations are thus known to have affected this region. It has undoubtedly been glaciated repeatedly during Quaternary time.

Ice from the Knik Valley was evidently a more effective eroding agent in the Knik Arm lowland than the Matanuska ice; during each glacial episode the Knik ice, much closer to its source, must have reached this area sooner and remained active later than that from the Matanuska Valley. This more effective erosion is shown by several lines of evidence: the wide mouth of the Knik Valley, ~~with~~ where only small hills ~~or~~ of the hard, rocks typical of the Chugach ~~-type rocks~~ mountains left near the surface (Bodenburg Butte and other bedrock hills, which are probably part of the preglacial divide between the Matanuska and Knik Rivers); the conspicuous truncated spurs along the front of the Chugach Mountains; and the lesser altitude of the bedrock surface beneath the valley floor (where it is known) in the southern part of the valley, as compared with that in the softer Tertiary rocks to the north.

The older glacial drift of the agricultural area has no surface expression in the topography of the valley floor, and ~~the older glacial drift of the valley floor~~ is ~~therefore~~ known only from well logs and a few exposures. ~~stratigraphic data.~~ The drift in the northern part of the agricultural area, although ~~while of~~ complex, ~~character,~~ seems to record a relatively simple sequence of glacial advances and retreats and periods of erosion and deposition by melt water streams. Subsurface data ~~from near what is now Knik Arm~~ show that the sequence of unconsolidated deposits near Knik Arm ~~there~~ is much more complex than ~~that~~ farther north. It seems likely that this may be due in part to repeated glacier fluctuations there, in part to the formation of temperary lakes there during episodes of glacial retreat, and in part to the concentration of melt water streams in that part of the valley floor during later stages of the periods of deglaciation.

The drift of the last glacial episode, modified only slightly by later nonglacial processes, such as the deposition of loess forms the land surface in most of the agricultural area. The brief summary below describes the formation of the surface and near-surface deposits and the development of the topography of the valley floor.

The last ice tongue in the agricultural area extended a few miles west of what is now Big Lake, where its end moraine forms several prominent north-south bands of hills. During deglaciation the ice over most of the valley floor north of the present Knik Arm became stagnant. The Knik ice may have remained active longer than the Matanuska ice because its source was closer to the agricultural area, but eventually it also became stagnant. Outwash stream eroded the hills of ground moraine exposed by melting of the ice, ~~they~~ deposited gravel and sand around and upon blocks of stagnant ice, and ~~they~~ repeatedly trenched these deposits. The terraces thus formed, ~~together~~ with, and ~~the~~ pits, in them formed by ~~due to~~ the melting of buried ice and the collapse of the overlying material, are among the more conspicuous features of the valley floor. Meltwater streams from the now-separated Matanuska and Knik Glaciers were at first independent, but the Matanuska streams migrated southward as lower parts of the valley floor were uncovered, and finally all the meltwater from both glaciers flowed southwestward along what is now Knik Arm. Sea level gradually rose from its low position of the glacial maximum, and eventually salt water moved into part of the lower reach of the Matanuska-Knik valley, forming Knik Arm. Estuarine deposits above the level of the present average high tides suggest that sea level was somewhat higher than it is now, relative to the land surface, at least once during postglacial time. The presence of a thick estuarine sediments at the community of Matanuska (base of section not reached in a hole drilled 170 feet below the present sea level), and the low altitude of the broad valley floor of the Knik River, further suggest that, during some part of postglacial time, the estuary has extended up the Knik valley somewhat farther than it does now. It is clear that the postglacial history of the estuary, and hence of the streams tributary to it, has been complex.

During and after deglaciation nonglacial processes modified the landscape. Windblown sediment, chiefly silt, was deposited upon the greater part of the valley floor and the marginal uplands. Alluvial fans and talus accumulated along the valley walls. The many lakes on the surface of the glacial drift have been modified by the accumulation of lake and organic deposits, and some have been completely filled.

Karlstrom (1955b) presents a chronology of late Pleistocene and Recent events in the Cook Inlet region, and he (1957) and Miller and Dobrovolny (1957) discuss some of the older drift deposits exposed in this region. The age of the old, buried drift deposits in the agricultural area and their relation to those older exposed deposits are not known, but it seems likely that the buried deposits represent at least part of the deposits which Karlstrom has named.

The surficial drift in the agricultural area has not been dated precisely but radiocarbon dating of samples from nearby areas provides an approximate minimum age for it. An outwash deposit near Anchorage, outside the end moraine of the last glacial advance and apparently formed during or shortly after the climax of that advance, is 11,600±300 radiocarbon years old (sample W- 540[1]; Miller

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[1] The prefix W indicates that the sample was dated in the laboratory of the U. S. Geological Survey in Washington, D. C.

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and Dobrovolny, 1957). Peat from a bog 6,000 feet in front of the present terminus of the Matanuska Glacier, about 50 miles east of the agricultural area and in a locality not overridden by ice since formation of the bog, has been dated at 8,000±300 years (W-431; J. R. Williams, U. S. Geological Survey, personal communication, 1957). The maximum age of the surficial drift in the agricultural area is less firmly established. Wood from peat in the bluff at Goose Bay is older than 38,000 years (Rubin and Suess, 1955, p. 486). Although this is not an absolute age and is thus indefinite, it suggests that the overlying drift may include deposits that represent a considerable span of time. The overlying deposits include a lower gravel and an upper till that extends nearly to the land surface. The till may be interpreted as including more than one depositional unit, if local boulder pavements in it are considered to represent unconformities.

Partly on the basis of other radiocarbon ages for material from the Knik Arm region (some of which have since been revised after re-analysis), and partly by correlation with deposits in other areas, the youngest drift in the agricultural area has been tentatively correlated with the deposits of late Wisconsin age of the midwestern United States (Karlstrom, 1952; Péwé and others, 1953, p. 12-13; Trainer, 1953, p. 14). The dates cited above, considered in relation to recently published radiocarbon dates from the midwestern United States and elsewhere, seem to be consistent with this correlation. Karlstrom (1957) believes that the last major glaciation (the Naptowne) in the Cook Inlet region, during which the surficial deposits of the agricultural area were formed, is the correlative of all rather than part of the Wisconsin glacial stage of the midwestern United States.

at about 10,500 B.C.

If the ~~Mankato~~ late Wisconsin correlation and the 8,000-year date cited above are accepted, it is necessary to conclude that the active front of the Matanuska Glacier receded 80 miles or more, from the end moraine to the position of the dated bog, in perhaps 3,000 years or less. Such recession is considered reasonable because of evidence of widespread stagnation of the ice in the agricultural area and because there seem to be no prominent end moraines between this area and the modern glacier.

GROUND WATER

Principles of Occurrence

Below a certain level in the near-surface part of the earth's crust the voids between fragments in unconsolidated sediments and the fissures and other openings in consolidated rocks are saturated with water under hydrostatic pressure. The upper surface of this zone of saturation is the water table, and water in this zone is ground water. Between the water table and the land surface is a zone of aeration, in which the pores and other openings may be either partly or entirely full of water, but the water is held by molecular attraction and does not drain by gravity.

Ground water is derived by infiltration of precipitation, directly from rainfall or indirectly from the melting of snow and from bodies of surface water. The water moves downward through the zone of aeration until it reaches the water table; it then moves under the force of gravity from points of higher to points of lower hydrostatic head until it is discharged naturally through seeps and springs into streams or lakes, or by evaporation, or by transpiration by plants. Artificial discharge takes place from wells or other artificial excavations extending below the water table.

The porosity and permeability of rock materials are of particular importance in determining their water-bearing character. The porosity of a material, its property of containing openings, may be expressed as the proportion of total volume of these openings to the total volume of rock material. The porosity of unconsolidated sediments ~~like those found in this area~~ commonly ranges from perhaps 20 to 40 percent for sands and gravels to as much as 80 or 90 percent for some newly-deposited clays. Fine-grained materials such as clay may therefore contain much more water per unit volume than coarser materials, but because their water is in large part held by molecular forces and will not drain under gravity the fine sediments are much less effective water-transmitting materials than the coarser ones. The permeability of a material, its capacity for transmitting water under pressure, thus depends on both the porosity of the material and the size of its pores.

In some places in the zone of saturation the bodies of water-bearing material, or <u>aquifers</u>, lie between ~~or beneath beds~~ bodies of relatively impermeable material. If an aquifer and such confining ~~beds~~ bodies are sufficiently extensive and have sufficient slope away from the place where the water enters the aquifer, the water moves through the aquifer under pressure; it rises above the level of the top of the aquifer in wells that pierce the overlying confining material. Such ground water is <u>confined</u>, or <u>artesian</u>, water. Where the water is ~~under pressure~~ confined there is no water table at which the saturated zone and zone of aeration meet. However, an imaginary pressure, head-indicating, or <u>piezometric</u> surface ~~that~~ which is analogous to the water table, and which shows the distribution of head in the artesian aquifer, may be constructed. Water moves into and out of an artesian aquifer at places where the confining bed is absent, locally discontinuous, or sufficiently permeable ("leaky") to permit this movement.

~~In~~ At some ~~localities~~ places relatively impermeable material in the zone of aeration may be surrounded by more permeable material. If ~~the upper surface of~~ such an impermeable mass ~~is below the land surface and~~ is sufficiently extensive, it may hold ~~in the permeable material~~ above it, in the permeable material, a body of <u>perched</u> ground water that is higher than the general water table in the surrounding area.

Many streams, marshes, and lakes are at places where the water table and the land surface meet; such bodies of water are therefore commonly considered to ~~make~~ mark the ~~local~~ main position of the water table. Lakes and other bodies of surface water may be perched upon impermeable material, however, and caution must be used in interpreting such surface features as indicators of the main water table.

Summary of Ground-Water Conditions

The Matanuska Valley agricultural area is in a wide valley floored with unconsolidated deposits, chiefly glacial drift, that represent several episodes of glacial advance and retreat. The stratigraphy of the materials that form aquifers and confining beds is therefore complex. The chief aquifers are composed of outwash sand and gravel laid down by meltwater streams or in lakes. Glacial till and the bedrock are aquifers of minor importance.

The outwash deposits are of two chief forms. The first consists of sheetlike deposits that lie just beneath the land surface. These deposits range in thickness from a few feet to 100 feet or more, and in some places the thickness differs markedly over short lateral distances. Where the deposits have been completely penetrated by wells they are known to rest on till or bedrock. The water in these deposits is unconfined—that is, it occurs under water-table conditions. In some places the water is perched upon layers of what appears to be stream-laid silt or clay, or upon till or bedrock. The thickest outwash deposits are between Bodenburg Butte and the

Knik River and beneath the broad terrace south of Palmer, where numerous farm and household wells obtain small quantities of water from these deposits. Larger supplies (100 gpm or more) might be obtained from properly developed wells in the outwash deposits where they are sufficiently permeable and where a sufficient thickness of the aquifer is penetrated. In part of the terrace south of Palmer, a sand that easily becomes quick was encountered by many of the existing wells. This unstable sand seems to be present chiefly in the bedrock valley that underlies this part of the agricultural area (fig. 3).

The other outwash deposits are buried beneath till. They are known to be as much as 50 to 60 feet thick, and probably are considerably thicker in some places. They commonly contain confined, or artesian, ground water. Well logs and data from pumping tests suggest that outwash sand and gravel form a continuous or nearly continuous buried layer or sheet in an area of more than 10 square miles north and west of Palmer. Similar deposits underlie several smaller tracts elsewhere in the agricultural area. It is consistent with the geology of the area that these be considered parts of a single more or less continuous sheet. Available subsurface data are insufficient to confirm this hypothesis, but they justify the conclusion that artesian conditions probably are present in much of the agricultural area, including places where only small or negligible quantities of water can be obtained from shallow water-table aquifers. The artesian aquifers are of nonuniform character; they probably are of variable thickness and grain-size composition from place to place and are characterized by lateral discontinuity of beds. In these characteristics they are similar to many nonglacial stream deposits.

obtained from shallow water-table aquifers in only limited or negligible quantities. The artesian aquifers are of nonuniform character; they probably are of variable thickness and grain-size composition from place to place and are characterized by lateral discontinuity of beds. In these characteristics they are similar to many nonglacial stream deposits.

Despite the irregular character of the buried deposits near Palmer it appears that their average water-transmitting capacity is relatively uniform over a fair part of their known extent. The city of Palmer has pumped about 100,000 gpd from these deposits since the autumn of 1953, and water-level records suggest that equilibrium of recharge to and discharge from the aquifer has been attained. The aquifer also provides many dependable farm and household water supplies.

Subsurface data pertaining to artesian aquifers near the Agricultural Experiment Station show that stratigraphic and hydrologic conditions there are complex and much less regular than near Palmer. There is much ~~The presence of~~ fine-grained material that tends to become quicksand during drilling and pumping, and successful wells must be developed in ~~limits well development to the~~ coarser ~~and less common~~ materials. Lateral changes in the water-transmitting capacity of the aquifer, shown by hydrologic data, may be due to thinning of the aquifer, to intercalation of more permeable and less permeable beds, to gradation of the aquifer material into less permeable material, or to a combination of such factors. Supplies of 100-200 to gpm or more can be obtained from wells finished in favorable material ~~and~~ properly developed, but the effect of the irregular stratigraphy of the aquifers on the maintenance of such discharge rates over long periods is not known.

The chief hydrologic significance of the till sheets in the agricultural area is ~~its~~ in their function as confining beds for the artesian aquifers. The till is in general poorly permeable, although locally ~~it~~ yields small quantities of water ~~from~~ thin layers of sandy material in it. Till that is present at or near the land surface in much of the agricultural area makes the aquisition of shallow ground water difficult or, locally, even impossible.

The bedrock is also poorly permeable. It yields water only from fractures, whose location and frequency ~~the presence of which~~ cannot be predicted with assurance on the basis of data from the few exposures. Records of the few existing wells in bedrock show that the frequency of fractures is considerably different in nearby localities. ~~Moreover, the area available for recharge to the bedrock near most existing or potential wells is limited, so that only small yields of wells are to be expected even where other conditions are favorable.~~ Several of the rock wells have obtained salt water which is thought to have been in the rock since ~~it was formed.~~ this region was last covered by marine water.

Ground water in the agricultural area is in general suitable for human consumption, although a few wells have obtained salty water or water that has objectionable hardness, iron content, or other characteristics. The water is of a moderately hard calcium-magnesium bicarbonate type.

Recharge of the ground-water is chiefly from precipitation. Probably only a small proportion of the annual precipitation reaches the water body, and very dry seasons are accompanied or followed by a conspicuous decline of water levels in many wells. Water-table aquifers in the terrace south of Palmer and in the area near Bodenburg Butte receive underground flow from the Matanuska River. Movement of stream water into the ground is also known or thought to occur along several smaller streams. Natural discharge is by seeps and springs into streams and lakes, by evaporation, and by transpiration by plants.

Detailed quantitative ground-water information is available for relatively few localities in the agricultural area. The areas of withdrawal of ground water are well distributed throughout the settled parts of the area, and except for pumpage by the city of Palmer the withdrawal of water has probably had a negligible effect on ground-water levels. The only ground-water problems observed that cannot be solved by improved well construction are thought to be due to the ~~apparent~~ absence of suitable water-bearing material in some ~~a few~~ places. ~~where the material is unstable and forms quicksand or where there is little or no sorted sediment in extensive deposits.~~ It appears that the quantity of ground water available is sufficient to meet reasonable future needs, particularly if future wells are as widely spaced, as are those in use today. It is possible that in some places where the aquifers might not provide moderately large supplies under continuous pumping ~~for long periods~~, ~~such~~ supplies could be obtained for short periods each year for such uses as supplemental irrigation. The complexity of the stratigraphy of glacial drift, particularly in this ~~an~~ area ~~such as this one~~ where two large trunk glaciers joined to form a piedmont ice lobe, makes prediction of the location and characteristics of aquifers difficult. Available subsurface data suggest that most wells drilled for household or farm water supplies, in the better-known parts of the agricultural area, at least, will be successful. However, careful test drilling, development, and pumping will be required to provide adequate information for each locality where a large ground-water supply ~~supplies are~~ is desired.

Hydrologic Character of Rock Units

Consolidated Rocks

Bedrock underlies the entire area and is near the surface ~~is near or above~~ the land surface in the vicinity of Palmer and Bodenburg Butte, in the eastern part of the agricultural area. The known occurrences of bedrock there are shown ~~summarized~~ by figure 3.

no ¶ Several wells obtain adequate household water supplies from bedrock (see records of the following wells in table 5: McKenzie, 24; Falk, 70; McKinley, 80; Stacey, 137; Thuma, 146; and Moffitt, 229). Other wells in bedrock (Thuma, 147, and Mehan, 376) yield only small supplies. The records of wells 70 and 146 report water at several levels that are interpreted as fractured zones in the rock. Bedrock examined at surface exposures is relatively impermeable; probably none of it transmits water readily except through fractures. The rock is exposed in so few places that there is no satisfactory way of predicting where fractures are most likely to be present. Well 80 was drilled nearly 90 feet into greenstone before a water-bearing fracture was encountered. One well (147) on the Thuma property extends 117 feet into bedrock (shale?); it passes through two water-bearing zones and yields about 350 gpd. A second well (146), nearby, extends only 16 feet into the rock; it was pumped at the rate of 8 gpm for 42 hours, and bailed at 16 gpm for a short period.

On the basis of data from existing wells the writer concludes that there is a fair chance of developing small ground-water supplies from the bedrock in the eastern part of the agricultural area, but that some holes would be dry. It is not considered likely that large quantities of water could be obtained from the bedrock.

In most places except perhaps along the Matanuska River, recharge of water to the bedrock must take place from overlying unconsolidated deposits.

The old slaughter-house well (144), in rock, and the old hospital well (135), which may have penetrated rock, obtained salt water (see section on Quality of Water). Two other wells, probably also in Palmer, are reported to have obtained salt water from what may be bedrock. Because several other bedrock wells in the vicinity of Palmer have produced water of good quality, it is assumed that the highly mineralized water came from small bodies of saline water trapped in the rock. It is probably old sea water, modified by chemical reaction while in the rock; it is not modern salt water from Knik Arm. The likelihood of encountering highly mineralized water in new (penetrating) bedrock wells cannot be estimated; it is quite possible that almost any new well would encounter such water.

Till ("hardpan")

About 25 wells have obtained water from till in the Matanuska Valley agricultural area, although a number of these produced insufficient supplies and have been abandoned or deepened.

The tough, silty and clayey till is commonly impervious; sandy, less compact till transmits water somewhat more readily and in some places yields small supplies to large-diameter wells. The permeability of sand layers in the till, on the other hand, is comparable with that of surficial outwash sand. Where till lies near the land surface, bodies of surface water or bodies of ground water in gravel may be perched above it; where till lies immediately below the water table, water in reasonable quantity may not be available in the upper part of the saturated zone.

In most places where wells obtain water from till the water occurs in sand or gravel layers or sandy zones in the till. These permeable layers are commonly one foot thick or less, ~~in thickness,~~ as in the Nash (6), Venne (22), Moore (230), and Bailey (343) wells, but some thicker water-bearing zones have been found. The Withey well (474) obtains water from a 2½-foot zone of sandy material; a Geological Survey test well (3) in till penetrated one foot of coarse sand, two feet of gravel and one foot of fine and medium sand before passing into till again at a depth of 26 feet. In some wells (as Beechik, 5; Hecker, 320, and Bacon, 371a) several widely separated water-bearing layers were encountered.

A 20-foot aquifer of sand and gravel in till supplied water to well 4, at the Lazy Mountain Childrens Home, during one winter. The water initially rose five feet above the top of the aquifer, but with continuing withdrawal the water level declined until after four months only three feet of the aquifer was still saturated. It was estimated that about 400,000 gallons had been pumped from the well. The relatively rapid unwatering of the aquifer indicates that recharge to it is much slower than the rate of withdrawal (an average of about 3,300 gpd). ~~and it is~~

concluded that the aquifer ~~is~~ may be completely enclosed in till, water may be recharged to it and discharged from it through connected sandy layers in the till, but the rate of inflow of the water is small.

Water obtained from sand or gravel layers in till is probably derived from the till itself by downward percolation; if this is correct the quantity of water obtainable from one of these aquifers depends not only on the permeability of the till and the size of the well which collects the water but also upon the roof area of the aquifer. The range in altitude of the water levels in nearby wells that tap sand layers in till (see records of wells 3,4,5, and 6,) shows that these thin aquifers are not effectively interconnected.

Relatively soft, loose till reported to yield water to some shallow wells (for example, an old well near well 4; see table 5) ~~well 4a)~~ may be superglacial till, more permeable than the hard, compact till at greater depth, which was compressed by the weight of the ice.

The areal distribution and frequency of fractures cutting the till, and of streaks of sandy till, cannot be estimated because of the inadequacy of exposures. If these features are widely distributed they may be of some importance in the downward movement of water from the land surface in areas of ground moraine. If they are common ~~in some places~~ they may control the local effectiveness of the till as an artesian confining layer in some places.

Artesian water has been obtained in several parts of the agricultural area by wells that pass through till into permeable sand and gravel (fig. 6). Near Palmer, where these wells are most closely spaced and the inferred contours on the artesian-pressure surface most reliable (fig. 8), ~~it is possible~~ that the till is a single continuous layer. ~~A stratigraphic section (pl. 2)~~ shows that the thickness and form of the till ~~stratum~~ are irregular. The till was evidently laid upon an irregular surface; the variations in its thickness and in the shape of its upper surface are probably due both to ~~glacial deposition~~ and to later ~~glacial-stream~~ erosion. The water table in the overlying sand and gravel differs considerably from the pressure surface of the deeper artesian water. In depressions on the buried till the water table ~~is~~ lower than the pressure surface. In some places where the till ~~comes nearly~~ to the land surface, as about ~~one~~ mile north of Palmer, water ~~is perched~~ above the till ~~and~~ is relatively close to the land surface.

Springs issuing from till are ~~unimportant.~~ Seepage from thin sand layers in till may be seen in the east bluff of the Matanuska river about half a mile north of the highway bridge. Some seeps may derive their water from more permeable till present locally just beneath the land surface. The flow of water from seeps the writer has observed is not sufficient for more than small supplies, but it presents a drainage problem in some places where the till is to be excavated.

The yields of wells in till are small at best and most of the wells probably ~~prove~~ inadequate over a period of years. The Cook well (338) yielded about 50 gpd in 1949 but has been dry since the dry summer of 1950. The Kibbe well (586) yielded 150 gpd for some time after it was dug in 1949, but later proved ~~an~~ unreliable ~~supply~~ and was replaced by a drilled well. A Geological Survey test well (3) was pumped steadily at the rate of 30 gph over a 3-hour period with a drawdown of 19 feet, but it seems unlikely that this rate could have been maintained for a long period. ~~The recovery of~~ water levels in some wells in till ~~is slow;~~ an extreme example is the old Bradley well (607), a large-diameter dug well, in which the water level required 7 days to recover after 250 gallons had been pumped in 45 minutes.

~~Despite the unfavorable character of the till as a water-~~bearing material, the development of ground water supplies from it~~, even in limited quantities,~~ must be considered because of the need for water supply in areas of ground moraine already settled and because of possible future needs in such areas that are ~~potential agricultural land.~~

Outwash Sand and Gravel

General Occurrence. In the Matanuska Valley agricultural area sandy gravel, gravel, and part of the sand in the outwash deposits are good water-bearing materials wherever they are saturated. Most wells obtain their water from these materials. Finer and "dirtier" materials that are also part ~~part of~~ the outwash deposits, chiefly silty gravel and fine silty sand, do not form highly productive aquifers.

In a large part of the agricultural area ground water is present under water-table conditions. The form of the water table in the eastern part of the agricultural area is shown by figure 7. ~~Artesian-pressure~~ Piezometric-surface contours are shown for a similar area by figure 8. The water table and ~~pressure~~ piezometric surface do not coincide, although they are close in many places. Both these maps are based on measurements made over a period of years, but the probable fluctuations of the water levels are much less than the contour interval used, and the general forms of the water table and ~~pressure~~ piezometric surface are considered to be those shown by the contours.

Apparent irregularities in the form of the water table, ~~found~~ in many places, are due in part to the presence of relatively impermeable material. Perched ground water has been found in several localities and is probably fairly common in the agricultural area. In other places where impervious material is present, holes that reach the assumed level of the general water table are reported to have been dry.

In several wells (339, 340, 341, 342, 344, 345, 346, and 350) about ~~one~~ a mile north of Palmer perched water in the gravel and sand near the surface or in the upper part of the underlying till, stands considerably higher than water in several deeper wells nearby that pass through the till or that do not ~~encounter~~ penetrate it.

Figure 4. - Particle-size distribution in samples of water-bearing materials.

(in pocket)

East and southeast of Bodenburg Butte the Brown (42), Rippy (43), and Bastian (44) wells ~~encountered water at depths of~~ 28 to 35 feet. In other wells ~~within~~ a few hundred feet to the west and southwest (Kirk, 45, 47; Gallagher, 46) the static water level is 53 to 58 below the surface; several bodies of perched water were reported in well 46, one at 34 feet. It seems likely that all these wells reached or passed through the same body of perched ground water. The impervious layer beneath ~~it~~ the perched water may ~~consist of~~ be stream-laid silt such as may be seen in abandoned channels on the modern flood plains in this area.

~~Another type of situation, in which impervious material interrupts the general water table locally, has been found in several places.~~ ~~Of~~ Several holes were reported (Max Sherrod, Palmer, personal communication, 1951) to have been dug near the railroad north of Palmer and south of the Matanuska River. One near the railroad curve obtained water but the others reached till within a few feet of the surface and were dry. Several shallow dug wells in Wasilla encountered a layer of till or till-like material as much as a few feet thick at about the level of the water table; those that did not obtain water above the impervious layer were continued through it to water-bearing gravel beneath. Three wells (Nelson, 103; Brewer, 104; and Sandvik, 105) south of Bodenburg Butte are 93 to 112 feet deep, although the water table here, as in nearby wells to the east and south, is about 50 feet below the surface. The logs of wells 103 and 104 record gravel without giving any reason why the wells were drilled farther below the water table. Well 104 is reported originally to have obtained an insufficient supply of water at 47 feet. Well 105 is reported to have penetrated gravel (dry?) and finally 10 feet of clay before reaching water-bearing gravel at 92 feet. It seems likely, on the basis of these data, that much of the material penetrated by these wells consists of a relatively impermeable river deposit such as interbedded sandy gravel and silt or clay. The water-bearing material originally encountered at 47 feet in well 104 is evidently not sufficiently permeable to permit the continued flow of water to the well at a rate of perhaps a few hundred gallons per day. Other wells nearby reach permeable gravel at the water table, and the consistent water levels indicate that all the wells, deeper and shallower, are probably interconnected hydraulically.

Some lakes and marshy tracts in areas of ground moraine appear to be perched upon the till. Deposits of sand and gravel beside the lakes also contain water that may be above the general water table.

Near several small streams that flow across gravel deposits the water table stands many feet lower than the beds of the flowing streams. In a preliminary report (Trainer, 1953, p. 15) the writer concluded, on the basis of data from available wells, that these streams were probably perched. Records were later obtained for new observation wells near the mouth of Palmer (Bodenburg) Creek, north of the Knik River, and water-table contours were constructed for several periods during and after the annual flood of Knik River (fig. 5). Water from the river moves into the ground during the rising stage, both directly from the river and from the lower, flooded reaches of the creek, and the normal ground-water gradient (toward the river) is reversed near the streams for a few days. Hydrographs of four observation wells (58g, 58m, 59, and 60) near the river show rapid fluctuations of water levels that correspond to those of the river. Chemical analyses of river and ground-water samples collected during and after the flood show (G. W. Whetstone, U. S. Geological Survey, personal communication, 1955) temporary changes in the chemical quality of the ground water at all four wells; these changes indicate that river water moved into the aquifer at least as far as from the river as well 58g (fig. 5). No change in chemical quality

Figure 5. - Maps showing fluctuations of the water table near the Knik River during and after the annual flood of the river.

(in pocket)

was found in samples from more distant observation wells, and the rise in water levels observed there is attributed to the damming effect of the river and perhaps to increased infiltration from backwater in the creek. Data obtained from the hydrographs (time lag and stage ratio for the crest in each well relative to that in the river) were used to calculate the water-transmitting capacity of the aquifer according to a method described by Ferris (1951). The value obtained (a transmissibility of several million gallons per day per foot) is considered inconsistent with the character of the aquifer. It is concluded that the equations are not applicable in this situation because the water moves into the aquifer from two directions and because the edge of the river moves toward the wells during the rising stage of the flood.

In three other wells (Kircher and Menk, 412; Curtis, 424; and Carson, 576) the water table is lower than the beds of nearby streams, but the data are not sufficient to show whether the streams are perched at these localities or whether the water table merely slopes steeply away from them.

Discharge measurements were made at three stations on Wasilla Creek by W. H. Sherman (535 Eng. Det. (Terrain), Army Map Service, U. S. Army, personal communication, 1956), during a brief period on June 11, 1955. The stations are at the bridge on the Palmer-Fishhook Road northwest of Palmer, near the Palmer-Wasilla Road west of Palmer, and at the Matanuska-Wasilla Road west of Matanuska. The computed discharge rates at these stations for the time of measurement are 40, 43, and 56 cubic feet per second, respectively. These data, together with available well records (412 and 424, cited above, and Kyger, 297, where the water table is close to the level of the stream), suggest that Wasilla Creek is losing water to the ground in part or much of the reach upstream from well 424 (about a mile south of the Palmer-Wasilla Road) and receiving water from the ground in part or much of the reach downstream from well 424.

The relatively high permeability of the sand and gravel just beneath the land surface facilitates waste disposal. Sewage from the city of Palmer is discharged into the Matanuska River, but disposal of waste elsewhere in the agricultural area is commonly underground.

Sand and gravel buried beneath till are important water-bearing materials in much of the agricultural area. The wells that tap these buried outwash deposits commonly obtain artesian water. Most of these wells are northwest of Palmer, but others are widely distributed to the west and southwest (fig. 6).

With the exception of a few seeps and springs from till and from bedrock, all the springs seen by the writer flow from sand or gravel. These springs are of two types: those at the contact of saturated gravel and underlying till, and those situated where the general water table meets the land surface, as along the base of the bluff near the community of Matanuska.

Most of the wells in the agriculture area, and all those that produce more than about 200 gpd, obtain their water from outwash sand

Figure 6. - Map showing locations of wells that obtain water from sand or gravel beneath till.

(in pocket)

and gravel. There is no reason to doubt that the yields of wells in sandy gravel in the agricultural area can be substantially increased by the use of well screens and proper development practices, provided the wells penetrate a sufficient thickness of saturated material.

<u>Artesian Conditions Near Palmer</u>

Sand and gravel beneath till north and west of Palmer ~~are an important aquifer (or aquifers) and~~ yield water to many of the wells in this part of the agricultural area. Plate 2 shows the places where the till cover is known to be present. The wells are too widely spaced to permit the conclusion ~~one to conclude~~ that the till sheet is uninterrupted, although it is reasonable to assume that it is uninterrupted over considerable areas. The section in plate 2 shows the irregularity of its form and of the upper surface of the buried gravel and sand.

The maximum thickness of the aquifer is not known. An abandoned Alaska Railroad Company ~~ARRC~~ well (near well 305; see log, table 4) records buried till, an underlying gravel, and a deeper deposit ~~that is~~ thought to be an older till ~~and~~ that rests on bedrock. The gravel is 97 feet thick, ~~However, this material~~ but may not be the same as ~~comparable with~~ the water-bearing gravel penetrated by most of the wells shown by plate 2; it may be either a remnant of still older outwash gravel left by erosion and later buried, or ~~a sequence of~~ interbedded gravel and till

Figure 7. - Map showing altitudes of water levels in wells, and contours on the water table, near Palmer.

(in pocket)

Figure 8. - Map showing altitudes of water levels in artesian wells, and contours on the artesian-pressure surface, near Palmer.

(in pocket)

("cemented gravel"). Great difficulty has been experienced in obtaining water from these deeper deposits in this vicinity (see records of wells 305 and 306a), and several unsuccessful holes were drilled here in colony days.

The thickest [deposits of] gravel ~~sections~~ penetrated by successful wells are 58 and 51 feet thick, in wells 363a and 363 respectively, and there is no indication in the logs that either well reaches the [base] ~~bottom~~ of the aquifer. Most other wells here, as elsewhere in the agricultural area, were drilled only deep enough to reach stable saturated material, and do not penetrate [such material] ~~the aquifer~~ more than a few feet.

Wells 360a, 362, 363, and 363a obtain water from fine to medium sand. The logs of most of the other artesian wells record gravel, but probably the material is sandy gravel or pebbly sand in most places.

Two pumping tests were [made] ~~conducted~~ to determine the hydrologic characteristics of the aquifer near the Palmer municipal wells, the only high-capacity wells in this part of the agricultural area. ~~In December 1952 and January 1953,~~ Well 363 was pumped for five days at [the rate of] 76 gpm, and fluctuations of the water level were measured in well 363a. ~~In July and August 1953,~~ Well 363a was [later] pumped for ~~six~~ [6] days at 93 gpm, and well 363 was used as an observation well. Two additional wells

(364 and 365) were observed during each test but the data obtained are inconclusive, possibly because of lag in water-level changes, and were not used in the analysis of the pumping tests.

The effectiveness of a water-bearing formation as an aquifer may be described in terms of the coefficients of transmissibility and storage. The coefficient of transmissibility (Theis, 1935, p. 520), is a measure of the total ~~average~~ permeability of the part of the aquifer sampled during the test; it is expressed in gallons per day transmitted through a 1-foot strip that extends the height of the aquifer, under a hydraulic gradient of ~~1~~ one foot per foot, at the prevailing temperature of the water. The coefficient of storage is the volume of water the aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

These coefficients were computed/ by means of a logarithmic

/ Computations for the test of well 363 ~~Dec. 1952-Jan. 1953~~ were made by D. J. Cederstrom of the Geological Survey.

"type-curve" solution of the Theis nonequilibrium formula (Wenzel, 1942, p. 88-89). The test data were also plotted to give the semi-logarithmic ("straight-line") solutions of the nonequilibrium formula described by Theis (1935, p. 522) and by Cooper and Jacob (1946).

Table 2. - Coefficients of transmissibility and storage determined from pumping tests of the artesian aquifer near Palmer

Pumped well	Observation well	Type of test	Type of solution	Coefficient of transmissibility (gpd per foot)	Coefficient of storage
363	363a	Drawdown, observation well	Type-curve method (Theis)	7,900	0.00059
363	363a	do.	Straight-line method (Cooper and Jacob)	4,200	
363a	363	do.	Type-curve method (Theis)	10,000	0.00054
363a	363	Recovery, observation well	do.	10,200	0.00048
363a	363	Drawdown, observation well	Straight-line method (Cooper and Jacob)	4,700	
363a	363a	Drawdown, pumped well	do.	6,000	
363a	363a	Recovery, pumped well	Straight-line method (Theis)	6,000	

The nonequilibrium formula is based upon several assumptions: the aquifer is homogeneous, its properties are similar in all directions, and it is of indefinite areal extent; the discharge well is of infinitesimal diameter and penetrates the entire thickness of the aquifer; the coefficient of transmissibility is constant at all times and places; and water taken from storage by the decline in water level is discharged instantaneously with the decline in head. These assumptions, which were necessary for the development of the method, are only partly satisfied by wells and aquifers. In some places conditions diverge so greatly from these ideal conditions that the analytical method may not be applicable.

Wells 363 and 363a are 208 feet apart. The parts of the aquifer sampled by the two tests are, therefore, not identical; they may be thought of as overlapping cylinders that eventually became several thousand feet wide, whose altitudes equal the thickness of the aquifer. The area of overlap of the two cylinders was small relative to the total area sampled during the early parts of the tests, but because nearly the whole sample area in the later parts of these 5- and 6-day tests. Computations by the type-curve method, which depends on comparison of the observed drawdown-time curve with an ideal curve, are based on the initial 21- to 33-minute periods of the tests. The difference in computed transmissibility values--7,900 gpd per foot for one test, and ~~10,900~~ 11,000 gpd per foot (drawdown) and 10,200 gpd per foot (recovery) for the other—is thought to represent differences in the character of the aquifer near the two wells. The aquifer has a higher transmissibility near well 363a than near 363, which seems reasonable because of the coarser material reported by the log of well 363a (see table 5). The three values of the coefficient of storage range from 0.00048 to 0.00059, and are considered to be of the same order of magnitude.

Where several observation wells are used it may be possible to locate discontinuities in the character of the aquifer. Data from the~~se~~ tests described above are not sufficient to locate discontinuities, or boundaries, but do show that they are present. The values of the coefficient of transmissibility determined by the straight-line method range from 4,200 to 6,000 gpd per foot. ~~but~~ The data from which these values are computed ~~on which the computations are based~~ were obtained later in the tests (after 100 minutes), however, so these ~~and these~~ values are ~~, therefore,~~ not comparable with those determined for earlier parts of the tests by the type-curve method. Changes in the type-curve graphs and in one straight-line graph represent changes in the form of the cone of depression produced by the pumping. Increase in the rate of drawdown shows that the sides of the cone were steepening, which in turn shows that somewhere ~~less~~ water was moving more slowly into the cone. Such a hydrologic change in this glacial-outwash aquifer may reasonably be ~~might be caused by~~

The physical significance of the coefficient of transmissibility may be illustrated as follows: The coefficient of transmissibility is an index of the natural rate of ground-water movement in the part of the aquifer sampled. Darcy's law, a fundamental hydrologic relationship which states that the rate of flow of a fluid through a porous medium is directly proportional to the hydraulic gradient, can be written (Stuart and others, 1954, p. 59) in the form

$$Q = T I W$$

where, in the units commonly used in the Geological Survey, Q is the quantity of water, in gallons per day, T is the coefficient of transmissibility, in gallons per day for each vertical strip of the aquifer 1 foot wide; I is the hydraulic gradient, in feet per foot; and W is the width in feet (perpendicular to the direction of flow) of the strip of aquifer through which the quantity Q flows. If the coefficient of transmissibility and the average piezometric-surface slope are known the average rate of flow of the ground water under natural conditions can be determined. For example, if the coefficient of transmissibility near the two wells tested is taken as 7,900 gpd per foot and the hydraulic gradient as 80 feet per mile (=0.015 foot per foot; estimate based on fig. 8), then the flow of water through the aquifer under nonpumping conditions is

$$Q = 7{,}900 \text{ gpd per foot} \times 0.015 \text{ feet per foot} \times 1 \text{ foot} = 120 \text{ gpd}$$

through each vertical strip of the aquifer 1 foot wide.

any of several changes in its geology: changes in the thickness at some distance from the wells; intercalation of more and less permeable beds, changing the effective thickness of the aquifer; lateral changes in the permeability of the sand and gravel; or the presence of one or more barriers to the flow of water, such as a till or bedrock wall of an outwash channel, with or without changes in the character of the aquifer in other directions.

Any or several of these factors may affect the aquifer in this area near Palmer. Most wells do not penetrate this aquifer deeply, and their logs do not describe it in detail. However, the known geology suggests that the observed hydrologic changes are due in part to changes in the thickness and composition of the aquifer, and perhaps in part to the buried bedrock (pl. 2 and fig. 3) that delimits the aquifer near Palmer.

Figure 9 shows fluctuations of water levels in wells 364 and 365, about 1200 and 1800 feet, respectively, from the Palmer wells. The decline in water levels in August 1953 is due to one of the pumping tests and to emergency pumping by the city. The fluctuations between late September 1953 and early 1956 occurred during essentially continuous pumping at an average rate estimated to be about 100,000 gpd. Records maintained by the City of Palmer show that during the period from November 1954 to September 1955 the average daily pumpage was 105,000 gallons. The graphs suggest that equilibrium of discharge and recharge has been attained. The water-level fluctuations after the initial steep decline appear to represent seasonal changes in the aquifer, like those recorded by the other graphs in figure 9. Computations using the water-level data for wells 363 and 363a and two measurements in well 398, 1,200 feet from the Palmer wells, suggest that the transmissibility of the part of the aquifer sampled by the 28-month period of pumping is somewhat higher than the 11,000 gpd per foot indicated by one test for the part of the aquifer very near well 363a. Because additional suitable observation wells were not available for this study and because there is little supplementay information from well logs regarding the aquifer as a whole, the computed transmissibility values should not be assumed to represent the aquifer at any locality; they are averages for the parts of the aquifer sampled, and there may be many places where the water-transmitting capacity of the aquifer is considerably greater or less than these averages. The discontinuities in aquifer characteristics indicated by the pumping tests, together with the available geologic data, show that the aquifer departs somewhat from the ideal assumed for analysis of the test data but not sufficiently to prevent use of the method.

It is difficult to compare this aquifer with others described in the literature because the available data permit only an approximation of its character. If, for purposes of illustration, the thickness of sand and gravel recorded by the log of well 363a, 58 feet, were taken as the average thickness of the aquifer in the area tested, and ~~4,400~~ 7,900 gpd/~~ft~~ per foot as its transmissibility in this area, then the average coefficient of permeability, (expressed in gallons per day transmitted through a cross-sectional area of ~~1~~ one square foot, under a gradient of 1 foot per foot, ~~at 60° F.~~), corrected ~~for temperature~~ to 60° F (Wenzel, 1942, p. 62), would be

$$\frac{\text{4,400 gpd per foot}}{\text{58 ft}} \times 1.41 = 107 \text{ gpd/square foot}$$

~~If 10,900 gpd per foot were used for the transmissibility, the average coefficient of permeability would be 265 gpd per square foot.~~ By way of comparison, one may cite Meinzer's (1936, p. 710) statement that ~~considered~~ the Carrizo sandstone in the Winter Garden region of Texas, where it has a coefficient of permeability of about 200 gpd per square foot, ~~to be~~ is an average example of a moderately productive aquifer.

Most of the wells that penetrate th~~is~~e aquifer near Palmer are household or farm wells that were not developed to yield large supplies of water. The two wells (363 and 363a) drilled for the city of Palmer are capable of producing moderately large quantities of water. During the pumping tests described in preceding paragraphs the drawdown in well 363 after ~~five~~ 5 days of pumping at the rate of 76 gpm was 40 feet; this represents a specific capacity of 1.9 gpm per foot of drawdown. The drawdown in well 363a, after ~~six~~ 6 days of pumping at 93 gpm, was 62 feet; the specific capacity was thus about 1.3 gpm per foot of drawdown. Part of the observed drawdown in each well is due to friction at the screen openings, and part is due to the position of the well screens opposite only part of the aquifer. Well 363a was later reconstructed with a 20-foot, 40-slot screen, in place of the 20-foot, 10-slot screen originally used; the well then produced 100 gpm with 37 feet of drawdown, for a specific capacity of 2.7 gpm per foot of drawdown. The well is thus twice as effective with the coarser screen, which reduces entrance loss due to friction.

Pressure-surface contours (fig. 8) show that ground-water movement in this artesian area is from the north and north-northwest. The source of the water that recharges the aquifer is, therefore, in that direction. The wells on which the contours are based are too widely spaced to rule out the possibility that part of this recharge takes place locally through gaps in the till sheet caused by the combined effects of glacial deposition upon an irregular land surface and later meltwater erosion. However, it seems likely that, even if no gaps interrupt the till sheet, part of the recharge is by percolation of water through thin or sandy parts of the till. Such percolation could occur only where the water table above the till stands higher than the artesian-pressure surface of the water confined beneath it.

Artesian Conditions near the Agricultural Experiment Station

~~Artesian water has been obtained from sand or gravel beneath till in several parts of the agricultural area (see fig. 6).~~ The greatest concentration of artesian ~~these~~ wells (fig. 6), outside the area near Palmer described in the preceding section, is near the Agricultural Experiment Station. ~~but even there the available information is meager.~~

The logs of 15 wells near the Experiment Station record till or till-like (possibly including lake(?) sediments) ~~material.~~ Till crops out at the land surface about 1.7 miles west-southwest of the Station (pl. 1) in hills that stand above stream terraces. To the east the till is buried beneath sand and gravel. Wells 445a and 445c, at the Experiment Station, passed through two ~~2~~ till sheets and reach a third. The uppermost till is a continuous sheet near the Experiment Station, where artesian water from beneath the till ~~it~~ stands nearly 30 feet higher in wells than the unconfined water above the till. The second till is continuous near wells 445a and 445c; a 5-day pumping test, during which water was withdrawn from the aquifer beneath the second till, appeared not to affect the water level in the artesian aquifer above this till. The thickness and probable extent of the lowermost till are not known. Interbedded till and ~~washed drift~~ found below 284 feet in well 445c are considered part of a single sedimentary sequence because the sorted material is part of the thick aquifer penetrated by both wells. (Well 445a, which was drilled first, might also have encountered this interbedded sequence if it had been drilled deeper.)

All the aquifers penetrated by these wells are composed predominantly of fine to medium sand. Chunks in the drill cuttings show that in ~~part~~ places finer material is present as silt-clay laminae in clean sand. ~~but~~ Probably much of the sand is itself silty, however. Numerous ~~Single~~ pebbles were found ~~frequently~~ in the sand, but only a few beds of clean gravel or sandy gravel were encountered, and they are thin.

The logs of other wells near the Experiment Station are difficult to interpret and hence to correlate (see discussion in section on geology). The drillers' descriptions and a comparison of the logs suggest that many of the wells ~~encountered~~ penetrated till. At other wells the till cannot be identified in the logs with confidence; it may be absent. Probably the apparent complexity of the stratigraphy is due both to irregular deposition and to later meltwater erosion. The relatively complex history implied is not surprising because this area has probably been overridden alternately and repeatedly by both Matanuska and Knik ice and because it may have been covered at one or more times by standing water.

Well 445a was pumped for ~~five~~ 5 days at an average rate of 142 gpm; changes in water levels were measured in it, and also in wells 445c and 445b, which penetrate the same and the shallower artesian aquifers respectively. Drawdown-time data for well 445c, 99 feet from the pumped well, were used in a graphical solution of the Theis non-equilibrium formula; the computed coefficient of transmissibility is

32,600 gpd per foot, and the coefficient of storage 0.00035. These coefficients were also determined from the same data by means of the straight-line method; the values are 37,500 gpd per foot and 0.00044, respectively. Both graphs show the presence of several discontinuities in the character of the aquifer. The computed coefficient of transmissibility suggests a moderate permeability, but calculation of an average coefficient of permeability, using the coefficient of transmissibility and the observed thickness of the aquifer, is meaningless because of the complex stratigraphy and the observed hydrologic discontinuities. Wide departure of the plotted drawdown-time data from the ideal or type curve suggests that a decrease in the water-transmitting capacity of the aquifer, beginning perhaps about 1,000 feet from the test-well site, is due to a gradual and continuing change in the aquifer rather than a simple barrier such as the wall of a stream channel. This presumed change in the aquifer might be due to one or more factors such as thinning of the aquifer, intercalation of till or clay beds with the sand and gravel, or gradation of the sand and gravel into finer and more silty sand. Any of these alternatives is reasonable judged on the basis of available data.

The observed drawdown in the pumped well after five days of pumping at 142 gpm was 64 feet. At that time the pumping level was declining at a rate that would give a drawdown of 77 feet after

30 days of pumping at 142 gpm, and 84 feet after 60 days.

In the vicinity of the Experiment Station the artesian water moves southward, and the recharge area is therefore north of the station. Because the head in the upper artesian aquifer at the Station is 9 to 10 feet higher than that in the deep aquifer (wells 445b and 445c), it seems likely that recharge to the deep aquifer is by flow from the upper artesian aquifer, perhaps at places where the till sheet between them is thin or relatively ~~somewhat~~ permeable. Recharge of the upper artesian aquifer is probably derived from the unconfined ground water near the land surface, at places where the water table stands higher than the piezometric surface and where the upper till is missing or relatively permeable. The water-table aquifer is replenished by water from precipitation which percolates downward from the land surface.

The unconfined ground water near the Experiment Station discharges naturally through springs into lakes in the pitted and terraced outwash deposits and into streams along the base of the bluff that overlooks Knik Arm. Well logs suggest that the youngest till is absent locally near the bluff; water from the shallower artesian aquifer therefore may discharge in part directly to streams at the base of the bluff, as well as in part to the water-table aquifer. The top of the deeper artesian aquifer is about 80 feet below sea level at the Experiment Station and may be deeper at the bluff (see log of well 447; the top of what appears to be the deeper aquifer is at 250 feet, or 124 feet below sea level). A hole drilled at the community of Matanuska is reported (Bruce Cannon, Alaska Railroad, personal communication, 1955) to have penetrated estuarine silt and clay to a total depth of 200 feet, or about 175 feet below sea level, without reaching the base of the formation or obtaining fresh water. It seems likely, on the basis of the few data available, that estuarine deposits fill an eroded trough beneath Knik Arm and its adjacent flats, and that discharge from the deeper confined aquifer near Knik Arm is by upward leakage at some place between the Experiment Station and the dam of estuarine material at the bluff. Such leakage could occur only at places where the till is absent or relatively permeable and where the head of the leaking water is higher than that of the water in the shallower aquifer. The water level for what appears to be the deeper artesian aquifer, in well 447, stands 52 feet above sea level, or apparently somewhat above the level of the water in the shallower aquifer there.

Wind Deposits

The windblown silt and sand which mantle glacial drift in the agricultural area is nearly everywhere above the water table, but the deposit is of hydrologic importance because it permits ready infiltration of precipitation when the ground is not frozen.

Studies of the soils in the agricultural area (Neil Michaelson, Alaska Agricultural Experiment Station, personal communication, 1955) show that the silt has a ~~total pore space~~ porosity as high as 50 to 60 percent ~~by volume~~. Field tests made by the writer, with a variable-head permeameter of the type described by Wenzel (1943, p. 64-65), show that for downward flow the permeability of the wind-blown sand is comparable to that of much of the outwash sand. The silt (loess) is much less permeable but transmits water readily. The results of the tests, expressed in Meinzer's ~~units~~ (gallons per day through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent, at 60°F.) are as follows:

> Outwash sand, 6 samples, 50 to 3400 ~~units~~;
>
> dune sand, 4 samples, 90 to 190 units; ~~and~~
>
> compact loess, 3 samples, 0.7 to 1.0 ~~unit~~.

Much of the loess, particularly near the land surface where it contains considerable plant debris and is very porous, is much more permeable than these data indicate. During irrigation experiments conducted at the Alaska Agricultural Experiment Station (Michaelson, 1956, p. 1) water was sprinkled on pasture land at a rate of 0.5 inch per hour for periods of ~~one~~ 1 to ~~two~~ 2 hours without surface runoff.

Small perched bodies of ground water occur in windblown sand and silt on the Holtet property (well 275), near the Matanuska bluff about ~~4~~ four miles north of Palmer. The water is present only in ice-block depressions. The impermeable layer ~~which~~ that retains the water is thought to be ~~a~~ silt~~y~~ deposit ~~formed~~ ed in a pond in the depression during melting of the ice. Ground water has not been reported in wind-blown material elsewhere in the agricultural area.

Summary of Ground-Water Conditions in Physiographic Units

In an earlier report ~~discussion~~ (Trainer, 1953) the agricultural area was divided into several physiographic units in order to facilitate description of ground-water conditions. The differences in the land surface in these units reflect major differences in geology, which in turn produce different hydrologic conditions in the several units. The physiographic units are shown in figure 2. They are not formal subdivisions, and geographic names are applied to them only for convenience of reference in this report.

Lazy Mountain (Unit 1)

The western slope of Lazy Mountain and the tract that extends westward from it to the Matanuska River (hereafter termed the lower slope) constitute~~s~~ physiographic unit 1.

Talus and frost-disturbed deposits on the higher slopes and alluvial fans at intermediate levels are of some importance in regulating the flow of small streams because they permit ready infiltration of water from the surface. ~~Part of the water is derived from rain and melting snow on the mountain slope; part~~ Most of the stream water probably comes from the unconsolidated material, but part of it may flow to the streams after temporary storage in fractured bedrock beneath the higher slopes. Seeps occur along the lower edges of the alluvial fans where the underlying till reappears at the surface.

The lower slope, more than half the unit, consists of ground moraine or of terraces cut into it. Much of the ground-moraine section of this tract is poorly drained. Wells in the till (Nos. 3-6 and several dry holes, including one 50 feet deep about a quarter of a mile north of well 3) have ranged from unsuccessful to moderately successful. It seems unlikely that more than moderate water supplies can be obtained from the till. The aquifers are (1) sandy layers in the till and (2) slightly permeable till at the land surface. Springs are few and generally small, but seeps on the hillside overlooking the lower country south of unit 1 affect excavation work in some places.

Several terraces indent the ground moraine in the triangular tract between the Matanuska river and Wolverine Creek. The land surface is in general well drained. The terraces are underlain at shallow depth by bedrock at several places along the Matanuska River and Wolverine Creek. In wells 1 and 2 coarse gravel, 18 and 10 feet thick, respectively, rests on till. On the basis of analogy with terraces elsewhere in the agricultural area, the writer believes that till is commonly near the surface in all the terraces here and that the gravel cover on each probably represents the load of gravel normally in transit downstream on an outwash flood plain. Nonetheless, this terraced tract is considered the most promising part of unit 1 for the development of ground-water supplies. The most successful wells would probably be (1) in places where depressions or channels in the surface of the buried till contain greater-than-average thicknesses of saturated gravel (there appears to be no surface indication of such places, if they are present), and (2) near the centers and on inner edges of the terraces where low mounds of ground water may be built up by water from precipitation.

It has been suggested in another section of this report that the thick till at Lazy Mountain Childrens Home represents two or more units. If the 20-foot aquifer penetrated there by well 4 is an isolated mass of sand and gravel similar to that which composes the artesian aquifer near Palmer, it is possible that other parts of the same deposit, possibly more extensive than the aquifer in well 4, also are buried by till in unit 1. However, there appears to be no way of testing this possibility by ordinary surface methods.

Bodenburg Terrace Area (Unit 2)

The land surface in most of physiographic unit 2, which is the tract between the Matanuska and Knik Rivers and the mountains to the east, is underlain by stream-laid sand and sandy gravel. Bodenburg Butte and smaller hills of bedrock, and a few hills of till (pl. 1), protrude through the stream deposits. The land surface slopes generally southward and southwestward.

The area covered by this unit is in general well drained; to the southeast, however, part of the land surface is marshy. At existing wells the ground water is under water-table conditions. The water is derived from runoff from the mountains to the east, from precipitation upon the land surface, and from infiltration from the Matanuska River and Palmer (Bodenburg) Creek. Ground-water movement, as is shown by the water-table contours (fig. 7), is generally southward and southwestward.

North of the bedrock hills that include Bodenburg Butte, and also in much of the area south of that hill, the water table stands close enough to the land surface to be accessible to suction pumps. Perched ground water is present near the southeast end of Bodenburg Butte (see records of wells 42-47). South of this hill impermeable material near the water table has locally made deeper-than-average drilling necessary (wells 103-105). The acquisition of ground-water supplies may be similarly complicated elsewhere in this unit, but nearly all the existing wells reach the water table in permeable sand or gravel. No large-capacity wells have been constructed in the Bodenburg terrace area and the potential yield of wells is not known. Ground-water supplies adequate for household and farm use should be available nearly everywhere from the sand and gravel. Moreover, the fluctuation of ground-water levels during and after the annual flood of the Knik River (fig. 5) indicates that in much of this unit the sand and gravel are readily permeable. Undoubtedly, ground-water supplies much larger than those now obtained could be developed from properly constructed wells ~~in the sand and gravel~~.

Two wells (70 and 80) obtain water from bedrock. ~~The well logs show that the water in the bedrock moves through fractures in the rock~~; the success of a bedrock well here, as elsewhere in the agricultural area, depends on ~~its intersecting~~ the number and size of the fractures intersected by the well. The quantity of water obtainable from fractured bedrock in the vicinity of Bodenburg Butte may be greater than that near Palmer, given comparable frequency and size of fractures, because of the likelihood of recharge here from the Matanuska River. The lake on the east end of Bodenburg Butte is spring-fed, possibly from both the bedrock and the overlying glacial drift.

On the basis of the quantity of water available and the cost of its aquisition, this physiographic unit is probably the most favorable part of the Matanuska Valley agricultural area for the development of ground-water supplies.

Matanuska-Knik Flood Plains and Estuarine Flats (Unit 3)

The modern flood plains of the Matanuska and Knik Rivers constitute a considerable tract in which the water level stands within a few feet of the land surface. Large quantities of water could undoubtedly be developed from these alluvial deposits, but recurrent flooding renders settlement of such areas unwise. The community of Matanuska is said to have been abandoned because of flooding by the Matanuska River.

Estuarine silt and clay underlie ~~interfinger with~~ the stream deposits ~~at the land surface~~ near the community of Matanuska, and are known to extend to a depth of at least 200 feet. Stream deposits may be interbedded with the silt and clay at depth upstream (to the east), but the likelihood of encountering ~~obtaining~~ gravel and fresh ground water by drilling at Matanuska or farther west is poor. Water has been found at shallow depth in gravel that underlies estuarine deposits at the Eklutna CAA station, south of Knik Arm near Matanuska, but the gravel appears to be a relatively thin creek-fan deposit of only local significance, and the water in it is brackish at high tide.

Palmer Terrace (Unit 4)

This unit consists chiefly of the extensive~~, generally flat~~ terrace on which Palmer is situated. Smaller, lower terraces along its eastern and southern edges are included for convenience. These, ~~with~~ and a few low terraces on the broad ~~flat~~ surface south of Palmer, a few ice-block depressions, and a few bedrock hills, ~~that rise above the general land surface,~~ provide local relief of a few feet to a few tens of feet.

East and south of Palmer the land surface is generally underlain by gravel and sand. In many places the ~~this~~ near-surface material is coarser than that below it; the subsurface data available suggest that in general the alluvium is chiefly sandy below a depth of 30 to

50 feet. The logs of 11 wells record material that may be till, but elsewhere east and south of Palmer wells penetrated only sand, gravel, and (in a few places) bedrock.

Farm wells south of Palmer have generally been successful. The water stands below the limit of suction lift; it is commonly 75 to 100 feet below the surface near Palmer but stands nearer the surface farther south. The water table slopes generally southward. The water-table contours (fig. 7) showing a dominantly downvalley movement, suggest that much of the recharge occurs by influent seepage from the Matanuska River at times of high water. However the altitudes of reported water levels in the area 1 to 2 miles south of Palmer suggest the presence of a low mound in the water table in the middle of the terrace, which would indicate recharge from the land surface. Natural discharge of the ground water occurs through seeps and springs at the base of the bluff along the southern edge of unit 4.

Because much of the alluvium below the water table is sand that tends to become quick during drilling or pumping, many wells were drilled a considerable distance below the water table. The water table in this part of the Palmer terrace probably does not fluctuate more than a few feet from season to season or year to year (fig. 9, wells 185), and the records of existing wells provide accurate information concerning the depth to water at nearby localities. However, the ~~depths~~ depth to which a well will have to be drilled at any locality, to reach a stable part of the aquifer, cannot be determined before ~~the~~ drilling. ~~The available~~ Subsurface data suggest, however, that there is greater likelihood of ~~encountering~~ penetrating thick sand in the area of the ~~over the~~ buried bedrock valley (fig. 3) than to the east or west.

Because of local interest in the possibility of obtaining ground-water supplies for irrigation in the Matanuska Valley agricultural area, and because of the favorable topographic conditions in unit 4, the availability of moderate to large quantities of ground water in the Palmer terrace is of potential economic importance. Well 195, ~~about~~ 2 two miles south of Palmer, was finished with a 60-slot screen (openings 0.060-inch wide) set at 110-114 feet. After development the well was pumped at 53 gpm for 27½ hours. The final drawdown was 23 feet, and the specific capacity of the well was thus 2.3 gpm per foot of drawdown. The screen openings were suitable for the upper ~~two~~ 2 feet of the aquifer ~~exposed~~ screened, but were too large ~~in~~ for the lower ~~two~~ 2 feet of screen, which filled with sand. The water ~~pumped~~ therefore moved into the well chiefly through a 2-foot section of the screen. ~~It seems likely that~~ The observed specific capacity would have been exceeded considerably if the well had been finished in coarse sand or gravel and the full length of screen utilized. ~~and therefore that~~

Yields of 100 gpm or more probably could be obtained from favorable materials in the Palmer terrace by wells that extend far enough below the water table. The short test of well 195 does not justify conclusions regarding the potential yield of this unconfined aquifer over long periods of pumping. However, the observed specific capacity is considered reasonable for the periods of a few weeks during which supplemental irrigation probably would be most desirable. The presence of favorable water-bearing material at any locality must be proved by test drilling and pumping.

Subsurface and ground-water conditions in the northern part of unit 4 are complex. Till is at shallow depths in some places north of Palmer. A bedrock hill, exposed only locally, extends beneath the area near Palmer. Three shallow dug wells (128, Bugge; 130, Felton; and 145, Thuma) obtain water from gravel that rests on the bedrock. The water appears to be held up by the rock and to move along its sloping surface; farther east and south the water table is much deeper. Wells 120-127, in Palmer, have produced small quantities of water. Several other wells (now abandoned and filled) dug by individuals in Palmer are reported to have been successful, and during establishment of the agricultural colony four successful colony wells, 37 to 46 feet deep, were constructed in gravel. Five other colony wells in Palmer, in gravel, till(?), or bedrock, where "dry holes". Two wells (146 and 147, Thuma) recently drilled into bedrock south of Palmer obtained small quantities of water of good quality (see table 3, ~~analysis of sample from~~ well 147). A colony well in Palmer, which reached bedrock at 72 feet, is reported (ARRC log) to have obtained "sulphur water" at 121 feet. Two colony wells (135 and 144) at Palmer obtained salt water; two others, probably in Palmer, also obtained salt water. In three of these wells the salt water was reached at 140 to 160 feet above sea level. In the old slaughterhouse well (144) salt water was reached at a depth of 569 feet, or about 300 feet below sea level; this well is reported to have penetrated shale and limestone from 18 to 590 feet below the surface. The difference in reported chloride content of water from ~~two of the~~ wells, 134 and 135, (see well records, table 5), and the absence of salt water in other bedrock wells ~~in the vicinity of~~ near Palmer, suggest that the highly mineralized water is of local occurrence. It probably has been trapped in the ~~a~~ rock since ~~a time when~~ the ~~this~~ area was covered by marine or estuarine water; it is not modern salt water from Knik Arm.

Because of the wide range of conditions ~~encountered~~ represented by these wells, it is not possible to predict the presence and quality of ground water in the vicinity of Palmer. New wells constructed there may or may not be successful, depending upon chance location. ~~However, sand and gravel, where present, are generally thin; and the bedrock, even~~

where it is fractured and thus may be water-bearing, has a small potential recharge area. For these reasons it is thought that only small quantities of ground water are available in even favorable localities in the vicinity of Palmer.

Eske Creek - Experiment Station Area (Unit 5)

Unit 5 lies west of the Matanuska River and the Palmer terrace. The dominant surface ~~figures~~ are eskers, pitted deposits, and terraces, all ~~composed of outwash~~ sand and gravel. ~~The thickness of~~ these outwash deposits ranges from a few feet to 100 feet or more. In most places where deep wells have been drilled they have encountered buried till, ~~and~~ most wells drilled through this till have obtained artesian water from sand or gravel beneath it. Unconfined ground water is also present at shallow depth in much of the unit; in ~~many~~ places this water is probably ~~perched above~~ the till.

There are few wells in the northeastern part of unit 5, and ~~consequently~~ little is known of hydrologic conditions there. The land surface is commonly irregular but it is underlain by sand and gravel ~~and is well drained.~~ Several wells near Eska Creek obtain shallow unconfined ground water; others (Postishek, 244; Murdoch, 245; James 251a; and Estep, 251b) are known to obtain artesian water from beneath till. Records for the wells near Eska Creek probably provide reliable information on the range of geologic and hydrologic conditions to be expected, although they are too widely spaced to permit detailed estimates of conditions at new localities. Existing wells show that sand and gravel (in part bouldery) along the creek are underlain by till that overlies deeper sand and gravel. In some places the higher sand and gravel evidently does not provide continuous water supply, for several wells were later deepened.

Wells 253-258, between Eska and Moose Creeks, reached or penetrated till; these occurrences, together with the surface geology here and the known stratigraphy farther west, suggest that most or all of this tract is underlain by till. In one well (Wallace, 257) the till is about 400 feet thick, although the writer believes that more than one depositional sequence of till is represented (see discussion of till, under Geology). None of these wells encountered buried deposits of well-sorted sand or gravel like those found near Palmer, and it is not known whether such deposits are present beneath the till. The meager information available suggests that this part of unit 5 is not a promising area for ground-water development.

Southwest of the tract of eskers and pitted deposits near Moose Creek the land surface is irregular but more gently rolling; it consists in large part of pitted outwash terraces. Plate 2 illustrates the interbedding of till and outwash deposits and the distribution of artesian wells that pierce the till in the area north and west of Palmer. In general these wells provide water supplies adequate for household and farm use, although few of them were screened or otherwise developed to discharge more than small quantities of water. ~~Both~~ The Palmer municipal wells (363 and 363a), which were screened and developed, produce considerably larger quantities of water. ~~These wells, and the ground-water conditions in the area near them, are discussed in the section describing the occurrence of ground-water in the outwash deposits.~~

Several wells on the Cullison property (ARRC tract 132, near well 305) were "dry holes" even though they penetrated sand and gravel to greater depths than successful wells nearby. This may be due to local relative impermeability ~~because of~~ resulting from slight cementation of the sand and gravel; or the material described as "cemented gravel" may be part of a sequence of interbedded gravel and till that is relatively impermeable. The logs of wells 306 and 306a (W. Moffitt), which are a few hundred feet apart and near well 305, record dissimilar materials. The stratigraphy of the deposits in the vicinity of these wells is evidently ~~very~~ irregular.

In general, the records of existing wells should offer a reliable guide to the kinds of subsurface conditions to be expected in the central part of unit 5. ~~It appears that~~ The till sheet is probably present in most of this tract. Most existing wells reached water-bearing deposits beneath it, although conditions near well 305, cited above, show that these favorable conditions are not present everywhere.

Many wells in this part of the unit obtain unconfined ground water from sand and gravel. As is true beneath many terraces elsewhere in the agricultural area, the outwash deposits here are relatively thin in many places. In some wells (for example, 370, 372, 386, and 396) that reach till at depths of about 10 to 20 feet, the water is probably perched. Many of the outwash deposits beneath terraces in the agricultural area are relatively thin. Surface drainage is commonly well developed in this tract, and there is usually no surface evidence of the presence of till at shallow depth. In some places (see cross section, pl. 2) the underlying till is absent or was eroded more deeply, and the cover of outwash sand and gravel is much thicker than average. Average values for the thickness of the outwash and of water-bearing parts of it beneath any of the terraces are therefore likely to be more misleading than useful. However, well records for localities near a proposed well, on the same terrace, will generally provide a fair idea of the conditions to be expected.

discussing the hydrologic character of the wind deposits.

Brazil Springs, at the bend of the Palmer-Fishhook Road about three miles northwest of Palmer, provided the Palmer water supply for many years. The water issues from gravel at the base of a small hill. It probably reaches the springs by movement down (southwest) a small valley that crosses the Yadon property (near wells 314 and 315) and in which there are two small lakes (pl. 1). The lakes and the nearest well (317) show that the water table is near the land surface. The writer believes that the gravel hills and the valley are probably underlain by till at shallow depth, and that the springs mark the intersection of the water table by a slight topographic depression. Spring flow is probably about 150 to 200 gpm when the water table is at its average position; during the dry season of 1950 and in 1951 the flow declined so markedly that the existing pipe line was extended north to Carnegie Creek to obtain surface water.

The southwestern part of unit 5 is characterized by pitted outwash deposits, and except for the area near the Experiment Station it is sparsely settled. Little is known, therefore, of the ground-water hydrology of this part of the agricultural area. In general the movement of ground water here is southwestward, as is shown by the artesian-pressure surface contours (fig. 8) and by the occurrence of seeps and springs along the bluff north of Matanuska River and Knik Arm. Most of these seeps and springs are small, but one supplied the Alaska Railroad at the community of Matanuska with 8,000 to 9,000 gpd in 1949. Artesian conditions near the Experiment Station have been considered in the section of this report that describes ground water in outwash deposits. The stratigraphy of the glacial drift is more complex here than farther north. Probably the composition and form of the deposits are a result of erosion and deposition by both the Matanuska and the Knik Glaciers and by their meltwater streams; some of the deposits appear to have been laid down in standing water, probably lakes. The limited information available from well logs and from a pumping test (well 445a) suggest that this part of the agricultural area is less favorable for the development of ground-water supplies than many other parts of it. The presence of till, "mud", and fine sand require deeper-than-average drilling for many of even the small-capacity farm wells. Moreover, ~~the range in~~ subsurface geologic conditions here ~~is so great~~ that the records of existing wells are useful chiefly in emphasizing this change ~~range~~ rather than in indicating the conditions to be expected at a given locality.

Little Susitna River-Goose Bay Morainic Area (Unit 6)

The Little Susitna River-Goose Bay morainic area is characterized by extensive areas of ground moraine separated by gravel-floored drainage courses. The topography shows a conspicuous southwestward ~~trend~~ "grain", and surface drainage is chiefly in that direction.

Plate 1 shows several elongate tracts of ground moraine that trend southwestward. In each of these tracts till is at the land surface, ~~of~~ or is mantled by thin deposits of sand and gravel, over extensive areas. Many small valleys and closed depressions contain somewhat thicker outwash deposits; these ~~places~~ deposits are the most promising sources of near-surface ground water in the ground moraine, although the quantities of water available are probably small. Wells in the till are not likely to obtain water unless they penetrate layers of sand or gravel ~~in the till~~.

Little is known of the thickness of outwash deposits in the drainage courses that cross the ground moraine, but poor surface drainage in many places and the presence of till ridges that protrude through the outwash deposits west of Pittman indicate that in many places till is probably near the surface. Poor surface drainage, a few outcrops (Pl. 1), and well records (623, 630?) show that till is probably near the surface over much of the terraced area along the north side of Knik Arm. It seems likely that ground water is present in these outwash deposits, perhaps generally, but that only small quantities are available at most places because the layer of saturated material is ~~relatively~~ thin.

Outwash-stream deposits that flank the lakes near Wasilla provide adequate household and farm supplies to a number of wells. There is a considerable range in the depths to the till, ~~where it is~~

~~known~~ (well 498, 56(?) feet; well 505, 28 feet; well 502, 12 feet); a well begun beside Swamp Lake, north of Wasilla, was in till from the surface and was ~~dry when~~ abandoned several feet below lake level. ~~It is possible that~~ till may be near the surface at any place beside these lakes, and the records of existing successful wells may thus not present a fair picture of ground-water conditions.

Considerable areas near Kings Lake and Swamp Lake and northwest of Wasilla are underlain by pitted outwash deposits about which little is known. A well at the Kings Lake camp (470) penetrated 46 feet of sand and gravel without encountering till.

Most of the springs the writer has seen in unit 6 ~~appear to be contact springs that~~ issue from sand or gravel where it rests on till. Examples include a spring east of the mouth of Fish Creek, and probably those on the Fleckenstein property, 1½ miles southwest of Wasilla and on the Dinkle property, 2½ miles southeast of Wasilla.

Wells in several parts of unit 6 (fig. 6) obtain artesian water from sand and gravel beneath the surface or near-surface till. The distribution of these wells and the ~~occurrence~~ of gravel beneath the till at Goose Bay suggest that this buried aquifer may extend over much of the western part of the agricultural area. If this ~~suggestion~~ is correct, larger ground-water supplies may be available ~~to~~ deeper wells than are probably available from surface gravel west of Wasilla. None of the wells ~~was~~ developed to yield more than small quantities of water but there appears no reason to believe that ~~the more~~ favorable materials would not furnish at least moderately large supplies ~~upon~~ after proper development.

Till is present beneath the community of Wasilla. Most wells there are shallow and obtain plentiful supplies of water from the overlying gravel, but wells 522a (Alaska Railroad) and 535 (Wasilla School) obtain artesian water from gravel beneath the till. What appears to be a layer of till as much as ~~3~~ three feet thick was penetrated by several dug wells in Wasilla; its relation to the thicker till ~~encountered~~ penetrated by the deep wells is not known.

Fluctuations of Ground-Water Levels, and Discharge and Recharge of Ground Water

Reports of well owners indicate that in some places the fluctuation of ground-water levels between wet and dry ~~seasons~~ years is as much as several feet. Seasonal fluctuations, the water levels being lower in winter and early spring, are also reported. Figure 9 shows hydrographs for observation wells for 4½- to 6½-year periods during 1949-56. Withdrawal of ground water near these wells is so small that the fluctuations may be considered to be the natural changes in the ground-water level at each well. In general these records show decline of the water levels for a 1- to 2-year period after

Figure 9. - Flcutuations of water levels in wells.

(in pocket)

observation began, and later partial or complete recovery. The graphs show considerble similarity, with a tendency to rise slightly in late spring and more prominently in late summer or autumn.

Precipitation data for the period 1949-55, from records of the U. S. Weather Bureau, are plotted by monthly totals beneath the hydrographs. None of the observation wells is near a surface source of water. Water from precipitation percolating ~~Rain water that percolates~~ from the land surface, ~~appears to be~~ is probably the chief source of ground water in most of the agricultural area. This general conclusion is suggested by the similarity of the hydrographs, which represent wells in a wide range of topographic and geologic situations. ~~None of these observation wells is near a surface body of water. The infiltration of water from precipitation is also suggested by data from one small area, the altitudes of water levels in wells one to two miles south of Palmer are thought to show the presence of a ground-water mound that could have been formed only by water from precipitation.~~ The period of rising water levels shown by the hydrographs, after the ~~relatively high~~ summer rainfall, is ~~thought to be~~ the time of greatest recharge. A relatively minor part of the recharge is probably derived from ~~by~~ snow melt during the spring. Most of the winter snow cover is ~~removed by blowing~~ blown away by the wind or is removed by sublimation, or ~~and~~ by melting and overland runoff. A small part of the melt water collects in depressions, however, and some of it percolates into the ground after the frost thaws. A third source of recharge, infiltration from the beds of streams, is important locally. Water-table contours (fig. 5, 7) show that such recharge occurs along the lower course of Palmer (Bodenburg) Creek, and along Matanuska River east and southeast of Palmer and north (?) and west of Bodenburg Butte. Recharge by infiltration may also occur along the small streams farther west in the agricultural area.

Comparison of the precipitation and water-level data (fig. 9) shows that any relation between them is probably complex. Water cannot move downward out of the mantle of wind-blown silt and sand until the pore spaces in the mantle have been filled. Therefore, heavy rains that follow a dry period probably contribute less to the ground-water body than lighter rains that fall on wetter soil. Deep wetting of the surficial material by heavy autumn rains is thought important in favoring recharge during the succeeding summer. A succession of two or more wetter-than-average years also probably leads to increased recharge. Weather Bureau records show that, during the period 1943-49, there was an accumulated excess of about 4 inches more than the mean annual precipitation. This series of "wet years" is thought to explain the high water levels observed in 1949. On the other hand a deficit of about 7 inches in 1950, (below the mean annual precipitation) was accompanied and followed by rapid decline of the water levels.

The hydrographs of wells 185, 449, and 533 probably show the maximum fluctuations of water levels to be expected in these localities if the future pattern of precipitation is similar to that observed in recent years. Near wells 185 and 449 the level of the water table is controlled by the shallow water level in the Matanuska River flood plain and in the sand-covered flat near the community of Matanuska. Near well 533, in Wasilla, the level of the water table is controlled by the levels of Wasilla and Lucile Lakes. ~~Well 314 is on a hillside, and is far from any feature that would control the water-table slope; these factors probably explain the large water-table fluctuations shown by its hydrograph.~~

The Palmer municipal wells discharge somewhat more than 100,000 gpd; the total withdrawal of ground water from other wells in the entire agricultural area is estimated to be perhaps twice this amount. The remaining ground-water discharge ~~is~~ occurs by natural means, probably chiefly by flow into the Matanuska and Knik Rivers, into the many lakes in the area, and perhaps into some of the small streams that flow to Knik Arm.

The apparent equilibrium attained during pumping of the Palmer wells suggests that the quantity of ground water available from favorable aquifers in the agricultural area is sufficient to meet reasonable future needs. It seems likely that moderately large quantities of water could be pumped even from aquifers less favorable than that tapped by the Palmer wells, especially if pumping were limited to a relatively short period each year such as that desirable for supplemental irrigation. ~~Because~~

Areas in which the ground water is known to be recharged by surface streams also would appear to be favorable hydrologically for the production of moderately large ground-water supplies. Because of the wide spacing of wells and the relatively small quantities discharged, the present withdrawal of ground water for farm and household use is thought to have little effect on water levels in the ground.

Quality of Water

The samples represented by the analyses in table 3 are considered representative of the chemical character of the ground water in the Matanuska Valley agricultural area. These analyses show that the water is in general suitable for ordinary domestic uses.

Water containing less than 500 parts per million (ppm) of dissolved solids is generally satisfactory for domestic use unless it is exceptionally hard or contains an objectionable amount of iron. The ground water in the agricultural area commonly contains less than 300 ppm of dissolved solids. The hardness is generally in the range from 100 to 300 ppm and is due chiefly to calcium and magnesium bicarbonate. A few wells (see 145 and 494, table 3) obtain very hard water (about 500 ppm or more). Artificial softening of such water, and of that from some of the other wells, is desirable. Hardness in excess of 150 ppm is noticeable in ordinary use and may cause the formation of scale in boilers and heating units. The concentration of iron or of iron and manganese in the samples from wells 462, 244a, and 522a is much higher than that of 0.3 ppm of iron and manganese together recommended in the drinking-water standards of the U. S. Public Health Service. In other samples analyzed the concentration of iron and manganese is within this limit. In all samples for which fluoride was determined the concentration is well within the mandatory limit (1.5 ppm) specified by the U. S. Public Health Service for water used on interstate carries. The nitrate content, a possible indicator of organic pollution, is high in a few samples (for example, wells 4a, 123, 145, 347, and 494). All but one (494) of these samples are from shallow dug wells, which are particularly susceptible to pollution. Samples from wells 145, 347, and 494 contain more than the 45 ppm considered (Comly, 1945) to be the maximum safe nitrate content for water used in feeding formulas for infants; higher concentrations may lead to cyanosis. Water of the character of nearly all these samples would be satisfactory for irrigation. The high sodium content of the samples from wells 4 and 147, however, might make such water undesirable for irrigation.

Triangular diagrams (fig. 10) illustrating the composition of the water samples analysed show that, except for samples 4 and 147, the water is of the calcium magnesium bicarbonate type and has a rather narrow range in composition. The samples were collected from till, outwash sand and gravel, wind-blown sand, and bedrock, and from both water-table and artesian aquifers. The uniformity of composition is thought to show that all the unconsolidated deposits represent fairly well the mineral composition of the bedrocks of the region.

Figure 10. - Diagrams showing the chemical composition of samples of ground water.

(in pocket)

The analyses show a considerable range in concentration of dissolved solids. In several places where less than average mineralization was found (wells 244, 244a, and 275) the water has probably been in contact with the sediments for a shorter time than elsewhere in the agricultural area. The relatively high concentration of dissolved solids in a few samples is more difficult to explain. Well 494, which is finished in gravel, obtains hard water (hardness, 530 ppm) that has a higher content of dissolved solids (638 ppm) than all but one of the other wells sampled. Robert Warner (535 Eng. Det. (Terrain), Army Map Service, U. S. Army, personal communication, 1956) suggests that this hardness may be due to solution of a buried deposit of calcareous marl such as that to be found in some of the modern lakes. This explanation is ~~would be~~ consistent also with the high nitrate content of water from this well, which could have been derived from organic material in the lake deposit.

The presence of high-sodium water in two wells (4 and 147) which penetrate shale (in well 4 the till enclosing the aquifer may contain fragments of the shale which was found beneath the till) suggests that the high sodium content may be related to the shale. In that case, however, it would appear that the sulfate content of these samples should be higher than was observed. Possibly the high sodium content and low hardness (relative to those of other Matanuska Valley samples) are due to natural base exchange between the ground water and the shale.

During the early days of the agricultural colony several drilled wells obtained highly mineralized water. An abandoned well in Palmer, listed in the files of the Alaska Rural Rehabilitation Corp., is reported to have obtained "sulphur water" in bedrock at a depth of 121 feet. Salt water was found in the old slaughterhouse (144) and hospital (135) wells and in two other wells. According to information in the ARRC files, analysis of water from the hospital well showed a carbonate hardness of 4,300 ppm, a chloride content of 3,520 ppm, and a pH of 6.0. In contrast, water from the old power-house well (134) is reported to have contained 26 ppm of chloride. The differences in composition of samples from nearby bedrock wells and the absence of chlorides in many of the samples of bedrock water are thought to show that the highly mineralized water is of local occurrence. It is not related to modern salt water in Knik Arm.

Construction of Wells

Dug Wells

Most wells constructed by individuals ~~in the agricultural area~~ for their own use are dug by hand. They are generally less than 50 feet deep but a few are much deeper. Well 272 (Allman) is 105 feet deep, and well 305 (Cullison) was 95 feet deep before it was deepened by drilling. These dug wells are generally square or rectangular in plan, three to four ~~rectangle, 3 to 4~~ feet on a side.

The walls of wells dug in till commonly stand without support after excavation, but in most places gravel must be supported during the digging. Some of the gravel and sand are particularly difficult to dig because the walls slump before they can be supported. Wood cribbing is most commonly used to line dug wells. Several types of wood have been used; spruce is considered excellent, but cottonwood is said (Wilson, T. J., personal communication, 1949) to give the water a taste of organic decomposition. Concrete blocks or pipe, poured concrete, metal barrels, wood-stave pipe, and steel well casing have also been used for lining ~~some~~ dug wells. In a number of the wells the~~se~~ linings have been put down in the cribbed hole to below the water table and the hole back-filled with gravel. The~~se~~ other types of lining are more permanent than wood and, if properly constructed, more sanitary. They do not, however, permit much inflow of water from water-bearing layers ~~higher~~ above ~~than~~ the bottom of the well, which ~~as may be desirable in~~ wells dug in till, especially, may need all the infiltration area possible in order to yield an adequate supply.

Although dug wells are less satisfactory than drilled wells for many reasons, the fact that they can be constructed without special equipment ~~by individuals~~ made them important during the early days of the agricultural colony. Moreover, in some places where till appears to be the only water-bearing material available the dug wells may be more effective than drilled wells for shallow supplies because they expose a greater well area and because the wooden cribbing permits inflow from all the water-bearing zones penetrated by the dug shaft. Dug wells generally cannot be extended more than a few feet below the water table, and some wells dug during seasons of high water table have gone dry when the water table declined. Some of these wells have been deepened by additional digging or by drilling.

Few dug wells in this area are satisfactory on the basis of sanitation. The wooden cribbing commonly used does not prevent the entrance of surface or near-surface water into the wells because few of the wells are adequately sealed at and near the surface.

Driven Wells

Conditions generally are not suitable for the construction of driven wells in this area. The presence of gravel or till at or near the land surface in most of the agricultural area makes the success of driven wells unlikely. However, a few driven wells (Johnson, 35; Rocca, 650; Kimbrell, 670) obtain water from sand or pebbly sand at depths of less than 20 feet.

Drilled Wells

Most of the wells constructed since the establishment of the agricultural colony, and all but a few of those deeper than 50 feet, have been drilled. For many years the Alaska Rural Rehabilitation Corp. operated a cable-tool drilling machine. Several private drillers have been active in this area in recent years.

Most of the older drilled wells were constructed with 4-inch steel casing. Most of the newer wells are of 6-inch diameter. They are generally finished with open-end casing, or with the lower few feet of the casing slotted, although a few have been finished with slotted well screens. These open-end and slotted-casing wells have proved suitable for the development of small water supplies, but in most places the water-bearing materials will not yield larger supplies (roughly 50 to 100 gpm or more) without the use of well screens for proper development.

The 4-inch wells are generally adequate for household use, but 6-inch wells may be preferable because the heavier drill tools permit more rapid drilling. If a well is to be used for a large water supply a 6-inch or larger casing is desirable because it permits the installation of a larger pump. For smaller supplies, the small electric pumps used in this area, which discharge less than 10 gpm, may be used satisfactorily in 4-inch casing. Of the several types of drilling machines the cable-tool type is the only one that is well suited to the conditions encountered in this area.

Utilization of Ground Water

Public Supply

Palmer is the only community in the Matanuska Valley agricultural area that has a public water supply. Several successful wells were constructed in and around Palmer during establishment of the agricultural colony, and earlier, but drilling in the townsite was generally unsuccessful. For many years, thereafter, the Matanuska Valley Farmers Cooperating Association supplied water to its creamery and other establishments by means of a 22,000-foot conduit of wooden-stave pipe from Brazil Springs, about 3 miles northwest of Palmer. Excess water was sold to the residents of Palmer. After the dry season of 1950 the spring flow was insufficient to meet the needs, and in 1951 the existing pipeline was extended and water obtained from Carnegie Creek, about a mile northwest of the springs.

Inasmuch as the then-expanded water supply for the town was considered of questionable sanitary quality, thought was given to the acquisition of additional supplies. Surface-water sources already in use were considered by the designing engineer, but, upon strong recommendation of theAlaska Department of Health, attention was given to the possibility of acquiring a safe and more economical supply of ground water. At this stage, on the basis of data which were at hand and which form the foundation of the present report, the Geological Survey informed theAlaska Department of Health that the chances of obtaining a ground-water supply at moderate cost were excellent. Shortly thereafter, personnel of an engineering firm engaged by the town were informed by the Geological Survey on details of local geology and hydrology, which provided a reasonable basis for an estimate of costs of a test well in the area where the present supply is developed.

The test well was subsequently drilled with favorable results. Later two production wells which are the source of water for the present supply system were drilled in the immediately adjacent area. According to Mr. A. J. Alter, Chief, Section of Sanitation and Engineering, Alaska Department of Health (personal communication, Sept. 25, 1958), Palmer thus became the first community in Alaska to achieve what public-health authorities would term a model water supply.

The present municipal-supply wells were completed during 1952 at a site about a mile northwest of the city. A reservoir was constructed at the well site. A gravity-flow distribution system connects the reservoir with the city. The new system went into operation during 1953.

A community well (515) was dug in Wasilla several years ago, but it is no longer in use. At present private wells supply water for all the inhabitants.

Domestic and Farm Supplies

During most seasons individual wells are capable of providing sufficient water for domestic and farm use throughout most of the agricultural area. Many farm houses have plumbing and pressure-water systems, and the water use includes supplying livestock and cooling milk.

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Table 3. - Chemical Analyses of ground water from the Matanuska Valley agricultural area, Alaska 1/ (parts per million)

Chemical constituents in

Well no.	4	4 9/	38	70
Alaska laboratory no.	2259	217	158	306
Owner	Lazy Mt Childrens Home	Lazy Mt Childrens Home	King	Falk
Geologic source	Sand, gravel	Till	Gravel	Rock
Depth (feet)	280	11	12	110
Date of collection	11-13-53	8-29-49	8-27-49	7-13-50
Silica (SiO_2)	8.6	20	8.2	19
Iron (Fe), dissolved 2/				
Iron (Fe), total	.07	.02	.02	.03
Manganese (Mn), dissolved 2/	.05			.02
Manganese (Mn), total				
Calcium (Ca)	7.7	29	51	
Magnesium (Mg)	.9	7.6	5.6	
Sodium (Na)	35	) 3.9	) 5.5	
Potassium (K)	1.1			
Bicarbonate (HCO_3)	94	91	143	194
Carbonate (CO_3)	0			
Sulphate (SO_4)	17	6.1	36	120
Chloride (Cl)	1.1	8.0	4.5	4
Fluoride (F)	-	.0	.1	.2
Nitrate (NO_3)	1.8	24	.8	.3
~~Total~~ dissolved solids	120	143	182	-
Hardness as $CaCO_3$	23	104	150	244
Noncarbonate	0	29	33	
Specific conductance (micromhos at 25° C)	193	224	307	515
pH	6.4	6.9	7.7	8.0

1/ Analyses by Branch of Quality of Water, U. S. Geological Survey.
2/ In solution at time of analysis.
9/ Shallow well near well 4; see table 5.

Table 3. - Analyses of ground water - continued
(parts per million)

Well no.	80	101	123	145	147
Alaska laboratory no	3256	2025 3/	157	215	3327
Owner	McKinley	ARRC 9/	Lester	Thuma	Thuma
Geologic source	Rock	Gravel	Rock(?)	Gravel	Rock
Depth (feet)	144	49	37	27	146
Date of collection	11-28-55	10-4-49	8-26-49	8-30-49	2-4-56
Silica (SiO_2)	7.8	10	16	16	9.6
Iron (Fe), dissolved 2/	.00	.03			.00
Iron (Fe), total	.09	.11	.06	.02	
Manganese (Mn), dissolved 2/					.00
Manganese (Mn), total	.01				
Calcium (Ca)	56	76	75	147	14
Magnesium (Mg)	5.9	9.4	20	30	1.8
Sodium (Na)	6.0	) 9.2	) 34	) 33	62
Potassium (K)	1.2				.9
Bicarbonate (HCO_3)	147	236	266	371	206 4/
Carbonate (CO_3)	0				
Sulphate (SO_4)	41	38	35	73	6.0
Chloride (Cl)	5.0	4.8	42	74	5.0
Fluoride (F)	.0	.1	.1	.0	.9
Nitrate (NO_3)	2.4	9.4	35	96	.4
~~Total~~ dissolved solids	197	273	388	652	203
Hardness as $CaCO_3$	164	228	269	490	42
Noncarbonate	44	34	51	186	0
Specific conductance (micromhos at 25° C)	327	444	657	1,050	327
pH	7.3	-	6.8	6.8	8.6

2/ In solution at time of analysis.
3/ Salt Lake City laboratory number.
4/ Includes the equivalent of 7 ppm CO_3.
9/ Alaska Rural Rehabilitation Corporation.

Table 3. - Analyses of ground water - continued
(parts per million)

Well no.	195	244	244a	277	315	347
Alaska laboratory no.	3257	3050	3051	1060	155	2024[3]
Owner	USGS	Postishek	Norris	Holtet	Yadon	Albrecht
Geologic source	Sand	Gravel	Gravel	Sand	Gravel	Gravel
Depth (feet)	112	129	58	14	36	35
Date of collection	11-16-55	6-21-55	6-21-55	11-16-51	8-22-49	Oct.1948
Silica (SiO_2)	8.9	9.9	8.9	15	13	14
Iron (Fe), dissolved[2]	.00	.02	.70			
Iron (Fe), total	.10	.12	2.4	.02	.02	.05
Manganese (Mn), dissolved[2]						
Manganese (Mn), total	.00	.01				
Calcium (Ca)	39	21	15	14	46	55
Magnesium (Mg)	4.2	3.6	2.7	2.5	5.9	20
Sodium (Na)	6.3	4.8	4.4	) 3.2	) 2.5	) 11
Potassium (K)	.8	1.6	1.0			
Bicarbonate (HCO_3)	97	91	63	55	160	172
Carbonate (CO_3)	0	0	0			
Sulphate (SO_4)	40	3.5	3.0	5.9	8.7	58
Chloride (Cl)	5	1.0	1.0	.8	1.8	3
Fluoride (F)	.0	.0	-	-	.1	-
Nitrate (NO_3)	1.0	1.6	2.7	.8	2.3	46
[illegible] dissolved solids	153	92	70	69	159	292
Hardness as $CaCO_3$	115	67	49	45	140	219
Noncarbonate	35	0	0	0	8	78
Specific conductance (micromhos at 25° C)	255	156	115	102	274	444
pH	7.8	7.1	6.8	6.9	7.3	-

2/ In solution at time of analysis.
3/ Salt Lake City laboratory number.

Table 3. - Analyses of ground water - continued
(parts per million)

Well no.	363	443	445a	462	494	522
Alaska laboratory no	1672	861	2648	159	153	216
Owner	City of Palmer	Alaska Agr. Exp. Station	USGS	Duff	Valley Christian Children's Home	Alaska Railroad
Geologic source	Gravel	Gravel	Gravel	Gravel	-	Gravel
Depth (feet)	165	36	295	32	40	21
Date of collection	11-1-52	9-11-51	11-9-54	8-14-49	8-22-49	8-31-49
Silica (SiO_2)	13	11	20	23	26	15
Iron (Fe), dissolved 2/				-		
Iron (Fe), total	.06	.02	.15	7.2	.02	.02
Manganese (Mn), dissolved 2/				.08		
Manganese (Mn), total						
Calcium (Ca)	34	54	26	-	178	27
Magnesium (Mg)	9.1	8.7	8.2	-	21	5.1
Sodium (Na)	6.2	) 3.4	11	3.4	) 15	) 5.5
Potassium (K)	1.2		.9			
Bicarbonate (HCO_3)	160	194[illegible]	140	128	471	94
Carbonate (CO_3)	0		0			
Sulphate (SO_4)	9.9	12	5.5	2.6	20	7.6
Chloride (Cl)	2.5	2.5	6.0	7.0	65	5.2
Fluoride (F)	.2	.0	-	.1	.0	.0
Nitrate (NO_3)	.2	3.2	.1	.6	81	9.9
~~Total~~ dissolved solids	155	191	147	-	638	122
Hardness as $CaCO_3$	122	170	99	111	530	88
Noncarbonate	0	11	0		144	12
Specific conductance (micromhos at 25° C)	26[illegible]	326	235	223	1,040	201
pH	7.5	7.3	7.5	7.7	7.0	7.8

2/ In solution at time of analysis.
~~5/ Includes the equivalent of 9 ppm CO_3.~~

Table 3. - Analyses of ground water - continued
(parts per million)

Well no.	522a	535	660	Spring[6]	Spring[7]	Spring[8]
Alaska laboratory no	3003	3208	324	2023[3]	214	1753
Owner	~~ARR,~~ Alaska Railroad Wasilla	Wasilla School	~~ARR,~~ Alaska Railroad Pittman	MVFCA[10]	Dinkle	-
Geologic source	Gravel	Gravel	Till(?)	Gravel	Gravel	Sandstone
Depth (feet)	131	73	40			
Date of collection	5-25-55	11-14-55	6-28-50	Oct. 1948	8-22-49	12-4-52
Silica (SiO_2)	14		28	16	18	10
Iron (Fe), dissolved[2]	.02			.04		
Iron (Fe), total	1.1	.02	1.5	.09	.02	
Manganese (Mn), dissolved[2]	.23					
Manganese (Mn), total	.46	.00				
Calcium (Ca)	28			46	18	37
Magnesium (Mg)	8.3			3.5	5.5	4.6
Sodium (Na)	6.4		) 2.8	) 7.8	) 1.6	5.7
Potassium (K)	1.2					1.0
Bicarbonate (HCO_3)	140	136	145	162	76	96
Carbonate (CO_3)	0	0				0
Sulphate (SO_4)	1.3	5	1	8.2	3.8	40
Chloride (Cl)	1.0	2	2	3	2.0	5.0
Fluoride (F)	.0	.0	.0	-	.2	-
Nitrate (NO_3)	.7	.6	1.1	1.6	1.3	1.7
dissolved solids	130		-	166	88	152
Hardness as $CaCO_3$	104	112	118	130	68	112
Noncarbonate	0			0	5	33
Specific conductance (micromhos at 25° C)	220	221	227		140	247
pH	7.6	7.9	8.0	-	6.5	6.8

2/ In solution at time of analysis.
3/ Salt Lake City Laboratory number.
6/ Brazil Spring, 3 miles northwest of Palmer.
7/ Bluff overlooking Knik Arm, 2-½ miles southeast of Wasilla.
8/ Bluff, Matanuska River half a mile southwest of Wolverine Creek.
10/ Matanuska Valley Farmers Cooperating Association.

Table 4. - Logs of representative wells in the

Matanuska Valley agricultural area, Alaska

Introductory Note

The ~~following~~ terms listed below have been used in different ways by the drillers whose logs are included in this table, or in ways that differ from the more or less standardized usage of the geologist. The following note is intended as an aid in the interpretation of the logs.

__Hardpan.__ In this area this term is commonly used for glacial till.

__Cemented sand, cemented gravel.__ These terms seem to be applied both to till and to somewhat consolidated sand or gravel.

__Glacial mud.__ Drill cuttings from several types of materials are described as "glacial mud". Clayey or silty till (especially where it [does] ~~is~~ not [contain stones] ~~conspicuously stony~~), clayey or silty sand, and ~~possibly~~ [what may be lake or] estuarine sediment, are included under this term. Hydrologic and drilling characteristics are useful in distinguishing these materials, but [because such information is generally not available for the older wells] the interpretation of many logs depends on comparison with [those] ~~the logs~~ of nearby wells.

__Gravel.__ This term seems to be used in two ways: (a) any sandy material containing stones; and (b) the stones in the deposit. Thus, many materials described as "sand and gravel" or "sand with gravel" are probably pebbly sand.

__Boulder.__ The boulders recorded by the logs probably include stones of all sizes coarser than pebbles.

Lime and limestone. It seems likely that the materials described as "lime" and "limestone" ~~probably~~ include both shale and glacial till; ~~and~~ ~~that~~ there may be little or no predominantly calcareous rock may be included.

Shale. Three usages of "shale" have been followed by drillers in this area: (a) a fine-grained consolidated rock, particularly one that breaks down to a thick mud during drilling; "slate" has also been used for such rock; (b) glacial till, which is hard and gray and breaks down to mud during ~~on~~ drilling; and (c) "slide-rock" or talus. Each reference to "shale" in the following logs probably follows one of the first two usages.

Table 4.- Logs of Representative Wells in the

Matanuska Valley Agricultural Area, Alaska

Well 4, Lazy Mountain Childrens Home; SW¼ SE¼ sec. 23, T. 18 N., R. 2 E.

Log by drillers, S. Cotton and H. K. Hamilton

	Thickness (feet)	Depth (feet)
Hardpan: clay, sand, and stones	260	260
Sand and gravel; sand at top, gravel beneath; water-bearing	20	280
Hardpan	28	308
Record missing	24	332
Boulders, hard; brown and gray clay	2	334
Record missing	26	360
Clay, brown to blue; black slate; brown quartzite; rock becomes harder with depth; open hole drilled below 334 ft; dry	365	725

Remarks: Till, 0-260 and 280-308 ft; top of bedrock probably between 334 and 360 ft; bedrock probably shale with interbedded sandstone layers.

Well 70, Victor Falk, Jr.; SE¼ SW¼ sec. 14, T. 16 N., R. 2 E.

Log by Alaska Rural Rehabilitation Corp. (ARRC)

	Thickness (feet)	Depth (feet)
Topsoil and gravel	15	15
Gravel, with boulders	21	36
Rock; a little water at 65 ft	30	66
Rock; makes 9 ft of water per hour	26	92
Rock; got more water at 107 ft; makes 45 ft of water in 1½ hours	18	110

Remarks: Water level 62 (?) ft, June 1936.

Table 4, Logs of wells - Continued

Well 80, Lee McKinley; SW¼ SW¼ sec. 22, T. 17 N., R. 2 E.

Log by driller, J. D. Conboy

	Thickness (feet)	Depth (feet)
Soil	3	3
Sand and gravel; a little water in gravel above 56 ft., but easily bailed out	53	56
Greenstone, crumbly; easy drilling	4	60
Greenstone, moderately hard drilling; dry; casing to 64 feet	52	112
Greenstone; hard drilling; dry to approximately 144 feet	32	144

Remarks: Water apparently from a fracture at 144 ft. Water level 39 ft.

Well 134, Old Civic Center Powerhouse, Palmer

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; gravel	26	26
Gravel and blue shale	27	53
Lime, blue	27	80
Mud, glacial	2	82
Water sand	13	95

Remarks: The "gravel and blue shale" is probably till; the blue lime, glacial mud, and sand may be limestone or shale and sandstone; the reported chloride content of the water (55ppm) suggests that the well penetrates bedrock. See log, well 135.

Table 4.- Logs of wells - Continued

Well 135, Old Civic Center Hospital, Palmer

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; gravel	34	34
Shale, blue	23	57
Lime, blue	69	126
Shale, broken with blue lime	13	139
Water sand, hard	16	155

Remarks: Log suggests bedrock below 34 ft; reported analysis of water (see well 135, table 5) suggests an old sea water.

Table 4.- Logs of wells - Continued

Well 142, John Cope; NE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 4, T. 18 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; boulders	28	28
Boulders and gravel; 6-in. casing ends at 39 ft.	11	39
Gravel	30	69
Boulders and gravel	5	74
Pea gravel	16	90
Mud, blue	3	93
Gravel and blue mud; makes some water at 97 ft., which will not clear	11	104
Gravel; heaves; makes some water; 4-in. casing ends at 112 ft.	8	112
Limestone and shale; 226 ft of 3- and 2½-in. liner set in hole; water cleared slowly	188	300

Remarks: Water apparently from bedrock; water level 75 feet, 1936(?).

Table 4.- Logs of wells - Continued

Well 143, E. J. LeDuc; NW¼ SW¼ sec. 4, T. 18 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; gravel and boulders	23	23
Gravel	11	34
Granite shell, blue	13	47
Lime, blue	3	50
Sand	14	64
Lime shells, broken	7	71
Gravel, broken	9	80
Gravel	8	88
Shale, sandy, blue	2	90
Gravel, heavy	7	97

Remarks: Log suggests till, 34-90 ft; see log, well 142, 90-112 ft.

Well 154, R. P. Mohan; NE¼ NE¼ sec. 9, T. 18 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; gravel and boulders	63	63
Mud, glacial, with some water	4	67
Shale, blue, sandy	12(?)	9
Gravel, fine	4	83
Quicksand; heaves 6-15 ft into casing during drilling	35	118
Gravel	5	123

Remarks: Mud and "shale", 63-79 ft, might be interpreted as till or ~~probably better,~~ as a bed of alluvial silt and sandy silt.

Table 4. Logs of wells - Continued

Well 160, H. S. Bauer, $NW\frac{1}{4}$ $SW\frac{1}{4}$ sec. 10, T. 17 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil	8	8
Gravel	23	31
Sand and gravel	11	42
Gravel	8	50
Gravel and quicksand	4	54
Gravel and sand	5	59
Gravel	7	66
Clay	12	78
Sand	87	165
Gravel	10	175

Remarks: Water level 79 ft/, 1949; sand, 78-165 ft, is assumed to have been fine sand that become unsuitable during drilling ~~been quicksand~~, because ~~inasmuch as~~ the well was not finished until gravel was reached.

Well 176, George Crowther; $NE\frac{1}{4}$ $SW\frac{1}{4}$ sec. 9, T. 18 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; gravel and large boulders	39	39
Gravel and sand, broken	7	46
Sand with glacial mud, blue	5	51
Gravel	20	71
Quicksand	32	103
Gravel	10	113

Remarks: Water level 70 ft.

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Table 4. Logs of wells - Continued

Well 179, A. C. Erickson; NW¼ SW¼ sec. 9, T. 18 N., R. 2 E.

Log by driller, A. R. Moffitt

	Thickness (feet)	Depth (feet)
Soil	4	4
Rock	2	6
Sand	1	7
Gravel with clay	8	15
Rock	2	17
Hardpan; "cemented sand"	55	72
Gravel	29	91

Remarks: Driller's description of hardpan, 17-72 ft, suggests that it may be till; water level 82.10 ft, Aug. 4, 1952.

Well 182, Ray Rebarchek; NW¼ SE¼ sec. 8, T. 18 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; gravel and boulders	47	47
Clay, blue, with some water that appears to rest upon the clay	6	53
Gravel	15	68
Quicksand	5	73
Gravel	14	87
Water, gravel and sand	2	89

Remarks: Water level 84 feet.

Table 4.- Logs of wells - continued

Well 195, Test well, U. S. Geological Survey;

E½ NE¼ sec. 17, T. 18N., R. 2 E.

Log by U. S. G. S.

	Thickness, (feet)	Depth, (feet)
Silt, tan to gray	3	3
Gravel, sandy, with pebbles and cobbles; light brown	12	15
Gravel, sandy, with small pebbles; light brown	12	27
Sand, medium to coarse, with pebbles; light brown	2	29
Silt and fine sand, with pebbles; light brown	8	37
Gravel, sandy and pebbly, with streaks of silt and clay; rusty brown	3	40
Sand, medium to coarse, with streaks of silt and clay; rusty brown	9	49
Gravel, with sand, silt, and clay; dark brown; hard; casing drives with difficulty but hole does not stand open ahead of casing	9	58
Silt and clay, with fine to medium sand; brown; hard; hole stands open ahead of casing, 58-77 ft	19	77
Sand, medium to fine, with pebbles and streaks of silt and clay; brown	12	89
Sand, medium to fine, with streaks of silt and clay; brown	14	103
Sand, medium to coarse; pebbly; brown, heaves into casing during drilling	2	105
Sand, with streaks of silt and clay; brown	4	109
Sand, medium to coarse, pebbly; brown	2	111

	Thickness, (feet)	Depth, (feet)
Sand, medium to coarse, with small pebbles and streaks of silt or clay; brown; 60-slot screen set at 110-114 ft; drawdown 23 ft, after pumping 27½ hrs at 53 gpm..........	6	117
Sand, fine to medium, with streaks of silt and clay; dark to rusty brown; heaves into casing during drilling..........	48	165
Sand, fine to medium, with silt or clay; dark brown; hole stands open ahead of casing..........	6	171
Sand, fine and medium, silty; brown; heaves into casing during drilling..........	39	210
Sand, fine, silty; brown..........	8	218
Sand, fine to coarse, with silt, clay, and occasional pebbles; light to dark brown; heaves into casing during drilling..........	22	240
Sand, fine to medium, and silt or clay; brown to gray or greenish gray; hole stands open 6 to 10 ft. ahead of casing during drilling, before walls cave...	19	259
Sand, coarse, and small pebbles; gray..........	2	261
Gravel, fine, and clay; gray..........	3	264
Greenstone; hard; dry..........	18	282

__Remarks__: See graphs, fig. 4, showing particle-size distribution in representative samples from this well.

Table 4.- Logs of wells - Continued

Well 228, Fred Joiner; NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 8, T. 17 N., R. 2 E.

Log by driller, A. R. Moffitt

	Thickness (feet)	Depth (feet)
Soil	2	2
Gravel	12	14
Sand, coarse	1	15
Gravel, coarse	7	22
Gravel, fine, loose	20	42
Sand and clay	2	44
Gravel	4	48
Rock	2	50
Gravel	26	76
Sand, coarse	16	92
Hardpan	9	101
Sand and gravel, with water	12	113

Remarks: Water level 97 ft. See log of well 229.

Table 4.- Logs of wells - Continued

Well 229, A. R. Moffitt; NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 8, T. 17 N., R. 2 E.

Log by driller, A. R. Moffitt

	Thickness (feet)	Depth (feet)
Soil	4	4
Gravel	12	16
Hardpan	9	25
Gravel	14	39
Boulders	2	41
Gravel	15	56
Rock	3	59
Sand, very dry	7	66
Hardpan	5	71
Sand and clay	25	96
Hardpan	9	105
Bedrock, black; some water on top of it	4	109
Sand and gravel; some water	2	111
Rock, black	13	124
Gravel	2	126
Rock, black	3	129

Remarks: Well cased to 119 feet; water level 103 feet. It is concluded from verbal description by the driller and from examination of cuttings of the black rock, 105-109 feet, that the log represents bedrock below 105 feet; the black rock is hard graywacke and the sand and gravel may be softer (shaly?) material.

Table 4.- Logs of wells - Continued

Well 251 a, Paul James; NE¼ NW¼ sec. 27, T. 19 N., R. 3 E.

Log by driller, S. Cotten

	Thickness (feet)	Depth (feet)
Gravel, with boulders, and sand	11	11
Gravel, with boulders, and sand and clay	6	17
Gravel, fine, with sand and clay; water-bearing in part	11	28
Gravel, fine, with sand and clay; dry	2	30
Hardpan: clay, fine gravel, and sand, hard, dry	30	60
Gravel, fine, water-bearing	12	72

Remarks: Originally drilled to 42 ft, and casing pulled back to 29 ft, water level was 20 ft, summer, 1953; water level of deepened well, 55 ft, January 1954.

Table 4.- Logs of wells - Continued

Well 251 b, Harve Estep; NE¼ NW¼ sec. 27, T. 19 N., R. 3 E.

Log by driller, S. Cotten

	Thickness (feet)	Depth (feet)
Soil, clay and fine gravel	6	6
Clay, with sand and fine gravel	6	12
Sand and medium gravel; less clay	6	18
Clay and silt, brown, with fine gravel	6	24
Clay and silt, brown, with coarse gravel; water at 30 ft	6	30
Sand, coarse gravel, and clay	3	33
Sand and coarse gravel	3	36
Record missing	6	42
Hardpan	22	64
Gravel, sandy, with pebbles; water-bearing	2	66

Remarks: Originally drilled to 41 ft but well went dry; deepened to 66 ft. Water levels in deepened well, 43 ft in February 1954 and 23 ft in June 1954.

Table 4. - Logs of wells - Continued

Well 256, Walter Mayr; SE¼ NW¼ sec. 32, T. 19 N., R. 3 E.

Log by drillers, S. Cotten and H. K. Hamilton

	Thickness (feet)	Depth (feet)
Soil, fine gravel	22	22
Clay, sand, and medium gravel; very dry except for a little water at 55 ft	39	61
Clay and medium gravel	8	69
Clay, heavy	22	91
Rocks, large, and clay	2	93
Rocks, large	8	101
Clay, heavy, and medium gravel	6	107
Clay and coarse gravel	11	118
Gravel, fine, with sand and a little clay	9	127
Gravel and sand, brownish, with less clay	23	150
Gravel, loose, and clay and sand	13	163
Gravel, fine, and sand; little clay	11	174
Gravel, sand, and clay, water (7-9 ft)	5	179
Gravel and sand, less clay; water	7	186

Remarks: Water level, 171 ft, summer 1953. Log of older, shallow well suggests gravelly material to 33 ft, till below 33 ft. Material to 118 ft is interpreted as till, and the absence of water until about 174 ft (confirmed verbally by drillers) suggests that till extends ~~at least~~ to 174 ft.

Table 4. - Logs of wells - Continued

Well 257, Kenneth Wallace; SE¼ NW¼ sec. 31, T. 19 N., R. 3 E.

Log by driller, S. Cotten

	Thickness (feet)	Depth (feet)
Record missing (see remarks)	280	280
Hardpan; at 307 ft, "sludge soil, brown"	27	307
Clay, brown	23	330
Boulders and clay	5	335
Clay with much sand and fine gravel	5	340
Sand with clay and fine gravel	10	350
Record missing	7	357
Clay, brown, and gravel; open hole drilled ahead of casing, 357-367 ft	18	375
Sand and clay	7	382
Gravel, medium, and sand, with interbedded layers of brown clay; water encountered at 412 ft	36	418

Remarks: Water level, 401 ft, August 1955. Verbal description by driller suggests till, 0-280 ft; log of old well records interbedded "hardpan" and gravelly layers to total depth of 37 ft. The sequence is interpreted as till to a depth of about 412 ft. The character and significance of the "sludge soil" at 307 ft are not known, but it may be ~~represent~~ a weathered zone in the till.

Table 4. - Logs of wells - Continued

Well 258, Richard Diedrick; SE¼ SW¼ sec. 30, T. 19 N., R. 3 E.

Log by driller, S. Cotten

	Thickness (feet)	Depth (feet)
Record missing	—	—
Hardpan	—	173
Clay, brown, wet	3	176
Gravel, dry	2	178
Clay, brown, wet	1	179
Gravel, fine, with water	3	182
Gravel, fine, and brown clay, in alternating streaks	8	190

Remarks: Water level, 178 ft, June 20, 1955. Verbal description by driller indicates there is no distinctive lithologic break just above 173 ft. Log of old well records gravel, 0-10 ft, and hardpan (till), 10-148 ft. The sequence is interpreted as till to a depth of at least 178 ft.

Table 4.- Logs of wells - Continued

Well 267, Frank Rush; NW¼ SE¼ sec. 9, T. 18 N., R. 2 E.

Log by driller, A. R. Moffitt

	Thickness (feet)	Depth (feet)
Gravel	18	18
Sand	18	36
Hardpan	7	43
Rock	3	46
Hardpan	24	70
Sand, water-bearing	2	72
Clay, blue	4	76
Sand	10	86
Hardpan	2	88
Sand, water-bearing	5	93

Remarks: Casing to 93 ft.; water level 72 ft., winter 1953. Formations between 36 and 88 ft. interpreted as one till sequence.

Table 4.- Logs of wells - Continued

Well 270, Leroy Hammond; NW¼ SE¼ sec. 9, T. 18 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; gravel with large boulders	39	39
Clay, blue, hard	4	43
Shale, sandy, blue	9	52
Gravel and sand	19	71
Sand, blue, with glacial mud	12	83
Gravel, fine	7	90
Gravel; water encountered at 90 ft.	5	95

Remarks: Blue sand and mud, 71-83 ft., interpreted as till; clay and "shale", 39-52 ft., may be interpreted as till, or, probably more reasonably, as alluvial or pond silt and clay; see log of well 271. Well deepened to 99 ft.; water level 83 ft., September 1955.

Table 4.- Logs of wells - Continued

Well 271, Richard Tunnicliff; SE¼ SE¼ sec. 9, T. 18 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; gravel with large boulders.............	41	41
Sand and gravel, gray............................	55	96
Sand and glacial mud............................	12	108
Gravel, brown; water encountered at 118 ft......	16	124

Remarks: Sand and mud, 96-108 ft., interpreted as till; the brown color of the underlying gravel may indicate weathering before the overlying material was deposited; water level 80 ft., summer 1950. Well deepened to 143 ft., 1955; according to verbal description by the driller, hardpan was encountered at some level below 124 ft, a "soft zone" was penetrated at 136 ft, and water was encountered below 140 ft; the water level did not rise above 136 ft.

Table 4.- Logs of wells - Continued

Well 273, Len Allman; SE¼ SW¼ sec. 9, T. 18 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; gravel with large boulders and sand.....	43	43
Gravel and sand..................................	25	68
Sand, blue, with some water......................	18	86
Gravel, brown, with water........................	3	89

Remarks: Blue sand lying over brown gravel is interpreted as till (?), by comparison with material in well 271 (see log). Water level, 86 ft, when well drilled (1936?); dry, September 1950.

Well 285, James Berry; SW¼ SW¼ sec. 17, T. 18 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; gravel..................................	29	29
Gravel with boulders.............................	11	40
Gravel...	12	52
Lime shell, gray.................................	30	82
Sand, brown, hard, water-bearing.................	12	94

Remarks: Water level reported to have been 45 ft. "Gray lime shell", 52 - 82 ft, interpreted as till overlying weathered sand.

Table 4. - Logs of wells - Continued

Well 294, S. A. Boyd; SW¼ SE¼ sec. 14, T. 18 N., R. 1 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil	5	5
Gravel	66	71
Mud, blue, and sand	5	76
Muck, blue	29	105
Mud, blue, and sand	19	124
Mud, blue; 13 ft/ of water	5	129
Clay formation	34	163
Sand and clay; casing to 193 ft; water level 61 ft	31	194

Remarks: Blue mud, sand, and clay, 71 - 163 ft/, interpreted as till.

Table 4. - Logs of wells - Continued

Abandoned well near well 305; ARRC tract 132;

probably SW¼ NE¼ sec. 20, T. 18 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil	15	15
Gravel	48	63
Mud, blue, and gravel	38	101
Gravel, loose-running	15	116
Gravel	39	155
Gravel, cemented	23	178
Pea gravel	3	181
Gravel, cemented	6	187
Gravel	11	198
Mud, blue	17	215
Mud, blue, and shale rock; pipe stopped at 226 ft on 2-ft ledge of hard shale	11	226
Shale; open hole below 226 ft; well abandoned: dry hole	284	510

Remarks: Blue mud and gravel, 63-101 ft, and blue mud and shale, 198-226(?) ft, are interpreted as till. The layers of cemented gravel may be slightly consolidated gravel; or, with the intervening pea gravel and the underlying blue mud, they may be part of one till sequence. The blue mud and shale, 198-226(?) ft, are considered to be till that contains shale, rather than shale bedrock, because the driller distinguished between the mud and the harder shale below 226 ft.

Table 4. - Logs of wells - Continued

Well 306a, Wallace Moffitt; SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 20, T. 18 N., R 2 E.

Logs by driller, A. R. Moffitt

	Thickness (feet)	Depth (feet)
Soil	10	10
Sand	4	14
Boulders	27	41
Sand	4	45
Hardpan	15	60
Sand, brown	3	63
Hardpan; boulder at 68-69	16	79
Sand and clay; water	4	83
Clay, blue, soft	10	93
Sand, cemented	34	127
Clay, blue, hard	30	157
Hardpan	13	170
Sand, gray, hard	20	190
Sand, loose, dry	10	200

Remarks: The section between 45 and 170(?) ft appears to comprize one or more tills.

Table 4- Logs of wells - Continued

Well 308, Oscar Kerttula; NE¼ SE¼ sec. 20, T. 18 N., R. 2 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil; gravel with boulders	76	76
Clay, blue, hard	3	79
Shale, sandy, blue	8	87
Sand, blue, and glacial mud	4	91
Gravel and sand, water-bearing	5	96

Remarks: The section between 76 and 91 ft is interpreted as till and is correlated with till exposed in the river bluff a quarter of a mile to the east.

Well 320, Earl Hecker; SW ¼ NW¼ sec. 30, T. 18 N., R. 2 E.

Log by driller, A. R. Moffitt

	Thickness (feet)	Depth (feet)
Soil; gravel	10	10
Hardpan; boulder at 35-37 ft	31	41
Sand; water	2	43
Sand, cemented	7	50
Sand; water	2	52
Sand, cemented	16	68
Sand; water	5	73
Hardpan; casing to 73 ft; water level, 43 ft, March 1953	2	75

Remarks: Entire section below 10 ft interpreted as till with thin water-bearing sandy beds.

Table 4.- Logs of wells - Continued

Well 346, Richard Demming; NW¼ SW¼ sec. 28, T. 18 N., R. 2 E.

Log by owner

	Thickness (feet)	Depth (feet)
Sand and silt, windblown; water at 33-34 ft is reported to have risen 4 ft in well	34	34
Hardpan; ~~with~~ layer of wet sand at 92-94 ft	66	100
Gravel; water level, 96.42 ft, Jan. 1954	26	126

~~Remarks:~~

Table 4. - Logs of wells - Continued

Well 371a, Dexter Bacon; NE¼ NE¼ sec. 32, T. 18 N., R. 2 E.

Log by driller, A. R. Moffitt

	Thickness (feet)	Depth (feet)
Soil	7	7
Boulders	13	20
Sand; water	2	22
Hardpan with boulders	20	42
Sand; water	3	45
Hardpan	5	50
Rock	2	52
Sand, cemented	66	118
Boulders	7	125
Clay, blue gummy; no stones	20	145
Sand; water	5	150
Clay	2	152

Remarks: Water level 82 ft, November 1954. Units between 22 and ~~118~~ 125 (?) ft interpreted as till.

Table 4. - Logs of wells - Continued

Well 434, Fred Larson; SE¼ NW¼ sec. 16, T. 17 N., R. 1 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Soil; gravel with boulders	31	31
Mud, glacial, blue, with sand; water	35	66
Sand, blue; some water	6	72
Mud, glacial, blue, very fine; water	40	112
Sand, grey; water	7	119
Sand; water	17	136

Remarks: Driller was unable to stabilize formation between 72 and 112 ft., and water would not clear. Well first finished at 119 ft., but after 30 days ~~use~~ the overlying "blue mud" broke through the sand ~~at the bottom of the casing~~ and filled the casing.

Table 4. - Logs of wells - Continued

Well 437. Eugene Kneff; NW¼ SE¼ sec. 16, T. 17 N., R. 1 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Soil; sand	12	12
Gravel with boulders	6	18
Sand, brown, with boulders	11	29
Mud, glacial, blue; some water	51	80
Mud, glacial, blue, with gravel and boulders	6	86
Sand, brown, soft; water-bearing	5	91

Remarks: Mud with gravel and boulders, 80-86 ft, interpreted as till. Mud with some water, 29-80 ft, may be all or in part till, or stream or standing-water deposits laid down near the ice; interpretation is difficult because it is not known whether the reported water was encountered in thin zones or was found generally through the unit, whether any sand or stones were present, or what were the drilling characteristics of the material. ~~If stony~~ If it contained stones, and if the water ~~occurs in~~ more permeable zones are relatively thin ~~zones~~, the material is ~~likely to be~~ probably till. See discussion of till in section on geology, in text. Logs 438, 439, 442, 445a, 445c, 447, 496, 578, and 596a illustrate the range in character of deposits that are probably similar to these materials.

Table 4. - Logs of wells - Continued

Well 438. Henry Jensen; SW¼ SE¼ sec. 16, T. 17 N., R. 1 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Soil; gravel with boulders and sand	67	67
Mud, glacial, blue; with water	137	204
Clay, blue, hard	4	208
Gravel, water-bearing; water level 30 ft	8	216

Remarks: See log, well 437.

Well 439. R. C. Collins; SE¼ SE¼ sec. 16, T. 17 N., R. 1 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Soil; gravel with boulders	35	35
Gravel and sand	34	69
Mud, glacial, blue; heaves into casing as much as 30-60 ft during drilling	111	180
Sand and gravel	7	187
Sand and gravel; water	2	189
Gravel; water level 25 ft, July 1949	3	192

Remarks: The mud that heaves is considered not to be till. See log, well 437.

Table 4. - Logs of wells - Continued

Well 442, Eugene Kneff; NE¼ SE¼ sec. 16, T. 17 N., R. 1 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Soil; sand	13	13
Gravel, fine	29	42
Mud, glacial, blue, with gravel and boulders	24	66
Gravel; water	2½	68½
Sand, brown; water	½	69
Gravel	39	108
Mud, glacial, blue, with gravel and boulders	18	126

Remarks: Casing was pulled back to 68½ ft and well finished there. Mud with gravel and boulders, 42-66 and 108-126 ft, interpreted as till.

Table 4. Logs of wells - Continued

Well 445a, Test well, U. S. Geological Survey;

Alaska Agricultural Experiment Station

NE¼ NW¼ sec. 15, T. 17 N., R. 1 E.

Log by U. S. G. S.

	Thickness, (feet)	Depth, (feet)
Silt, wind-blown	3	3
Sand and gravel	18	21
Sand, fine	11	32
Quicksand, fine	7	39
Sand, fine, pebbly	3	42
Sand, fine, with silt and clay	5	47
Quicksand, fine to medium, pebbly	5	52
Clay, sandy, blue-gray	3	55
Quicksand, fine, gray-brown	6	61
Sand, fine, with silt and clay; occasional pebbles; soft; gray to gray-brown	29	90
Quicksand, fine to medium; gray to dark brown	17	107
Sand and pebbles, with some cobbles; gray-brown; heaves	6	113
Till ("hardpan"): clay, silt, sand, and stones; hard, gray; stands open ahead of casing	19	132
Sand, fine to medium	4	136
Sand, fine, silty	4	140
Sand, fine, pebbly	6	146
Sand, fine, with silt and clay; heaves	4	150
Sand, fine, pebbly; heaves	2	152

	Thickness, (feet)	Depth, (feet)
Sand, fine to coarse, silty, with small pebbles; heaves	7	159
Sand, coarse, pebbly; bailed at 161 ft for 30 min, at about 20 gpm; water level dropped from 25 ft below land surface to 60 ft below land surface; after bailing, water rose 6 in above land surface..................................	2	161
Sand, fine, pebbly..................................	4	165
Gravel with silt and clay..................................	2	167
Till ("hardpan"): clay, silt, sand, and stones; gray; hard till, stands open ahead of casing: 167-185, 196-215, 223-224; soft till, caves: 185-196, 215-223, 244-254	87	254
Sand with pebbles	5	259
Sand, fine to coarse	3	262
Sand, medium to coarse	1	263
Sand and gravel: medium to coarse sand with occasional pebbles and cobbles; pebbly and cobbly, 287-295 ft; heaves during bailing, 263-269 ft; <u>At 289 ft</u>: drawdown 69 ft after pumping 2½ hours at an average rate of 73 gpm from open end of 6-in casing..................................	32	295
<u>At 295 ft</u>: with slotted 5-in liner, drawdown 64 ft after pumping 5 days at 142 gpm		
Till; hard, gray..................................		at 295

<u>Remarks</u>: Material above 52 ft is dominantly brown; material below 52 ft is dominantly gray except where noted. See log of well 445c.

Table 4.- Logs of wells - continued

Well 445c, Test well, U. S. Geological Survey;

Alaska Agricultural Experiment Station

NE¼ NW¼ sec. 15, T. 17 N., R. 1 E.

Log by U. S. G. S.

	Thickness, (feet)	Depth, (feet)
Silt, tan to gray-brown	3	3
Gravel, sandy; brown	2	5
Sand; brown	4	9
Gravel, pebbly, cobbly, and silty; brown	15	24
Sand, silty; brown	8	32
Quicksand; silty fine sand with silt laminae; brown	6	38
Sand, fine, silty, with medium to coarse sand and granules; brown	10	48
Sand, fine, silty, with medium to coarse sand, granules, and pebbles; gray	6	54
Sand, fine, silty, with medium to coarse sand and granules; contains layers of silt at least a half an in thick that have occasional granules; generally gray, but brownish sand noted at 69 ft	20	74
Sand, fine to medium, silty and pebbly, with occasional layers of clean coarse sand and pebbles; heaves into casing between 106 and 112 ft; gray	38	112

	Thickness, (feet)	Depth, (feet)
Till; silt, sand, and clay with angular to rounded granules and pebbles; drill cuttings include massive, tough silt-clay chunks with embedded sand, granules, and pebbles; occasional sandy streaks; gray	25	137
Sand, fine to medium, very silty, in part pebbly, with occasional layers of clean sand; heaves into casing; gray	17	154
Sand, fine, silty; in part coarser and pebbly; gray	11	165
Till; silt, sand, and clay with angular to rounded granules and pebbles; cuttings include tough silt-clay chunks with embedded sand, granules, and pebbles; gray; stands open ahead of casing: 166-194 and 198-248 ft; stony till, "drills like gravel", does not stand open ahead of casing: 194-198 ft; sandy till (?), 248-256 ft	91	256
Sand, fine, silty, with medium to coarse sand and pebbles; gray; heaves into casing, 256-257 ft	11	267
Sand, silty, with many granules and pebbles; hard; gray; stands open ahead of casing	4	271
Sand, fine to medium, clean, with streaks of silty sand; gray	9	280
Sand, fine, and silt with many granules and small pebbles; gray; heaves into casing	4	284

	Thickness, (feet)	Depth, (feet)
Till(?); silt and fine sand with coarser sand, granules, and pebbles; many angular rock chips, probably broken by the drill; cuttings also include massive silt-clay chunks with embedded sand, granules, and pebbles; gray; stands open ahead of casing, 291-295 ft..................................	11	295
Sand, coarse, silty and pebbly; gray; heaves into casing..	3	298
Till (?); silt and fine sand with coarser sand and pebbles; silt-clay chunks in drill cuttings; gray....	6	304
Sand, medium to coarse, with fine sand and granules; clean; gray; heaves into casing......................	2	306
Sand, medium to coarse; clean; gray..................	2	308
Sand, coarse, very silty; gray; stands open ahead of casing..	2	310
Sand, coarse and pebbly; gray........................	3	313

Remarks: The log units interpreted as till (?), 284 to 295 and 298-304 ft, are indistinguishable in drilling characteristics and in the nature of the drill cuttings from the higher units interpreted as till.

Table 4. - Logs of wells - Continued

Well 447, C. I. Branton; NW¼ NW¼ sec. 22, T. 17 N., R. 1 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Soil	4	4
Gravel	92	96
Quicksand	130	226
Mud and gravel; water level 126 ft	24	250
Gravel and coarse sand; water level 73 ft	23	273
Record missing; water level 74 ft	25	298

Remarks: The reported difference in water levels suggests that the mud and gravel, 226-250 ft, is somewhat impervious. If the reported water level, 126 ft, was observed at or near the top of the formation only, it could be considered to be the water level in the overlying sand. If the water level was observed only near the bottom of the formation it probably reflects leakage from the deeper aquifer, which is considered to be artesian.

Table 4. - Logs of wells - Continued

Well 448, Allen Linn; NE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 15, T. 17 N., R. 1 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Soil	5	5
Gravel	19	24
Mud and gravel	15	39
Quicksand	6	45
Gravel, boulders	16	61
Rock, solid	4	65
Gravel, rock	4	69
Rock formation	24	93
Gravel; water	13	106
Solid formation	2	108

REMARKS: The formations between 69 and 93 ft and below 106 ft are thought to be till. Well 449, a few hundred ft away, records "shale and sand (blue)" at 79 to 89 ft. The "mud and gravel" at 24 to 39 ft may also be till, although no comparable formation is recorded for well 449.

Table 4. - Logs of wells - Continued

Well 496, Valley Christian Childrens Home; SW¼ SW¼ sec. 6, T. 17 N., R. 1 E.

Log by driller, S. Cotten

	Thickness (feet)	Depth (feet)
Soil; loose gravel with boulders	6	6
Sand and gravel, loose; a little water at 40 ft	34	40
Clay, blue	42	82
Clay, blue, and gravel; rocks and a little water at 107 ft; clean sand with water, 158-161 ft	87	169
Sand, fine to medium, clean; water encountered at 169 ft, rose to about 130 ft; sand heaves 25-35 ft into casing	61	230
Sand, fine, with a little fine gravel and clay	12	242
Record missing	16	258
Clay	26 ~~(27)~~	284
Clay, blue, and gravel	21	305
Bedrock: gray quartzitic sandstone		at 305

Remarks: Clay and gravel, 82-169 and 284-305 ft, interpreted as till. See records of wells 490, 491, and 492, table 5. Till is exposed in a hill between wells 491 and 496.

Table 4. - Logs of wells - Continued

Well 578, Joseph Gislason; $SW\frac{1}{4}$ $SW\frac{1}{4}$ sec. 18, T. 17 N., R. 1 E.

Log by ARRC

	Thickness (feet)	Depth (feet)
Topsoil	5	5
Sand and gravel	70	75
Sand, coarse	15	90
Gravel, mud, and sand; blue and mucky water, easily bailed out	20	110
Mud, glacial, and gravel, blue and thick; some water	18	128
Mud, glacial, and sand	11	139
Mud, blue	35	174
Gravel, red; water level 80 ft, summer 1948	6	180

Remarks: The red gravel below 174 ft is interpreted as weathered gravel that was covered by other deposits during a later glacial episode. The high artesian water level and the description of the material between 90 and 174 ft suggest that at least part of that material is till.

Table 4.- Logs of wells - Continued

Well 596 a, Ralph Bradley; NW¼ NE¼ sec. 23, T. 17 N., R. 1 W.

Log by driller, S. Cotten

	Thickness (feet)	Depth (feet)
Hardpan; dug well (no. 596)........................	25	25
Hardpan, sandy; wet; open hole can be drilled ahead of casing only about 1-2 ft..............	21	46
Hardpan, contains more clay; hole stands open for several ft. ahead of casing................	14	60
Record missing; owner reports that hardpan extents to 90 ft...............................	30	90
Sand, ~~at 90 ft~~..................................		at 90

Remarks: Till is exposed in surface cuts nearby. For information regarding dug well, see well 596, table 5.

Table 5. - Records of wells in the

Matanuska Valley agricultural area, Alaska

Explanation

(Location of wells shown on plate 1.

Type of well: B, bored with auger; D, dug; Dn, driven; Dr, drilled; J, jetted.

Depth of well, and water level: depth of well or water level recorded to nearest foot was reported; a depth of the nearest tenth or hundredth of a foot was measured.

Water-bearing material: R, bedrock; T, till ("hardpan"); G, gravel; S, sand; C, clay.

Method of lift: Power-E, electric motor; H, hand. Pump-C, centrifugal; J, jet; L, lift; P, pitcher; S, submersible; T, turbine; W, windlass.

Use of water: D, domestic; N, not in use; O, observation well; P, public supply; S, stock (may include cooling milk).

Well-numbering system: The wells are designated by simple consecutive numbers. In sequence the well numbers follow approximately the physiographic units described in this report. The first wells listed are on the lower slope of Lazy Mountain. Wells east of the Matanuska River and north of the Knik River are listed next. Then follow, in order, wells on the terrace at and south of Palmer, wells between Eska Creek and the vicinity of the Matanuska Agricultural Experiment Station, and wells located in the remainder of the agricultural area to the west and southwest.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
317	SW¼ SW¼ sec. 19	Mrs. R. Burocher	ARRC	1935	Level surface	440	D	21	36	G	19	....	EJ	D,S	
318	NE¼ NW¼ sec. 30	Alfred Kirsch	do.	1936	do.	440	Dr	50	4	G	37	Sept. 21,1936	EJ	D	
319	Do.	J. R. Elmore	J. Currie	1951	Gentle slope	454 450	Dr	53	6	G	24	Aug. 1951	EJ	D	Small inflows of water reported at 23 ft and at 32 ft during drilling; soil, gravel and sand, 0-53 ft.
320	SW¼ NW¼ sec. 30	Earl Hecker	A. R. Moffitt	1953	Level surface (river terrace)	441	Dr	75	4	S	43	Mar. 1953	EJ	DS	Bailed 5 gpm with 6 ft of drawdown; see log; former dug well on this property, gravel to 47 ft, had water level 42 ft.
325	NE¼ SW¼ sec. 30	T. Bentti	Owner	1946	Depression	..	D	9	36	S	4.0	July 6, 1946	HL	D	
326	NW¼ NW¼ sec. 30	Harry Campbell	ARRC	1936	Level surface	429	Dr	28	4	S	24	....	HL	D	Gravel to 28 ft.
327	NW¼ SE¼ sec. 30	Thomas Moffitt	do.	1936	Hill-side	453	Dr	52	4	G	45.05	May 24, 1955	..	O	Gravel to 52 ft; MP top of casing, 0.5 ft above land surface.
327 a	NE¼ SE¼ sec. 30	do.	A. R. Moffitt	1955	Level surface (river terrace)	455	Dr	~~70~~ 70.4	6	GS	45.05	May 24, 1955	EJ	DS	Bailed 12 gpm with 7 ft of drawdown; till, 40(?)-66 ft; MP top of well curb, 0.3 ft above land surface; well is 325 ft east of well 327.
330	SW¼ SW¼ sec. 20	L. W. Hanson	S. Cotton	1954	do.	506	Dr	84	6	GS?	70	July 1954	..	D	Bailed 14 gpm; till, 39-74(?) ft.
331	NE¼ NW¼ sec. 29	Vernon Williams	ARRC	1936	Gentle slope	487	Dr	63	4	G	55	Feb. 4, 1936	EJ	D,S	Gravel to 63 ft.
332	SE¼ SW¼ sec. 20	John Reed	....	..	Depression	484	D, Dr	60	4	G	...	....	EJ	D	Originally dug to 48 ft; till below 45 ft; water from gravel in till, 53 to 58 ft.
333	NW¼ NE¼ sec. 29	B. L. Sisco	ARRC	1935	Level surface (river terrace)	485	D, Dr	107	4	G	95	Dec. 5, 1935	EJ	D, S	Originally dug to 65 ft; gravel to 107 ft.
334	NW¼ NW¼ sec. 29	Alva Saxton	do.	..	do.	480	Dr	101	4	G	88	....	..	D	Gravel to 101 ft.
338	SW¼ NW¼ sec. 28	Earl Cook	T. Moffitt	1947	do.	476	Dr	45	4	T	...	....	..	N	Dry since 1949; never yielded more than 50 gpd.
339	Do. ~~SW¼ NW¼ sec. 28~~	T. Dickinson	Owner	1949	Gentle slope	490	D	70	42	S	66	1949	HW	D	MP top of well cribbing, about 5 ft below original land surface; well on dune ridge, sand 40 ft thick.
340	Do. ~~SW¼ NW¼ sec. 28~~	Ferber Bailey	do.	1949	do.	472	D	58	42	T	46.0	July 12, 1949	HW	D	Sand and silt, 0-22 ft; gravel, 22-36 ft; till, 36-58 ft; ~~Till below 36 ft~~; water derived from till at depth of 48 to 58 ft.
341	NW¼ SW¼ sec. 28	William Reid	F. Bailey	1950	Level surface (river terrace)	440	D	27	42	G	25.42	June 15, 1950	EJ	D	MP top of well cribbing, ~~0.50~~ 0.5 ft above land surface.
342	Do.	John Sisley	do.	1950	do.	440	D	25	42	G	24.00	June 15, 1950	EJ	D	MP top of well cribbing, at ground level.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
293	[illegible] SE¼ sec. [illegible]	R. N. Cather	A. and J. D. Frey	1951	Hilltop	[illegible]	Dr	[illegible]	4	G	[illegible]	Dec. 11, 1956 1951	EL EJ	D,S D S	See log. Childrens Home
294	SW¼ SE¼ sec. 14	S. A. Boyd	ARRC	1935	Level surface (river terrace)	560	Dr	194	4	S	61	July 1951	EC	D	
295	SE¼ SE¼ sec. 14	Leonard Kyger	....	..	Gentle slope	498	D	20	36	G	12	Aug. 27, 1951	EJ	D,S	MP top of concrete well curb, 7 ft, below ground surface
297	SE¼ SW¼ sec. 13	do.	....	..	Level surface (floodplain)	489	D	14	24	G	12				
300	~~T. 19 N., R. 2 E.~~ NW¼ NE¼ sec. 19	R. L. Busby	ARRC	1935	Level surface (river terrace)	513	DDr	50	4	G	40	Jan. 1949	EJ	D,S	Originally dug to 44 ft; sand and gravel to 50 ft.
301	NE¼ NW¼ sec. 19	G. LaRose	do.	1936	do.	508	D	38	..	G	34	Mar. 12, 1936	..	D,S	
302	SE¼ NW¼ sec. 19	Lew Hanks	do.; A and J. O. Frey	1936	do.	512	DDr	53	4	S	42	Aug. 1951	EJ	D	Drilled to 43 ft, 1936, and to 53 ft, 1951.
304	NW¼ NW¼ sec. 21	~~Swoboda~~ Bernard Swoboda	S. Cotten	1955	do.	533	Dr	70	6	G	58	May 1955	E	D	On levelled ground 10 ft, below original land surface; till at 70 ft; bailed 1.5 gpm.
305	SW¼ NE¼ sec. 20	Patrick Cullison	ARRC; ~~S. Moffitt~~ Oren Moffitt	1936 1951 1954?	Gentle slope	540	Dr	160	4	S	...	....	EJ	DS	Soil, gravel, 0-71 ft; till, 71-140 ft; hard sand, some water, 140-152 ft; clay, 152-155; sand, water 155-160 ft; several deep wells on this property have been dry.
306	SE¼ NE¼ sec. 20	Wallace Moffitt	ARRC	1935	Level surface (river terrace)	528	Dr	120	4	G	79	Nov. 13, 1935	..	N	Soil, gravel, 0-70 ft; quicksand and gravel 70-79 ft; blue mud (till), 79-90 ft; gravel, 90-103 ft.
306 a	Do.	do.	A. R. Moffitt	1955	Low bluff (terrace scarp)	533	Dr	84	6	SG	80	Summer 1955	E	D	6-in casing to 179.5 ft, open hole to 200 ft; backfilled, cemented, and dynamited at 84 ft; see log.
307	NW¼ SE¼ sec. 20	William Lentz	Owner	..	Level surface (river terrace)	528	D	66	24	G	65(?)	....	EJ	D,S	Lined with metal culvert pipe.
308	NE¼ SE¼ sec. 20	Oscar Kerttula	ARRC	..	do.	..	Dr	96	4	G	...	....	EJ	D,S	See log.
310	SW¼ NW¼ sec. 20	Mrs. F. Werner	....	..	do.	501	Dr	84	12	G	...	....	EJ	D,S	Dug before 1914.
311	NE¼ SE¼ sec. 19	Watts and Adams	ARRC	1936	do.	461	D	58	12	G	49	June 30, 1936	HL	D	Topsoil, gravel, 0-58 ft.
312	SE¼ SE¼ sec. 19	James Woods	....	..	do.	495	Dr	80	6	G.	.....	....	EJ	D	
~~313~~	~~[illegible] sec. 19~~	~~[illegible]~~	~~S. Kozloski~~	~~1952~~	~~Hillside~~	[illegible]	Dr	[illegible]	[illegible]	[illegible]	[illegible]	~~Spring 1952~~	[illegible]	[illegible]	~~[illegible] which is 1.0 ft above land surface; casing plugged May 1954.~~
313	Do.	R. G. Asay	S. Kozloski	1952	do.	493	Dr	93	6	G	53	spring 1952	EJ	D	Till, 28-85 ft.
315	NE¼ SW¼ sec. 19	do.	Henry LaRose	..	do	465	Dr	35	4	G	"	....	EJ	D,S	See analysis.
314	NW¼ SE¼ sec. 19	V. Yadon	ARRC	..	Hillside	488	Dr	58.0	4	G	42.38	Aug. 30, 1949	..	N	MP top of casing, 1.0 ft above land surface; casing plugged (?), May 1954.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
~~[illegible]~~	~~SE¼ SW¼ sec. 30~~	~~Richard Diedrich~~	~~S. Cotton and H. E. Hamilton~~	~~1955~~	~~Level surface~~	~~523~~	~~Dr~~	~~190~~	~~6~~	~~G~~	~~175~~	~~June 20, 1955~~	~~EJ~~	~~DS~~	~~See log; bailed 10 gpm.~~
	T. 18 N., R. 2 E.														
266	NE¼ SW¼ sec. 1	N. W. Wade	Owner	1952	Gentle slope	455	Dr	155	6	..	120 110	Winter 1952 June 1956	EJ	D	
267	NW¼ SE¼ sec. 9	Frank Rush	A. R. Moffitt	1953	do.	623	Dr	93	4	S	72	Winter 1953	EJ	D	See log.
268	~~do.~~ Do.	Vincent Daughtry	S. Cotton	1955	do.	615	Dr	82	6	~~SG~~ SG	52	June 1956	EJ	D	Till, 41-73(?) ft; sand and fine gravel, 73(?)- 82 ft.
270	Do.	Leroy Hammond	ARRC; S. Cotton	1955	Level surface (river terrace)	612	Dr	99	6	G	85	Sept. 1955	EJ	DS	See log.
271	SE¼ SE¼ sec. 9	Richard Tunnicliff	ARRC; S. Cotton	1955	Gentle slope	608	Dr	~~106~~ 140±	~~6½~~ 6	..	80 136(?)	1950 Oct. 1955	EJ	DS	See log; originally 124 ft, deep; drilled to 143 ft, October 1955, and cemented to 140± ft.
272	SE¼ SW¼ sec. 9	Len Allman	E. Stephan	..	Level surface (river terrace)	600	D	105	48	G	...	....	..	D	Reported by some individuals to be 220 ft. deep.
273	Do.	do.	ARRC	1936?	do.	600	Dr	89	6,4	G	86	June 1950 ~~.............~~	..	N	Dry in September 1950; 6-inch casing to 48 ft; see log.
276	NW¼ NE¼ sec. 16	Olav Holtet	Owner	..	Depression		B	14	10	S	9.0	Nov. 26, 1951	..	D/	Water in windblown sand above impermeable layer in ice-block hole (pit) well representative of several others not in use; temperature, November 26, 1951, 37° F.
280	NW¼ SW¼ sec. 16	Harold Stephan	ARRC	1936	Level surface (river terrace)	558	Dr	90	4	S	82	Apr. 1936	EJ	D/S	Sand and gravel to 90 ft.
282	NE¼ NE¼ sec. 17	Miss Louise Kellogg	T. Moffitt	..	Hill-top	~~505~~ 556	Dr	224	4	G	20	....	EJ	D/S	
283	SW¼ NW¼ sec. 17	James Mcsherry	....	..	do.	596	Dr	46.5	4	..	37.5	Aug. 16, 1949	HL	D/S	
285	SW¼ SW¼ sec. 17	James Berry	ARRC	1936	Hill-side	525	Dr	94	6,4	S	45	....	EJ	D/S	See log.
286	SE¼ SE¼ sec. 18	Lewis Pinkham	do.	1936	do.	530	Dr	84	6	G	46 15(?)	Apr. 25, 1936 1948	EJ	D/S	Gravel and sand to 84 ft.
287	NW¼ SE¼ sec. 18	Richard Washburn	do.	1936	do.	545	Dr	132	4	S	25	Feb. 17, 1936	EJ	D	Till, 30-116 ft.
	T. 18 N., R. 1 E.														
290	NE¼ NE¼ sec. 14	Ralph Ware	ARRC	1936	Level surface (river terrace)	578	Dr	76	4	G	46	Oct. 7, 1936	~~HL~~ HL	D/S	Blue mud, 45-65 ft, interpreted as till.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
230	SE¼ SW¼ sec. 5	Harold Moore	A. R. Moffitt	1949	Level surface (river terrace)	800	Dr	96	4	T		....	EJ	D	Slotted casing set at 86 ft; water from 1-ft sand layer in till at 77 ft; till below 65 ft.
	T. 19 N., R. 5 E.														
244	SW¼ NW¼ sec. 22	John Postishek	S. Cotten	1955	Gentle slope	661	Dr	129	6	G	118	Spring 1955	ES	D	Base of till at 110 ft; 110-129 ft, sand grading downward into coarse gravel; see analysis.
244a	Do.	A. R. Norris	do.	1955	do.	633	Dr	58	6	G	18	Spring 1955	EJ	D	See analysis.
245	NE¼ SW¼ sec. 22	C. J. Murdoch	do.	1955	Level surface (river terrace)	557	Dr	105	6	..	58	Spring 1955	EJ	D	Boulder gravel, 0-28 ft; till, 28-60 ft; clean dry sand at 60 ft; record missing, 60-105 ft.
246	Do.	Rudolph Yerbich	do.	1955	Face of bluff (terrace scarp)	537	Dr	98	6	..	85	Spring 1955	EJ	D	MP for altitude and well measurements is top of casing, 6 ft below upper surface of terrace.
248	SE¼ NW¼ sec. 27	Robert Eckard	A. R. Moffitt	1953	Level surface (river terrace)		Dr	32	4	S	25	Spring 1953	EJ	D	Gravel and sand, 0-10 ft; till 10-26 ft; sand, 26-32 ft; reported to have been deepened since 1953.
249	Do.	Alpine Grocery	Owner	1953	do.	456	D	28	42	G	22	Summer 1953	EJ	D	
251a	NE¼ NW¼ sec. 27	Paul James	S. Cotten	1954	do.	504	Dr	72	6	G	55	Jan. 1954	EJ	D	Originally drilled to 42 ft and casing pulled back to 29 ft; water level 20 ft, summer 1953; see log
251b	Do.	Harve Estep	do.	1954	do.	488	Dr	66	6	G	43 23	Feb. 1954 June 1954	EJ	D	Originally drilled to 41 ft; dry during winter 1953-54; reported originally bailed 17 gpm; see log.
251c	Do.	Kenneth Killian	Owner	...	Gentle slope	484	D	48	..	G	46 33	Late winter Late summer	EJ	D	Blue clayey material (till?) at 48 ft.
251d	SW¼ SW¼ sec. 22	D. F. Maynick	....	...	do.	494	Dr	72	4	..	51	1954	EJ	D	
251e	Do.	Robert Fancher	S. Cotten	1953	do.	504	Dr	74	6	G	50	1953	EJ	D	Water level during drilling, at depth of 66 ft reported to have been 59 ft.
253	NE¼ NE¼ sec. 28	Don Boulter	A. R. Moffitt	1951	Level surface (river terrace)	582	Dr	81	4	GS	75	Aug. 1951	EJ	D	Till, 51(?) to 71 ft; water in gravel and sand beneath till.
255	SW¼ NW¼ sec. 28	Drift Inn	Ralph Dye	1949	do.	680	D	18	42	G	...	....	..	N	Till at 18 ft; went dry in 1950.
256	SE¼ NW¼ sec. 32	Walter Mayr	Cotten and Hamilton	1953	Hilltop	710	Dr	186	6	GS	171	Summer 1953	ES	D	See log.
257	SE¼ NW¼ sec. 31	Kenneth Wallace	S. Cotten	1955	do.	851	Dr	418	6	GS	401	Aug. 1955	E	DS	See log.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
199	SE¼ NE¼ sec. 17	C. F. Liebing	ARRC	..	Level surface ~~196~~ (river terrace)	154	Dr	88	4	S	56 60	 1955	EJ	D	Quicksand, 66-80 ft., stable sand, 80-82 ft.
201	NE¼ SE¼ sec. 17	Joseph Loyer	do.	1935	do.	151	Dr	63	4	G	52	....	EJ	D	
202	NW¼ SE¼ sec. 17	do.	do.	..	do.	146	Dr	61	4	Silty G	...	....	..	D	
203	Do. ~~NW¼ SE¼ sec. 17~~	A. Carlson	T. Moffitt	1950	do.	141	Dr	60	4	S	48	April 1956	EJ	D	
208	NW¼ NW¼ sec. 20	William Smith	ARRC	1936	do.	124	D, Dr	56	4	G	51	1949	EL	D, S	Topsoil, gravel, 0-56 ft.
209	NE¼ NE¼ sec. 19	Woodward Bros.	do.	..	do.	124	Dr	45	4	S	39	Oct. 15, 1946	EJ	D, S	Topsoil, gravel and sand, 0-31 ft; gravel and sand with blue clay, 31-43 ft; brown sand 43-45 ft; at 45 ft muddy brown gravel.
210	~~NW¼ SW¼ sec. 17~~	R. R. Webb	ARRC	1936	do.	128	D, Dr	154	4	S	44 55	Apr. 15, 1936 June 1948	EJ	..	Sand and gravel, 0-45 ft; coarse brown sand, 45-154 ft.
213	NW¼ SW¼ sec. 17	D. S. Dodds	do.	1945	do.	137	Dr	187	4	G	47	1948	EJ	D	Quicksand, 47-187 ft; fine gravel dropped into well to stabilize sand.
214	SW¼ NW¼ sec. 17	Joseph Loyer	S. Cotton	1955	do.	140	Dr	85	6	G	45.46	Dec. 5, 1955	EJ	D	Gravel and sand 0-40 ft; hard pan, 40-60 ft; gravel and sand, 60-85 ft. Altitude of lake to west, 97 ft, June 1955.
215	SE¼ NE¼ sec. 18	Warren Rice	ARRC	..	do.	134	Dr	165	4	G	...	....	EJ	D	Greenhouse.
217	SW¼ SE¼ sec. 18	I. T. Sawby	do.	..	do.	132	D, Dr	37	4	G	28.5	Sept. 26, 1955	EL	D, S	MP top of casing, 6.0 ft below surface.
218	NW¼ SE¼ sec. 18	J. C. Church, Jr.	A. and J. D. Frey	1950	do.	128	Dr	32	4	G	22	1950	EL	D,	
219	SW¼ NE¼ sec. 18	B. A. Anderson	ARRC	..	do.	130	Dr	55	4	G	47	....	EJ	D, S	
220	NE¼ NE¼ sec. 18	William Hoskins	do.	..	do.	130	Dr	41	4	G	39	....	EJ	D, S	Gravel to 41 ft.
221	NW¼ NE¼ sec. 18	Rolland Graver	do.	1935	do.	140	D, Dr	42	4	G	39	....	EJ	D, S	Bedrock reported at 42 ft.
224	SW¼ NW¼ sec. 8	Claire Patten	do.	1936	do.	179	Dr	93	4	G	68	....	EJ	D, S	Topsoil, gravel and sand, 0-93 ft.
228	NW¼ NE¼ sec. 8	Fred Joiner	A. R. Moffitt	1953	do.	196	Dr	113	4	G	97	Sept. 1953	EJ	D	Reported bailed 10 gpm with little or no drawdown; See log.
229	Do.	A. R. Moffitt	do.	1953	do.	198	Dr	128	4	R	105	Oct. 1953	EJ	D	Reported drawdown 16 ft, while bailing 5 gpm; see log; old well nearby, 93 ft deep, reported to have had small yield from sand and gravel; water level in old well, 85 ft, spring 1949.

Table 5.- Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
168	SE¼ SW¼ sec. 10	E. T. Foster	AERC	..	Level surface (river terrace)	189	Dr	76	4	G	72	....	EL	D	Log of nearby well: Large boulders and gravel, 0-40 ft; gravel and sand, 40-70 ft; quicksand, 70-147 ft. (Typed remark crossed out: Well nearby on same property was in quicksand from 70 ft to total depth of 147 ft.)
165	NE¼ NW¼ sec. 15	Paul Martin	do.	..	do.	165	Dr	77	6,4	G	74	....	EJ	D	6-inch casing to 33 ft; gravel and boulders, 0-33 ft; gravel, 33-54 ft; blue glacial mud, 54-56 ft; gravel, 56-77 ft.
170	SE¼ NE¼ sec. 16	Clifford Grover	do.	1936	do.	150	Dr	63	4	G	56	Jan. 2, 1936	EJ	D,S	
171	NW¼ NE¼ sec. 16	Theodore White	do.	1936	do.	176	Dr	81	4	G	~~75~~ 76	June 30, 1936	EJ	D,S	Soil, gravel, 0-78 ft; sand, 78-81 ft.
173	NE¼ NW¼ sec. 16	A. Brooks	do.	..	do.	160	Dr	72	6	G	62	....	EL	D,S	Also reported to be 95 ft deep.
175	NW¼ SE¼ sec. 9	James Cottrell	do.	..	do.	198	Dr	84	4	G	78	Aug. 1949	..	D,S	
176	NE¼ SW¼ sec. 9	George Crowther	do.	..	do.	187	Dr	115	4	G	90	....	..	D,S	See log.
179	SW¼ SW¼ sec. 9	A. C. Erickson	A. R. Moffitt	1952	do.	185	Dr	91	4	G	82.10	Aug. 4, 1952	EJ	D	MP top of casing, 2.5 ft below surface; see log.
180	do.	do.	AERC	..	do.	177	Dr	96	4	G	81	May 1949	EJ	D	
182	NW¼ SE¼ sec. 8	Roy Robarchek	do.	..	do.	190	Dr	89	6,4	SG	84	....	EJ	D,S	Well a few hundred feet away, not completed, reported to have struck water at 87 ft; see log.
185	SW¼ SW¼ sec. 9	D. M. Woods	do.	..	do.	172	Dr	85	4	SG	72.44	Aug. 30, 1949	..	O	MP top of casing, 0.80 ft above land surface; gravel and sand, 0-85 ft; temperature, November 23, 1951, 39°F.
186	NE¼ NE¼ sec. 17	do.	do.	1936	do.	168	Dr	75	4	SG	...	....	EL	D,S	
187	SW¼ NW¼ sec. 16	Henry Liebing	do.	..	do.	166	Dr	79	4	G	67.88	Nov. 16, 1935	EJ	D	Gravel and boulders, 0-35 ft; gravel, 35-55 ft; quicksand, 55-67 ft; gravel, 67-79 ft.
188	SW¼ SE¼ sec. 8	William Bowers	do.	..	do.	160	Dr	78	4	G	72	....	EL	D,S	
189	NW¼ NE¼ sec. 17	D. L. Siess	do.	..	do.	165	Dr	85	6,4	S	...	....	..	D,S	6-inch casing to 42 ft; gravel and boulders, 0-46 ft; sand, 46-59 ft; sand and gravel, 59-71 ft; gravel, 71-82 ft; sand, 82-85 ft.
190	NE¼ NW¼ sec. 17	Frank Pettit	do.	..	do.	157	Dr	74	4	[illegible]	71	[illegible] 1935	..	D,S	Topsoil, gravel and sand, 0-74 ft.
191	SW¼ SW¼ sec. 8	William Hoskins	....	..	do.	158	Dr	70	4	[illegible]	60	....	EL	D	
195	NE¼ NE¼ sec. 17	USGS Test well	George Ramsey	1955	do.	164	Dr	112	4	[illegible]	63.06	Nov. 15, 1955	..	O	8-inch well drilled to 282 ft; see log; screened at 110-114 ft, drawdown 23 ft after pumping 27.5 hrs at 53 gpm; temperature 38.5°F; see analysis; well lined with 4-in casing and 8-in casing removed.
196	SW¼ NW¼ sec. 16	Martin Malwics	AERC	1935	do.	166	Dr	65	4	[illegible]	57	Dec. 15, 1935	..	D,S	Topsoil, gravel and sand, 0-65 ft.

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146	Do.	do.	S. Cotten	1956	do.	222	Dr	48	6	R	29	Mar. 1956	EJ	DS	Bedrock (shale?) below 32 ft; well cased to 35 ft, dynamited at 39 ft; pumped 8 gpm for 42 hrs; see well 147.
147	Do.	do.	do.	1956	do.	222	Dr	146	6	R	49	Feb. 10, 1956	..	N	Bedrock (shale?) below 29 ft; water encountered at 60 ft and 80-90 ft; well cased to 30 ft, produced 250 gpd; dynamited at 50 ft, then produced 350 gpd; see analysis.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use	Remarks
142	NE¼ SW¼ sec. 4	John Cope	ARRC	1936	Level surface (river terrace)	225	Dr	500	6,4	R(?)	75	......(?)1936	..	N	See log.
143	NW¼ SW¼ sec. 4	E. J. LeDuc	do.	..	do.	225	Dr.	97	4	G	...	....	..	N	Casing pulled; see log.
144	SW¼ NW¼ sec. 4	Slaughter House	do.	1936	do.	225	Dr	590	4	R	...	....	..	N	Soil, gravel, 0-18 ft; shale, 18 to 80 ft; limestone, 80 to 590 ft; salt water at 569 ft; well plugged.
145	NE¼ SE¼ sec. 5	Harold Thuma	Ferber Bailey	1955	do.	222	D	27	8	G	25	Spring 1955	E	DS	Reported to have hit boulder at 27 ft; dug well lined with wood-stave pipe and backfilled; old well 15 ft, may hit bedrock at 24 ft; southeastward movement of water observed in the old well.
see cut page {146, 147}															
148	~~R. 19 E., R. 8 E.~~ SE¼ SW¼ sec. 4	William Fogg	ARRC	1936	do.	208	Dr	115	4	G	107	1936	EL	D	Soil, gravel, 0-60 ft; sand, 60-91 ft; gravel and sand 91-115 ft. ~~gravel to 114 ft.~~
149	SW¼ SW¼ sec. 4	John Cope	do.	1936	do.	208	Dr	114	4	G	108	1936	..	N	Capped; gravel to 114 ft.
150	NW¼ NW¼ sec. 9	H. L. Hamilton	....	..	do.	198	Dr	106	4	102	100	....	EJ	D,S	
152	NE¼ NW¼ sec. 9	L. G. Stock	J. Currie	1950	do.	208	Dr	109	6	G	99	Aug......1950	EJ	D	Gravel and sand to 109 ft.
153	SE¼ sec. 4	Harold Thuma	....	..	do	212	D	105	..	G	105	....	EL	N	
154	NE¼ NE¼ R. P	R. P. Mohan	ARRC	1936	do.	21?	Dr	123	6	G	..	....	EL	D,S	See log.
154a	SW¼ SW¼ sec. 5	J. G. Horn	L. Schaehle	1953	do.	215	Dr	118	6	G	100	1953	..	N	Topsoil, gravel, 0-118 ft.
155	SW¼ NE¼ sec. 10	J. J. Tully	Owner	..	do.	203	D	56	48	G	..	....	HW	N	Dry in 1949, 1954.
156	NE¼ NW¼ sec. 10	E. LeWalters	ARRC	1936	do.	199	Dr	65	4	G	..	....	EJ	D	
157	SW¼ NW¼ sec. 10	L. E. DePriest	do.	1935	do.	202	Dr	106	4	G	87	1950	EJ	D,S	
158	NE¼ SE¼ sec. 9	Donald Cook	S. Kozloski	1952	do.	197	Dr	100	6	G	75	Aug. 1952	EJ	D	Also reported to be 92 ft deep, with water level 67 ft.
160	NW¼ SW¼ sec. 10	L. S. Bauer	ARRC	1935	do.	196	Dr	175	4	G	79	Aug. 22, 1949	EL	D,S	MP top of casing, 2 ft above land surface; see log.
161	Do.	do.	do.	..	do.	196	Dr	200	4	...	..	....	..	N	

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Table 5.- Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
104	NW¼ NW¼ sec. 26	C. Brewer	ARRC	..	Level surface (river terrace)	95	Dr	112	4	G	65	....	EJ	D	Originally 47 ft. deep; deepened to increase yield; gravel, 0-112 ft.
105	Do.	I. H. Sandvik	G. Chapman	1953	do.	90	Dr	93	6	G	47.38	Apr. 5, 1953	EJ	D	Gravel, dry(?), 0-82 ft.; clay, yellowish, 82-92 ft.; water-bearing gravel 92-93 ft.
120	T. 18 N., R. 2 E. SE¼ NW¼ sec. 35	A. Gregersen	Owner	..	do.	260	D	25	6	B R	...	....	EL	N	Bedrock below 17 ft.; casing gravel-packed; formerly yielded 75 gpm.
121	Do.	Edward Uscek	do.	..	do.	256	D	31	42	S	30	....	..	N	
122	SW¼ NW¼ sec. 35	J. L. Allman	do.	..	do.	255	D	27	42	G	24	Aug. 1948	EL	D	Soil, 0-5 ft.; gravel, 5-25 ft.; till, 25-27 ft.
125	Do.	Mrs. Harriet Lester	A. Moffitt	1949	do.	258	D	37	48	B R(?)	...	....	EJ	N	Soil, sand, and gravel, 0 to 19 ft.; till, 19 to 28 ft.; bedrock, 28 to 37 ft; very slow recovery after pumping; see analysis.
126	NW¼ SW¼ sec. 35	H. Smith	....	..	do.	257	D	21	36	..	20	....	EJ	D	
127	NE¼ SE¼ sec. 32	C. Lee	John Dugge	..	do.	254	D	35	36	G	33	July 1949	EL	D	
128	SE¼ SE¼ sec. 32	John Dugge	Owner	1918	do.	240	D	30	36	G	29	....	EL	D	Bedrock encountered at 30 ft.; well formerly supplied 40 people.
130	NW¼ SW¼ sec. 35	James Felton	do.	..	do.	250	D	30	..	G	26	....	EL	N	Bedrock at 26 ft.
134	SE¼ SW¼ sec. 35	Old Civic Center Power House	ARRC	..	do.	255	Dr	95	4	B R(?)		....	..	N	See log; reported analysis: hardness 55 ppm; chloride, 36 ppm.
135	T. 17 N., R. 2 E. NE¼ NW¼ sec. 4	Old Civic Center Hospital	do.	..	do.	255	Dr	155	4	B R(?)		....	..	N	See log; reported analysis: hardness, 4300 ppm; chloride, 3600 ppm; ph, 6.0.
136	NW¼ NW¼ sec. 4	Roy Knapp	do.	..	do.	230	Dr	47	4	B R	...	....	..	D	Soil, gravel 0-10 ft., bedrock, 10-47 ft.
137	NW¼ NW¼ sec. 3	Arthur Stacey	do.	..	Gentle slope	227	Dr	100	4	B R	61	....	EJ	D	Sand and gravel, 0-99 ft; rock below 99 ft.; water rose rapidly after rock was hit; a little water previously hit at 60 (?) ft.
138	Do.	A. Dickow	Leslie Green	1949	Level	230	D	76	42	S	76	1949	..	N	Well no longer in existence; sand and gravel, 0-76 ft.
139	NW¼ NE¼ sec. 4	Lloyd Hill	T. Moffitt	..	do. surface (river terrace)	225	D, Dr	72	4	S	70 64	1949 1950	EJ	D	Originally dug by owner to 52 ft.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
80	SW¼ SW¼ sec. 22	Lee McKinley	J. D. Combey	1954	Level surface (river terrace)	118	Dr	144	8	~~D~~ R	30	June 1954	EJ	D	Water from greenstone beneath gravel (see log); well pumped 3 hrs. at an average of 15 gpm, with drawdown not more than 14 ft; see ~~chemical~~ analysis. See well 80a.
80a	Do.	do.	ARRC	..	do.	118	Dr	52	4	G	38.2	Aug. 18, 1949	..	N	Discharge declined markedly in 1954; new well (no. 80) drilled; gravel, 0-52 ft. ~~chemical analysis.~~
81	NW¼ NW¼ sec. 27	E. Winsok	do.	..	do.	115 ~~100~~	Dr	55	4	G	54(?) ~~...~~	....	EJ	D	Well formerly used for construction camp; gravel, 0-55 ft.
82	SE¼ NW¼ sec. 27	Mrs. G. Dreghorn	do.	..	do.	105 ~~97~~	Dr	56	4	G	...	....	..	N	Gravel, 0-56 ft.
83	Do.	do.	....	..	Face of bluff (terrace scarp)	79	D	40	..	G	35	....	EJ	D	
84	SW¼ NW¼ sec. 27	Oswald Hansen	ARRC	..	Level surface (river terrace)	88	~~DR~~ Dr	24	4	G	22	....	HL	S	
85	NE¼ SW¼ sec. 27	W. Benbow	do.	..	do.	54	Dr	18.5	4	G	11.55	Aug. 27, 1949	..	D	MP well-house floor, 1 ft. above land surface.
86	Do. ~~NE¼ SW¼ sec. 27~~	Harold Moline	do.	..	do.	56	Dr	26	4	G	12	....	EJ	DS	
88	NW¼ NW¼ sec. 34	Harry Kendrick	do.	..	do.	54	Dr	22	4	G	21	....	HL	D,S	
90	SW¼ NW¼ sec. 34	V. K. Mesmier	T. Moffitt	1949	do.	51	Dr	22	4	G	20	1949	EJ	D	
91	NW¼ SW¼ sec. 34	Byron Hollenbeck	ARRC	..	do.	51	Dr	22	4	G	16	....	HL	D	
94	NW¼ NE¼ sec. 34	Paul Nelson	do.	..	do.	64	Dr	22	4	G	20	....	EJ	DS	
95	NE¼ NE¼ sec. 34	Donald Parks	do.	..	do.	64	Dr	30	4	G	21	....	EL	D,S	
96	SE¼ SE¼ sec. 27	do.	do.	..	do.	67	Dr	33	4	G	24	....	EJ	D,S	Formerly watered 1,000 sheep.
97	SW¼ SE¼ sec. 27	H. Hartner	do.	..	do.	72	Dr	35	4	G	...	....	EJ	D,S	
99	SW¼ NE¼ sec. 27	J. Gibson	do.	..	do.	76	Dr	34	4	G	...	....	HL	D,S	
101	SW¼ NW¼ sec. 26	ARRC	do.	..	do.	83	Dr	~~48~~ 49	4	G	48(?)	....	EJ	D	Gravel, 0-49 ft.
103	NE¼ NE¼ sec. 27	Paul Nelson	do.	..	do.	86	Dr	~~111~~ 112	4	G	50	....	EJ	D,S	Gravel, 0-112 ~~111~~ ft.; see analysis; well on adjoining 40-acre tract to west, not in use, reached water at 36 to 41 ft.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
47	SW¼ SE¼ sec. 25	E. E. Kirk	A. and J. D. Frey	1951	Level surface (river terrace)	100	Dr	65	4	G	55.10	Nov. 14, 1955	EJ	DO	MP top of casing, 4.4 ft below surface.
	T. 17 N., R. 2 E.														
49	SW¼ SE¼ sec. 25	Midway Market	S. Cotten	1956	do.	94	Dr	65	6	G	51	May 1956	EJ	D	
50	Do.	W. B. Barnhardt	A. and J. D. Frey	1951	do.	94	Dr	60	6	G	52	1951	EJ	D	
51	NE¼ NE¼ sec. 26	Martin Sherman	S. Cotten	1955	do.	93	Dr	62	6	G	48.97	Oct. 28, 1955	EJ	DO	MP top of casing, 9.5 ft below land surface; gravel and sand, 0-62 ft.
53	NW¼ NE¼ sec. 26	"The Butte"	Ferber Bailey	1951	do.	93	D	57	48	G	54	1951	..	DP	Roadhouse.
56	SE¼ NE¼ sec. 26	J. D. Frey	A. and J. D. Frey	1951	do.	[illegible]	Dr	55	4	G	45	1951	..	D	Top of casing, 6.56 ft below land surface; bed of stream, 64 ft. from well, is 8 ft below land surface at well;
57	NE¼ SE¼ sec. 26	USGS test well	L. Reynolds	1950	do..	92	J	52.0	4	G	41.21	Nov. 14, 1955	..	O	MP, gravel and sand, 0-52 ft.
58a	NW¼ SE¼ sec. 26	A. W. Bauder	Owner	1952	do.	79	D	44	48	G	37.45	July 10, 195[illegible]	EJ	DO	MP top of wooden well curb, level with ground surface.
58g	SE¼ NW¼ sec. 35	V Bar	B. W. Huebner	1952	do.	62	D	26		G	22.50	July 10, 195[illegible]	EC	PDO	Roadhouse. MP is 2-in collar set in well cover, 4.5 ft. below land surface.
58m	SE¼ SW¼ sec. 35	P. C. Peterson	Owner	1952	do.	58	D	20	42	G	18.72	July 10, 195[illegible]	EJ	DO	MP top of floor of well cover, 0.5 ft. above land surface.
	T. 16 N., R. 2 E.														
59	NE¼ NW¼ sec. 2	R. and R. Dow	....	....	do.	57	D	20	30	G	17.20	June 15, 1950	H	DO	MP top of wood cribbing, 2.21 ft. above land surface; temperature, 38° F, Aug. 8, 1955.
60	NE¼ NE¼ sec. 2	do.	Owner	..	do.	52	D	15.5	42	G	11.06	July 26, 1950	..	DO	MP top of well cover, 1.5 ft. above land surface.
	T. 17 N., R. 2 E.														
70	SE¼ SW¼ sec. 14	Victor Falk, Jr.	ARRC	1936	Hillside	152	DR	110	6	R	62 (?)	June 1936	HL	S	See log and analysis.
72	SE¼ NW¼ sec. 23	Charles Weidner	A. and J. D. Frey	1951	Level surface (river terrace)	141	Dr	47	4	G	38	1951	EJ	D	
79	SE¼ SW¼ sec. 22	Laurin Smith	Owner	..	Swale	118	D	18	..	G			EJ	D	Sand and silt, windblown 0-16 ft.; "peaty" layer 16-16½ ft., gravel 16½(?) -18ft, at 18 ft. bedrock.
	T. 17 N., R. 2 E.														
75	SW¼ SE¼ sec. 15	Victor Falk	ARRC	1936	Level surface (river terrace)	156	Dr	80	64	G	30 35	May 193[illegible] June 193[illegible]	EJ	DS	Has watered as many as 50 cows; gravel, 0-80 ft.
76	SW¼ NE¼ sec. 22	Robert Durham	do.	..	do.	130	Dr	44	4	G	34	....	EJ	DS	Gravel, 0-44 ft.
78	SE¼ NW¼ sec. 22	Victor Falk, Jr.	do.		do.	120	D	32	42	G	29	1947	EJ	DS	Gravel, 0-32 ft.

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Table 5. - Records of wells - Continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
24	SW¼ NE¼ sec. 2	Frank McKenzie	Cotten and Hamilton; J. Cox	1953; 1955	Bluff (scarp of river terrace)	187	Dr	122	6	R	34	Nov. 1955	EJ	D	Well originally drilled 86 ft; deepened, Nov. 1955; water from greenstone, 109-122 ft.
25	Do.	Glen Shanks	Former owner	1950	Level surface (river terrace)	180	D	27.0	30	G	24.46	Aug. 28, 1950	HP	N	MP top of wood cribbing, 3.1 ft. above land surface.
25a	Do.	Merle Anderson	H.K. Hamilton	1950	do.	173	Dr	48	6	S	26 to 29		EJ	D	Water level reported to vary with the seasons; gravel 0-25 ft., sand 25-48 ft., yellow clay 48-49 ft.
25b.	Do.	M. B. Martin	....	..	do.	176	D	28.0	42	G	21.5	July 13, 1949	..	D	
26	SW¼ SE¼ sec. 2	L. W. Bixby	Ferber Bailey	1951	do.	162	D	22	48	G	19	Nov. 1951	..	D	
27	Do.	F. R. Sims	T. Moffitt	1948	do.	160	Dr	17	4	G	8.7	July 13, 1949	EJ	D	
28	Do.	E. Mackie	do.	1948	do.	165	Dr	17	4	G	10	Apr. 1949	HP	D	
29	Do.	Mrs. M. Keeler	....	1950	do.	156	D	17	36	G	14	May 1950	EJ	D	Greenhouse.
35	NW¼ SE¼ sec. 11	Clay Johnson	Owner	1948	do.	143	Dn	18	1¼	S	10	....	HP	DS	Screened drive point.
36	NW¼ NE¼ sec. 14	Ralph Goodrich	Alaska Rural Rehabilitation (ARRC)	..	do	133	Dr	22	5	G	6	....	EL	D	Water level reported to be level with and to fluctuate with that of Palmer (Bodenburg) Creek, nearby.
38	SW¼ SE¼ sec. 14	Clyde King, Jr.	Owner	..	do.	118	D	12	36	G	10	1948	EJ	D	See analysis.
39	Do.	Oswald Huntley	do.	1950	do.	115	D	18.2	48	G	17.1	June 18, 1950	EJ	D	
42	SE¼ NE¼ sec. 23	Wallace Brown	do.	1950	do.	107	D,Dn	38	..	G	30	May 1950	EL	D	Dug to 28 ft; dry in 1951; probably perched ground water.
43	Do.	John Rippy	do.	1950	do.	105	D	31	24	G	27.42	Aug. 18, 1951	HP	D	Probably perched ground water.
44	Do.	C. L. Bastian	Ferber Bailey	1951	do.	202	D	38	48	G	35	Spring 1951	..	D	Do.
45	NW¼ SE¼ sec. 23	H. H. Kirk	A. and J. D. Frey	1951	do.	100	Dr.	68	4	G	58	1951	..	D	
46	Do.	Peter Gallagher	do.	1951	do.	106	Dr	59	4	G	53	Sept. 1951	..	D	Driller reports several perched water bodies as much as 5 ft. thick; one is 24 ft. beneath surface.

Table 8 - Records of wells in the Matanuska Valley agricultural area, Alaska

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
	T. 18 N., R. 2 E.														
1	SW¼ SW¼ sec. 14	Frank Haunschild	Owner	..	Level surface (river terrace)	550	D	18		G	14	....	HP	D	Gravel 18 ft. thick, resting on till.
2	SW¼ NW¼ sec. 23	Robert Stewart	do.	1949	do.	590	D	22	36	G	...	....	EJ	N	Gravel 19 ft. thick, resting on till; well dry after 1950.
3	NW¼ SW¼ sec. 23	USGS test well	L. Reynolds	1950	Hillside above stream	584	DJ	26.5	4	T	3.8	Aug. 8, 1950	...	N	Water from layer of sand and gravel at 22 to 26 ft. in till; pumped at ½ gpm, 5 hrs; drawdown 19 ft.
4	SW¼ SE¼ sec. 23	Lazy Mountain Children's Home	Cotton and Hamilton	1955	Gentle slope	721	Dr	280	6	SG	255 277	Aug. , 1955	...	N	Well used about 4 mos. but discharge declined markedly; total pumpage about 400,000 gal.; well deepened to 725 ft. without encountering water; casing dynamited at 280 ft. in unsuccessful attempt to redevelop original aquifer; see log. Old dug well, 11 ft deep in till, obtained 150 gpd in 1949; see analysis.
5	SE¼ SE¼ sec. 22	Paul Bocchik	do.	1955	do.	630	Dr	145	6	T	106	Oct. , 1955	...	D	Drilled to 270 ft.; till, 0-270 ft.; casing pulled to 145 ft.; thin water-bearing zones at 147 and 180 ft., and in older well at 18, 45, and 56 ft.
6	NE¼ NE¼ sec. 26	John Nash	Owner	..	Hillside	748	D	24	42	T	7 30	Spring 1949 Sept. , 1950	EJ EJ	D,S D	1-foot sand layer in till yields 100 gpd.
18	NE¼ sec. 34	Ray Perrin	do.	1951	Hillside	839	D	11	36	T	10.5	Aug. 6, 1951	EJ	D	Water from sand layer in till. Measuring point (MP) top of wood cribbing, 5 ft. below land surface.
20	SW¼ NW¼ sec. 35	Horace DuFour	do.	..	Valley	260	D	6	..	G	0	July 9, 1949	N	D,S	
21	SW¼ SE¼ sec. 36	H. Kepperud	George Venne	..	Base of hill	219	D	9	..	G	...	....	HL	D	
22	Do.	George Venne	do.	..	Level hilltop	242	D	23	..	T(?)	...	....	HL	D	Water in gravel, which is on bedrock and beneath till, at 22 to 23 ft.
	T. 17 N., R. 2 E.														
22a	NW¼ NE¼ sec. 2	William Cook	S. Cotton	1953	Base of bluff (terrace scarp)	186	Dr	42	6	G	32.56	Sept. 8, 1953	EJ	D	MP top of casing, 1.25 ft. below land surface; gravel and sand, 0-42 ft.
23a	Do.	Bud Hudgins	do.	1953	do.	180	Dr	55	6	G	32.77	Dec. 5, 1953	EJ	D	MP top of casing, 0.4 ft. above land surface; gravel and sand, 0-53 ft.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
343	NW¼ SW¼ sec. 28	Ferber Bailey	F. Bailey	1950	Level surface (river terrace)	440	D	31	42	T	...	....	..	N	Sand and silt, 0-12 ft; gravel, 12-27 ft; till, 27-31 ft; water in 6-inch gravel layer at 28 ft
344	Do.	Carl Steckle	do.	1950	do.	442	D	27	42	G	25	1950	..	N	
345	Do.	Mrs. C. Edmunds	do.	1950	do.	429	D	14	42	G	12	1950	..	N	
346	Do.	Richard Denning	S. Koslocki	1952	do.	435	Dr	126	6	G	96.42	Jan. 13, 1954	ES	DO	MP top of casing, 14.5 ft below land surface; perched water at 30-34 ft; see log.
347	SW¼ SW¼ sec. 28	C. E. Albrecht	A. R. Moffitt	..	Base of bluff (terrace scarp)	342	D	35	48	G	33(?)	....	EJ	D	See analysis.
350	NE¼ SE¼ sec. 29	Palmer Nursery	....	1949	Bluff (terrace scarp)	451	D	37	36	G	28.10	July 6, 1949	EJ	D	Greenhouse; soil, gravel, to 30 ft, MP well curb 7.0 ft below land surface.
352	SE¼ SE¼ sec. 29	Howard Estelle	ARRC	1935	Level surface (river terrace)	422	Dr	62	4	G	45	Dec. 28, 1935	EL	D, S	Soil; gravel, to 62 ft; another well to west obtained water from gravel beneath till.
355	NE¼ SW¼ sec. 29	Clarence Hoffman	do.	1936	do.	438	Dr	63	4	S	45	....	EJ	D, S	Till, 45 to 61 ft.
356	SE¼ SW¼ sec. 29	Leonard Moffitt	do.	1936	do.	415	Dr	80	4	G	53	July 27, 1936	EJ	D, S	Till, 50 to 70 ft.
359	SE¼ SW¼ sec. 30	Mrs. L. L. Scott	do.	..	do.	451	Dr	120	4	T	55	Sept. 1947	EJ	D	Till below 55 ft; originally dug to 55 ft.
360	NW¼ NE¼ sec. 31	L. Wiederkehr	Owner	1948	Gentle slope	400	D	18	48	G	11.6	July 7, 1949	..	N	
360a	Do.	do.	J. D. Cowboy	1955	do.	400	Dr	128	6	S	16	April 1955	E	D	Washing vegetables; was pumped 10 gpm during development; till, 50-124 ft.
362	NE¼ NE¼ sec. 31	A. Thompson	ARRC	1947	Level surface (river terrace)	400	Dr	110	1¼	S	50	....	EJ	D, S	Till, 28 to … ft; … 165 ft; gravel on till at 28 ft. (fine-med. sand, 114-139 ft; pebbly fine sand, 139-160 ft)
363	NW¼ NW¼ sec. 32	City of Palmer	J. Currie, E. Young, S. Koslocki	1951	Hilltop	375	Dr	166	6	S	19.19	July 31, 1953	ET	P	Till, 90 to 114 ft; well finished with 20 ft, 10-slot screen; drawdown 40 ft; after 5 days pumping at 76 gpm; MP top of casing 3 ft above land surface; slanting measurement pipe is 0.36 ft farther from … than MP; see analysis
363a	SE¼ NE¼ sec. 31	do.	S. Koslocki, S. Cotten	1952, 1955	do.	388	Dr	159	8, 6	S	17.88	July 31, 1953	ET	P	20-ft, 40-slot screen set between 139 and 159 ft; MP top of casing, 16.6 ft below land surface at manhole on top of reservoir; temperature 35.5°F, Apr. 21, 1954; reported originally to have been 170 ft deep; till, 70-112 ft; coarse tight gravel, 112-140 ft; sand, 140-150 ft; medium gravel and sand, 150-170 ft.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
364	SW¼ NW¼ sec. 32	Mrs. Irene Benson	ARRC	1936	Level surface (river terrace)	366	Dr	88	4	G	26	May 23, 1936	..	O	Till, 28 to 86 ft; MP top of casing, 1.0 ft above land surface.
365	SE¼ NW¼ sec. 32	Oscar Boylund	do.	1936	do.	365	Dr	79	4	G	...	....	..	O	Till, 58 to 76 ft; MP top of casing, 0.5 ft above land surface.
368	NE¼ NW¼ sec. 32	Watts and Adams	do.	..	do.	376	Dr	67	4	G	30	1942	EJ	D,S	Estimated use 800 gpd; gravel to 67 ft.
369	NW¼ NE¼ sec. 32	Robert Klem	do.	1936	do.	321	Dr	72	4	S	50	Nov. 26, 1936	..	N	No till reported; water reported struck at 70 ft.
370	Do.	do.	do.	..	do.	321	D	15	42	G	14	....	..	D,S	Till at 15 ft; estimated use 500 gpd.
371	NE¼ NE¼ sec. 32	Dexter Bacon	do.	..	do.	309	D	24	..	G	22	....	EC	D	In nearby well, 16 ft deep, till was tapped at 15 ft; 2 ft of water in overlying gravel.
371a	Do.	do.	A. R. Moffitt	1954	do.	309	Dr	152	6	S	82	Nov. 1954	..	N	Water at 20-22 ft cased off during drilling; see log.
372	SE¼ NE¼ sec. 32	Virgil Eckert	ARRC	..	do.	309	D	18	..	G	16	....	EJ	D,S	Water in gravel that rests on till.
375	NE¼ SE¼ sec. 32	Eino Wirtanen	....	..	do.	283	D	25	..	G	15	....	..	D	Till reported, 8 to 25 ft; water in gravel layer in till, 16 to 21 ft.
	T. 17 N., R. 2 E.														
376	SE¼ NE¼ sec. 5	John Mohan	Arre	..	Gentle slope	239	Dr	34	4	R	15	Spring 1949	EJ	D	Casing set in rock 20 ft below ground surface; well yields 30 to 40 gal between periods of recovery.
377	Do.	Leo Lucas	....	..	do.	265	D	28	..	G	24	....	HL	D,S	
378	NE¼ NW¼ sec. 8	H. H. Blunck	ARRC	..	Level surface (river terrace)	247	Dr	126	4	G	119	Summer 1948	HL	D,S	Till, 41 to 76 ft; well yields 20 to 30 gal between periods of recovery.
379	NW¼ NE¼ sec. 5	William Roark	S. Cotton	1953	do.	275	Dr	64	6	SC	58.83	Aug. 4, 1953	EJ	D	MP top of casing 4.75 ft below surface; reported bailed 7.5 gpm during development; boulder or bedrock hit at 64 ft.
380	NE¼ NW¼ sec. 5	D. L. Irwin	ARRC	..	do.	266	Dr	74	4	G	66	....	EJ	D	Soil, gravel, 0-74 ft.
381	NW¼ NW¼ sec. 5	T. A. Moyer	A. R. Moffitt	1948	do.	266	Dr	90	4	G	60	1948	EJ	D	
382	Do.	Cliff Marcus	J. Cebula	1949	Hill-side	254	D	44	48	G(?)	42	Spring 1949	EC	D	Till below 42 ft.
383	Do.	Hodgson and Hurley	S. Cotton	1954	Level surface (river terrace)	277	Dr	139	6	SG	59	Feb. 1954	EJ	D	Drilled to 188 ft, casing pulled back to 139 ft; 50 ft of sand and gravel in casing; bailed 6 gpm; till 139-188 ft.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well below land surface (feet)	Diameter of well (inch)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
385	NW¼ NE¼ sec. 6	Miles France	ARRC	..	Level surface (river terrace)	337	Dr	144	4	SG	104	Autumn 1954	EJ	D	Till, 60-130 ft.
386	NE¼ NW¼ sec. 6	Mrs. G. France	....	1947	Depression	284	D	16	..	G	~~...~~ 15(?)	....	EJ	D	Hit till at 16 ft.
387	NW¼ NW¼ sec. 6	Wayne Bouwens	S. Cotten	1953	do.	322	Dr	126	6	G	...	....	E	D	Water in gravel, 122-126 ft, beneath till.
388	Do.	Carl Mielke	....	..	Hillside	337	Dr	63	4	G	55	....	EJ	D	
	T. 18 N., R. 2 E.														
395	SW¼ SE¼ sec. 33	A. W. Pearson	ARRC	1947	Level surface (river terrace)	280	Dr	100	4	T	55	1947	EJ	D	Another well 200 ft east hit boulder or bedrock at 100 ft; altitude of land surface 280 ft; [bailed] 3 gpm with 15 ft of drawdown.
396	SE¼ SW¼ sec. 32	Henry Harrison	Don McKechnie	..	Gentle slope	222	D	14	..	G	11	....	E	D	Hit till at 14 ft.
397	SW¼ SW¼ sec. 32	Harold Dunn	ARRC	1936	Level surface (river terrace)	287	D, Dr	88	4	G	78	1936	EJ	D, S	Till, 55 to 64 ft; originally dug to 44 ft.
398	NW¼ SW¼ sec. 32	P. J. Hemmer	[illegible]	1936	do.	291	Dr	61	4	S	[7.33] ~~8~~ / 10.82	[July 31, 1953] ~~1949~~ / Oct. 18, 1955	EJ	D, S	Till, 28 to 59 ft; yielded 5.65 gpm, drawdown 7 ft, in 28-hr. test; MP top of casing 6.2 ft below land surface.
399	SW¼ SE¼ sec. 31	Glenn Harrison	Owner	1949	Hillside	300	D	28	36(?)	G	27.16	July 8, 1949	HW	D	Ground surface built about 3 ft higher than original surface; till below about 27 ft.
	T. 18 N., R. 1 E.														
401	SE¼ SE¼ sec. 36	Mrs. Lois McLean	ARRC	..	Knoll	388	Dr	108	4	..	82	....	EJ	D, S	Also reported to be 142 ft deep.
402	SW¼ SE¼ sec. 36	M. J. Rodrigues	do.	..	Level surface (river terrace)	373	Dr	100	4	G	95	....	EJ	D	Till, 30-90 ft.
403	SW¼ SW¼ sec. 36	Frank Gagnon	do.	1936	Hilltop	363	D, Dr	108	4	GS	50	Sept. 1954	EJ	D	Originally dug to 62 ft; 0-47 ft, record missing; 47-107 till; 107-108 gravel and sand.
405	SE¼ SE¼ sec. 35	George Black	....	..	Level surface (river terrace)	383	D, Dr	86	4	G	61	Feb. 1947	EL	D	Originally dug to 60 ft.
410	NW¼ NE¼ sec. 35	Eugene Reid	Owner	..	Hilltop	380	D	53.0	12	G	56.0	July 18,1949	EJ	D	
411	SW¼ SE¼ sec. 27	Mrs. A. Havemeister	ARRC	1936	do.	366	D	83	36	G	19.0	July 18,1949	EJ	D, S	
411a	NE¼ SW¼ sec. 27	U. S. Air Force	S. Cotten	1955	Gentle slope	457	Dr	100	6	GS	71.81	Nov. 1, 1955	..	..	Till 20-87 ft; bailed 20 gpm with less than 5 ft of drawdown.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
412	SE¼ SE¼ sec. 27	Emil Kircher and Walter Munk	Owners	1942	Level surface	576	D	16	..	G	14	1942	EJ	D,S	On floodplain 20 ft from Wasilla Creek; drilled well nearby reported to have been 60 ft deep, in gravel.
	T. 17 N., R. 1 E.														
420	NW¼ NE¼ sec. 2	Mrs. Robert Wendt (~~Mrs.~~)	A. W. Pearson	1948	Hill-side	345	D	22	6	T?	21	1948	EJ	D	Cased after concrete slabs were placed in bottom to make a reservoir, till below 16 ft.
421	NE¼ NW¼ sec. 2	Charles Schaeffer	Owner	..	Hilltop	338	D	40	..	G	32	....	EJ	D	Till at 40 ft.
422	NW¼ NW¼ sec. 2	Peter Johnson	do.	..	Hill-side	300	D	21	42	G	17.8 19.27 18.46	June 28, 1949 Aug. 25, 1950 June 14, 1955	HW	D,S	On levelled ground.
424	NW¼ SE¼ sec. 5	A. H. Curtis	do.	..	Level Surface	..	D	14	..	G	9	....	HW	D,S	On floodplain, near Wasilla Creek.
428	NW¼ NW¼ sec. 21	John Hornung	A. and J. D. Frey	1951	Gentle slope	149	Dr	110	4	T	88	Dec. 1951	EJ	DS	0-110 ft, till; water thought to have come from sand layer in till; pumped 5 gpm for ½ day.
429	NE¼ SE¼ sec. 17	M. M. Newby	ARRC	..	do.	180	Dr	361	4	G	46.0 50.70	July 2, 1949 June 23, 1955	EJ	DS	MP top of casing, 1.0 ft above surface; gravel, 0-40 ft; blue mud 40-120 ft; blue quicksand, 120-355 ft; gravel and sand 355-361.
430	SW¼ SW¼ sec. 16	David Phile	do.	..	do.	168	D,Dr	50	4	G	25	....	EJ	D	
431	SE¼ SW¼ sec. 16	J. E. Church	do.	..	Level surface (river terrace)	178	Dr	70	4	G	50	1945	EJ	D,S	Blue quicksand and mud, ~~Till~~, 54 to 69 ft.
432	NW¼ SW¼ sec. 16	Henry Jensen	ARRC	1936	Gentle slope	168	Dr	24	4	G	20.8	Aug. 31, 1949	..	N	MP top of casing, which is 0.5 ft above land surface.
434	SE¼ NW¼ sec. 16	Fred Larsen	do.	..	Level surface (river terrace)	180	Dr	136	4	S	...	....	..	N	See log.
435	NE¼ SW¼ sec. 16	do.	do.	..	do.	180	Dr	300?	4	..	50?	....	EJ	D,S	Blue mud (till?), 40-60 ft.
437	NW¼ SE¼ sec. 16	Eugene Knoff	do.	..	do.	163	Dr	91	6,4	S	...	....	HL	D,S	See log.
438	SW¼ SE¼ sec. 16	Henry Jensen	do.	..	do.	141	Dr	214	6	G	30	....	EJ	D,S	See log.
439	SE¼ SE¼ sec. 16	R. C. Collins	do.	..	do.	141	Dr	192	4	G	25	July 1949	..	D,S	Well once supplied several thousand chickens but yielded only about 40 gal between periods of recovery; see log.
440	SE¼ NE¼ sec. 16	Albert Johanson	Charles Marine	..	do.	168	D	39	42	G	34	....	HL	D	Supplied 20 families and 17 horses in 1935.
441	NW¼ NW¼ sec. 15	C. E. Dearborn	....	..	do.	159	D	11.0	..	G	8.34 8.85	Sept. 14, 1950 May 23, 1955	HL	N	MP top of well platform, level with surface.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)		Method of lift	Use of water	Remarks
442	NE¼ SE¼ sec. 16	Eugene Kneff	ARRC	..	Level surface (river terrace)	±176	Dr	68	4	T	... 58.14	.... June 20, 1950	HL	N	See log; well reported to have low yield.
443	SW¼ NE¼ sec. 15	Alaska Agr. Exper. Station	....	..	do.	..	D	56	42	G	51 53	July 1947 Sept. 1948	EJ	D,S	Agricultural Experiment Station; see analysis.
444	NE¼ NW¼ sec. 15	do.	Peter Johnson	..	Base of bluff (terrace scarp)	173	D	40	..	...	26.28	June 14,1955	..	O	MP top of wooden well cover, 1 ft above surface.
445a	Do.	USGS Test well	George Ramsey	1955	do.	172	Dr	295	6	G	8.77	Sept. 12,1955	..	O	MP slot in casing, 1.0 ft above surface; finished with [illegible] 4 ft after pumping 5 days at 142 gpm; see log, analysis; temperature 38.5°F.
445b	Do.	do.	do.	1955	do.	172	Dr	160	8, 6,4	S	42.43	Sept. 12,1955	..	O	MP top of casing 3.6 ft above surface; drilled to 259 ft but finished with perforated 4-in casing at 160 ft after drill-tools jammed in casing.
445c	Do.	do.	do.	1955	do.	172	Dr	313	6	G	7.83	Sept. 12,1955	..	O	MP top of casing, 1.5 ft above surface; see log.
446	SE¼ SW¼ sec. 10	M. G. Sanders	Peter Johnson	1922	Level surface	234	D	61	48	T?	56.57	July 11, 1955	EJ	DS	Gravel, sand, 0-15 ft; till, 15-61(?) ft.
447	NW¼ NW¼ sec. 22	C. I. Branton	ARRC	1936	do. (river terrace)	126	Dr	298	4	[illegible]	74	....	EJ	D,S	See log.
448	NE¼ SE¼ sec. 15	Allen Linn	do.	..	do.	136	Dr	96	4	[illegible]	...	....	EJ	D,S	
449	Do.	do.	do.	..	do.	138	Dr	108	3,4	[illegible]	84	Aug. 31, 1949	..	O	MP top of casing, which is 1.00 ft above land surface temperature, November 23, 1951, 38°F.
450	SW¼ NE¼ sec. 23	J. T. Kepler	Owner	..	Hill-side beside lake	40	D	12	..	[illegible]	...	....	EJ	D	Land surface at well 12 ft above lake level (July 1949).
451	Do.	John Dryden	A. R. Moffitt	1954	Bluff	106	Dr	91	6	GS	77	1954	EJ	D	Hardpan (till?), 37-47 ft.
452	SW¼ NW¼ sec. 24	D. C. Kepler	S. Cotton	1955	do.	140	Dr	108	6	S	90	May 1955	ES	D	Finished with 40-slot screen, 5 ft long; bailed 17 gpm.
459	T. 18 N., R. 1 E. NE¼ SW¼ sec. 17	....	....	...	Base of hill	577	D	...	36	..	34.7	Sept. 4,1950	..	N	
460	SE¼ NW¼ sec. 33	E. W. Barry	Owner	..	Hill-side near stream	..	D	10	..	[illegible]	8	....	B	D,S	

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year Completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
462	SW¼ NW¼ sec. 29	Harry Duff	ARRC	T.	Gentle slope	445	Dr	32	4	G	8	....	EJ	D	High iron content ~~(see analysis)~~.
463	SW¼ SW¼ sec. 30	Kings Lake Camp	Clyde King, Sr.	..	Hill-side near lake	..	D	10	..	..	...	....	..	..	Gravel, 0-10 ft; till at 10 ft; two dry wells in till, 50 and 60 ft deep, are on this property.
469	T. 18 N., R. 1 W. NE¼ SE¼ sec. 25	do. ~~Kings Lake Camp~~	U. S. Bureau of Reclamation	1951	Hill-side above lake	462	Dr	35	4	G	21.6	Nov. 7, 1951	EJ	D	Scout camp; former dug well nearby was inadequate.
470	Do.	do.	do.	1951	Hilltop	460	Dr	45.8	4	G	25.8	Nov. 7, 1951	..	N	Scout camp.
471	~~SE¼~~ SE¼ sec. 24	Clyde Feisel	Owner	1951	Level surface	505	D	31	36	T	30	Sept. 4, 1951	..	N	Inadequate supply.
472	NE¼ sec. 25	Frank Sorensen	do.	1949	Hill-side above lake	476	D	20	30	G	15	Sept. 1951	E	D	MP basement floor, 5 ft below land surface; lined with concrete pipe.
473	Do.	J. H. Shreck	do.	1946	Level surface	..	D	20	..	..	...	....	HL	D	Well has been dry, September to March ~~of every winter~~ each year.
474	SE¼ sec. 26	A. E. Withey	do.	1950	do.	462	D	[illegible]	48	T	20	1950	..	D	Till below 10 ft; water from sandy streaks, 19.5 to 22 ft.
480	NE¼ sec. 35	H. Mickles	Owner	1950	Hill-side	489	D	60	..	..	48	....	EJ	D	Water probably derived from sandy till or from gravel beneath till.
481	NW¼ sec. 35	do.	do.	1950	....	..	D	55	..	G	53	1951	..	N	
490	T. 17 N., R. 1 E. SE¼ SE¼ sec. 6	Anthony Vickaryous	ARRC	..	Hilltop	380	Dr	106	4	G	56	1946	EJ	D, S	Till, 30 to 81 (?) ft.
491	SW¼ SE¼ sec. 6	do.	do.	..	Gentle slope	390	Dr	109	4	G	....	....	..	N	Till 42 to 107 ft; water from brown gravel, 107-109 ft.
492	NE¼ NW¼ sec. 7	E. B. Kjellen	....	..	Level surface (river terrace)	382	Dr	42	6	..	38	June 1, 1951	EJ	D	A 78 ft well on this property penetrated till(?), 42 to 55 ft, with sand and gravel beneath.
494	SW¼ SW¼ sec. 6	Valley Christian Childrens Home	Thomas Moffitt	..	do.	390	Dr	40	4	..	...	....	EJ	DS	Children's home, about 50 people; hard water (see analysis).
495	NE¼ SW¼ sec. 6	do.	....	..	do.	335	D	16	4	..	15.6	Aug. 27, 1951	..	N	

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
496	SW¼ SW¼ sec. 6	Valley Christian Children's Home	S. Cotton	1955	Level surface (river terrace)	388	Dr	172	6	S	128.10	Oct. 28, 1955	..	N	Drilled to bedrock at 308 ft; casing pulled back and 6 ft 30-slot screen set at 166-172 ft; sealing.
497	T. 17 N., R. 1 W. NW¼ SE¼ sec. 1	Leslie Green	Owner	1954	Hilltop	348	D	29	6	G	20(?)	1954	E	D	
498	SW¼ SW¼ sec. 1	C. M. Tracy	do.	1954	Gentle slope near lake	331	Dr	56	6	S	6	1954	EJ	D	Quicksand most of way down to a "hard formation" (till?) at 56 ft below surface; casing bailed down by hand; well in cellar, 4 ft below surface.
499	Do.	K. N. Hurd	do.	1954	do.	334	D	14	..	G	...	....	EL	D	
500	Do.	Fred Hurd	Owner	..	Level surface near lake	329	D	14	..	G	12	....	EC	D/S	
501	NE¼NE¼ sec. 11	D. W. Roth	....	..	do.	330	D	14	..	G	...	....	EC	D	Greenacres Roadhouse.
502	SE¼ NW¼ sec. 11	Martin Olson	Owner	..	Shore of lake	..	D	22	..	..	13.0	July 20, 1949	E	D	Till below 12 ft; well may obtain water from gravel above till.
505	SW¼ SW¼ sec. 2	E. L. Peck	do.	..	Hillside near lake	..	D	18	42	G	15	....	..	D	Nearby well hit till at 28 ft.
510	NE¼ NW¼ sec. 10	Mrs. Wilma Wilson	....	..	Level surface	341	D	19.6	48	G	15.98	May 25, 1955	EJ	D	MP top of wooden cribbing, 6.0 ft below land surface
510 a	Do.	H. E. Byers	....	..	do.	349	D	26	60	G	23.41	May 25, 1955	HL	D	
510b	Do.	O. E. Johnson	Owner	..	Gentle slope	336	D	18	48	G	14.10	May 25, 1955	HL	D	
511	Do.	T. L. Carter	....	..	Hilltop	350	D	30	..	G	28	....	E	D	
512	Do.	A. L. Hilburn	....	..	Gentle slope	348	D	26	..	G	22.0	July 25, 1949	EC	D	Lined with concrete pipe.
513	Do.	Frank Swanson	....	..	do.	348	D	23	..	G	19	....	..	D	Till(?), 20 to 21 ft.
516	NE¼ NW¼ sec. 10	B. Gustafson	Owner	..	do.	345	D	17	36	G	15	1955	..	D	
517	SE¼ NW¼ sec. 10	Do.	do.	..	do.	345	D	21	36	G	15	1946	EC	D	

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
519	SE¼ NW¼ sec. 10	Wasilla Hotel	Jack Fabian	..	Gentle slope	335	D	22	..	G	18	1948	EJ	D	Hotel and restaurant; till (?), 3-ft layer with top at 15 ft.
520	Do.	Gus Swanson	....	..	do.	342	D	16.6	..	G	15.7	July 28, 1949	HW	D	Till (?) layer reported.
520a	Do.	Walter Teeland	Jack Fabian	1955	do.	340	D	21	..	G	17	1955	E	D	do.
521	Do.	Teeland's Shopping Center	Jack Fabian	..	do.	338	D	16	36	G	13	April 1949	E	D	Till (?) below 15 ft.
522	Do.	U. S. Dept. of Interior, Alaska Railroad	....	..	Level surface	333	D	21	..	G	18	....	..	N	Well lined with concrete pipe; on low divide between Wasilla Lake and Lake Lucile; see analysis
522a	Do.	do.	C. Martin	1954	do.	333	Dr	121	6	G	15.57	Aug. 25, 1955	EJ	D	Water in fine gravel beneath till at 12(?) ft; see analysis
523	Do.	F. D. Smith	Cotton and Hamilton	1953	Gentle slope	332	Dr	44	6	G(?)	35	Summer 1953	E		Garage
524	SW¼ NW¼ sec. 10	William Botts	Owner	1951	do.	340	D	26	..	G	24(?)	Nov. 1951	E	D	
525	SE¼ NW¼ sec. 10	Frank Smith	S. Cotton	1955	do.	350	Dr	58	6	G	29.21	Sept. 8, 1955	..	N	0-58 ft, gravel.
530	Do.	C.L. Cadwallader	....	..	Hillside	340	Dr	16	4	G	~~12~~ 13	Feb. 1949	EJ	D	
531	NW¼ NW¼ sec. 10	Ray Bergman	Owner	..	do.	348	D	26	..	G	23	Aug. 1948	HL	D	Till (?) at 26 ft.
533	Do.	Oscar Tryck	~~Owner~~ do.	..	Level hilltop	350	D	28	36	G	~~25.90~~ 24.16	~~Aug. 02, 1949~~ Sept. 7, 1949	HW	DO	MP top of cribbing, 3.0 ft above land surface.
535	Do.	Wasilla School	Myers and Meehan	1954	Gentle Slope	346	Dr	73	6	G	26.75	May 25, 1955	E	P	MP top of casing, 0.25 ft above land surface; gravel, 0-46 ft; sand, 46-54 ft; till 54-66 ft; gravel, 66-73 ft; see analysis
536	Do.	Fred Nelson	Owner	..	do.	336	D	15	30	G	12.59	May 25, 1955	EC	D	MP top of concrete well curb, 7.3 ft below land surface.
537	Do.	Jack Fabian	do.	..	do.	334	D	12	24	G	9.38	May 25, 1955	E	D	MP top of concrete well curb, 6.25 ft below land surface.
540	SW¼ NW¼ sec. 10	Peter Nelson	do.	..	Hillside	340	D	25	30	G	...	....	E	D	Lined with poured concrete
541	Do.	James Kennedy	do.	..	~~Gentle slope~~ Level surface near lake	326	D	9.6	36	G	6.7	July 20, 1949	..	D	

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Years completed	Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
542	SE¼ NE¼ sec. 9	Garrett Snider	Owner	..	Lake Shore	315	D	9	..	G	7	1949	EJ	D	
545	SW¼ sec. 4	J. C. Baldwin	do.	..	Hillside	380	D	5	..	G	4	July 1949	..	D,S	Lined with poured concrete.
560	T. 17 N., R. 1 E. NW¼ SW¼ sec. 4	Henry Ohnstad	Owner	1949	Level hilltop (river terrace)	382	D	32	48	G	...	....	..	N	Not completed; gravel to 30 ft, till below 30 ft.
561	SW¼ SW¼ sec. 4	J. W. Reeder	do.	..	Hillside	342	DDr	74	4	..	...	....	E	D	0-10 ft, gravel; 10-7?(?) till; water in gravel(?) beneath till; former dug well 30 ft deep yielded insufficient supply.
562	NE¼ NE¼ sec. 8	J. E. Dunlap	ARRC	..	do.	300	Dr	62	4	G	42(?)	....	EJ	D,S	
565	NW¼ SW¼ sec. 9	H. Roach	....	..	do.	205	D	12	..	G	7	....	..	..	Several springs issue from hillside ~~in valley~~ near well.
566	SW¼ SW¼ sec. 9	John McDonald	ARRC	1935	Level surface	198	D	12	..	G	11	....	E	D,S	On floodplain of Wasilla Creek.
572	NW¼ SE¼ sec. 18	Watts and Adams	do.	..	Gentle slope	191	D	10	36	G	9	....	EJ	D,S	
573	SW¼ NW¼ sec. 18	H. Gerschmel	do.	..	Hilltop	253	Dr	95	4	S	...	....	EL	D,S	Till(?) 24-56 ft.
574	SW¼ sec. 7	Carl Fritsler	....	..	do.	290	D	65	48	..	49.7	July 18, 1949		N	Till below 12 ft in excavation nearby.
576	NE¼ SW¼ sec. 18	A. R. Carson	ARRC	..	Hillside	202	D,Dr	44	4	G	33	....	EJ	D,S	Originally dug to 33 ft.
577	SE¼ SW¼ sec. 18	Johan Johnson	do.	1936	Hilltop	238	Dr	136	4	S	50	July 1949	EJ	D,S	Till, 60 to 75 ft; brown quicksand, 75-135 ft; sand 135-136 ft.
578	SW¼ SW¼ sec. 18	Joseph Gielason	do.	1936	do.	230	D, Dr	180	4	G	75 80	July 24, 1936 1949	EJ	DS	See log.
585	T. 17 N., R. 1 W. NE¼ sec. 17	....	....	..	Level surface	320	D	..	42	T	14.40	Aug. 28, 1950	..	N	MP top of cribbing, which is 2.50 ft above land surface.
586	NW¼ SE¼ sec. 13	R. C. Kibbe	....	1949	do.	260	D	42	..	T	18	....	..	N	About 150 gpd formerly used; new well reported to have been drilled in 1953.
~~580~~ 588	SW¼ SE¼ sec. 13	George McKeese	Owner	1954	Gentle slope	240	D	35	48	T	30 26	Autumn 1954 Spring 1955	EJ	D	

Table 5 - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
589	SW¼ NE¼ sec. 24	James Wilson	....	...	Level surface	172	Dr	35	4	..	27 20.06	Aug. 1948 June 22, 1955	HL	N	Measured depth, June 1955, 25.6 ft; well reported partly full of sand; MP top of casing 1.0 ft above land surface.
591	SE¼ SE¼ sec. 25	John Hornung	T. Moffitt	..	do.	76	Dr	..	..	G	64.56	Aug. 28, 1950	HL	N	Till, 5 to 55 ft.
595	SE¼ SE¼ sec. 14	Carl Kelly	Earl McHenry	..	Gentle slope	240	D	20	36	S	6.2 9.50	July 19, 1949 July 13, 1955	HW	D,S	MP top of wooden cribbing 3.3 ft above land surface.
596	NW¼ NE¼ sec. 23	Ralph Bradley	....	..	Level surface	249	D	25	48	T	11.84	Aug. 31, 1949	..	N	MP top of platform, 1.0 ft above land surface; Recovery in 7 days after 250 gal pumped in 45 min.
596a	Do.	do.	S. Cotton	1954	do.	249	Dr	90	6	S	38	March 1954	EJ	DS	Bailed 20 gpm with 15 ft of drawdown; see log.
597	NE¼NW¼ sec. 23	T. J. Wilson	do.	1954	do.	252	Dr	89	6	SG	43	June- 1954	EJ	D	Bailed 15 gpm, till, 0-80 ft (?); nearby dug well in till, depth 31 feet, went dry in 1954.
598	SE¼ SW¼ sec. 14	Herbert Holstein	do.	1954	do.	253	Dr	114	6	S	55	Aug 1955	EJ	D	Till, 0-68 ft and (?) 90-108 ft; pumped 6 gpm.
599	NW¼ NW¼ sec. 23	James Wilson	do.	1955	Gentle slope	255	Dr	66	6	SG	45	Oct 1955	EJ	D	Till, 0-41 ft; quicksand, 41-64 ft; dug well in till 20 ft deep, 100 ft away, has 1-3 ft of water during summers, is usually dry in winter.
604	SE¼ NE¼ sec. 22	Fritz Flemming	Owner	..	do.	171	D	14	..	G			HW	D	
605	NW¼ SW¼ sec. 25	Theodore Knutson	....	...	Level surface	168	Dr	42	4	G	21.	July 18 49	HL	D	
610	SW¼ NE¼ sec. 21	L. W. Hunter	Owner	1949	do. (river terrace)	207	D	9.7	36	G	9.1	Aug 28. 50		N	
615	SE¼ NE¼ sec. 16	F. D. Smith	do.	..	Hillside	313	D	18	..	..	12	49	HL	D	Till, 13-18 ft; water derived from gravel beneath till (may be gravel layer in till).
616	NE¼ SE¼ sec. 16	S. D. Fleckenstein	do.	..	Bluff (river terrace)	311	D	16	36	G	15	49	EJ	D	
618	SE¼ SE¼ sec. 17	Hubert Sager	....	..	Hillside	283	D	7	..	G	6	...	HL	D	
620	NW¼ NW¼ sec. 20	Mrs. Ilah Senske	Owner	..	Level surface (river terrace)	267	D	18	48	G	14 15	Aug. 50 49	AW	DS	
621	NW¼ NW¼ sec. 19	J. L. Levan	do	1950	Gentle slope	311	D	27	48	T	26	Aug. 1950		N	Well deepened, summer, 1950; dry, 1955.
621a	Do.	do.	Carpenter and Gehr	1955	do.	311	Dr	74	6	GS	56.36	Sept. 1, 1955	EJ	D	MP top of casing 0.9 ft above land surface; till 0-70 ft.

Table 5. - Records of wells- continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (ft.)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
622	SW¼ SW¼ sec. 19	O. L. Byers	Owner	..	Level surface (river terrace)	..	D	27	42	GS	18.26	Aug. 11, 1951	HL	D	Gravel to 16 ft; till 16 to 26 ft; gravel (possibly layer in till), 26 to 27 ft; MP top of cribbing, which is 4 ft below land surface.
623	NW¼ NW¼ sec. 30	Vincent Smith	do.	..	do.	..	D	20	..	G(?)	...	....	..	D	Till below 16 ft.
624	SW¼ NW¼ sec. 30	J. Masy	do.	..	Hillside	..	D	11	..	G	...	....	HL	D	Water level low, January to March each winter.
625	SE¼ sec. 30	Earl Combs	do.	..	Level surface (river terrace)	136	D	11	..	G	7 9	1948 1955	HL	D	Land surface at well is about 9 ft higher than water in stream 300 ft away, July 1955.
	T. 16 N., R. 2 W.														
630	NW¼ NW¼ sec. 1	W. S. Osborne	Owner	..	do.	..	D	30	[illegible]	[illegible]	25	....	HW	D, S	Water may be derived from till (clay with stones, soft); till is exposed in nearby bluff.
631	NW¼ SE¼ sec. 2	Robert Lothrop	do.	..	Hillside	..	D	60	48	G	...	....	..	..	Dry in August, 1950.
	T. 17 N., R. 2 W.														
635	SW¼ NW¼ sec. 25	A. H. Tober	do.	..	do.	239	D	13	42	S	10.64	Aug. 16, 1950	HW	D	Water apparently derived from sand layer in till; MP is well cover, 1.8 ft above ground surface.
	T. 16 N., R. 2 W.														
640	NW¼ NW¼ sec. 18	Stanley Collins	do.	..	Hilltop	..	D	30	42	T	28	,950		..	Small inflow of water reported at 20 and 26 ft; water at 30 ft may be from gravel layer.
641	NE¼ NE¼ sec. 24	Raymond Redington	do.	1950	Level surface ~~Terrace~~ (river terrace)	70	D	28	36	G	25.95	Aug. 18, 1950	HL	N	Till at 16 ft in terrace nearby.
	T. 16 N., R. 3 W.														
642	SE¼ SW¼ sec. 24	Chester Burden	do.	..	do.	88	D	30	..	G	28	1950	HL	D	
643	SE¼ NE¼ sec. 26	Roy Tuttle	....	..	do.	..	D	30	..	S	28.0	Aug 26, 1950	HL	D	MP TOP of welll cribbing, which is 2.4 ft above ground surface.
650	NW¼ NE¼ sec. 21	Clayton Rosen	Owner	..	Lake Shore	..	Dn	14	1¼	S	...	.....	HL	D	
651	NE¼ NW¼ sec. 28	Herman's Place	....	..	do.	..	D	17	36	G	15	....	HL	DP	Tavern
652	SW¼ NE¼ sec. 28	Oscar Anderson	do.	..	do.	..	D	16	..	G	14	....	HL	DP	DO.
653	NW¼ SE¼ sec. 29	Payton's Point	....	..	Peninsula in lake	160	D	14	..	..	5	....	E	DP	do., reported in "hardpan"; well lined with concrete pipe.
	T. 17 N., R. 2 W.														
655	NE¼ sec. 12	H. E. Myers	do.	1954	Level surface	344	Dr	25	6	G	20	....	hl	D	Gravel, 0-12 ft; ~~gravel, 12-20 ft~~. clay and stones (till?), 12-20 ft; ~~20-25 ft~~, pebble-gravel, 20-25 ft.
656	NE¼ NE¼ sec. 11	W. R. McPherson	Carpenter and Gehr	1955	Hillside	332	Dr	23	6	G	18	Aug. 1955	EJ	D	Gravel to 23 ft.

Table 5. - Records of wells - continued

Well No.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (ft.)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
657	SW¼ sec. 1	Roy Bull	Carpenter and Gehr	1955	Level surface	344	Dr	48	6	G	46	Aug. 1955	ES	D	Till, 20-46 ft.
658	SE¼ sec. 10	Robert Bechtel	do.	1955	do.	327	Dr	67	6	G	30	Aug. 1955	..	D	Till, 40-54 ft, with gravel 50-55 ft, bearing a little water.
660	NE¼ NE¼ sec. 9	U. S. Dept. Interior, Alaska Railroad (Pittman station)	....	1945	Gentle slope	286	Dr	40	4	T?	...	....	HL	D	About 500 gpd used; well easily pumped dry. analysis
661	NW¼ sec. 5	Russell Birdsall	Carpenter and Gehr	1955	Level surface	312	Dr	26	6	G	6	Sept. 1955	..	D	Well 100 ft from Railroad Lake and 11 ft. above it; gravel, 0-26 ft.
	T. 18 N., R. 2 W.														
664	SW¼ sec. 28	Symore	....	...			D	26	...		20	Aug. 1955		D	Well 24 ft above lake level (Aug. 1955)
	T. 18 N., R. 3 W.														
670	NW¼ sec. 27	F. H. Kimbrell	Owner	...	Level Surface	..	Dn	15	1½	S	....	....	HL	D	On low terrace of Little Susitna River.

Plate 1a

Note to reviewers:

MAP SHOWING GEOLOGY AND WELLS

The attached map was prepared for a preliminary report, Circular 268. Copies of the printed map, bearing revisions, are being used for convenience in this first draft of the revised report. Corrected and added well numbers, changes in names and roads, and changes in a few geologic features are indicated.

This map was originally prepared in the Section of Illustrations as a colored plate. The drafted map consisted of a base (culture, drainage, geologic boundaries, explanation, and letter symbols) and two overlays for the colors. After the map had been drafted it was determined that the cost of reproduction was greater than is justified for a circular; only the base was used, therefore, in reproduction of the map for publication at that time. However, the color overlays were retained for use in the revised report. If I were now preparing an entirely new map I would make numerous minor changes in boundaries and would simplify the set of geologic units. However, I have no great disagreement with the map as originally prepared, and because of the very considerable cost of drafting a new map, the investment already made in the present map, and the time involved, it is thought wise to use the old map for the revised report.

Changes suggested for the map are almost all in the black-and - white base, which is most readily altered. The explanation has been revised, and a copy of the new explanation is attached to the map.

F. W. Trainer