Geology and Hydrology of the Site of the Hallam Nuclear Power Facility, Nebraska

GEOLOGICAL SURVEY BULLETIN 1133-B

Prepared in cooperation with the U.S. Atomic Energy Commission

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By C. F. KEECH

STUDIES OF SITES FOR NUCLEAR ENERGY FACILITIES

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By C. F. Keech

ABSTRACT

The site of the Hallam Nuclear Power Facility is at the upper end of the Salt Creek drainage basin near the intersection of the divides separating the drainage basins of Salt Creek, the Big Nemaha River, and the Big Blue River. It is 1½ miles north of Hallam, Nebr., and about 18 miles south of Lincoln.

The area is underlain by unconsolidated deposits of Pleistocene age which in places are more than 400 feet thick. These deposits rest on limestone and shale of Permian age. The saturated unconsolidated deposits of Pleistocene age are the principal aquifer from which ground water is pumped; irrigation wells that tap this aquifer yield copious supplies. Perched-water zones that rest on compact deposits of glacial till also are common and supply many shallow wells in the area.

The depth to water in the principal aquifer ranges from a few feet to about 185 feet. In general, the depth to water in the valleys is much less than that in the upland. The aquifers are recharged by precipitation within the area and by ground-water movement from the west. The annual amount of local recharge from precipitation to the principal aquifer is believed to be very small.

The topography of the land surface and hydraulic gradient of the ground water indicate that water from precipitation in the area moves overland or underground toward points of discharge along Olive Branch. If this water should become contaminated by accidentally spilled radioactive liquid, the contaminated water also would move along the natural drainageways toward the points of discharge. Any contaminated liquid spilled on the ground at the site would probably be retained in one or both of two retarding structures that have been constructed along the drainageway which drains the area immediately surrounding the powersite. If contaminated water should reach the stream, it would flow into Salt Creek, which flows through the city of Lincoln and thence via the Platte, Missouri, and Mississippi Rivers to the Gulf of Mexico. Nowhere along its 60-mile course is water taken from Salt Creek for drinking purposes, and in only a few places is water diverted for irrigation.

INTRODUCTION

PURPOSE AND SCOPE OF INVESTIGATION

This investigation is one of several studies being made by the U.S Geological Survey in cooperation with the Atomic Energy Commission for the purpose of evaluating the hydrologic and geologic conditions at the sites of nuclear-power facilities. Special considerations are presented which would establish the probable direction of movement of contaminated water in the event that a radioactive fluid should be spilled on the ground at the plant site. In addition, the geology and hydrology of the area are described, information on wells is presented, and an evaluation of the existing hydrologic data is made.

WELL-NUMBERING SYSTEM

Wells and test holes are numbered according to their location within the U.S. Bureau of Land Management's system of land subdivision. The well number gives the location by township, range, section, and position within the section. The well-numbering system is illustrated in figure 1. The first number indicates the township, the second the range, and the third the section in which a well is located. The first

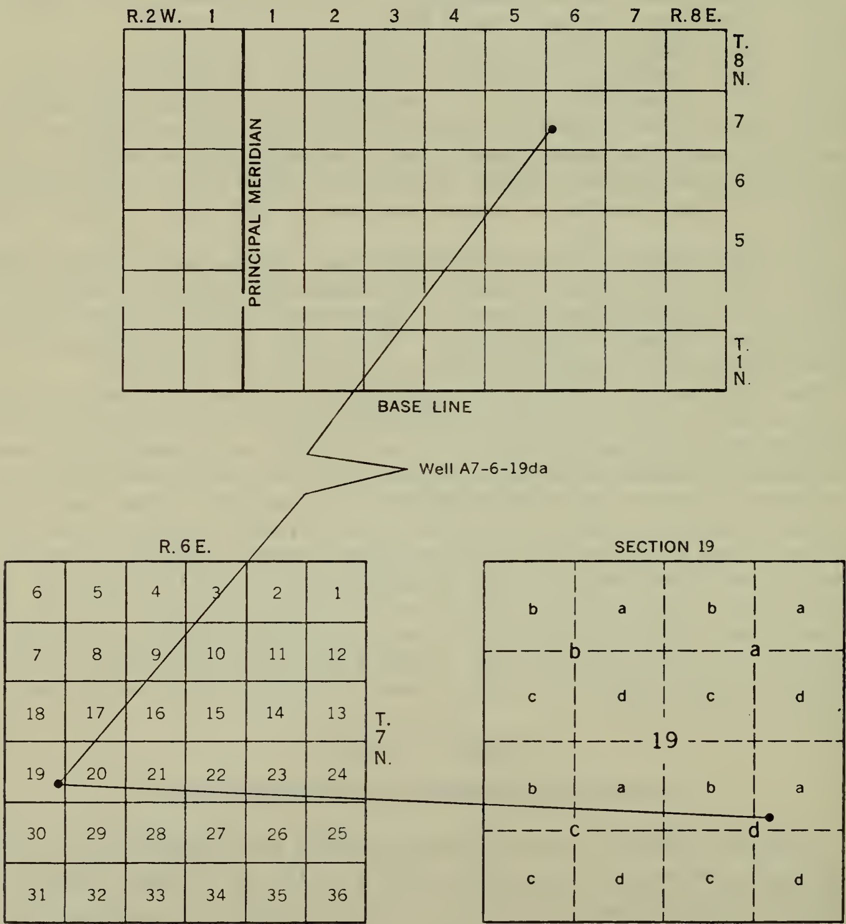

FIGURE 1.—Well-numbering system

letter following the section number denotes the quarter section, the second the quarter-quarter section (40-acre tract). The subdivisions of the section are lettered *a*, *b*, *c*, and *d* in a counterclockwise direction, beginning in the northeast quarter or quarter-quarter. Consecutive numbers follow the lowercase letters when more than one well is shown in a 40-acre tract. The capital letter A that precedes the well number indicates that the well is east of the sixth principal meridian.

The Consumers Public Power District assigned the numbers given the test holes in table 3. These numbers were used in this report.

ACKNOWLEDGMENTS AND PERSONNEL

General information concerning the proposed powerplant and specific information regarding wells and test-hole borings on the reactor site were supplied by Mr. Ivan O. Sunderman, engineer, Consumers Public Power District. The test holes and the wells on the site were drilled for Consumers Public Power District by the Layne-Western Co., Omaha, Nebr. Other information pertinent to the Hallam area was furnished by residents of the area. The geologic sections in the report are based on interpretations made by Mr. V. H. Dreeszen, geologist, Conservation and Survey Division, University of Nebraska. Mr. Dreeszen also collaborated in the determination of altitudes of measuring points of wells and test holes. Locations of waterway-improvement works in the area of study was furnished by Mr. D. R. Vallicott, engineer, Soil Conservation Service. Streamflow data were furnished by Mr. F. F. LeFever, district engineer, U.S. Geological Survey, and the chemical-quality data and interpretations were prepared by Mr. R. H. Langford, chemist, U.S. Geological Survey. Mr. E. S. Simpson, geologist, U.S. Geological Survey, in company with Mr. Dreeszen and the author, made a brief reconnaissance of the Hallam area and outlined the scope of the study needed to meet the requirements of the Atomic Energy Commission.

GEOGRAPHY

LOCATION AND EXTENT OF AREA

The Hallam Nuclear Power Facility is in southeastern Nebraska and is near the upper end of the drainage basin of Olive Branch, a tributary of Salt Creek. This study is limited to an area of 9 square miles which includes and surrounds the site of the Hallam Nuclear Power Facility, being built near Hallam, Lancaster County, Nebr., by the Consumers Public Power District. The powerplant site is about 18 miles south of Lincoln, 21 miles north of Beatrice, and 10 miles east of Crete. (See fig. 2.) Hallam, the village nearest the site, is about 1½ miles south of the site. The Rock Island Railroad serves

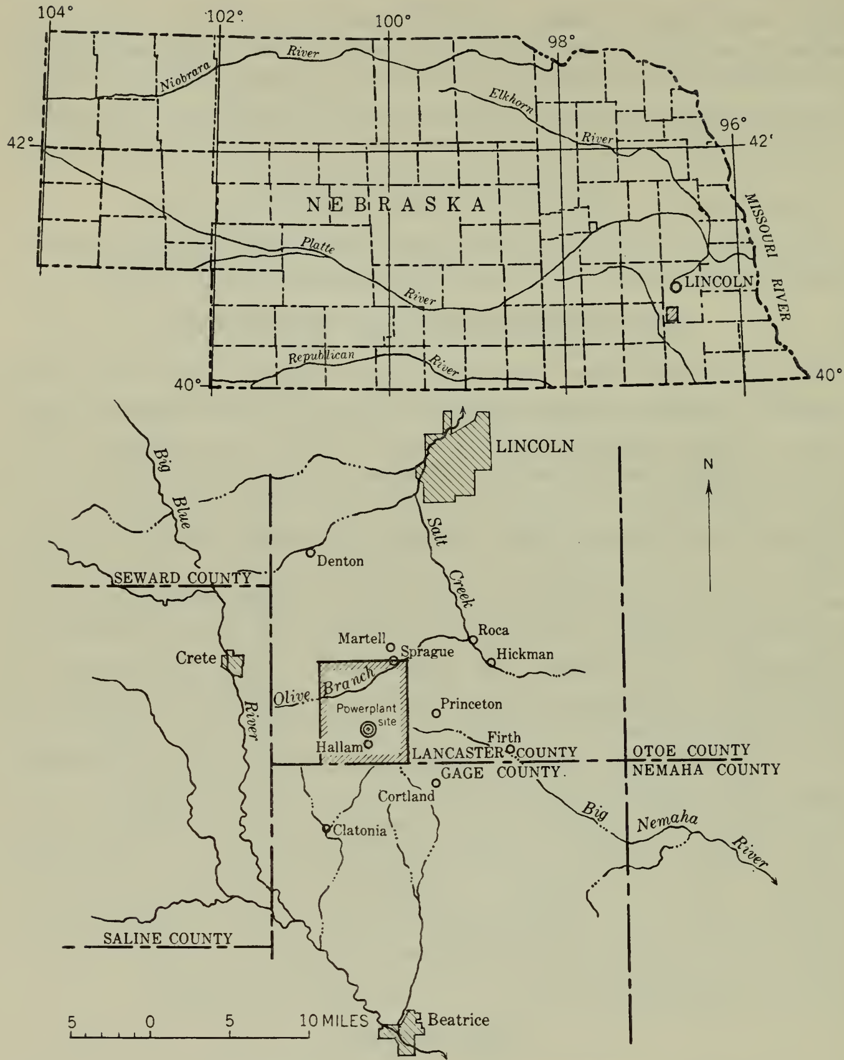

FIGURE 2.—Maps showing area described in this report.

the area; U.S. Highway 77 traverses the region 4 miles east of the powerplant site, and State Highway 33 traverses the region 6 miles north of the plant. (See pl. 1.)

TYPOGRAPHY AND DRAINAGE

The Hallam powerplant site lies within the glacial-drift hills in the drainage basin of Salt Creek, a tributary of the Platte River, but it is near the divides separating the Salt Creek drainage basin from the basins of the Big Blue River, which drains to the Republican River, and the Big Nemaha River, which drains to the Missouri River.

The area is well drained, and rainwater runs off rapidly to the natural drainageways. Surface runoff from the Hallam powerplant site collects in small drainageways that flow almost due north to Olive Branch. Water then flows down Olive Branch about 8 miles before entering Salt Creek.

A floodwater-retarding structure now being built immediately downgradient from the reactor site will slow the runoff, and, in the event of accidental spillage of radioactive material during a rainstorm, the outlet to the structure can be closed and the runoff can be retained in the reservoir above the dam. The reservoir created by the dam will provide 267.5 acre-feet of flood storage, or the equivalent of 6.04 inches of runoff from the entire drainage area of 530 acres. Additional storage is provided for 58 acre-feet of sediment, a volume equal to 1.32 inches from the entire drainage basin. This amount is estimated to be a 50-year sediment production. The capacity of the reservoir is almost double that which is necessary to store the runoff from a 100-year storm. The control structure is part of the Upper Salt Creek watershed project being developed under the technical guidance of the U.S. Soil Conservation Service. Another control structure was built in 1957 by the Soil Conservation Service downgradient 2 miles from the plant site on the drainageway leading to Olive Branch. This flood-control reservoir, which was designed for the 25-year rainstorm, provides 414 acre-feet of detention storage. Unlike the reservoir at the powerplant site, this reservoir has no gate at the outlet to prevent the emptying of the stored water; however, a gate feasibly could be installed.

POPULATION

The study area is rural. The unincorporated village of Hallam, with a population of 172, is the largest concentration of inhabitants near the powersite. According to Mr. I. O. Sunderman, engineer, Consumers Public Power District, no person lives within half a mile of the plant site and only 26 persons live within a mile. Mr. Sunderman estimates that the population, excluding the residents of villages, within a 5-mile radius is 766 and within a 10-mile radius is 3,291.

Lincoln, Nebr., with a population of 130,000 (1958), Beatrice with a population of about 13,000, and Crete with a population of 3,692 are the largest population centers nearest the powerplant site.

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CLIMATE

Southeastern Nebraska is characterized by climate of the continental type. The weather is variable from year to year, but usually the summers are very hot and the winters are very cold. The precipitation reaches a maximum in the spring or early summer and dwindles to small amounts, mostly in the form of snow, in winter. Most of the rain in the summer falls in heavy thundershowers. Torrential rains are rare, although occasionally the storms are intense enough to cause considerable destruction to crops, roads, bridges, and buildings. Floods resulting from rainstorms have several times been very destructive to crops and property and also have taken human lives. Rarely tornadoes accompany storms. Table 1 shows temperature and precipitation data for Lincoln.

From February 1 to May 1 the prevailing wind is from the north; during most of the rest of the year it is from the south. Strong winds are common. The average annual wind velocity is 10.5 miles an hour.

The growing season is about 6 months. At Lincoln, the nearest point for which frost data are available, the average last killing frost is April 18, and the first is October 15. Killing frosts have occurred as late as May 10 and as early as September 12.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Lincoln, Lancaster County, Nebr.*

[Altitude, 1,180 feet; from records of U.S. Weather Bureau]

Month	Temperature, in degrees Fahrenheit			Precipitation, in inches			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year	Total for the wettest year	Average snowfall
December	29.1	75	−20	0.86	0.88	1.96	5.4
January	25.0	72	−29	.82	1.64	1.02	5.7
February	29.3	79	−26	.92	.68	.14	6.5
Winter	27.8	79	−29	2.60	3.20	3.12	17.6
March	39.4	91	−14	1.47	0.18	0.37	5.4
April	52.6	97	9	2.29	2.29	.67	1.1
May	62.5	104	25	3.10	1.95	3.65	0
Spring	51.5	104	−14	6.86	4.42	4.69	6.5
June	72.8	109	41	4.10	1.13	8.83	0
July	79.2	115	48	3.10	.08	11.35	0
August	76.9	110	42	3.08	1.63	4.35	0
Summer	76.3	115	41	10.28	2.84	24.53	0
September	68.1	106	27	2.92	3.38	4.10	0
October	56.4	99	3	1.66	.19	2.81	.4
November	40.3	83	−15	1.41	.06	1.97	1.8
Fall	54.9	106	−15	5.99	3.63	8.88	2.2
Year	52.6	115	−29	25.73	14.09	41.22	26.3

EARTHQUAKES

Only three earth tremors intense enough to be felt have been reported in the southeastern part of Nebraska. These occurred in 1877, 1935, and 1952. Although they were felt throughout a wide area, no property damage was reported. Although the cause of these tremors has not been definitely established, they were thought not to be the result of a local disturbance.

GEOLOGY

The Hallam area is underlain by unconsolidated deposits of Pleistocene age which in places reach a maximum thickness of slightly more than 400 feet. (A generalized stratigraphic section is given below.) These deposits overlie limestone and shale of Permian age which are not sufficiently permeable to serve as aquifers. The area lies within a horseshoe-shaped reentrant in the eastern border of the Dakota sandstone. (See pl. 1) Where present north, west, and south of the report area the Dakota overlies rocks of Permian age and underlies the sediments of Pleistocene age. In eastern Nebraska, the Dakota sandstone typically consists of an upper sandstone, a middle shale, and a lower sandstone. Locally, the upper sandstone grades into sandy shale and shale. Water contained in the upper sandstone is of relatively good quality, whereas that in the lower sandstone is of poor quality. In the buried channel west of Hallam the upper sandstone of the Dakota has been removed by erosion and in the deeper part of the channel all the Dakota sandstone has been removed. (See pl. 2, section *B–B′*.) Thus, the part of the Dakota sandstone nearest the report area is the lower member. Highly mineralized water percolates laterally out of this lower member of the Dakota sandstone and into the adjoining lower sands and gravels of Pleistocene age. Thus, the water in the lower deposits of Pleistocene age is chemically similar to the water in the Dakota.

Before the sediments of Pleistocene age were deposited, a drainage pattern was developed on the surface of the rocks of Permian and Cretaceous age. The direction of drainage on that surface is shown on plate 1. The eastward-trending broad valley in the vicinity of the Hallam powerplant site was filled with sediment during Quaternary time, and now no surface evidence of it remains. Glacial ice sheets, which advanced from centers of snow accumulation in Canada, transported the tremendous quantities of clay, silt, sand, and gravel that fill the buried valley.

The first of the ice sheets was the Nebraskan. It overrode or encircled the high places and filled the valleys in its course with sand and gravel of the David City formation and, when it melted left the area

Generalized section of the stratigraphic units and their water-yielding properties in the vicinity of Hallam, Nebr.

System	Series	Formation	Thickness (feet)	Description	Water Supply
Quaternary	Recent	Alluvium, loess, and soil	0–5	Alluvium restricted to a few feet of reworked surface materials in stream valley.	Undetermined.
	Pleistocene	Peorian loess	0–15	Wind deposits of silty massive yellow to buff clay; widespread on uplands and terraces.	Significant principally as a transmitting agent for ground-water recharge from precipitation; yields water to wells only slowly where it occurs below the water table.
		Loveland formation	0–15	Stratified silt and clay and laminae of very fine sand in valley phase; massive reddish-brown silt and clay loess in upland phase; capped with a persistent fossil soil.	Do.
		Crete formation	0–15	Sand and gravel deposits, modified by locally derived materials; generally occur in buried channels, but broader than exisiting surface channels; upland equivalent in areas of Kansan drift is a thin deposit of boulders and gravel.	Yields water to wells where present below the water table.
		Unconformity			
		Sappa formation	0–10	Greenish-gray silty clay of aqueous-eolian origin, capped by fossil soil; generally present at high levels in side slopes of Salt Creek valley.	Not a source of water for wells
		Unconformity			
		Grand Island formation	0–15	Stream-deposited sand and gravel, principally fine sand near its top, and some glacial outwash.	Yields abundant supplies of water where present below the water table; water is of good quality.
		Kansan drift	30–210	Heterogeneous, unsorted deposits ranging in size from clay to boulders and some isolated sand bodies.	Yields small supplies of water to domestic and stock wells. Contains in most places a perched water body.
		Unconformity			
		Red cloud sand and gravel	0–110	Stream-deposited sand; sand and gravel in lower part.	Yields abundant supplies of water to wells. Principal source of water to deep wells in the Hallam area; water is of good quality.
		Unconformity			
		Fullerton formation	0–20	Fluvial and eolian silt and calcareous clay.	Not a source of water to wells.
		Unconformity			
		Nebraskan drift	0–80	Heterogeneous, unsorted deposits ranging in size from clay to boulders; dark bluish gray; oxidized and leached near the top.	Do.
		Unconformity			
		David City formation	0–70	Fluvial sand and gravel, deposited principally in pre-Pleistocene valleys.	Yields abundant supplies ofwater to wells. Water of poor quality in Hallam area.
		Unconformity			
Cretaceous	Lower Cretaceous	Dakota sandstone	0–140	Fine- to medium-grained sandstone interbedded with clay shale and sandy shale.	Yields water of poor quality.
		Unconformity			
Permian		Undifferentiated limestone and shale	170–210	Limestone and shale, interbedded.	Not a source of water to wells.

mantled with a bluish-gray till studded with boulders (Condra and Reed 1950, p. 17). As the Nebraskan glacier melted away, additional sediments were deposited on the till and in the eroded valleys by wind and stream. The deposits of the Nebraskan ice sheet were later removed locally by erosion, but remnants of these deposits in the Hallam area are as much as 80 feet thick. Later the Kansan ice sheet advanced into the area. It also blocked the eastward-trending streams and caused them to aggrade their valleys with thick deposits of clay, silt, sand, and gravel. When the Kansan glacier melted away, it left a mantle of till which locally is more than 200 feet thick. Vast quantities of sand and gravel were laid down during the Kansan glacial epoch and now constitute the most important aquifer in the Hallam area.

Although the Kansan till is the principal surficial material in part of the Hallam area, it is mantled in many places by thin loess or alluvium. The surface of the Kansan till was eroded into many small valleys and divides which form a well-developed natural drainage system. The topography of the Hallam area is typical of that of the drift-hills region of eastern Nebraska.

An investigation of the hydrologic properties of the soils and underlying unconsolidated sediments in sec. 19, T. 7 N., R. 6 E., was begun by the Consumers Public Power District in January 1955 and continued through 1958. Part of this study included the drilling of 17 test holes to bedrock. (See fig. 3 and table 3. Other logs of test holes drilled in the Hallam area are given in tables 4 and 5.)

The U.S. Geological Survey in cooperation with the Conservation and Survey Division of the University of Nebraska made electric logs of the following test holes drilled by the Layne-Western Co. for the Consumers Public Power District: 55–1, 55–3, 55–4, and 55–5. Data from the electric logs and from examination of the samples obtained from the test holes were used in the preparation of geologic section *C–C′*. (See fig. 4.) The electric logs indicate that the lower sediment are saturated with salt water and that a fresh-water zone, approximately 150 feet thick, is present above the salt-water zone. It is from this fresh-water zone that water will be pumped for production of steam to generate electric power. Heat to produce this steam will be obtained from either the burning of coal or from the nuclear reactor. The location of the wells from which the water will be pumped are shown in figure 3. These wells, together with other wells in the Hallam area, are shown in table 6 and on plate 3.

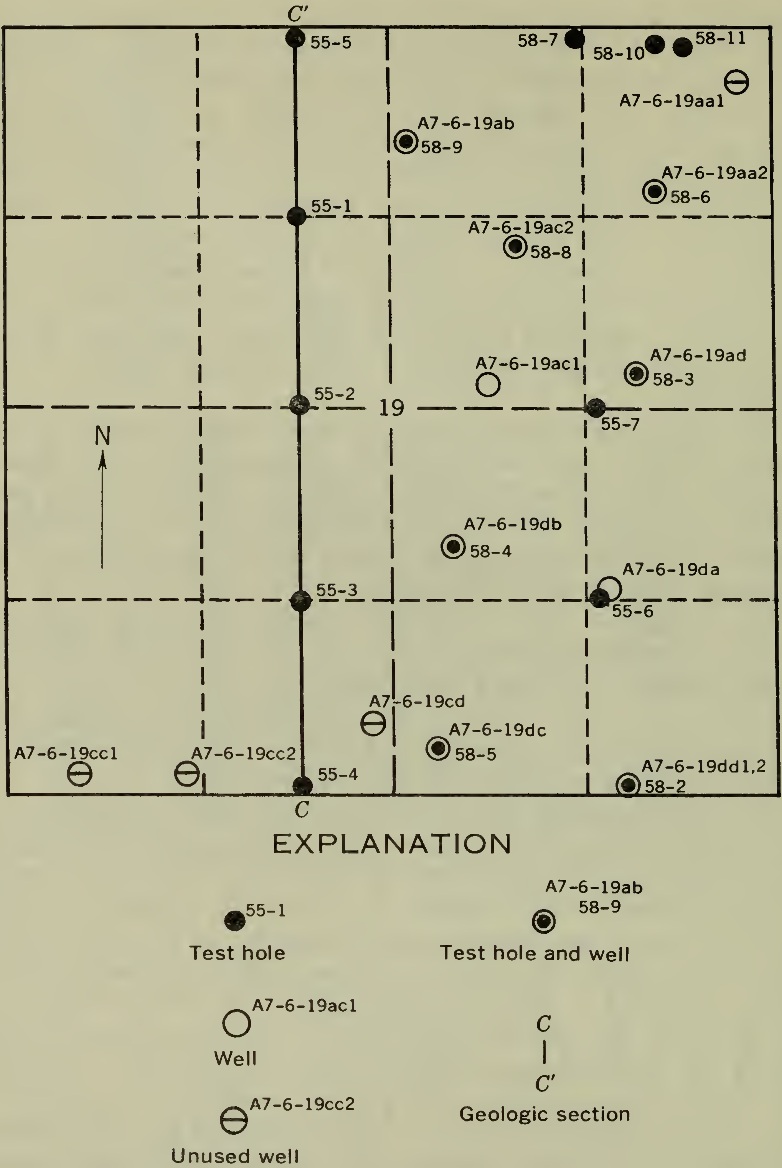

FIGURE 3.—Map showing the location of test holes and wells in sec. 19, T. 7 N., R. 6 E. See plate 2 for location of map area and figure 4 for section *C–C′*.

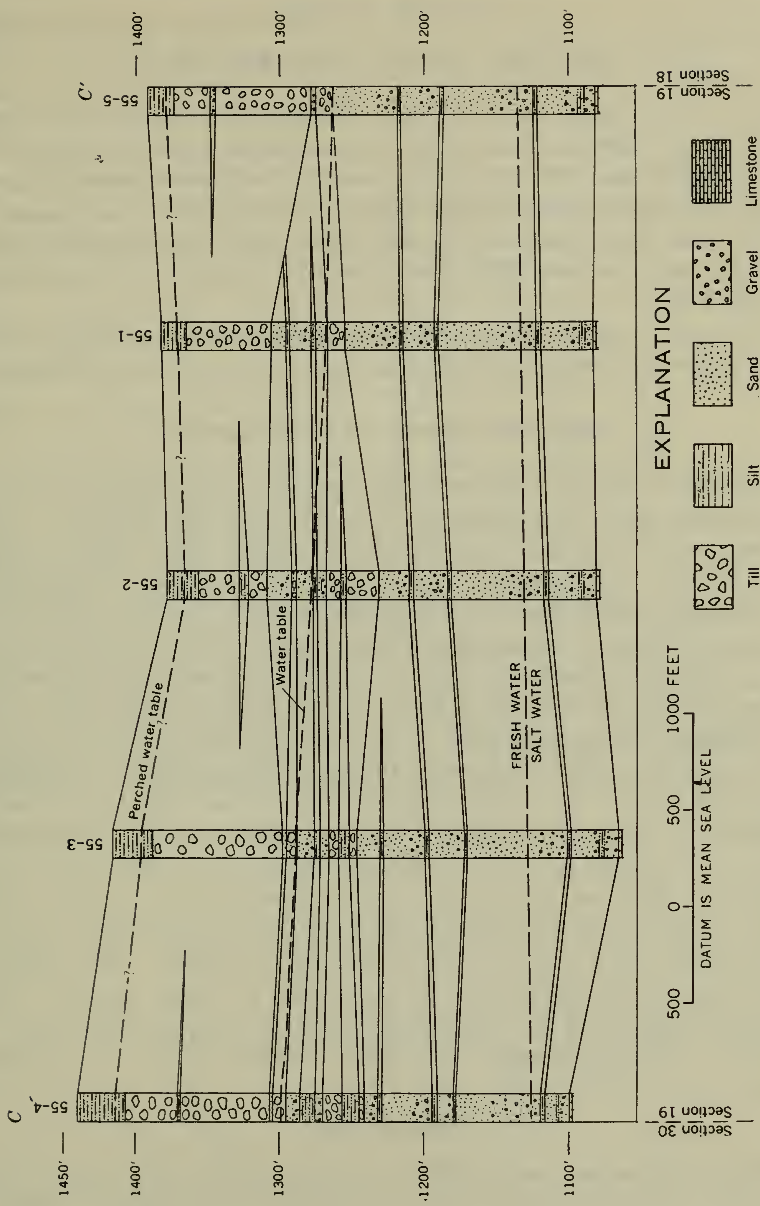

FIGURE 4.—Geologic section *C–C'* across sec. 19, T. 7 N., R. 6 E., Lancaster County, Nebr. See figure 3 for location of *C–C'*.

GROUND WATER

PRINCIPAL ZONE OF SATURATION

The unconsolidated sand and gravel deposits of Pleistocene age that lie below the regional water table are considered in this report to be one aquifer because the formations are generally interconnected and all may contribute water to a deep well. The saturated thickness of the sand and gravel ranges from only a few feet to more than 200 feet. The zone of stauration is thickest along the centerline of the buried bedrock valley.

The depth to the regional water table ranges from less than 10 feet in the valley of Olive Branch to more than 180 feet below the highest hills.

PERCHED ZONES OF SATURATION

Glacial till is for the most part very compact. Although it contains small bodies of sand and gravel that are relatively permeable, the greater part of the till is so slightly permeable that water moves through it at an extremely slow rate. In many places infiltrating precipitation moves downward so slowly through the till that the till acts essentially as an impervious platform, and water collects above it and completely saturates the lower parts of the loess that overlies the till and forms a perched ground-water body that is much higher than the regional ground-water body. Perched water may not occur in all places, however, nor at all times, but it probably occurs in most places during wet years. In many places perched water is present in amounts sufficient to supply small yields of water to shallow wells. Three such wells (now unused) in section 19 in the Hallam area were visited on October 19, 1958, and the depth to water in each was measured. The depths to water were found to be 9.27 feet in well A7–6–19aa1, 7.71 feet in well A7–6–19cd, and 2.73 feet in well A7–6–19dd2. The regional water table beneath section 19, however, is much deeper. For example, on October 19, 1958, the water level stood at 151.26 feet in well A7–6–19da, a new well constructed for water supply to the power-plant.

RECHARGE

Recharge is the process by which water is added to the ground-water reservoir. In any area, the rate and quantity of recharge are dependent on the intensity, type, and duration of precipitation, the vegetative cover, the topography and drainage, and the physical conditions of the soils and subsurface materials. A large part of the water that infiltrates the soil becomes part of the soil moisture. During the growing season, the soil moisture is normally deficient owing to the high use of soil moisture by growing plants. Therefore, in summer almost no water passes through the soil and reaches the zone of saturation. Recharge to the ground-water reservoir is more likely to occur during periods when vegetation is dormant—in the Hallam area particularly in the early spring.

The rate at which water moves downward in response to gravity is governed by the permeability of the earth material through which the water moves. Therefore, if the earth materials were of uniform permeability, the rate of downward movement would be constant. However, because the earth materials in the Hallam area range in texture from clay to gravel, water percolates through them at varying rates. The physical structure of clay or silt also may have an effect on permeability. Massive clay or silt lacking fissures or cracks are too tight to permit water to move through them freely, but such material containing fissures or cracks may transmit water readily.

The loess that in most places caps the glacial-drift hills in the Hallam area has a columnar structure that permits water to move downward more readily than it can move laterally. During periods of precipitation, water filtering down through the loess soon reaches the relatively impermeable glacial till. As more and more water moves downward, it collects rapidly above the till, and the perched water table quickly rises. Water levels in observation wells in glacial-drift hills indicate this fact, because they rise rapidly during and immediately after periods of precipitation and then recede during dry periods. Figure 5 shows the fluctuation of the water level in a well south of Sprague. Shallow wells in these areas, which furnish adequate water

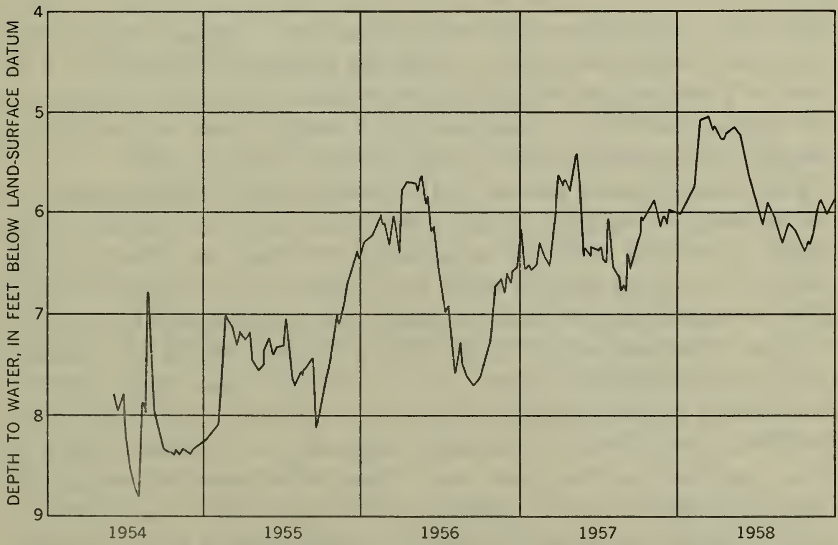

FIGURE 5.—Hydrograph of well A8-6-34dd near Sprague, Nebr.

supplies during normal or wet periods, tend to become dry during droughts; because of this fact many farmers who formerly depended on shallow wells have replaced them in recent years with deep wells that tap the deeper principal aquifer.

The principal, or regional, aquifer, which for the most part is overlain by glacial till, probably receives a very small amount of recharge locally because the glacial till serves as a barrier to downward movement of water. Locally in places where the till is absent or thin or is in large part composed of sand or gravel, recharge to the lower sands and gravels may occur in significant amounts, but it is likely that most of the recharge to the principal aquifer takes place by underflow from areas of intake to the west.

According to Mr. E. C. Reed, state geologist of Nebraska (oral communication, 1958), who has made several computations of recharge through soils like those near the Hallam powerplant site, the average annual recharge from precipitation is on the order of 1 percent of the average annual precipitation, or about one-third inch per year. In most of the Hallam area, however, this amount would apply to the perched water body; the proportion that reaches the principal aquifer below is doubtless very small.

MOVEMENT

Unconfined ground water moves by the most direct route from areas where the water table is high to areas where it is low. In general, ground water moves toward areas of natural discharge. The discharge areas are streams, seeps, springs, and areas of shallow water table. In the shallow-water-table areas the capillary fringe may extend to the land surface to be exposed to direct evaporation; or the roots of phreatophytic vegetation may reach the capillary fringe and use ground water by transpiration. Locally where water is being pumped, the ground water moves toward pumped wells.

The perched water moves to the local natural drainageways. In the immediate vicinity of the powerplant site, the perched water slowly percolates toward drainageways tributary to Olive Branch. During the wetter periods when the perched water aquifer becomes filled to capacity, the local drainageways temporarily become live streams. On October 19, 1958, Spring Branch, which is considered to be an intermittent stream, was a flowing stream beginning at a point about 1 mile northeast of the plant site, and Olive Branch was live from ground-water discharge beginning at a point about 2½ miles northwest of the plant site. Several wet-weather springs are reported in the immediate vicinity of the plant site. One occurs in the drainageway near the SE. cor. sec. 19; another is in the drainageway near the center of the south line of sec. 19. The latter spring was reported to have served in the past as a source of water supply for livestock. Some of the perched water is intercepted by growing plants and transpired to the atmosphere, some is evaporated directly from the land surface, and some likely percolates downward through the till to the regional water table.

The regional water table also slopes toward the areas of natural discharge, and so toward the principal tributaries of Salt Creek in the vicinity of the Hallam powerplant site. Plate 3 shows by means of contour lines the configuration of the regional water table in the vicinity of the plant site. Ground water moves in the direction of the greatest slope of the water table, and the contours indicate that the water table slopes toward areas of natural discharge along Olive Branch and its tributaries.

UTILIZATION

Ground water is pumped from many domestic and stock wells, from 1 public-supply well and, during the growing season, from 3 irrigation wells. Nine industrial wells have been installed to supply water for the powerplant. Location of the wells is shown on plate 3. No attempt was made to determine the total annual withdrawal of ground water from wells. The total amount pumped, however, is small in proportion to the total amount of available ground water.

Downstream from the study area, but within the Salt Creek basin, the city of Lincoln obtains a part of its public water supply from 22 deep wells. Although the city obtains most of its water supply from wells near Ashland, Nebr., in the Platte River valley about 30 miles northeast of Lincoln, the local wells in summer furnish as much as 10 to 12 mgd (million gallons per day). All the 22 local wells receive water from the upper member of the Dakota sandstone.

The part of the Dakota sandstone that furnishes water to the Lincoln wells is younger than the part in the vicinity of Hallam and is separated from it by a shale. The water in the upper sandstone is relatively fresh, in contrast to the highly mineralized water in the lower, or older, part of the formation. Whether there is a physical connection between the upper part of the Dakota sandstone and that of the sand and gravel of Pleistocene age in the Salt Creek valley has not been determined positively; but the evidence indicates that there is none. Ground water in the alluvium of the Salt Creek valley at Lincoln is of poorer quality than that in the upper part of the Dakota sandstone; therefore, there is no evidence that the Dakota sandstone receives recharge from Salt Creek.

The State Penitentiary south of Lincoln in the Salt Creek valley also receives a water supply from 6 wells, of which 4 tap water of the Dakota sandstone and 2 tap fresh-water zones in the alluvium of the Salt Creek valley.

The village of Roca, in the Salt Creek valley downstream from Hallam and about 8 miles south of Lincoln, also is supplied by a well in the valley alluvium. The villages of Sprague and Martell, about 6 miles downgradient from Hallam are supplied water from small privately owned wells.

CHEMICAL QUALITY

Although no special study of the chemical quality of the ground water in the Hallam area was made, several samples of water from aquifers present beneath the Hallam site had previously been obtained and analyzed as part of the Nebraska cooperative ground-water program. (See table 2.) Four of these samples were obtained at the powerplant site; three were from different depths in a test hole and one was from the test well.

Ground water from Pleistocene sand and gravel in the vicinity of Hallam is moderately mineralized, very hard, and generally of the calcium bicarbonate type. Of seven samples of water collected during 1945–52, six came from municipal wells in the villages of Clatonia (A6–5–22cc), Cortland (A6–6–11ad), Firth (A7–7–35bd), Sprague (A8–6–28dd), Hickman (A8–7–33ad), and Roca (A8–7–17cc); the seventh (A8–6–2da) came from a domestic and stock well. The specific conductance of water from these wells ranged from 525 to 1,300 micromhos per centimeter at 25° C, and the hardness ranged from 228 to 444 ppm (parts per million). The most highly mineralized water (well A6–5–22cc) contained an appreciable amount of sodium and chloride, and water from four of the wells contained more than 10 ppm of nitrate. The percent sodium was generally less than 25.

The chemical characteristics of water from test hole 55–7 at the powerplant site varied with depth. Three samples were obtained in December 1955 through the drill stem from three different depths. The chemical characteristics of water from the shallow depth resembled those of water from Pleistocene sand and gravel elsewhere in the vicinity (see table 2); the water was moderately mineralized (424 ppm of dissolved solids) and of the calcium bicarbonate type. However, the chemical characteristics of water from the deeper part of the test hold were radically different; the water was moderately saline (6,350 ppm of dissolved solids) and of the sodium chloride type. Well A7–6–19da, which was drilled a quarter of a mile south of test hole 7 to a depth of 288.5 feet, yielded water whose chemical characteristics were intermediate between those of water from the shallow and deep parts of test hole 55–7. The samples collected from test hole 55–7 may have been contaminated slightly by the presence of drilling mud, but they are considered to be sufficiently representative for comparative purposes.

The chemical characteristics of water from the lower part of the Dakota sandstone and from limestone of Pennsylvanian age are shown by the analyses of water from wells A9–6–5dd and A7–9–10da. Although water from the deep well tapping the lower part of the Dakota sandstone 15 miles north of Hallam (near Lincoln) is much more mineralized than water from the lower part of test hole 55–7, it is of the same chemical type—sodium chloride. The limestone of Pennsylvanian age yields water of the calcium sulfate type about 20 miles east of Hallam.

The presence of relatively high concentrations of sodium, chloride, and fluoride in water from the deep part of the test hole indicates that water from the lower part of the Dakota sandstone probably is moving into the lower part of the Pleistocene sand and gravel in the vicinity of the powerplant site. The presence of relatively high concentrations of nitrate in water from several of the wells in villages near Hallam suggests that an important source of recharge to the shallow water body in the Pleistocene sand and gravel is local precipitation that infiltrates the soil, the nitrate originating from organic material in the soil.

ION EXCHANGE

If a contaminated liquid should be spilled on the ground at the plant site at a time when the land surface was receptive to liquid, it would infiltrate the soil but before it could reach the water table it would percolate through a considerable thickness of clay and silt. Passage through the clay and silt would afford opportunity for natural decontamination by adsorption, ion exchange, and radioactive decay. Radioactive ions in the liquid may be adsorbed on the surfaces of grains in the ground, or they may be exchanged for innocuous stable ions in the ground. The ions in the ground that are available for exchange are principally sodium and calcium. Thus if radioactive elements are introduced into the earth materials, they in part may be exchanged. Ion exchange is accomplished by clay and silt minerals in the soil which are also generally present in some amounts in sand and gravel. Tests made in the laboratories of the U.S. Geological Survey have shown that the near-surface earth materials from other Atomic Energy Commission sites in the United States have exchange capacities ranging from ¼ to 15 equivalents per cubic foot (½ to 30 milliequivalents per 100 grams); in other words, each cubic foot contains from about 5 to about 300 grams of exchangeable sodium and calcium.

TABLE 2.—*Chemical analyses of ground-water*

[Results in parts per

Well or test hole	Depth of well (feet)	Depth to water (feet)	Date of collection	Temperature (° F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)
Wells tapping Pleistocene sand and												
A6-5-22cc	222	90	*1945* Mar 26	55	-------	------	77	23	179		408	0
A6-6-11ad	258	117	do	55	-------	------	84	21	22		382	0
A7-7-35bd	-------	-------	Apr. 2	54	-------	------	83	17	15		272	0
Powerplant site												
55-7	380	136.6	*1955* Dec. 14 [1]	51	33	0.72	79	29	30	4.4	373	6
			do [2]	55	-------	------	-------	------	-------	-------	-------	-------
			Dec. 13 [3]	52	26	2.4	292	95	1,890	9.7	382	0
Powerplant												
A7-6-19da	288.5	-------	*1956* Jan. 19[4]	-------	33	0.76	117	22	146	4.4	388	0
Wells tapping Pleistocene sand												
A8-6-2da	-------	-------	*1952* May 12	55	-------	------	------	------	-------	-------	320	0
A8-6-28dd	80	20	*1950* May 31	57	28	0.12	111	13	47	3.8	419	0
A8-7-17cc	40	10	do	57	23	.16	125	32	63	3.2	412	0
A8-7-33ad	42	16	do	54	32	.14	115	27	58	5.4	360	0
Well tapping Dakota (?)												
A9-6-5dd	2,000	Flowing.	*1949* Aug. 8.[5]	61	9.8	0.1	183	143	9,990	35	448	0
Well tapping of Pennsylvanian												
A7-9-10da	80	15	*1955* Nov. 15[6]	54	18	0.02	180	88	135	9.0	328	0

[1] Water from 260–270 ft.
[2] Water from 290–300 ft. Turbidity as SiO_2, 4 ppm.
[3] Water from 350 ft. Density, 1.005 g per ml at 20 °C.
[4] Collected after 23½ hours of pumping.

samples from the Hallam area, Nebraska

million except as indicated]

Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Calculated	Dissolved solids: Residue on evaporation at 180 °C	Hardness as $CaCO_3$	Noncarbonate hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25 °C)	pH	Alkalinity as $CaCO_3$
gravel southeast of Hallam												
54	201	0.2	0.7	-------	--------	--------	286	0	58	1,300	------	335
11	14	.0	.6	-------	--------	--------	296	0	14	606	------	313
54	12	.0	17	-------	--------	--------	277	54	11	572	------	223
test hole												
54	7.5	0.3	0.1	0.01	--------	424	317	1	17	663	8.2	316
--------	--------	--------	--------	-------	--------	--------	--------	--------	------	1,120	------	--------
617	3,030	1.6	2.7	.50	6,150	6,350	1,120	807	78	10,300	7.9	313
site well												
95	207	0.1	0.2	0.09	--------	834	384	66	45	1,390	7.3	318
and gravel north of Hallam												
15	7.0	0.3	0.6	-------	--------	315	228	0	21	525	7.5	262
47	16	.2	25	0.13	--------	546	331	0	23	806	7.2	344
83	52	.3	130	.3	--------	730	444	106	23	1,060	7.3	338
116	35	.2	84	.37	--------	658	398	103	24	949	7.4	295
sandstone north of Hallam												
3,150	13,800	2.4	2.9	5.5	27,000	28,200	1,040	673	95	38,000	7.4	367
limestone age east of Hallam												
671	81	0.4	1.2	-------	1,350	1,430	811	542	26	1,810	7.4	269

[5] Density, 1.017 g per ml at 20°C.
[6] Uranium, 0.4 micrograms per liter; radium, 0.2 micro-microcuries per liter; beta-gamma activity, <45 micro-microcuries per liter.

SURFACE WATER

Most of the water received from precipitation at the Hallam powerplant site area runs off the land to the nearest drainageway tributary to Olive Branch, and thence down Olive Branch to Salt Creek, which flows through the city of Lincoln and on to the Platte River 30 miles beyond Lincoln. The Platte River discharges into the Missouri River about 35 miles downstream from the mouth of Salt Creek. Thus, it is possible that a drop of water falling at the Hallam plant would move down the natural drainageways to the Gulf of Mexico. It is likely, however, that the drop would be delayed considerably in its journey to the sea by floodwater-retarding structures. In 1954 the upper Salt Creek basin was designated a pilot demonstration watershed project under the Agricultural Appropriation Act for fiscal year 1954 (Public Law 156, 83d Cong.) under authority of the Soil Conservation Act of 1935 (Public Law 46, 74th Cong.). The program objective is to protect and improve land through conservation practices and to reduce flood-plain damage through flood-protection measures. This project is nearing completion in the Hallam area. Floodwater-retarding structures, combination floodwater-retarding and grade-stabilization structures, and sediment-control structures have been or are now being constructed. The ground surface surrounding the powerplant has been graded to slope toward the west to insure that surface runoff will move westward to the drainageway above the floodwater-retarding structures. To insure further that no surface runoff will move eastward to Spring Branch, the spur railroad constructed along the east side of the plant site was built on a grade higher than the land surface. Two floodwater-retarding structures have been constructed across the natural drainageway that carries water originating on the land surrounding the powerplant site. The upper structure is being built on the plant site immediately down drainage from the proposed nuclear reactor. This dam will provide storage to retain 6.04 inches of runoff from the entire drainage area of 530 acres, or a total of 267.5 acre-feet. Storage below the overflow outlet is adequate to retain a 100-year storm. However, if the valve in the overflow outlet is closed, additional storage equal to a 50-year storm could be retained before water would spill over the crest of the dam. In addition to the available flood storage in the reservoir, space is provided for 58 acre-feet of sediment, which is equivalent to a yield of 1.32 inches from the entire drainage area. This reservoir is specially provided with a manually operated gate to retain or release water. In the event of an accidental release of radioactive material, the gate presumably could be closed if it were open.

Approximately 2 miles below the upper structure in the same drainageway, a similar floodwater-retarding dam has been constructed and is in operation. It provides a permanent storage capacity of 11.2 acre-feet when the siphon drain tube is open and 51.3 acre-feet when the orifice is closed, as it normally is. The dam also provides a flood-flow reservoir of 228.89 acre-feet and an emergency flood-flow capacity of 660.2 acre-feet.

Additional downstream reservoirs and flood-control structures on Olive Branch and Salt Creek to be constructed by the Corps of Engineers have been authorized by Congress, but funds for construction have not yet been appropriated.

Numerous smaller drainageways in the Hallam area have been dammed to form small reservoirs of water for livestock. No record of the number or the location of these stock ponds has been made. Most of the water that collects in the ponds is lost by direct evaporation and thereby is prevented from moving downstream.

None of the water moving down Salt Creek is used for human consumption. Livestock pastured along the creek drink the water, and some of the water is diverted by means of pumps for irrigation. Untreated as well as treated sewage and industrial wastes are discharged into the creek at Lincoln and other towns along its course.

Salt Creek often has overflowed its banks and subjected the cities and farms along its course to severe flood damage and to some loss of human life. Much of the industrial section of the city of Lincoln has been inundated when the stream was in flood stage.

No continuous record has been obtained of the discharge of Olive Branch, but a crest-stage gaging station was installed in April 1956 on the creek at a bridge 2 miles upstream from Sprague. The record from this gage indicates that Olive Branch exceeded bank-full stage near the gage site three times in 1956, twice in 1958, and twice in 1959, but that no serious flooding has occurred during the 4-year period of record. A continuous recorder station installed May 1951 on Salt Creek just below the confluence of Olive Branch with Hickman Branch (the two branches which meet to form Salt Creek) records runoff from an area of which Olive Branch drainage basin is only a part.

CONCLUSIONS AND RECOMMENDATIONS

All the precipitation on the reactor site that is not evaporated or transpired immediately by plants, retained as soil moisture for later evapotranspirative discharge, or otherwise used moves downgradient by natural or manmade drainageways or through the earth materials. Unless the water is intercepted en route, it will eventually reach a tributary of Salt Creek, where it will become part of the streamflow.

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It is probable, however, that a radioactive liquid spilled at the powersite would change in character somewhat as it is transported through the earth materials by water from precipitation. The earth materials near Hallam, as in most places, have an ion-exchange capacity; thus, if they should come into contact with newly introduced elements, they could exchange ions with the introduced elements.

If radioactive liquid is accidentally spilled on the ground at the site, the liquid may take one of or all the following paths (pl. 4):

1. Spilled liquid may filter into and be retained by soil at the site of spillage.
2. Spilled liquid might flow on the land surface down a local drainageway and be contained in the reservoir on the site; this reservoir is designed to impound as much as the equivalent of a 6-inch rain and to stop and hold any contaminated surface water on the site until it can be decontaminated. If contaminated surface water moves past this reservoir it will probably be intercepted by another reservoir about 2 miles farther downstream. If it passes the second reservoir, then it will flow directly down the drainageway to Olive Branch and on to Salt Creek on its way down the streams that eventually discharge to the ocean.
3. The liquid might infiltrate the soil, move down to the perched water zone, and thence percolate laterally to hillside seeps and springs and into the drainageways that lead to Olive Branch. The time required for water to move via the perched groundwater zone from the point of contamination to the areas of discharge may be many days or many months, depending, in part, on the permeability of the earth materials and the hydraulic gradient.
4. The liquid might percolate from the perched water zone down to the principal aquifer and thence move laterally at or below the water table toward the points of natural discharge of the principal aquifer. The natural points of discharge from the principal aquifer are believed to be seeps and springs along Olive Branch. Probably many years would elapse before a contaminant would reach a point of natural recharge via this route. Some time would elapse before the contaminant could percolate to the principal aquifer because it is relatively deep and in most places lies beneath thick deposits of clay and silt that are very low in permeability. Much more time would elapse before the contaminated water could reach points of discharge because the regional water table has a small hydraulic gradient and thus the rate of lateral movement of the regional water is very slow, probably less than a foot per day.
5. The liquid might percolate to the principal aquifer to be pumped out by wells at the plant site. Ground water will be used at a

rate of about 2,000 gpm (gallons per minute) to make up losses in producing electricity from steam at the power plant. This amount of pumping probably will cause a cone of depression of considerable diameter around the pumped wells, and therefore locally the ground water will move toward wells. A contaminant in the water would thus move with the ground water to the wells and be pumped out.

Further investigation would be needed to determine the time required for water to move downgradient to the discharge points via both surface- and ground-water routes. More data would be needed in regard to streamflow, both base flow and flood flow and much additional information would be needed about the permeability of glacial till and other sediments through which water moves. The gradient of the water table would need to be determined more precisely. Studies of the movement of ground water by the use of tracer elements would help establish the time required for a contaminant to travel through the aquifers.

Periodic measurement of water levels in wells in the vicinity of the plant site is recommended. One deep observation well equipped with a recording gage would furnish valuable data concerning changes in fluctuations of the main water table at the plant site. A record of the fluctuation of the perched water table should be obtained by means of a recording gage installed on a shallow well at the power site.

A network of deep observation wells in the vicinity of the powerplant would make it possible to construct a comprehensive water-table map, and the observation of the water levels in wells of the network when the powerplant is in operation would give valuable information concerning the size and shape of the cone of depression that will be formed when ground water is pumped for use at the powerplant.

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TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*

[Altitude of land surface determined by spirit leveling. Depth to water given in feet below land surface. All test holes were drilled in sec. 19, T. 7 N., R. 6 E., Lancaster County, and were given numbers by Consumers Public Power District. See figure 3 for location of test holes]

	Thickness (feet)	Depth (feet)
55-1. Altitude 1,382.14 feet above mean sea level. Depth to water unknown.		
Till: Silt, slightly to moderately clayey, slightly sandy, slightly calcareous, light medium-brown; contains fine to medium sand	5	5
Till: silt and very fine to coarse sand with a trace of fine gravel, moderately clayey, medium-light brownish-gray and mottled light yellow-brown; contains limy nodules	5	10
Till: silt and very fine to coarse sand with some fine gravel, moderately clayey, slightly calcareous, medium light-gray and mottled yellow and brown; contains limy nodules	5	15
Till: silt and fine to medium gravel, light grayish-brown	5	20
Till: silt and fine gravel	5	25
Till: silt, moderately clayey, moderately calcareous, medium-gray; contains scattered medium to very coarse sand and gravel grains; contains some yellow-brown claystone	5	30
Till: silt, sand, and yellow-brown claystone, moderately calcareous	5	35
Till: silt, slightly to moderately calcareous; contains some yellow-brown clay	5	40
Till: silt and fine sand, moderately calcareous; contains scattered coarse sand and fine gravel	5	45
Till: silt and fine sand with a trace of medium sand, moderately calcareous	5	50
Till: silt	10	60
Till: silt; contains some scattered fine gravel	15	75
Till: silt and very fine to medium sand with a trace of coarse sand, slightly clayey	5	80
Sand, very fine to medium	5	85
Sand, very fine to very coarse with a trace of fine gravel, contains 70 percent very fine to medium sand; contains a trace of slightly calcareous yellow silt; contains moderately calcareous medium-gray till	5	90
Sand, very fine to medium with some coarse to very coarse, slightly silty, medium-gray	5	95
Sand, very fine to coarse with a trace of very coarse	5	100
Sand, very fine to coarse with a trace of very coarse; contains more coarse sand	5	105
Sand, fine to very coarse with a trace of fine gravel; contains a trace of slightly silty light-gray clay	5	110
Sand, fine to very coarse with some fine to medium gravel	5	115

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
55-1—Continued		
Till: silt and very fine to medium with some coarse to very coarse sand, very calcareous, medium-gray; contains some scattered fine to medium gravel	5	120
Till: silt and very fine to medium with a trace of coarse to very coarse sand and some fine gravel, moderately calcareous	5	125
Till: silt and fine to coarse with a trace of very coarse sand and medium gravel	5	130
Sand, fine to coarse	5	135
Sand, medium to coarse with a trace of very coarse	5	140
Sand, very fine to very coarse	5	145
Sand, fine to very coarse with a trace of fine gravel	5	150
Sand, fine to very coarse	5	155
Sand, fine to very coarse; contains 5 percent gravel	5	160
Sand, fine to very coarse	5	165
Sand, very fine to very coarse; slightly finer below 170 ft	15	180
Sand, fine to very coarse with a trace of fine gravel	5	185
Sand, medium to very coarse with some fine gravel	5	190
Sand, very fine to very coarse; coarser sand below 195 ft; contains some fine gravel below 205 ft	20	210
Sand, fine to very coarse with some fine gravel; contains 5 percent gravel to 215 ft, 20 percent gravel below 215 ft	10	220
Sand, medium to very coarse, and fine to medium gravel	15	235
Sand, medium to very coarse and fine to medium gravel; contains 60 percent gravel	5	240
Sand, very fine to very coarse, and fine gravel; contains 20 percent gravel	5	245
Sand, very fine to very coarse, with a trace of very light yellow-gray clay	5	250
Sand, fine to very coarse, with some fine to medium gravel	10	260
Sand, very fine to very coarse; contains some medium-gray till	5	265
Sand, fine to very coarse, with a trace of fine to medium gravel	15	280
Sand, medium to very coarse, with some fine gravel; contains a trace of limestone below 285 ft	10	290
Limestone and shale, weathered, light to medium-gray; contains fine to very coarse sand and a trace of gravel	5	295
Limestone, light-gray; contains a little sand	5	300

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
55–2. Altitude 1,377.1 feet above mean sea level. Depth to water unknown.		
Till: silt, slightly clayey, slightly sandy, light yellow-brown; contains a few limy nodules	5	5
Till: silt, medium-gray	5	10
Silt, moderately clayey, moderately calcareous, light-gray with mottled yellow, brown, and light-gray	5	15
Silt with a trace of medium to very coarse sand, slightly to moderately calcareous, light brownish-gray	5	20
Till: silt, moderately calcareous, medium-gray; contains scattered sand and gravel grains; clayey below 35 ft	30	50
Till: silt and very fine to very coarse sand, light medium-gray	5	55
Till: silt with some medium to very coarse sand and fine to medium gravel, slightly to moderately calcareous, medium-gray	10	65
Till: silt and medium to very coarse sand; contains a trace of limestone	5	70
Sand, fine to coarse; contains a trace of medium-gray silt	5	75
Sand, very fine to coarse	5	80
Sand, medium to very coarse, with some fine gravel; contains some limestone and ironstone	5	85
Sand, fine to very coarse, with some fine gravel; contains a trace of yellow clay and limestone	5	90
Sand, very fine to very coarse, with a trace of fine gravel; contains less medium to very coarse sand below 95 ft	10	100
Sand, very fine to coarse with a trace of very coarse, and fine gravel; contains some medium-gray silt	5	105
Sand, very fine to very coarse, with a trace of fine gravel	4	109
Till: silt, moderately calcareous, medium-gray; contains scattered sand and gravel grains	6	115
Till: silt; contains a few scattered sand and gravel grains and some limestone	5	120
Till: silt and sand with fine to medium gravel; iron stained in part	5	125
Till: silt with a trace of sand and gravel. moderately calcareous; contains slightly more gravel and a trace of yellow clay below 130 ft	10	135
Till: silt with a trace of sand and gravel, moderately calcareous	11	146
Sand, very fine to very coarse, slightly to moderately silty, medium-gray	4	150
Sand, medium to very coarse, with a trace of fine sand and gravel	5	155
Sand, fine to very coarse, with a trace of fine gravel, gray; slightly coarser below 160 ft	10	165
Sand, medium to very coarse, with some fine gravel; contains 10 percent fine gravel below 180 ft	20	185

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
52-2—Continued		
Sand, fine to very coarse, with some fine gravel; contains some very fine sand from 190 to 195 ft; contains 10 percent fine gravel from 205 to 210 ft	30	215
Sand, medium to very coarse with some fine gravel; contains a trace of fine sand and 15 percent fine gravel below 220 ft	10	225
Sand, coarse to very coarse with a trace of medium sand and 20 percent fine gravel	5	230
Sand, coarse to very coarse, and fine gravel; contains 35 percent fine gravel to 235 ft, 10 percent below 235 ft	10	240
Sand, fine to very coarse, and fine gravel	20	260
Sand, very fine to very coarse, with a trace of fine gravel	10	270
Sand, fine to very coarse, with some fine gravel; contains some very fine sand from 280 to 285 ft	20	290
Sand and weathered limestone and shale, medium to very light gray and light-brown	6	296
55-3. Altitude 1,414.94 feet above mean sea level. Depth to water unknown.		
Till: silt, moderately to very clayey, slightly sandy, slightly to moderately calcareous, light brownish-gray and mottled yellow with white streaks; contains some limy nodules	10	10
Till: silt and very fine to very coarse sand with some fine gravel, slightly clayey, slightly to moderately calcareous, light yellow-brown to very light gray; contains a trace of scattered limestone	10	20
Till: silt and very fine to very coarse sand, moderately to very clayey, moderately calcareous, light-to medium yellow-brown and medium-gray; contains some scattered limestone below 25 ft	10	30
Till: silt, mottled dark- and light-gray; contains some tubular calcite crystals	5	35
Till: silt, slightly clayey, slightly sandy, moderately calcareous, light yellow-brown and light-gray; contains some carbonaceous material	5	40
Till: silt, moderately clayey, slightly sandy, light to medium yellow-brown; contains scattered limestone	5	45
Till: silt, slightly clayey, slightly sandy, slightly calcareous, light yellow-brown to light-gray	10	55
Till: silt, moderately clayey, slightly sandy, moderately calcareous, medium-brown to light yellow-brown and mottled light-gray to white; contains some scattered limestone	5	60
Till: silt with some scattered fine to very coarse sand, slightly clayey, slightly calcareous, medium-gray	5	65

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
55-3—Continued		
Till: silt, moderately calcareous; contains a trace of yellow clay; contains scattered limestone	20	85
Till: silt, slightly to moderately clayey, moderately calcareous, medium-gray; contains a trace of tubular calcite crystals and scattered sand and limestone grains	5	90
Till: silt, slightly clayey, medium-gray; contains a trace of scattered sand and limestone grains; slightly more sandy from 95 to 100 ft	15	105
Till: silt, moderately calcareous	5	110
Till: silt, slightly clayey, moderately calcareous, medium-gray; contains scattered limestone grains	5	115
Till: silt, slightly clayey, slightly sandy; contains scattered limestone and gravel grains	10	125
Till: silt and very fine to very coarse sand with some fine gravel, moderately calcareous	10	135
Till: silt and very fine to very coarse sand with a trace of fine gravel	10	145
Till: silt and very fine to very coarse sand, slightly calcareous	10	155
Sand, fine to very coarse, with some fine gravel slightly to moderately silty, medium-gray; contains some weathered limestone	10	165
Sand, fine to very coarse, with a trace of fine gravel, slightly silty	5	170
Sand, very fine to very coarse; contains a trace of slightly calcareous yellow clay and noncalcareous medium-gray shale; contains some limestone	5	175
Sand, fine to very coarse	5	180
Sand, fine to very coarse, with some fine gravel contains a trace of yellow clay below 190 ft	15	195
Sand with some fine gravel; contains a trace of calcareous yellow clay and medium-gray silt	10	205
Sand, very fine to very coarse with a trace of fine gravel; contains a trace of medium-gray silt	5	210
Sand, very fine to medium with a trace of coarse	5	215
Sand, very fine to very coarse, and fine gravel	5	220
Sand, very fine to very coarse, with some fine gravel, slightly silty, medium-gray; contains a trace of moderately calcareous yellow clay	5	225
Sand, very fine to very coarse, with some fine gravel	10	235
Sand, fine to very coarse, with some fine to medium gravel; contains weathered shale and limestone from 260 to 265 ft; contains a trace of light brownish-gray silt below 290 ft	60	295
Sand, fine to very coarse, and fine to medium gravel, moderately to very silty, light-gray	5	300
Sand, fine to very coarse, with some fine gravel	10	310

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
55-3—Continued		
Sand, fine to very coarse, and fine to medium gravel; contains a trace of slightly calcareous medium-gray till	10	320
Sand, fine to very coarse, and fine to medium gravel; contains a trace of light-gray silt	5	325
Sand, very fine to very coarse, with some fine to medium gravel	10	335
Sand, fine to very coarse, and fine to medium gravel, slightly silty, light-gray	5	340
Sand, fine to very coarse, and fine to medium gravel, slightly to moderately silty, light-gray; contains weathered shale and limestone; contains a trace of yellow clay below 345 ft	8	348
55-4. Altitude 1,440.22 feet above mean sea level. Depth to water unknown.		
Till: silt, slightly clayey, slightly sandy, slightly to moderately calcareous, light yellow-brown and mottled dark to very light gray, white, and yellow	5	5
Till: silt, slightly sandy, slightly calcareous, light yellow-brown	5	10
Till: silt, moderately clayey, slightly sandy, light yellow-brown and mottled light-gray	5	15
Till: silt, slightly sandy; very clayey and contains a trace of white material below 20 ft	10	25
Till: Silt and weathered limestone, slightly calcareous	15	40
Till: silt and weathered limestone with a trace of fine gravel, mottled medium dark-brown	20	60
Till: silt, moderately clayey, slightly sandy, moderately calcareous, medium-gray with some light yellow-brown; contains some limestone fragments	10	70
Till: silt with scattered sand and gravel grains, medium-gray to light to medium yellow-brown; moderately calcareous below 95 ft	30	100
Till: silt and weathered limestone, sandy, mottled light yellow-brown; medium-gray below 105 ft; moderately calcareous from 120 to 125 ft	30	130
Till: silt, slightly to moderately clayey, slightly sandy, moderately calcareous, medium-gray; contains a trace of fine gravel and limestone	10	140
Sand, very fine to coarse with a trace of very coarse, slightly silty, medium-gray; contains some calcareous light yellow-brown silt below 145 ft	10	150
Till: silt with scattered sand and gravel and limestone grains, slightly clayey	5	155

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
55-4—Continued		
Till: silt, slightly clayey, slightly sandy; contains a trace of light brownish-gray clay from 155 to 160 ft	20	175
Sand, very fine to very coarse, with some fine gravel, moderately to very silty, medium-gray; contains some limestone fragments	5	180
Sand, fine to very coarse, with some fine gravel, slightly silty, medium-gray; contains some limestone fragments	5	185
Sand, fine to very coarse; contains some fine gravel below 190 ft	10	195
Sand, very fine to coarse with a trace of very coarse; contains a trace of light-gray silt below 205 ft	15	210
Sand, very fine to very coarse with a trace of fine gravel	5	215
Sand, very fine to very coarse with some fine gravel, slightly silty, slightly calcareous, medium-gray; contains a trace of yellow silt from 220 to 225 ft	15	230
Sand, fine to very coarse with some fine to medium gravel; contains a trace of medium-gray silt	25	255
Sand, very fine to very coarse with a trace of fine gravel, medium light-gray; slightly silty, slightly calcareous to 260 ft	10	265
Sand, fine to very coarse, and fine gravel; slightly silty below 270 ft	10	275
Sand, fine to very coarse, and fine to medium gravel; slightly silty to 280 ft and below 285 ft; no medium gravel below 285 ft	15	290
Sand, fine to very coarse, and fine gravel with a trace of medium gravel, slightly silty, medium-gray; contains a trace of slightly calcareous medium-gray silt below 295 ft	10	300
Sand, medium to very coarse, and fine to medium gravel	10	310
Sand, fine to very coarse, and fine to medium gravel, slightly silty, slightly calcareous, medium-gray	5	315
Sand, very fine to very coarse, and fine to coarse gravel; contains a trace of medium- and light-gray silt	5	320
Sand, very fine to very coarse, and fine to medium gravel; contains a trace of slightly calcareous medium-gray silt and yellow silt	5	325
Sand, with a trace of fine gravel; contains medium-gray silt	5	330
Sand, fine to very coarse, with a trace of fine gravel, slightly silty	4	334
Sand, fine to very coarse, with some fine to medium gravel; contains some medium-gray silt; contains a trace of weathered limestone and slightly to moderately calcareous light-yellow silt	3	337

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
55-5. Altitude 1,390.58 feet above mean sea level. Depth to water unknown.		
Till: silt, slightly clayey, moderately sandy, moderately calcareous, light yellow-brown and mottled light-gray; contains a trace of fine gravel	5	5
Till: silt, slightly sandy	5	10
Till: silt with a trace of medium to very coarse sand and fine gravel, moderately clayey, moderately calcareous, light yellow-brown, slightly gray	5	15
Till: silt, slightly clayey, moderately calcareous, light to medium yellow-brown and mottled yellow; contains a trace of sand, gravel, and limestone	5	20
Till: silt, with some sand and gravel, slightly clayey, moderately calcareous, light yellow-brown	15	35
Till: silt, slightly to moderately clayey, moderately calcareous, light yellow-brown and light-gray	5	40
Till: silt, moderately clayey, light-gray and mottled yellow; contains a trace of medium sand to fine gravel	5	45
Till: silt and fine to very coarse sand with some fine to medium gravel, slightly clayey, light-yellow and light-gray; contains a trace of yellow and some medium-gray silt	5	50
Till: silt and medium sand to fine gravel, slightly clayey, moderately calcareous; contains a trace of yellow clay to 55 ft; contains some limestone and shale fragments; contains medium sand to coarse gravel from 55 to 60 ft	20	70
Till: silt and fine to very coarse sand with some coarse gravel, slightly clayey; contains some limestone and ironstone; slightly sandy below 75 ft	25	95
Till: silt with some scattered medium sand to fine gravel grains, slightly clayey, moderately calcareous; contains some limestone fragments	15	110
Till: silt with some scattered corase sand to fine gravel grains, slightly clayey, moderately calcareous, medium-gray	5	115
Till: silt and some scattered sand and fine to very coarse gravel grains	15	130
Sand, very fine to very coarse with some fine gravel, slightly silty, medium-gray	5	135
Sand, very fine to coarse with a trace of very coarse; contains a trace of slightly calcareous yellow-brown silt	5	140
Sand, very fine to very coarse; contains a trace of fine gravel and medium-gray silt below 145 ft	10	150
Sand, very fine to very coarse, with some fine gravel, slightly to moderately silty, medium-gray; contains some fine to medium gravel from 160 to 165 ft; moderately calcareous below 165 ft	20	170

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
55-5—Continued		
Sand, very fine to very coarse, with some fine to medium gravel; contains a trace of slightly calcareous yellow silt from 170 to 175 ft and a trace of medium-gray silt from 180 to 185 ft and a trace of yellow clay from 190 to 195 ft	35	205
Sand, very fine to very coarse, with a trace of fine gravel; contains a trace of moderately calcareous yellow silt below 210 ft	15	220
Sand, very fine to very coarse, with fine to medium gravel; contains more very fine to fine sand below 225 ft	10	230
Sand, fine to very coarse, with fine to medium gravel	5	235
Sand, fine to very coarse, with fine to medium gravel; contains much very coarse sand	5	240
Sand, medium to very coarse, with fine to medium gravel	5	245
Sand, fine to very coarse, with fine to medium gravel; contains a trace of medium-gray silt below 250 ft	25	270
Sand, fine to very coarse, with fine gravel and a trace of medium gravel; contains a trace of noncalcareous light-gray silt to 275 ft	10	280
Sand, fine to very coarse, with fine to medium gravel; contains a trace of coarse gravel and a large amount of limestone below 300 ft	25	305
Sand, fine to very coarse, with fine to coarse gravel; contains a trace of light-gray silt	5	310
Gravel, fine to coarse, coarse to very coarse sand with a trace of fine to medium sand, and limestone, light-gray	2	312
55-6. Altitude 1,455.12 feet above mean sea level. Depth to water, 151 feet, January 13, 1956.		
Silt, slightly clayey, noncalcareous, light yellow-brown	5	5
Silt, slightly to moderately clayey, noncalcareous, medium light-brown and mottled light-gray	5	10
Till: silt, slightly to moderately clayey, slightly sand, noncalcareous to moderately calcareous, medium light-brown to light yellow-brown; contains a trace of limestone from 15 20 ft	15	25
Till: silt, slightly sandy, moderately to very calcareous, medium-brown to very light gray	5	30
Till: silt, slightly clayey, slightly sandy, moderately calcareous, light yellow-brown	5	35
Till: silt, moderately calcareous; contains some limestone fragments	5	40
Till: silt, slightly sandy	5	45
Till: silt, moderately calcareous, light to medium yellow-brown and mottled light to very light gray	5	50

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
55-6—Continued		
Till: silt, sandy, medium red-brown; contains some limy material, moderately to very calcareous	5	55
Till: silt, moderately clayey, slightly sandy, light to medium yellow-brown with some light-gray; contains more sand below 65 ft; contains some limestone grains	15	70
Till: silt, moderately to very clayey, slightly sandy with a trace of gravel, moderately calcareous, light yellow-brown with some mottled medium-gray; more yellow in color below 75 ft	10	80
Till: silt and fine to very coarse sand with a trace of fine gravel, moderately clayey, light-yellow and mottled light-gray; contains less sand below 85 ft	10	90
Till: silt and some fine to medium sand with some fine to medium gravel, moderately calcareous	5	95
Till: silt and fine to very coarse sand, moderately calcareous, medium light-gray	5	100
Till: silt, slightly to moderately clayey, slightly sandy, moderately calcareous, light yellow-brown with mottled light-gray and medium-brown; contains more sand below 105 ft	10	110
Till: silt, slightly clayey, slightly sandy, moderately calcareous, light yellow-brown	5	115
Till: silt and very fine to coarse sand, medium light-brown	5	120
Sand, fine to coarse, slightly clayey, very silty, medium light to yellow-brown	5	125
Till: silt and fine to coarse sand, slightly clayey, slightly to moderately calcareous, medium-gray and medium yellow-brown; contains some limestone fragments	5	130
Till: sand, fine to very coarse, moderately to very silty, moderately calcareous, light-brown and medium-gray; contains some very coarse limestone	10	140
Till: silt and fine to very coarse sand with some fine gravel, moderately calcareous, medium-gray; contains much limestone; contains fine to coarse gravel below 145 ft	10	150
Till: silt with some sand and gravel, moderately calcareous; contains some yellow-brown silt; moderately clayey below 155 ft	10	160
Sand, very fine to coarse; contains a trace of medium-gray till and very light yellow brown silt	10	170
Sand, fine to very coarse, with a trace of fine to medium gravel	5	175
Sand, very fine to coarse, with a trace of very coarse; contains a trace of yellow-brown silt	10	185
Sand, very fine to very coarse, moderately silty, moderately calcareous, medium-gray	5	190

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
55-6—Continued		
Till: silt, slightly clayey, slightly sandy; contains some fine gravel and moderately clayey, moderately calcareous, medium-gray silt	5	195
Till: silt and fine to very coarse sand, with some fine to medium gravel; contains a trace of light yellow-brown silt	5	200
Sand, very fine to coarse with a trace of very coarse sand to fine gravel; contains a trace of medium-gray silt; contains a trace of yellow silt from 215 to 220 ft; contains a trace of yellow-brown silt, moderately calcareous, from 235 to 240 ft	40	240
Sand, very fine to very coarse; contains some fine gravel below 245 ft; contains a trace of slightly calcareous light yellow-brown silt from 260 to 265 ft	30	270
Sand, fine to very coarse, with some fine gravel; contains a trace of light-gray, yellow, and brown-gray silt	5	275
Sand, very fine to very coarse, with a trace of fine gravel; contains a trace of moderately calcareous light yellow-brown silt	10	285
Sand, fine to very coarse, with some fine gravel; contains some fine to medium gravel below 295 ft	15	300
Sand, medium to very coarse, with some fine to medium gravel	10	310
Gravel, fine to medium, with some medium to very coarse sand; contains a trace of fine sand below 315 ft	10	320
Sand, medium to very coarse with a trace of fine, and fine to medium gravel	5	325
Sand, very fine to very coarse, with some fine and a trace of medium gravel; contains a trace of noncalcareous light-gray silt below 345 ft	25	350
Sand, very fine to coarse with a trace of very coarse, moderately silty, noncalcareous, light-gray	10	360
Sand, very fine to very coarse; contains a trace of noncalcareous brownish-gray clay	5	365
Sand, very fine to very coarse, with some fine to coarse gravel	5	370
Gravel, fine to coarse, with fine to very coarse sand	3	373
Sand, coarse to very coarse, with fine to medium gravel; contains weathered light-gray limestone	1	374

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
55–7. Altitude 1,443.14 feet above mean sea level. Depth to water, 136.6 feet, December 13, 1955. Chemical analysis made of water.		
Silt, soillike, noncalcareous, medium light-gray; contains some limy material	10	10
Till: silt, slightly clayey, slightly sandy, noncalcareous to slightly calcareous, light yellow-brown	5	15
Till: silt, moderately calcareous, slightly mottled light- and dark-gray; contains some limy nodules	5	20
Till: silt, slightly sandy, moderately calcareous; contains some fine to coarse gravel and limestone	5	25
Till: silt, moderately clayey, slightly sandy, light yellow-brown and mottled light-gray; contains some gravel from 30 to 45 ft and below 60 ft; more clayey below 45 ft	40	65
Till: silt, slightly sandy, moderately clayey, moderately calcareous, light yellow-brown; contains a trace of fine to medium gravel from 70 to 75 ft; contains a trace of medium-gray silt below 75 ft	20	85
Till: silt, moderately clayey, slightly sandy with a trace of fine gravel, moderately calcareous, medium-gray	10	95
Till: silt, with a trace of fine to coarse gravel, moderately to very calcareous, medium-gray and mottled yellow and yellow-brown; contains some limestone	10	105
Till: silt and very fine to coarse sand	5	110
Till: silt, slightly sandy, moderately calcareous, medium-gray, light yellow-brown, and dark-gray; contains a trace of gravel and limestone	5	115
Till: silt and very fine to very coarse sand with a trace of fine to medium gravel	5	120
Till: silt, slightly sandy, moderately calcareous, medium-gray with a trace of yellow-brown; contains a trace of fine to medium gravel below 125 ft	10	130
Till: silt, slightly clayey, slightly sandy with a trace of fine gravel, moderately calcareous, medium-gray; contains some limy material	5	135
Till: silt and very fine to very coarse sand; contains a trace of light yellow-brown clay; contains a trace of fine gravel below 155 ft	25	160
Sand, very fine to very coarse, with a trace of fine gravel, slightly silty, moderately calcareous, light yellow-brown	10	170
Sand, very fine to very coarse, with some fine gravel; contains a trace of moderately calcareous yellow clay below 175 ft	10	180

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
55-7—Continued		
Sand, very fine to very coarse with some fine gravel, slightly silty, slightly to moderately calcareous, medium-gray	10	190
Sand, very fine to very coarse, with a trace of fine gravel; contains a trace of slightly calcareous yellow silt	25	215
Sand, fine to coarse with a trace of very coarse; contains a trace of moderately calcareous yellow-brown silt below 225 ft	15	230
Sand, fine to very coarse, with a trace of fine to medium gravel; contains a trace of yellow-brown and medium-gray silt	20	250
Sand, very fine to very coarse, moderately calcareous; contains a trace of yellow-brown silt	5	255
Sand, very fine to very coarse, with a trace of fine gravel	15	270
Sand, fine to very coarse, with fine to medium gravel	5	275
Sand, very fine to very coarse, with a trace of fine gravel	10	285
Sand, fine to very coarse, with some fine gravel; contains more very coarse sand to fine gravel below 290 ft	10	295
Gravel, fine to medium, with very coarse sand	5	300
Sand, fine to very coarse, with fine to medium gravel; contains a trace of moderately calcareous medium-gray silt from 315 to 320 ft	40	340
Sand, very fine to very coarse	5	345
Sand, fine to very coarse, with fine to medium gravel; contains a trace of moderately calcareous yellow silt	5	350
Sand, fine to very coarse, with fine to medium gravel, slightly to moderately silty, moderately calcareous, medium-gray and mottled light yellow-brown	5	355
Sand, fine to very coarse, with fine to medium gravel, silty, moderately clayey, slightly calcareous, medium- to light-gray	5	360
Silt and fine sand to medium gravel, moderately clayey, moderately calcareous, medium light-gray	5	365
Sand, very fine to very coarse, with fine to medium gravel, moderately silty, light to medium gray	5	370
Limestone, slightly weathered, with some fine to very coarse sand and fine to medium gravel, medium to very light gray and light yellow-brown; contains some medium-gray silt	5	375
Limestone and sand, light-gray with brown tint	5	380

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
58–2. Altitude 1,458 feet above mean sea level. Depth to water, 153 feet, August 4, 1958.		
Clay, brown	12	12
Clay, sticky, gray; contains a few limestone chips	64	76
Clay, blue; contains a trace of boulders	29	105
Clay, blue	15	120
Sand, course, and gravel; contains a trace of clay	3	123
Clay, blue; contains a trace of boulders	4	127
Sand, fine to coarse, buff	16	143
Clay, sandy, blue; contains boulders	5	148
Sand, coarse, and gravel, blue; contains boulders	3	151
Gravel, blue; contains boulders and clay streaks	5	156
Gravel, blue; contains boulders	4	160
Gravel, blue; contains boulders and a trace of clay streaks	10	170
Sand, coarse, and gravel, blue	11	181
Sand, coarse, and fine gravel, blue	10	191
Sand, fine to coarse, blue	10	201
Sand, fine, blue	5	206
Sand, coarse, and gravel, blue	5	211
Sand, fine to coarse, and fine gravel, blue	20	231
Gravel, fine, and coarse sand, blue and buff	10	241
Gravel and coarse sand, blue and buff	10	251
Sand, fine to coarse, and fine gravel, buff and blue	20	271
Sand, fine to coarse, blue and buff	10	281
Sand, coarse, and gravel, blue and buff	12	293
58–3. Altitude 1,440 feet above mean sea level. Depth to water, 135 feet, July 29, 1958.		
Clay, silty, brown	5	5
Clay, brown	6	11
Clay; contains limestone chips	74	85
Sand, fine, buff	46	131
Clay, blue; contains boulders	8	139
Sand, fine to coarse, blue	6	145
Clay, blue, sandy	4	149
Sand, coarse, and fine gravel, blue	12	161
Sand, fine to coarse, blue	10	171
Gravel and coarse sand, blue	10	181
Clay, blue; contains boulders	12	193
Sand, fine to coarse, and fine gravel, blue	8	201
Sand, fine to coarse, with a trace of fine gravel	10	211
Sand, coarse, and fine gravel, blue and buff	10	221
Gravel and coarse sand, buff	10	231
Gravel, fine, and coarse sand, buff	10	241
Sand, coarse, and fine gravel, buff	20	261
Sand, fine to coarse, buff	14	275

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
58-4. Altitude 1,434 feet above mean sea level. Depth to water, 129 feet, July 31, 1958.		
Clay, brown; contains limestone chips	4	4
Clay, gray	27	31
Clay, yellow, sticky	15	46
Clay, sticky, brown	22	68
Clay, brown; contains a trace of gravel	3	71
Sand, coarse, and gravel, buff; contains a trace of clay	8	79
Clay, blue; contains a trace of boulders	48	127
Gravel, consolidated, blue; contains boulders	22	149
Clay, blue	14	163
Sand, fine; contains a trace of clay, blue	11	174
Clay, blue	2	176
Sand, coarse, blue	1	177
Clay, blue	7	184
Sand, fine to coarse, blue	17	201
Sand, fine to coarse, with fine gravel, blue	10	211
Gravel, fine, and coarse sand, blue	30	241
Sand, coarse, and fine gravel, blue	20	261
Gravel, fine, and coarse sand, blue	8	269
58-5. Altitude 1,419 feet above mean sea level. Water level, 114 feet, August 2, 1958.		
Clay, brown	2	2
Clay, gray; contains limestone chips	46	48
Clay, blue	32	80
Sand, fine, clayey	11	91
Clay, blue	10	101
Sand, fine to coarse, with a trace of fine gravel, blue	25	126
Clay, blue; contains gravel and boulders	5	131
Clay, blue	18	149
Clay, blue; contains a trace of sand streaks	15	164
Sand, coarse, slightly clayey	2	166
Sand, fine to coarse, blue	5	171
Sand, coarse, and fine gravel, blue	30	201
Gravel, fine, and coarse sand, blue	20	221
Sand, coarse, and fine gravel	20	241
Gravel and coarse sand, blue and buff	20	261
58-6. Altitude 1,423 feet above mean sea level. Depth to water, 117 feet, August 1, 1958.		
Clay, brown	5	5
Clay, gray; contains limestone chips	11	16
Clay, yellow; contains limestone chips	5	21
Clay, gray, sticky	40	61
Clay, blue	7	68
Sand, coarse	1	69

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
58-6—Continued		
Clay, blue	10	79
Gravel; contains a trace of blue clay	7	86
Clay, blue; contains a trace of boulders	25	111
Gravel, clayey, buff	10	121
Sand, fine, clayey, blue	10	131
Clay, sandy, blue	8	139
Sand, coarse, and gravel, blue	2	141
Gravel and coarse sand, blue	41	182
Clay, blue; contains a trace of sand	9	191
Sand, fine to coarse, blue	10	201
Sand, coarse, and fine gravel, blue	30	231
Sand, fine to coarse, and fine gravel, buff	10	241
Sand, coarse, and fine gravel	17	258
58-7. Altitude 1,428 feet above mean sea level. Depth to water, 123 feet, July 28, 1958.		
Clay, silty, brown	3	3
Clay, brown; contains limestone chips	9	12
Clay, gray and brown	58	70
Clay, sticky, blue; contains a trace of boulders	19.5	89.5
Sand, fine, buff	11.5	101
Clay, blue; contains some boulders	22	123
Sand, coarse	1	124
Clay, sandy, blue	1	125
Sand, coarse; contains clay streaks	6	131
Clay, blue	17	148
Sand, fine, blue	13	161
Sand, fine to coarse, blue	10	171
Sand, coarse, with a trace of fine gravel, blue	6.5	177.5
Clay, blue	2	179.5
Sand, coarse, and gravel, blue	1	180.5
Clay, blue	.5	181
Sand, coarse, and fine gravel	10	191
Gravel and coarse sand	5	196
Clay, blue; contains a trace of gravel streaks	5	201
Clay, blue	23	224
Sand, fine to coarse, with a trace of fine gravel, buff and blue	17	241
Sand, fine to coarse, blue and buff	10	251
Sand, coarse, and fine gravel, buff and blue	10	261
Sand, coarse, and gravel	20	281

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
58–8. Altitude 1,449 feet above mean sea level. Depth to water, 144 feet, July 26, 1958.		
Clay, silty, sticky, brown	2	2
Clay, gray	8	10
Clay, sticky, dark-brown	2	12
Clay, gray and brown; contains some gravel	9	21
Clay, sticky, gray	66	87
Sand, fine to coarse, buff	10	97
Clay, blue	12	109
Clay, blue; contains a trace of boulders	27	136
Sand, coarse, and gravel, blue	1	137
Clay, sandy, blue	11	148
Sand, coarse, blue	3	151
Sand, fine to coarse, blue	22	173
Clay, blue	1	174
Sand, coarse, blue	10	184
Clay, blue	1	185
Sand, coarse, and fine gravel, blue	7	192
Gravel and coarse sand, blue	20	212
Sand, coarse, with a trace of fine gravel, blue	13	225
Sand, coarse, and gravel, blue	7	232
Sand, fine to coarse, and fine gravel, blue	10	242
Sand, fine to coarse, blue	10	252
Sand, fine to coarse, and fine gravel, blue	10	262
Sand, fine to coarse, and fine gravel, blue	22	284
58–9. Altitude 1,428 feet above mean sea level. Depth to water, 123 feet, July 30, 1958.		
Clay, brown	5	5
Clay, gray; contains a trace of limestone chips	51	56
Clay, blue	10	66
Clay, yellow	15	81
Clay, blue	10	91
Sand, fine to coarse, and gravel, buff; contains clay streaks	10	101
Sand, coarse; contains a trace of clay	5	106
Clay, sandy, blue; contains a trace of boulders	9	115
Sand, fine to coarse, buff	6	121
Sand, fine to coarse, with a trace of fine gravel, buff	10	131
Sand, fine to coarse, buff	40	171
Sand, coarse; contains clay streaks	2	173
Sand, coarse, and fine gravel, buff	8	181
Clay, sandy, blue	5	186
Sand, coarse, and gravel, blue	5	191
Gravel and coarse sand, blue	10	201
Sand, coarse, and gravel	20	221
Sand, fine to coarse, and fine gravel, blue	20	241
Sand, coarse, and fine gravel, blue	10	251
Gravel and coarse sand, buff	12	263

TABLE 3.—*Logs of test holes drilled by Consumers Public Power District*—Continued

	Thickness (feet)	Depth (feet)
58-10. Altitude 1,411 feet above mean sea level. Depth to water, 106 feet, August 5, 1958.		
Clay, brown	10	10
Clay, sticky, gray; contains a few limestone chips	39	49
Clay, sandy, yellow	10	59
Clay, blue; contains a trace of sand	2	61
Clay, blue; contains gravel and boulders	10	71
Clay, blue; contains a trace of boulders	19	90
Sand, fine to coarse, buff	31	121
Sand, very fine, blue; contains a trace of clay	10	131
Clay, sandy, blue	10	141
Clay, blue	20	161
Gravel and coarse sand, blue; contains a trace of boulders	20	181
Sand, coarse, and fine gravel, blue	40	221
Sand, fine to coarse, blue	10	231
Sand, very fine, blue; contains a trace of clay	10	241
Sand, fine to coarse, blue	5	246
Sand, coarse, and gravel	15	261
58-11. Altitude 1,400 feet above mean sea level. Depth to water, 95 feet, August 6, 1958.		
Clay, brown	5	5
Clay, gray; contains a trace of limestone	32. 5	37. 5
Clay, blue	34. 5	72
Sand, fine to coarse, buff	9	81
Sand, coarse, and fine gravel	13	94
Clay, sandy, blue	8	102
Sand, very fine, blue; contains clay	29	131
Clay, sandy, blue	10	141
Clay, blue	18	159
Clay, blue; contains a trace of sand streaks	3	162
Sand, coarse, and gravel, blue	9	171
Gravel and coarse sand, blue	30	201
Sand, fine to coarse, and fine gravel, blue	10	211
Sand, fine to coarse, blue	10	221
Sand, very fine, blue	6	227
Sand, fine to coarse, blue	4	231
Sand, coarse, and gravel, blue	4	235

TABLE 4.—*Logs of test holes drilled by the Conservation and Survey Division, University of Nebraska, in cooperation with the U.S. Geological Survey*

[Altitude of land surface determined by altimeter. Depth to water given in feet below land surface. See plate 2 for location of test holes]

	Thickness (feet)	Depth (feet)
A6-5-2cc. Gage County. Altitude 1,475 feet above mean sea level. Depth to water, 24.2 feet, October 10, 1949.		
Soil: silt, clayey, black	1	1
Clay, silty, dark-brown	1	2
Clay, medium-brown	.5	2.5
Silt, clayey, slightly calcareous, light-brown	2.5	5
Silt, light grayish-brown with iron stain	3	8
Silt, clayey, light-gray with iron stain; contains nodules	2.5	10.5
Silt, clayey, mottled dark reddish-brown to green	4	14.5
Clay, mottled reddish-brown to green	2	16.5
Till: silt, clayey to sandy, slightly to very calcareous, yellowish- to grayish-tan with limonitic stains; contains very fine to very coarse sand	88.5	105
Sand, fine, and some fine gravel, yellowish-brown and red	6.5	111.5
Silt and very fine to very coarse sand, slightly calcareous, grayish-tan to yellow	4.5	116
Sand, very fine to very coarse, yellowish-brown; contains calcareous fragments and limonitic nodules	25.5	141.5
Silt, dark-brown to black	4.5	146
Silt and very fine to medium with some coarse sand, slightly calcareous, bluish-gray	14	160
Silt, sandy, to sandy clay, slightly calcareous, bluish-gray; contains very fine to fine sand, quartzitic pebbles and calcareous fragments	10	170
Silt, slightly clayey to slightly sandy, slightly calcareous, bluish-gray with limonitic stains; contains very fine to medium sand; contains calcareous fragments	37.5	207.5
Sand, very fine to medium, bluish-gray; contains a few calcareous fragments	2.5	210
Silt and very fine to medium with some coarse sand, slightly calcareous, bluish-gray	7.5	217.5
Sand, very fine, to medium gravel, bluish-gray to white	19.5	237
Silt and very fine sand, slightly calcareous, bluish-gray	13	250
Silt, slightly clayey to slightly sandy, slightly calcareous, bluish-gray; contains very fine to medium sand; contains calcareous fragments	30	280
Clay, slightly silty, slightly calcareous, light bluish-gray	10	290
Clay, slightly sandy, silty, slightly calcareous, bluish-gray; contains very fine to fine sand	7	297
Silt and very fine to fine sand, slightly calcareous, bluish-gray	4.5	301.5
Sand, very fine to very coarse, light to dark brownish-orange	19.5	321
Shale, slightly calcareous, brownish-orange to dark bluish-gray	9	330
Sand, very fine to coarse, slightly consolidated, brownish-orange to dark yellowish-orange	23	353
Shale, sandy, dark bluish-gray; contains very fine to fine sand	3	356
Shale, light-red	1	357

TABLE 4.—*Logs of test holes drilled by the Conservation and Survey Division, University of Nebraska, in cooperation with the U.S. Geological Survey*—Con.

	Thickness (feet)	Depth (feet)
A7-5-3dc. Lancaster County. Altitude 1,362 feet above mean sea level. Depth to water, 46 feet, May 13, 1948.		
Soil: clay, silty, dark brownish-gray	1.5	1.5
Clay, silty, medium brownish-buff	1	2.5
Clay, silty, medium red-brown	5.5	8
Clay, silty, reddish-tan; light-brown with red tint and contains some limonitic stain below 9.5 ft	6.5	14.5
Silt and very fine sand, slightly clayey, light-brown	5	19.5
Sand, very fine to medium with some coarse, and silt, light-brown	4	23.5
Sand, medium, to fine gravel with some medium gravel, brown to pink; contains a few greenish-gray clay granules	11	34.5
Sand, fine to coarse, and silt, light-gray with brown tint	6	40.5
Sand, medium, to fine gravel, slightly silty, medium brownish-gray	2.5	43
Clay, silty, light-gray; contains a few limy nodules and shell fragments; yellow tint below 48 ft	8.5	51.5
Silt, dark-gray to light-gray with bluish-green tint	3.5	55
Silt and very fine to fine sand, dark-gray	2.5	57.5
Silt, light buff-gray with some limonitic stain	0.5	58
Sand, medium, to fine gravel with some medium gravel, light brownish-gray to pink	2	60
Till: silt, clayey to gravelly, yellowish-brown	3	63
Till: silt, clayey, dark-gray; contains limy fragments and embedded sand and gravel	18	81
Sand, fine, to fine gravel, medium-gray	2	83
Silt and fine to medium sand, medium-gray; contains some interbedded sand and gravel below 85 ft	12	95
Silt, clayey, medium-gray; contains much embedded sand and gravel below 100 ft	10	105
Sand, fine, to fine gravel with some medium gravel, light-gray to green; light brownish-gray to greenish-gray below 170 ft; contains a few pelecypod shells from 205 to 210 ft; slightly coarser below 255 ft	158	263
Sandstone, silty, fine-grained, light-gray; slightly coarser and contains some ironstone below 270 ft; green below 280 ft	26	289
Limestone, light-gray	1	290

TABLE 4.—*Logs of test holes drilled by the Conservation and Survey Division, University of Nebraska, in cooperation with the U.S. Geological Survey*—Con.

	Thickness (feet)	Depth (feet)
A7-5-14dd. Lancaster County. Altitude 1,409 feet above mean sea level. Depth to water, 27.4 feet, July 28, 1945.		
Soil, dark-gray to black	2	2
Clay, silty to pebbly, calcareous, light-gray to yellowish-brown; more pebbly in lower part	58	60
Sand, fine to medium, light-gray	15	75
Sand, medium to coarse, light-gray	20	95
Silt, very calcareous, medium- to dark-gray	30	125
Silt, clayey to sandy, very calcareous, dark-gray	10	135
Silt, clayey to sandy, pebbly, calcareous, dark-gray	15	150
Sand, fine to coarse, medium-gray to green	10	160
Sand, medium to coarse, light-gray to green	17	177
Sand, light-gray to green; contains a trace of fine gravel	8	185
Sand, fine, to fine gravel with some medium to coarse gravel, light-gray to green	55	240
Sand, gray to green; contains a trace of fine gravel; coarser below 255 ft	20	260
Sand, coarse, to medium gravel, pinkish- to greenish-gray	10	270
Silt, very calcareous, light-gray	17	287
Silt, in part sandy, very calcareous, medium-gray	2. 5	289. 5
Sand, fine, to medium gravel, gray to green	18. 5	308
Shale, light-gray to yellow	4	312
Limestone, medium-gray	. 5	312. 5
Shale, black	2	314. 5
Limestone, medium-gray; contains fossils	. 5	315
A7-5-27bb. Lancaster County. Altitude 1,463 feet above mean sea level. Depth to water unknown; test hole caved at 142 feet, August 2, 1945.		
Soil: clay, silty, dark brownish-gray	1	1
Clay, silty, dark reddish-brown	2	3
Clay, silty, medium brown-gray to pink	2	5
Till: clay, silty to pebbly, slightly calcareous, light yellowish-gray	2	7
Till: clay, silty to pebbly, very calcareous, light yellowish-gray	23	30
Till: clay, silty to pebbly, very calcareous, yellowish-brown	10	40
Till: clay, silty to pebbly, very calcareous, light yellowish-gray	15	55
Till: clay, silty to pebbly, very calcareous, yellowish-gray with some iron stain	42	97
Gravel, fine to medium, medium-gray	3	100

TABLE 4.—*Logs of test holes drilled by the Conservation and Survey Division, University of Nebraska, in cooperation with the U.S. Geological Survey*—Con.

	Thickness (feet)	Depth (feet)
A-5-27bb—Continued		
Till: clay, silty to pebbly, very calcareous, yellowish-gray	5	105
Till: clay, silty to pebbly, very calcareous, yellowish-gray to medium-gray	15	120
Till: clay, silty to pebbly, calcareous, medium greenish-gray	4.5	124.5
Sand, fine to medium, brownish-gray	35.5	160
Sand, fine, to fine gravel, brownish-gray	20	180
Sand, fine to medium, brownish-gray	15	195
Sand, fine to coarse, with some fine gravel, brownish-gray	30	225
Clay, silty, gray to yellow	5	230
Sand, fine to medium, brownish-gray; contains some interbedded silty clay below 235 ft	10	240
Sand, fine to coarse, with a trace of fine gravel, brownish-gray	15	255
Sand, fine to coarse, with some fine gravel, pinkish- to greenish-gray	9	264
Silt, moderately calcareous, medium-gray	36	300
Clay, silty, dark-gray	11	311
Clay shale, red and light-gray to white	9	320
A7-6-3bb. Lancaster County. Altitude 1,340 feet above mean sea level. Depth to water, 15.5 feet, August 10, 1944.		
Soil: silt, black	2	2
Silt, sandy, reddish-brown	3	5
Silt, sandy, yellow; contains limonitic fragments and limestone nodules	15	20
Sand and clay, interbedded	13.5	33.5
Clay, silty, calcareous, bluish-gray	2.5	36
Sand, fine, limonitic-stained from 36 to 40 ft	8	44
Till: clay, silty, calcareous, bluish-gray	69	113
Gravel, principally green silicates and red feldspars; contains many reworked shale and limestone fragments	27.5	140.5
Clay, silty, calcareous, gray	14.5	155
Sand, fine to coarse, with a trace of fine gravel, principally green silicates	14	169
Clay, silty, calcareous, light bluish-gray; contains some limestone fragments	16.5	185.5
Sand or sandstone, fine- grained, iron-stained	4.5	190
Shale, light green-gray and light-blue	3	193
Limestone, gray to pink	1	194

TABLE 4.—*Logs of test holes drilled by the Conservation and Survey Division, University of Nebraska, in cooperation with the U.S. Geological Survey*—Con.

	Thickness (feet)	Depth (feet)
A7-6-8bc. Lancaster County. Altitude 1,379 feet above mean sea level. Depth to water, 25.7 feet, July 26, 1945.		
Clay, silty, medium brownish-gray	2	2
Soil: clay, silty, dark-gray	1	3
Clay, silty, to clayey silt, medium brownish-gray	2	5
Silt, clayey, medium to light brownish-gray	2	7
Silt, clayey to pebbly, brownish-gray to pink	2	9
Clay, pebbly, brownish-gray to red	1	10
Till: clay, silty to pebbly, yellowish-gray	5	15
Till: clay, silty to pebbly, light-gray to yellowish-gray	30	45
Till: clay, silty to pebbly, medium- to dark-gray	36	81
Sand, medium to coarse, with some fine gravel, medium-gray	19	100
Silt, medium-gray	7	107
Clay, silty, medium-gray	3	110
Clay and fine to medium sand, silty, medium-gray	5	115
Sand, fine to coarse, medium brownish-gray	67	182
Clay, silty, medium-gray	3	185
Sand, fine, gray	2	187
Clay, silty, medium-gray	13	200
Sand, medium to coarse, with a trace of fine gravel, medium-gray	6	206
Clay, silty to pebbly, medium-gray	5	211
Sand, fine to coarse, with a trace of fine gravel, medium-gray; contains interbedded gray silty clay	11	222
Silt, clayey to sandy, medium-gray; contains some pebbles	33	255
Silt, clayey to sandy, medium-gray; contains a few pebbles	8	263
Shale, brownish-red; micaceous	1	264
Limestone, light-gray with red stains	.5	264.5
Shale, black	2	266.5
Limestone, mottled medium-gray and dark-gray; contains fossils	.2	266.7

TABLE 4.—*Logs of test holes drilled by the Conservation and Survey Division, University of Nebraska, in cooperation with the U.S. Geological Survey*—Con.

	Thickness (feet)	Depth (feet)
A8-5-14bb. Lancaster County. Altitude 1,462 feet above mean sea level. Depth to water, 18.6 feet, May 19, 1948.		
Soil: silt, slightly clayey, dark brownish-gray	0. 5	0. 5
Clay, silty, medium-brown with gray tint	1. 5	2
Silt, clayey, medium brownish-buff; contains a few calcareous nodules	1	3
Silt, slightly clayey, brownish-buff with much limonitic stain; contains a few limy nodules; light-gray below 7.5 ft	9. 5	12. 5
Clay, silty, soillike, brown	. 5	13
Clay, silty, light buff-tan; lighter below 15 ft	4	17
Till: clay, silty, to clayey silt, slightly calcareous, yellowish-brown to gray with much limonitic stain; contains limy pebbles	23	40
Till: clay, silty to slightly sandy, slightly calcareous, light-gray to yellowish-brown; contains a few pebbles; moderately calcareous below 60 ft	58	98
Sand, coarse, to coarse gravel, brown; contains much reworked material	8. 5	106. 5
Till: silt, clayey to sandy and gravelly, slightly calcareous, yellowish-brown; contains a few pebbles; medium-gray and moderately calcareous below 110 ft	18. 5	125
Sand, fine to coarse, brownish-gray; contains some fine to medium gravel below 140 ft	27. 5	152. 5
Silt, slightly sandy to slightly clayey, moderately calcareous, dark-gray	2. 5	155
Silt, slightly to moderately calcareous, light-gray with bluish-green tint	10	165
Sand, fine to medium with some coarse, brownish-gray	7	172
Silt, slightly calcareous, light- to buff-gray	8	180
Silt, clayey, slightly calcareous, medium brownish-gray; less clayey and light-gray below 190 ft	75. 5	255. 5
Sand or sandstone, fine- to coarse-grained, yellowish-brown with much limonitic stain	. 5	256
Silt, slightly sandy, yellowish-brown; contains a trace of brown sandstone	4	260
Siltstone, sandy, light-gray; contains very fine sand; contains some yellowish-brown and red silty clay below 266 ft	10	270
Clay, silty, white to yellowish-brown and red	5	275
Sandstone, very fine grained, yellowish-brown	5	280
Ironstone, sandy, yellowish-brown; contains very fine sand; contains some very fine sandy siltstone below 285 ft	10	290
Siltstone, sandy, light brownish-gray; contains very fine sand; contains some ironstone	10	300

TABLE 4.—*Logs of test holes drilled by the Conservation and Survey Division, University of Nebraska, in cooperation with the U.S. Geological Survey*—Con.

	Thickness (feet)	Depth (feet)
A8-5-27dd. Lancaster County. Altitude 1,456 feet above mean sea level. Depth to water, 49 feet, August 10, 1944.		
Soil: silt, dark-brown to black	2	2
Clay, silty, brown	11	13
Clay, silty, soillike, reddish-brown	5	18
Till: clay, silty, yellowish-tan; contains much calcareous material; contains some gravel below 65 ft	65	83
Till: clay, silty, calcareous, bluish-gray; contains some gravel and limestone fragments	77	160
Sand, fine to coarse, principally quartz with some green silicates and red feldspars; contains some pyrite and white sandstone fragments	25	185
Sand, fine, to fine gravel, principally quartz and green silicates; contains a few black shale pebbles and limonitic fragments; contains more gravel below 300 ft	139. 5	324. 5
Clay shale, light-gray; limonitic-stained in lower part	8	332. 5
Sandstone, fine- to medium-grained, white with some limonitic stain	7. 5	340
No sample obtained, probably sandstone	2	342
A8-6-26ad. Lancaster County. Altitude 1,259 feet above mean sea level. Depth to water, 10.2 feet, November 21, 1945.		
Clay, silty, brown	1	1
Silt, clayey, light brownish-buff	9	10
Silt, medium grayish-brown	4	14
Clay and silt, light-gray to brown; contains a few limonitic stains	6	20
Clay, light-gray; contains a few pebbles; medium-gray with bluish tint below 30 ft	28	48
Limestone fragments, light-gray	. 5	48. 5
Clay, silty, light-gray	1. 5	50
Silt, clayey, black; carbonaceous	1	51
Clay, silty, medium-gray	7. 5	58. 5
Limestone. light-gray to light-brown	3. 5	62

TABLE 5.—*Drillers' logs of test holes at sites of privately owned wells*

[Altitude of land surface: a, altimeter; i, spirit leveling. Depth to water given in feet below land surface. See plate 3 for location of test holes]

	Thickness (feet)	Depth (feet)
A7-5-25bb. Lancaster County. Frank L. Rejcha. Driller: Ray Burke. Altitude (a) 1,489.6 feet above mean sea level. Depth to water unknown.		
Silt, moderately clayey	15	15
Silt, brown with some dark soil	5	20
Clay, mottled light yellow-gray with some light-brown	18	38
Till, mottled light yellow-gray with some light yellow-brown; dark-gray below 90 ft; sandy from 85 to 90 ft. with some scattered gravel	62	100
Till, mottled light- to medium-gray and yellow-gray	10	110
Till, medium-gray	90	200
Till, sandy	40	240
Sand with some interbedded till	10	250
Sand, fine to very coarse; contains a little gravel	30	280
Sand, medium to very coarse; contains 15 percent gravel below 295 ft	20	300
Sand and fine gravel	16	316
Clay, blue, and shale	14	330
A7-6-30dc. Lancaster County. Village of Hallam. Driller: Layne-Western. Altitude (i) 1,487.0 feet above mean sea level. Depth to water, 181 feet, January 5, 1954.		
Soil, black	2	2
Clay, sticky, brown	15	17
Clay, sticky, hard, gray	15	32
Clay, sticky, yellow	40	72
Sand, coarse, with some clay	2	74
Clay, sticky, hard, brown	16	90
Clay, sticky, black; contains a trace of boulders below 115.5 ft	60	150
Sand, fine to coarse, with a trace of gravel and clay, tight	9.5	159.5
Sand, fine, with thin clay streaks	12.5	172
Sand, fine to coarse, with some fine gravel from 172 to 182 ft. and from 212 to 220.5 ft	48.5	220.5
Sand, fine, with a trace of clay	7.5	228
Clay, black	4	232
Sand, very fine, with a trace of clay	16	248
Sand, fine to coarse	13	261
Clay, black	1	262
Sand, coarse, with some fine gravel	16	278
Clay, black	2	280
Sand, fine to coarse	12	292
Sand, coarse, with some fine gravel	25	317
Clay, black; contains some sand streaks	8.6	325.6
Shale, blue	2.4	328

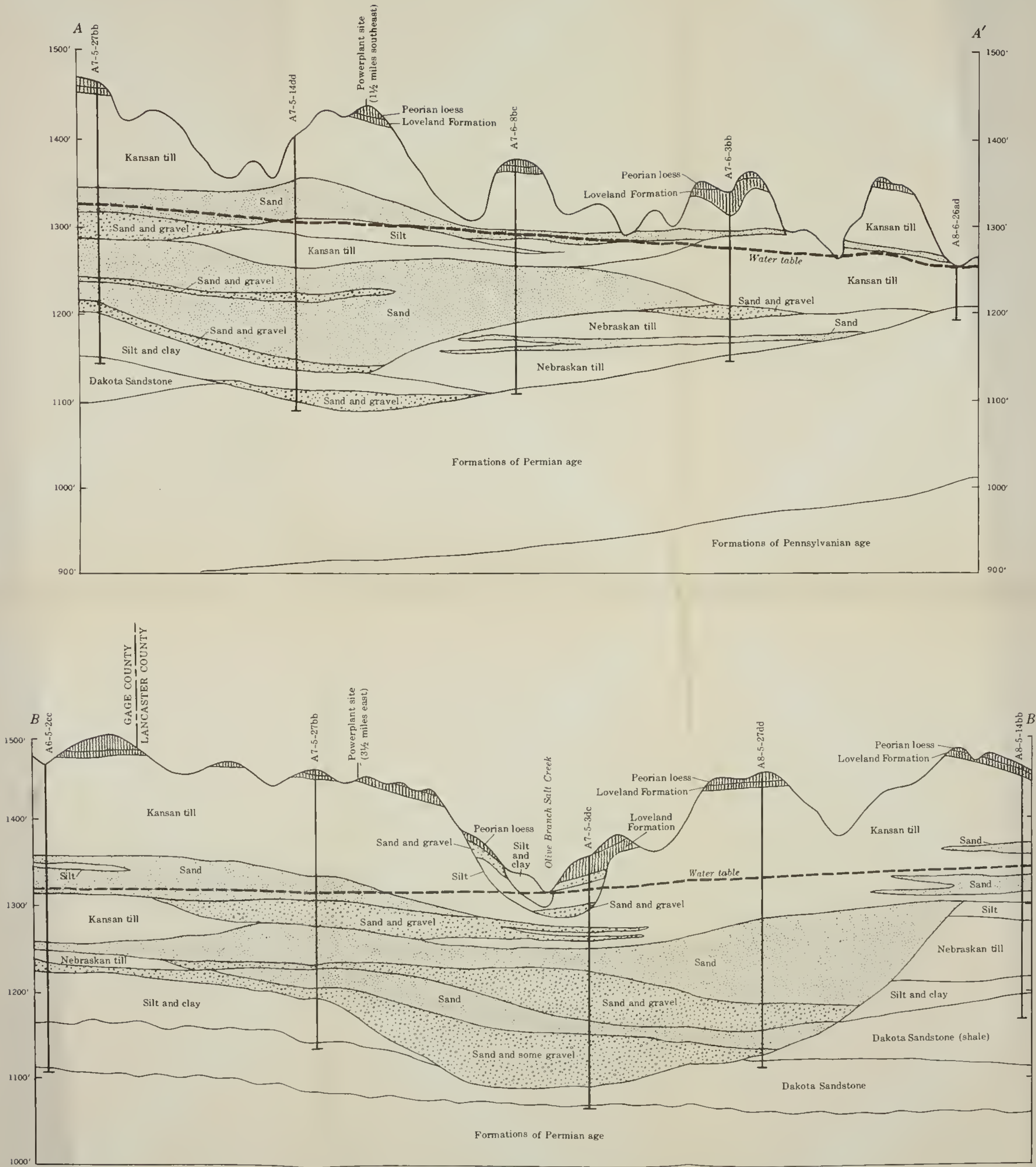
TABLE 6.—*Records of wells*

Well number: See text for explanation of well-numbering system.
Depth of well: Reported depths given in feet; measured depths given in feet and tenths.
Type of casing: C, concrete, P, iron or steel pipe; T, tile.
Type of pump: Cy, cylinder; N, none; T, turbine.
Type of power: E, electric, G, gasoline or tractor fuel; H, hand; N, none; NG, natural gas; W, wind.
Description of measuring point: Hb, hole in base; Ls, land surface; Tc, top of casing.

Depth to water: Reported depths given in feet; measured depths given in feet, tenths and hundredths. F, flowing well.
Use of water: D, domestic; I, irrigation; Ind, industrial; N, none; PS, public supply; S, stock.
Remarks: Ca, sample collected for chemical analysis; Hy, hydrograph of water-level fluctuations for well included in this report; L, log given in table 5.

Well	Owner or user	Year drilled	Depth of well below land surface (feet)	Diameter of well (inches)	Type of casing	Type of pump	Type of power	Measuring point			Depth to water level below measuring point (feet)	Date of measurement	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
								Description	Distance above land surface (feet)	Altitude above mean sea level (feet)						
Gage County																
A6-5-22cc	Village of Clatonia	1914	222	8	P	T	E	Ls	0.0		90	3-26-45			PS	Ca.
-6-11ad	Village of Cortland		258			T	E	Ls	.0		117	3-26-45	21	300	PS	Ca.
Lancaster County																
A7-5-13ab	Emil Molzer	1891	130	2	P	Cy	W	Ls	0.0		98	2-16-59			D, S	
13cc	Ed Vlasak	1928	190	2	P	Cy	N	Ls	.0		75	2-17-59			N	
13cd	do	1920	200	2	P	Cy	N								N	
13db	Ben Cerveny	1956	179	2	P	Cy	E	Ls	.0		89	2-16-59			D, S	
24ab	Ed Helovic			2	P	Cy	N								N	
24bb	Vince Chrrastil	1905	230	2	P	Cy	W								N	
24bd	Anton Rejcha	1911	152	2	P	Cy	W	Ls	.0		125	2-16-59			D, S	
24cc	Frank J. Rejcha	1915	150	2	P	Cy	E	Ls	.0		136	2-16-59			D, S	
24dc	August Lahm	1910	220	2	P	Cy	W								N	
24dd	do					Cy	W									
25ad			41.0	10	T	Cy	W	Tc	.0		8.17	2-17-59			N	
25bb	Frank L. Rejcha	1956	310.0	18	C	T	NG	Tc	.5	1,489.6	180.98	2-16-59	48	900	I	L.
25bc	do	1942	178	2	P	Cy	W	Ls	.0		178	2-16-59			N	
25cd	Loy Messman	1890	28			Cy	W	Tc	1.0		13.04	2-17-59			D, S	
25da1	Carrie Messman	1909	70	10	T	N	N	Tc	.5		26.01	2-17-59			N	
25da2	do	1942	260	2	P	Cy	W								S	
6-5ac1	Herbert Reller		133	18	P	N	N								N	
5ac2	do	1957	103	18	P	T	G	Hb	1.0		16.52	3-10-59	10	750	I	
5ad	do	1958	98	18	P			Tc	1.0		16.94	3-10-59			I	
17cb	Carl Schwaninger	1898	100	2	P	Cy	W	Ls	.0		65	2-17-59			D, S	

17cd	Herman Schwaninger	1880	115	2	P	Cy	N								N	
17dc1	do	1872	70	2	P	Cy	W	Ls	.0		20	2-17-59			D, S	
17dc2	do	1953	120	2	P	Cy	E	Ls	.0		90	2-17-59			D, S	
18ba	Emil Molzer	1928	135	2	P	Cy	W	Ls	.0		105	2-16-59			S	
18bc	do	1904	28.0	10	T	N	N	Tc	1.0		15.84	2-16-59			N	
18cb	John Dave		130	2	P	Cy	E								D, S	
18db	Farmers National		180	2	P	Cy	W									
19aa1	Consumers Public Power District.		28.5	10	T	Cy	W	Tc	.0		9.27	10-19-58			N	
19aa2	do	1959	257	18	P			Ls	.0		120	4-15-59	20	1,000	Ind	
19ab	do	1959	263	18	P			Ls	.0		125	4-15-59	12	1,000	Ind	
19ac1	do	1959							2.7		122.58	5-18-59	25	1,002	Ind	
19ac2	do	1959	283	18	P			Ls	.0		145	4-15-59	15	1,000	Ind	
19ad	do	1959	272	18	P			Ls	.0		135	4-15-59	27	1,000	Ind	
19cc1	do		209	2	P	Cy	W								N	
19cc2	do		27.0	10	T	Cy	H	Tc	1.0		4.50	2-17-59			N	
19cd	do			8	T	Cy	W	Tc	.0		7.71	10-19-58			N	
19da	do	1956	288.5	18	P			Tc	1.5	1,455.12	151.26	10-19-58	22	1,000	Ind	Ca.
19db	do	1959	269	18	P			Ls	.0		129	4-28-59			Ind	
19dc	do	1959	255	18	P			Ls	.0		116	4-15-59	12	1,000	Ind	
19dd1	do	1959	287	18	P	T	E	Ls	.0		143	4-15-59	14	1,040	Ind	
19dd2	do			6	T	Cy	W	Ls	.0		2.73	10-19-58			N	
20ad	Ervin Rahorst		90	2	P	Cy	W								S	
20bb	John Miller		40.0	4	P	Cy	E	Tc	.5		8.70	4-22-59			D, S	
20cd	Mrs. Elsie Kurzen	1900	125	2	P	Cy	E	Ls	.0		75	2-17-59			D, S	
20dc	Mrs. Eunice Rihley	1910	190	2	P	Cy	E								D, S	
29ad1	Delton Wells	1953	230	2	P	Cy	E								D	
29ad2	do		200	2	P	Cy	E								S	
29ba			23.0	8	T	Cy	W	Hb	.0		.10	4-22-59			S	
29cc1	Schwaninger Bros	1900	38	60	C	Cy	W	Hb	1.0		17.58	4-22-59			D, S	
29cc2	do		66.0	10	T	Cy	H	Tc	3.0		16.26	2-17-59			N	
29dd1	Andrew Benes	1910	205	2	P	Cy	E	Ls	.0		70	2-17-59			D, S	
29dd2	do	1953	43.5	8	T	Cy	H	Hb	1.0		16.38	2-17-59			S	
29dd3	do	1954	12	34	P	N	N	Tc	.0		4.22	2-17-59			N	
30ab1	Everett Luhrs	1947	218	2	P	Cy	E	Ls	.0		145	2-17-59			D, S	
30ab2	do	1947	20	10	T	Cy	H	Ls	.0		3	2-17-59			N	
30cb	August Messman	1944	267	2	P	Cy	W	Ls	.0		150	2-17-59			D, S	
30dc	Village of Hallam	1954	261	8	P	T	E	Ls	.0	1,487.0	183	1- 5-54	0	65	PS	Ca, L.
7-35bd	Village of Firth					T	E								PS	Ca.
A8-6-2da	C. S. Guenzel			4		Cy	W								D, S	Ca.
28dd	Village of Sprague		80	12	T	Cy	H	Ls	0.0		20	5-31-50			PS	Ca.
34dd	U.S. Geol. Survey		53	8	P	N	N	Tc	1.0	1,283.7	7.43	4-25-59			N	Hy.
7-17cc	Village of Roca	1949	40	8				Ls	.0		10	5-31-50	10		PS	Ca.
33ad	Village of Hickman	1936	42	12	P	T	E	Ls	.0		16	5-31-50	8	200	PS	Ca.
A9-6-5dd	J. T. Hiltner		2,000	16		N	N				F	8- 8-49		100	N	Ca.
	Otoe County															
A7-9-10da	Village of Douglas	1928	80	4	P	T	E	Ls	0.0		15	11-15-55		20	PS	Ca.

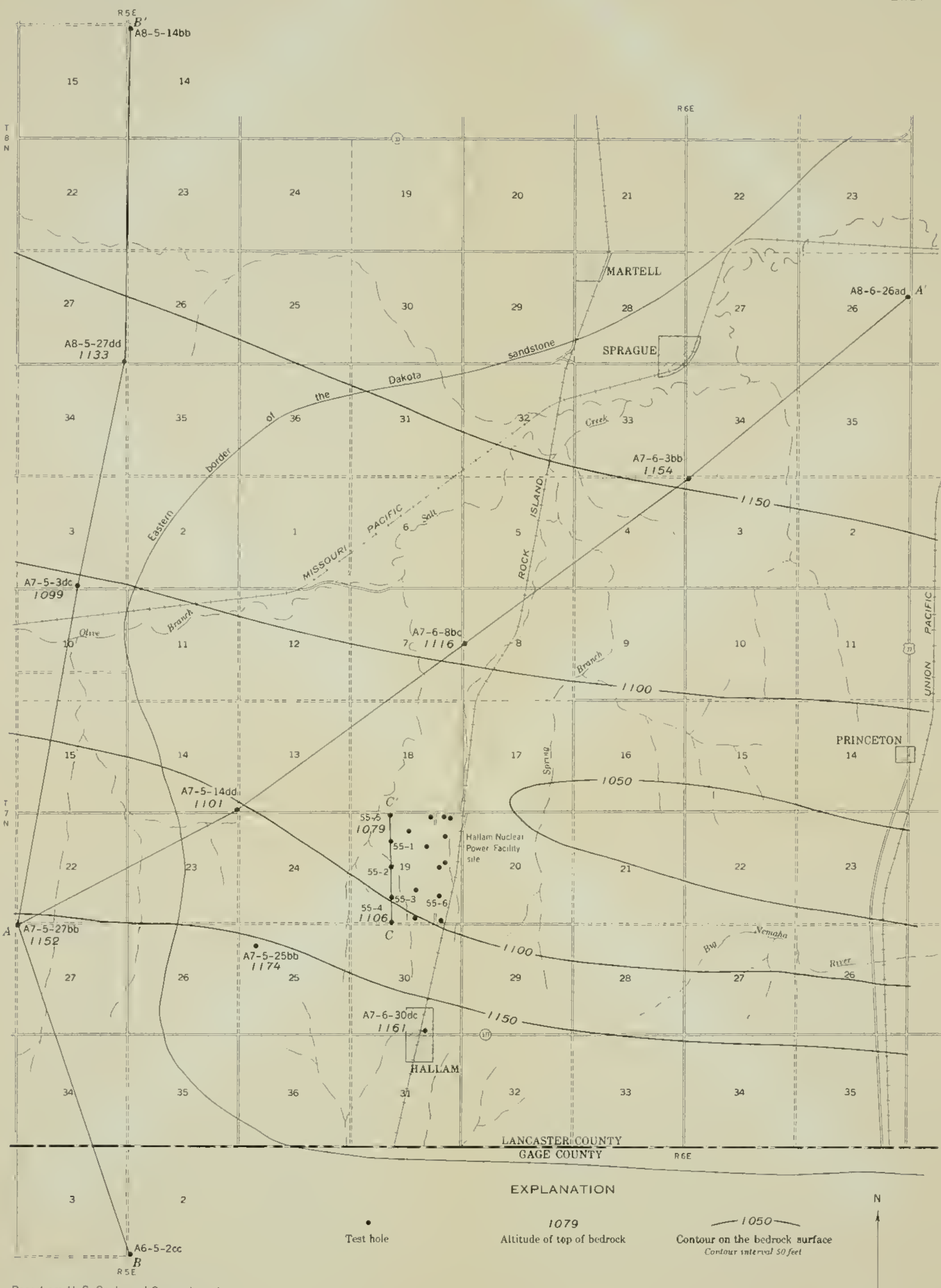


GEOLOGIC SECTIONS A-A′ AND B-B′, HALLAM AREA, NEBRASKA

1 0 1 2 3 4 MILES

DATUM IS MEAN SEA LEVEL

644811 O - 62 (In pocket)



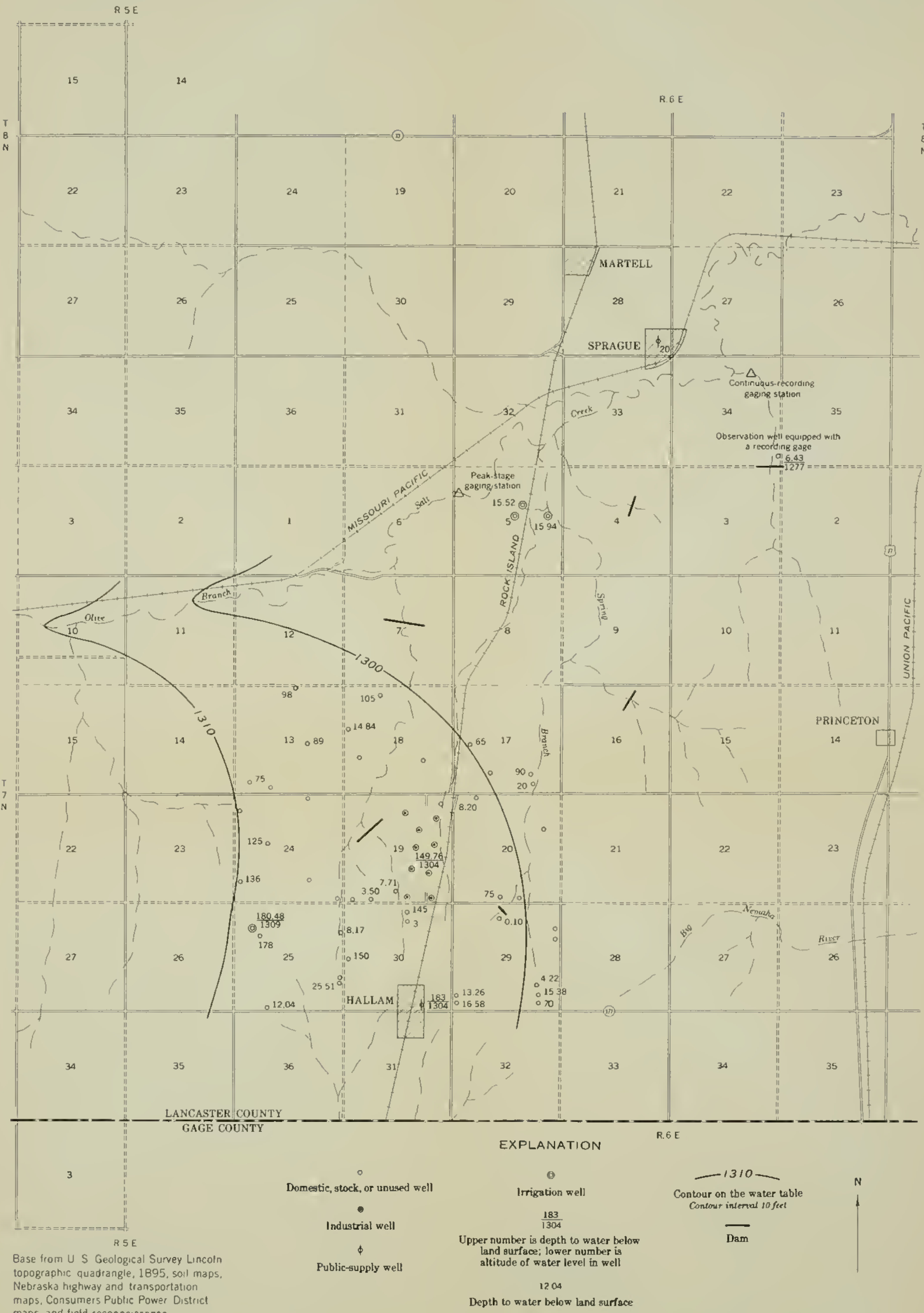
Base from U S Geological Survey Lincoln topographic quadrangle, 1895, soil maps, Nebraska highway and transportation maps, Consumers Public Power District maps, and field reconnaissance

MAP OF HALLAM AREA, NEBRASKA, SHOWING THE CONFIGURATION OF THE TOP OF THE BEDROCK, LOCATION OF TEST HOLES, AND LOCATION OF GEOLOGIC SECTIONS

1 0 1 MILE

DATUM IS MEAN SEA LEVEL

644811 O - 62 (In pocket)



Base from U S Geological Survey Lincoln topographic quadrangle, 1895, soil maps, Nebraska highway and transportation maps, Consumers Public Power District maps, and field reconnaissance

MAP OF HALLAM AREA, NEBRASKA, SHOWING THE LOCATION OF WELLS DEPTHS TO WATER, AND WATER-TABLE CONTOURS

1 0 1 MILE

DATUM IS MEAN SEA LEVEL

644811 O - 62 (In pocket)