1981-7

GEOLOGY AND GROUNDWATER SUPPLIES

OF

SOUTHERN DAWES AND NORTHERN SHERIDAN COUNTIES, NEBRASKA

A Report Prepared for the

Upper Niobrara-White Natural Resources District

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ABSTRACT

The upland plain in southern Dawes and northern Sheridan counties of northwest Nebraska is underlain by rocks of Tertiary age. These rocks overlie those of Cretaceous and Jurassic ages in this region of about 2250 square miles. Strata of Tertiary age are a source of groundwater for most of the irrigation, municipal, stock, and rural-domestic needs of the area.

Nine stratigraphic units of Tertiary age were defined by examination of test hole samples and logs and by examining electric logs of oil and gas tests, driller's logs of irrigation wells, and outcrops. Stratigraphic correlations are difficult in the area because the stratigraphy and structural geology is complex. An unnamed section of brown, sandy siltstones overlying the Whitney Member of the Brule Formation is given the informal name, Beaver Wall siltstone beds.

Rocks of the Ogallala Group are the most permeable rocks in the area. More than 300 irrigation wells and wells of two municipalities tapped water supplies in these rocks by the end of 1979. At that time, approximately 100 irrigation wells and wells of another two municipalities obtained groundwater supplies from the Arikaree Group, which is comprised of the Gering Formation, Monroe Creek-Harrison formations, and the Upper Harrison beds. The Arikaree Group is estimated to contain more water than the Ogallala Group, but the fine grain size of the Arikaree presents difficulties for efficiently utilizing this water.

INTRODUCTION

Purpose and Scope

Water for irrigation, municipal, stock, and rural-domestic needs in southern Dawes and northern Sheridan counties is supplied primarily by groundwater. The number of irrigation wells has been increasing, especially in Sheridan County, and in the 1960s the city of Chadron developed a well field on the tableland 18 miles south of the city. A few other municipalities experience some difficulties with water supplies and may eventually seek other sources of groundwater. Irrigators in the Mirage Flats Irrigation Project in west-central Sheridan County have had to supplement supplies from the Niobrara River with groundwater to meet their needs. Furthermore, the electric-generating industry has shown interest in establishing a power plant in Box Butte County which would use groundwater from the southern Sheridan County area.

Because of these developments, the Upper Niobrara-White Natural Resources District and the Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, agreed on a cooperative project to investigate the geology and related groundwater supplies of southern Dawes and northern Sheridan counties. The initial agreement was signed in June, 1978, and an extension was signed in April, 1979. This agreement called for the drilling, sampling, and logging of a minimum of 42 holes (the number eventually drilled), so that, a) the major aquifer system or systems could be identified and delineated, b) the water-table configuration could be determined, c) the base of the major aquifer system or systems could be mapped, and d) the amount of groundwater in storage could be estimated. This report, through narration, maps, and geologic sections, achieves these objectives. In addition, the performance of wells tapping different hydrologic units is summarized and the complexity of the geologic structures in the area is indicated.

This report is an examination of the geology of the area as it relates to groundwater, but some of the information presented can be applied to certain aspects of uranium and oil and gas exploration. The information may also be useful in an evaluation of soils, construction materials, construction sites, and other utilizations of natural resources related to geology.

Conversion factors

All measurements in this report are expressed in English units. Factors used in converting these measurements to metric units are as follows:

Length-

1 foot = .3048 meters

1 mile = 1609 meters = 1.609 kilometers

Area-

1 acre = 4.047 square meters = .4047 hectares = .004047 square kilometers

1 square mile = 259.0 hectares = 2.590 square kilometers

Volume-

1 acre-foot = 1,234 cubic meters = .1234 cubic hectares

1 gallon = 3.785 liters = .003785 cubic meters

Slope rate-

1 foot per mile = .1894 meters per kilometer

Flow rate (volumetric)-

1 gallon per minute = 3.785 liters per minute = .0639 liters per second = .003785 cubic meters per minute = 5.450 cubic meters per day

Hydraulic conductivity (hydrologic term)-

1 gallon per day per square foot = .04074 meters per day

Transmissivity (hydrologic term)-

1 gallon per day per foot = .01242 square meters per day

Specific capacity (well-performance term)-

1 gallon per minute per foot of drawdown = 12.42 liters per minute per meter of drawdown = .01242 cubic meters per minute per meter of drawdown

Location and extent of area

The area investigated with test-drilling extended from the Pine Ridge south to the Niobrara River in southern Dawes and northern Sheridan counties, Nebraska. This area of northwestern Nebraska is in the central and northeast parts of the Upper Niobrara-White Natural Resources District (Fig. 1). Northern Dawes County borders the study area on the northwest; South Dakota is on the north; and Cherry County is on the east. Southern Sheridan County and Box Butte County lie to the south of the study area and Sioux County is to the west. The area represented by the maps in figures 5-12 of this report is about 2250 square miles with a maximum east-west dimension of 72 miles and a maximum north-south dimension of 39 miles.

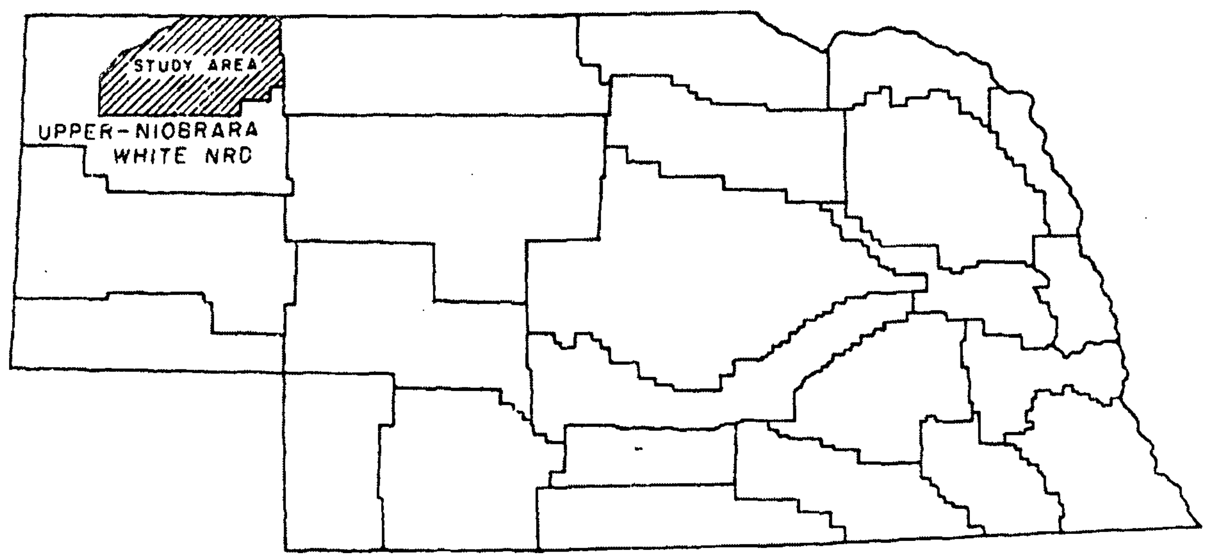

Fig. 1. Location of study area and Natural Resources District boundaries in Nebraska

Methods of investigation

Forty-two (42) test holes were drilled in southern Dawes and northern Sheridan counties between August 1, 1978, and August 12, 1979 (Fig. 2). Depths of the holes ranged from 410 to 800 feet and averaged 614 feet.

A hydraulic rotary-drill rig belonging to tne Conservation and Survey Division was used for drilling the test holes. At most sites the upper part of the hole, the younger rocks, was drilled in intervals of 5 feet and the rest of the hole was drilled in intervals of 10 feet. The hole was flushed after each interval was drilled so that material from up the hole would not contaminate samples from the next deeper interval. Representative samples of the cuttings were collected from each interval or from significantly different materials within an interval. While the drilling was in progress, a geologist described the samples and noted the drilling action and drilling time of each interval. One or more electric logs were made for 39 of the holes. Because of hole problems, electric logs were not obtained for 3 holes. The elctric logs and the geologist's field logs are on file at Conservation and Survey Division offices in Lincoln and Scottsbluff and at the Upper Niobrara-White Natural Resources District office in Chadron.

The depth to water was measured with a chalked, steel tape in 31 of the holes after the water level in the test hole had stabilized. Electric logs and depths at which holes caved indicated the depth to water in another 5 holes. Land surface altitudes of the test holes were taken from U.S. Geological Survey 7.5-minute and 15-minute topographic maps.

Test-hole samples at critical sites and depths were examined with a binocular microscope in the laboratory. In a few cases, individual grains were mounted on slides and examined under high magnification in order to identify individual mineral grains. The electric logs and the field and laboratory descriptions are the basis for identifying the stratigraphic units and assessing their water-bearing characteristics.

The geologic sections and one half of the maps in this report are based largely on information obtained from the drilling. Supplemental information includes the following: data from 4 test holes drilled near the Dawes-Box Butte county line in 1975-76 (Souders et al., 1980); driller's logs and water-level information on irrigation- and municipal-well-registrations (all available records of this type were examined and information from many were used); records of test drilling for the cities of Chadron, Rushville, and Gordon; test-hole logs recorded by well drillers contained in Conservation and Survey Division files; electric logs of 20 oil and gas tests; water-level measurements made by the Conservation and Survey Division staff; and data gleaned from topographic maps and satellite imagery.

Test-hole and well-numbering system

Each test hole, well, or oil and gas test referred to in this report is identified by a number indicating its location in the U.S. Bureau of Land Management's survey of Nebraska. The figure preceding N (for "north") indicates the township, the figure preceding W (for "west") indicates the range, and the figure preceding the lowercase letters indicates the section. The lower-case letters denote location within the section. As shown in figure 3, the first of these letters indicates the quarter section, the second the quarter-quarter section, and the third, if given, the quarter-quarter-quarter section. Thus, in this system of numbering, a test hole or well in the SE¼ SE¼ SE¼ section 17, Township of 30 North, Range 47 West, is identified by the number 30N-47W-17ddd.

Each test hole drilled for the project is also identified by a field number which consists of a sequential designation, a letter which identifies the drill rig, and the year in which the hole was drilled. Thus, field number 12-B-78 indicates the twelfth hole drilled with the B rig in 1978.

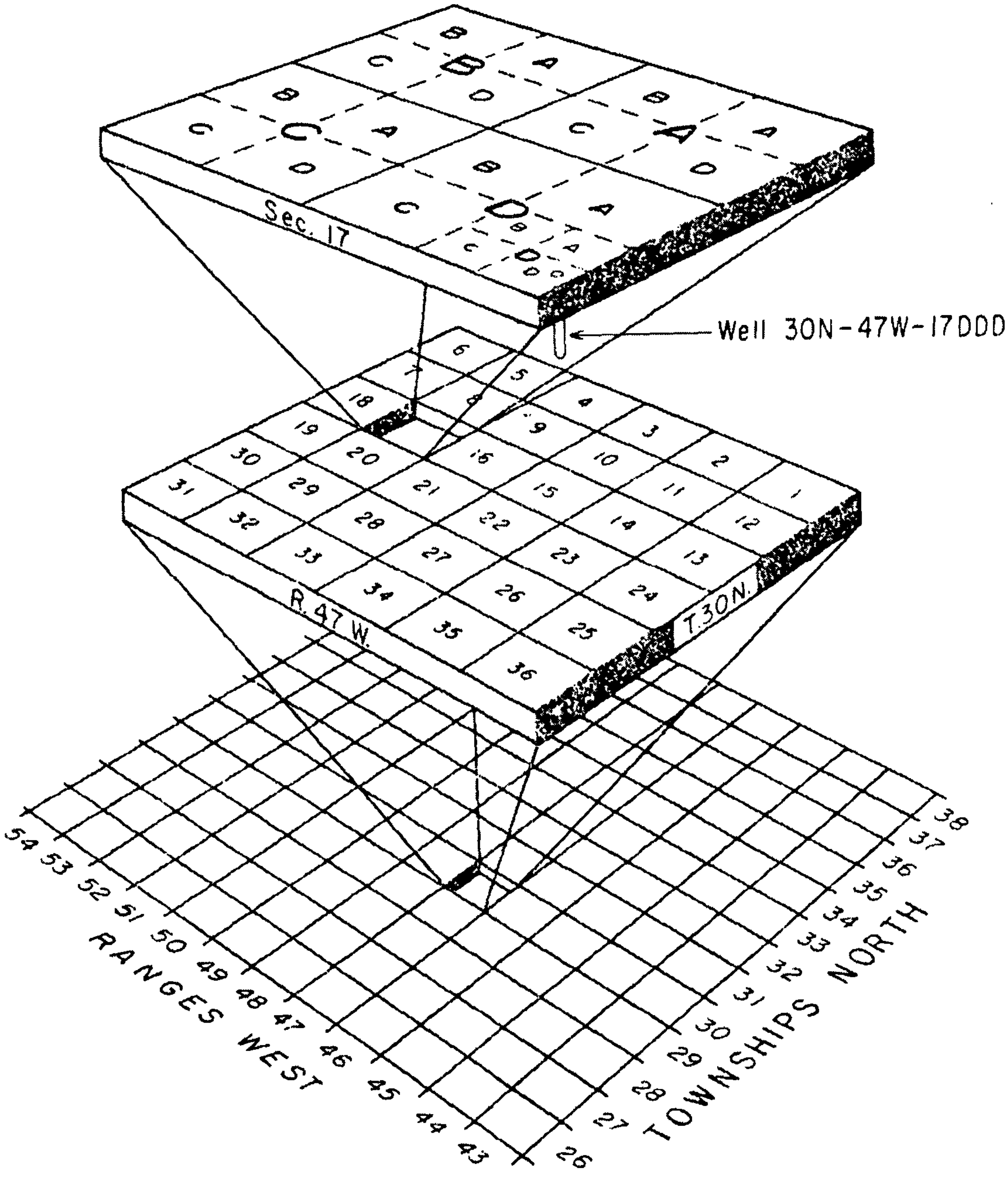

Fig. 3. System used for identifying test holes and wells according to location

Previous investigations

Keech (1964) described the groundwater resources of the Mirage Flats area in west-central Sheridan County. His report contains very little geological information but has detailed records of wells and water levels and an excellent water-table map. Southern Dawes and northern Sheridan counties are included in several very general reports about groundwater resources. Bradley (1956) probably presented the most useful report of this kind. Hydrologic information from the Box Butte County reports by Souders et al, (1980), Cady and Scherer (1946), and Nace (1953) is helpful in understanding groundwater resources of Dawes and Sheridan counties. All of these reports also include some information about the quality of groundwater in the areas covered by the reports. Streumpler (1979) and the National Uranium Resource Evaluation (NURE) Program Report K/UR-141 (anonymous, 1980) provide additional information about groundwater quality in northwest Nebraska.

The classic general report on the geology of western Nebraska was by Darton (1899). Lugn (1939) provided the basic stratigraphic classification for the Tertiary system in Nebraska but there now appears to be problems with his stratigraphy. Schultz and Stout (1955) made a detailed classification of Oligocene outcrops in western Nebraska and Singler and Picard (1980) suggested a modification. DeGraw (1969) provided a comprehensive view of the relations of the Cretaceous and Tertiary in western Nebraska. Souders et al. (1980) described the geology of Box Butte County. Skinner et al. (1977) gave a detailed account of some Miocene strata in south-central Sioux County and placed these strata in a broader context.

Detailed papers on segments of Tertiary stratigraphy in parts of northwest Nebraska are more common than comprehensive reports. McKenna (1965) summarized the nomenclatural and geologic problems of the younger Tertiary rocks. Galusha (1975) described the Box Butte Formation outcropping in southern Dawes and northern Box Butte counties. Hunt (1978), Yatkola (1978), and Cook (1965) reported on Miocene rocks exposed in the vicinity of the Niobrara River from southwest Dawes County west to the Wyoming border.

In the 1960s, J. R. MacDonald and J. C. Harksen, together and separately, published numerous reports and papers about the geology and fossils in South Dakota just north of the study area (eg. MacDonald, 1963, Harksen, 1967, 1968, MacDonald and Harksen, 1968, Harksen and MacDonald, 1969a, 1969b). Skinner *et al*. (1968) disputed some of their interpretations.

The references mentioned above, while not complete, give ideas about the rocks of the study area and some of the controversies about the sequence, grouping, ages, and significance of the strata. One important fact remains--much more work will have to be done before the stratigraphy of the study area is fully understood.

Acknowledgments

Financial assistance for drilling the test holes was provided by the Upper Niobrara-White Natural Resources District. The encouragement and support of the board of directors and manager, John Williams, is appreciated.

The test holes were located and drilled by the author. Gene Debus operated the drill rig at most of the test-hole sites. Drill helpers were Brad Goff and Carl Jackson in 1978 and Hans Ingold in 1979. Professional staff members who served as geologists at different times during the drilling were: H. M. DeGraw, J. B. Swinehart, D. R. Lawton, J. D. Boellstorff, J. W. Goeke, and R. K. Pabian. DeGraw and Swinehart helped plan the project and provided liaison with the Lincoln office, technical information, and advice. J. J. Gottula, Water Scientist at the Scottsbluff office, mapped the water table, organized a mass of data which was used for making maps, and corroborated groundwater-storage calculations. J. B. Swinehart and my wife, Rebecca, made large contributions to the writing of this report. R. L. Diffendal reviewed it. Ann Mack and Deanna Ebbeka drafted the figures and plates. Audrey Schardt and Melba Stemm typed the manuscript.

The University of Nebraska Panhandle Station, Scottsbluff, Nebraska, furnishes office space to the Conservation and Survey Division. We appreciate the support of the station and its director, Dr. John Weihing.

STRATIGRAPHIC UNITS AND THEIR WATER-BEARING PROPERTIES

General geology

The strata at or near the land surface in southern Dawes and northern Sheridan counties are divided into rock-stratigraphic units (Fig. 4). A rock-stratigraphic unit is a body of rock that has some lithologic unity and has identifiable boundaries, which may be gradational. The stratigraphic units used in this report are members, formations, combinations of two formations, and groups (a unit of two or more formations).

Shale and chalk of Cretaceous age are exposed along the White River from near Crawford in western Dawes County northeast to the state line. These exposures extend from 1 to 8 miles south of the river and thus occur in the northwest part of the study area in Dawes County and northwest Sheridan County. Shale and chalk also outcrop along the state line in the vicinity of White Clay in Sheridan County.

The land surface slopes gently upward from the White River south to the base of the Pine Ridge escarpment. Most of this long slope is underlain by older Tertiary rocks which consist of siltstones, some claystones, and minor amounts of sand and gravel. The Pine Ridge is an abrupt topographic rise of 400 to 700 feet that marks the north edge of a broad tableland area. Siltstones, sandstones, and some gravel of younger Tertiary age are exposed along this escarpment and underlie the tableland. The total thickness of the Tertiary rocks south from the crest of the Pine Ridge to the Niobrara River ranges from about 800 feet to more than 1400 feet.

Unconsolidated silt, sand, and gravel of Quaternary age mantle the older rocks in many places throughout the study area but reach a thickness of more than 50 feet only along the Niobrara River in Sheridan County. This report deals with the younger Tertiary rocks beneath the tableland, but the older Tertiary, Cretaceous, and some pre-Cretaceous rocks need a brief description.

SYSTEM	SERIES	GROUP		STRATIGRAPHIC UNIT
QUATERNARY	Holocene and Pleistocene			Undifferentiated
TERTIARY	Miocene	Ogallala		Ogallala Group
		Arikaree		Upper Harrison beds
				Monroe Creek—Harrison Formations
	Oligocene			Gering Formation
		White River	Brule Formation	Beaver Wall siltstone beds (Nonpareil ash zone)
				Whitney Member (upper ash, lower ash)
				Orella Member
				Chadron Formation
CRETACEOUS	Upper Cretaceous	Montana		Pierre Shale
		Colorado		Niobrara Chalk
				Carlile Shale
				Greenhorn Limestone
				Graneros Shale
	Lower Cretaceous	Dakota		Dakota Group
JURASSIC				Morrison Formation
				Sundance Formation
PERMIAN and OLDER ROCKS				

Fig. 4. Rock-stratigraphic units

Jurassic System

Uplift along the Chadron Arch at the end of the Cretaceous caused many of the pre-Tertiary rocks along the arch to be eroded away. Thus, the Tertiary strata in southern Dawes and northern Sheridan counties cover an ancient, extensively-weathered landscape (the pre-Chadron surface) of Cretaceous and older rocks. Part of this surface was exhumed by later erosion and is exposed in a very few places in the study area along the White River. The uplift and erosion produced a complicated outcrop pattern and a subcrop pattern* (Fig. 5) that is poorly known because it is, for the most part, deeply buried.

DeGraw (1969) inferred from subsurface data that the Tertiary rocks may lie directly on the Morrison and Sundance formations of Jurassic age along the crest of the Chadron Arch in west-central Sheridan County. These formations consist of mudstones, siltstones, sandstones, and some limestone. The formations would occur beneath the Tertiary rocks at depths of 1400 feet or more and would underlie the Cretaceous rocks at even greater depths throughout the remainder of the study area. Rocks of Permian age underlie the Sundance Formation.

Sandstone beds of the Sundance could be reservoir rocks for fluids or gases in some localities along the Chadron Arch, according to DeGraw (1969). If water does occur in these beds, it is likely to be of very poor quality. Jurassic rocks could be a potential source of uranium.

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* A subcrop pattern would be the pattern of rocks outcropping if the Tertiary rocks were stripped off. Or, a subcropping stratigraphic unit is one that was exposed at an ancient land surface that is now buried by younger rocks.

Cretaceous System

Rocks of the Upper and Lower Cretaceous Series constitute most of the pre-Chadron surface (Fig. 5) and some Upper Cretaceous rocks crop out in the northwest part of the study area. The Cretaceous stratigraphic units, from oldest (lowermost) to youngest (uppermost) are the Dakota Group, Graneros Shale, Greenhorn Limestone, Carlile Shale, Niobrara Chalk, and Pierre Shale.

Dakota Group rocks consist of sandstones, shales, mudstones, and siltstones. The Dakota has a maximum thickness of about 1000 feet in the study area. Some of the sandstone beds are medium- to coarse-grained and are excellent reservoir rocks for fluids and gases. Sandstones of this group are a source of oil and gas in the southern Nebraska Panhandle. Depths to the top of the Dakota in the study area range from about 600 feet just north of the Pine Ridge north-northwest of Hay Springs to about 1400 feet where the rocks subcrop at the pre-Chadron surface beneath the tableland in Sheridan County. The group underlies younger Cretaceous rocks at generally greater depths throughout the remainder of the study area.

Sandstone beds of the Dakota are known to be unsaturated (contain no fluids or gases) or undersaturated along the Chadron Arch (DeGraw, 1969). Water or other fluids or gases should be present in the Dakota in most other places and parts of the group comprise an aquifer in South Dakota. Water contained in Dakota Group sandstones in the study area probably would be warm and have relatively large amounts of dissolved minerals, so that water likely would not be suitable for domestic or irrigation purposes. The most favorable locality for exploring for water in these beds could be several miles north-northwest of Hay Springs. Dakota Group rocks are probably of more interest as potential sources of oil, gas, and uranium.

The Graneros Shale and Greenhorn Limestone subcrop at the pre-Chadron surface in eastern Dawes County and across Sheridan County and underlie younger Cretaceous rocks down the slope of the strata away from the subcrop areas. The maximum thickness of the Graneros is about 350 feet while that of the Greenhorn is about 30 feet. The Greenhorn is exposed at one spot just north of the White River about 2 miles south-southwest of the point where the river enters South Dakota. Neither the Greenhorn nor the Graneros are considered to be a source of water in the study area.

The Carlile Shale crops out in the northeast corner of Dawes County south of the White River and make a subcrop belt around older rocks in the subsurface to the south (Fig. 5). The maximum thickness of the Carlile in southern Dawes and northern Sheridan counties is about 260 feet. The formation is not considered to be a source of groundwater.

The Niobrara Formation consists of chalk, calcareous shale, and some limestone and has a maximum thickness of about 460 feet in the study area. The formation is exposed throughout much of northeastern Dawes and northwestern Sheridan counties and outcrops in the vicinity of White Clay. The chalk and calcareous shale weather to a distinctive yellow-brown or orange. In some localities where the Niobrara outcrops or subcrops; joints, faults, and solution channels may occur and the formation becomes a source of water, especially for stock and domestic wells. The Niobrara is also a potential source of natural gas where the formation is overlain by the Pierre Shale.

The Pierre is the youngest Cretaceous unit present in the study area. The dark shales of this unit are exposed northward from just south of the White River. Other exposures occur in northwest Sheridan County and near White Clay. The Pierre is not a source of water supply.

The relationship of some of the Cretaceous rocks to the overlying Tertiary rocks is shown in geologic sections A-A', B-B', C-C', and H-H' (Plates 1, 2, and 4).

Tertiary System

White River Group

Chadron Formation-

Rocks of the Paleocene and Eocene series are missing in the study area and erosion and weathering presumably dominated during these epochs. The basal Tertiary strata in southern Dawes and northern Sheridan counties are those of the Chadron Formation, White River Group, Oligocene Series. Most of the rocks comprising this formation are claystones and clayey siltstones (mudstones), but some sandstones and gravels occur locally near the base of the formation. Chadron rocks are mostly green-hued but yellow, brown, and bright red colors also appear. The Chadron is exposed above the Cretaceous rocks for short distances south of the White River and directly overlies the pre-Tertiary rocks throughout the remainder of the area (Plates 1, 2, and 4).

Most of the fine-grained rocks of the Chadron contain large percentages of swelling clay (smectite) derived from weathering of volcanic ash. Sand and silt (including ash) were probably deposited in stream channels, ponds, and floodplains while windblown silt was deposited on stream divides of low relief. Resting on nearly impermeable rocks, these sediments were saturated for long periods of time and strongly alkaline conditions could have prevailed. Such circumstances may have hastened the weathering of the volcanic ash to smectite clays.

I follow Darton's classification (1899) and restrict the Chadron Formation to the claystones, mudstones, and associated sandstones near the base of the White River Group because these beds can be identified readily in the subsurface, especially on electric logs. Schultz and Stout (1955) and Singler and

Picard (1980) include some higher siltstone beds in the Chadron Formation, but these siltstones cannot be easily correlated on a regional basis, especially in the subsurface. Furthermore, over a broad area, the siltstones are more lithologically similar to the overlying Orella Member. The Chadron ranges from about 50 to 200 feet thick where it is overlain by the Brule Formation in southern Dawes and northern Sheridan counties.

Sandstone and gravel beds at the base or within the Chadron are sources of water for some domestic and stock wells north of the Pine Ridge. Similar beds occur in some localities south of the Pine Ridge but are from 800 to 1400 feet deep. The water is generally under artesian pressure and there are some flowing wells in the Crawford area. DeGraw (1969) notes that these beds may not be saturated in places along the Chadron Arch.

In some localities the basal sandstones and gravels may exceed 50 feet in thickness. Wells yielding up to a few hundred gallons per minute possibly could be developed at these sites, but the drawdowns required to obtain such yields would be a few hundred feet. The quality of water probably would not be suitable for irrigation or municipal uses. The Chadron Formation contains potentially exploitable uranium ores in the Crawford area and commercial quantities may occur in other localities.

Brule Formation-

Orella Member:

The Orella Member of the Brule Formation overlies the Chadron Formation, generally in a conformable relation, and consists of siltstones, mudstones, and minor amounts of sandstone. The rocks are gray, greenish-gray, olive, and brown. The Orella is exposed north of the Pine Ridge and occurs in the subsurface throughout the remainder of the area south of the outcrop belt. This member is about 240 feet thick in southwest Dawes County (geologic section A-A', plate 1) but thins rapidly to the east-northeast and is only 60 to 70 feet thick in Sheridan County (geologic section H-H', plate 4). Electric logs of oil and gas tests indicate the member may also become finer grained to the east-northeast. Environments of deposition of the Orella Member include floodplains, stream channels, and uplands.

Some of the thin sandstone beds could be a source of water to stock and domestic wells, especially where the beds occur at shallow depths north of the Pine Ridge. Joints, fractures, and faults in the Orella could make it an aquifer in some localities. Generally, this stratigraphic unit is not a good source of groundwater.

Whitney Member:

The Whitney Member of the Brule Formation crops out at the base and footslope of the Pine Ridge escarpment. The predominant rock type is a well-sorted, brown siltstone with small amounts of clay and sand. Locally fine-grained sandstone beds occur near the base of the unit, but elsewhere sandstones occur throughout much of the Whitney and contain medium to coarse sand (see log of Test Hole 31N-49W-22acb). Most of the Whitney siltstones are interpreted to have been deposited by wind. The sandstone beds indicate some stream systems crossed the area.

Volcanic ash, primarily glass shards, is a major constituent of the Whitney siltstones (Souders et al, 1980, and Swinehart, 1979a) and several beds of nearly pure volcanic ash occur within the member. Two of these beds, the Upper Ash and Lower Ash of Schultz and Stout (1955), are relatively thick (more than 5 feet in parts of the study area) and generally easy to identify on electric logs, thus making them excellent stratigraphic markers for subsurface correlation. Using electric logs of oil and gas tests these two beds can be traced from the southern Nebraska Panhandle to east-central Sioux, southern Dawes, and west-central Sheridan counties. The logs available for the Pine Ridge area of Dawes County and for northernmost Sheridan County indicate that the ash beds are absent and that their stratigraphic intervals consist of mudstone and sandstone, Geologic sections A-A' (Plate 1) and H-H' (Plate 4) indicate the relationship of the ash beds to the base and top of the Whitney.

The maximum thickness of the Whitney Member is about 400 feet in southwest Dawes County. The member thins to the east-northeast and is about 280 feet thick in the subsurface in west-central Sheridan County. In Dawes County, the Whitney is commonly much thinner near the Pine Ridge and in outcrop because the upper part has been removed by post-Whitney pre-Gering and post-Ogallala erosion.

In most places the lower boundary of the unit appears to be marked by a break in the continuity of the strata (unconformity) between uniform Whitney siltstones above and more or less distinctly bedded siltstones and mudstones of the Orella below. Channel sandstones at the base of the Whitney unconformably overlie the Orella in some localities. The interval between the base of the Whitney and the Lower Ash is about 80 feet in southwest Dawes County and thins somewhat to the east-northeast. Correlations north and east of western Sheridan County are difficult because well control is limited, the Lower Ash is absent, and the lithologic character of the Whitney is not distinctive.

The Whitney Member is generally not a source of water to wells but the medium- to coarse-grained sandstone in Test Hole 31N-49W-22acb should be capable of yielding several tens of gallons per minute. The fine-grained sandstones at other sites might yield a few gallons per minute. More importantly, the Whitney, like the Orella, may be jointed, fractured, or faulted in some localities. These features can create zones of secondary permeability in an otherwise relatively impermeable mass of rock. A well installed at Ft. Robinson in 1977 produces about 75 gallons per minute and the source of water appears to be fractured rock and some thin sandstone beds in the lower part of the Whitney and/or upper part of the Orella.

Beaver Wall siltstone beds (informal name):

Souders et al (1980) recognized that a thick section of relatively uniform, brown, sandy siltstones occurs above the Whitney in northern Box Butte County. This section of rocks, which essentially represents a continuation of Whitney sedimentation but is coarser-grained, extends northward into the study area. The section reaches a maximum thickness of more than 400 feet in the subsurface in southeast Dawes and in central Sheridan counties.

These sandy siltstone beds crop out along the Niobrara River in southwest Dawes, northwest Box Butte, and east-central Sioux counties. Swinehart (1977) noted that these outcrops have been misidentified as Monroe Creek Formation (Lugn, 1939, Cady and Scherer, 1946, Yatkola, 1978). Field reconnaissance by Gottula and me and observations made in 1951 by Morris Skinner, then with the Frick Laboratory, American Museum of Natural History, (personal communication, 1981) indicate extensive outcrops of these beds occur along Beaver Wall, a prominent north-south trending cliff which forms the Pine Ridge escarpment in northwest Sheridan County. The lower two-thirds of this section of siltstones is quite distinct in Test Hole 33N-45W-31dad, which is about 5 miles southeast of the south end of Beaver Wall. Because of the exposures along Beaver Wall, this stratigraphic unit is given the informal name, Beaver Wall siltstone beds.

In many localities the base of the Beaver Wall unit seems to be defined by the Nonpareil ash zone (Swinehart and Souders, 1979) which appears to conformably overlie the Whitney siltstones. This zone is prominently developed in the subsurface in southwest Dawes County (e.g., T.H. 29N-51W-24bba) where it consists of a thick bed of nearly pure volcanic ash overlying a bed of very ashy siltstone. The zone produces a distinctive electric-log curve which can be correlated in many wells and test holes east-northeast into Sheridan County. Many of the test-holes for this study were designed to reach this zone.

The Nonpareil ash zone does not occur everywhere in the subsurface in the study area. In some localities the stratigraphic interval in which it occurs is replaced by silty, fine- to medium-grained sandstones. Similar beds of sandstone locally occur throughout the Beaver Wall unit (e.g., Test Hole 31N-49W-22acb) and appear to be more common in the northeast part of the study area. However, most of the Beaver Wall rocks are well-sorted, very sandy siltstones which locally grade to well-sorted, very silty, very fine-grained sandstones. The unit generally coarsens upwards and calcareous nodules and concretions are common in the upper part. The mineralogy of the Beaver Wall unit is dominated by volcanic ash, principally glass shards (Souders et al., 1980; Swinehart and Souders, 1979; Swinehart, 1977) and ash beds in addition to the Nonpareil do occur in the unit (e.g., T.H. 32N-44W-22abb). The large amount of volcanic material and the relatively uniform character of these fine-grained rocks indicate that most of the sediment was deposited by wind. Stream systems deposited silt, sand, and some clay in several localities.

The top of the Beaver Wall unit is marked by an unconformity. Post-Beaver Wall pre-Gering erosion removed most or all of the unit along the Pine Ridge in Dawes County and much of the upper part of the unit north of Highway 20 in northern Sheridan County. Sand and sandstone of the Gering Formation overlie the Beaver Wall (or Whitney if all the Beaver Wall siltstone beds were eroded) throughout this area of extensive erosion. South of this area the Beaver Wall is unconformably overlain by brown, sandy siltstone and silty sandstone of the Monroe Creek-Harrison formations and the contact is often difficult to determine with precision. Furthermore, the contacts between all the White River units and between the Beaver Wall siltstone beds and the overlying Arikaree units generally become less and less distinctive as one works east-northeast from southwest Dawes County. The geologic sections (Plates 1 through

4) illustrate my interpretation of how the post-White River rocks overlie the Beaver Wall and Whitney rocks.

Singler and Picard (1980) suggested that the Brule Formation be elevated in rank to a subgroup and that the Orella and Whitney members be recognized as formations. Although I have not used this ranking, I agree with their suggestion and would extend the concept further. The informal Beaver Wall stratigraphic unit of this report needs to be examined in more detail, especially the lower boundary. Then the unit should be given a formal name and included as a third and uppermost formation of a Brule Subgroup.

The Nonpareil ash zone was recognized as a possible ash zone on electric logs of oil and gas tests as early as 1965 by DeGraw and Dreeszen (personal communication, 1975). Test drilling in Box Butte County in 1975 and for this project verified their interpretation of the logs. They speculated that the zone might be equivalent to the Rockyford Ash of South Dakota (Nicknish and Macdonald, 1962). To date, no one has demonstrated that the Rockyford and the Nonpareil are equivalent units, but the units do appear to occupy similar stratigraphic positions. If the two units are equivalent, then part of the Sharps Formation of South Dakota and part or all of that sequence of rocks in South Dakota called "Rosebud" by Skinner et al. (1968) would then appear to be equivalent to the Beaver Wall siltstone beds of this report.

The sandy siltstones and silty sandstones of the Beaver Wall unit can be a source of water to stock and domestic wells. Wells yielding from a few tens up to 200 gallons per minute could be developed in some localities if more than 300 feet of saturated Beaver Wall beds were penetrated. The drawdown during pumping would be large because the discharge of a well in the unit probably would be less than 0.5 gallons per minute per foot of drawdown. Larger yields or less drawdown might be possible in places where the unit is fractured.

Probably more than 10 million acre-feet of good-quality groundwater is stored in the Beaver Wall unit in southern Dawes and northern Sheridan counties. The economic feasibility of developing this supply on any sizable scale appears to be impractical, at least for the forseeable future.

Arikaree Group

Gering Formation-

The extensive erosion that occurred after the deposition of the Beaver Wall siltstone beds appears to have been confined largely to the northern part of the study area. Here, a river (or rivers) cut a deep valley more than 15 miles wide in northern Dawes and northernmost Sheridan counties (Fig. 6). The north side of this ancient valley (paleovalley) was removed by post-Ogallala erosion in Dawes and northwest Sheridan counties and lies north of the study area east of White Clay, Nebraska. The south wall of the paleovalley is high and steep except in northeast Sheridan County. The abruptness and height of the south side of the paleovalley indicate faulting may have influenced the location and depth of erosion. Faults are interpreted to occur along this south wall in several localities (geologic sections A-A' through D-D', plates 1 and 2).

Figure 6 shows, in plan view, the location and present configuration of the floor of the paleovalley. The major fault in northeastern Sheridan County is accounted for on this map, but other known and inferred faults are suggested only indirectly by the contours. Faults and lack of detailed control limit the accuracy of this map.

The Gering Formation of the Arikaree Group is limited to deposits within the paleovalley and its small tributaries. The dominant lithologies are sandstones with some interbedded siltstones and mudstones. Some of the sandstone beds are relatively uniform, very fine- to fine-grained and silty. Other sandstone beds, however, are more poorly sorted and very fine- to medium-grained. In places these beds contain coarse sand to fine gravel grains derived from igneous and metamorphic rocks. The coarser-grained sandstone beds typically contain fragments, or clasts, of locally-derived sedimentary rocks, principally siltstone and mudstone. These lithic clasts generally range from medium sand to fine gravel in size, but some coarser clasts were found. Volcanically-derived grains, mainly glass shards, occur in many of the siltstones and fine-grained sandstones. Thin beds of relatively pure volcanic ash are locally present.

The maximum drilled thickness of the Gering is 280 feet (Test Hole 32N-44W-2bbb, north of Rushville). The variable lithology and relative coarse grain size, stratigraphic position, and relatively high resistance on electric logs were the criteria used to identify the Gering Formation. The lower boundary of the formation is difficult to establish with subsurface data in localities where the Gering overlies fluvial beds of the White River Group, particularly in the northeast part of the study area. The upper boundary generally is a conformable contact, locally gradational, between fluvial and possible wind-deposited sands of the Gering and relatively uniform, brown, sandy siltstones above. I have restricted the Gering Formation to stream and floodplain deposits which contain what appear to be interbedded eolian deposits. The overlying finer-grained rocks, which are from about 10 to 95 feet thick, also could be included in the formation inasmuch as they seem to be limited to the paleovalley.

Geologic section G-G' (Plate 4) is a profile of the stratigraphic units west to east down the paleovalley. The units correlate well, especially on electric logs, from western Dawes County to north of Rushville. Between Rushville and Gordon the Gering thins. Furthermore, the base of the formation occurs at a much higher altitude north of Gordon than it does north of Rushville. This situation is difficult to reconcile with the interpretation of a single Gering valley. If the stratigraphic units are correctly identified, then the Gering sands in the Gordon area are either part of a different fluvial system or part of the same fluvial system that was uplifted after the deposition of the sands. The electric log of oil test 32N-43W-4db is the only usable control available to correlate across the area and the log is not definitive.

Nevertheless, correlations using this log indicate structural movement, possibly a north-south striking fault east of Rushville, could have occurred during or after the deposition of the Monroe Creek-Harrison formations and before the deposition of the Upper Harrison beds. A fault could explain the anomalous altitude of the base of the Gering north of Gordon. Additional test holes are needed in the Rushville to Gordon area to clarify the geology and to further evaluate the groundwater resources.

Correlations from the western part of the study area, where the stratigraphic units are generally more distinct, northeast to the South Dakota line indicate the Sharps Formation of South Dakota is probably equivalent to the Beaver Wall siltstone beds and part or all of the Gering Formation of this report.

The sands and sandstones of the Gering at the base of the Arikaree Group are the most permeable part of that group and furnish water to stock, domestic, municipal, and irrigation wells. The base of the Gering Formation (Fig. 6) can be viewed as the base of a complex aquifer system composed of rocks of the Arikaree Group. Water supplies of this group will be discussed later.

Monroe Creek-Harrison formations (undifferentiated)-

The Monroe Creek-Harrison and Gering stratigraphic units are the predominant rocks exposed along the Pine Ridge escarpment. Well-sorted silty, sandstones and sandy siltstones containing numerous calcareous nodules and ledge-forming concretions characterize the Monroe Creek-Harrison. The sand is very fine to fine. Dominant colors are brown and grayish-brown. Volcanic-glass shards comprise about a quarter of the very-fine sand grains (Souders, et al, 1980; Stanley, 1976). The excellent sorting, the presence of significant amounts of volcanic material, and the relative uniformity of the rocks indicate the sediments were deposited by wind. From west to east across the study area, the average grain size appears to decrease and the rocks generally become browner.

The Monroe Creek-Harrison unit conformably overlies the Gering Formation in the large west-east paleovalley and unconformably overlies the Beaver Wall unit south of that valley. The maximum drilled thickness of the Monroe Creek-Harrison is 362 feet near the crest of the Pine Ridge southeast of Chadron (Test Hole 32N-47W-33cbc). The unit is thicker in the paleovalley than it is on the ancient upland south of the valley except east of Rushville in Sheridan County. The Monroe Creek-Harrison appears to be only 15 feet thick at the South Dakota border in northeast Sheridan County (geologic section F-F', plate 3).

The upper boundary of the Monroe Creek-Harrison unit is marked by an unconformity throughout the study area. Erosion that followed the deposition of the Monroe Creek-Harrison unit and preceded the deposition of the next younger unit, the Upper Harrison, removed the Monroe Creek-Harrison from southwest Dawes County and from other localities in the south part of the county (geologic sections A-A' and C-C', plates 1 and 2). Post-Upper Harrison pre-Ogallala erosion removed more of the Monroe Creek-Harrison from southern Dawes County (geologic sections B-B', C-C', and H-H', plates 1, 2, and 4). The Monroe Creek-Harrison occurs throughout the subsurface in northern Sheridan County south of the Pine Ridge (geologic sections D-D' through F-F', plates 2 and 3).

Electric logs and test-hole samples indicate the Monroe Creek-Harrison stratigraphic unit may be divisible locally into six or more subunits. The electric logs provide better definition for subdivision than do the samples. More subunits occur in the paleovalley, where the Monroe Creek-Harrison is thickest, than on the ancient upland. Subunits on this upland appear to correlate with the uppermost subunits in the paleovalley. However, differences between subunits are small and correlations of such units are questionable, especially on a regional basis. The differences noted are probably due to subtle changes in grain size and the arrangement of the grains (fabric). Although differences are noticeable, I found no solid evidence for making any significant subdivisions within the Monroe Creek-Harrison stratigraphic unit. The traditional division of the unit into an uppermost Harrison Formation and a lowermost Monroe Creek Formation appears to me to be highly suspect, and I think the classification of this section of rocks should be revised so that only one formation is recognized.

The grain size and fabric of the Monroe Creek-Harrison indicate the unit is not highly permeable. The calcareous-cemented concretions further reduce the permeability although fractures may increase the permeability in some localities. On the whole, the Monroe Creek-Harrison cannot be considered a source of water for large-yield wells. The unit is permeable enough to furnish water to stock and domestic wells and it undoubtedly contributes some water to municipal and irrigation wells in the study area. The Gering, Monroe Creek-Harrison and the Upper Harrison stratigraphic units constitute a complex aquifer system throughout the area of the west-east paleovalley. The water supplies available from this aquifer will be discussed in the section, "Water Supplies of the Arikaree Group."

Upper Harrison beds (informal name)-

Upper Harrison beds are exposed at the top of the Pine Ridge escarpment and they occur at the surface of the tableland in east-central Dawes County and north of U.S. Highway 20 in northern Sheridan County (Plates 1 through 3). This stratigraphic unit consists of a thick section of brown, sandy siltstones overlying generally thin basal sandstone beds. The basal sandstone beds do not occur everywhere throughout the study area and locally the brown siltstones lie directly on older units. In some localities the unconformity at the base of the unit is overlain by at least a few feet of slightly coarser-grained material and, at a number of sites, by concentrations of dark, heavy-mineral grains. The slightly coarser-grained rocks consist of brown to grayish-brown sandy siltstones or silty sandstones. Sand grains range from very fine to medium but a few coarser grains and some lithic clasts are present at a few sites. The medium and coarser grains are noticeable because the rocks above and below generally contain only very fine to fine sand. Relatively thick and well-cemented concretion zones are generally associated with these basal beds.

At still other sites the basal beds consist of a few feet to more than 40 feet of very fine- to medium-grained sandstones. Clasts of igneous and metamorphic rocks ranging from coarse sand to fine gravel size are commonly present as are clasts of locally-derived mudstone and siltstone. Concretion zones also occur with the sandstone beds. Test drilling and outcrop examination indicate these basal sandstones are generally thicker in northernmost Sheridan County north of Rushville and Gordon. Although little formal work has been done in this area, I believe these sandstone beds generally have been misidentified as the Harrison Formation by most geologists.

The brown siltstones which overlie the basal zone of the Upper Harrison are 200 feet thick in parts of the study area. The siltstone section varies in thickness in southern Dawes and northern Sheridan counties because post-Upper Harrison pre-Ogallala erosion and post-Ogallala erosion removed some to all of the Upper Harrison in many localities (Plates 1 through 4). The siltstones constitute a relatively uniform section of rocks, ranging from clayey siltstone to very silty sandstone. A considerable amount (25%) of volcanically derived material, principally glass shards, occurs in the siltstones (Souders et al, 1980). The rocks are generally brown, but zones a few feet to several tens of feet thick are green-hued where the siltstones are directly overlain by saturated Ogallala rocks (see log of Test Hole 31N-44W-34ddc). Brown colors are probably due to oxidized iron particles. Reducing conditions within the saturated rocks have de-oxidized the particles and produced the green hues.

A reconstruction of the depositional history of the Upper Harrison beds begins with post-Monroe Creek-Harrison pre-Upper Harrison erosion producing a mildly undulating landscape. Then streams flowing in shallow valleys deposited mostly sand which partly filled the valleys. Large volumes of windblown dust (silt, volcanic ash, and fine sand) then blanketed this landscape.

The Upper Harrison beds rest unconformably on the Monroe Creek-Harrison and Beaver Wall units in the study area. The base of the siltstone section of the Upper Harrison is easily determined on electric logs and from samples but where the basal sandstone beds rest on the Monroe Creek-Harrison unit the contact is more difficult to establish. Problems in distinguishing the base of the Upper Harrison beds arise in the few localities where the basal sandstones are absent and siltstones of the Upper Harrison lie directly on the Beaver Wall siltstone beds. Otherwise, the base of the Upper Harrison siltstone section is one of the easiest horizons to map throughout the study area, and such a map is more reliable than maps of older surfaces or horizons. The base of the siltstone section was mapped and several profiles were made using this horizon as a datum. The map and profiles were useful in making correlations of older horizons, reconstructing geologic history, and defining structural movements.

The grain size and fabric of the sandy siltstones of the Upper Harrison indicate the rocks could be a source of water for stock and domestic wells. These rocks, however, are not sufficiently permeable to support large-yield wells. The more permeable basal sandstones of the unit would also be limited as a source of water for only stock and domestic wells. The Upper Harrison beds do contribute water to large-yield wells penetrating the Arikaree Group, particularly the few irrigation wells located near the South Dakota border north of Gordon.

Water Supplies of the Arikaree Group

The Arikaree Group is a water-bearing system composed of a complex set of rocks, the Upper Harrison, Monroe Creek-Harrison, and Gering units. This system is restricted to the Gering paleovalley because the Gering sandstones constitute the principal water-yielding materials. Hydraulic conductivities* of this material, based on grain size and sorting, are estimated to range from less than 50 gallons per day (gpd) per square foot (ft^2) for the finer-grained beds to perhaps as much as 400 gpd/ft^2 for the coarser-grained beds. The hydraulic conductivity of most of the sandstones is probably from 150 to 200 gpd/ft^2. The basal Upper Harrison sandstones probably have similar hydraulic conductivities.

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*Hydraulic conductivity is, generally speaking, the volume of water that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. The hydraulic conductivity is a measure of the permeability of the rock. (Lohman, 1972, p. 4)

Silty, fine-grained sandstones in the Monroe Creek-Harrison and Upper Harrison units are estimated to have hydraulic conductivities that range from 50 to 100 gpd/ft^2. The sandy siltstones of both units are less permeable, hence these beds would have conductivity values that are less than 50 gpd/ft^2.

Between 90 to 100 irrigation and municipal wells obtain water from the Arikaree Group in northern Sheridan County. In Dawes County, one irrigation well taps the Arikaree Group, two wells apparently obtain water from the Monroe Creek-Harrison and Beaver Wall units, and perhaps as many as six wells obtain some irrigation supplies from the Beaver Wall siltstone beds or, possibly, from that unit and the Ogallala Group.

Yields of wells developed in the Arikaree Group range from about 80 gallons per minute (gpm) to as much as 1000 gpm. Thicknesses of saturated Arikaree at the well sites are from less than 100 feet to more than 650 feet. To obtain more than 400 gpm, the water-bearing materials generally must be more than 200 feet thick and have a considerable thickness of Gering sandstone.

The drawdown of the water level when the well is pumped is an important factor in well production. The relationship of the discharge of the well to the drawdown is an indication of the efficiency of the well construction and the transmissivity* of the aquifer. The specific capacity of a well is the discharge divided by the drawdown. Assuming the discharge remains constant, the drawdown will increase with the length of time the well is pumped. The rate of drawdown diminishes after one to several hours of pumping, but the rate is dependent on the transmissivity of the aquifer.

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*Transmissivity is, generally speaking, the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. It is equal to a summation of the hydraulic conductivities across the saturated part of the aquifer perpendicular to the flow paths (Lohman, 1972, p. 13).

Many irrigation- and municipal-well registrations include reported measurements of yield, depth to static water level, and depth to water level during pumping. Specific capacities for the wells can be computed from these reported data but the duration of pumping is unknown. Specific capacities were determined from the available information and the average value per township was calculated. Figure 7 shows these average values and the locations of wells. The northern limit of the uppermost aquifer system, the Ogallala, is indicated on the map. Most or all of the wells north of this limit in Sheridan County tap water in rocks of the Arikaree Group as does the well in Township 31 North, Range 47 West, Dawes County.

Specific capacities of wells developed in the Arikaree Group range from one to about 20 gpm per foot of drawdown. The average for all the wells was slightly less than 6 gpm per foot of drawdown. Township averages indicate the specific capacities are generally greater in the vicinity of Gordon. The Gering in this area is relatively shallow and the sands, while not thick, are relatively coarse and well-sorted. Wells of shallow depth are generally easier to install and tend to be more efficient.

Low specific capacities indicate large drawdowns are needed to obtain large yields. For example, 6 gpm per foot of drawdown means that 100 feet of drawdown will be required to get 600 gpm. 300 feet of drawdown would be required to get 600 gpm if the specific capacity is 2 gpm per foot of drawdown. The reported drawdowns for several wells are greater than 300 feet.

The large drawdowns indicate rocks of the Arikaree Group have a low transmissivity. The maximum transmissivity at favorable sites is probably about 40,000 gpd/ft. In most areas the transmissivity is probably from 10,000 to 15,000 gpd/ft, and lower values occur in numerous localities. Large drawdowns are also indicative of potential well problems because they are responsible for high entrance velocities of the water and for water cascading into the wells. These factors, in turn, lead to corrosion and incrustation to well screens and the movement of sand and silt into the well. Some or much of the sand and silt may be discharged from the wells, causing numerous problems when the suspended matter is put into irrigation and municipal systems. The fine-grained nature of the group is responsible for the low transmissivity and the poor well performance. Designing wells which will obtain large yields efficiently and which will remain trouble-free is extremely difficult.

The map showing the saturated thickness of the group (Fig. 8) was used to estimate the volume of saturated Arikaree rocks in the area of the Gering paleovalley. Lack of detailed control prohibits a precise calculation of this volume, but a general figure of 100 million acre-feet is believed to be reasonable. If the average porosity* is 35 percent, then about 35 million acre-feet of water is stored in the rocks.

No laboratory or field tests have been made to determine the storage coefficients** of the different rocks of the aquifer, and the fine grain size of the rocks would make such tests difficult. The layering of the different rock types also indicates artesian or semi-artesian conditions could exist, at least locally. Such conditions make an evaluation of the amount of groundwater the rocks may yield more complicated. Because of these problems, I had to make some assumptions. I assumed that the water in the rocks was unconfined and, given a sufficient length of time, would drain by gravity. I also assumed an average storage coefficient of 0.10. Using this value, I estimate that about 10 million acre-feet of water theoretically could be drained from the aquifer.

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* The porosity of a rock is its property of containing interstices, or voids, and may be expressed quantitatively as a ratio or percentage of the volume of the interstices to the total volume (Lohman, 1972, p. 10).

** The storage coefficient, a dimensionless value, is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. In an unconfined body of saturated rock, the amount of water derived from or added to the aquifer comes from gravity drainage or filling of pores (Lohman, 1972, p. 13).

The average storage coefficient could be more or less than 0.10, and my guess is that it is somewhat more, especially after several years of drainage.

All the water could be drained from the Arikaree Group only at an exorbitant price. In fact, such drainage could be done only by trenching the entire thickness of the aquifer at close intervals and pumping from sumps, or by installing small-yield wells only a few feet apart throughout the area of the aquifer. Consequently, the amount of water practically recoverable is much less than the estimated 10 million acre-feet.

The Arikaree aquifer system is difficult to evaluate and to utilize. The system contains a large volume of water, but this water cannot be extracted easily, cheaply, or efficiently.

Ogallala Group

Rocks of the Ogallala Group occur in most parts of Dawes County south of the Pine Ridge and are present south of Highway 20 in Sheridan County (Fig. 9). Arikaree and White River strata are generally fine-grained, relatively uniform, and contain large amounts of volcanic material. In contrast, Ogallala strata are coarser grained, more diverse lithologically, more poorly sorted, and contain only small amounts of volcanic material (Souders et. al. 1980; Swinehart 1977; Stanley 1976). Ogallala rocks include large amounts of sand and sandstone with some gravel, silt and siltstone, and mudstone, all of which may be complexly interbedded. A few, thin beds of pure volcanic ash occur locally. Igneous and metamorphic rock fragments, derived from western mountains and washed eastward, are major constituents of the coarser sands and gravels. Grays, olives, and browns are the most common colors.

Extensive erosion occurred throughout the study area following the deposition of the Upper Harrison beds. A large valley, or series of valleys, was eroded across central Sioux County eastward through southern Dawes County and into Sheridan County. This large west-to-east paleovalley undoubtedly has a complex erosional history and is the location of several episodes of valley cutting followed by deposition. The Ogallala Group is more than 350 feet thick in the paleovalley north of the Niobrara River in west-central Sheridan County. The group is thicker south of the river in central and eastern Sheridan County. Figures 9 and 10 show the location of the paleovalley, the thickening of the rocks into the valley and into southern Sheridan County, and the irregularity of the surface on which the Ogallala sediments were deposited. Geologic section B-B' through F-F' (Plates 1 through 3) show the paleovalley in profile. Geologic section H-H' (Plate 4) is a geologic section west to east down the paleovalley.

The Ogallala Group includes several formations in the study area and in general represent successive episodes of valley cutting and filling. The sediments comprising these formations are primarily the products of fluvial deposition. However, since most of these formations share many lithologic characteristics differentiation of them is difficult. The formations include, from oldest (lowermost) to youngest (uppermost), the Runningwater, Box Butte, Sheep Creek, a possible unnamed formation, and the Valentine-Ash Hollow formations (undifferentiated). Some information about each of these is given in this section but, for hydrologic purposes, the Ogallala Group is mapped as a single system.

The Runningwater Formation consists mostly of sandstones and siltstones, but includes some gravels and minor amounts of mudstone. The formation is generally coarser grained and has a considerable amount of gravel near the axis of its paleovalley in southern Dawes County (Test Hole 29N-49W-21aa). Along the north margin of the paleovalley the rocks are generally finer grained and include fine-to medium-grained sandstone, silty sandstone, and siltstone. Sections of brown and gray siltstone more than 50 feet thick occur in some localities north of the deepest part of the paleovalley (Test Hole 30N-47W-17ddd)

The Chadron city wells and most of the irrigation wells in Dawes County tap the Runningwater Formation, which constitutes the largest volume of Ogallala rock in the county. In this county, the formation can be identified throughout much of the tableland area on the basis of lithology and stratigraphic position. The Runningwater unconformably overlies Arikaree and White River units and the coarser-grained rocks of the Runningwater, derived mostly from plutonic source rocks, contrast sharply with the fine-grained rocks of the older units which contain abundant volcanic material. The Box Butte Formation, a thin but distinctive, fine-grained unit that is an excellent stratigraphic marker, unconformably overlies the Runningwater in many localities on the tableland.

The presence of this marker makes identification of the Runningwater a relatively straightforward matter.

The Runningwater Formation is not easily identified along the Niobrara River valley in southeast Dawes County or in Sheridan County. The Box Butte Formation is absent in these areas and younger Valentine-Ash Hollow strata, which are similar to Runningwater strata, rest directly on the Runningwater. Test Holes 32N-44W-34ddd (131-239 feet) and 32N-42W-2 (157-280 feet) illustrate the problem of differentiating the Runningwater and the Valentine-Ash Hollow. Finer-grained rocks occur in the lower part of the Ogallala Group in these two test holes and at other sites. These finer-grained Ogallala rocks may be part of the Runningwater Formation, but lack of stratigraphic markers, detailed well control and compositional data precludes a positive identification at this time. Additional information about these finer-grained rocks is needed if they are to be mapped.

The Box Butte Formation (Galusha, 1975) overlies the Runningwater throughout much of the tableland area in southern Dawes County. Test Holes 30N-51W-13ccc (2-18 feet) and 30N-49W-16ddd (2-13 feet) penetrated the formation, which consists mostly of gray and brown clayey silt and large lime nodules. The formation was not observed in Sheridan County. Thin, generally calcareous, beds of silty sandstone and sandy siltstone occur above the Box Butte in parts of Dawes County and are probably part of the Sheep Creek Formation. Another unit, consisting of siltstones and fine-grained sandstones, may occur above the Sheep Creek on the tableland in western Dawes County and may be equivalent to the Olcott Formation in central Sioux County (Skinner et al., 1977). These three units have little bearing on water supplies in the study area and they were not examined in detail.

The Valentine-Ash Hollow unit is the principal water-bearing unit of the Ogallala in Sheridan County. This unit unconformably overlies older strata and consists of fine- to very coarse-grained sandstones, some gravels, and some siltstones and mudstones. The rocks range from unconsolidated to moderately consolidated. Pebbles of igneous and metamorphic rocks along with quartz and feldspar grains dominate the mineralogy of the sandstones and gravels. Locally-derived lithic clasts occur in some of the gravel beds. Beds of volcanic ash are rare. Finer-grained rocks range from clayey to sandy silts and sandstone beds are commonly silty. A few, well-sorted beds of sand and silt are present in the Valentine-Ash Hollow but most beds are moderately-well to poorly sorted. Olives and browns, or variations between these, are the predominant colors.

The Valentine-Ash Hollow unit appears to be present in southeast Dawes County and throughout most of the area where the Ogallala Group occurs in Sheridan County. Remnants of the unit may occur on the crest of the Pine Ridge in northwest Sheridan County (Test Hole 33N-45W-31dad). Ogallala rocks, presumably including Valentine-Ash Hollow strata, extend north of Highway 20 east of Rushville and also occur in the northeast corner of Sheridan County. The outlying remnants of the formation indicate the Valentine-Ash Hollow may have once covered the entire area. The unit is interpreted to reach a thickness of 343 feet (Test Hole 29N-46W-24abb) north of the Niobrara River in the Mirage Flats area and is thicker south of the river in Sheridan County.

The test-hole samples and electric logs indicate the Valentine-Ash Hollow (undifferentiated) and the Runningwater formations are mostly comprised of mixed-load deposits of streams. Gravel beds indicate some of the sediments are bed-load deposits, but these beds do not constitute a large percentage of the total volume of sediment. The finer-grained rocks of the two units appear to be suspended-load and overbank deposits. Deposits produced by the wind appear to be insignificant, particularly in the Valentine-Ash Hollow.

Water Supplies of the Ogallala Group

The Runningwater and Valentine-Ash Hollow units are the most permeable formations of the group. The group occurs in south-central and southeast Dawes County, throughout most of northern Sheridan County south of Highway 20 (Figs. 7, 9, and 10), and the northeast corner of Sheridan County where it is thin. The Ogallala Group is the major source of water supply of the study area.

Hydraulic conductivities of some of the clayey silts of the Ogallala may be less than 20 gpd/ft^2 while some sandy gravel beds may have hydraulic conductivities greater than 1500 gpd/ft^2. Beds of slightly consolidated fine- to medium-grained sandstone, common in both the Runningwater and Valentine-Ash Hollow, probably have hydraulic conductivities of 400 to 500 gpd/ft^2. The grain size, sorting, fabric, and cementation of the rocks are factors that affect the hydraulic conductivity. Because these factors vary so greatly in the rocks of the Ogallala Group, no average hydraulic conductivity value can be assigned to the aquifer.

Transmissivity values can be estimated from well performances, as was done in the section about "Water Supplies of the Arikaree Group," or it can be estimated by a method devised by E. C. Reed, former State Geologist of Nebraska. Piskin (1971) refined and revised the method, which works in the following way: Each layer of material drilled in the test hole is classified and assigned a value for hydraulic conductivity. This value is multiplied by the thickness of that material to obtain a transmissivity value for the layer. The sum of all the saturated layers is the estimated transmissivity of the aquifer at the test-hole site.

The transmissivity will differ from site to site for the Ogallala Group because of differences in materials (see logs of test holes) and because of the variability in saturated thickness (Fig. 10). For example, using the Reed-Piskin method the transmissivity of the Ogallala at Test Hole 32N-44W-34ddd is estimated to be about 20,000 gpd/ft. Here, at the south edge of Rushville, the group is 116 feet thick. At Test Hole 29N-46W-24abb, located on Mirage Flats less than one mile north of the Niobrara River, the saturated Ogallala is coarser grained and is 303 feet thick. The estimated transmissivity for the group at this site is about 150,000 gpd/ft, or more than 7 times greater than the transmissivity of the materials at the test-hole site at Rushville. In general, transmissivities will be higher where the saturated thickness is greater (Fig. 10) and where there are significant thicknesses of coarse sand and gravel.

Transmissivity values, along with other hydrologic factors, are used to estimate the amount of groundwater seeping from one area to another and to describe the cone of depression in the water table caused by pumping a well or wells. A transmissivity value at a particular site is useful in predicting what a well might yield at a specified drawdown, assuming that the well efficiently utilizes the full saturated thickness of the rocks. For instance, a well at the Rushville test-hole site probably would discharge about 200 gpm with 30 feet of drawdown while one at the Mirage Flats site probably would yield about 1500 gpm with the same drawdown. The specific capacity of a well at the Rushville site, after several hours of pumping, would be between 6 and 7 gpm per foot of drawdown. The specific capacity of a well at the Mirage Flats site would be about 50 gpm per foot of drawdown.

Data reported on irrigation- and municipal-well registrations show that such large variations in specific capacities do occur in wells developed in the Ogallala Group. Reported measurements for 251 wells in the study area indicated specific capacities range from less than 5 to more than 50 gpm per foot of drawdown. The average specific capacity for the 251 wells is 17 gpm per foot of drawdown, which is nearly 3 times the average value for wells tapping the Arikaree Group.

Figure 7 shows average specific capacities in each township in the study area and the number of wells used to compute the average. Values in townships south of the line showing the northern limit of the saturated Ogallala Group are the specific capacities for wells in that groundwater reservoir. Averages are generally higher in the two townships in southeast Dawes County, in the Mirage Flats area, and in two townships south of Gordon. Southeast Dawes County and Mirage Flats are near the deepest part of the paleovalley where the saturated Ogallala rocks are relatively coarse-grained and thick. More than 200 feet of good water-bearing material was encountered in our second test hole south of Gordon.

Average specific capacities of wells tapping the Ogallala are lower along the margins of the group and in townships 31N-42W, 31N-43W, and 31N-44W, Sheridan County. The group is generally thinner and finer grained in these areas. Lower average values in the townships along or south of the Niobrara River in Sheridan County are probably attributable to lack of wells for an adequate sample, partial penetration of the aquifer by wells, and ineffective well construction.

The complex interbedding and large range in grain size of the Ogallala can be responsible for some inefficient wells. One type of well screen or gravel pack is generally not suitable for effectively utilizing the water from these different beds. Some inefficiency is to be expected unless large expenses for materials and engineering are made for well-construction.

At the end of 1979, nearly 320 registered irrigation and municipal wells tapped the Ogallala. The municipal supplies for Chadron and Rushville are from this group. Additional irrigation wells are being installed, especially in Sheridan County, and other municipal supplies may eventually be derived from the Ogallala in the study area.

The saturated volume of Ogallala strata in southern Dawes and northern Sheridan counties is estimated to be 45 to 50 million acre-feet based on figure 10. If the average porosity of the rocks is 35 percent, then the total volume of water stored in the aquifer in the study area is about 15 to 18 million acre-feet. Only a portion of this water is recoverable at a reasonable cost. The storage coefficient (or coefficients) of an aquifer is a hydrologic property of the rocks that is useful in hydrologic evaluations, especially in determining rates at which water levels may lower in areas of large ground-water withdrawals. Such a coefficient (or coefficients) has not been determined for the Ogallala aquifer in the study area. I suspect such coefficients, after long periods of drainage, would range from .20 to more than .30 at different sites.

Water from the Ogallala Group is being widely used in the study area, especially in Sheridan County, and recent developments indicate such use will probably increase in the near future. Numerous wells are developed in the Ogallala in the Mirage Flats Irrigation District, where the aquifer materials are thick, and the water is used to supplement irrigation supplies from the Niobrara River. The amount of water available to the district from the river has been less than the amount that was originally hoped for. The presence of the Ogallala Group in the area made the conjunctive use of surface water and groundwater possible. Such a use is generally regarded as a desirable goal of water management.

Quaternary System

Quaternary sediments were only casually investigated. Test drilling and roadside outcrop observations indicate these sediments are generally less than 50 feet thick except in some localities along the Niobrara River in Sheridan County. They consist of wind-deposited silt (loess) and sand, slope-wash (colluvium), and stream-deposited silt, sand, and gravel (alluvium). Most modern streams and drainages in the study area are underlain by several feet of alluvium. Terraces associated with these drainages usually are underlain by similar material. Some alluvial deposits consist of coarse gravels composed of concretion fragments derived from underlying bedrock. More than 100 feet of sandy alluvial material occurs along the Niobrara River in parts of Sheridan County.

Some stock and domestic wells probably obtain water from Quaternary rocks in the study area.

STRUCTURAL GEOLOGY

Southern Dawes and northern Sheridan counties lie at the northern apex of the Denver structural basin. The edge of this part of the basin is defined on the northwest by the Old Woman anticline and related structural features between Lusk, Wyoming and the Black Hills. The Black Hills uplift terminates the basin at the extreme north end, and the Chadron Arch, which passes through Sheridan County (Fig. 5), marks the northeast edge of the Denver basin in Nebraska. Rocks along these marginal structures have been strongly folded, and faulted in Wyoming and the Black Hills. Less intense deformation occurred within the basin near the north end including the study area.

The Pine Ridge in northwest Nebraska is a prominent topographic feature that marks the south approach to the Black Hills Uplift. The ridge parallels the southern margin of the hills but is quite distant from the major area of uplift. West of the Chadron Arch, strata comprising the Pine Ridge dip southeast at rates of from one-third of a degree to 3 degrees. Tertiary strata dip 30 to 40 feet per mile to the southeast immediately south of the Pine Ridge in Dawes County and throughout most of northern Sheridan County. In southernmost Dawes and central Sheridan counties, the Tertiary strata generally dip to the east (geologic section H-H', Plate 4).

Faulting is apparent in some localities along the Pine Ridge and at other sites throughout the study area (geologic sections A-A' through F-F', Plates 1, 2, and 3). Most faults located or inferred from the test drilling are normal faults downthrown to the north, but one fault located on outcrop and one fault inferred from drilling are downthrown to the south. All faults are suspected to have high-angles of dip. Vertical offset of beds ranges from less than 10 feet to more than 250 feet.

The fault with the largest amount of vertical displacement appears to be the one near the South Dakota border north of Gordon (geologic section F-F', Plate 3, Figs. 6 and 8). This fault trends northwest to southeast and is defined on the surface by a topographic break. The fault could be a continuation of the State Line fault (DeGraw, 1969) at White Clay, Nebraska. Test-hole spacings were too far apart to determine the vertical offset across the fault precisely, but I have interpreted a vertical displacement ranging from 250 to 300 feet. Two test holes were drilled north of this fault (Test Holes 35N-41W-19bc and 35N-41W-31ccc) and correlation of strata in these holes indicates an apparent dip to the north. I believe, however, that other faults occur in this area and the dip is actually to the southeast. Closely spaced test holes would be necessary to clarify the structural geology of the locality.

Test-drilling results indicate that most of the faulting occurred sometime after the deposition of the Upper Harrison beds. The lowland north of the fault near the South Dakota border (geologic section F-F', Plate 3) is mantled by what appear to be Valentine-Ash Hollow and Quaternary fluvial rocks while similar rocks are absent on the higher land immediately south of the fault. I therefore suspect, but cannot prove, that at least some of the faulting in the study area is post-Valentine-Ash Hollow. The steep, high, south wall of the Gering paleovalley in Dawes County and the difficulties encountered in correlating the Gering Formation between Rushville and Gordon indicate structural movements may have occurred contemporaneously with the deposition of the Gering or immediately following the deposition of the Monroe Creek-Harrison. Schultz and Stout (1955, p. 28, Fig. 3, geologic section 9) report evidence for post-White River pre-Arikaree faulting. These observations, plus the presence of an angular unconformity* between the Cretaceous and Tertiary rocks, indicate that structural movements, including faulting, have occurred at different times in northwest Nebraska since late in the Cretaceous period.

Numerous linear features (linears) appear on topographic maps, satellite images, and aerial photographs of northwest Nebraska (Fig. 11). Linears were primarily derived from the Alliance 1:250,000-scale topographic map, but satellite images of the same scale were also utilized. 1:20,000 scale aerial photographs and 7.5-minute topographic maps reveal additional but shorter linear features, most of which are not included on Figure 11.

A few of the linears are known to represent faults, some of them coincide with inferred faults, and others probably represent joints or fractures. Many of the linears reflect drainage alignments while some indicate other linear topographic features such as ridges. Although Figure 11 presents a complicated picture, some patterns can be elicited. Many linears are nearly parallel to the Pine Ridge or the Niobrara River, which roughly parallel each other. Some linears run parallel, or nearly so, to parts of the axis of the Chadron Arch. Other linears are oriented at nearly right angles to the prominent topographic or structural features of the study area. Still other linears are aligned with the prevailing wind direction. While numerous interpretations can be made from Figure 11, most would be speculative. The principal reason the map is included in this report is to indicate the possible complexity of the structural geology of the area.

Geologic structures, especially faults, can influence groundwater conditions. If a formation that can serve as an aquifer is faulted, then wells may need to be deeper on the downthrown side of the fault. In some cases, the

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* An unconformity in which the beds above the unconformity transgress the edges of folded and tilted beds.

formation may be saturated on the downthrown side and unsaturated on the upthrown side. Faults or dipping beds can influence the direction and rate of groundwater movement either by creating groundwater dams or by serving as conduits. Faults, joints, and fractures in an otherwise relatively impermeable mass of rock can make the rock permeable enough to be considered an aquifer.

Drilling fluid losses encountered during test drilling are indicative of fractured, jointed, and possible faulted rocks. The basic drilling mud was a thick slurry of bentonite, lime, and water. Of 46 holes drilled in or near the study area, drilling-fluid losses were slightly above normal in 5 holes, moderately above normal in 4 holes, and greatly above normal in 7 holes. Drilling-fluid losses greatly above normal were severe enough to produce a complete disruption in the drilling fluid circulation. One test-hole site (T.H. 30N-42W-1bcc) had to be moved because of circulation loss encountered at shallow depths in the Ogallala Group. Drilling-fluid losses in White River rocks terminated the drilling of 5 holes which were near their targeted depths. Another test hole (T.H. 31N-45W-19bbc), which had complete loss of circulation in Arikaree rocks, was finally aborted before reaching the targeted depth because a sufficient supply of water for drilling could not be maintained. Test holes with moderate drilling-fluid losses were completed by adding large amounts of bentonite (up to 1000 pounds); lime, organic polymers, and sugar-beet pulp; and very small amounts of borax. Seven (7) of the 16 holes in which drilling-fluid losses occurred were located within 3 miles of the Niobrara River and half of the holes drilled within this distance of the river had circulation problems.

This study indicates that the structural geology of southern Dawes and northern Sheridan counties is more complicated than was previously suspected. Faults and tilted beds can influence the availability of water and other resources, so additional studies of the structural geology of the area could be worthwhile.

CONFIGURATION OF THE WATER TABLE

In general, the shape of the water table is a subdued reflection of topography. The landscape of the study area is dominated by a prominent ridge that separates two drainage basins with different topographic characteristics. Similarly, the water table is dominated by a prominent groundwater divide which nearly coincides with the topographic ridge and which separates two distinctly different gradients of the water table. In northeastern Sheridan County, where the crest of the Pine Ridge becomes indistinct, the groundwater divide also becomes less prominent and trends east-southeast.

Similarities in the topography and the water table occur because both surfaces are fundamentally products of the geologic history and climatic conditions of the area. The slope of the water table is determined by topography, transmissivity, stratigraphy, and geologic structures, and local variations in the quantity of recharge and discharge.

Several sources of information were utilized to map the water table. The depth to water was obtained from 36 test holes as described in the introduction. Co-operative, water-level-measuring programs of the Division with the Upper Niobrara-White Natural Resources District and the U.S. Geological Survey provided data at 46 sites. The altitudes of springs and perennial lakes and streams, all of which are fed by groundwater, were determined from 7.5-minute and 15-minute topographic maps. Depths to water reported on irrigation-well registrations were considered. The water-table map of northwest Nebraska (Souders and Freethey, 1975) was used for regional information.

Most of the water-level measurements were made south and east of the crest of the Pine Ridge in the area where test holes were drilled (Fig. 12). A large number of observation wells are located in the Mirage Flats Irrigation District in west-central Sheridan County. Topographic maps furnished most of the control for the area north of the crest of the ridge.

The water table north of the grounwater divide in Dawes County slopes steeply to the north-northwest. Water-table gradients along the Pine Ridge escarpment are generally greater than 50 feet per mile and may exceed 150 feet per mile. North of the escarpment the landscape and water table flatten northward to the White River and the water-table gradient is generally less than 50 feet per mile.

The configuration of the water table in northwest Sheridan County is complicated because topographic spurs extend north from the crest of the Pine Ridge and the ridge itself gradually terminates in north-central Sheridan County. Water-table gradients slope away from the ridge and spurs toward all points of the compass (Fig. 12). Gradients are generally greater than 50 feet per mile to the west, northwest, north, and northeast.

Water-table gradients are generally steep north of the crest of the Pine Ridge because there is a large amount of topographic relief, the saturated formations range from nearly impermeable, to only moderately permeable and the strata dip gently to the southeast. Saturated Tertiary formations at the crest of the ridge are the Upper Harrison, Monroe Creek-Harrison, Gering, Beaver Wall, Brule, and Chadron. None of these are highly transmissive. The water table forms a mound along the crest because the source of recharge is local precipitation which, once it reaches the water table, cannot rapidly percolate away to points of groundwater discharge.

In southern Dawes County, the water table slopes southeast from the Pine Ridge to the Niobrara River at gradients ranging from less than 25 to about 75 feet per mile. The steeper gradients occur in the southwest part of the county where saturated, permeable Ogallala rocks are absent and the slope of the land is greater. The Ogallala Group, comprised of the most permeable rocks of the study area, occurs in south-central and southeast Dawes County where the water-table gradient and the slope of the land are less.

South of the crest of the Pine Ridge at the Dawes-Sheridan line, and extending for several miles east and west of that point, is an area where the water table slopes due east at rates ranging from less than 10 to nearly 50 feet per mile. The eastward slope and different gradients are probably due to topographic and geologic variations. The surface drainage, which south of the Pine Ridge is normally oriented to the southeast, is to the east in this particular area, and the edge of the Ogallala Group crosses the locality. Faulting may play a role in the configuration of the water table in this area either directly, by slowing or speeding the percolation of groundwater, or indirectly, by being one of the causes for the peculiar topographic and geologic features. Except for this area of eastward slope, the water table generally slopes to the southeast between the groundwater divide and the Niobrara River in northern Sheridan County. North of the groundwater divide in northeast Sheridan County, the water-table gradient is to the north and northeast.

The prominent groundwater ridge, or divide, includes isolated high mounds which indicate the principal source of groundwater recharge in the study area is local precipitation. Canal losses and deep percolation from irrigation in the Mirage Flats Irrigation District also provide some groundwater recharge in that area (Pederson and Johnson, 1979, p. 100-101, and Gottula, 1980). Groundwater moves slowly, probably only a few feet per day, down the slope of the water table to points of discharge. Discharge north of the Pine Ridge is principally to streams along the escarpment, to vegetation in the stream valleys, and possibly to the White River. South of the Pine Ridge, groundwater is discharged to shallow streams, vegetation along streams and in lowlands, a few ponds and small lakes, wells, and the Niobrara River. The deep depression made in the water table by the river indicates the Niobrara is a principal area of groundwater discharge. The water-table configuration also indicates large amounts of groundwater may be discharged by evaporation and transpiration from the depressions and broad, shallow valleys south of Hay Springs.

The contour interval of the water-table map (Fig. 12) is 50 feet. Water-table rises due to surface-water irrigation on Mirage Flats and water-table lowerings due to pumping groundwater for irrigation and municipal uses are not apparent using this contour interval, thereby implying such rises or lowerings of the water table are local and of small-magnitude. The map can be considered a base, or bench-mark, from which large-scale changes can be determined in the future if such changes should occur. Smaller and more localized changes would have to be investigated in more detail than was done in this study.

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LOGS OF TEST HOLES

The rock descriptions and the identification of stratigraphic units were based on field and laboratory observations and electric log characteristics. Colors were determined by comparing a wet sample with the Munsell soil color chart. The term lithic clast used in the rock descriptions refers to sand and gravel particles composed of sedimentary rocks, primarily siltstone, claystone, or lime-cemented sandstone.

Test hole 28N-48W-1aba
(Field No. UNW 22-76)

Location: About 1,870 ft. west and 6.9 ft. south of northeast corner, sec. 1, T. 28 N., R. 48 W.
Ground altitude: 3,926 ft. (Box Butte NE 7.5-minute quadrangle)
Depth to water: 83.1 ft. (April 2, 1976)

	Depth, in feet From	To
Quaternary:		
Sand, very fine to medium, very silty	0	3
Ogallala:		
Sandstone, very fine to medium, in part very fine to coarse with a little fine gravel, slightly silty, pale yellow, some pale olive, in part very to slightly calcareous; some rootlet casts	3	75
Upper Harrison:		
Siltstone, sandy, clayey, yellow-brown; some calcareous nodules and zones	75	110
Silt to siltstone, sandy, clayey, yellow-brown; some medium sand; some calcareous zones, some lime-cemented sandstone; pale brown below 120 ft	110	130
Sandstone, very fine to fine, silty, dark yellow-brown; some calcareous nodules and zones	130	140
Siltstone, very sandy, dark yellow-brown; some medium sand; some calcareous nodules and zones	140	170
Beaver wall siltstone:		
Silt to siltstone, sandy, clayey, yellow-brown; some calcareous nodules and zones, some silty sandstone	170	200

Test hole 28N-49W-6aaa
(Field No. UNW 7-75)

Location: 62 ft. south and 70 ft. west of northeast corner, sec. 6, T. 28 N., R. 49 W.
Ground altitude: 4,046 ft. (Box Butte Reservoir East 7.5-minute quadrangle)
Depth to water: 80.9 ft. (November 1, 1975)

	Depth, in feet From	To
Quaternary:		
Sand, very fine to medium, trace of coarse sand to fine gravel, very silty	0	3
Sand, very fine to coarse, trace of very coarse sand to fine gravel	3	10
Silt, moderately sandy, slightly clayey, dark brown, slightly calcareous; little medium sand	10	20
Ogallala:		
Sand, gravelly; very fine sand to very coarse gravel	20	30
Limestone, sandy; light brown, silty; sand is very fine	30	33
Siltstone, slightly clayey, slightly sandy, brown to yellowish brown; few calcareous and siliceous fragments	33	48
Beaver Wall siltstone:		
Limestone, sandy, light gray	48	58
Silt, moderately sandy, slightly clayey, brown to yellow-brown, moderately calcareous; some calcareous nodules; some silty sandstone, brown below 80 ft	58	100
Sandstone, very fine, yellowish brown; some calcareous material	100	108
Silt, slightly clayey, slightly sandy, yellow-brown, in part moderately calcareous	108	117
Silt to siltstone, slightly clayey, slightly sandy, brown, in part very calcareous; some calcareous material; some sandstone lenses from 206 to 214 ft	117	220

Test Hole 28N-51W-19aaa
(Field No. UNW 10-75)

Location: 146 ft. south and 256 ft. west of northeast corner of sect. 19, T. 28 N., R. 51 W.
Ground altitude: 4,300 ft. (Marsland 15-minute quadrangle)
Depth to water: 119.7 ft. (November 13, 1975)

	Depth, in feet From	To
Quaternary:		
Sand, very fine to fine, some medium, a trace of coarse sand to fine gravel	0	10

	Depth, in feet From	To
Ogallala:		
Sand, very fine to medium, a trace of coarse to very coarse, rare fine gravel, in part some sandstone, rare root casts; slightly finer grained below 30 ft..........	10	47
Monroe Creek-Harrison:		
Sandstone, very fine, some fine, calcareous, light gray...	47	58
Beaver Wall siltstone:		
Silt to siltstone, very sandy, slightly clayey, pale brown to light yellowish brown; some calcareous zones..	58	90
Silt to siltstone; very sandy, moderately calcareous, light brown; moderately sandy below 140 ft..............	90	170
Silt to siltstone, slightly clayey, slightly sandy, slightly to moderately calcareous, yellowish brown......	170	280
Nonpareil ash zone:		
Volcanic ash, light gray..................................	280	300
Whitney:		
Silt to siltstone; moderately clayey, slightly sandy, brown with some yellowish brown; some calcareous material..	300	320

Test hole 29N-45W-6bbb
(Field No. 5-B-79)

Location: 181 ft. south and 17 ft. east of northwest corner of sec. 6, T. 29 N., R. 45 W.
Ground altitude: 3,757 ft. (Hay Springs SW 7.5-minute quadrangle)
Depth to water: 12.4 ft. (May 29, 1979)

	Depth, in feet From	To
Quaternary:		
Soil..	0	2
Silt, sandy, clayey, dark gray and gray-brown............	2	6
Silt, very sandy, gravelly, pale brown..................	6	10
Ogallala:		
Sandstone, silty, gray and light yellow-brown; sand is mostly fine to medium with some very fine; some lithic gravel below 23 ft.; contains some interbedded silt....	10	26
Silt, sandy, clayey in parts, pale olive and light yellow-brown; sand is mostly very fine to fine with some medium..	26	35
Sandstone and sand, very fine to fine with a trace of medium, mostly light yellow-brown; silty in parts......	35	56
Silt, very sandy, pale olive, with some very silty sand; sand is very fine to medium...........................	56	68

Test hole 29N-45W-6bbb - continued

	Depth, in feet From	To
Sand, medium to coarse; some very fine to fine and very coarse sand and trace of fine gravel; more gravel and coarser below 80 ft.; contains some thin silt seams.....	68	85
Silt, sandy, mostly brown; sand is very fine to medium with some coarse; sand bed from 90-94 ft., mostly medium sand......................................	85	100
Sand and sandstone, fine to coarse, some very coarse sand and fine gravel; very silty with some silt from 113-120 ft.; more very coarse sand and fine gravel below 120 ft.	100	135
Sandstone, silty, lime-cemented, white; sand is mostly fine to medium......................................	135	138
Sand, fine to very coarse with some fine gravel...........	138	140
Sand and sandstone with interbedded silt, mostly pale brown; sand is mostly fine to medium with some coarse sand to fine gravel in parts; limy zones common.........	140	179
Silt and siltstone with interbedded sand and sandstone, mostly pale brown; sand is mostly very fine to medium...	179	190
Sandstone, fine to medium, some very fine, coarse and very coarse sand with trace of fine gravel; silty in upper part..	190	205
Sandstone and sand, slightly gravelly, mostly medium sand to fine gravel..................................	205	215
Sandstone, mostly fine to medium with some coarse sand to fine gravel; contains some interbedded silt............	215	221
Upper Harrison:		
Silt and siltstone, very sandy, light brown; sand is very fine to fine with trace of medium; contains limy zones..	221	236
Limestone, silty, sandy, white; silt, very sandy, brown; siltstone, sandy, lime-cemented, very pale brown........	236	241
Siltstone, sandy, slightly clayey, mostly brown; sand is very fine to fine; limy zones abundant..............	241	270
Siltstone, moderately to very sandy, mostly brown; sand is very fine to fine with trace of medium below 304 ft.; limy zones abundant..............................	270	310
Sand and sandstone, silty, pale brown; sand is mostly very fine to fine with some coarser grains; lithic clasts common..	310	317
Siltstone, very sandy, brown; sand is very fine to fine; contains limy zones below 327 ft......................	317	332
Sandstone, very silty, lime-cemented, very pale brown; sand is very fine to fine with some medium.............	332	334
Limestone, sandy, silty, white to very pale brown.........	334	338
Sandstone, slightly silty, light brown; sand is very fine to fine with trace of medium to coarse.................	338	340
Monroe Creek-Harrison:		
moderately silty, brown and yellow-brown; sand is very fine to fine; limy zones abundant..........	340	368

Test hole 29N-45W-6bbb - continued

	Depth, in feet From	To
Siltstone, very sandy, mostly yellow-brown; sand is very fine to fine; limy zones common....................	368	420
Beaver Wall siltstone: (approximate contact)		
Siltstone and silt, moderately sandy, yellow-brown; very sandy in parts; sand is very fine to fine; contains some limy zones; less sandy below 580 ft.; slightly clayey in parts below 600 ft...........................	420	686
Siltstone and silt, sandy, yellow-brown; sand is mostly fine; lithic clasts abundant...........................	686	690
Siltstone, very sandy, grading to sand, very silty; sand is very fine to fine with trace of medium to coarse.....	690	693
Silt and siltstone, sandy, slightly clayey, yellow-brown; sand is very fine to fine..............................	693	740
Nonpareil ash zone?:		
Silt and siltstone, sandy, very pale brown; probably very ashy; contains a few lithic clasts......................	740	754
Whitney:		
Silt and siltstone, sandy, slightly clayey, yellow-brown..	754	770

Test hole 29N-46W-24abb
(Field No. 6-B-79)

Location: Estimated 5-20 ft. south and about 2,400 ft. west of northeast corner of sec. 24, T. 29 N., R. 46 W.
Ground altitude: 3,775 ft. (Skunk Lake 15-minute quadrangle)
Depth to water: 50.1 ft. (June 11, 1979)

	Depth, in feet From	To
Quaternary:		
Soil...	0	3
Silt, clayey, sandy....................................	3	4
Gravel, sandy, silty, fine sand to medium gravel, lithic clasts...	4	10
Ogallala:		
Silt, very sandy, and sand, very silty, pale brown and pale olive; sand is very fine to fine with a trace of medium; trace of coarse to very coarse sand below 22 ft..	10	28
Sandstone, slightly silty, pale brown and pale olive; sand is very fine to fine with a trace of medium; trace of coarse to very coarse sand from 60-75 ft.; contains some thin silt beds in parts..........................	28	82
Silt, very sandy, slightly clayey, pale olive to pale yellow; less clayey below 85 ft.......................	82	90

Test hole 29N-46W-24abb - continued

	Depth, in feet From	To
Sand and sandstone, slightly silty, pale brown; sand is very fine to fine with a trace of medium; trace coarse sand from 95-100 ft.; some coarse to very coarse sand and trace of fine gravel from 100-105 ft..........	90	113
Silt, clayey, sandy, pale yellow.........................	113	114
Sand and sandstone, medium to very coarse, some fine sand and trace of fine gravel..............................	114	122
Silt, sandy, slightly clayey, olive; sand is very fine to medium with trace of coarse; some interbedded medium sand to fine gravel below 125 ft......................	122	130
Sand and sandstone, medium to coarse, with some very coarse sand to fine gravel, coarser from 135-140 ft.; contains a few silt beds less than 1-foot thick.........	130	145
Silt, sandy, slightly clayey, olive; sand is very fine to medium...	145	147
Sandstone, silty; sand is fine to medium.................	147	150
Sandstone, fine to coarse, some very coarse sand to fine gravel...	150	155
Sand, slightly gravelly, medium sand to medium gravel.....	155	160
Interbedded sand and silt; sand is fine to very coarse and silt is clayey and sandy, mostly olive.............	160	165
Silt, sandy, slightly clayey, olive to pale brown; sand is fine to coarse with some coarser grains.............	165	175
Sand and sandstone, silty, with some interbedded silt seams; sand is very fine to very coarse with trace of gravel...	175	180
Sand, slightly gravelly, medium sand to medium gravel, some fine sand; contains two thin silt seams...........	180	190
Sand, gravelly, medium sand to medium gravel, much very coarse sand to fine gravel.......................	190	196
Silt, sandy, olive to pale brown, with some sand seams; sand is very fine to very coarse......................	196	205
Sandstone, very fine to medium with trace of coarse.......	205	212
Silt, sandy, slightly clayey, olive to pale brown.........	212	215
Sand and sandstone, fine to coarse, some very fine and very coarse sand and fine gravel......................	215	223
Sand and sandstone, very silty, light brown; sand is very fine to medium with some coarse; less silty in lower part...	223	230
Sandstone, medium to very coarse, some fine sand and trace of fine gravel.................................	230	245
Siltstone, sandy, with some interbedded sandstone, light brown; sand is very fine to medium with trace of coarse...	245	260
Sand and sandstone, very fine to medium with trace of coarse...	260	265
Siltstone, sandy and sandstone, silty, light brown; sand mostly very fine to medium with some coarser grains.....	265	275

	Depth, in feet From	To
Sand and sandstone, medium to very coarse, some very fine and fine sand and fine to medium gravel; more gravel 275-280 ft.	275	285
Silt, sand, and sandstone; sand mostly fine to coarse	285	290
Sandstone, fine to very coarse, trace gravel	290	305
Gravel, sandy, medium sand to medium gravel	305	310
Sandstone, gravelly, medium sand to medium gravel, lithic clasts abundant	310	315
Gravel, sandy, medium sand to medium gravel, trace lithic clasts below 320 ft.; some interbedded silt below 335 ft.	315	340
Sand, gravelly, fine sand to fine gravel, trace of medium gravel, with silt layer from about 346-349 ft.; coarser below 350 ft.	340	353
Monroe Creek-Harrison:		
Siltstone, very sandy, which grades to sandstone, very silty in many parts, light brown and light yellow-brown; sand is very fine to fine, limy zones abundant	353	460
Beaver Wall siltstone:		
Silt and siltstone, moderately to very sandy, slightly clayey, mostly yellow-brown; sand is very fine to fine	460	520

Test hole 29N-46W-34dd
(Field No. 7-B-79)

Location: 8 ft. north and 561 ft. west of southeast corner of sec. 34, T. 29 N., R. 46 W.
Ground altitude: 3,785 ft. (Skunk Lake 15-minute quadrangle)
Depth to water: 34.4 ft. (June 11, 1979)

	Depth, in feet From	To
Road fill	0	6
Ogallala:		
Sandstone, silty and siltstone, sandy, light gray and pale brown; sand is mostly very fine to medium with some coarser grains; limy zones abundant	6	60
Sandstone, mostly fine to coarse, some very fine; finer grained below 70 ft.; silty near base	60	80
Silt, sandy, and sandstone, silty, mostly olive; sand is very fine to medium with trace of coarse; more coarse sand and trace of very coarse sand below 95 ft.	80	100
Sandstone and sand, fine to coarse, some very coarse sand and trace of gravel	100	119
Silt, sandy, olive	119	122
Sandstone, fine to coarse, some very coarse sand and fine gravel; trace of medium gravel below 135 ft.; slightly coarser overall below 140 ft.	122	145

	Depth, in feet From	To
Sand and sandstone, gravelly; fine sand to medium gravel with a trace of coarse gravel in parts; some interbedded silt from 180-210 ft.	145	220
Silt, sandy, slightly clayey, pale yellow; sand is very fine to fine.	220	224
Sand, fine to very coarse with some very fine sand and trace of fine gravel; contains sandy, clayey silt bed 2-ft. thick between 235-240 ft.	224	240
Upper Harrison:		
Siltstone and silt, slightly sandy, slightly clayey, mostly yellow-brown; sand is very fine to fine; grades to very sandy at base; limy zones common, more abundant at base.	240	300
Monroe Creek-Harrison: (approximate contact)		
Siltstone and silt, very sandy, slightly clayey, yellow-brown; sand is very fine to fine.	300	350
Siltstone, very sandy, grading down to sand, very silty, pale brown to gray-brown; sand is very fine to fine with trace of medium; limy in upper part. (This interval is an alternative choice for the basal part of the Upper Harrison).	350	369
Siltstone and silt, very sandy, grading to very silty sandstone in parts, yellow-brown, pale brown, and brown; sand is very fine to fine with trace of medium in parts; limy zones abundant.	369	421
Beaver Wall siltstone: (approximate contact)		
Siltstone and silt, very sandy, mostly brown; sand is very fine to fine; limy zones in upper part.	421	462
Siltstone and silt, moderately to very sandy, slightly clayey, brown and yellow-brown; sand is very fine to fine; few limy zones.	462	524
Volcanic ash, impure, gray to brown-gray.	524	528
Siltstone and silt, moderately sandy, slightly clayey, light brown; sand is very fine to fine; few limy zones.	528	603
Volcanic ash, impure, gray.	603	605
Siltstone, slightly to moderately sandy, slightly clayey, light brown to brown; sand is very fine to fine.	605	640

Test hole 29N-47W-4bcb
(Field No. 11-B-78)

Location: About 1,640 ft. south and 55 ft. east of northwest corner of sec. 4, T. 29 N., R. 47 W.
Ground altitude: 3,929 ft. (Chadron 3 SE 7.5-minute quadrangle)
Depth to water: Unable to measure. Test hole caved at 48.3 ft. (October 17, 1978), which is about the depth to water indicated on the electric log.

	Depth, in feet From	To
Quaternary:		
Soil	0	3
Silt, sandy, brown and gray-brown; sand is very fine to very coarse with some fine gravel; contains lithic clasts	3	15
Silt, slightly sandy, dark brown; sand is very fine	15	17
Gravel and sand, silty, brown; very fine sand to very coarse gravel	17	20
Ogallala:		
Sand, fine to medium with some very fine and coarse to very coarse sand and fine gravel	20	45
Sand, very fine to medium with some coarse; some very coarse sand and trace of fine to medium gravel from 60-70 ft., 75-80 ft., and 85-97 ft.; silt beds or silty zones from 50-52 ft., 65-66 ft., 70-71 ft., and 82-84 ft.	45	96
Silt, sandy, gray	96	100
Sand, very fine to medium, trace of coarse	100	105
Sand, fine to medium with some very fine and very coarse sand; silt bed from 110-112 ft	105	115
Sand, fine to very coarse with trace of fine to medium gravel	115	125
Sand, gravelly, fine sand to fine gravel; much very coarse sand to fine gravel	125	130
Sand, fine to medium with some very fine, coarse and very coarse sand, trace of fine gravel; silty in lower part	130	140
Sand, very fine to medium, trace of coarse and very coarse	140	145
Sand, fine to medium, some very fine, coarse and very coarse	145	155
Sand, fine to coarse, some very fine sand and trace of fine gravel	155	160
Sand, sandstone, and gravel, fine sand to fine gravel with much very coarse sand to fine gravel	160	170
Sand, very fine to medium with some coarse sand to fine gravel	170	175
Sand, medium to very coarse with some very fine to fine sand and fine gravel	175	180
Sand, medium to coarse with some very fine, fine, and very coarse sand, trace of fine gravel	180	190
Sand and gravel, fine sand to medium gravel; much coarse sand to fine gravel	190	198
Monroe Creek-Harrison:		
Sandstone, very silty, mostly brown; sand is very fine; grades to very sandy silt in parts; contains some thin limy zones	198	251

Test hole 29N-47W-4bcb - continued

	Depth, in feet From	To
Beaver Wall siltstone: (approximate contact)		
Silt, sandy, brown; sand is mostly very fine; grades to very sandy silt in parts and is slightly clayey in parts; contains some limy zones	251	520
Sand, very silty, brown; sand is very fine to fine except below 550 where there is also some medium to coarse; lithic clasts common to abundant	520	560
Silt, very sandy, light brown	560	570
Sand, very silty, light brown and brown; sand is very fine to fine with some medium to very coarse; lithic clasts common to abundant	570	610
Silt, slightly sandy, slightly clayey, brown	610	635
Nonpareil ash zone:		
Volcanic ash, impure, brownish gray to gray	635	643
Silt, very slightly sandy, possibly very ashy, grayish brown to brown	643	650
Whitney:		
Silt, moderately clayey, mostly brown	650	680

Test hole 29N-47W-18daa
(Field No. 10-B-78)

Location: About 2,395 ft. north and 36 ft. west of southeast corner of sec. 18, T. 29 N., R. 47 W.
Ground altitude: 3,908 ft. (Box Butte NE 7.5-minute quadrangle)
Depth to water: Unable to measure. Estimated to be about 50 ft. from electric log (September 20, 1978).

	Depth, in feet From	To
Quaternary:		
Soil	0	3.5
Sand, very silty, dark brown; sand is very fine to fine	3.5	5.5
Sand, fine to medium with some coarse sand to coarse gravel	5.5	8.0
Ogallala:		
Silt and siltstone, sandy, pale yellow; sand is very fine to medium	8.0	14
Silt, very sandy, mostly pale olive and brown, with interbedded silty sand; sand is mostly very fine to medium but has some coarse in parts and contains a gravelly zone somewhere between 30 and 35 ft	14	75
Sand and sandstone, very fine to medium with some coarse to very coarse, yellow-brown	75	95
Sand and sandstone, very fine to fine, brown	95	112
Silt, slightly sandy, pale olive and light yellow-brown, with a few interbedded silty sand zones. Sand is very fine	112	128

	Depth, in feet From	To
Sandstone, gravelly, silty, pale olive; very fine sand to fine gravel; bed is lime-cemented..................	128	130
Sand, very fine to fine with some medium, pale olive and light yellow-brown; sandy silt zones from 131-132 ft., 135-137 ft., 146-147 ft.; contains some limy zones in lower part..	130	154
Monroe Creek-Harrison:		
Sandstone, silty, brown; sand is very fine to fine; contains some thin limy zones..........................	154	176
Silt, very sandy, brown and yellow-brown; grades to very silty sand in parts; sand is very fine to fine; contains a few, thin limy zones.......................	176	196
Beaver Wall siltstone:		
Silt, very sandy, yellow-brown; sand is very fine with some fine; less sandy and slightly clayey in parts below 370 ft..	196	504
Silt, very sandy, yellow-brown, probably grades to silty sand in parts; sand is very fine to fine; interval contains lithic clasts................................	504	516
Silt, sandy, yellow-brown; sand is very fine............	516	524
Sand, very silty, and silt, very sandy, yellow-brown and brown; sand is very fine; contains lithic clasts.......	524	560

(Note: aborted hole at 560 ft. because of drilling problems.)

Test hole 29N-49W-21aad
(Field No. 9-B-78)

Location: About 740 ft. south and 10 ft. west of northeast corner of sec. 21, T. 29 N., R. 49 W.
Ground altitude: About 4,180 ft. (Box Butte Reservoir East 7.5-minute quadrangle)
Depth to water: 159.9 ft. (September 18, 1978)

	Depth, in feet From	To
Ogallala:		
Sandstone, very fine to coarse, olive-brown, yellow-brown and pale olive, with some very silty and lime-cemented zones...	0	30
Siltstone, sandy, pale yellow; sand is fine to coarse....	30	40
Sand, very fine to very coarse with a trace of fine gravel..	40	65
Sand, slightly gravelly; fine sand to fine gravel with a trace of medium gravel; less gravel below 85 ft.; contains a silt bed from 89-90 ft.......................	65	94
Silt, moderately sandy, very pale brown and light yellow-brown; sand is very fine to fine...............	94	110

Test hole 29N-49W-21aad - continued

	Depth, in feet From	To
Sand, very fine to medium, pale brown, with some silty sand zones; slightly gravelly from 110-112 ft..........	110	121
Silt, slightly sandy, slightly clayey, pale yellow.......	121	124
Sand, very fine to medium; more medium and some coarse at top...	124	130
Sand and sandstone, very fine to coarse with some very coarse sand and gravel................................	130	135
Gravel and sand, very fine sand to medium gravel.........	135	141
Silt, sandy, pale olive..................................	141	144
Sand, gravelly, fine sand to medium gravel...............	144	149
Silt, sandy, pale brown..................................	149	151
Sand, very fine to medium, some coarse...................	151	157
Sand, silty, pale brown and yellow-brown; sand is mostly very fine to fine; limy zones abundant.................	157	178
Sand, mostly very fine to medium; some coarse sand to fine gravel from 185-190 ft...........................	178	195
Sand and gravel, very fine sand to fine gravel...........	195	200
Sand, very fine to fine with some medium; sandy silt beds from 212-213 ft. and 217-219 ft..................	200	220
Sand, slightly gravelly, very fine sand to fine gravel...	220	230
Sand and gravel, very fine sand to medium gravel.........	230	240
Sand, very fine to medium; contains some coarse sand to fine gravel in upper part; silt lenses from 240-242 ft. and 248-250 ft...	240	250
Sand, very fine to fine with some medium and trace of coarse..	250	260
Sand and gravel, fine sand to medium gravel..............	260	265
Silt, sandy, clayey, pale brown; sand is very fine to fine..	265	275
Gravel, sandy; medium sand to coarse gravel; lithic clasts common..	275	286
Beaver Wall siltstone:		
Silt, slightly clayey, mostly pink.......................	286	294
Silt, probably sandy, mostly light yellow-brown..........	294	315
Sand, very silty, light gray to brown; sand is very fine..	315	320
Silt, slightly to very sandy, slightly clayey in parts, mostly light yellow-brown; sand is very fine; grades to very silty sand in parts..........................	320	406
Nonpareil ash zone:		
Volcanic ash, impure, light gray.........................	406	414
Silt, slightly sandy, slightly clayey, probably very ashy, pale to very pale brown.........................	414	425
Whitney:		
Silt, light yellow-brown.................................	425	450

Test hole 29N-51W-24bba
(Field No. 1-B-78)

Location: 35 ft. south and 883 ft. west of northwest corner of sec. 24, T. 29 N., R. 51 W.
Ground altitude: 4,175 ft. (Marsland 15-minute quadrangle)
Depth to water: 93.1 ft. (August 14, 1978)

	Depth, in feet	
	From	To
Quaternary:		
No sample	0	4
Silt, moderately sandy, slightly clayey, yellow-brown	4	9
Gravel, slightly sandy, fine sand to coarse gravel; gravel mostly composed of lithic fragments	9	30
Sandstone, slightly gravelly, fine sand to fine gravel	30	36
Beaver Wall siltstone:		
Silt, very sandy, yellow-brown, some calcareous zones; sand is very fine	36	45
Sand, very silty, yellow-brown; some limy nodules; sand is very fine	45	52
Silt, moderately sandy, yellow-brown; contains a few limy nodule zones; sand is very fine; very slightly to slightly clayey below 75 ft	52	95
Silt, slighty sandy, slightly clayey, yellow-brown; lost circulation at 126 ft.; less sandy and more clayey below 150 ft	95	185
Nonpareil ash zone:		
Volcanic ash, gray	185	204
Silt, slightly clayey, some ash intermixed, mostly yellow-brown	204	218
Whitney:		
Silt, slightly sandy, slightly clayey, yellow-brown to brown; few limy nodules; moderately clayey below 300 ft	218	330
Silt, moderately clayey, brown	330	378
Volcanic ash, silty, clayey, gray-brown (Upper Whitney Ash)	378	382
Silt, moderately clayey, brown to gray-brown; slightly sandy in upper part	382	470
Volcanic ash, silty, clayey, light brownish gray (Lower Whitney Ash)	470	475
Silt, moderately clayey, gray-brown	475	500

Test hole 29N-51W-33cad
(Field No. UNW 9-75)

Location: 2,460 ft. east and 1,430 ft. north of southwest corner of sec. 33, T. 29 N., R. 51 W.
Ground altitude: 4,150 ft. (Marsland 15-minute quadrangle)
Depth to water: 37.9 ft. (November 13, 1975)

Test hole 29N-51W-33cad - continued

	Depth, in feet From	To
Quaternary:		
Silt, very sandy, slightly clayey, moderately calcareous, pale brown	0	1
Gravel, sandy, fine sand to coarse gravel; gravel is composed principally of lithic material	1	36
Beaver Wall siltstone:		
Silt to siltstone, very sandy, brown; in part moderately to slightly sandy; in part very calcareous with some calcareous nodules	36	140
Sandstone, very fine to fine, slightly silty, slightly calcareous, brown	140	147
Silt to siltstone, slightly clayey, slightly sandy, brown; in part slightly to moderately calcareous	147	220

Test hole 30N-42W-1bcc
(Field No. 24-B-79)

Location: About 2,270 ft. south and about 95 ft. east of northwest corner of sec. 1, T. 30 N., R. 42 W.
Ground altitude: 3,652 ft. (Rushville 4 SW 7.5-minute quadrangle)
Depth to water: Unable to measure

	Depth, in feet From	To
Soil and subsoil	0	6
Ogallala:		
Sandstone, silty, brown, pale yellow, and yellow-brown; sand is very fine to fine; contains root casts	6	30
Volcanic ash, light gray	30	36
Sandstone and sand, silty in parts, yellow-brown; sand is very fine to fine with some medium; severe mud loss at 51 ft., stem dropped from 51.0-51.3 ft. This was second hole at this site; first hole drilled about 1046 ft. north of this site and had complete and unrecoverable circulation loss at 42 ft	36	101
Silt, clayey, sandy, pale yellow	101	104
Sandstone and sand, very fine to fine, light browinsh-gray and pale brown	104	135
Sandstone and sand, silty, with interbedded sandy silt, olive; sand is very fine to medium	135	176
Sandstone and sand, fine to medium with some coarse sand to fine gravel, olive-brown; contains some interbedded silt and silty sand	176	225
Silt, sandy, light olive-brown	225	230
Sandstone and sand, fine to coarse, some very coarse sand to medium gravel	230	258
Silt, sandy, clayey in parts, pale yellow, pale brown, and light gray; contains some interbedded sandstone	258	273

	Depth, in feet From	To
Sandstone and sand, fine to medium grading downward to fine to coarse; contains some fine to medium gravel....	273	295
Sand and sandstone, very fine to medium, silty, grading downward to sandy silt, yellow-brown..................	295	300
Siltstone, sandy, grading downward to silty sandstone, pale brown; sand is very fine to medium................	300	310
Sandstone and sand, fine to medium with some coarser grains, pale brown......................................	310	324
Silt, sandy, light yellow-brown; sandier with depth; sand is very fine to medium with some coarser grains...	324	336
Sandstone and sand, fine to medium with some coarse sand to fine gravel...	336	347
Silt, sandy, clayey, gravelly, pale yellow..............	347	351
Sandstone and sand, fine to coarse with some very coarse sand to fine gravel.................................	351	366
Upper Harrison:		
Silt and siltstone, slightly sandy, slightly clayey, yellow-brown; sand is very fine to fine; small limy zones common; olive-gray from 444-450 ft...............	366	488
Siltstone and silt, moderately to very sandy, light yellow-brown with some light gray and olive-gray; sand is very fine to fine; limy zones abundant..............	488	517
Sandstone and sand, silty, light brown; sand is very fine to coarse with some very coarse sand; contains some gravel-size lithic clasts; limy in parts..........	517	532
Monroe Creek-Harrison:		
Siltstone and silt, very sandy, grading to very silty sandstone in parts, pale brown; sand is very fine to fine; limy zones abundant.............................	532	617
Beaver Wall siltstone:		
Silt and siltstone, moderately sandy, clayey in parts, yellow-brown..	617	669

Test hole 30N-44W-15dba
(Field No. 12-B-79)

Location: About 2,500 ft. north and about 1,900 ft. west of southeast corner of sec. 15, T. 30 N., R. 44 W.
Ground altitude: 3,752 ft. (Rushville SW 7.5-minute quadrangle)
Depth to water: Unable to measure. Caved at 129.9 (June 25, 1979). Electric log and depth of caving indicate a depth to water of about 130 ft.

	Depth, in feet From	To
Quaternary:		
Soil..	0	1.5
Sand, silty, dark brown and light brown; sand is very fine to medium, much fine.............................	1.5	10

	Depth, in feet From	To
Sand, very fine to coarse, much fine to medium	10	16
Sand, very fine to medium, much fine; contains some thin silt beds	16	48
Sand and gravel, fine sand to coarse gravel; gravel mostly lithic clasts; samples more than 70 percent gravel in parts	48	80
Sand, very fine to very coarse with some fine to coarse gravel; more gravel from 90-95 ft.; lithic clasts common	80	105
Ogallala: (approximate contact)		
Sand, very fine to coarse, much medium; contains root casts	105	130
Sand and sandstone, very fine to very coarse; contains some lithic clasts	130	140
Sand and gravel, fine sand to medium gravel; gravel mostly lithic clasts	140	155
Gravel, sandy, fine sand to coarse gravel; gravel mostly lithic clasts. (Interval from 105-160 ft. also could be Quaternary.)	155	160
Sand and sandstone, silty in parts with some interbedded sandy silt, pale olive, light brownish-gray, and pale yellow; sand is very fine to very coarse with much medium	160	183
Sand and sandstone, very fine to coarse, much medium; silty in parts from 190-195 ft	183	200
Sand and sandstone, slightly gravelly; fine sand to fine gravel, much coarse sand; contains some silt seams	200	207
Sand and sandstone, silty, with some interbedded silt and non-silty sand; colors are pale olive, light yellow-brown, pale yellow, and light gray; sand is very fine to very coarse but is mostly fine to medium; thin limy zones common	207	231
Sand and sandstone, very fine to coarse, some very coarse and trace of fine gravel; silty in lower part	231	243
Interbedded silty sand, sandy silt, sand, and clayey silt, pale yellow; sand is mostly very fine to medium but some coarser grains occur; individual beds generally less than a foot thick	243	275
Silt, sandy, pale yellow; sand is very fine to fine with some coarser grains	275	280
Sand and sandstone, silty and clayey in parts, pale yellow; sand is mostly very fine to medium	280	290
Silt, clayey, sandy, pale yellow	290	295
Sandy silt grading downward to silty sand, light yellow-brown	295	300
Sand, silty in parts, light gray with brown; sand is very fine to fine with some medium; limy in parts with limy zone at base	300	309

	Depth, in feet From	To
Upper Harrison:		
Silt and siltstone, slightly clayey, light yellow brown; contains some limy zones................................	309	330
Silt and siltstone, sandy in part, mostly light brown; very sandy below 430 ft.; sand is mostly very fine; contains some limy zones................................	330	434
Sand, silty, brown; sand is very fine to medium; limy in parts..	434	439
Monroe Creek-Harrison: (approximate contact)		
Sandstone, very silty, brown and pale brown; sand is very fine to fine with some medium; limy zones numerous..	439	467
Silt and siltstone, sandy, light brown; sand is very fine; contains some limy zones........................	467	481
Beaver Wall siltstone: (approximate contact)		
Silt and siltstone, slightly sandy, light brown with pinkish brown below 540 ft.; sand is very fine; contains some limy zones................................	481	560

Test hole 30N-44W-35ccc
(Field No. 13-B-79)

Location: 115 ft. north and 28 ft. east of southwest corner of sec. 35, T. 30 N., R. 44 W.
Ground altitude: 3,802 ft. (Rushville SW 7.5-minute quadrangle)
Depth to water: Unable to measure. Test hole caved at 162 ft. (July 9, 1979)

	Depth, in feet From	To
Quaternary:		
Soil and subsoil..	0	4
Sand, very fine to fine................................	4	8
Ogallala:		
Sandstone and sand, very fine to fine, some medium below 14 ft., mostly light yellow-brown; more medium sand from 20-41 ft. and below 109 ft.; contains root casts and white siliceous zones; contains a few silty zones..	8	122
Interbedded silty sand, sand, silt, clayey silt, and clayey sand; colors are pale brown, pale yellow, and light gray; sand is mostly very fine to fine.......	122	141
Sand and sandstone, very fine to medium, trace of coarse below 180 ft.; silty in parts, especially so below 212 ft..	141	231
Sand, clayey, silty, light gray; sand is very fine to medium..	231	249
Sand and sandstone with interbedded silty sand and sandy silt, very pale brown; sand is very fine to medium.....	249	255

	Depth, in feet From	To
Sand and sandstone, very fine to medium; mostly pale brown; contains root casts and a few silt seams........	255	315
Sand and silty sand, mostly light gray; sand is very fine to medium..	315	325
Sand and sandstone, very fine to medium, light gray; contains some interbedded clayey and sandy silt........	325	345
Interbedded silty sand, sand, sandstone, and sandy silt, mostly pale yellow; sand is very fine to medium........	345	365
Sand, gravelly, very fine sand to medium gravel..........	365	377
Silt, sandy, light gray..................................	377	380
Sand, very fine to medium; some coarse sand to fine gravel below 395 ft..................................	380	410
Sand and gravel, very fine sand to medium gravel; much very fine to medium sand and fine gravel; contains some interbedded silt below 417 ft....................	410	420
Interbedded sand, sandstone, silty sand, and sandy silt, very pale brown; sand mostly very fine to fine.........	420	429
Silt and siltstone, sandy, limy in most parts, very pale brown and white.......................................	429	441
Sand and sandstone, silty, with sandy silt and siltstone, light gray and very pale brown; sand is very fine to fine with trace of medium in parts; limy zones common..	441	470
Sand, very fine to fine; silty at base..................	470	485
Upper Harrison:		
Silt and siltstone, very sandy, pale brown and light brown, limy zones common............................	485	505
Sand and sandstone, mostly very silty, light brown; sand is very fine to fine with trace of medium; contains some limy zones..	505	513
Sand and sandstone, very silty, light brown; sand is very fine to fine; some limy zones....................	513	540
Sandstone and sand, very silty, light brown; sand is very fine to fine with some medium and trace of coarse; some limy zones................................	540	548
Monroe Creek-Harrison:		
Sandstone and sand, very silty, grading to very sandy siltstone in parts, light gray, pale brown and brown, sand is very fine to fine with rare medium grains in parts; limy zones abundant..........................	548	650
Beaver Wall siltstone: (approximate contact)		
Silt and siltstone, slightly to very sandy, brown; sand is very fine to fine; few limy zones; less sandy below 680 ft..	650	720

Test hole 30N-46W-13ddd
(Field No. 16-B-78)

Location: 24 ft. north and 527 ft. west of southeast corner of sec. 13, T. 30 N., R. 46 W.
Ground altitude: 3,780 ft. (Hay Springs SW 7.5-minute quadrangle)
Depth to water: 28.2 ft. (October 26, 1978)

	Depth, in feet From	To
Quaternary		
Soil and subsoil	0	4
Silt, clayey, sandy, brown	4	17
Gravel, sandy, silty; gravel mostly composed of lithic clasts; sand is mostly very fine to medium	17	25
Ogallala:		
Sand, silty, very pale brown and pale yellow, with some interbedded silt; sand is very fine to medium	25	35
Sand and sandstone, fine to coarse, mostly pale brown; some very coarse sand and trace fine gravel below 40 ft.; some interbedded silt	35	47
Sand and sandstone, mostly very fine to medium, mostly pale brown, interbedded with silt, sandy, very pale brown; sand is mostly very fine to medium but contains a trace of coarse in parts; sand is silty in parts; about 50% sand beds throughout the interval with no bed more than 4-ft. thick	47	97
Sand and sandstone, very fine to medium, very pale brown; contains a few, thin, silt beds	97	108
Clayey silt and sandy silt, light gray, very pale brown, and light yellow-brown, with some interbedded sand; sand is mostly very fine to medium	108	120
Sand and sandstone, mostly very fine to medium, mostly very pale brown; contains some thin, sandy silt beds	120	133
Silt, sandy, light gray	133	136
Sand and sandstone, gravelly, very fine sand to medium gravel, trace of coarse gravel	136	143
Upper Harrison:		
Silt, sandy, slightly clayey in parts, mostly brown; sand is very fine to fine; limy zones common; large mud loss at 145 ft.	143	170
Silt, sandy, mostly light brown; grades to very silty sand near top and below 260 ft.; sand is mostly very fine; contains a few limy zones	170	270
Sand and sandstone, silty, brown; sand is very fine to fine; lime-cemented below 274 ft.	270	276
Monroe Creek-Harrison:		
Sand and sandstone, very silty, mostly brown; sand is mostly very fine with some fine; intermittent limy zones throughout	276	360

Test hole 30N-46W-13ddd - continued

	Depth, in feet From	To
Beaver Wall siltstone: (approximate contact)		
Silt and siltstone, very sandy, mostly brown; sand is very fine; less sandy below 560 ft.; contains some small limy zones	360	620
Silt and siltstone, mostly slightly sandy, mostly brown; more sandy from 660-680 ft.; few limy zones	620	729
Nonpareil ash zone:		
Volcanic ash, very impure, pinkish white	729	731
Silt, probably very ashy, light yellow-brown	731	740
Whitney:		
Silt and siltstone, light yellow-brown	740	775

Test hole 30N-47W-17ddd
(Field No. 12-B-78)

Location: 11.5 ft. north and 102 ft. west of southeast corner of sec. 17, T. 30 N., R. 47 W.
Ground altitude: 4,105 ft. (Chadron 3 SE 7.5-minute quadrangle)
Depth to water: 156.6 ft. (October 17, 1978)

	Depth, in feet From	To
Quaternary:		
Soil	0	2
Silt, very slightly clayey, yellow-brown and olive-brown	2	8
Ogallala:		
Silt, mostly slightly sandy, pale brown with some olive and pale yellow; sand is very fine; limy zones common	8	68
Silt, slightly to very sandy, light brown; sand is very fine with some fine; limy zones common	68	78
Sand, very silty, limy, white; sand is very fine to fine	78	80
Sand, very fine to medium, some coarse to very coarse, limy in part	80	82
Sand, very silty, grayish brown; sand is very fine to fine with some medium; some coarse sand below 85 ft.	82	90
Sand, very fine to medium with some coarse; limy silt bed from 98 to 99 ft.	90	103
Sand, very silty, and very sandy silt, brown; sand is mostly very fine to fine with some medium	103	110
Sand, fine to medium with some very fine, coarse and very coarse	110	116
Sand, very silty, brown; sand is very fine to fine with some medium	116	120
Sand, fine to coarse with some very fine and very coarse; mostly fine to medium below 125 ft.	120	130
Sand, silty; sand is very fine to medium, some coarse	130	136
Sand, fine to coarse, some very coarse	136	142

	Depth, in feet From	To
Sand, silty, pale yellow and olive; sand is very fine to fine	142	150
Sand, fine to very coarse with some fine gravel; much medium to coarse; silty below 155 ft	150	157
Silt, sandy, pale brown; sand is mostly very fine but contains coarser grains in parts	157	175
Sand, very fine to very coarse, some very coarse; sandy silt bed from 180-182 ft.; some fine gravel from 175-180 ft. and below 190 ft	175	200
Sand, gravelly, very fine sand to fine gravel; mostly medium to very coarse sand	200	205
Upper Harrison:		
Silt, mostly very sandy, brown; sand is mostly very fine but some fine and trace of medium occur in parts; numerous thin limy zones	205	285
Monroe Creek-Harrison: (approximate contact)		
Sandstone, very silty, brown and light brown; sand is very fine; limy zones abundant	285	330
Silt, mostly very sandy, light brown and brown; sand is very fine; limy zones abundant	330	370
Beaver Wall siltstone: (approximate contact)		
Silt, mostly very sandy, brown and yellow-brown; grades to very silty sandstone in a few parts; sand is very fine; slightly clayey in parts; limy zones common except below 550 ft	370	600

Test hole 30N-49W-3bbb
(Field No. 6-B-78)

Location: 102 ft. south and 9 ft. east of northwest corner of sec. 3, T. 30 N., R. 49 W.
Ground altitude: 4,334 ft. (Ft. Robinson 4 SE 7.5-minute quadrangle, advanced print)
Depth to water: 106.3 ft. (September 18, 1978)

	Depth, in feet From	To
Road fill	0	3
Ogallala:		
Sandstone, fine to very fine with a trace of medium, brown	3	8
Sandstone, slightly silty, yellow-brown and olive; sand is very fine to fine; much lime cement	8	17
Lime-cemented siltstone and silty limestone, sandy, yellow-brown to white	17	31
Upper Harrison:		
Silt and siltstone, slightly to very sandy in parts, clayey in parts, mostly brown; sand is very fine; some limy zones present	31	70

	Depth, in feet From	To
Silt, very sandy, very pale brown to yellow-brown; sand is very fine to fine; limy zones abundant..............	70	105
Silt, mostly moderately sandy, slightly clayey in parts, pale brown to yellow-brown; sand is mostly very fine; contains some limy zones............................	105	260
Sand, silty, limy, pale brown; sand is very fine with trace of fine; dark, heavy minerals abundant below 265 ft...	260	270
Monroe Creek-Harrison: (approximate contact)		
Sandstone, very fine to fine, mostly pale brown; silty in parts and contains numerous hard limy zones.........	270	315
Siltstone, very sandy, pale brown and yellow-brown; sand is very fine; contains some limy zones............	315	350
Sandstone, moderately silty, yellow-brown and brown; sand is very fine with some fine; limy zones common....	350	366
Siltstone, very sandy, mostly yellow-brown; sand is very fine; contains some limy zones........................	366	400
Gering: (approximate contact)		
Sandstone, moderately silty grading downward to very slightly silty, brown to yellow-brown; sand is very fine to fine..	400	420
Sand, very fine to fine, yellow-brown....................	420	430
Sand, fine to very fine with a trace of medium to coarse; contains some marly zones...........................	430	436
Beaver Wall siltstone:		
Silt, very sandy, yellow-brown, with some very silty sand zones; sand is very fine; some limy zones.........	436	546
Sand, very silty, brown; sand is very fine; trace of lithic clasts below 550 ft...........................	546	560
Probably silt, very sandy, brown (from e-log)..........	560	567
Sand, silty, yellow-brown; sand is very fine to fine; lithic clasts common................................	567	577
Mostly silt, sandy, brown to yellow-brown...............	577	586
Sand, very fine to fine with a trace of medium to very coarse sand, pale brown; lithic clasts abundant........	586	600
Interbedded sand, silt, and some claystone, pale brown; sand is mostly very fine; contains some lithic clasts..	600	617
Silt, sandy, clayey, mostly pale brown; sand is very fine to fine; trace of lithic clasts..................	617	630
Sand, mostly very fine to fine but contains some medium in parts, pale brown; silty and clayey in parts; contains trace of lithic clasts in parts..............	630	671
Whitney:		
Silt, moderately to very clayey, slightly sandy in parts, yellow-brown; sand is very fine.......................	671	730

Test hole 30N-49W-16ddd
(Field No. 7-B-78)

Location: 0.5 ft. north and 94 ft. west of southeast corner of sec. 16, T. 30 N., R. 49 W.
Ground altitude: 4,306 ft. (Ft. Robinson 4 SE 7.5-minute quadrangle, advanced print)
Depth to water: Unable to measure. Hole plugged at 91.5 ft.

	Depth, in feet From	To
Top soil	0	2
Ogallala:		
Silt, very clayey and clay, silty, pale brown with some olive-gray; contains large, white, lime nodules	2	13
Siltstone and silt, sandy in parts, mostly light gray to grayish brown	13	21
Siltstone and silt, mostly very sandy, mostly pale brown but with light gray, pinkish-brown, and yellow-brown; grades to silty sandstone in parts; sand is mostly very fine but has some fine in parts; limy zones common	21	65
Sand, very fine to medium, light gray and pale brown; silty in parts; lime-cemented in a few parts	65	89
Silt, sandy, brownish-gray; sand is very fine to fine; limy in part	89	91
Sand, very fine to medium, pale brown to white; lime-cemented at the base	91	98
Upper Harrison:		
Silt, very sandy, mostly pale brown; grades to very silty sandstone in parts; sand is very fine to fine; contains some thin limy zones	98	130
Silt, slightly to moderately sandy, slightly clayey in parts, mostly pale brown but with some light-gray and pinkish brown; sand is very fine; contains a few limy zones	130	175
Probably silt, very sandy grading to sand, very silty, pale brown; sand is very fine	175	190
Monroe Creek-Harrison: (approximate contact)		
Siltstone and silt, very sandy, and sandstone, very silty, brown to light gray; sand is very fine; numerous limy zones	190	210
Sand and sandstone, mostly moderately silty, brown to light gray; sand is very fine to fine; limy zones abundant	210	264
Sand, moderately silty, mostly brown; sand is very fine; contains some limy zones	264	281
Silt, probably very sandy, mostly yellow-brown; sand is very fine; contains some limy zones	281	330
Gering?:		
Sand, silty, pale brown; sand is very fine; contains lithic clasts	330	334

Test hole 30N-49W-16ddd - continued

	Depth, in feet From	To
Beaver Wall siltstone?:		
Silt, very sandy, mostly brown, grading to very silty sand, mostly brown, in parts; sand is very fine........	334	510

(Aborted hole at 510 ft.; problems with hole from 145 ft. on down.)

Test hole 30N-49W-34ccc
(Field No. 8-8-78)

Location: 189 ft. north and 7 ft. east of southwest corner of sec. 34, T. 30 N., R. 49 W.
Ground altitude: 4,148 ft. (Ft. Robinson 4 SE 7.5-minute quadrangle, advanced print)
Depth to water: 77.6 ft. (September 18, 1978)

	Depth, in feet From	To
Road fill and slope wash..................................	0	10
Ogallala:		
Sandstone, silty, pale brown to light gray with interbedded sandy silt; sand is very fine to fine; numerous lime-cemented zones....................................	10	55
Sand and sandstone, very fine to medium, brown; some coarse sand from 55-60 ft.; silty from 75-80 ft.........	55	83
Silt, clayey, pale yellow, grading downward to sandy silt and silty sandy, brown; sand is very fine to fine..	83	95
Sand, slightly gravelly; sand is mostly fine to medium but very fine sand to medium gravel is present..........	95	114
Sandstone, probably silty, very pale brown, with some interbedded sandy silt; sand is very fine to fine with some medium in parts......................................	114	127
Silt, sandy, light yellow-brown grading downward to silty sand; sand is very fine to fine with some medium..	127	133
Sand and sandstone, very fine to medium, brown, interbedded with gray limy and silty sandstone and some sandy silt...	133	150
Sand, gravelly, with some interbedded silty and limy sand; grain size ranges from very fine sand to medium gravel..	150	170
Sand and sandstone, very fine to medium..................	170	175
Sand, silty, light brown and gray; sand is very fine to fine and limy at top.....................................	175	185
Sand and sandstone, very fine to fine, brown, with some thin silty and limy zones............................	185	208
Silt, slightly clayey, light yellow-brown and light brown.	208	222
Silt, sandy, light brown..................................	222	229
Sand and sandstone, very fine to fine, brown; limy near base...	229	236

	Depth, in feet From	To
Silt, sandy, limy, gray with some interbedded silty sand.	236	247
Sand, very fine, pale green, with some interbedded silty sand and sandy silt....................................	247	268
Gering?:		
Silt, slightly sandy, clayey, gray at top grading down to pale brown; sand is very fine......................	268	282
Sand, silty, light gray; sand is very fine; lithic clasts common and reach gravel size...................	282	290
Beaver Wall siltstone:		
Sand, very silty, light olive-gray at top grading down through grayish-brown to pale brown at base; sand is very fine; contains a few limy zones..................	290	310
Silt, probably mostly very sandy, mostly brown; grades to very silty sand in parts; sand is very fine; contains a few limy zones; less sandy below 380 ft.....	310	434
Nonpareil ash zone:		
Volcanic ash, light gray................................	434	442
Silt, slightly sandy, probably very ashy, light yellow-brown; sand is very fine............................	442	453
Whitney:		
Silt, slightly sandy, slightly clayey, yellow-brown and brown; sand is very fine; more clayey below 490 ft.....	453	500

Test hole 30N-51W-2aa
(Field No. 4-B-78)

Location: 28 ft. south and about 600 ft. west of northeast corner of sec. 2, T. 30 N., R. 51 W.
Ground altitude: 4,456 ft. (Ft. Robinson 3 SE 7.5-minute quadrangle, advanced print)
Depth to water: 211 ft. (September 5, 1978)

	Depth, in feet From	To
Upper Harrison:		
Silt, very sandy, brown; sand is very fine; contains abundant limy zones..................................	0	40
Sandstone, very silty, brown; sand is very fine with trace of fine; contains hard, well-cemented limy zones and dark, heavy minerals..............................	40	56
Monroe Creek-Harrison: (approximate contact)		
Sand, moderately silty increasing downward to very silty, brown; sand is very fine to fine; limy zones common....	56	100
Silt, very sandy, with some interbedded very silty sandstone, brown; sand is very fine; limy zones common..	100	160

	Depth, in feet From	To
Sand, moderately silty decreasing downward to non-silty, mostly pale brown; sand is very fine to fine; below 200 ft. contains a trace of medium sand; limy zones common	160	214
Silt, very sandy, yellow-brown; sand is very fine	214	240
Gering:		
Sand, very silty, brown; sand is very fine to fine; marly below 243 ft	240	245
Sand, fine to very fine with some medium, brown to pale brown; contains lithic clasts and some limy zones	245	260
Sand and lime-cemented sandstone, silty, brown and gray; sand is very fine	260	265
Sand, fine, with some medium and very fine; contains lithic clasts	265	284
Volcanic ash, impure, silty, sandy, gray	284	285
Sand, very silty, brown; sand is very fine to fine; contains limy and marly zones	285	296
Silt, slightly to moderately sandy, mostly slightly clayey, brown and pale brown; sand is very fine	296	335
Sand, silty, brown; sand is very fine to fine with a trace of medium	335	344
Silt, very sandy, brown; sand is very fine	344	357
Sand, very fine to medium with, in parts, some coarse; contains lithic clasts and a few limy zones	357	387
Sand, very silty, brown, with some thin beds of silt; sand is very fine to fine	387	401
Silt, sandy, brown	401	407
Sand, silty, brown; sand is very fine to fine; contains some lithic clasts from 407-410 ft. and some limy zones	407	415
Whitney:		
Silt, slightly sandy, slightly clayey, pale brown; sand is very fine except from 444-450 ft. where there is some fine sand and lithic clasts	415	500
Silt, slightly sandy, pale brown; possibly impure volcanic ash	500	501
Silt, slightly to moderately clayey, brown to pale brown.	501	550

Test hole 30N-51W-13ccc
(Field No. 3-B-78)

Location: 322 ft. north and 60 ft. east of southwest corner of sec. 13, T. 30 N., R. 51 W.
Ground altitude: 4,545 ft. (Ft. Robinson 3 SE 7.5-minute quadrangle map, advanced print)
Depth to water: 215 ft. (August 22, 1978)

	Depth, in feet From	To
Soil	0	2
Ogallala:		
Silt, very clayey, slightly to very sandy, light gray; sand is very fine to fine; contains some lime concretions	2	11
Sandstone, very silty, moderately clayey, light gray and light yellow; sand is very fine to fine with a trace of medium; lime-cemented in parts	11	18
Upper Harrison:		
Silt, mostly slightly sandy, mostly slightly clayey, brown; sand is very fine; contains some limy zones	18	40
Silt, moderately sandy, brown; sand is very fine; less sandy below 52 ft	40	56
Silt, very sandy, brown; contains some limy zones; sand is very fine	56	71
Sand, very silty, pale brown; sand is very fine	71	80
Silt, very sandy, pale brown; sand is very fine	80	92
Silt, slightly to very sandy, very slightly clayey, pale olive and light brown; sand is very fine	92	110
Sand, moderately silty, brown; sand is very fine to fine.	110	114
Silt, slightly to very sandy, slightly clayey in parts, pale brown to yellow-brown; sand is very fine; contains some limy zones	114	189
Monroe Creek-Harrison:		
Sandstone, moderately to very silty, pale brown to light brownish-gray; sand is very fine with some fine; limy zones common	189	215
Silt, very sandy, brown; sand is mostly very fine; limy zones common	215	238
Siltstone, very sandy, with some sandstone, very silty, brown; many hard, well-cemented limy zones	238	270
Beaver Wall siltstone:		
Silt, moderately to very sandy, brown; sand is mostly very fine; limy zones common	270	310
Silt, slightly sandy, slightly clayey in most parts, brown; sand is very fine; contains some limy zones	310	390
Sand, very silty, brown; sand is very fine with trace of fine	390	400
Silt, mostly moderately sandy but with some slightly and very sandy zones, mostly slightly clayey, pale brown and brown; sand is very fine; contains some limy zones	400	508
Silt, slightly sandy, moderately clayey, brown; sand is very fine	508	536
Nonpareil ash zone:		
Volcanic ash, impure, light brownish-gray	536	552
Silt, moderately clayey, slightly sandy, probably very ashy, pale brown; sand is very fine	552	566

Test hole 30N-51W-13ccc - continued

	Depth, in feet From	To
Whitney:		
Silt, moderately to very clayey, brown to yellow-brown...	566	570

Test hole 30N-51W-36ccc
(Field No. 2-B-78)

Location: 192 ft. north and 35 ft. east of southwest corner of sec. 36, T. 30 N., R. 51 W.
Ground altitude: 4,348 ft. (Ft. Robinson 3 SE 7.5-minute quadrangle, advanced print)
Depth to water: 178.1 ft. (August 22, 1978)

	Depth, in feet From	To
Road fill..	0	5
Ogallala:		
Sand and sandstone, medium to fine, trace of coarse, brown and pale brown..................................	5	20
Upper Harrison:		
Sandstone, very fine to fine, interbedded with sandy siltstone, brown......................................	20	32
Sandstone, very fine, very silty, mostly yellow-brown....	32	58
Silt, very sandy, mostly yellow-brown; contains numerous limy zones; sand is very fine........................	58	108
Beaver Wall siltstone: (approximate contact)		
Silt, moderately sandy, very slightly clayey, yellow-brown; contains some intermittent limy zones; less sandy below 130 ft.; sand is very fine................	108	163
Silt, slightly sandy, slightly clayey, yellow-brown; sand is very fine; some intermittent limy zones; moderately sandy 235-242 ft., 285-300 ft., 308-340 ft..	163	340
Silt, slightly sandy, moderately clayey, pale brown; sand is very fine; more uniform than above............	340	362
Nonpareil ash zone:		
Volcanic ash, light brownish gray to light gray..........	362	383
Silt, slightly clayey, probably very ashy, pale brown....	383	397
Whitney:		
Silt, moderately clayey, brown..........................	397	410

Test hole 31N-42W-1bcb
(Field No. 23-B-79)

Location: About 1,707 ft. south and 37 ft. east of northwest corner of sec. 1, T. 31 N., R. 42 W.
Ground altitude: 3,634 ft. (Rushville 4 NW 7.5-minute quadrangle)
Depth to water: 128.7 ft. (August 8, 1978)

	Depth, in feet From	To
Soil	0	1
Ogallala:		
Sand, silty, dark brown; sand is fine to medium with trace of coarse	1	4
Sand, medium to coarse; trace of very coarse in parts	4	55
Sandstone, silty, olive and olive-brown; sand is very fine to fine with some coarser grains	55	65
Sandstone and sand, very fine to medium with some coarse sand to fine gravel	65	73
Sandstone and sand, very silty grading downward to slightly silty, light olive-brown and brown; sand is very fine to fine at top with medium to very coarse sand in lower part	73	80
Sand and sandstone, fine to very coarse with trace of fine gravel; silty near base	80	100
Sand, silty, brown; sand is mostly very fine to medium	100	105
Sand, medium to coarse with some coarser grains	105	111
Sand and sandstone, silty, with some interbedded sandy silt and sand, olive, light yellow-brown and brown; sand is mostly very fine to medium with some coarser grains from 111-127 ft. and fine to medium with some coarser grains below 127 ft	111	145
Sand and sandstone, fine to coarse with trace of very coarse and fine gravel	145	160
Sand and sandstone, silty in parts, brown; sand is very fine to medium with trace of coarse; contains trace of coarser grains in parts	160	201
Silt, very sandy, and sandstone, silty, brown; sand is very fine to fine with some medium to coarse	201	210
Sandstone and sand, fine to coarse with some very coarse and fine gravel, trace of medium gravel	210	215
Sand, very fine to medium with some coarse	215	217
Silt, sandy, and silty sandstone, pale brown; sand is very fine to fine; some medium sand and lime-cemented at base	217	224
Silt, sandy, clayey, pale yellow, pale olive, and light yellow-brown	224	230
Sandstone, very silty, brown; sand mostly very fine to fine	230	243
Sand and sandstone, very fine to medium with some coarse to very coarse; trace of fine gravel in parts; contains some interbedded sandy silt below 255 ft	243	263
Silt, sandy, pale brown, with some interbedded silty sandstone and sand; sand is very fine to medium with some coarser grains	263	275
Sand and sandstone, very fine to medium with some coarse to very coarse and trace of fine gravel; slightly finer grained below 285 ft.; silty below 290 ft	275	293

	Depth, in feet From	To
Upper Harrison:		
Siltstone and silt, slightly to moderately sandy, slightly to moderately clayey, yellow-brown and brown; sand is very fine to fine; small limy zones common.....	293	410
Siltstone and silt, very sandy grading downward to very silty sandstone, brown; sand is very fine to fine with trace of medium; contains lithic clasts in parts; very limy below 418 ft....................................	410	422
Sandstone, very silty, brown and white; sand is very fine to fine with trace of medium and possibly coarse below 430 ft.; large limy zones abundant...............	422	436
Monroe Creek-Harrison:		
Siltstone, slightly to very sandy, clayey in parts, brown and yellow-brown; sand is mostly very fine but with some fine; limy zones abundant..................	436	484
Beaver Wall siltstone: (approximate contact)		
Silt and siltstone, mostly slightly sandy, slightly to moderately clayey, yellow-brown and brown; sand is mostly very fine; small limy zones common.............	484	560

Test hole 31N-42W-23add
(Field No. 25-B-79)

Location: About 2,250 ft. south and 46 ft. west of northeast corner of sec. 23, T. 31 N., R. 42 W.
Ground altitude: 3,535, ft. (Rushville 4 NW 7.5-minute quadrangle)
Depth to water: About 73 ft. (August 11, 1979-estimated from electric log)

	Depth, in feet From	To
Quaternary:		
Soil...	0	2
Sand, silty, gray-brown; sand is fine to medium..........	2	4
Gravel, sandy; fine sand to very coarse gravel; gravel mostly composed of lithic clasts.......................	4	11
Ogallala:		
Silt, sandy, pale olive................................	11	12
Sandstone and sand, fine to very coarse, olive-brown.....	12	21
Sandstone and sand, fine to coarse with some very coarse sand to fine gravel, light olive-brown................	21	25
Sandstone and sand, fine to medium with some coarse sand to fine gravel, light olive-brown.....................	25	37
Silt, sandy, clayey, pale olive, with some interbedded sand, fine to medium..................................	37	42
Sandstone and sand, fine to medium with some coarse to very coarse, olive-brown; trace of fine gravel below 75 ft.; contains some silty zones below 85 ft..........	42	100

	Depth, in feet From	To
Sand and sandstone, fine to very coarse with some gravel, olive-brown; silty in parts; limy at base.............	100	121
Sandstone and sand, very fine to medium with some coarse and trace of coarser grains, olive-brown; silty in parts..	121	143
Silt, sandy, grading to silty sandstone in parts, yellow-brown; sand is very fine to medium; less silty below 150 ft..	143	155
Sandstone and sand, fine to very coarse with some fine to medium gravel...................................	155	161
Interbedded silt, silty sandstone, and gravelly sand.....	161	170
Sandstone, mostly very silty, olive-brown; sand is very fine to medium.....................................	170	185
Sandstone and sand, very fine to very coarse, some gravel in parts; interbedded silt seams in parts.......	185	200
Sand and sandstone, very fine to medium, trace of coarse; much medium sand.............................	200	215
Sand and sandstone, very fine sand to fine gravel, much coarse sand; contains gravel-size lithic clasts........	215	220
Sand and sandstone, very fine to coarse.................	220	225
Sand and sandstone, very fine to medium, much fine; silty in parts....................................	225	230
Sand and sandstone, silty, with interbedded sandy silt; sand mostly very fine to fine.........................	230	240
Upper Harrison:		
Silt and siltstone, mostly slightly sandy, mostly slightly clayey, brown and yellow-brown; sand is very fine to fine; small limy zones common; sandier below 340 ft..	240	350
Sandy silt to silty sand and sandstone, light yellow-brown; sand is very fine to fine; contains some interbedded sandy silt (olive); contains small limy zones..	350	360
Sand and sandstone, very fine to fine with some medium, yellow-brown; some limy zones........................	360	370
Monroe Creek-Harrison:		
Sandstone and sand, silty, mostly yellow-brown; sand is very fine to fine; limy zones abundant................	370	390
Beaver Wall siltstone:		
Silt and siltstone, very sandy, yellow-brown; sand is very fine to fine; small limy zones common............	390	420

(Aborted hole at 420 ft. because of mechanical problems.)

Test hole 31N-44W-14ccc
(Field No. 10-B-79)

Location: 7 ft. north and 465 ft. east of southwest corner of sec. 14, T. 31 N., R. 44 W.
Ground altitude: 3,670 ft. (Rushville 7.5-minute quadrangle)
Depth to water: 22.7 ft. (June 25, 1979)

	Depth, in feet From	To
Road fill	0	3
Ogallala:		
Sand, fine to medium with some coarse to very coarse	3	5
Sand and sandstone, fine sand to medium gravel; much coarse to very coarse sand	5	10
Sand, fine to very coarse with a trace of gravel	10	17
Sandstone and sand, silty in parts, mostly pale brown; sand is very fine to medium with trace of coarse; finer-grained from 17-20 ft.; contains some thin silt beds	17	30
Sand, gravelly, fine sand to medium gravel, much coarse sand to fine gravel	30	35
Sand and sandstone, fine to coarse, some very coarse sand and some gravel	35	40
Sand and sandstone, very fine to coarse, much fine to medium	40	55
Silt, sandy, grading down to silty sand, pale yellow and light yellow-brown; sand is very fine to medium	55	60
Sandstone, very fine to fine with some medium and coarse, mostly light olive-brown; more medium sand from 95-105 ft.; silty in parts	60	115
Sandstone, fine to very coarse with trace of gravel	115	125
Siltstone, sandy and sandstone, lime-cemented, white to very pale brown; sand is very fine to medium	125	134
Siltstone and silt, sandy, light yellow-brown; sand is very fine to fine	134	140
Sand, silty, light yellow-brown; sand is very fine to medium	140	143
Upper Harrison:		
Silt and siltstone, sandy in parts, clayey in parts, pale yellow and pale olive; sand is very fine to fine	143	158
Silt and siltstone, slightly clayey in parts, light brown and pinkish-brown; hard limy zones (grading to limestones) below 180 ft.	158	187
Silt and siltstone, light brown; some small limy zones below 210 ft.	187	261
Sandstone and sand, silty, brown and light brownish-gray; sand is very fine to fine; some medium and coarse sand below 271 ft.; limy zones abundant	261	282
Sandstone and sand, probably silty, brown; sand is very fine to medium; limy zones abundant; some olive below 300 ft.	282	308

Test hole 31N-44W-14ccc - continued

	Depth, in feet From	To
Limestone, sandy, white	308	309
Sandstone and sand, probably silty, mostly olive; sand is very fine to coarse, much fine to medium	309	320
Monroe Creek-Harrison:		
Sandstone, very silty and siltstone, very sandy, light olive-brown and light yellow-brown; sand is very fine to fine	320	331
Beaver Wall siltstone:		
Silt and siltstone, moderately to very sandy, mostly light brown; sand is very fine to fine; less sandy and slightly clayey below 480 ft.; limy zones common in parts	331	520

Test hole 31N-44W-34ddc
(Field No. 11-B-79)

Location: 12 ft. north and 676 ft. west of southeast corner of sec. 34, T. 31 N., R. 44 W.
Ground altitude: 3,773 ft. (Rushville SW 7.5-minute quadrangle)
Depth to water: 110.1 ft. (June 25, 1979)

	Depth, in feet From	To
Quaternary:		
Road fill	0	1
Sand, slightly silty; sand is fine to medium with some very fine and coarse	1	30
Ogallala: (approximate contact)		
Sand and sandstone, very fine to coarse; much fine to medium sand; contains root casts	30	45
Sandstone and sand, very fine to coarse, much fine; contains interbedded sandy silt, clayey silt, and silty sand	45	70
Sand and sandstone, very fine to coarse, much fine	70	90
Sandstone and sand, silty in parts; sand is very fine to coarse with much fine	90	110
Sandstone and silty sand, light gray to pale brown; sand is mostly very fine to medium with some coarse	110	140
Silt, sandy in parts and clayey in parts, light gray, pale olive, and white; contains some limy zones	140	156
Sand and sandstone, very fine to coarse, much fine to medium; silty from 156-160 ft.	156	164
Sand, silty, clayey, pale yellow; sand is very fine to coarse, trace of gravel in parts; contains a few limy zones	164	176
Sandstone, limy sand, and silt, pale olive and pale yellow; sand is very fine to coarse, some very coarse and fine gravel	176	185

Test hole 31N-44W-34ddc - continued

	Depth, in feet From	To
Sand and sandstone, very fine to coarse, much fine to medium; some silt seams from 200-205 ft................	185	212
Silt, sandy, clayey in parts, with some interbedded sand, pale olive and pale yellow......................	212	230
Sand and sandstone, very fine to coarse, pale yellow and pale olive; silty in parts...........................	230	249
Silt, sandy in parts, clayey in parts, mostly pale yellow...	249	258
Sand and sandstone, very fine to very coarse with some fine gravel, olive.....................................	258	266
Silt, sandy, pale yellow................................	266	270
Sand, very fine to medium, much fine, silty in parts.....	270	275
Sand, slightly gravelly, fine sand to medium gravel......	275	285
Sand, gravelly, fine sand to medium gravel with some coarse gravel below 290 ft.; limy at base.............	285	301
Upper Harrison:		
Silt and siltstone, sandy in parts, clayey in parts, pale olive; sand is mostly very fine; limy zones common...	301	421
Silt and siltstone, sandy, brown; sand is mostly very fine; limy zones abundant............................	421	442
Sandstone and sand, silty, pale brown and brown; sand is very fine to fine with some medium; limy zones abundant..	442	462
Monroe Creek-Harrison:		
Siltstone and silt, moderately sandy, brown; sand is mostly very fine; limy zones common...................	462	502
Beaver Wall siltstone: (approximate contact)		
Silt and siltstone, slightly sandy, slightly clayey in parts, brown; sand is very fine; contains some thin limy zones; olive-gray below 548 ft...................	502	550

Test hole 31N-45W-19bbc
(Field No. 3-B-79)

Location: 906 ft. south and 9 ft. east of northwest corner of sec. 19, T. 31 N., R. 45 W.
Ground altitude: 3,788 ft. (Hay Springs 7.5-minute quadrangle)
Depth to water: 31 ft. (May 19, 1979).

	Depth, in feet From	To
Road fill...	0	4
Ogallala:		
Sandstone, fine to coarse, some very coarse, limy, light gray; some fine gravel from 4-10 ft. and gravelly below 15 ft.; contains lithic clasts below 15 ft.......	4	21

	Depth, in feet From	To
Upper Harrison:		
Siltstone and silt, very sandy, mostly light yellow-brown but with some light olive, gray-brown, and olive-brown; sand is mostly very fine to fine; contains some limy zones	21	79
Sand and sandstone, silty, pale brown; sand is very fine to fine with some coarser grains; contains limy zones..	79	84
Monroe Creek-Harrison:		
Siltstone, very sandy, yellow-brown with some brownish gray; sand is mostly very fine; limy zones abundant, lost circulation at 117 ft	84	196
Beaver Wall siltstone: (approximate contact)		
Siltstone, very sandy, yellow-brown and brown; grades to very silty sandstone in some parts; sand is very fine with some fine in sandier parts; contains limy zones but fewer than above	196	480

(Aborted hole at 480 ft. because of circulation problems.)

Test hole 31N-45W-31ccd
(Field No. 4-B-79)

Location: 4.5 ft. north and 663 ft. east of southwest corner of sec. 31, T. 31 N., R. 45 W.
Ground altitude: 3,774 ft. (Hay Springs SW 7.5-minute quadrangle)
Depth to water: 26.1 ft. (May 29, 1979)

	Depth, in feet From	To
Soil and fill	0	5
Ogallala:		
Sandstone, silty, light yellow-brown to pale olive; sand is very fine to fine with some medium; numerous limy zones	5	16
Silt, sandy, clayey in parts, light gray to pale olive; sand is mostly very fine to fine; limy zones in upper part	16	42
Sand, fine to coarse, some very coarse; more medium to coarse below 45 ft	42	48
Silt, sandy, clayey, light gray to pale olive, with interbedded silty sand; sand is very fine to fine with some medium below 53 ft. and some coarser grains below 57 ft	48	60
Sand and sandstone, silty, gray to olive; contains some interbedded silt; sand mostly fine to medium with coarser grains in parts	60	82
Gravel, sandy; gravel mostly composed of lithic clasts; sand is medium to very coarse; contains some coarse to very coarse crystalline gravel below 85 ft	82	90

Test hole 31N-45W-31ccd - continued

	Depth, in feet From	To
Sand and sandstone, silty, mostly pale yellow; sand is mostly very fine to medium; contains some interbedded silt	90	110
Sand, medium, with some fine and coarse; contains a trace of very coarse sand and fine gravel	110	115
Gravel, sandy; gravel mostly composed of lithic clasts; sand mostly medium to very coarse	115	120
Sandstone, mostly very fine to medium; silty in parts; contains some coarse sand to fine gravel in parts	120	140
Interbedded sand, sandstone, and silt with some claystone seams; sand is very fine to medium	140	156
Silt, sandy, mostly gray to olive, with interbedded silty sand and sand; silt is clayey from 156-161 ft. and 179-181 ft.; sand is mostly very fine to medium	156	185
Sand and sandstone, fine to coarse, some very coarse sand and fine gravel	185	190
Sand, medium to coarse with some very fine, fine, and very coarse sand, trace of gravel; more coarse sand to fine gravel below 195 ft	190	205
Upper Harrison:		
Silt and siltstone, mostly very sandy, mostly brown; sand is very fine to fine; contains some limy zones; contains some flesh-colored claystone below 250 ft	205	260
Sandstone, silty, brown; sand is fine to very fine with some medium and trace of coarse; contains many limy zones	260	270
Monroe Creek-Harrison:		
Sandstone, very silty, mostly yellow-brown; grades to very sandy siltstone in parts; sand is very fine to fine; contains numerous limy zones	270	360
Beaver Wall siltstone: (approximate contact)		
Silt and siltstone, very sandy, light yellow-brown and yellow-brown; grades to very silty sand in parts from 510-600 ft. and from 670-680 ft.; sand is very fine; contains some limy zones; contains some lithic clasts in parts from 480-510 ft, 560-570 ft.; 590-600 ft.; and 660-690 ft	360	747
Nonpareil ash zone:		
Volcanic ash, very impure, light yellow-brown	747	750
Silt and siltstone, very ashy, light yellow-brown	750	756
Whitney?:		
Silt and siltstone, yellow-brown	756	760

Test hole 31N-47W-20aaa
(Field No. 14-B-78)

Location: 119 ft. south and 10 ft. west of northeast corner of sec. 20, T. 30 N., R. 47 W.
Ground altitude: 4,044 ft. (Chadron 3 NE 7.5-minute quadrangle)
Depth to water: 42.8 ft. (October 30, 1978)

	Depth, in feet From	To
Quaternary:		
Road fill	0	3
Silt, dark brown with some yellow-brown	3	15
Gravel, sandy; fine to coarse gravel composed of lithic clasts	15	20
Quaternary or Ogallala?:		
Sand with some sandstone, very fine to medium	20	30
Upper Harrison:		
Siltstone and silt, very sandy, light yellow-brown, yellow-brown, and brown; grades to very silty sandstone in parts; sand mostly very fine; few limy zones	30	142
Sandstone, silty, brown; sand is very fine to fine with a trace of medium to coarse; contains root casts and dark minerals or manganese stain	142	146
Monroe Creek-Harrison:		
Sandstone, very silty, mostly brown from 146-253 ft. and mostly yellow-brown below 253 ft.; sand is very fine with some fine; grades to very sandy silt in parts; limy zones abundant	146	336
Siltstone and silt, very sandy, light yellow-brown and yellow-brown; sand is very fine; only slightly sandy below 348 ft.; few limy zones	336	366
Gering:		
Silt, sandy, yellow-brown and pinkish-brown; sand is very fine; contains claystone and lithic clasts	366	371
Sand, slightly silty, yellow-brown; sand is very fine to fine with a trace of medium below 380 ft.; few lithic clasts	371	390
Sand, probably slightly silty, brown; sand is very fine to fine with some medium to coarse; abundant gravel-size lithic clasts from 390-400 ft.	390	410
Sand, probably slightly silty, brown; sand is very fine to very coarse with a trace of fine to medium gravel; contains some gravel-size lithic clasts	410	420
Sand, probably slightly silty, mostly brown; sand is very fine to fine with some medium to coarse; coarser and with a trace of fine gravel from 440-449 ft.; limy from 449-451 ft. and in a few other parts	420	465
Silt, very sandy, brown and pink; sand is very fine to fine; limy in parts	465	484
Sand, silty, pink; sand is very fine to fine	484	493
Sandstone and sand, very fine to fine, brown; contains a few lithic clasts and limy zones	493	500

	Depth, in feet From	To
Beaver Wall siltstone:		
Silt, moderately to very sandy, pink, pinkish gray, and pale brown except from 526-538 ft. where it is light gray to pale olive; sand is very fine; lithic clasts or thin, interbedded claystone from 520 to 530 ft.; some lithic clasts 550-560 ft.	500	562
Sand, slightly silty, pale brown and pinkish gray; sand is very fine to fine; contains lithic clasts	562	578
Silt, very sandy, pinkish-gray; sand is very fine to fine; contains a few lithic clasts	578	595
Sand, moderately silty, pale brown; sand is very fine with some fine	595	605
Silt, sandy, slightly clayey, pink; sand is very fine	605	610
Sand, very silty, pink; sand is very fine; interval also contains two ft. of very fine to fine sand between 610-619 ft.; possibly some volcanic ash between 619-620 ft.	610	622
Silt, sandy, light olive-gray to light gray; possibly very ashy; sand is mostly very fine	622	637
Whitney:		
Silt, slightly to moderately clayey, light brown, pink, and pinkish-gray	637	690

Test hole 31N-47W-32ddd
(Field No. 13-B-78)

Location: 4.5 ft. north and 170 ft. west of southeast corner of sec. 32, T. 31 N., R. 47 W.
Ground altitude: 4,155 ft. (Chadron 3 SE 7.5-minute quadrangle)
Depth to water: 147.2 ft. (October 17, 1978)

	Depth, in feet From	To
Quaternary:		
Road fill	0	3
Silt, very to slightly clayey, brown and pale brown	3	5
Ogallala:		
Siltstone, sandy, light olive-brown and white; sand is very fine; lime-cemented; grades to very silty, limy, sandstone in lower part	5	18
Silt, very clayey with less clay downward, pale yellow; lime zones or nodules from 20-21.5 ft	18	24
Siltstone and silt, very sandy, pale olive, pale yellow, and light brown; grades to very silty sandstone in parts; sand is very fine; limy zones abundant	24	65
Sand, very fine to very coarse with some fine gravel; much very fine to medium sand	65	80

	Depth, in feet From	To
Silt, very sandy, pale yellow, yellow-brown, gray and olive; sand is very fine; contains sand bed from 83-84 ft.	80	90
Sand, very fine to medium with trace of coarse; sandy silt from 99-100 ft.	90	102
Silt, very sandy, pale brown; sand is very fine with some fine	102	108
Sandstone and sand, silty, light yellow-brown; sand is very fine to coarse	108	110
Upper Harrison:		
Silt, mostly very sandy, light yellow-brown; sand is very fine; limy zones common	110	140
Silt, slightly sandy, slightly clayey, light yellow-brown	140	162
Silt, very sandy, mostly light yellow-brown; grades to very silty sand in a few parts; sand is very fine; limy zones common	162	283
Sandstone, very silty, and silt, very sandy, yellow-brown and very pale brown; sand is very fine; dark minerals abundant below 289 ft.	283	290
Monroe Creek-Harrison:		
Sandstone, very silty, yellow-brown and light yellow-brown; sand is very fine and probably some fine; grades to very sandy silt in a few parts; limy zones common	290	396
Beaver Wall siltstone: (approximate contact)		
Silt, very sandy, yellow-brown; grades to very silty sandstone in parts; sand is very fine with some fine in parts; limy zones more common in upper part	396	590
Silt, slightly to very sandy, slightly clayey in most parts, yellow-brown with some brown; sand is very fine.	590	725
Nonpareil ash zone:		
Volcanic ash, very impure, and very ashy silt, clayey, all very pale brown	725	738
Whitney:		
Silt, slightly sandy, clayey, yellow-brown; sand is very fine	738	750

Test hole 31N-49W-22acb
(Field No. 5-B-78)

Location: 824 ft. north and 11 ft. east of the center of sec. 22, T. 31 N., R. 49 W.
Ground altitude: 4,135 ± 10 ft. (hand level from Potter-Federal #1 oil test)
Depth to water: 59.0 ft. (September 5, 1978)

Test hole 31N-49W-22acb - continued

	Depth, in feet From	To
No sample; road fill	0	3.5
Upper Harrison:		
Sand, very silty, brown to yellow-brown; sand is mostly very fine; contains a few limy zones	3.5	34
Sandstone, slightly silty, brown; sand is very fine to fine; contains abundant dark, heavy minerals and a trace of lithic clasts	34	40
Monroe Creek-Harrison:		
Sandstone, slightly silty, brown and gray; sand is fine to very fine; contains abundant lime-cemented zones	40	53
Sandstone, mostly moderately silty, brown to pale brown; sand is very fine; contains abundant lime-cemented zones	53	126
Sand and sandstone, very silty, brown with some yellow-brown; sand is very fine; limy zones abundant	126	195
Sand and sandstone, slightly silty, brown; sand is very fine to fine; limy zones common	195	216
Sand, mostly moderately silty, pale brown; sand is very fine; some limy zones	216	274
Gering:		
Sand, moderately silty, pale brown; sand is very fine to fine with some lithic clasts at base	274	284
Sand, slightly silty, pale brown; sand is fine to very fine	284	294
Volcanic ash, possibly interbedded with sand	294	296
Sand, very slightly silty, pale brown; sand is fine to very fine with trace of medium; contains lithic clasts	296	312
Sand, silty and marly, gray; sand is very fine to fine	312	317
Sand, fine, with trace of medium to coarse; lithic fragments abundant	317	325
Beaver Wall siltstone:		
Silt, very to moderately sandy, pale brown; sand is very fine; contains a few limy zones	325	366
Sand, silty, with some interbedded sandy silt, pale brown; sand is very fine to fine	366	390
Silt, sandy, clayey in parts, pale brown with some pale olive; sand is very fine; contains a few limy and marly zones	390	410
Sand, fine to very fine, brown; contains some lithic clasts	410	417
Silt, very sandy, brown; sand is very fine	417	425
Sand, very silty, pale brown; sand is very fine to fine; contains lithic clasts	425	449
Silt, very sandy, slightly clayey, brown; sand is very fine	449	457
Sand, very silty, pale brown; sand is very fine with some fine; contains trace of lithic clasts	457	473

	Depth, in feet From	To
Silt, slightly to very sandy, slightly to moderately clayey, pale brown; sand is very fine; marly in parts	473	503
Nonpareil ash zone?:		
Volcanic ash, impure, mostly light gray	503	514
Whitney?:		
Silt, slighty sandy, slightly clayey, brown; sand is very fine	514	526
Silt, very sandy, and silty sand, pale brown; sand is mostly very fine; contains lithic clasts	526	570
Silt, slightly sandy, moderately clayey, yellow-brown; sand is very fine	570	582
Sand, very silty, brown; sand is very fine to fine; contains lithic clasts	582	594
Clay to claystone, brownish-yellow	594	596
Sand, silty, mostly pale brown, with interbedded sandy and clayey silts and abundant lithic clasts; sand is very fine to fine	596	618
Silt, very clayey in parts, very sandy in parts, mostly pale brown	618	635
Sand, silty, with interbedded siltstone and claystone, mostly pale brown; sand is mostly very fine; lithic clasts common	635	667
Silt, very clayey, light brown, with a little interbedded claystone and silty sandstone	667	676
Sand, silty, mostly brown, with interbedded sandy silt and claystone; sand is very fine with some fine; lithic clasts abundant	676	710
Sand, fine to very fine with some medium and a trace of coarse; coarse lithic clasts abundant	710	733
Sand, medium with some coarse and very coarse; coarse lithic clasts abundant	733	740
Claystone, silty, light yellow-brown	740	741
Sand, medium to fine with some coarse to very coarse, probably silty and clayey	741	743
Silt, mostly slightly sandy, mostly moderately clayey, yellow-brown and pale brown; possible volcanic ash zones in the intervals from 763-770 ft., 773-776 ft., 780-789 ft., and 790-796 ft	743	800

Test hole 32N-42W-2
(Field No. 21-B-79)

Location: About 1,075 ft. south and about 75 ft. west of northeast corner of sec. 2, T. 32 N., R. 42 W. Note: This is a short section in the north-south direction.
Ground altitude: 3,665 ft. (Gordon 7.5-minute quadrangle)
Depth to water: Unable to measure. Test hole caved at 117 ft. (August 8, 1979). The electric log and depth of caving indicate a depth to water of about 120 ft.

	Depth, in feet From	To
Quaternary:		
Soil and subsoil	0	4
Sand, silty, pale brown; sand is very fine to fine	4	9
Ogallala:		
Interbedded claystone and sandy silt, pale olive	9	23
Sandstone, silty in parts, olive; sand mostly fine to medium with some coarser grains; some lithic gravel	23	30
Sand and gravel; fine sand to medium gravel; most of the gravel composed of lithic clasts	30	33
Claystone, silty with some interbedded sandy silt, mostly pale olive	33	40
Sandstone and sand, silty, with interbedded sandy silt and minor amounts of claystone; individual beds are less than 2-ft. thick; mostly brown with some pale olive; contains a thin bed of lithic gravel between 45-50 ft.; sand is mostly very fine to fine but contains coarser grains	40	66
Sand and sandstone, fine to medium with some coarse to very coarse; trace of fine gravel; contains lithic clasts	66	70
Silt, sandy, with some interbedded sand and claystone	70	80
Sand and sandstone, mostly medium, brown in upper part and olive in lower part; also contains some very fine to fine and coarse to very coarse sand; contains trace to some fine crystalline gravel and some lithic gravel clasts in parts; silty in parts	80	157
Sand and sandstone, silty, with interbedded sandy silt, mostly very pale brown; sand is very fine to fine	157	170
Sand and sandstone, silty in parts, brown; sand is very fine to fine with some medium; some interbedded clayey silt below 185 ft	170	190
Silt, very sandy, clayey in parts, with interbedded silty sand, pale olive to pale brown; sand is very fine to fine	190	220
Sand, silty, with interbedded sandy silt, pale brown; sand is very fine to fine; contains some small limy zones	220	230
Silt, very sandy, with interbedded clayey silt and some silty sand, pale brown with some pale olive; sand is very fine to fine	230	260

Test hole 32N-42W-2 - continued

	Depth, in feet From	To
Sand, very silty, and sandy silt, light brownish gray and pale yellow; sand is very fine to fine; contains lithic clasts from 260-263 ft.	260	266
Sand, fine to coarse with some very coarse and trace of fine gravel, pale brown; contains some lithic clasts...	266	280
Upper Harrison:		
Silt and siltstone, sandy, clayey, light yellow-brown with some olive at top; sand is very fine; small limy zones common	280	312
Monroe Creek-Harrison: (approximate contact)		
Sandstone and sand, very silty, light brown and brown; sand is very fine to fine with a trace of medium from 340-351 ft.; limy zones abundant	312	376
Siltstone and silt, mostly very sandy, pale brown and brown; sand is mostly very fine; limy zones common to abundant	376	408
Beaver Wall siltstone:		
Silt and siltstone, slightly to very sandy, slightly to moderately clayey, brown; sand is mostly very fine; small limy zones common	408	615
Silt, very sandy, grading to silty sand, pale brown; sand is very fine to fine; lithic clasts common and some are gravel size	615	630
Silt and siltstone, slightly to moderately sandy, slightly to moderately clayey, pale brown and brown; sand is mostly very fine; very sandy with some fine sand from 668-673 ft.	630	680

Test hole 32N-42W-23aaa
(Field No. 22-B-79)

Location: 9 ft. south and 165 ft. west of northeast corner of sec. 23, T. 32 N., R. 42 W.
Ground altitude: 3,610 ft. (Rushville 4 NW 7.5-minute quadrangle)
Depth to water: 64.5 ft. (August 8, 1976)

	Depth, in feet From	To
Road fill and colluvium	0	6
Ogallala:		
Sandstone and sand, silty in parts, light olive-brown; sand is very fine to medium with trace of coarse sand to fine gravel below 10 ft.	6	25
Sand and sandstone, fine to medium with some coarse and very coarse, trace of fine gravel, brown; finer and contains some silty zones below 45 ft.	25	46

	Depth, in feet From	To
Sandstone and sand, silty, olive; sand is very fine to fine; less silty and contains medium sand to fine gravel below 57 ft	46	60
Sand and sandstone, silty, light olive-brown and olive; sand mostly very fine to medium, trace coarse to very coarse below 65 ft	60	75
Sand, fine to medium, trace coarse to very coarse, brown.	75	82
Sand and sandstone, very silty at top with decreasing silt downward, olive; sand is very fine to fine at top grading downward to very fine to medium with some coarse to very coarse and a trace of fine gravel	82	90
Sand and sandstone, fine to coarse, some very coarse, and trace of fine gravel, brown	90	100
Sandstone and sand, silty, brown; sand is very fine to medium with trace of coarse and very coarse	100	105
Sand and sandstone, very fine to medium with trace of coarse and very coarse grading downward to fine to coarse with some very coarse sand and fine gravel	105	117
Sandstone, very fine to fine, very silty, pale brown	117	120
Sand and sandstone, very fine to medium with trace of coarse and very coarse; coarser with trace of fine gravel from 130-135 ft	120	139
Sandstone, very silty at top with less silt at depth, yellow-brown; sand is very fine to fine	139	145
Sand and sandstone, very fine to medium with some coarse and trace of very coarse; silty and limy at base	145	155
Silt, very sandy, pale brown, with some interbedded sand and siltstone, mostly very fine to medium	155	165
Sand and sandstone, very fine to medium with trace of coarser grains, silty in parts	165	180
Sand, fine to very coarse with some fine and trace of medium gravel	180	185
Silt, very sandy, slightly clayey, olive and very silty sand and sandstone, pale brown; sand is very fine to fine; contains some limy zones	185	203
Sandstone, silty in parts, brown; sand is mostly very fine to medium with trace of coarse in parts	203	213
Silt, sandy, very pale brown, with some interbedded silty sandstone; sand is mostly very fine to fine	213	225
Sandstone and sand, very fine to medium with trace of coarse, olive-brown; contains some lithic clasts	225	237
Interbedded sandstone, sand, and sandy silt, pale brown with some pale olive; sand is mostly very fine to fine; some medium and trace of coarse from 245-248 ft.	237	254
Sand, very fine to medium, some coarse to very coarse	254	260
Silt, clayey, sandy, pale olive	260	265
Sand, very fine to very coarse with trace of fine gravel; coarser sand and more fine gravel below 270 ft.; contains some olive silt seams	265	275

	Depth, in feet From	To
Silt and siltstone, sandy, slightly clayey, pale olive, grading downward to a very silty sand; sand is very fine to fine	275	285
Sand and sandstone, slightly silty, olive-brown, with some interbedded olive silt; sand is very fine to fine with some medium	285	295
Silt, clayey, sandy, pale yellow; sandier at base; contains some limy zones	295	300
Sand and sandstone, silty in parts, brown; sand is very fine to fine; contains a few limy zones	300	312
Monroe Creek-Harrison:		
Silt and siltstone, slightly sandy, slightly clayey, pale yellow and light brownish-gray; sand is mostly very fine; limy zones abundant	312	330
Sandstone and sand, very silty, grayish brown, light yellow-brown, and pale olive at base; grades to sandy siltstone in parts; sand is very fine to fine; contains trace of medium grains from 345-360 ft.; limy zones abundant	330	371
Beaver Wall siltstone:		
Silt and siltstone, slightly to very sandy, slightly clayey in parts, brown except at top where it is pale yellow and olive; sand is very fine to fine; small limy zones common	371	480

Test hole 32N-44W-2bbb
(Field No. 14-B-79)

Location: 63 ft. south and about 3 ft. east of northwest corner of sec. 2, T. 32 N., R. 44 W.
Ground altitude: 3,826 ft. (Clinton SW 7.5-minute quadrangle)
Depth to water: 63.1 ft. (July 9, 1979)

	Depth, in feet From	To
Quaternary:		
Soil	0	2
Silt, clayey, grading down to silty sand	2	7
Upper Harrison:		
Silt and siltstone, slightly sandy, mostly light yellow-brown and light brown; more sandy in parts from 7-80 ft. and at base; sand is very fine; limy zones common from 7-88 ft	7	137
Sand, silty, pale brown; sand is very fine with some fine; little or no silt and some medium sand below 140 ft	137	141

	Depth, in feet From	To
Sandstone, very fine to medium with some coarse sand to fine gravel, olive yellow to pale olive; contains lithic clasts and much lime in parts..................	141	159
Monroe Creek-Harrison:		
Siltstone and silt, mostly very sandy, mostly pale brown; sand is very fine to fine; limy zones abundant.........	159	220
Silt and siltstone, slightly sandy, brown, more sandy near base; sand is very fine, some fine................	220	259
Gering:		
Sand and sandstone, silty in parts, mostly light brown; sand is very fine to fine; limy zones common...........	259	276
Silt, slightly sandy, light brown; sandier in parts; sand is mostly very fine..............................	276	318
Sand and sandstone, very fine to fine, brown; silty at top..	318	326
Silt and siltstone, mostly very sandy, mostly light brown; grades to very silty sand in parts; sand is mostly very fine; few limy zones......................	326	351
Silt and siltstone, slightly sandy, light brown; sand is very fine; few limy zones..........................	351	380
Sand, silty, light brown and brown; sand is very fine with some fine; limy zones common near base............	380	395
Silt, slightly sandy grading downward to very sandy, light brown; sand is mostly very fine; trace of lithic clasts in lower part.................................	395	410
Sand, silty in parts, pinkish-gray and pink; sand is very fine with some fine; contains some lithic clasts; limy at base..	410	428
Volcanic ash, pinkish-white............................	428	431
Silt, sandy, grading downward to silty sand, light brown; sand is very fine to fine.............................	431	440
Sand, silty in parts, mostly light brown but with some pink; sand is very fine to fine; contains some interbedded claystone, some limy zones, and some lithic clasts in parts...............................	440	456
Silt and siltstone, light brown; contains a few lithic clasts from 470-480 ft...............................	456	500
Silt, sandy, light brown; sand is mostly very fine.......	500	505
Sand, silty in parts, light brown and light yellow-brown; sand is very fine to fine; contains a few lithic clasts and a few limy zones. (The interval from 456-536 ft. possibly could be the Beaver Wall siltstone.)...	505	536
Beaver Wall siltstone:		
Silt and siltstone, slightly to very sandy, light brown; grades to very silty sand in a few parts; sand is very fine to fine; trace of small limy zones...............	536	576
Silt and sandstone, brown; possibly clayey in lower part. (This interval possibly could be the Whitney.).........	576	660

Test hole 32N-44W-22abb
(Field No. 8-B-79)

Location: 24 ft. south and about 2,460 ft. west of northeast corner of sec. 22, T. 32 N., R. 44 W.
Ground altitude: 3,757 ft. (Rushville 7.5-minute quadrangle)
Depth to water: 22.2 ft. (June 11, 1979)

	Depth, in feet From	To
Quaternary:		
Road fill	0	3
Silt, sandy, gray to brown	3	7
Upper Harrison:		
Siltstone and silt, slightly to moderately sandy, pale brown and light yellow-brown; sand is very fine to fine; limy zones common	7	153
Sandstone and sand, silty, yellow-brown and pale brown; sand is very fine to medium with a trace of coarse; lime-cemented at base	153	165
Monroe Creek-Harrison:		
Siltstone and silt, mostly very sandy, pale brown and yellow-brown; grades to very silty sandstone in a few parts; sand is very fine to fine; limy zones common, especially in upper part	165	270
Siltstone and silt, mostly very sandy, slightly clayey, yellow-brown; sand is very fine to fine; contains trace of medium sand from 300-310 ft. and 316-319 ft.; few thin limy zones	270	365
Siltstone and silt, moderately sandy, slightly clayey, yellow-brown; sand is very fine to fine	365	387
Gering:		
Sandstone and sand, slightly silty, mostly brown; sand is very fine to fine with some medium and coarse, trace of very coarse; very silty in parts; contains some lithic clasts below 410 ft	387	425
Siltstone and silt, very sandy, light brown and light yellow-brown; sand is very fine to fine; limy below 436 ft	425	437
Sandstone and sand, moderately to very silty, yellow-brown and pale brown; sand is very fine to fine with trace of medium	437	450
Sandstone and sand, slightly to moderately silty, yellow-brown; sand is very fine to medium; lithic clasts, many of gravel size, abundant	450	466
Interbedded siltstone, lithic gravel, and sandstone	466	477
Sand, silty, yellow-brown; sand is very fine to fine with a trace of medium; contains a few lithic clasts	477	485
Sandy silt and silty sand, yellow-brown; sand is very fine to fine	485	494

Test hole 32N-44W-22abb - continued

	Depth, in feet From	To
Sandstone and sand, silty, mostly yellow-brown; sand is very fine to fine with some medium to very coarse; some fine gravel below 510 ft.; contains lithic clasts, some of gravel size; contains some silt seams..........	494	520
Beaver Wall siltstone:		
Siltstone and silt, mostly very sandy, slightly clayey in parts, brown; sand is very fine to fine.............	520	615
Volcanic ash, gray; contains gold biotite flakes.........	615	620
Siltstone and silt, moderately sandy, slightly clayey, yellow-brown; sand is very fine to fine...............	620	644
Nonpareil ash zone:		
Volcanic ash, very impure, gray..........................	644	646
Silt and siltstone, moderately sandy, slightly clayey, mostly yellow-brown; probably very ashy...............	646	656
Whitney:		
Silt and siltstone, sandy, clayey, brown.................	656	680

Test hole 32N-44W-34ddd
(Field No. 9-B-79)

Location: 18 ft. north and 180 ft. west of southeast corner of sec. 34, T. 32 N., R. 44 W.
Ground altitude: 3,795 ft. (Rushville 7.5-minute quadrangle)
Depth to water: Unable to measure. Test hole caved at 122.5 ft. Electric log and depth of caving indicate depth to water of about 123 ft.

	Depth, in feet From	To
Quaternary:		
Soil...	0	1.5
Silt, sandy, pale brown..................................	1.5	3.5
Sand, silty, gravelly, light yellow-brown...............	3.5	4
Ogallala:		
Sand and sandstone, silty in parts, pale yellow and pale olive; sand is very fine to medium with some coarse; contains some interbedded sandy silt..................	4	18
Silt, sandy, light gray to brownish-gray; sand is very fine to fine..	18	22
Sand and sandstone, fine to coarse, mostly light yellow-brown with some pale olive and very pale brown; mostly very fine to medium from 22-30 ft.; contains some very coarse sand below 30 ft. and some lithic clasts below 45 ft.; contains a few thin silt beds.....	22	64
Silt, sandy, light brownish-gray to pale yellow..........	64	73
Sand and sandstone, very fine to medium with some coarse, very pale brown..	73	86

	Depth, in feet From	To
Silt, pale yellow to pale brown, with some interbedded sandy silt and silty sand..............................	86	95
Sand and sandstone, fine to coarse, with some gravel-size lithic clasts below 100 ft.; contains a few, thin silt seams..	95	120
Sand and sandstone with some interbedded silty sand and silt; sand is fine to very coarse with some fine to coarse gravel..	120	131
Interbedded silt, sandy silt, and silty sand, light gray in upper part, pale yellow in middle part, and pale brown in lower part; sand is very fine to fine....	131	162
Silt and siltstone, pale yellow and pale brown; contains thin sandy beds..............................	162	198
Sandstone, gravelly, fine sand to medium gravel, with interbedded sandy silt..............................	198	210
Sandstone, silty, with interbedded sandy silt, light gray; sand is mostly very fine to medium but includes some coarse and very coarse sand and gravel...........	210	239
Upper Harrison:		
Silt, slightly clayey, sandy in parts, pale yellow; sand is very fine to fine............................	239	250
Siltstone and silt, slightly to very sandy, pale brown and light yellow-brown; sand is very fine to fine; very limy below 277 ft..............................	250	285
Monroe Creek-Harrison: (approximate contact)		
Siltstone and silt, mostly very sandy, grades to very silty sand in parts, brown; sand is very fine to fine; limy zones common....................................	285	370
Beaver Wall siltstone: (approximate contact)		
Siltstone and silt, mostly moderately sandy, brown; grades to very sandy silt and silty sand in parts; sand is very fine to fine; limy zones common from 370-440 ft., less common below 440 ft............	370	511
Siltstone and silt, mostly slightly sandy, pinkish brown and brown; sand is mostly very fine; few limy zones..	511	664
Sand, very silty, slightly clayey in parts, pale brown; sand is very fine to fine with some medium in parts; contains some lithic clasts below 680 ft..............	664	762
Whitney?:		
Siltstone and silt, slightly clayey, brown..............	762	780

Test hole 32N-45W-18ccc
(Field No. 1-B-79)

Location: 11 ft. north and 116 ft. east of southwest corner of sec. 18, T. 32 N., R. 45 W.
Ground altitude: 3,960 ft. (Hay Springs 7.5-minute quadrangle)
Depth to water: 58.8 ft. (May 14, 1979)

	Depth, in feet From	To
Soil..	0	3
Upper Harrison:		
Sandstone, very silty, and siltstone, very sandy, yellow-brown; sand is very fine; few limy zones........	3	30
Siltstone, very sandy, yellow-brown and brown; sand is mostly very fine; contains a few limy zones...........	30	70
Sandstone, very silty, and siltstone, very sandy, mostly brown; sand is mostly very fine.................	70	156
Sand and sandstone, silty, light brown; sand is very fine to fine with some medium to coarse; limy zones common...	156	170
Monroe Creek-Harrison:		
Siltstone, very sandy, mostly brown; sand is mostly very fine; limy zones common................................	170	200
Sandstone, very silty, mostly brown; sand is mostly very fine..	200	240
Silt and siltstone, sandy, mostly yellow-brown; sand is very fine; some limy zones...........................	240	270
Gering:		
Sand and sandstone, silty, yellow-brown and pale brown; sand is very fine to fine; some medium sand and lithic clasts below 310 ft..................................	270	317
Beaver Wall siltstone:		
Sand, very silty, and silt, very sandy, mostly yellow-brown; sand is very fine; limy zones common............	317	460
Silt, very sandy, mostly yellow-brown; grades to very silty sandstone in a few parts; sand is very fine; contains lithic clasts in sandy zones from 542-567 ft..	460	612
Nonpareil ash zone:		
Silt, very sandy, yellow-brown grading down to pale brown, sand is very fine; contains lithic clasts; probably very ashy at base.....................................	612	620
Volcanic ash, very impure, pale brown....................	620	624
Silt, sandy, yellow-brown; sand is very fine.............	624	630
Whitney: (approximate contact)		
Silt, slightly sandy, dark yellow-brown..................	630	650

Test hole 32N-45W-31ccc
(Field No. 2-B-79)

Location: 120 ft. north and 1 ft. east of southwest corner of sec. 31, T. 32 N., R. 45 W.
Ground altitude: 3,870 ft. (Hay Springs 7.5-minute quadrangle)
Depth to water: 40.4 ft. (May 14, 1979)

	Depth, in feet From	To
Soil and subsoil	0	7
Upper Harrison:		
Siltstone and silt, mostly very sandy, mostly yellow-brown; sand is mostly very fine; limy zones common	7	115
Sand and sandstone, silty; sand is very fine to fine with some medium to very coarse; contains lithic clasts and limy zones	115	125
Monroe Creek-Harrison: (approximate contact)		
Sandstone, silty, brown and yellow-brown; sand is mostly very fine to fine and may contain some coarser grains; contains numerous limy zones	125	150
Sandstone, very silty, mostly yellow-brown; grades to very sandy siltstone in parts; sand is very fine with some fine; limy zones common	150	230
Siltstone, very sandy, mostly yellow-brown; grades to very silty sandstone in many parts below 260 ft.; sand is very fine; limy zones common	230	310
Silt and siltstone, sandy, yellow-brown; sand is very fine; contains some limy zones	310	340
Gering:		
Sand and sandstone, silty, light yellow-brown; sand is very fine to fine with some medium	340	360
Sand and sandstone, silty, yellow-brown; sand is fine to medium and contains lithic clasts and limy zones	360	367
Sand and sandstone, silty, light yellow-brown; sand is very fine to fine with some medium below 380 ft.; possible volcanic ash bed from 370-371 ft.; contains lithic clasts from 371-376 ft.; sandy silt in parts	367	384
Sand, very fine to very coarse, yellow-brown; contains lithic fragments below 390 ft. and some gravel below 400 ft.; probably silty	384	406
Silt, sandy, yellow-brown; sand is very fine	406	414
Sand and sandstone, silty, light yellow-brown; sand is very fine to very coarse and contains lithic clasts	414	421
Silt, very sandy, pale brown and yellow-brown, with some interbedded silty sand; sand is very fine; contains few lithic clasts from 421-428 ft.	421	434
Sand, very fine to very coarse, with some gravel	434	440
Beaver Wall siltstone:		
Silt and siltstone, sandy, yellow-brown; sand is very fine; contains some limy zones	440	508
Sand and sandstone, silty, light yellow-brown and pale brown; sand is very fine except below 520 ft. where it is very fine to medium and contains lithic clasts	508	525
Silt and siltstone, sandy, yellow-brown; sand is very fine; some lithic clasts from 539-540 ft. and 547-564 ft.; grades to very silty sand, very fine to medium from 547-560 ft.	525	580

Test hole 32N-45W-31ccc - continued

	Depth, in feet From	To
Sand and sandstone, very fine to very coarse, pale brown, with interbedded sandy silt; contains lithic clasts and limy zones in parts........................	580	604
Whitney:		
Silt, slightly sandy, mostly slightly clayey, yellow-brown and brownish yellow; sand is very fine; contains some small limy zones................................	604	740

Test hole 32N-47W-33cbc
(Field No. 15-B-78)

Location: About 1,420 ft. north and 8 ft. east of southwest corner sec. 33, T. 32 N., R. 47 W.
Ground altitude: 4,080 ft. (Chadron 3 NE 7.5-minute quadrangle)
Depth to water: 131.3 ft. (October 30, 1978)

	Depth, in feet From	To
Quaternary:		
Road fill..	0	6
Silt, slightly sandy, pale brown; sand is very fine......	6	12
Gravel and sandy silt; gravel composed of lithic clasts..	12	14
Upper Harrison:		
Silt and siltstone, very sandy, light brownish gray with some olive-brown at base; grades to very silty sand in parts; sand is very fine to fine.....................	14	40
Sand, very silty, light olive-brown; sand is very fine to fine..	40	55
Sand, slightly silty, light olive-brown; sand is very fine to fine with some medium to coarse; few limy zones...	55	68
Monroe Creek-Harrison:		
Sandstone, very silty, and siltstone, very sandy, mostly brown; sand is very fine to fine; numerous hard limy zones...	68	110
Sandstone and sand, mostly very silty, mostly light yellow-brown; grades to very sandy silt in one part; sand is mostly very fine with some fine in parts; limy zones common; volcanic ash from 270-271 ft............	110	282
Silt and siltstone, very sandy, mostly yellow-brown; sand is very fine; limy zones common..................	282	374
Silt, slightly sandy, brown and pinkish-brown; sand is very fine; contains a few limy zones; lost circulation at 400 ft..	374	430

	Depth, in feet From	To
Gering:		
Sand and sandstone, silty, yellow-brown to light gray with some pale olive in lower part; sand is mostly very fine to fine; below 442 ft., contains trace medium sand to fine gravel and lithic clasts; some interbedded silt	430	451
Sand and gravel, fine sand to fine gravel, poorly sorted.	451	453
Sand and sandstone, slightly silty, mostly very pale brown; sand is very fine to fine; contains some sandy silt, lithic clasts, and a few limy zones in parts	453	510
Sand, very fine to fine with some medium to coarse; numerous lithic clasts	510	519
Silt, pale brown; limy in parts	519	523
Sandstone, silty, brown, with some interbedded sandy silt and pink claystone; sand is very fine to fine; lithic clasts common in parts	523	543
Silt, slightly clayey, pale green and pink, with some interbedded silty sandstone and, in lower part, claystone; sand is very fine; lithic clasts occur in parts	543	563
Silt, mostly very sandy, light brown, with some interbedded silty sand; sand is mostly very fine	563	576
Sand, silty, yellow-brown; sand is very fine	576	583
Silt, light gray and pale brown	583	585
Sand, silty, light brown; sand is very fine with some fine; limy below 588 ft.	585	589
Conglomerate composed mostly of lithic clasts	589	590
Sand, slightly silty, brown, grading downward to sandy silt; sand is very fine with some fine	590	596
Whitney:		
Silt, slightly clayey, pink and light brown; limy zones common; lost circulation at 630 ft.	596	630

Test hole 33N-41W-5bbc
(Field No. 17-B-79)

Location: 922 ft. south and 23 ft. east of northwest corner of sec. 5, T. 33 N., R. 41 W.
Ground altitude: 3,696 ft. (Gordon 7.5-minute quadrangle)
Depth to water: 81.9 ft. (July 23, 1979)

	Depth, in feet From	To
Soil and subsoil	0	5
Upper Harrison:		
Silt and siltstone, mostly moderately sandy, slightly clayey, yellow-brown and brown; sand is mostly very fine; contains small limy zones which are more common below 70 ft.	5	116

	Depth, in feet	
Sand and sandstone, silty, yellow-brown and pale brown; sand is very fine to fine with trace of medium to very coarse; finer grained from 122-130 ft.; more coarse to very coarse sand with trace of fine gravel below 130 ft.; some small limy zones	116	135
Sand and sandstone, very silty, grading to very sandy siltstone in a few parts, gray-brown; sand is very fine to fine; limy zones abundant	135	150
Sand and sandstone, silty in parts, gray-brown; sand is very fine to medium with trace of coarse sand to fine gravel; limy zones common; contains lithic clasts below 167-181 ft.; slightly finer grained and lime-cemented below 181 ft	150	185
Monroe Creek-Harrison:		
Sandstone, very silty, grading to very sandy siltstone in parts, mostly brown; sand is very fine to fine with trace of medium from 198-202 ft.; small limy zones common	185	220
Silt and siltstone, mostly very sandy, clayey in parts, brown; sand is very fine to fine; small limy zones abundant	220	270
Gering:		
Sandstone and sand, moderately silty, brown and gray-brown; very silty in parts; sand is very fine to fine..	270	297
Sandstone and sand, very fine to fine with some medium, gray-brown; very silty and finer grained from 302-306 ft.; lime-cemented from 306-309 ft.; more medium sand and silty below 330 ft	297	335
Beaver Wall siltstone:		
Silt and siltstone, mostly very sandy, slightly clayey in parts, brown; sand is very fine to fine; few small limy zones	335	380
Silt and siltstone, very sandy, grading to very silty sandstone in parts, brown; sand is mostly very fine; sandiest from 380-390 ft	380	410
Silt and siltstone, very sandy, slightly clayey, brown; sand is mostly very fine; small limy zones common	410	430
Sand and sandstone; very silty, brown; sand is mostly very fine; few small limy zones	430	448
Sand and sandstone, silty, brown; sand is very fine to fine with trace of medium; more medium sand below 460 ft.; contains lithic clasts; lime-cemented from 452-458 ft.; and below 462 ft	448	463
Siltstone and silt, mostly slightly sandy, mostly slightly clayey, yellow-brown; sand is very fine; contains some small limy zones	463	490

Test hole 33N-42W-14ddd
(Field No. 16-8-79)

Location: 284 ft. north and about 7 ft. west of southeast corner of sec. 14, T. 33 N., R. 42 W.
Ground altitude: 3,603 ft. (Gordon 7.5-minute quadrangle)
Depth to water: 39.3 ft. (July 23, 1979)

	Depth, in feet From	To
Quaternary:		
Road fill	0	1.5
Clay, silty, very dark gray	1.5	6
Sand and gravel; gravel predominantly lithic clasts	6	10
Upper Harrison:		
Silt and siltstone, mostly moderately sandy, mostly slightly clayey, yellow-brown with some brown; sand is mostly very fine; contains some small limy zones	10	90
Silt, very sandy, grading downward to very silty sand, yellow-brown; sand is mostly very fine; contains lithic clasts of gravel size below 95 ft	90	96
Monroe Creek-Harrison:		
Sandstone and sand, mostly moderately silty, gray-brown; sand is very fine to fine; limy zones abundant	96	139
Sandstone and sand, very silty, grading to very sandy siltstone in parts, brown; sand is mostly very fine with some fine; limy zones abundant	139	147
Gering:		
Sandstone and sand, moderately silty, gray-brown; sand is very fine to fine; contains some small limy zones	147	160
Sand, very fine to fine with some medium, brown to gray-brown; contains some lithic clasts	160	185
Sandstone, very silty, lime-cemented, gray; sand is very fine	185	186
Sandstone, very silty, grading to very sandy siltstone, slightly clayey, brown; sand is very fine; limy zones common	186	204
Sand and sandstone, very fine to fine with some medium and trace of coarse, gray-brown; contains trace of lithic clasts; silty and limy at top	204	216
Sandstone, very silty, brown; sand is very fine to fine	216	220
Sand, fine to medium with trace of coarse, brown; finer grained and limy below 222 ft	220	223
Beaver Wall siltstone:		
Silt and siltstone, slightly to very sandy, slightly clayey in parts, brown and yellow-brown; grades to very silty sandstone in a few parts; sand is very fine to fine; limy zones common to abundant in parts	223	434
Silt very sandy, grading to silty sand, pale brown; sand is very fine to fine with a trace of medium; contains some lithic clasts below 459 ft.; limy zone from 458-459 ft	434	465

Test hole 33N-42W-14ddd - continued

	Depth, in feet From	To
Silt and siltstone, slightly to very sandy, slightly clayey in parts, brown; sand is mostly very fine; contains some small limy zones........................	465	530
Interbedded silty sand, sandy silt, and some claystone; brown in color; sand is mostly very fine..............	530	551
Silt and siltstone, mostly slightly sandy, mostly slightly clayey, mostly brown; sand is very fine; contains some small limy zones........................	551	650
Nonpareil ash zone:		
Very ashy silt and very impure volcanic ash, pale brown..	650	668
Whitney:		
Silt and siltstone, slightly sandy, slightly clayey, brown to gray-brown..................................	668	680

Test hole 33N-44W-23bcc
(Field No. 15-B-79)

Location: About 2,440 ft. south and 51 ft. east of northwest corner of sec. 23, T. 33 N., R. 44 W.
Ground altitude: 3,860 ft. (Clinton SW 7.5-minute quadrangle)
Depth to water: 140.9 ft. (July 7, 1979)

	Depth, in feet From	To
Old road fill...	0	5
Upper Harrison:		
Silt and siltstone, slightly sandy, light brown; sandier below 40 ft.; sand is very fine to fine; few limy zones..	5	66
Sand and sandstone, silty, pale brown; sand is very fine to medium with trace of coarse and very coarse sand....	66	80
Sand and sandstone, very fine to medium with some coarse to very coarse, olive-brown; silty and limy in parts; contains lithic clasts up to fine-gravel size.........	80	113
Sand and sandstone, silty, limy, white; sand is very fine to fine...	113	116
Monroe Creek-Harrison:		
Silt and siltstone, sandy, light brown and light yellow-brown: sand is mostly very fine; abundant hard limy zones from 116-181 ft................................	116	200
Gering:		
Sand, silty, light brown; sand is very fine to medium....	200	210
Sand and sandstone, very fine to coarse, much fine to medium; lithic clasts abundant; contains some inter-bedded silty sand......................................	210	230
Silt, sandy, light brown; grades to silty sand in lower part; sand is very fine to fine........................	230	240

	Depth, in feet From	To
Sand and sandstone, very fine to fine, light brown; lithic clasts abundant; contains some interbedded silty sand	240	262
Siltstone and silt, very sandy, yellow-brown and brown; sand is mostly very fine; limy zones abundant	262	272
Silt and siltstone, strong brown; sandy and contains limy zones below 288 ft	272	296
Sand and sandstone, silty, brown; sand is very fine to fine	296	300
Sand, and sandstone, very fine to fine with some medium and trace of coarse, light brown; contains some interbedded silty sand and some lithic clasts; lime-cemented below 312 ft	300	313
Sand, very fine to fine, light brown	313	317
Silt and siltstone, slightly sandy, light yellow-brown; sand content increases downward; sand is very fine to fine; limy below 329 ft	317	330
Sand, very fine to medium, light brown; lithic clasts common; contains some interbedded silty sand and, near base, siltstone	330	342
Volcanic ash, very pale brown	342	344
Silt and siltstone, mostly slightly sandy, brown; sand is very fine	344	355
Sand, silty in parts, brown; sand is very fine to fine with some medium	355	363
Silt and siltstone, sandy, light brown; limy zones common	363	373
Sand and sandstone, silty in parts, brown and pale brown; sand is very fine to medium; few limy zones	373	382
Silt and siltstone, sandy, brown and pinkish brown; sand is very fine to fine; few limy zones	382	390
Sand, silty, very pale brown; sand is very fine to fine with some medium	390	395
Silt and siltstone, slightly sandy, brown; sand is very fine; contains some silty sand from 406-413 ft.; few limy zones	395	430
Sand and sandstone, silty, pale brown and brown; sand is mostly very fine to fine with some medium; lithic clasts common in parts; limy at base	430	467
Beaver Wall siltstone?: (could be Whitney)		
Silt and siltstone, mostly brown, few small limy zones	467	560

Test hole 33N-45W-31dad
(Field No. 17-B-78)

Location: About 1,600 ft. north and 128 ft. west of southeast corner of sec. 31, T. 33 N., R. 45 W.
Ground altitude: 3,985 ft. (White Clay SW 7.5-minute quadrangle)
Depth to water: Unable to measure

Test hole 34N-42W-24aba
(Field No. 18-B-79)

Location: About 7 ft. south and about 1,640 ft. west of northeast corner of sec. 24, T. 34 N., R. 42 W.
Ground altitude: 3,755 ft. (Gordon NW 7.5-minute quadrangle)
Depth to water: Unable to measure

	Depth, in feet From	To
Top soil and subsoil	0	6
Upper Harrison:		
Silt and siltstone, mostly slightly sandy, mostly slightly clayey, yellow-brown and brown; sand is mostly very fine; small limy zones common from 6-76 ft.	6	94
Silt, very sandy, grading to sand, very silty, brown; sand is mostly very fine	94	100
Sand, very silty, brown; sand is very fine to fine with some medium and rare coarse grains; less silty and coarser downward	100	106
Sandstone and sand, silty in parts, mostly brown; sand is very fine to medium with rare coarse grains; contains lithic clasts below 122 ft.; limy zones abundant	106	130
Sand and sandstone, silty in parts, brown; sand is fine to medium with trace of coarse to very coarse; trace of crystalline fine gravel from 130-147 ft.; lithic clasts common from 130-147 ft., some of fine-gravel size; finer grained and siltier from 147-150 ft.; small limy zones common	130	151
Monroe Creek-Harrison:		
Sand and sandstone, silty, dark gray-brown; sand is very fine to fine with trace of medium; limy zones abundant	151	164
Silt and siltstone, mostly moderately sandy, yellow-brown and brown; sand mostly very fine; limy zones common	164	200
Silt and siltstone, slightly sandy, slightly clayey, brown; sand mostly very fine; contains some small limy zones; sandier and less clayey below 240 ft.	200	250
Gering:		
Sandstone and sand, slightly silty, brown; sand is very fine to fine with trace of medium; very silty from 253-256 ft.	250	260
Sand and sandstone, very fine to fine with some medium and trace of coarse, brown; contains some interbedded very silty sandstone, very fine to fine and some lithic clasts from 280-288 ft. and below 290 ft.; limy zones common below 280 ft.	260	297
Silt, very sandy, grading downward to sand, very silty, yellow-brown; sand is very fine to fine; some small limy zones	297	303

Test hole 33N-45W-31dad - continued

	Depth, in feet From	To
Quaternary:		
Soil	0	2
Silt, slightly clayey, yellow-brown	2	5
Sand, silty, pebbly, pale brown; pebbles are mostly lithic clasts	5	11
Ogallala:		
Sand, silty, pale brown; sand is very fine to fine with some medium sand to fine gravel; one limy zone	11	15
Sand and sandstone, very fine to medium with some coarse to very coarse and a little fine to coarse gravel; contains numerous limy zones and some inter-bedded silt	15	41
Upper Harrison:		
Silt, moderately to very sandy, brown and yellow-brown; sand is very fine to fine; limy zones common in upper part	41	101
Sand and sandstone, silty in upper part, brown and yellow-brown; sand is fine to very fine; trace of medium sand from 120-134 ft.; and trace of coarse sand below 130 ft.; contains some limy zones	101	134
Monroe Creek-Harrison:		
Sand, mostly moderately silty, mostly brown; sand is very fine to fine; contains few limy zones	134	189
Mostly silt, very sandy, yellow-brown and brown; sand is very fine to fine	189	225
Gering:		
Sand, silty, light brown and light gray; sand is very fine to fine; contains lithic clasts from 225-230 ft.; few limy zones	225	243
Sand and sandstone, silty in parts with small amount of pink claystone; sand is very fine to medium with some coarse; lithic clasts and limy zones common	243	254
Beaver Wall siltstone:		
Silt, sandy, yellow-brown to brown; grades to very silty sand is one or two parts; sand is mostly very fine	254	460
Silt, very sandy, and sand, very silty, yellow-brown; sand is very fine to fine; contains lithic clasts	460	468
Nonpareil ash zone:		
Volcanic ash, very impure, very pale brown	468	473
Silt, slightly sandy, yellow-brown; sand is very fine	473	489
Silt, very sandy, brown; sand is very fine to fine; lithic clasts common	489	508
Whitney:		
Silt, slightly sandy, slightly clayey, mostly yellow-brown and brown; very sandy in parts; sand is very fine	508	554
Silt, slightly clayey in parts, light brown	554	600
Silt, slightly to moderately clayey, mostly brown; contains a few limy zones	600	796

	Depth, in feet From	To
Sand and sandstone, silty, yellow-brown; sand is very fine to fine with some medium at top; limy zones common	303	313
Beaver Wall siltstone:		
Silt and siltstone, moderately to very sandy, mostly slightly clayey, yellow-brown; sand is very fine; small limy zones common	313	354
Sand, silty, brown; sand is very fine to fine with trace of medium and lithic clasts; very silty in parts and grades to sandy silt in parts; some small limy zones	354	374
Silt and siltstone, mostly very sandy, yellow-brown; sand is mostly very fine; some small limy zones	374	400
Sand, very silty, yellow-brown and brown; sand is very fine to fine; trace of lithic clasts from 400-410 ft.; some small limy zones below 415 ft.	400	420
Siltstone and silt, slightly to very sandy, yellow-brown; sand is mostly very fine; some small limy zones.	420	466
Sand and sandstone, mostly very silty, brown; sand is mostly very fine with some fine; contains trace of medium from 470-476 ft.; more fine sand and less silty below 480 ft.; few small limy zones	466	493
Silt, very sandy, brown; sand is very fine to fine	493	500
Silt and siltstone, mostly very sandy, yellow-brown and pale brown; grades to very silty sand in parts; sand is mostly very fine; some limy zones below 528 ft.	500	540
Silt and siltstone, mostly slightly sandy, slightly to moderately clayey, brown; sand is very fine; contains some small limy zones	540	610

Test hole 35N-41W-19bc
(Field No. 20-B-79)

Location: About 950 ft. south and about 600 ft. east of northwest corner of sec. 19, T. 35 N., R. 41 W.
Ground altitude: 3,560 ft. (Gordon NW 7.5-minute quadrangle)
Depth to water: 15.2 ft. (July 29, 1979)

	Depth, in feet From	To
Quaternary:		
Soil	0	2
Sand, fine to medium, brown	2	25
Silt, sandy, clayey, peaty, very dark gray	25	28
Sand, fine to medium, brown and olive-gray	28	46
Silt, sandy, clayey, olive-gray; contains some lithic gravel in lower part	46	50

Test hole 35N-41W-19bc - continued

	Depth, in feet From	To
Ogallala:		
Sand and sandstone, very fine to medium, brown; silty in a few parts	50	81
Upper Harrison:		
Silt and siltstone, mostly very sandy, greenish gray and olive-gray from 81-97 ft. and pale brown below 97 ft.; sand is very fine to fine; contains a few thin, clayey-silt beds and some limy zones	81	110
Silt and siltstone, slightly sandy, slightly clayey, pale brown	110	120
Siltstone, brown and pale brown; limy below 138 ft.	120	140
Siltstone and silt, mostly very sandy, grading to very silty sandstone in parts, pale brown and light yellow-brown; sand is very fine; contains a few claystone seams in parts; limy zones common	140	180
Siltstone and silt, slightly to moderately sandy, slightly clayey in parts, pale brown, brown, and light yellow-brown; grades to very silty sandstone in parts from 190-199 ft.; more sandy below 250 ft.; sand is mostly very fine	180	296
Sandstone and sand, very silty, mostly grayish brown with some brown; grades to very sandy siltstone in a few parts; sand is very fine to fine; some medium sand with rare coarse grains below 314 ft.; limy zones common	296	330
Sandstone and sand, fine to medium with a trace of coarse, gray-brown to brown; more coarse sand below 340 ft.; rare very coarse sand and fine gravel grains throughout; contains some lithic clasts, some of gravel size; lime-cemented from 337-340 ft.	330	350
Monroe Creek-Harrison:		
Sandstone and sand, very silty, gray-brown to brown; grades to very sandy siltstone in parts; sand is very fine to fine; limy zones common	350	365
Gering?:		
Sand and sandstone, silty in parts, mostly gray-brown; sand is very fine to fine with a trace of medium; rare coarse grains and some interbedded claystone seams in parts; contains lithic clasts and some limy zones	365	about 385
Sand and sandstone, mostly very silty, gray-brown; sand is very fine to fine; contains some lithic clasts and limy zones	about 385	415
Sand, very fine to medium with a trace of coarse, very pale brown; contains some interbedded sandy silt and silty sand and trace of lithic clasts	415	420
Sand, medium to coarse with some very coarse sand and fine gravel; contains some lithic clasts	420	423

	Depth, in feet From	To
Silt and siltstone, very sandy, gray-brown; grades to very silty sandstone in parts; sand is very fine to fine; contains a few limy zones	423	450
Sand, very fine to fine with trace of medium, gray-brown; contains a few lithic clasts	450	460
Sand, very fine to fine with some medium and trace of coarse to very coarse; contains some lithic clasts	460	470
Sand, medium to coarse with some very coarse sand to fine gravel, gray-brown; contains lithic clasts and a little interbedded silty sandstone, very fine to fine	470	480
Sand, very silty, grading downward to silt, very sandy, gray-brown to brown; sand is very fine to fine; trace of lithic clasts from 480-484 ft	480	490
Silt, very sandy, very slightly clayey, gray-brown; grades to very silty sand in lower part; sand is very fine	490	507
Sandstone, moderately silty, gray-brown; sand is fine to very fine; probably contains trace of lithic clasts	507	510
Beaver Wall siltstone:		
Silt and siltstone, moderately sandy, slightly clayey, brown; more sand and less clayey below 550 ft.; contains a few limy zones	510	560
Silt, very sandy, and sand, very silty, gray-brown to brown; sand is very fine with some fine; limy below 584 ft	560	585
Sand, very fine to fine with trace of medium, light brownish-gray to light gray-brown; contains some lithic clasts of fine-gravel size; limy and finer grained below 593 ft	585	594
Silt to siltstone, moderately to slightly sandy, mostly slightly clayey, light yellow-brown to brown; sand is very fine	594	630

Test hole 35N-41W-31ccc
(Field No. 19-B-79)

Location: 322 ft. north and 12 ft. east of southwest corner of sec. 31, T. 35 N., R. 41 W.
Ground altitude: 3,580 ft. (Gordon NW 7.5-minute quadrangle)
Depth to water: 6.8 ft. (July 23, 1979)

	Depth, in feet From	To
Quaternary:		
Soil	0	3.5
Sand, fine to medium	3.5	4.5
Sand and gravel; contains gravel-size lithic clasts	4.5	12

Test hole 35N-41W-31ccc - continued

	Depth, in feet From	To
Ogallala:		
Silt, sandy, clayey, with some interbedded sandstone, light gray and light olive-gray; sand is very fine to fine; contains some limy zones......................	12	18
Sand, fine to coarse, olive..................................	18	20
Upper Harrison:		
Siltstone and silt, slightly to very sandy, mostly slightly clayey, olive from 20-28 ft. and mostly yellow-brown below 28 ft.; limy zones common...........	20	64
Sand, very fine to fine; contains some lithic clasts.....	64	68
Silt, moderately sandy, slightly clayey, pale yellow-brown...	68	70
Sand, fine to medium with trace of coarse; contains lithic clasts..	70	73
Silt and siltstone, slightly to very sandy, mostly slightly clayey, mostly yellow-brown; small limy zones common...	73	100
Sand, very fine to medium with trace of coarse with silty clay seams.......................................	100	102
Siltstone and silt, mostly slightly sandy, variable clay content, mostly yellow-brown; grades to very silty sand, very fine in parts from 193-205 ft.; small limy zones common..	102	229
Lime-cemented siltstone and silty sandstone, mostly white; sand is very fine to fine with some medium......	229	234
Sandstone and sand, silty, pale brown; sand is very fine to fine with some medium to coarse with rare very coarse grains; lithic clasts common in parts and reach medium gravel size; few small limy zones..............	234	270
Monroe Creek-Harrison?:		
Sandstone, silty, gray-brown; sand is very fine to fine with trace of medium sand from 289-300 ft.; limy zones abundant, some as much as 2-ft. thick and hard.........	270	326
Gering?:		
Sand, very silty, very fine to fine, with some light brown claystone..	326	329
Sand, very fine to fine, gray-brown; with few lithic clasts..	329	341
Sand, fine to medium with some coarse to very coarse sand and trace of fine gravel; few lithic clasts.......	341	348
Silt, very sandy, slightly clayey, brown and yellow-brown; sand is very fine to fine; small limy zones common..	348	376
Sand, very silty grading downward to slightly silty, brown and gray-brown; sand is very fine to medium with less medium from 376-380 ft...........................	376	385
Silt, very sandy, grading to sand, very silty in parts, mostly yellow-brown; sand is very fine to fine with trace of medium below 395 ft..........................	385	410

	Depth, in feet From	To
Sand, moderately silty, brown; sand is very fine to fine.	410	420
Sand, slightly silty, very fine to fine with some medium and a trace of coarse, brown; contains a few lithic clasts up to fine-gravel size........................	420	430
Sand, moderately silty, very fine to fine with a trace of medium, brown; limy zones abundant.................	430	440
Beaver Wall siltstone:		
Silt and siltstone, slightly to moderately sandy, slightly to moderately clayey, yellow-brown; contains some small limy zones.................................	440	470

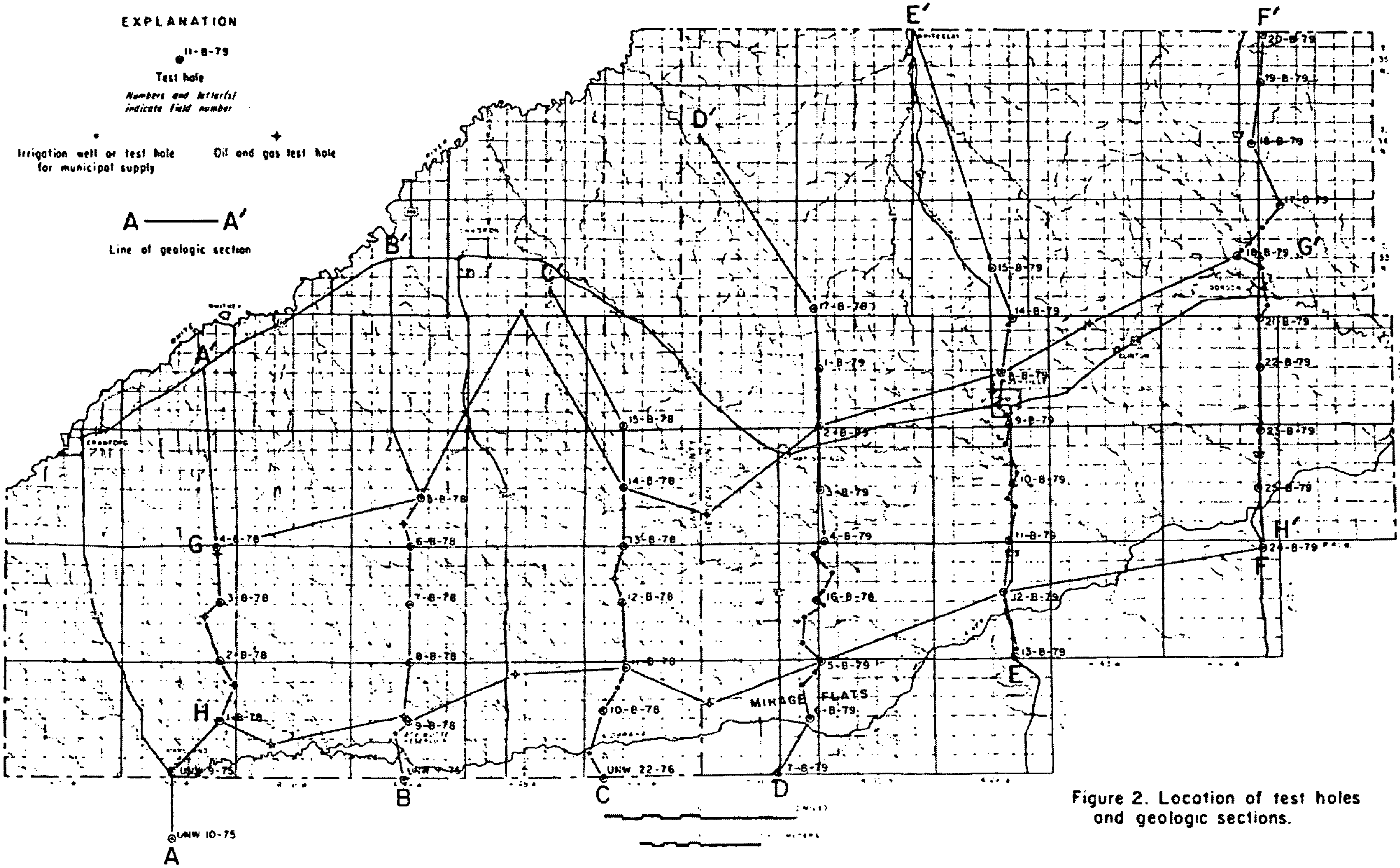

Figure 2. Location of test holes and geologic sections.

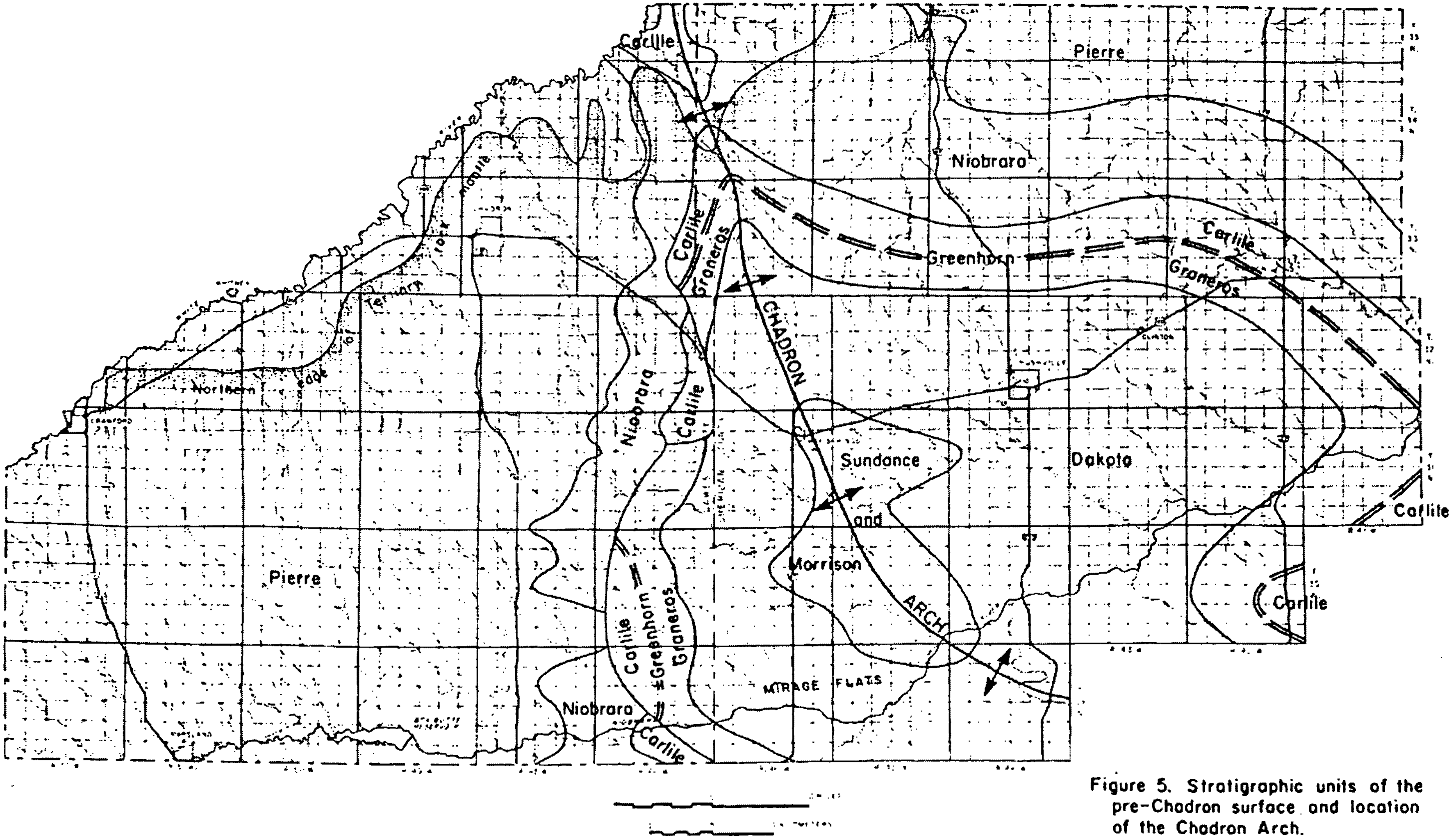

Figure 5. Stratigraphic units of the pre-Chadron surface and location of the Chadron Arch.

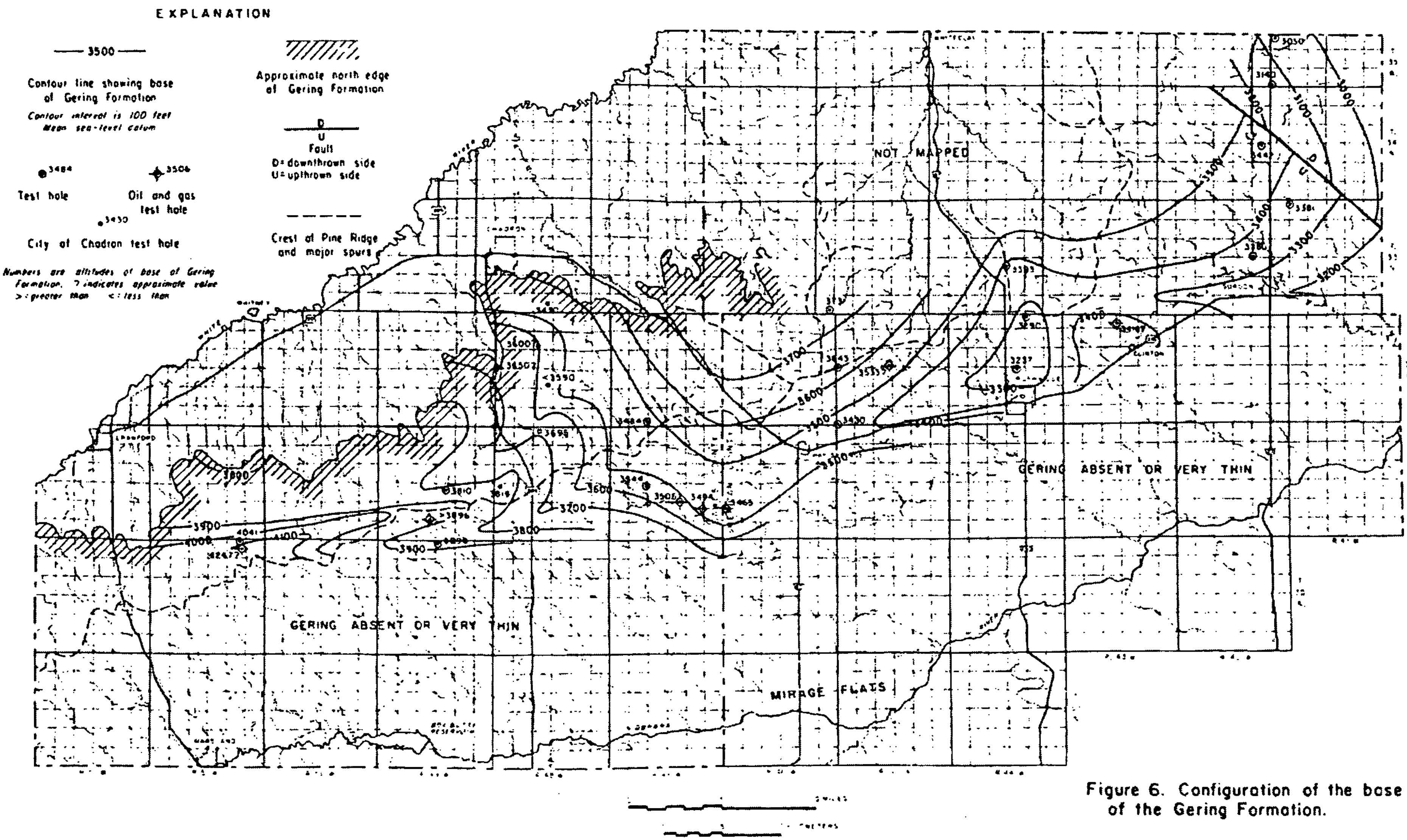

Figure 6. Configuration of the base of the Gering Formation.

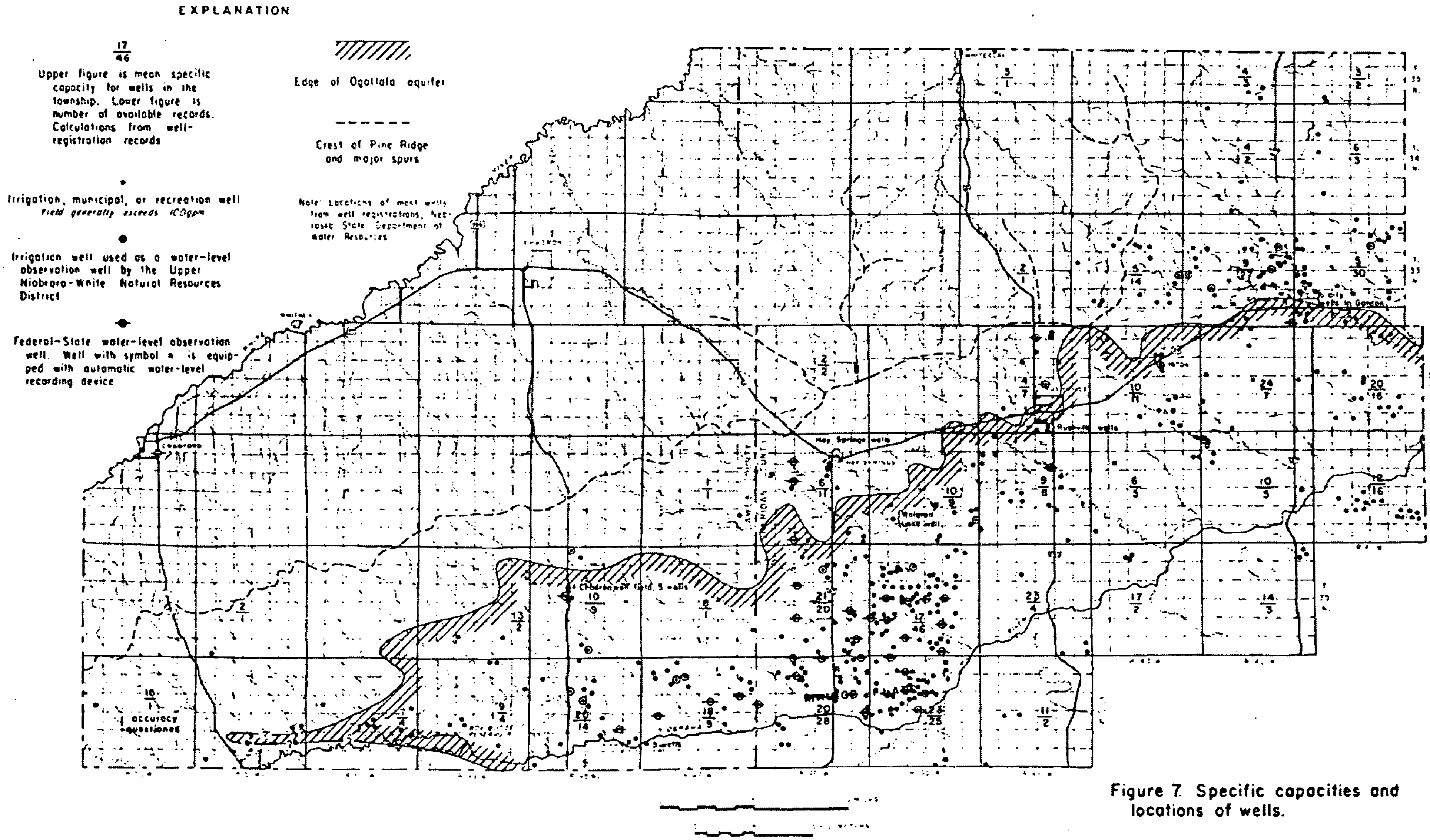

Figure 7. Specific capacities and locations of wells.

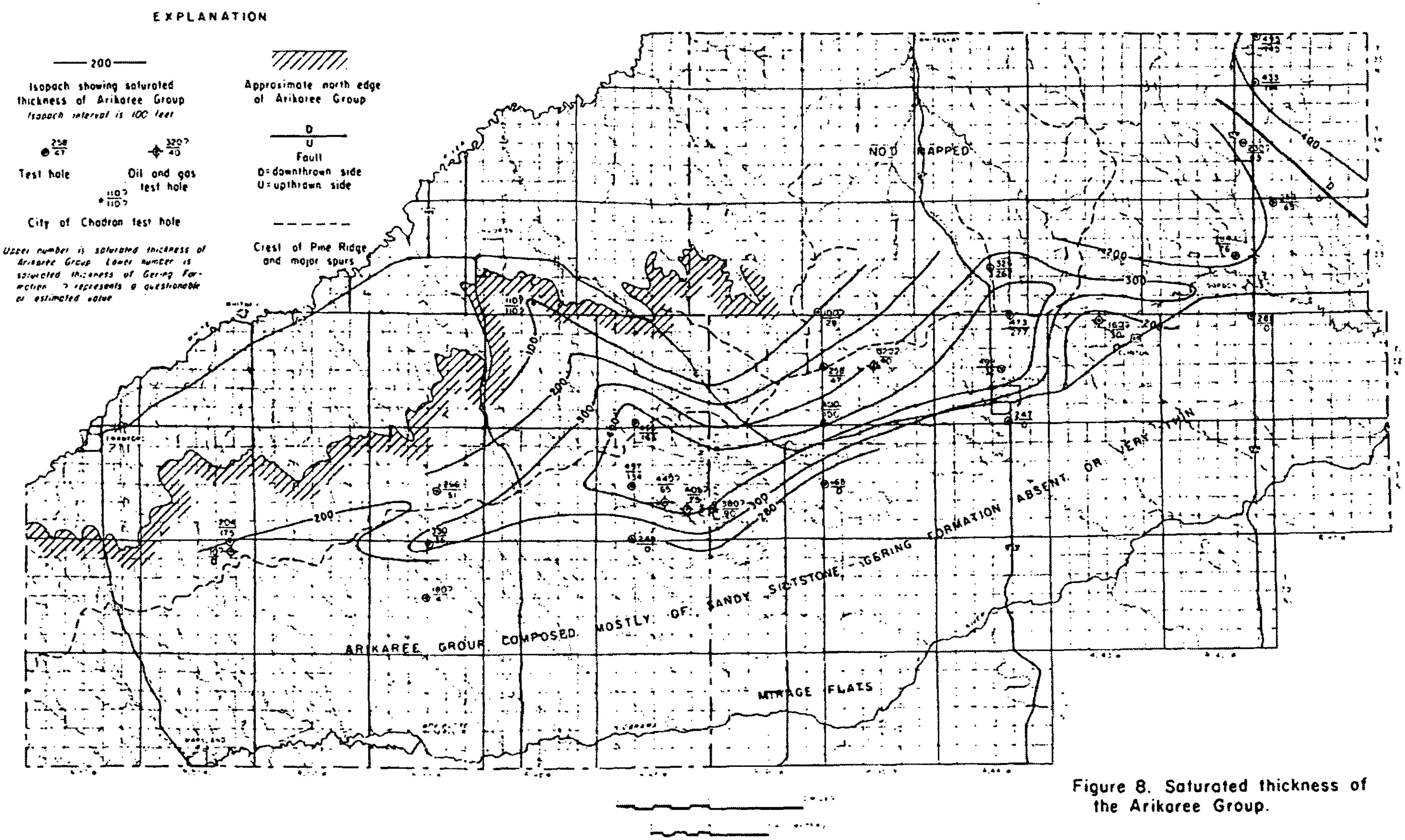

Figure 8. Saturated thickness of the Arikaree Group.

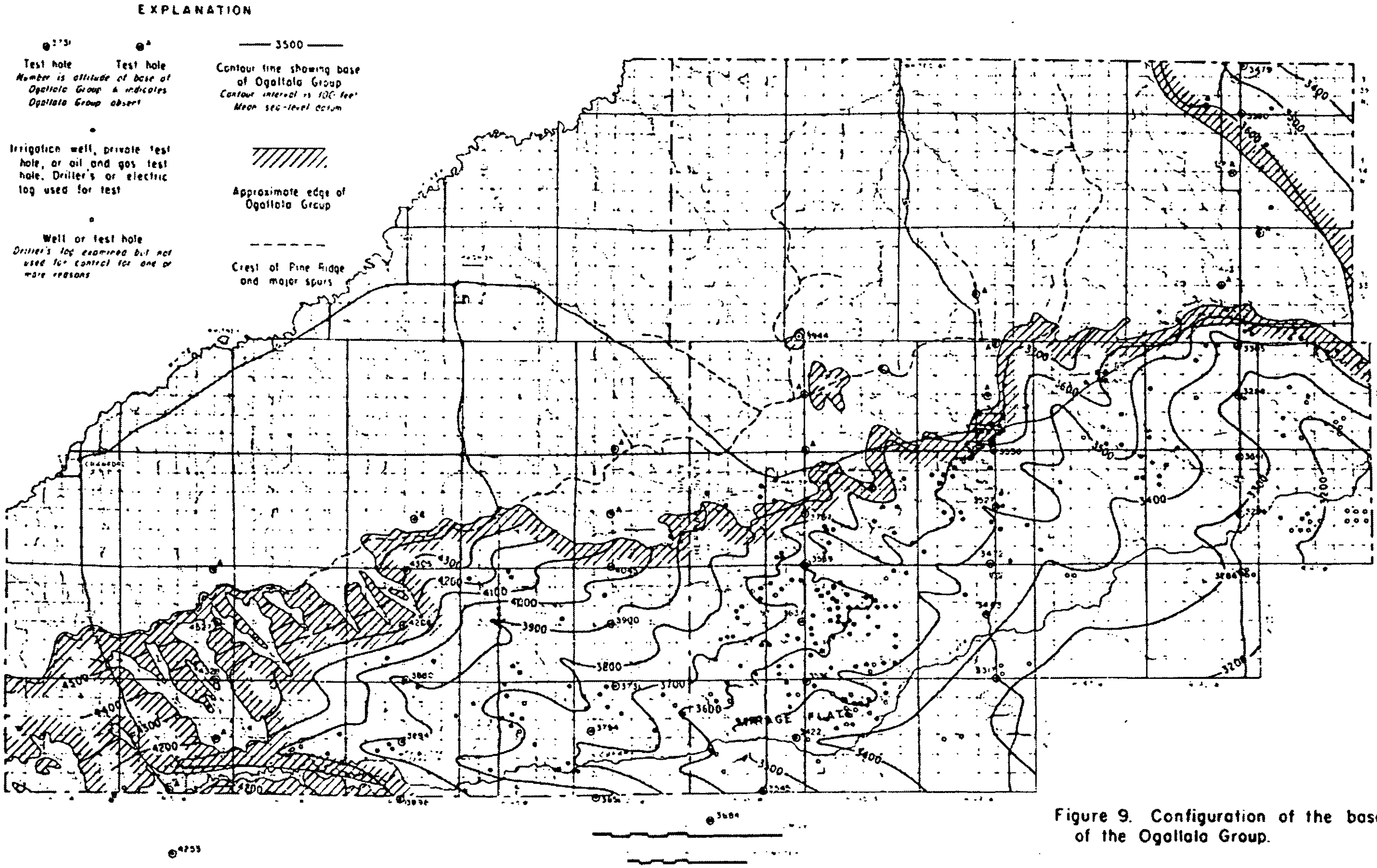

Figure 9. Configuration of the base of the Ogallala Group.

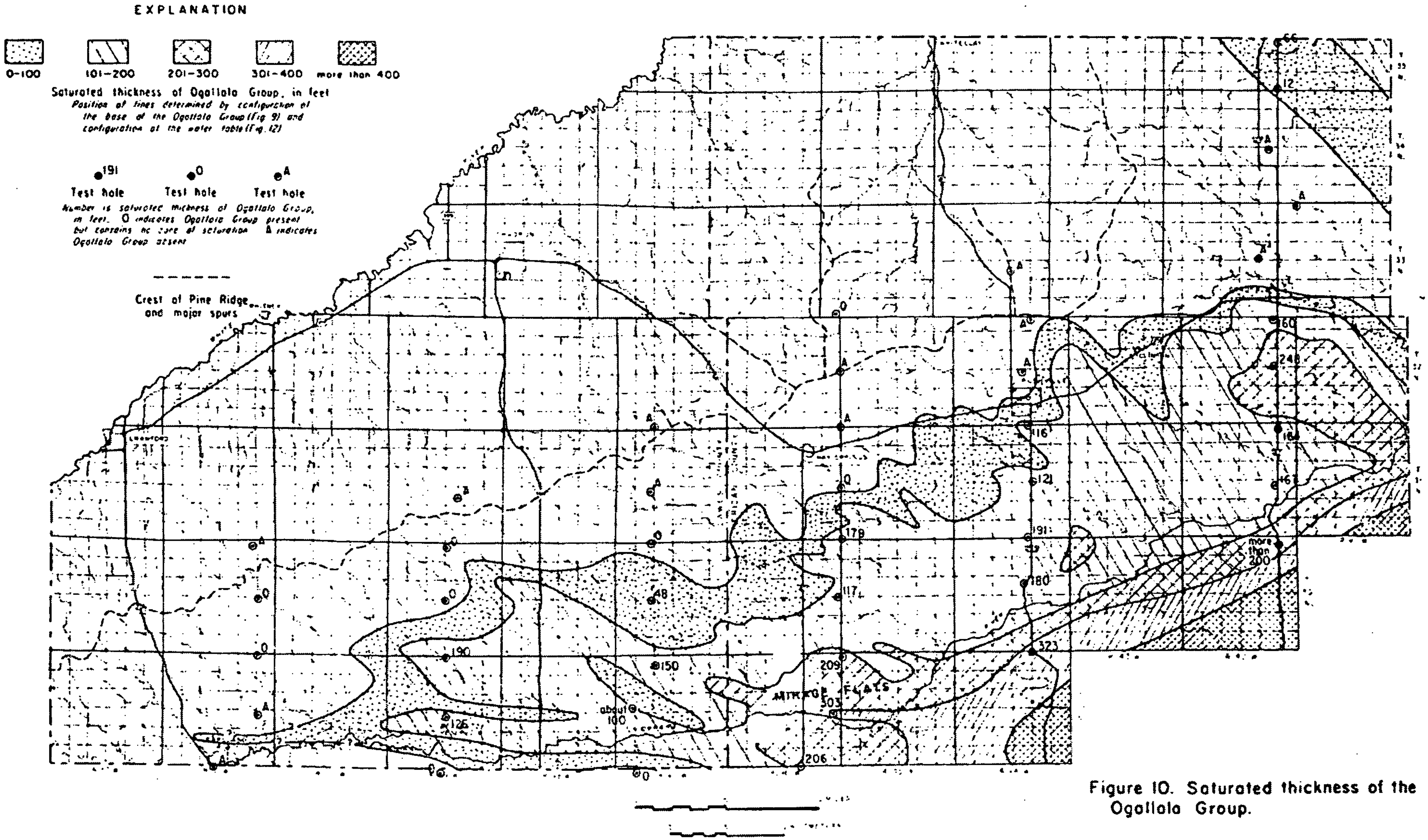

Figure 10. Saturated thickness of the Ogallala Group.

EXPLANATION

Linear

Crest of Pine Ridge and major spurs

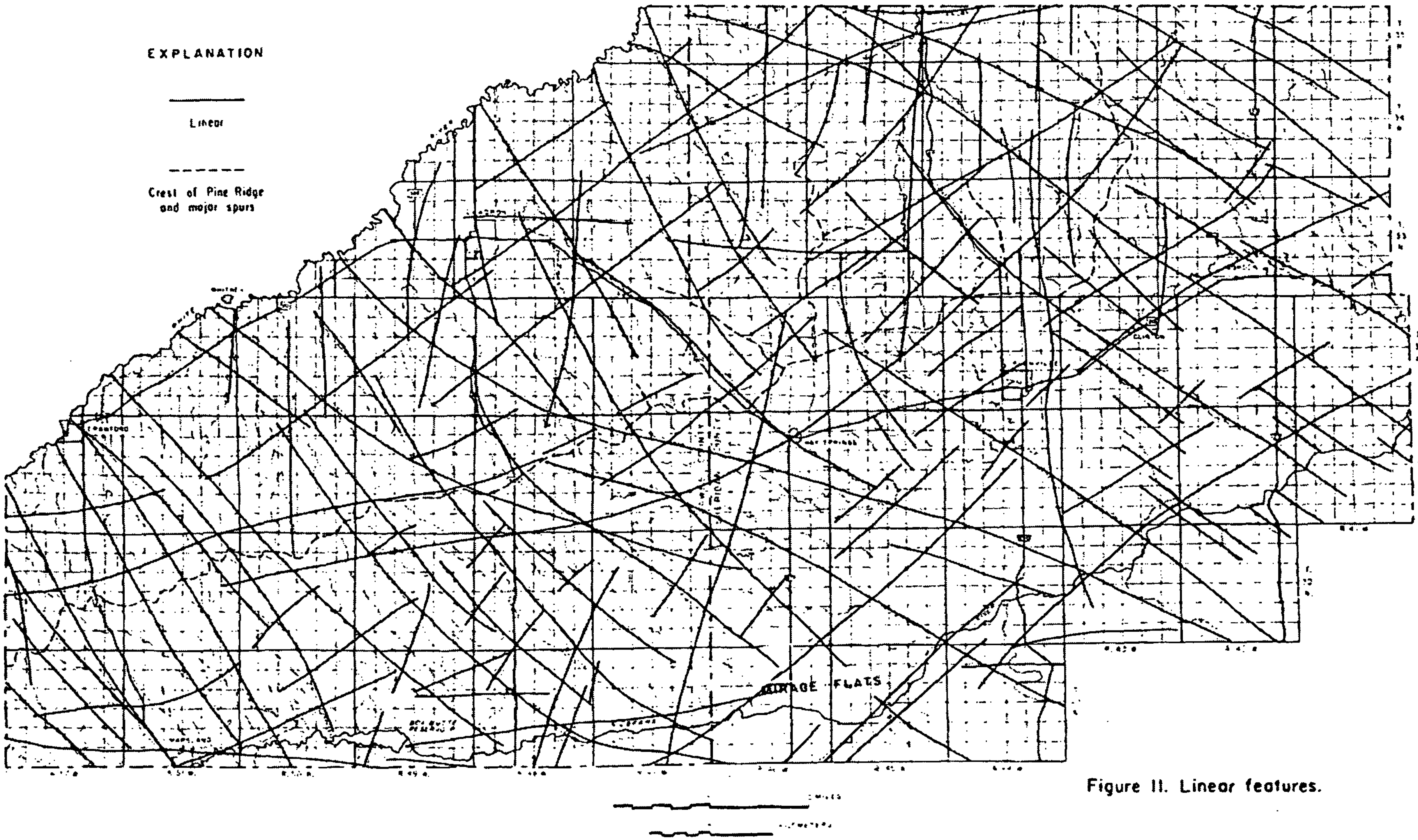

Figure 11. Linear features.

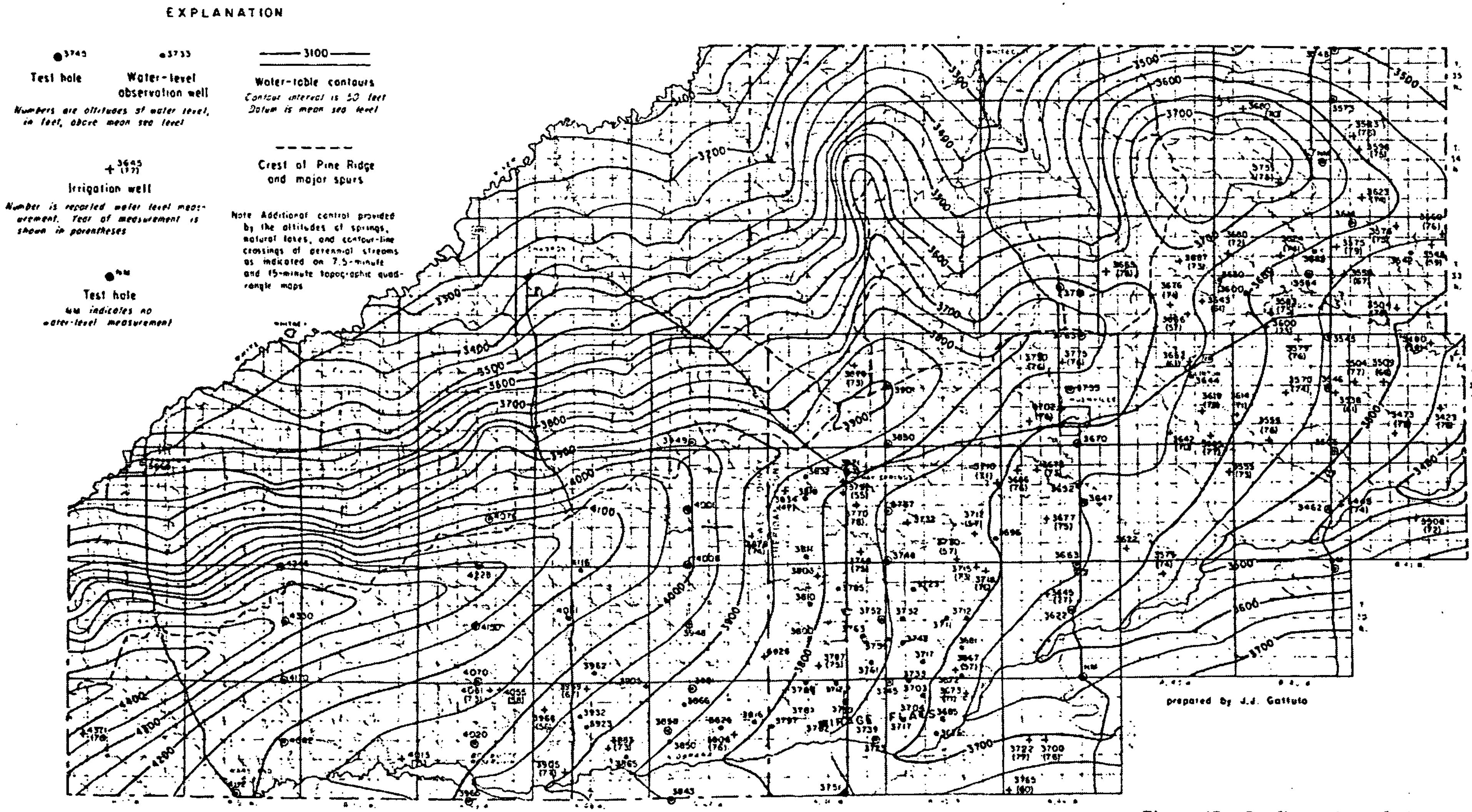

Figure 12. Configuration of the water table, 1979.

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