GROUND WATER IN THE NECHE AREA PEMBINA COUNTY, NORTH DAKOTA

By

Quentin F. Paulson
Geologist, Geological Survey
United States Department of the Interior

NORTH DAKOTA GROUND WATER STUDIES
NO. 16

Prepared by the United States Geological Survey in cooperation with the North Dakota State Water Conservation Commission, and the North Dakota Geological Survey

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NORTH DAKOTA STATE WATER CONSERVATION COMMISSION
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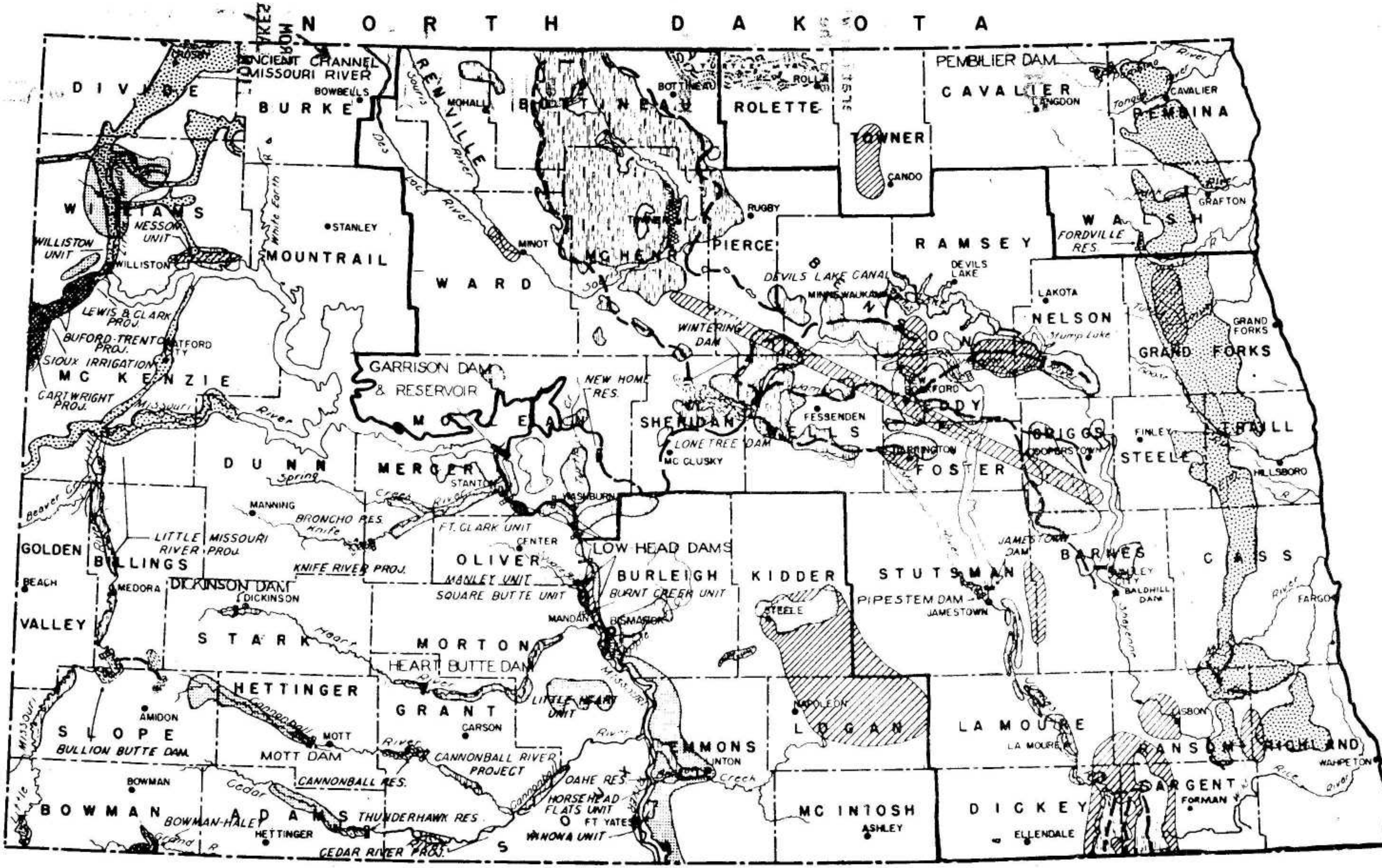
"BUY NORTH DAKOTA PRODUCTS"

HYDROLOGIC CYCLE



NORTH DAKOTA STATE WATER CONSERVATION COMMISSION

WATER RESOURCES DEVELOPMENT PLAN

LANDS UNDER IRRIGATION

AREAS CONSIDERED IRRIGABLE

AREAS BEING INVESTIGATED

PROPOSED FOR INVESTIGATION

EXISTING

UNDER CONSTRUCTION OR PROPOSED

DAM & RESERVOIR SITES

PROPOSED CANALS

GARRISON DIVERSION CONSERVANCY DISTRICT BOUNDARY

GROUNDWATER AQUIFERS

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ABSTRACT

The Neche area is in the extreme north-central part of Pembina County, North Dakota. It is entirely within the Red River Valley and physiographically, is a flat, relatively featureless lake plain which has undergone little erosion. It is drained imperfectly by Pembina River, Tongue River, and several coulees tributary to these streams.

Aside from the stream valleys and natural levees along Pembina River, Horrigan Ridge constitutes the only topographic relief in the area. Several beaches of glacial Lake Agassiz are present in the area but they are not conspicuous features.

The only community in the area is the village of Neche near Pembina River. According to the preliminary 1950 census figures, the population of Neche is 565. The village serves as a shipping and trading center for the surrounding farm territory.

The surficial sediments in the Neche area are the deposits of Pembina River, the silt unit of the Lake Agassiz deposits, and the deposits of Horrigan Ridge.

The deposits of Pembina River are made up of interbedded sand, clay, and silt strata reaching thicknesses as great as 40 feet near the stream. The deposits extend considerable distances on each side of the river and may occupy a width of nearly three-fourths of a mile in places. They form an important aquifer in the area and are the source of many farm water supplies along the river and of domestic water supplies in the northern part of Neche. Probably the most favorable sites for the development of wells for municipal supplies in Neche are along the banks of Pembina River, where these deposits are thickest and where conditions for infiltration of river water to the aquifers would be favorable as soon as pumping was begun.

The silt unit of the Lake Agassiz deposits is a poor though extensive aquifer in the area and a large number of shallow wells obtain small amounts of water from it for domestic and stock supply. It is not, however, considered to be a potential source of supply for municipal or other purposes requiring greater amounts of water.

The deposits of Horrigan Ridge are stratified materials ranging in size from clay and silt to gravel. The deposits are half a mile wide or more in some places and as much as 54 feet thick. Because of the high percentage of silt and clay in them, the deposits are not considered to

be a potential source of municipal or industrial water supplies. However, larger and more adequate supplies can be developed from these deposits than from the silt unit of the Lake Agassiz deposits.

The clay unit of the Lake Agassiz deposits is overlain unconformably by the silt unit of the Lake Agassiz deposits and other surficial sediments. So far as is known, it underlies the entire Neche area. It rests unconformably upon till and associated glacioaqueous deposits and may vary considerably in thickness. It is more than 75 feet thick near Neche but probably thins toward the west. For all practical purposes this unit is not water bearing, and no wells in the Neche area are known to yield water from it.

Till and associated glacioaqueous deposits underlie the Lake Agassiz deposits. The till is a heterogeneous mixture of clay, sand, gravel, and boulders and is not an aquifer. However, deposits of sand and gravel, generally of glaciofluvial origin, may be associated with the till and locally may be aquifers of some importance. In some places the deposits of sand and gravel may be sufficiently widely distributed and interconnected to make the entire unit an aquifer, although not greatly productive. Wells in the till and associated glacioaqueous deposits in the Neche area range in depth between 62 and 215 feet and some of them have a small flow. Most of the wells yield highly saline water, which is considered to be unfit for most domestic purposes.

The shales and sandstones of Cretaceous age, which are the youngest consolidated rocks underlying a large part of eastern North Dakota, probably are not present in the Neche area. Instead, the youngest consolidated rocks in the area probably are of Paleozoic age and may include representatives of such well-known water-bearing formations as the St. Peter sandstone, the Jordan sandstone, and the Dresbach sandstone. In western Minnesota and eastern North Dakota, representatives of these formations invariably yield highly mineralized water. Wells at Hamilton and St. Thomas, North Dakota, yield waters containing 20,290 and 42,345 parts per million of dissolved solids, respectively, and these waters are thought to come from the St. Peter (?) sandstone.

Pre-Cambrian gneiss and other crystalline rocks generally referred to as "granite" underlie the Paleozoic formations and extend downward to unknown depths. They essentially are not water bearing.

Chemical analyses of seven water samples obtained from the surficial sediments in the vicinity of Neche were made by the North Dakota State Department of Health. In these samples dissolved solids ranged from 710 to 3,280 parts per million and total hardness ranged from 420 to 2,350 parts per million.

INTRODUCTION

Purpose and Scope of the Investigation

This is a preliminary report covering a part of the study of the geology and ground-water resources of Pembina County, North Dakota, which is being made by the United States Geological Survey in cooperation with the North Dakota State Water Conservation Commission and the State Geological Survey as one of a series of investigations of different counties in the State. The purpose of these general studies is to determine the occurrence, movement, discharge, and recharge of the ground water, and the quantity and quality of such water available for municipal, domestic, irrigation, and industrial supplies. At present, the most critical need is for adequate perennial water supplies for many towns and small cities throughout the State wishing to construct municipal water-supply and sewage-disposal systems. For this reason, the county-wide studies are being started in the vicinity of those towns requesting the help of the State Water Conservation Commission and the State Geologist in determining the ground-water conditions in their area. Preliminary reports are being released before the completion of the general studies so that current data may be available as soon as possible for use in connection with immediate problems.

This report presents data for an area 12 miles long and 7½ miles wide, which is of immediate interest to the village of Neche in its search for a suitable ground-water supply. Neche is in the north-central part of the area.

Well-inventory work in the area and instrumental leveling in Neche were done in the fall of 1948. In order to determine the nature of the fluvial and lake depositis, 18 shallow test holes were drilled in the area in the early summer of 1949.

The investigation was made under the general supervision of A. N. Sayre, Chief of the Ground Water Branch, Water Resources Division, of the Federal Geological Survey. The field work and test drilling were done under the direct supervision of P. D. Akin, District Engineer. Wells were inventories by the author. In addition, unpublished well records obtained by the county assessors in 1939 as a part of a State-wide well inventory under the Works Projects Administration were available,and many of them are included in this report. Test drilling was done by Keith Hanson and John T. McMasters.

Acknowledgments

The work was facilitated by the excellent cooperation of residents in the area and particularly by the efforts of Mr. Grant Trenbeath, Mr. Vic Swenson, and other village officials.

Data were obtained from several of the reports of the North Dakota Geological Survey and references to them are given in the text. Chemical analyses of water samples were made by the North Dakota State Department of Health and the assistance received from this department is gratefully acknowledged.

Previous Investigations

No previous investigations dealing specifically with the ground-water resources in the Neche area have been made. Simpson (1929, pp. 182-186) discussed the general ground-water problems of Pembina County and he gave the locations and descriptions of several wells in the Neche area. The geology of northeastern North Dakota is described in a report on cement materials by Barry and Melstad (1908, pp. 115-211). Sources of information concerning the glacial Lake Agassiz and its deposits include the works of Upham (1895), Tyrell (1896, pp. 811-815). Johnston (1916, pp. 625-638), and Dennis, Akin, and Worts (1949).

Location and General Features of the Area

The Neche area is in the north-central part of Pembina County; it includes T. 163 N., Rs. 53 and 54 W., and a strip approximately 1½ miles wide by 12 miles long adjoining the Canadian border in T. 164 N., Rs. 53 and 54 W. It is entirely in the Red River Valley and is a part of the Central Lowlands physiographic province (Fenneman, 1938, pp. 559-568). (See fig. 1)

Except for the narrow, incised trench occupied by Red River, the modern Red River Valley is not a true valley produced by river erosion, but instead is a flat, relatively featureless lake plain which is little eroded. In the Neche area the plain is poorly drained and from Neche east to Red River marshy areas are particularly numerous.

The general land surface in the area slopes to the east at a rate of approximately 5 feet per mile and to the north at a somewhat lesser rate. Pembina River flows eastward in a meandering course across the plain and discharges into Red River and ultimately into Hudson Bay. Along the banks of Pembina River are low natural levees, deposited during the higher river stages.

Tongue River enters and leaves the area in the southeastern corner, and much of the area is drained imperfectly through shallow coulees to this stream.

Aside from the stream valleys and related features, Horrigan Ridge constitutes the only noticeable topographic relief in the area. It is a low ridge, gently rounded in cross section, which trends eastward across T. 163 N., R. 54 W., about 2 miles south of Pembina River. Its summit is from 5 to 10 feet above the general plain in the western part of the area, but in the eastern part of T. 163 N., R. 54 W., the surface of the ridge blends into the plain and is not traceable on the ground. At its apparent junction with Pembina River west of the area, its summit is 875 feet above sea level. It slopes eastward, and along State Highway 18 south of Neche, where it blends into the plain, its altitude is 830 feet above sea level.

Several beaches of glacial Lake Agassiz are present in the area but they are not conspicuous features.

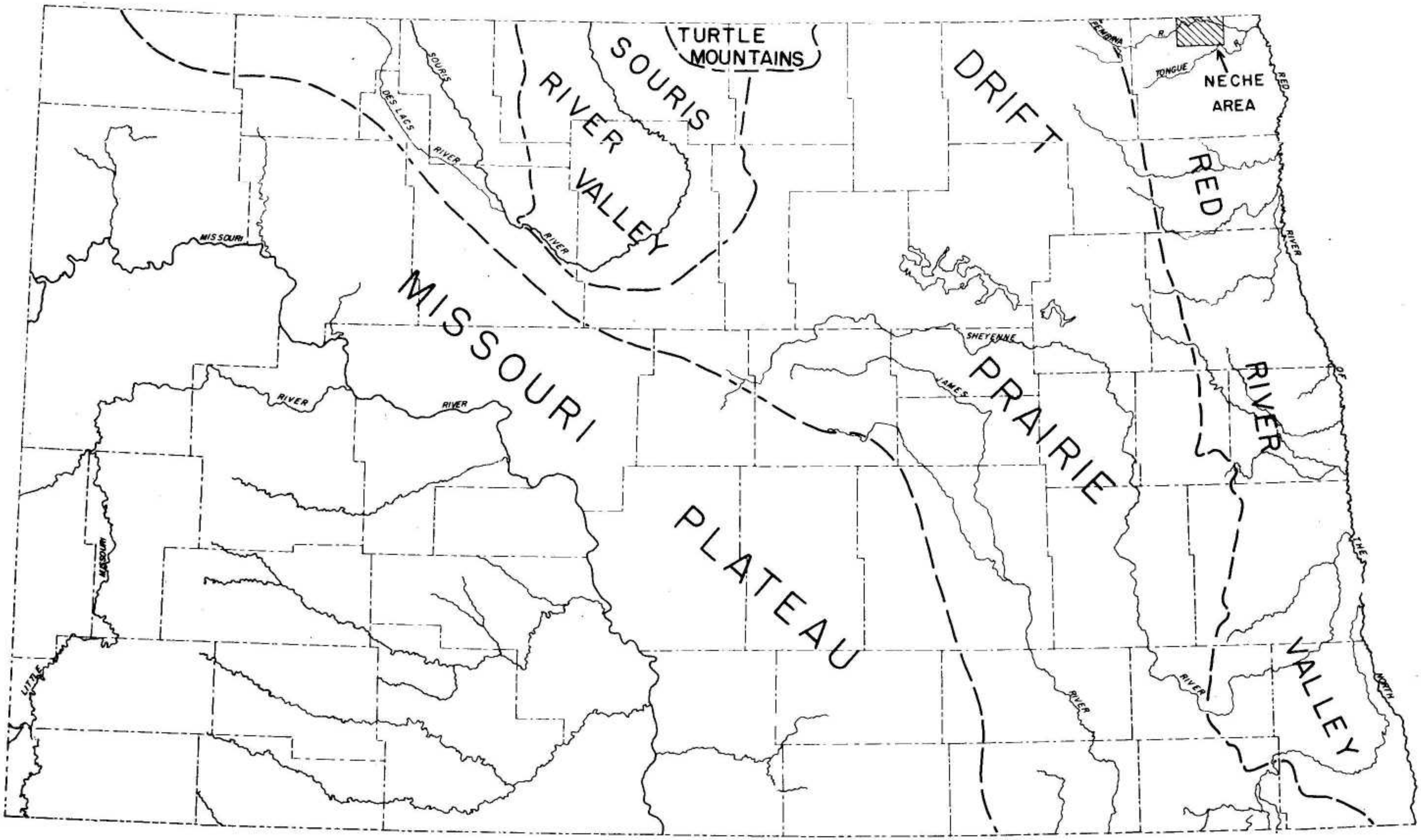

FIGURE 1.—MAP SHOWING PHYSIOGRAPHIC DIVISIONS IN NORTH DAKOTA (MODIFIED AFTER SIMPSON) AND LOCATION OF AREA OF THIS REPORT

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The village of Neche is in the north-central part of the area and is about a miles south of the 49th parallel. It has a population of 565 (1950 census) and is the only community in the area, a shipping and trading center for the surrounding farm territory. The village is served by a branch of the Great Northern Railroad and by State Highway 18. Neche is a port of entry for traffic from Canada and a U. S. Customs Office is about a mile north of the village on the international boundary.

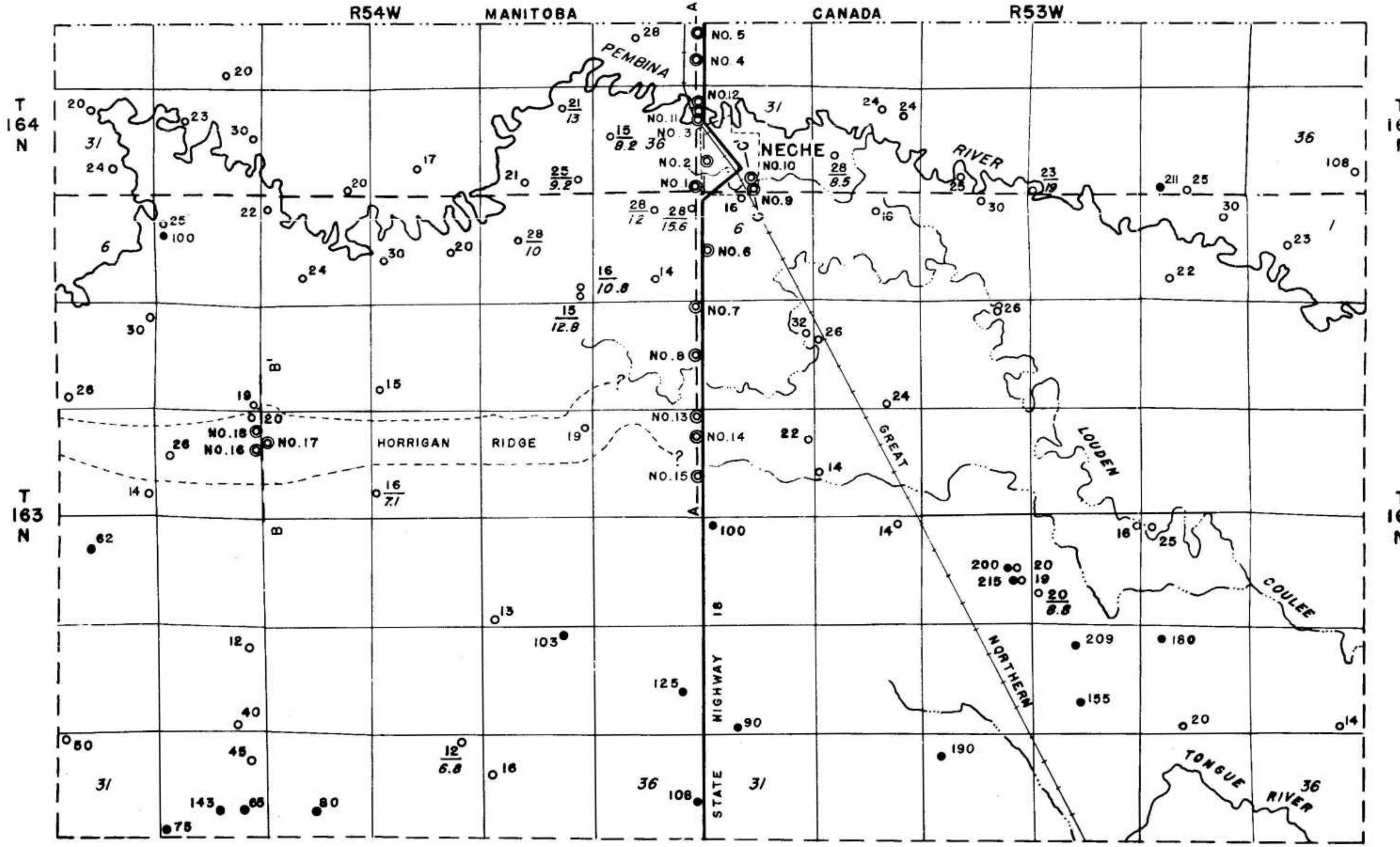
Present Water Supply and Future Needs

Except for municipal and industrial needs in Neche, there are no demands for large amounts of water in the area. Rural domestic and livestock supplies are obtained almost entirely from individual wells (see fig. 2). In some places rainwater may be caught and stored in cisterns for domestic supply.

At the present time, Neche has no municipal water-distribution or sewage-disposal systems and a large part of the water for domestic use is obtained from individual shallow wells scattered throughout the village. Some water is hauled from Cavalier and Walhalla, 16 and 19 miles away, by tank truck and sold to residents in Neche for domestic use.

The Great Northern Railroad utilizes water from Pembina River. The water is directed through a pipe intake to a 36-inch, circular concrete-curbed sump on the river bank, from which it is pumped for use.

If municipal water distribution and sewage-disposal systems were installed in Neche, it is estimated that an average of 50,000 to 60,000 gallons of water a day would be required to supply satisfactorily the demands for municipal and industrial uses.



EXPLANATION

NO. 17 USGS TEST HOLES

$\frac{20}{8.8}$ WELL ENDING IN LAKE AGASSIZ OR YOUNGER DEPOSITS.

100 WELL ENDING IN GLACIAL DRIFT OR YOUNGER DEPOSITS.

(UPPER OR SINGLE NUMBER BY WELL SYMBOL INDICATES DEPTH OF WELL. LOWER NUMBER INDICATES DEPTH TO WATER.)

0 1/2 1 2 3 4 MILES

FIGURE 2.-MAP OF NECHE AREA SHOWING LOCATIONS OF TEST HOLES AND WELLS.

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GEOLOGY AND HYDROLOGY

The Rock Materials and Their Water-Bearing Characteristics

The surficial sediments in the Neche area are the Lake Agassiz deposits, which cover the greater part of the area, the fluvial deposits associated with Pembina River, and the sandy deposits of Horrigan Ridge. There also may be fluvial deposits associated with the major coulees in the area and with Tongue River in the extreme southeastern part of the area.

The Lake Agassiz deposits may be divided, on the basis of texture and color, into a silt unit and a clay unit. These deposits, as they occur in the Fargo, North Dakota, area have been described by Dennis, Akin, and Worts (1949, pp. 18-21). The buff-colored silt unit is the surface material and unconformably overlies the dark-gray clay unit.

Horrigan Ridge, which trends eastward across the west-central part of the area, is composed largely of sand, and sand mixed with clay and silt, which extends downward through the silt unit of the Lake Agassiz deposits and rests unconformably upon the clay unit of the Lake Agassiz deposits. No satisfactory origin has been ascribed to Horrigan Ridge. It is possible that the ridge deposits should be regarded as a part of the silt unit of the Lake Agassiz deposits, which underlies most of the area; but, because of the uniqueness of the ridge in the area and because of the lithologic character of its sediments, it is considered sepertely in this report.

Beneath the Lake Agassiz deposits and unconformable with them are till and associated glacioaqueous deposits. No test holes penetrating these deposits were drilled during the present investigation; their thickness and character are not known except inferentially from the available well data for the area and from the logs of wells drilled within 15 to 30 miles of Neche, at Rosenfeld, Manitoba, at Hamboldt, Minn., and at Grafton, N. Dak.

The till and associated glacioaqueous deposits rest unconformably upon bedrock formations of probable Paleozoic age. At Rosenfeld, 892 feet of the rocks were penetrated (Upham, 1895, pl.15)

Pre-Cambrian gneiss and other crystalline rocks generally referred to as "granite" underlie the Palezoic formations and form the basement rock in the area. These rocks extend downward to unknown depths.

Deposits of Pembina River

Pembina River is the largest stream tributary to the Red River in North Dakota. It flows eastward across the lake plain in the northern part of the Neche area. The stream follows a tortuous, meandering course, many times bending in tight loops and flowing westward for a quarter of a mile or more before resuming the general eastward trend. Aerial photographs show clearly the numerous abandoned channels and meander scrools typical of lateral corrosion. The river channel is incised about 25 feet or more below the adjacent plain. The channel banks, however, are 5 feet or more higher than the plain and form natural levees along the river.

Several test holes were drilled in the vicinity of the river (see logs pp. 22, 23, 25, and 26. USGS tests 11 and 12 were drilled on the south and north river banks, respectively. The samples taken from these two test holes indicate as much as 40 feet of medium to coarse sand interbedded with clay and silt. Some of the sand beds are predominantly quartizitic whereas others consist chiefly of detrital shale. The thickness of these river deposits is 35 feet in USGS test 11 and 40 feet in USGS test 12.

Sand beds were penetrated also in USGS test 3, about 100 yards south of USGS test 11 and in USGS test 4, approximately 0.4 mile north of USGS test 12 (see fig. 3). However, the sand taken from these two test holes is finer than that from USGS tests 11 and 12 and contains considerably more clay and silt.

It is believed that the interbedded sand, silt, and clay found in USGS tests 3,4, 11, and 12 adjacent to Pembina River are fluvial deposits laid down by the stream during extreme flood stages. The unstable conditions of river deposition caused by shifting currents and changes in load and velocity account for the alternating beds of sand, silt, and clay. Small snail shells found at various depths in these deposits indicate relatively recent deposition.

The deposits extend for a considerable distance on each side of the river and apparently occupy a width of about three-fourths of a mile or more near Neche. They are bounded laterally by the silt unit of the Lake Agassiz deposits and, where drilled rest unconformably upon the clay unit. They form an important aquifer in the area and are the source of many farm water supplies along the river. The shallow domestic wells in the northern part of Neche also yield water from these deposits.

Although the fluvial deposits generally contain too much silt and clay to be considered ordinarily as a source of municipal or industrial water supplies, it is possible that the sands found in USGS tests 11 and 12 would yield sufficient water for the village of Neche. Because of the location of the deposits with respect to the river, it seems likely that they would be recharged by river infiltration when the water level in the sands was lowered by pumping. If this were the case, whatever yields could be obtained from the wells without continually lowering the pumping water levels would be assured for as long as there was water in the river channel. If it were not possible to obtain a sufficient quantity of water from one well, it probably could be obtained from a field of two or more wells. Spacing and location of additional wells should be based on data obtained from a pumping test on the initial well.

Lake Agassiz Deposits

Silt Unit. -- In the USGS test holes in the area, the silt unit of the Lake Agassiz deposits ranges in thickness from 20 to 35 feet. It is composed predominantly of silt, although the clay content is considerably higher than in other areas where the same unit has been studied. The color of the material ranges from light- gray to buff.

In his study of Lake Agassiz, Upham (1895, p. 202) recognized the presence of two distinct lithologic units in the Lake Agassiz basin. However, he

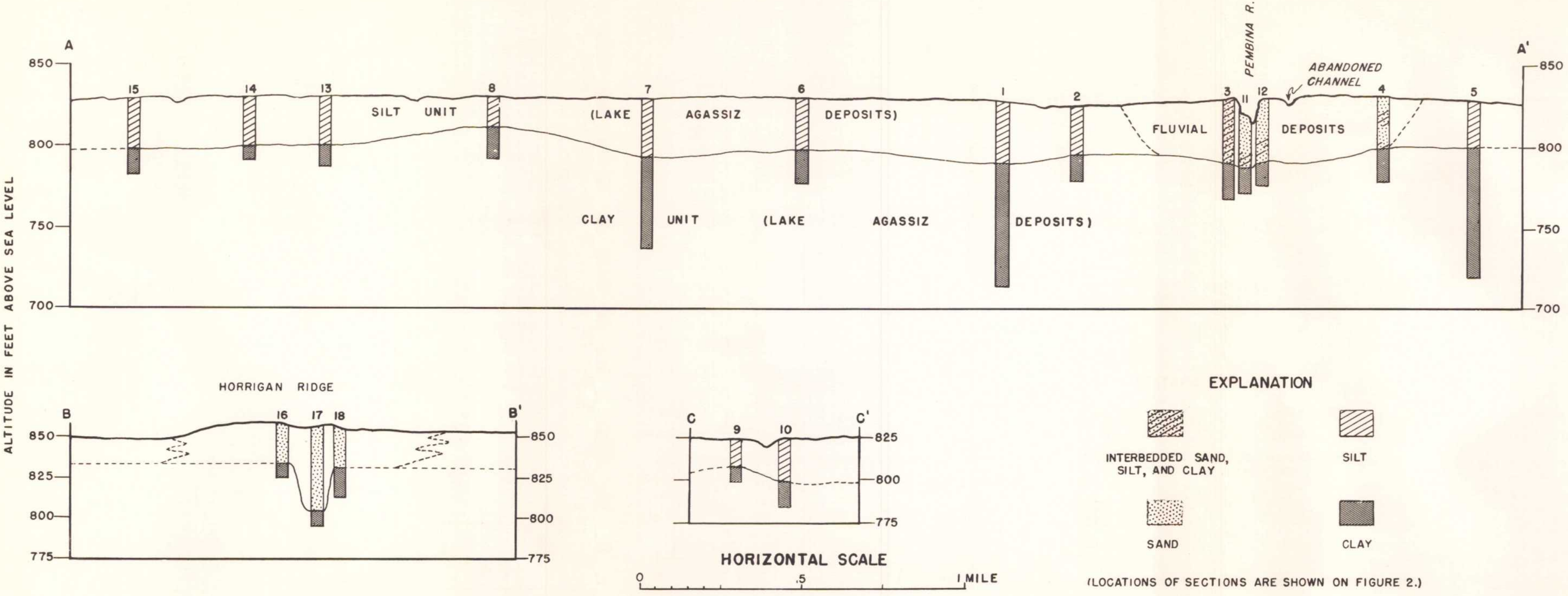

FIGURE 3.—GEOLOGIC SECTIONS IN NECHE AREA.

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ascribed a fluvial origin to the buff silty material overlying the dark-gray clay. Detailed examination of the drill cuttings from the test holes generally does not support the idea of such an origin. Only in samples obtained near the Pembina River were there any indications of river-deposited sediments.

In the Neche area the material of the silt unit is rather uniform, both in color and in texture. It seems probable that the silt was deposited in lake waters during the last stage of Lake Agassiz. The erosional unconformity separating the silt unit from the underlying clay unit represents a span of time during which the lake was at least partly, if not completely, drained.

The silt unit is a poor but extensive aquifer in the Neche area and is the source of a large number of shallow domestic and stock-water supplies. However, many of these supplies are reported to be inadequate even for the nominal demands for ordinary farm uses.

The water table in the silt unit is relatively near the land surface and may be subject to considerable fluctuation depending upon climatic conditions. Because the unit is composed of very fine-grained material, water is transmitted through it very slowly under natural conditions. Therefore, it is not considered to be a potential source of water supply for municipal or other purposes requiring water in amounts greater than is generally needed for ordinary farm and domestic purposes in this area.

Deposits of Horrigan Ridge. -- Horrigan Ridge is a low, inconspicuous ridge crossing the western part of the area. The ridge is hardly apparent under casual inspection, although it is conspicuous on the topographic map of the area (Cavalier quadrangle), which is printed on a scale of 1;62,500 (approximately 1 inch to the mile), with a 5-foot contour interval. From its junction with Pembina River in sec. 13, T.163 N., R. 55 W., the ridge trends eastward for a distance of about 7 miles, to the north edge of sec. 13, T. 163 N., R. 54 W., where it becomes indiscernible.

Three test holes were drilled in a line across one of the more prominent parts of the ridge in secs. 16 and 17, T. 163 N., R. 54 W. (see fig. 3). USGS test 16, drilled on the south flank of the ridge, penetrated 23 feet of saturated materials ranging from silt and clay to gravel. USGS test 17, drilled approximately on the crest of the ridge, penetrated 54 feet of similar material above the clay unit of the Lake Agassiz deposits. On the north flank of the ridge, USGS test 18 penetrated 24 feet of stratified sediments consisting of very fine sand and silt.

Because little information concerning the surface and subsurface features of Horrigan Ridge is available at the present time, the manner in which it was deposited is obscure. Any explanation of its origin must take into account the deeply incised trench in the clay unit of the Lake Agassiz deposits, which it occupies. The ridge could not have been formed solely by deposition for evidently an erosive agent was involved in scouring the trench in the clay unit of the Lake Agassiz deposits. Also, the ridge is not one of the Lake Agassiz beach ridges that cross the area in a northwesterly direction. A more detailed study of the area covered in this report, and of adjoining areas, is necessary to establish the full extent of the deposits of the ridge. In addition, more subsurface information from borings or test drilling is necessary to ascertain the true history of its origin.

Only a few domestic and farm wells have been constructed in the deposits of Horrigan Ridge in this area, but these are reported to yield sufficient water for the small demands made of them. A few wells near the margin of the ridge are reported to yield insufficient water for farm needs, but these may obtain their water from the silt unit of the Lake Agassiz deposits rather than from the deposits of Horrigan Ridge.

Because of the high percentage of fine sand, silt, and clay in the deposits of Horrigan Ridge, where tested, it is believed that water supplies sufficiently large for most municipal and industrial purposes could not be developed from them. However, larger and more adequate supplies can be developed from these deposits than from the silt unit of the Lake Agassiz deposits, which covers most of the area.

Although other features similar to Horrigan Ridge are not know to exist in the area, it is possible that additional borings or test drilling would reveal the presence of similar deposits, which may be entirely covered by lake sediments.

Clay unit. -- The sediments of the clay unit of the Lake Agassiz deposits are the oldest reaches by the test drilling in the Neche area. This unit is composed of a dense, somewhat silty clay having a dark bluish-gray color. Except for occasional pebbles which probably were floated into the lake by ice, the material is relatively homogeneous throughout. The upper surface of the unit is generally undulating, having a relief of as much as 17 feet in half a mile, and even more in some places, as beneath Horrigan Ridge (see fig. 3).

The clay unit is overlain unconformably by the silt unit and other materials and rests unconformably upon the till and associated glacioaqueous deposits. The upper surface of the till and associated deposits may have low to moderate relief somewhat greater than the surface of the clay unit. The clay unit, therefore, may vary considerably in thickness. USGS test 1, which was drilled to a depth of 112 feet near Neche, did not pass through the clay unit, which at this location is more than 75 feet thick. Simpson (1929, p. 184) reported the driller's log of a well (162-53-35) at Hamilton, N. Dak., in which 122 feet of blue clay" underlain by 43 feet of coarse sand was penetrated. It is probable that the 122 feet of "blue clay" represents both the silt unit and the clay unit of the Lake Agassiz deposits. In the southwestern part of the area, some wells as shallow as 60 feet are believed to yield water from the till and associated glacioaqueous deposits, indicating a much thinner section of the Lake Agassiz deposits in this part of the area.

For all practical purposes the clay unit is impermeable and will not yield even small supplies of water to wells. So far as is know, no wells in the Neche area yield water from the clay unit.

Till and Associated Glacioaqueous Deposits

Till and associated glacioaqueous deposits underlie the Lake Agassiz deposits. The till is a heterogeneous mixture of clay, sand, gravel, and boulders and is not an aquifer. However, deposits of sand and gravel, generally of glaciofluvial origin, are associated with the till and these are aquifers of varying importance. The deposits range in size from small to large, and in some places they may be sufficiently widely distributed and interconnected to make the entire unit a poor aquifer.

Many wells in the Neche area yield water from the glaciofluvial deposits associated with the till. The wells range in depth from 62 feet in the western part of the area to 215 feet in the eastern part, though it is possible that some of the deeper ones yield water from the bedrock formations. Many of these wells have small flows.

Most of the wells yield highly saline water, which is considered to be unfit for most domestic uses.

The thickness of the till and associated glacioaqueous deposits in the Neche area is not known, inasmuch as none of the drilled test holes reached these deposits. However, existing data and logs of wells in adjacent areas indicated that they may not be much thicker than about 100 feet.

Bedrock Formations

The shales and sandstones of Cretaceous age, which form the bedrock throughout a large part of eastern North Dakota, probably are not present in the Neche area. Logs of wells at St. Thomas and Hamilton in Pembina County (Simpson, 1929, pp. 183-184), at Grafton in Walsh County (Laird, 1941, pp. 27-28), North Dakota, and at Rosenfeld, Manitoba, (Upham, 1895, pl. 15) Canada, indicate that the glacial deposits are underlain by rocks of Paleozoic age. In the well at Rosenfeld a total thickness of 892 feet of these rocks were reported.

Rocks believed to represent such well-known water-bearing formations as the St. Peter sandstone, the Jordan sandstone, and the Dresbach sandstone may be present in the area. The water in these formations in western Minnesota and eastern North Dakota invariably is highly mineralized.The water from the Hamilton and St. Thomas wells, which is from the St. Peter (?) sandstone, is reported to contain 20, 290 and 42, 345 parts per million of dissolved solids, respectively (Simpson, pp. 292-293). The principal mineral constituents are chloride and sulfate of sodium and calcium.

The Paleozoic rocks are underlain by pre-Cambrian gneiss and other crystalline rocks generally referred to as "granite". The rocks extend downward to unknown depths, and essentially are not water bearing.

Recharge, Movement, and Discharge of the Ground Water in Shallow Lake Agassiz and Fluvial Deposits

The shallow aquifers in the silt unit and fluvial deposits are recharged directly by downward percolation of rain and meltwater derived from snow. The rather sandy nature of the surface materials in the vicinity of Neche and the very low surface gradient tends to retard the surface runoff and thereby increase the opportunity for recharge by absorption. Absorption is aided also by the natural levees along Pembina River which tend to prevent the surface runoff from entering the river directly.

A contour map of the water table beneath the village of Neche is shown in figure 4. Altitudes, above sea level, of the measuring points of many of the wells in the village were obtained by instrumental leveling. Depth from the measuring point to the water level in the wells and the altitude of the water table, in feet above sea level, were determined at different points in the village.

As shown on the map there is a mound or high area, in the water table under the central part of the village. This indicates an area of recharge, as is suggested by the basinlike nature of the surface topography. A small coulee drains eastward across the shallow depression, which is bounded on the north by the natural levee along the river and on the west and south by the general lake plain.

Precipitation and meltwater probably are impounded temporarily in the small basin, especially in the spring when the coulee is partly or completely choked with ice and snow. That part of the precipitation which is held in the basin and which is not lost through evaporation and transpiration percolates downward and laterally through the interstices of the surface materials, and most of it ultimately discharges into Pembina River. Part of the underflow moves more or less directly northward to the river while the remainder is dispersed in southerly and easterly directions, though eventually it also contributes to the river. Owing to the slowness with which water is transmitted through the surficial sediments of the area under natural conditions, it is doubtful that the total underflow toward the river beneath the quarter section of land upon which the town is situated would exceed 10,000 gallons per day.

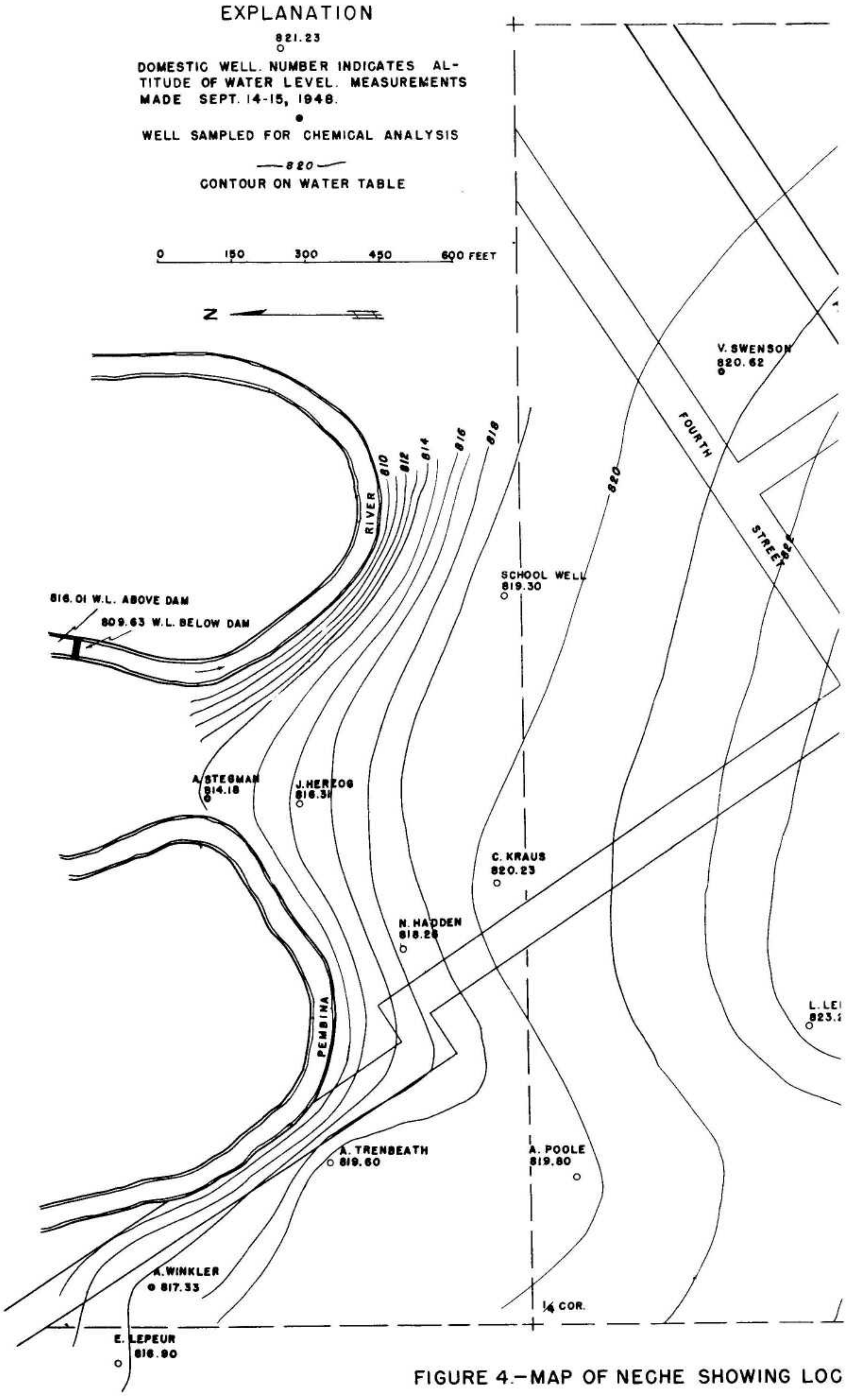
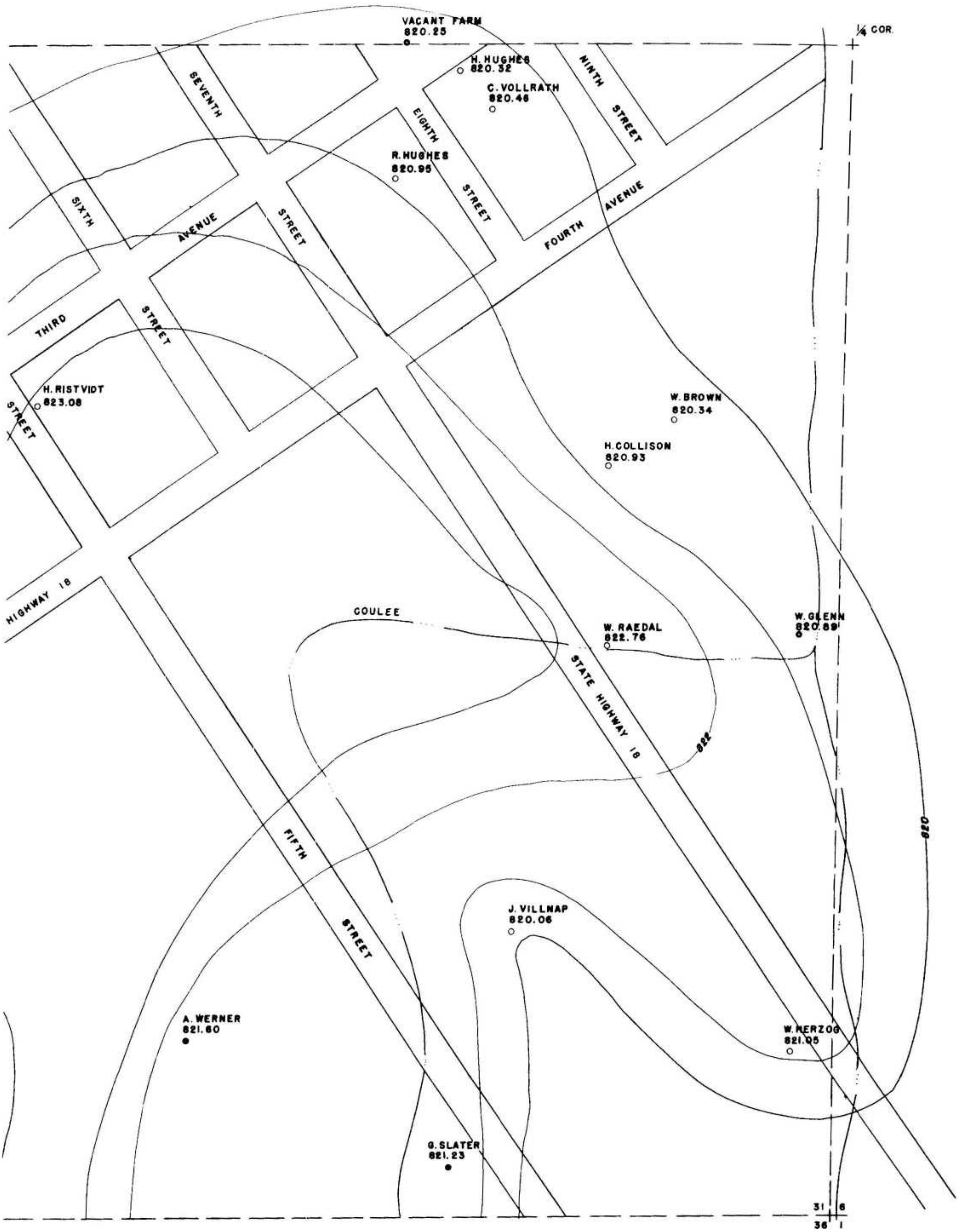


FIGURE 4.—MAP OF NECHE SHOWING LOC



S OF WELLS AND CONTOURS ON THE WATER TABLE.

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QUALITY OF GROUND WATER IN THE NECHE AREA

Water samples were collected from some of the wells in Neche and were analyzed by the North Dakota State Department of Health at Bismarck. The analyses are given on page 13.

In order that the reader may understand the significance of the chemical analyses, the following standards adopted by the U. S. Public Health Service for drinking water to be used on interstate carriers are given for comparative purposes:

Total solids should not exceed		1,000 p.p.m.
Sulfate (SO_4)	"	250 p.p.m.
Chloride (Cl)	"	250 p.p.m.
Magnesium (Mg)	"	125 p.p.m.
Iron and Manganese (FE+Mn)		0.3 p.p.m.

In water for domestic uses, total hardness probably should not exceed about 250 parts per million.

Ground water in shallow aquifers generally is of better quality than water in deeper horizons. However, of the seven water samples collected from the shallow aquifer at Neche, four contained more than 2,000 parts per million of dissolved solids and one of these contained more than 3,000 parts. Of the remaining three samples only two (164-53-31bcc3 and 164-53-31bcd2) contained less than 1,000 parts per million of dissolved solids; the sample from well 164-53-31dcc contained 1,120 parts.

Two samples (164-53-31cab and 164-53-31ccd2) contained excessive nitrate concentrations, probably owing to the shallowness of the wells which permitted contamination from surface sources.

In the seven samples analyzed, total hardness, expressed as calcium carbonate, ranged from 420 to 2,350 parts per million and averaged 1,320 parts per million, which is very high.

Analyses of Ground Water

(All analyses made by
Department of Health,

(Parts per

Location number	Owner	Depth of well (feet)	Date collected	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)
164-53-31bcc3	August Winkler	20	10-23-48	-	27	36
164-53-31bcd2	A. Stegman	20	10-23-48	1.5	88	49
164-53-31cab	Vic Swenson	23	10-23-48	1.5	400	320
164-53-31cbc2	Alex Werner	20	10-23-48	.15	400	150
164-53-31ccb	Glen Slater	13	10-23-48	.45	560	230
164-53-31ccd2	Wm. Glenn	20	10-23-48	.53	420	73
164-53-31dcc	Vacant farm	20	10-23-48	.88	180	63

WELL-NUMBERING SYSTEM

The well-numbering system used in this report is based upon the location of the well with respect to the land-survey divisions used in North Dakota. The first number is the township north of the base line which extends laterally across the middle of Arkansas. The second number is the range west of the fifth principal meridian. The third number is the section within the designated township. The letters a, b, c, and d designate, respectively, the northeast, northwest, southwest, and southeast quarter sections, the quarter-quarter sections, and the quarter-quarter-quarter sections. If more than one well is within a 10-acre tract, consecutive numbers are given to them as they are scheduled. This number follows the letters. Thus, well 164-54-36aad2 is in Township 164 North, Range 54 West, Section 36. It was the second well scheduled in the 10-acre tract in the southeast quarter of the northeast quarter of the northeast quarter of that section. Similarly, well 164-53-31cda (USGS test 10, fig. 2) is in the northeast quarter of the southeast quarter of the southwest quarter of Sec. 31, T. 164 N., R. 53 W. Numbers that contain only one or two letters after the section number indicate that the locations of such wells are accurate only to the quarter section or the quarter-quarter section, respectively.

The following diagram, showing the method of numbering the tracts within the section, may be helpful to the reader in identifying wells shown in the illustrations.

bbb	bba	bab	baa	abb	aba	aab	aaa
(b)		(a)		(b)		(a)	
bbc	bbd	bac	bad	abc	abd	aac	aad
	b				a		
bcb	bca	bdb	bda	acb	aca	adb	ada
(c)		(d)		(c)		(d)	
bcc	bcd	bdc	bdd	acc	acd	adc	add
cbb	cba	cab	caa	dbb	dba	dab	daa
(b)		(a)		(b)		(a)	
cbc	cbd	cac	cad	dbc	dbd	dac	dad
	c				d		
ccb	cca	cdb	cda	dcb	dca	ddb	dda
(c)		(d)		(c)		(d)	
ccc	ccd	cdc	cdd	dcc	dcd	ddc	ddd

Depth to water: Depths given to hundredths or tenths are measured; those given in units only are reported.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type	Date completed
162-54-2abd	C. R. Morrison	200	......	Drilled	....
162-54-3cad1	Charles Carrigan	16	52	Dug	....
162-54-3cad2	.......do.......	165	......	Drilled	....
163-53-1b	H. H. Kain	23	......	Dug	....
163-53-2a	W. H. Kain	30	......	..do...	1937
163-53-2b	Geo. Lembke	30	48	..do...	1936
163-53-3b1	Ed. Untae	22	48	..do...	1909
163-53-3b2	Frank Kelm	27	48	..do...	1934
163-53-3b3	T. W. Anderson	30	......	......	....
163-53-4abb	J. Quinnel	30	48	..do...	1937
163-53-4c	Stan Horgan	13	42	..do...	1933
163-53-5abc	Henry Thom	16	48	..do...	....
163-53-6b	Guss Swenson	16	36	..do...	....
163-53-6cbb	USCS test 6	52	5	Drilled	6-10-49
163-53-7a	Wallace Gavier	32	48	Dug	1938
163-53-8b	Roy Krueger	26	48	..do...	1925
163-53-8d	James Bear	24	42	..do...	1936
163-53-9abc	N. Lanier	25	48	..do...	1938
163-53-9b	Jerry Auger	16	48	..do...	1913
163-53-17c	Ernest Quinnel	14	......	..do...	1936
163-53-18a	Achilles Auger	22	48	..do...	1933
163-53-19b	James Barstrom	100	4	Drilled	....
163-53-20a	Louis Neviman	14	......	Dug	1910
163-53-21add1	Peter Brown	20	48	..do...	....
163-53-21add2	.....do.....	200	......	Drilled	1918
163-53-21daa1	G. Brown	19	48	Dug	1928
163-53-21daa2	.....do.....	215	......	Drilled	....
163-53-22a	Homer Miros	16	48	Dug	....
163-53-22cbc	H. Kelm	20	36	..do...	....
163-53-23b	Wm. Stegman	25	......	..do...	....

IN THE NECHE AREA, N. DAK.

Data for wells located only to nearest quarter section were obtained by county assessors in 1939 as part of State-wide well inventory under Works Projects Administration. All other records were obtained during present investigation.

Depth to water (feet below land surface)	Date of measurement	Use of water	Remarks
Flow	11-20-48	Unused	Water too saline for use.
....	11-20-48	Domestic	
Flow	11-20-48	Stock	
19	....	Domestic	Inadequate supply.
....	....	....	
29	1939	Domestic	Do.
18	1939	...do...	Do.
....	1939	....	
....	....	....	Do.
27.9	10-30-48	Domestic	Do.
9	10-30-39	...do...	Do.
7.88	10-30-48	Stock	
....	....	....	
....	....	Filled	See log.
29	1939	Domestic	Inadequate supply.
19	1939	Stock	Do.
22	1939	Domestic	Do.
10	1939	...do...	Do.
11	10-30-48	...do...	Do.
8	1939	...do...	Do.
17	1939	...do...	Do.
99	1939	....	Do.
12	1939	...do....	Do.
10	....	....	
....	....	....	
...	11-20-48	Domestic	
Flow	11-20-48	Stock	Flows 1 gallon per minute.
13	1939	....	
8.8	11-20-48	Domestic	
....	1939	...do...	Do.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type	Date completed
163-53-24a	C.LeDoux	20	48	Dug	1936
163-53-25d	Mrs.M. Tillett	14	48	..do...	1932
163-53-26b	Willis Slagerman	180	......	Drilled	....
163-53-26c	Albert Feidler	20	96	Dug	1915
163-53-27bac	Archie McCall	209	......	Drilled	1931
163-53-27cad	T. Martindale	155	......	..do...	1929
163-53-28c	T. Piening	20	36	Dug	1926
163-53-29c	Mary Chale	14	48	..do...	1909
163-53-30c	Walter Tom	90	......	Drilled	....
163-53-33b	Geo. Fidler	190	......	..do...	1938
163-53-35c	J. W. Martman	16	48	Dug	1937
163-54-1abc	Roy Vosper	28	48	..do...	1940
163-54-1a	C. F. Stegman	28	48	..do...	1939
163-54-1b	Harlen Turner	16	48	..do...	1937
163-54-1d	Sarah Trenbeath	14	42	..do...	....
163-54-2bca	Fred Menke	28	36	..do...	1937
163-54-2ddd1	Frank Trenbeath	15	40	..do...	1947
163-54-2ddd2	.....do........	16	30	..do...	....
163-54-3c1	Henry Stegman	26	42	..do...	1939
163-54-3c2	Mrs. Martha Omek	30	48	..do...	1925
163-54-3d1	J. N. Horgan	20	48	..do...	1899
163-54-3d2	......do........	22	30	..do...	1919
163-54-4b	Mike Wagner	22	42	..do...	1926
163-54-4c1	Earl Symington	20	36	..do...	1936
163-54-4c2	......do........	30	48	..do...	1899
163-54-4c3	......do........	24	......	..do...	1936
163-54-5b1	A. Guse	25	36	..do...	1900
163-54-5b2	G. Stegman	23	48	..do...	1909
163-54-5b3	Frank Horgan	100	42 and 8	Dug and bored	1939
163-54-5b4	......do........	25	42	Dug	1937

IN THE NECHE AREA, N. DAK. - - Continued

Depth to water (feet below land surface)	Date of measurement	Use of water	Remarks
14	1939	Domestic	Inadequate supply.
10	1939	...do...	Do.
.....	....	...do...	Do.
14	1939	...do...	Do.
.....	....	....	
.....	....	Stock	
.....	....	....	
7	1939	Domestic	Do.
.....	....	Stock	Do.
.....	1939	....	
13	1939	Domestic	Do.
12	10-30-48	...do...	
15.6	10-30-48	...do...	
14	1938	Domestic, stock	Adequate supply.
18	1938	...do...	Do.
.....	1938	....	
10	10-30-48	Domestic	Do.
10.84	10-30-48	Stock	Sand above blue clay.
12.79	10-30-48	Domestic	
24	1938	Stock	Inadequate supply.
	1938		
20	1938	Stock	Do.
20	1938	Domestic	
20	1938	Domestic, stock	Do.
17	1938	Domestic	Adequate supply.
30	1938	......	
20	1939	Stock	Adequate supply.
24	1939	Domestic, stock	Inadequate supply.
21	1939	...do...	Do.
95	1939	Stock	Do.
24	1939	Domestic	Do.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type	Date completed
163-54-7a	Harold Ross	30	48	Dug	1935
163-54-7c1	Gus Stegman	30	48	..do...	1930
163-54-7c2	Russell Horsley	26	48	..do...	1922
163-54-7c3	George Horsley	22	48	..do...	1938
163-54-8b1	C. D. Flynn	30	16	Bored	1937
163-54-8b2	Chester Symington	33	......	Dug	1938
163-54-8d	Lyle Symington	19	48	..do...	1927
163-54-9c	Fred Duncan	17	48	..do...	1918
163-54-10c	Robert Noice	15	42	..do...	1917
163-54-12c	Wm. Trenbeath	20	36	..do...	1927
163-54-12daa	USGS test 8	37	5	Drilled	6-13-49
163-54-12ddd	USGS test 7	92	5	..do...	6-10-49
163-54-13aaa	USGS test 13	42	5	..do...	6-21-49
163-54-13ada	USGS test 14	37	5	..do...	6-22-49
163-54-13dad	USGS test 15	47	5	..do...	......
163-54-14a	Adam Menke	19	48	Dug	.....
163-54-15c	Oscar Stegman	16	48	..do...	1939
163-54-16bcb	USGS test 17	62	5	Drilled	6-24-49
163-54-17a1	Howard Symington	24	48	Dug	1931
163-54-17a2	Archie Symington	20	48	Dug	1917
163-54-17a3	......do........	18	30	..do...	1909
163-54-17aad1	USGS test 16	32	5	Drilled	6-24-49
163-54-17aad2	USGS test 18	42	5	..do...	6-27-49
163-54-17b	Mrs. M. Hughes	26	48	..do...	1936
163-54-18d	Emil Thom	14	60	..do...	1914
163-54-19b	John Stark	62	48 and 8	Dug and drilled	1938
163-54-23c	Theo. Latoske	13	48	Dug	1933
163-54-25d	J. E. McFadden	125	36 and 2	Driven	....
163-54-26a	Irwin McFadden	103	48 and 2	Drilled	1909
163-54-29	Reinhold	12	12	Bored	1928
163-54-29d	A. Latraverse	40	36	Dug	....

Depth to water (feet below land surface)	Date of measurement	Use of water	Remarks
28	1939	Domestic, stock	Inadequate supply.
31	1939	...do...	Do.
23	1939	...do...	Adequate supply.
18	1939	...do...	Do.
26	1939	Domestic	Do.
28	1939	Domestic, stock	Do.
16	1939	...do...	Inadequate supply.
14	1939	Stock	
11	1939	...do...	Adequate supply.
17	1939	Domestic	Do.
....	....	Filled	See log.
....	....	...do...	Do.
....	....	...do...	Do.
....	....	...do...	Do.
....	....	...do...	Do.
18	1939	Domestic, stock	Adequate supply.
7.1	11-20-48	...do...	Do.
....	....	Filled	See log.
21	11-20-48	Domestic, stock	Adequate supply.
19	1939	...do...	Inadequate supply.
18	1939	Stock	Do.
....	....	Filled	See log.
....	....	...do...	Do.
24	1939	Domestic, stock	Adequate supply.
10	1939	...do...	Do.
17	1939	Stock	Do.
11	1939	Unused	
Flow	1939	Stock	Do.
12	1939	Domestic, stock	Do.
....	1939	Domestic	
37	1939	...do...	

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type	Date completed
163-54-31b	Ed. Martineau	50	48 and 14	Dug and bored	1920
163-54-32a	John Garknes	45	42 and 2	..do...	1899
163-54-32c	Ezra Schlachter	75	48 and 6	..do...	1931
163-54-32d1	Ray Lind	143	48 and 2	..do...	1914
163-54-32d2	L. A. Bailey	65	42 and 8	Bored	1910
163-54-33c	Alex Wisenthal	80	42 and 6	Dug and bored	1909
163-54-34aab	Albert Sagent	12	48	Dug	....
163-54-35b	Charles Renwick	16	60	..do...	1914
163-54-36d	John A Jenson	108	3	Drilled	1915
164-54-25daa	USGS Test 5	109	5	..do...	6-8-49
164-53-30c	Otto Winkler	26	48	Dug	1935
164-53-31adc1	School well	...	....	..do...	....
164-53-31adc2	.....do.....	28	....	..do...	....
164-53-31bcc1	Great Northern Railroad	...	36 and 8	Dug and bored	....
164-53-31bcc2	City Park well	16	14	Dug	....
164-53-31bcc3	August Winkler	20	33	..do...	....
164-53-31bcc4	Allen Trenbeath	24	14	Bored	1945
164-53-31bcd1	Norman Hadden	21.7	....	Dug	....
164-53-31bcd2	A. Stegman	20	36	..do...	Old
164-53-31bcd3	Carl Krans	24	35	..do...	1918
164-53-31bcd4	Julius Herzog	24	24 and 10	Drilled	....
164-53-31caa	Tom Thomson	...	48 and 12	Dug and bored	....
164-53-31cab	Vic Swenson	22.6	14	Bored	Old
164-53-31cac	H. Ristvedt	18	36	Dug	1946
164-53-31cbb1	Leon LePeur	22	36	..do...	....
164-53-31cbb2	Adolph Poole	16	24	..do...	....
164-53-31cbb3	E. LePeur	24	30	..do...	....
164-53-31cbc1	E. Ertman	19	43	..do...	....
164-53-31cbc2	A. Werner	20	36	..do...	1938
164-53-31cbc3	USGS Test 2	47	5	Drilled	6-6-49

Depth to water (feet below land surface)	Date of measurement	Use of water	Remarks
20	1939	Domestic, stock	Adequate supply.
12	1939	...do...	Do.
....	1939	...do...	
Flow	1939	Stock	Do.
Flow	1939	Domestic, stock	Inadequate supply.
Flow	1939	...do...	Do.
6.8	11-20-48	Domestic	
13	1939	...do...	Adequate supply.
Flow	1939	...do...	Do.
....	....	Filled	See log.
25	1939	....	
....	9-14-48	Domestic	
9.60	9-14-48	...do...	
16.8	9-14-48	Industrial	
14.36	9-14-48	Domestic	
14.34	10-2-48	...do...	
13.1	10-2-48	...do...	Adequate supply.
3.1	10-2-48	...do...	
19.1	10-2-48	...do...	Do.
11	10-2-48	...do...	Do.
15	10-2-48	...do...	Do.
....	....	....	
9	9-14-48	...do...	Do.
6	9-14-48	Industrial	
5.9	9-15-48	Domestic	
10.55	10-2-48	...do...	
16.20	10-2-48	...do...	
7.70	9-14-48	...do...	
3.30	9-14-48	...do...	
....	....	Filled	See log.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type	Date completed
164-53-31ccb	Glen Slater	13	36	Dug	1947
164-53-31ccc1	W. Herzog	12	33	..do...	....
164-53-31ccc2	Joe Villnap	14	60 and 12	..do...	....
164-53-31ccc3	Raymond Taylor	...	....	..do...	1942
164-53-31ccd1	Walter Raedal	23	8	Drilled	....
164-53-31ccd2	Wm. Glenn	20	44 and 40	Dug	1919
164-53-31cda1	H. Hughes	9	34	..do...	1947
164-53-31cda2	R. Hughes	20	10	Bored	1938
164-53-31cda3	C. Vollrath	16	14	..do...	1937
164-53-31cda4	USGS Test 10	42	5	Drilled	6-14-49
164-53-31cdc1	H. Collison	13	12	Bored	....
164-53-31cdc2	William Brown	...	....	....	....
164-53-31cdd	USGS Test 9	32	5	Drilled	6-14-49
164-53-32a1	Mrs. E. Denville	24	48	Dug	1910
164-53-32a2	Iver Nelson	24	....	..do...	1918
164-53-32cba	J. D. Gynn	28	48	..do...	....
164-53-33c1	Wm. Lembke	25	48	..do...	....
164-53-33c2	C. N. Morris	27	48	..do...	1905
164-53-34ccc	S. Quinnel	23	12	Bored	....
164-53-35c1	L. Morris	211	....	Drilled	1938
164-53-35c2	G. Morris	25	48	Dug	1937
164-53-36d	Clarence Kain	18	48	..do...	1936
164-54-25dda	USGS Test 4	52	5	Drilled	6-8-49
164-54-25c	W. H. Otten	28	48	Dug	1938
164-54-26d	Gustaf Menke	22	36	..do...	....
164-54-27d	Rack Renand	15	48	..do...	1915
164-54-29d1	J. G. Otten	20	48	..do...	1937
164-54-29d2	....do.....	28	48	..do...	1937
164-54-29d3	Otto Stegman	24	36	..do...	1918
164-54-30b	Percy Wessels	21	48	..do...	1938
164-54-31b	W. Wessels	20	48	..do...	1939
164-54-31c	J. G. Otten	21	48	..do...	1918
164-54-31d	Fred Latozke	24	48	..do...	1903
164-54-32b	John Sheard	23	36	..do...	1932
164-54-32d1	O. R. Foxen	28	36	..do...	1938

IN THE NECHE AREA, N. DAK. -- Continued

Depth to water (feet below land surface)	Date of measurement	Use of water	Remarks
7.2	9-14-48	Domestic	
7.38	10-2-48	...do...	
5.5	9-14-48	...do...	
....	....	....	
5	10-2-48	...do...	
6	9-14-48	...do...	Adequate supply.
5.3	9-15-48	...do...	
....	....	...do...	
5.4	9-14-48	...do...	
....	....	Filled	See log.
7	10-2-48	Domestic	Strongly alkaline.
7	10-2-48	...do...	
....	....	Filled	See log.
20	1939	Domestic	
....	1939	....	
8.5	10-30-48	Stock	
....	....	....	
20	1939	Domestic	Inadequate supply.
19	10-30-48	...do...	
....	....	...do...	
20	1939	...do...	Do.
10	1939	...do...	Do.
....	1939	Filled	See log.
17	1939	Domestic, stock	Adequate supply.
16	1939	Stock	Do.
14	1939	Domestic	Do.
17	1939	Stock	Inadequate supply.
26	1939	Domestic, stock	Do.
21	1939	...do...	Adequate supply.
17	1939	Stock	Do.
17	1939	Domestic	Do.
19	1939	Domestic, stock	Inadequate supply.
22	1939	...do...	Adequate supply.
21	1939	...do...	Do.
24	1939	Domestic	Inadequate supply.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type	Date completed
164-54-32d2	O. R. Foxen	30	48	Dug	1920
164-54-32d3	Adolph Stegman	18	48	..do...	1906
164-54-33d1	Pauline Sehler	20	16	Drilled	1918
164-54-33d2	Mrs. P. Sehler	24	48	Dug	1902
164-54-33d3	H. E. Sehler	19	12	Drilled	1937
164-54-34d1	Henry Lupien	13	16	Bored	1931
164-54-34d2	.....do.....	17	48	Dug	1935
164-54-35abd	Howard Hughes	21	30	..do...	1946
164-54-35c	Albert Cook	21	42	..do...	1928
164-54-35ddc	George Hughes	25	52	..do...	1936
164-54-36aad1	USGS test 3	62	5	Drilled	6-6-49
164-54-36aad2	USGS test 11	48	5	..do...	6-15-49
164-54-36aad3	USGS test 12	53	5	..do...	6-16-49
164-54-36bcd	Harris Cameron	15	20	Dug	1947
164-54-36d1	Ed Hintz	22	48	..do...	1900
164-54-36d2	Otto Lembke	25	42	..do...	1930
164-54-36ddd	USGS test 1	112	5	Drilled	6-1-49

Depth to water (feet below land surface)	Date of measurement	Use of water	Remarks
24	1939	Domestic	Inadequate supply.
16	1939	...do...	Adequate supply.
14	1939	...do...	Do.
20	1939	Stock	Do.
9	1939	Domestic	Do.
12	1939	Stock	Do.
22	1939	Domestic, stock	Do.
13	10-30-48	...do...	Do.
19	1939	...do...	Do.
9.2	10-30-48	...do...	Inadequate supply.
....	....	Filled	See log.
....	....	...do...	Do.
....	....	...do...	Do.
8.2	10-30-48	Domestic	Not in use.
21.0	1939	...do...	Inadequate supply
19.0	1939	Domestic, stock	Adequate supply.
....	....	Unused	See log.

LOGS OF TEST HOLES IN THE NECHE AREA

164-54-36ddd
USGS test 1

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Silt unit:		
Soil, black, silty	2	2
Silt, light-gray, appears to be mottled and slightly sandy	35	37
Clay unit:		
Clay, dark-gray; a few pebbles	75	112

164-53-31cbc3
USGS test 2

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Silt unit:		
Soil, black, silty	2	2
Silt, light-gray, appears to be mottled and slightly sandy	30	32
Clay unit:		
Clay, dark-gray, silty; a few pebbles	15	47

164-54-36aad1
USGS test 3

Formation Material	Thickness (feet)	Depth (feet)
Fluvial deposits:		
Soil, black, silty	2	2
Clay and silt, grayish-tan	5	7
Silt and fine sand, light olive-brown	20	27
Shaly gravel	5	32
Silt and clay, light olive-brown; shell material	10	42
Lake Agassiz deposits:		
Clay unit:		
Clay, dark-gray, silty; a few pebbles	20	62

164-54-25dda
USGS test 4

Formation Material	Thickness (feet)	Depth (feet)
Fluvial deposits:		
Soil, black, silty	3	3
Silt and very fine sand, gray	6	9
Clay and silt, buff	8	17
Sand, light-buff, very fine	10	27
No sample from 27 to 32 ft.; probably silt	5	32
Lake Agassiz deposits:		
Clay unit:		
Clay and silt, dark-gray; a few pebbles	20	52

164-53-25daa
USGS test 5

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Silt unit:		
Soil, black, silty	3	3
Silt, light grayish-tan	4	7
Silt, and very fine sand, tan	17	24
Silt, light-brown	5	29
Clay unit:		
Clay, dark-gray, slightly silty	80	109

163-53-6cbb
USGS test 6

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Silt unit:		
Soil, black, silty	2	2
Silt, grayish-tan	15	17
Clay and silt, gray	10	27
Clay unit:		
Clay, dark-gray, slightly silty	25	52

163-54-12ddd
USGS test 7

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Silt unit:		
Soil, black, silty	2	2
Silt and clay, grayish-tan to buff	35	37
Clay unit:		
Clay, dark-gray with tan streaks, indicating partial oxidation	55	92

163-54-12daa
USGS test 8

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Silt unit:		
Soil, black, silty	3	3
Silt, grayish-tan	8	11
Silt and clay, buff	8	19
Clay unit:		
Clay, dark-gray, silty	18	37

164-53-31cdd
USGS test 9

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Silt unit:		
Soil, black, silty	3	3
Silt, gray, clayey	4	7
Clay and silt, light-tan	10	17
Clay unit:		
Clay, dark-gray (drive sample)	1	18
Silt, tan, and gray clay	4	22
Clay, dark-gray silty	5	27

LOGS OF TEST HOLES IN THE NECHE AREA -- Continued

164-53-31cda4
USGS test 10

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Silt unit:		
Soil, black, silty	2	2
Silt and clay, grayish-tan	4	6
Silt, brown	1	7
Silt, clay, and fine sand, light olive-brown	15	22
Silt, and clay, light-brown	5	27
Clay unit:		
Clay, dark-gray silty	15	42

164-54-36aad2
USGS test 11

Formation Material	Thickness (feet)	Depth (feet)
Fluvial deposits:		
Silt, light-brown; fine sand	6	6
Sand, brown, fine shaly	1	7
Sand, gray, coarse, shaly and quartzitic	5	12
Sand, light-gray, coarse, shaly and quartzitic	10	22
Silt and clay, gray, with intercalated beds of sand; shell material	5	27
Sand, gray, medium and coarse, shaly	5	32
Sand, gray, intercalated with beds of clay; small snail shells	3	35
Lake Agassiz deposits:		
Clay unit:		
Clay, dark-gray, silty	13	48

164-54-36aad3
USGS test 12

Formation Material	Thickness (feet)	Depth (feet)
Fluvial deposits:		
Silt, dark-gray, stratified	7	7
Sand, light-gray, fine and medium; clay and silt	5	12
Sand, gray, fine and medium	5	17
Sand, light-brown, fine and medium	5	22
Sand, gray, fine, intercalated with silt beds (drive sample from 22 to 23 feet)	5	27
Silt, and clay and coarse shaly sand	13	40
Lake Agassiz deposits:		
Clay unit:		
Clay, dark-gray, silty	13	53

163-54-13aaa
USGS test 13

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Silt unit:		
Soil, black, silty	1½	1½
Silt, and clay, light-gray with intercalated beds of fine sand	5½	7
Silt, tan, clayey	17	24
Clay, tan and gray, spotty	15	39
Clay unit:		
Clay, dark-gray, silty	3	42

LOGS OF TEST HOLES IN THE NECHE AREA -- Continued

163-54-13ada
USGS test 14

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Silt unit:		
Soil, black, silty	1	1
Silt and clay, tan	5	6
Clay, tan	1	7
Silt, tan, and gray clay	1	8
Silt, light olive-brown, clayey	19	27
Clay, gray and tan	5	32
Clay unit:		
Clay, dark-gray, silty	5	37

163-54-13dad
USGS test 15

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Silt unit:		
Soil, black, silty	2	2
Silt, light-tan	4	6
Silt and clay, gray	1	7
Silt and clay, very dark-gray; traces of shaly sand and gravel	5	12
Silt, tan and black, clayey, shale pebbles	5	17
Mostly tan silt; rather coarse spotty material with some sand grains and gypsum	20	37
Clay unit:		
Clay, dark-gray, silty	10	47

163-54-17aad1
USGS test 16

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Deposits of Horrigan Ridge:		
Soil, black, sandy	2½	2½
Sand, light-brown, very fine and silty	6½	9
Silt,and clay, buff	3	12
Sand, light-brown, very fine; clay and silt	5	17
Gravel, light-gray; numerous shale pebbles	6	23
Clay unit:		
Clay, dark-gray, silty	9	32

163-54-16bcb
USGS test 17

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Deposits of Horrigan Ridge:		
Soil, black, sandy	1	1
Silt and very fine sand, tan	5	6
Sand, light-brown, very fine; clay and silt.	6	12
Sand, light-tan, very fine; clay and silt...	15	27
Sand, gray, very fine; clay and silt	4	31
Silt, and clay, gray, very fine; sand	6	37
Sand, grayish-tan, very fine; clay and silt.	17	54
Clay unit:		
Clay, dark-gray, silty	8	62

163-54-17aad2
USGS test 18

Formation Material	Thickness (feet)	Depth (feet)
Lake Agassiz deposits:		
Deposits of Horrigan Ridge:		
Soil, black, sandy	4	4
Sand and silt, grayish-tan; clay	20	24
Clay unit:		
Silt and clay, gray and tan	12	36
Clay, dark-gray, silty	6	42

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