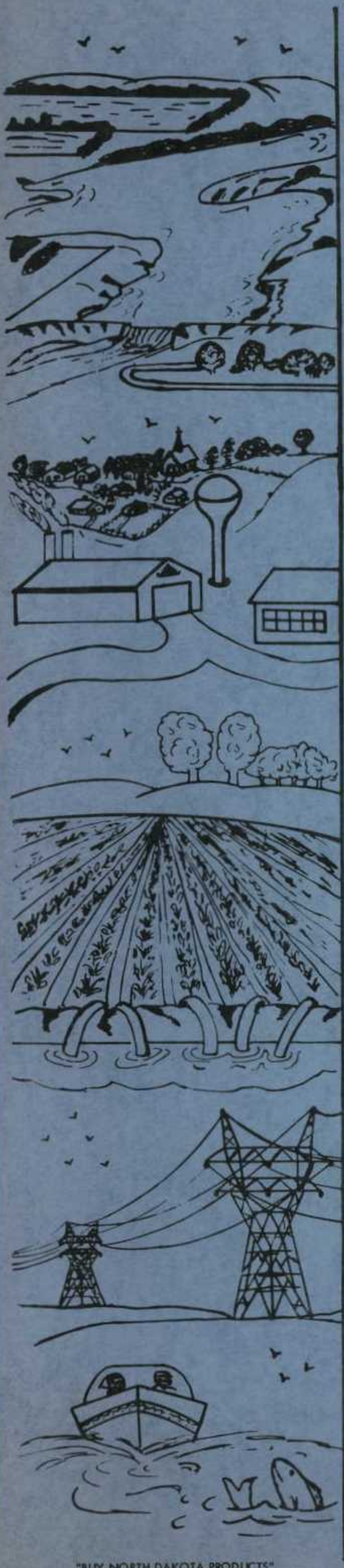

GROUND WATER IN THE ANETA AREA

NELSON COUNTY, NORTH DAKOTA

By
P. E. Dennis

NORTH DAKOTA GROUND WATER STUDIES

No. 7

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

PUBLISHED BY
NORTH DAKOTA STATE WATER CONSERVATION COMMISSION
1301 STATE CAPITOL, BISMARCK, NORTH DAKOTA

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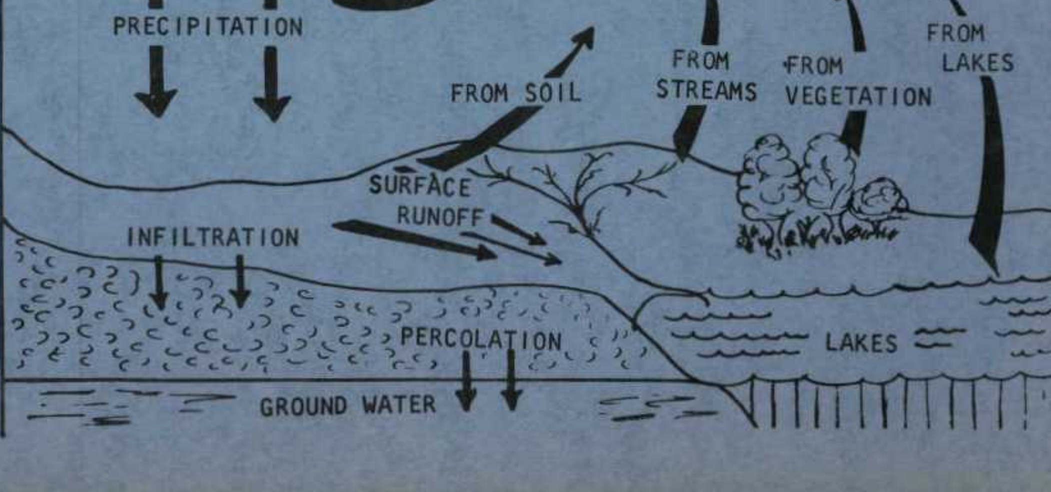

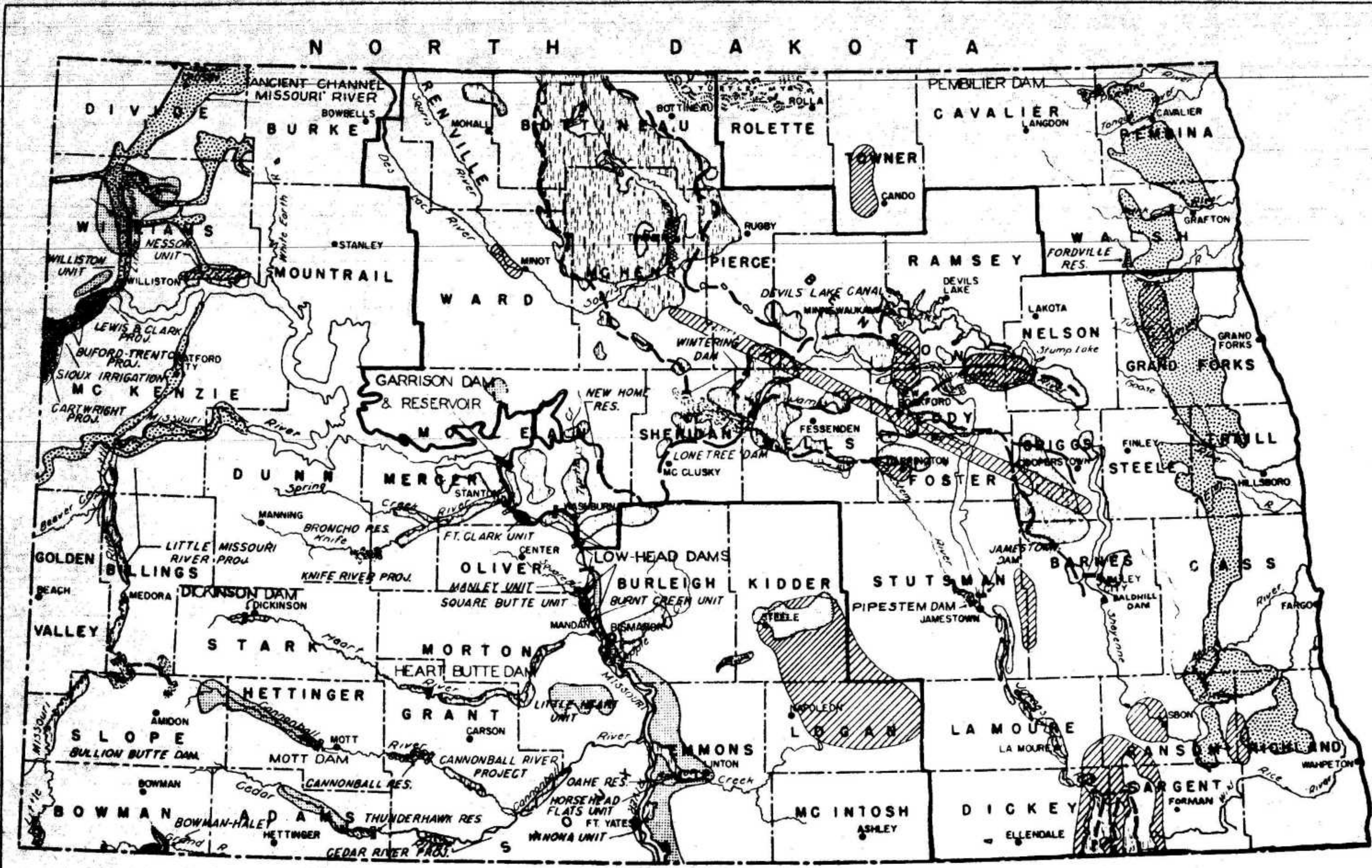

NORTH DAKOTA STATE WATER CONSERVATION COMMISSION

WATER RESOURCES DEVELOPMENT PLAN

LANDS UNDER IRRIGATION

AREAS CONSIDERED IRRIGABLE

AREAS BEING INVESTIGATED

PROPOSED FOR INVESTIGATION

EXISTING

UNDER CONSTRUCTION OR PROPOSED

DAM & RESERVOIR SITES

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ILLUSTRATIONS

GROUND WATER NEAR ANETA, NELSON COUNTY, NORTH DAKOTA

By P. E. Dennis

ABSTRACT

Aneta (population 509) is near the southeast corner of Nelson County on the west margin of the Fergus Falls-Leaf Hills recessional moraine. The till of the moraine is virtually non-water-bearing, as is also the Pierre shale, which forms the bedrock underlying the drift at depths of 5 to 35 feet in this area. No wells have been drilled to the Dakota sandstone, which lies about 1,200 or 1,300 feet below the surface at Aneta. However, in adjacent areas the waters from the Dakota are generally considered unsuitable for culinary purposes. Outwash gravels partly fill a glacial channel (or coulee) of a tributary of the glacial Sheyenne River about a quarter of a mile west of town. Test drilling indicates that there is from 20 to 30 feet of saturated gravel in the deeper part of this coulee.

Recharge of the outwash gravels probably comes chiefly from direct penetration of rain water and melting snow, although a considerable contribution probably comes from surface runoff from areas tributary to the coulee. The general direction of movement of ground water in the aquifer is down the slopes of the coulee into the deeper gravels at its bottom and southward in this deeper gravel to points of discharge. It is estimated that the total amount

of water discharged from the glacial outwash aquifer may be of the order of magnitude of about a million gallons a day. The discharge is chiefly by evaporation and transpiration from the lakes and marshes which occupy the lower portions of the coulee. Only part of the total natural discharge could be recovered by wells but it appears that a perennial supply of at least 30,000 to 50,000 gallons a day could be developed.

All the ground waters of the area are rather highly mineralized but those of the outwash aquifer contain the smallest amounts of dissolved minerals. Analyses indicate that the waters from this aquifer will probably range between 800 and 1,200 parts per million in dissolved solids content.

INTRODUCTION

Scope and purpose of investigation

This is a progress report on the general study of the geology and groundwater resources of Nelson County being made by the U. S. Geological Survey in cooperation with the State Water Conservation Commission and the State Geological Survey. These general studies are being made to determine the occurrence, movement, discharge, and recharge of the ground water and the quantity and quality of such water available for all purposes including municipal, domestic, irrigation, industrial, and other uses. However, the most critical need at the present time is for adequate and perennial water supplies for numerous towns and small cities throughout the State which are attempting to construct municipal water-supply systems for the first time. For this reason, the county studies are being started in the vicinity of those towns which have requested the help of the State Water Conservation Commission and the State Geologist. Progress reports are being released as soon as possible in order that the preliminary data may be available for use in connection with the solution of water-supply problems in the towns shortly after they are obtained and before the general studies and conclusions can be completed. The study described in this report was confined chiefly to obtaining information on ground water in that part of Nelson County which is of immediate interest to the village of Aneta in its search for sources of water for municipal use.

Location and general features of the area

Aneta is near the southeast corner of Nelson County, North Dakota, about 50 miles southwest of Grand Forks. It is on a branch line of the Great Northern Railway which runs from Fargo to Devils Lake. The town has a population of about 509 (1940 census) and serves as a shipping point and trading center for the farming area around it.

The part of the Central Lowland 1/ physiographic province in which Aneta is located has been called the Drift Prairie by Simpson. 2/ It is a plains area modified by little-eroded glacial drift which forms relatively rough low hills along the lines of the end moraines and a gently rolling topography elsewhere. The Drift Prairie is bordered on the west by the Missouri Plateau and on the east by the Red River Valley. Aneta is about 50 miles east of the escarpment which marks the eastern boundary of the Missouri Plateau and about 18 miles west of the highest (Herman) shoreline of Lake Agassiz which marks the western limit of the Red River Valley. 3/

1/ Fenneman, N.M., Physiography of eastern United States, pp. 559-588, McGraw-Hill Book Co., 1938.
2/ Simpson, H.E., Geology and ground-water resources of North Dakota: U.S. Geol. Survey Water-Supply Paper 598, p. 4, 1929.
3/ Upham, Warren, The glacial Lake Agassiz: U.S. Geol. Survey Mon. 25, 1896

The topography in the vicinity of Aneta consists of end moraine, ground moraine, and outwash plains and channels (fig. 1). The town is at the western edge of a small recessional moraine which has an average width of 3 to 4 miles. Its trend is essentially north-south in the vicinity of Aneta and for 10 or more miles southward, but a short distance north of the town the moraine is shown by Upham 4/ to turn northwestward and to join the heavy morainal area south of Devils Lake. It is a part of this Fergus Falls-Leaf Hills moraine. Typical knob and kettle topography characterizes much of the surface of the moraine, the maximum difference in elevation between the bottoms of the kettles and the tops of the knobs amounting to a little over 100 feet.

The end moraine grades eastward into ground moraine where the hill and swale topography is broken only by small and poorly developed glacial drainage channels. In contrast, the western edge of the end moraine is generally abrupt, its front forming a definite escarpment as viewed eastward from the outwash plain.

The town of Aneta is at the east edge of an outwash channel averaging about a quarter of a mile wide, which merges southward with extensive outwash plains. These plains extend to the Sheyenne River about 7 miles west of Aneta and they appear to have extensive development along the north and east margins of that stream for at least 8 or 10 miles both north and south of this area.

The Sheyenne River is the only perennial stream in the area. At its nearest point it is about 7 miles west of Aneta and here the general direction of its course changes from easterly to southerly. The river meanders in a broad glacial channel, the floor of which lies about 250 feet below the general elevation at Aneta. The coulee west of Aneta (fig. 1) was formed by a southward-flowing tributary of the glacial Sheyenne. No through-flowing stream now occupies the coulee but its lowest portions contain lakes and marshes (fig. 2).

4/ op. cit., pl. 19, p. 212.

Previous investigations and acknowledgments

The geology and ground water of the Aneta area have been previously treated only in a very general way in connection with studies of broad areas. A general discussion of the ground water in Nelson County with mention of one deep well near Aneta is contained in Simpson's paper on the ground-water resources of North Dakota 5/. Other works such as Upham's monograph 6/ and bulletins of the North Dakota Geological Survey are useful for their treatment of the general geology of the State.

The present study was facilitated by the ready cooperation of townspeople, farmers, and local well drillers. Thanks are due especially to those who permitted measurement of water levels in their wells and drilling operations upon their land.

Present water supply and future needs

Water for culinary purposes is obtained at present from several dug and bored wells in the west part of town and by hauling from springs and wells in adjacent areas. It is reported that for a number of years most of the townspeople hauled water from springs along the west margin of the coulee about a quarter of a mile northwest of town. The domestic supply is supplemented in many homes by rain water which is caught on the roofs of buildings and run into cisterns.

5/ Op. cit., p. 177.

6/ Op. cit.

The spring-fed lakes in the coulee about a quarter of a mile west of town serve as a source of water for purposes other than domestic. Early in the present century the northernmost lake was deepened by the railroad company by dredging two long, narrow reservoirs about 20 or 25 feet below the former lake bottom. Water from these reservoirs was pumped to a watering tank on the railroad in Aneta. For a number of years the engines have not been watering at Aneta and it is reported that the town has purchased the old pipe line from the reservoir to town in the hope that it might be used in connection with the installation of a municipal water supply.

It is estimated that approximately 50,000 gallons of water a day will be required for a satisfactory municipal water supply for the town, although probably less than half that amount is used at the present time.

GEOLOGY AND HYDROLOGY

General

Essentially all ground water is derived from precipitation. The water may enter the ground by direct penetration from rainfall or from melting snow, and by percolation from streams which cross the area. A part of the ground water in some areas comes from adjacent regions, entering the ground at higher elevations and moving slowly to lower elevations through the more permeable beds. The unconsolidated rocks such as clay, sand, and gravel are generally more porous than consolidated rocks such as sandstones, limestones, etc., although in some areas the consolidated rocks are highly porous. The amount of water that a rock can hold is measured by its porosity. If the pore spaces are large and interconnected, as they commonly are in sand and gravel, the water is transmitted more or less freely and the rock is said to be permeable; but where the pore spaces are very small, as they are in clay, the water is transmitted very slowly or not at all and the rock is said to be impermeable. Below a relatively shallow depth in practically all regions the pore spaces in the rocks are filled with water and the rocks are said to be saturated. This is true of the clay as well as the sand and gravel, but because of the difference in permeability it is possible to obtain wells only in the coarser materials. Where some part of the water-transmitting bed (aquifer) is exposed at the surface or comes in contact with another aquifer which is so exposed the water discharged naturally or through wells has an opportunity to be replenished each year in this "recharge area." Where the aquifer is more or less completely surrounded by clay, natural recharge may be very slow and the water taken by wells from storage in the aquifer is not fully replenished each year. The initial yield of wells in aquifers cut off from natural recharge may be as large as that from wells in aquifers having good recharge areas, giving an erroneous impression that an abundant perennial supply is available.

As ground water moves through an aquifer it dissolves a part of the more soluble mineral constituents of the rock particles. The amount of mineral matter dissolved in ground water is determined by the amount of the soluble materials present and the length of time the water is in contact with them. Therefore, the waters which have been underground longest and have traveled the greatest distance are commonly more highly mineralized than those which are relatively near the recharge area.

Rock materials and their water-bearing characteristics

The surface rock in the Aneta area consists of glacial drift of Pleistocene age. It forms a thin veneer on the underlying bedrock, which in this area is the Pierre shale of Cretaceous age. The drift may be divided conveniently into end and ground moraine, consisting chiefly of till; and glacial outwash and stream deposits, consisting chiefly of sand and gravel.

Glacial outwash and stream deposits

The ground moraine in the eastern part of the area is crossed by two small glacial channels which originally connected eastward with the Goose River. The channels are small and indistinct and can be traced with assurance only on the areal photographs. The nearest of these channels is nearly 4 miles east of Aneta and auger holes showed the outwash materials to be very thin, only 0 to 18 inches of sand lying above the till. Along this channel between the latitudes of Aneta and Sharon (fig. 1) are several kames composed of poorly assorted sand and gravel, boulders, and till. Some of the sand and gravel has been excavated for road metal but no evidence of extensive glacio-fluvial deposits was found in this area.

The coulee west of Aneta contains the only extensive outwash deposits in the immediate vicinity of the town. The slopes and poorly developed terraces along its sides are veneered with sand and gravel ranging in thickness from less than a foot to about 5 feet, but the bottom of the channel contains from 20 to 30 feet of gravel and sand. The outwash materials in some places rest directly on shale bedrock, whereas in other places they are separated from the bedrock by a few feet of till (fig. 2, section). The gravel is composed of about 70 to 80 per cent of shale pebbles and considerable clay and silt is mixed with the gravel and sand.

Till of the moraines

The till about 2 miles east of Aneta is reported to be 50 to 60 feet thick. However, in the immediate vicinity of Aneta the till cover above the shale bedrock is very thin, usually ranging from 6 to 15 feet, and having a maximum reported thickness of 35 feet. It is a compact clayey material composed chiefly of shale detritus with occasional boulders and pebbles of limestone and crystalline rocks. It is commonly somewhat more gravelly at the base and a few wells of small yield obtain water at this horizon in the eastern part of Aneta. The water is highly mineralized (See analysis for Andreski well.) Numerous holes have been put down to the shale bedrock (or slate, as it is termed by the well drillers) in and near Aneta in attempts to obtain satisfactory wells. Most the holes were bored with a large power-driven auger which yields excellent samples of the materials penetrated. From drillers' reports of the results of these borings it appears that the materials of the ground and end moraine in the vicinity of Aneta are almost exclusively clayey till which yields little or no water to wells.

Shale bedrock

The shale bedrock is encountered at very shallow depths in the vicinity of Aneta and is exposed at the surface a short distance south of the Seim spring (fig. 1) and in the coulee which crosses the highway between Aneta and McVille, about 6 miles northwest of Aneta. No wells are known to obtain water from the shale in the Aneta area, although wells yielding small amounts of soft but highly mineralized water are obtained from this formation at the town of Michigan in the same county. Holes several hundred feet deep are reported to have been drilled into the shale without finding any water-bearing materials. Simpson mentions the Edgar Gutormson farm well near Aneta which was drilled 744 feet into the shale without finding water. 7/ Similar deep holes have been drilled into the shale at Sharon without finding appreciable quantities of water.

Dakota sandstone

So far as known no wells in the vicinity of Aneta have been drilled to the Dakota sandstone, which underlies the Cretaceous shales in this area. This artesian aquifer is encountered about 600 feet below the surface (about 300 feet

7/ Op. cit., p. 179

above sea level) near Northwood and about 1,450 feet below the surface (about at sea level) at Devils Lake. The probable depth to this aquifer at Aneta would be about 1,200 to 1,300 feet. The water from the Dakota sandstone is highly mineralized near Northwood, at Devils Lake, and also west and southwest of Aneta at Harvey and Carrington. It is generally considered unsuitable for culinary purposes.

Test holes

Seven test holes were drilled in the Aneta area during the present investigation. All were drilled to bedrock using the State-owned hydraulic rotary machine. Because all the evidence from wells and test holes already drilled or bored within and near the town indicated the non-water-bearing character of the drift in the end and ground moraine and the shale bedrock, the test drilling was concentrated in the glacial outwash of the coulee west of town. Prior to the test drilling little information was available concerning either the thickness or the character of the outwash materials in this glacial drainage channel. Because the sand and gravel is saturated nearly to the land surface, the boring machines had been unable to penetrate the entire thickness of the fill. Most of the test holes were drilled in March and April 1947, when the ground was still deeply frozen, and it was possible to drill two holes in the central part of the coulee where it is marshy and soft during other seasons of the year.

Logs of the seven test holes are given in the tables at the end of this report and figure 2 shows graphically the character and thickness of the materials penetrated. In holes 1, 3, and 4 about 20 to 30 feet of saturated sand and gravel was encountered, indicating that the central part of the coulee, in this area at least, is filled to that depth with water-bearing materials.

Existing wells
Piezometric surface

Most of the presently accessible wells in Aneta range in depth between 26 and 48 feet, and according to reports of the well drillers they were bored to the base of the drift or into the upper part of the shale bedrock. Therefore, the water-bearing horizon is believed to be at or near the base of the drift in most wells. None of the wells are reported to have large yields, although a few furnish water for several families without serious drawdown or seasonal exhaustion.

The depth to water in most of the wells in Aneta was measured at least once and selected wells were measured at intervals for about a year. Elevations were established on the measuring points at these wells and the elevation of the water surface in the various wells thus determined. Using these data, contours were drawn through points having like elevations. The piezometric map of the water surface thus made is shown in figure 2. The surface is approximately that of June 1946 but the readings on some of the wells for that date could not be used because of drawdown caused by recent pumping. Periodic measurements indicated that small discharges caused large drawdowns in many of the wells and several days, or even weeks, were required for complete recovery of the original static levels. For these wells interpolations have been made from static levels measured on other dates. The water levels in test holes 1-7 could not be measured, owing to the method of drilling used.

The piezometric map indicates that the ground water is moving westward toward the large coulee and southwestward toward the small tributary of that coulee which skirts the south edge of town. In the north part of town, depression contours have been drawn around two of the most heavily used wells where the highest water levels measured were considerably below those of adjacent unused wells. It is believed that the depressions are the result of drawdowns caused by the relatively heavy withdrawals from these wells and that the water levels had never completely recovered between measurements.

Fluctuations in water levels

The water-level fluctuations caused by pumping are large in the wells in Aneta. The poorer wells are reported to "pump dry" after yielding only a few barrels of water, and measurements on the "stronger" wells 10 to 30 minutes after they had been pumped for stock and domestic use showed residual drawdowns of 5 to 8 feet.

Seasonal fluctuations are partly masked by the pumping effects, but it is clear that in 1946 there was a general decline in water levels during the summer months and that general recovery did not occur until April and May of the following year.

Recharge, movement, and discharge of water in the outwash gravels

Most of the recharge to the glacial-outwash aquifer in the coulee west of Aneta probably comes from direct penetration of rain water and from melting snow, although considerable contributions probably come from surface runoff from the areas tributary to the coulee. The sand and gravel deposits are covered by only a thin layer of sandy soil and there is excellent opportunity for recharge from the moisture which falls upon the area and also from the wet-weather streams which cross it.

The piezometric surface (fig. 2) indicates that there is some recharge to the gravel and sand in the coulee from the east slopes in the vicinity of Aneta. There is some evidence to indicate that similar recharge from the west slope occurs in considerably larger amounts. Practically all the springs and seep areas occur at the base of the slope on the west side of the coulee. Test holes and well records indicate that the covering of sand and gravel on the west slope is thicker than it is on the east slope. The water in the reservoir and from springs in the coulee is much less highly mineralized than that from wells in Aneta, indicating that only a relatively small amount of the total recharge could come from the highly mineralized waters from the east slope.

The glacial stream which formed the coulee flowed southward and present surface discharge after heavy rains also is in that direction. All the evidence indicates that the underground drainage is also to the south. Perennial springs in the bottom of the coulee about a mile north of the Seim spring probably represent discharge points in this southward movement from the Aneta area. The coulee is rather broad and receives several tributaries north of Aneta, and it seems probable that considerable recharge may be received from that area.

The general movement of water in the aquifer is, therefore, down the slopes of the coulee into the deeper gravel at its bottom and southward in this deeper gravel to points of discharge.

Discharge of the ground water from this aquifer is chiefly through evaporation and transpiration from the lakes, reservoirs, and marsh areas which occupy the lower portions of the coulee from about 2 miles north to about 3 miles south of Aneta. The total amount of water discharged in this area can be estimated only very roughly from available data. There was a total of approximately 150 acres of open-water surface on the lakes and reservoirs west of Aneta on September 1, 1941, as shown on areal photographs taken at that time. The amount of open water varies thoughout the season and from year to year, but assuming that this may represent the average amount and assuming 36 inches of evaporation a year from open water in this latitude 8/, the total evaporation from the lakes and reservoirs would be about 450 acre-feet a year. The areas in which most of the water loss is by transpiration from cattails, tules, and marsh grasses is more difficult to estimate but is probably considerably larger than the open water

8/ Meinzer, O.E., Hydrology, p. 79, McGraw-Hill Book Co., Inc., 1942.

surface and may be at least 200 acres. From work in other areas 9/ it appears that the transpiration from the tule and cattail areas might be between 4 and 5 acre-feet per acre a year and from the marsh grasses between 2 and 3 acre-feet per acre a year. Using a conservative figure of 2.5 acre-feet per acre a year as the transpiration from the 200 acres being considered, the transpiration losses would be about 500 acre-feet a year and the total transpiration and evaporation losses would be about 950 acre-feet a year or about 310 million gallons a year.

There is also some discharge from the aquifer by southward flow in the gravel fill of the coulee. Evidence of this is furnished by the springs which issue in the bottom of the coulee about a mile above the Seim spring. The surface flow from these springs disappears a short distance south of the Seim spring. The amount of underflow is not known but it is probably considerably smaller than the amount of discharge by evaporation and transpiration. The total discharge of ground water in the area is probably of the order of magnitude of a million gallons a day.

QUALITY OF THE GROUND WATER

Analyses of waters from 10 wells and other ground-water sources in the Aneta area are given in the table on page 18. Like most of the ground waters in North Dakota, they are rather highly mineralized. Only one sample showed total dissolved solids of less than 1,000 parts per million and the most highly mineralized showed 6,537 parts per million of dissolved solids. The wells in the eastern part of town which draw water from the shale and from the base of the drift are most highly mineralized, as indicated by the analysis for the Andreski well.

9/ Meinzer, O. E., op. cit., pp. 294-298.

The ground water from the gravel fill of the coulee is least mineralized, as indicated by analyses of the spring water and reservoir water.

The table of chemical analyses includes six analyses which were made in 1935 by G. A. Abbott at the University of North Dakota. Unfortunately no information was submitted at that time regarding the sources of the samples. Diligent search failed to reveal any written record of the sources from which the samples were collected. Nevertheless, on oral report of O. L. Walhood, who was village clerk at that time, and Olaf Wangen, who collected the samples, it appears that they were collected from the high school well, the Retzlaff farm well just west of town, the spring just north of the reservoirs, and from the Smallback, Holen, and Larsen wells. Whether the sources have been correctly identified or not, the analyses do indicate the general quality of the ground waters of the area.

SUMMARY AND CONCLUSIONS

Only one shallow aquifer of any considerable extent exists in the immediate vicinity of Aneta. It is composed of glacial-outwash sand and gravel which partly fills an old glacial channel or coulee. The deepest part of the coulee averages about a quarter of a mile in width, and the coulee extends at least 3 miles north and more than 6 miles south of Aneta. The sand and gravel are composed chiefly of shale particles and there is considerable silt and clay mixed with them. About a quarter of a mile west of Aneta there is a maximum thickness of 20 to 30 feet of saturated gravel in the coulee, composing the principal aquifer.

Other aquifers occur at the base of the drift and in the upper part of the shale but they yield very small quantities of highly mineralized water. No wells have been drilled to the Dakota sandstone in the Aneta area, but this aquifer could probably be reached there at a depth of about 1,200 or 1,300 feet below the surface. The water from the Dakota in this region is highly mineralized and generally considered unsuitable for culinary purposes.

Recharge of the outwash materials probably comes chiefly from direct penetration of rain water and melting snow, although a considerable contribution probably comes from surface runoff from areas tributary to the coulee. The general direction of movement of ground water in the aquifer is down the slopes of the coulee into the deeper gravel at its bottom and southward in this deeper gravel to points of discharge.

Discharge of the ground water is chiefly by evaporation and transpiration from the lakes and marshes which occupy the lower portions of the coulee. The total amount of water discharged from the aquifer can be estimated only very roughly, but it appears that the figure may be of the order of magnitude of about a million gallons a day. Only a part of the total natural discharge could be recovered by wells. However, one or more properly developed wells in the deeper gravels penetrated by test holes Nos. 1, 3, and 4, which probably extend some distance north and south of the area of test drilling, would probably yield a total of 30,000 to 50,000 gallons a day without depleting the supply.

There are no wells in the deeper gravels of the coulee and for this reason no pumping tests or other quantitative measurements could be made to determine more accurately the amount of water which can be salvaged from the aquifer for beneficial use. Before any large development is attempted it would appear desirable to have a test well completed on which such tests could be made. If permanent wells are constructed in the aquifer it would be desirable to obtain continuous records of water-level fluctuations in permanent observation wells in order that data may be available for determining the relations among pumpage, recharge, and storage in the aquifer at all times.

The ground waters of the area are rather highly mineralized, those derived from wells penetrating the drift and the shale bedrock in the eastern part of town containing the largest amount of dissolved mineral matter. The outwash gravels contain the least mineralized waters in the area, the analyses of spring and reservoir waters indicating a probable range of 800 to 1,200 parts per million of total dissolved solids for waters from these gravels.

ANALYSES OF GROUND WATERS

Owner	Location numbers	Date Collected	Source of Analysis	Depth of Well (Feet)	Iron (Fe)	Calcium (Ca)
A. Nelson	149-57-32 1/ (22-9)	7-12-46	A 2/	26.5	3	59
Reservoir	149-57-31 daa	do.	A	No data	1.7	82
T. Ringstad	149-57-31 (19-6)	do.	A	40	.8	216
G. Andreski	149-57-32 (12-8)	do.	A	37	2.3	311
Spring (?) ?	149-57-30 cdd	1935	B 3/	Spring	.1	218
High School ?	149-57-32	do.	B	45	1.0	99
R. Retzloff ?	149-58-36 aaa	do.	B	42	.04	100
M. Smallback (?)	149-57-31 (27.4)	do.	B	36	.4	175
Mrs. Holen ?	149-57-31 adc	do.	B	--	.6	192
L. Larson	149-57-31 adc	do.	B	28	.6	109

1/ First number in parenthesis is block number, the second is lot number.
2/ Analysis by State Laboratories Department.
3/ Analysis by Dr. G. A. Abbott.

IN THE ANETA AREA, IN PARTS PER MILLION

Magnesium (Mg)	Sodium (Na)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Total dissolved solids	Total hardness as ($CaCO_3$)
12	312	None	482	564	Trace	1,369	198
55	158	27.6	29.3	500	28	1,216	435
58	267.3	None	378	975	50	2,100	776
125	1,334	28.8	588	3,091	163	6,537	1,288
46	2.5	----	495	244	70	861	735
57	1,047	----	847	174	1,263	3,243	498
113	303	----	893	208	141	1,387	723
54	128	----	373	479	35	1,106	610
62	269	----	421	708	26	1,506	572
61	146	----	443	406	22	1,014	523

Location number	Owner or Name	Depth of well (feet)	Diameter (inches)	Type
149-57-29 ccc	USGS test well#6	48	5	Drilled
149-57-30 ddd	H. Samt	35	24	Bored
149-57-31 abb	USGS test well #2	35	5	Drilled
149-57-31 baa	do. well #1	36	5	do.
149-57-31 bab	do. well #3	56	5	do.
149-57-31 bdd	do. Well #4	48	5	do.
149-57-31 (18-12) 3/	Leo Colbert	39	30	Dug
149-57-31 (19-6)	T. Ringstad	40	18	do.
149-57-31 (19-7)	A. T. Retzlaff	--	24	Bored
149-57-31 (21-7)	Glen Hanson (tenant)	30	--	Dug
149-57-31 (27-4)	M. Smallback	36	36	Bored
149-57-31 adc	Mrs. Holen	--	18	do.
149-57-31 (29-3)	Mrs. Lippert	36	24	do.
149-57-31 adc	L. Larson	28	12	-------
149-57-31 (29-6)	Mrs. I. Ulvick	38	--	Bored
149-57-31 (30-5)	Ed Olson	33	9	do.
149-57-31 (33-6)	Carl Tingstadt	27	36-48	Dug
149-57-31 dac	USGS test well #7	33	5	Drilled
149-57-32 (3-3)	Henry Solberg	38	18	Bored
149-57-32 (3-8)	John Clark	34.4	36	do.
149-57-32 (12-8)	Gus Andreski	37.0	24	do.
149-57-32 (12-21)	City well (city hall)	48	96x96	Dug
149-57-32 (22-9)	A. Nelson	26.5	30	do.
149-58-25 ddd	USGS test well #5	45	5	Drilled
149-58-36 aaa1	R. Retzlaff	42	36	Bored
149-58-36 aaa2	do.	35	36	do.

1/ Land-surface datum.
2/ U-unused, S-stock, D-domestic, I-irrigation.
3/ First number in parenthesis is block number, second number is lot number.
4/ Test holes were drilled and refilled. Date given is date of refilling.

Date completed	Depth to water (feet) 1/	Date of measurement	Elev. of measuring point (feet)	Use 2/	Remarks
4-8-47 4/	-----	-------	------	U	See Log.
------	30	6-26-46	------	S	Pumps dry.
11-15-46 4/	-----	-------	------	U	See log.
11-15-46 4/	-----	-------	------	U	do.
3-31-47 4/	-----	-------	------	U	do.
4-1-47 4/	-----	-------	------	U	do.
1926	15.98	6-25-47	1500.2	D	Used by school & neighbors.
1925	17.44	6-27-47	1498.8	D	See analysis.
1906	15.69	6-28-47	------	U	------------------------------
1942	16.90	6-28-47	1496.8	D	------------------------------
old	25.76	6-26-47	1497.5	D	------------------------------
-------	24.02	6-27-46	1497.5	DS	------------------------------
old	22.49	8-28-46	1498.9	DS	------------------------------
-------	24.07	6-27-46	1497.9	DS	------------------------------
-------	23.70	6-28-46	1498.6	I	Pumps dry.
1934	18.79	6-28-46	1490.3	D	do.
1935	15.13	6-28-47	1492.8	S	------------------------------
4-9-47 4/	-----	-------	------	U	See log.
-------	16.43	6-26-46	1503.9	--	------------------------------
1928	11.55	6-25-46	1505.6	S	------------------------------
-------	5.96	6-28-46	1502.1	U	See anal. Bottomed in blue shale.
-------	10.12	6-26-46	1507.0	D	------------------------------
1926	16.04	6-28-46	1494.4	DS	See analysis.
4-8-47 4/	-----	-------	------	--	See log.
1929	25.0	6-26-46	------	DS	------------------------------
1934	10.0	6-26-46	------	DS	------------------------------

Logs of test holes near Aneta, Nelson County

No. 1, 149-57-31 baa

Material	Thickness	Depth
Soil, black, sandy	3	3
Gravel and sand with some black clay	5	8
Sand, gray, fine to medium	4	12
Sand, gray, fine to medium, silty	6	18
Gravel and sand, pebbles mostly of shale	7	25
Gravel and boulders with some clay	3	28
Shale	8	36

No. 2, 149-57-31 abb

Soil, yellow, sandy, with some pebbles.	5	5
Till, weathered, yellow clay with sand and gravel	14	19
Till, unweathered, gray clay with shale pebbles	11	30
Sand composed of shale grains	2	32
Shale	6	38

No. 3, 149-57-31 bab

Soil, black, sandy	5	5
Gravel and sand, mostly shale pebbles and grains	32	37
Till: gray clay with gravel and sand	9	46
Shale	10	56

No. 4, 149-57-31 bdd

Material	Thickness	Depth
Soil, black, sandy	4	4
Gravel with some sand and clay	7	11
Sand, brown, fine to medium	16	27
Gravel and sand, coarse, mostly shale pebbles and grains	11	38
Gravel & cobbles	6	44
Shale	4	48

No. 5, 149-58-25 ddd

Soil, black, gravelly	4	4
Till, weathered:yellow clay with gravel	11	15
Till, unweathered: gray clay with gravel	19	34
Shale	11	45

No. 6, 149-57-29 ccc

Till, weathered: yellow clay with gravel	19	19
Till, unweathered: gray clay with gravel	22	41
Shale	7	48

No. 7, 149-57-31 dac

Soil, black, gravelly	4	4
Sand, gravel and boulders	4	8
Till, weathered, gravelly	10	18
Till, unweathered, gray	8	26
Shale	7	33

FIGURE I. SKETCH MAP OF ANETA, NELSON COUNTY, AND SHARON, STEELE COUNTY AND VICINITY

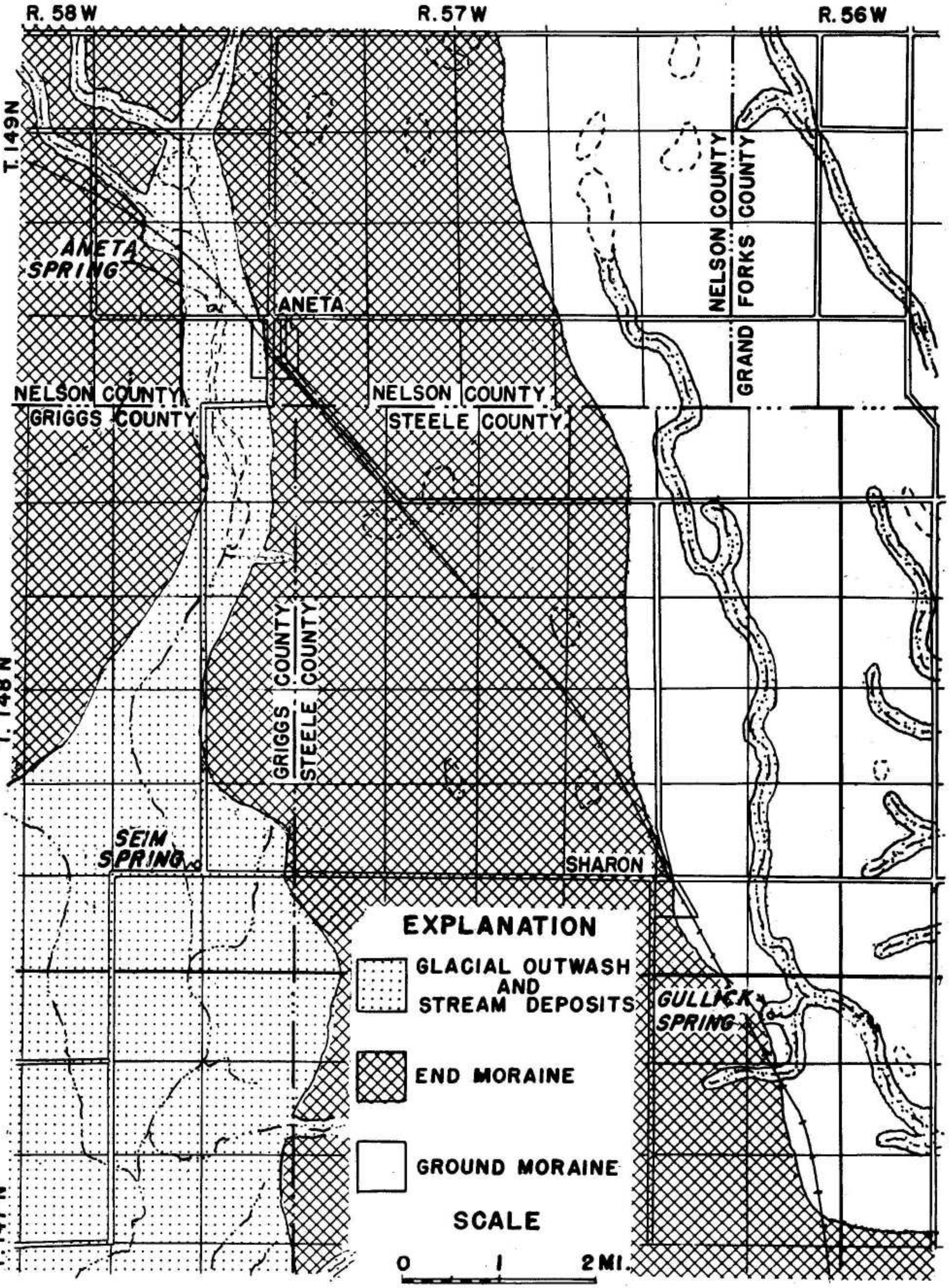

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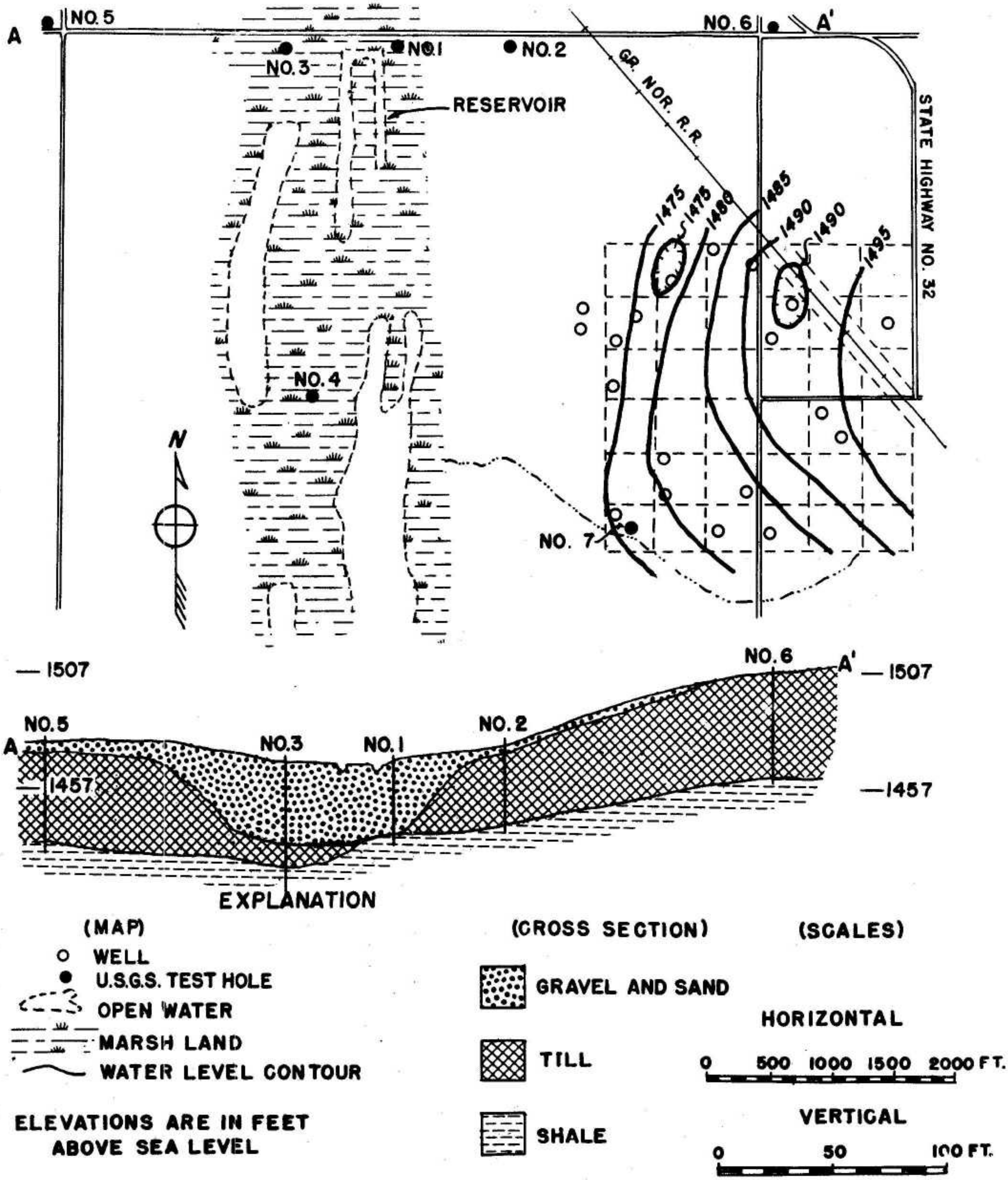
FIGURE 2
MAP OF ANETA SHOWING HYDROLOGIC FEATURES
AND GENERALIZED CROSS SECTION



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