1969

Ground Water Atlas of Nebraska (June 1969)

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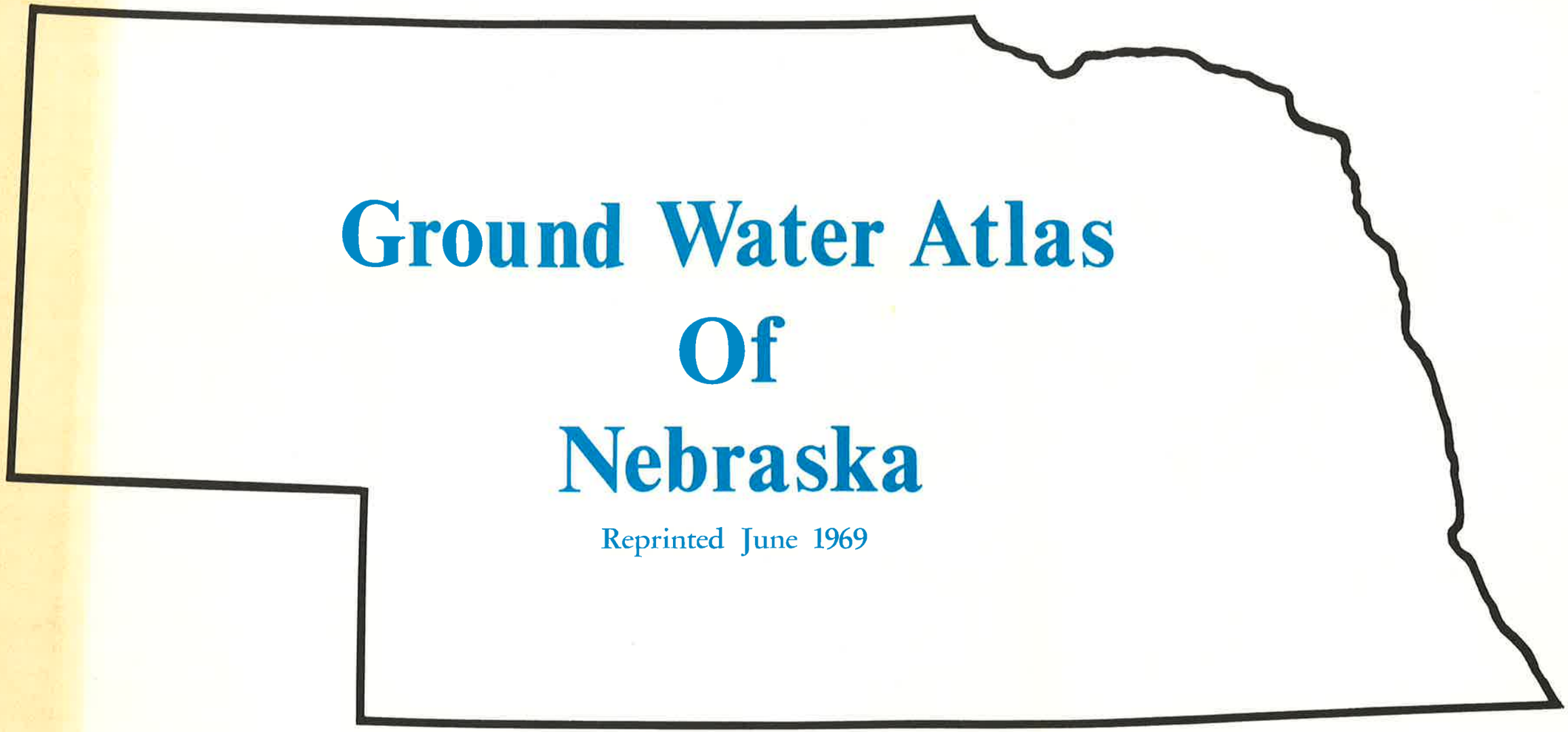

Ground Water Atlas Of Nebraska

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Conservation and Survey Division

University of Nebraska

(Compiled from cooperative investigations with
Water Resources Division, U. S. Geological Survey)

As defined by law, the duties of the Conservation and Survey Division of the University are to survey and describe the geology, topography, natural resources, industries, and conservation problems of Nebraska and serve as a factual Information Bureau relating to the conservation and development of the state's resources. The Division is authorized to cooperate with federal agencies actively engaged in these particular fields.

Reports of the Division are published by its departments: Geological Survey, Water Survey, Soil Survey, Resource and Industry Survey, and Conservation Survey. The Information Bureau is a service agency designed to facilitate the immediate practical application of the factual information developed by the research of the departments of the Division. This is accomplished through correspondence, local field examination in problem areas, office and public meeting conferences and hearings, and distribution of departmental publications.

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FOREWORD

This series of maps of the state is included herewith to illustrate the ground water conditions throughout Nebraska as they are known today. In addition, maps are included that will serve to locate data presented more specifically in reference to cities, towns, and geographic boundaries; the topographic regions are illustrated because of the influence of land forms and soils on the utilization of the ground water resources.

Studies of the geologic formations of the state, pursued over a long period of time, have contributed greatly to the understanding of the ground water conditions. The Conservation and Survey Division of the University has engaged in a cooperative study of the ground water of the state since 1930 with the Water Resources Division of the United States Geological Survey, and much of the data herein presented is the result of this joint effort. Many new techniques have been developed in this program through the years, including the drilling of test holes on a systematic basis for a better understanding of the distribution and continuity of the water-bearing materials; the location and periodic measurement of ground water levels in observation wells on a state-wide basis; the use of pumping tests to determine transmissibilities of water-bearing materials; and the estimation of permeabilities and transmissibilities of water-bearing materials from test hole records to permit the mapping of areas where significant yields of water from wells may be anticipated.

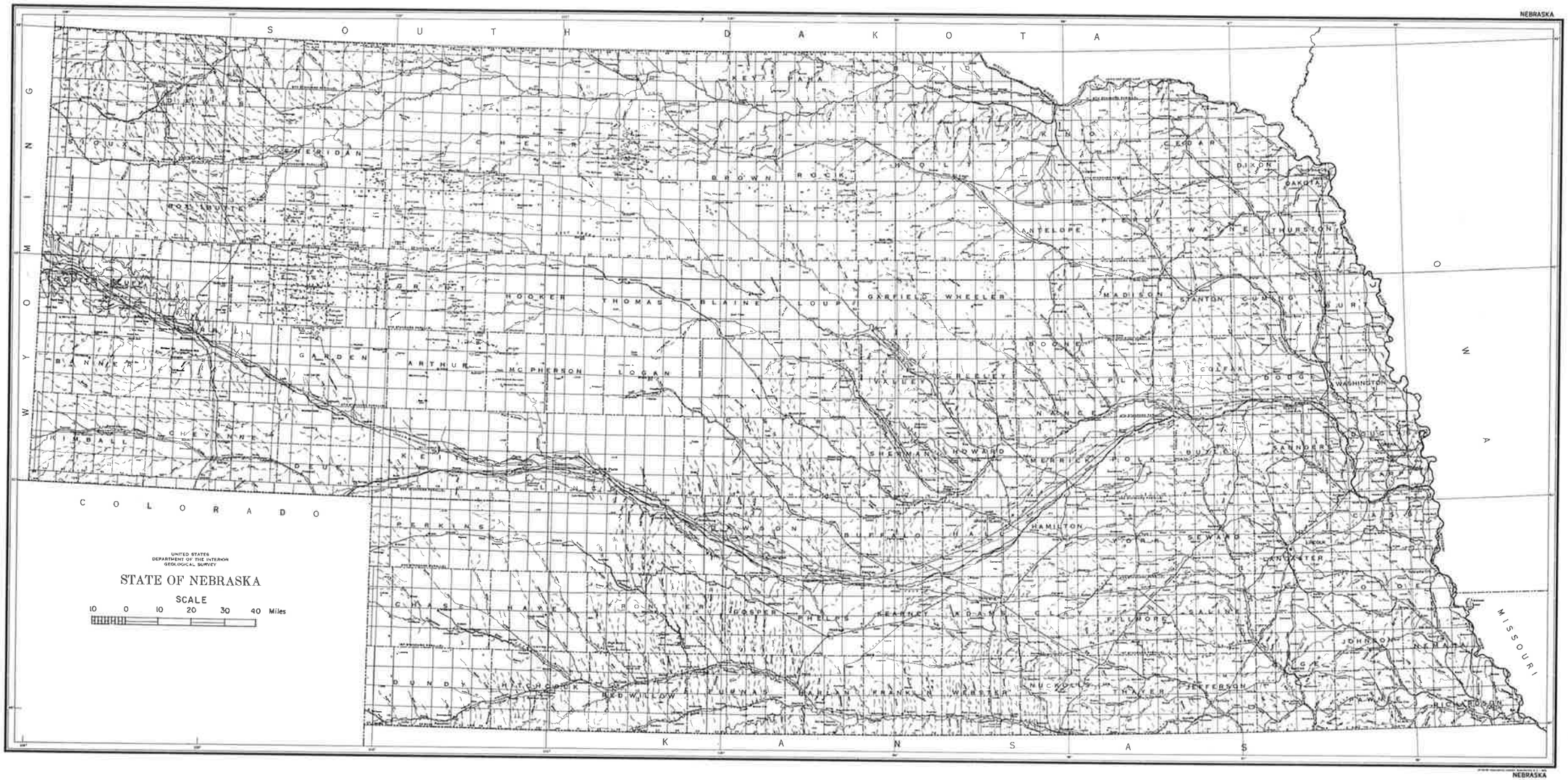
Much unpublished ground water data is available in the files of the Conservation and Survey Division and the federal Water Resources Division. This information is available for examination and evaluation by those interested. The Conservation and Survey Division is able to give assistance to the general public in locating water supplies in specific localities where generalized published information is inadequate. However, it is essential that requests for information be as specific in location as possible, preferably by legal description, because conditions vary greatly within short distances in some parts of the state.

It is impractical to include all pertinent ground water information in a single illustration, although most of the data presented is included in generalized form in the Ground Water Regions map of the state.

It is important to realize that ground water is probably the most satisfactory source of water supply. This is most important in connection with water supplies for municipal use because ground water is generally constant in temperature and does not vary greatly in quality throughout the year and from year to year. Surface water supplies for municipal use require extensive and variable treatment and are often in short supply during a period of dry years. The continued use of ground water in large amounts beyond the rate of replenishment can progressively reduce the supply in local and regional areas.

It is impossible to illustrate all of the variable conditions that exist in the state. More detailed descriptions and illustrations of ground water conditions in individual counties and regional areas have been prepared in both preliminary and published form by the Conservation and Survey Division of the University of Nebraska and the Water Resources Division of the United States Geological Survey. Lists of all available publications may be obtained from the Conservation and Survey Division.

PLATE 1 BASE MAP OF NEBRASKA



Base maps from United States Geological Survey

PLATE 2

The Topographic Regions Map outlines the physical features of the land surface. The map reflects the surficial and subsurface geology of the state, and illustrates the effects of water, ice, and wind in carving and building the present land surface. The map correlates generally with soil types and land use, and with the series of ground water maps in this atlas.

The *Valleys* are regions of low relief along the major streams; moisture conditions are favorable to plant growth and ground water recharge. The shallow water-table areas have relatively high evapotranspiration losses, and, locally, salts have been concentrated in the ground water and soils as a result of this process.

The *Large Reservoirs* were constructed to store water for irrigation, for the generation of electricity, and for flood control.

The *Plains* are constructional features of relatively flat uplands generally underlain by alluvial sands, sandstones, or gravelly sands. Soils have formed on a wind-deposited mantle of silts (loess). They are friable and fertile and allow moderate infiltration of precipitation. Runoff is low.

The *Dissected Plains* are constructional land forms which have been eroded by water and wind, resulting in land surfaces with moderate to steep slopes. Generally, the soils formed on wind-deposited silts are friable and fertile, with comparatively good infiltration of precipitation, but runoff from precipitation is high because of the land slopes.

The *Sand Hills Region* of the state is comprised of constructional alluvial plains overlying thick deposits of sand and sandstone that have been altered principally by wind action, resulting in a variable-thickness mantle of sand whipped into dunes and stabilized by a grass cover. The sandy soils permit rapid infiltration of precipitation. Streams originating in the area have a relatively constant flow of water because of the high rate of recharge through the sands to the ground water reservoir. Ground water in this region has very low concentrations of dissolved minerals.

The *Rolling Hills Region* of eastern Nebraska is a land form region made up of a series of ridges and valleys. The ridges and valleys represent continental glacial-ice features modified by erosion and more recent deposition. The glacial deposits consist largely of boulder-clay tills that are relatively impermeable. The entire area is mantled by thick to thin deposits of wind-blown silts (loess) that permit moderate amounts of precipitation to infiltrate the soils. Perched water tables occur above the clay tills at shallow depths in much of the area. The *Rolling Hills* of northwestern Nebraska is an area of eroded clay and clay-shale hills and even small ground water reservoirs are generally lacking. The soils are compact and clayey with low infiltration of precipitation.

The *Bluffs and Escarpment* areas occur alongside some of the major valleys. The rugged terrain discourages intensified agricultural use; runoff of precipitation is high. The bluffs and escarpments have formed generally on bedrock materials, such as sandstone, shale, or limestone, which resist weathering and erosion.

Valley-Side Slopes are areas of moderate to steep slopes occurring between the bluffs and escarpments and the nearly level valleys in the western part of the state. Agricultural use is limited, and soil-moisture conditions permit moderate plant growth.

PLATE 2 TOPOGRAPHIC REGIONS

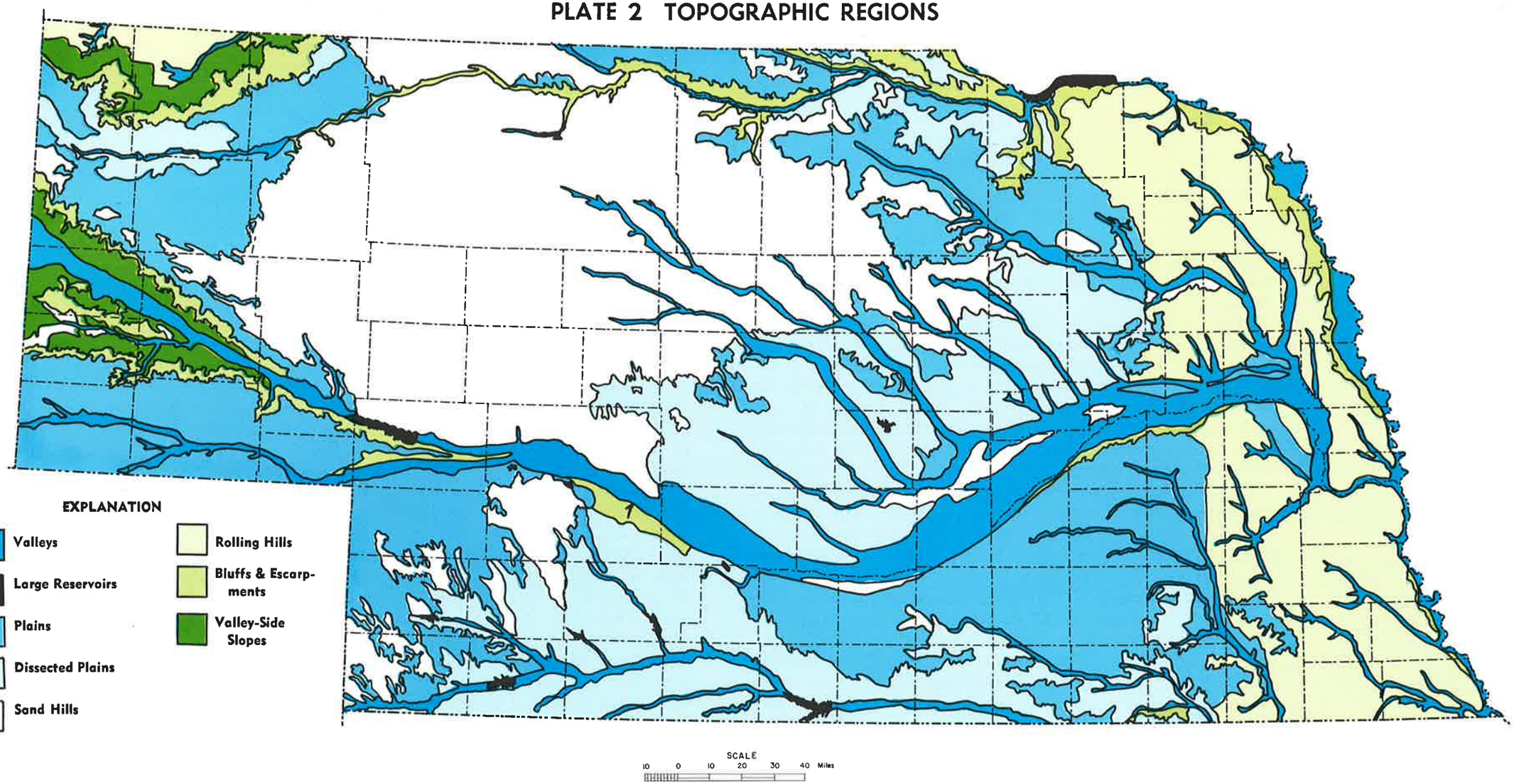


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PLATE 3

This series of maps presents current information concerning the status of the ground water test-drilling program, the location of water-table observation wells being measured periodically, and the number of irrigation wells registered at the State Department of Water Resources on a county basis, as of January 1, 1969.

The test hole location map indicates the parts of the state where subsurface conditions have been investigated on a systematic basis, and it is in these areas that our data is most detailed and more exact. Evaluation of ground water conditions in other parts of Nebraska is based on the records of wells and test holes drilled for other purposes that have been filed with the Conservation and Survey Division, and on interpretation of surficial geology.

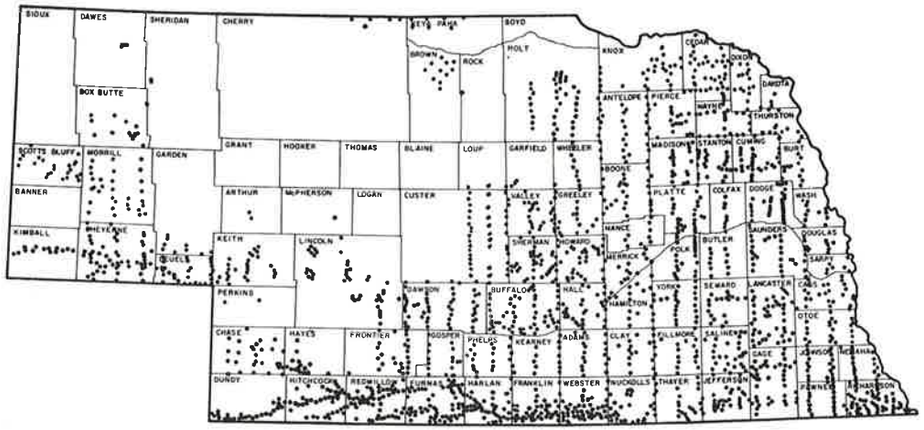
The water-table observation well location map indicates the locations where water-level measurements were made in 1968. Annual reports are published of water levels measured during the year. These reports indicate changes which have taken place during the year, as well as the relationship of the latest measurements to the measurements of record at each location. Water levels in 852 wells were measured in 1968, 49 of which now contain continuous-recording gauges. The records of water-table fluctuations are more useful in defining trends if they cover long periods of time. About three-fourths of these wells have records of ten or more years, almost two-thirds have records of fifteen or more years, about one-third have records of twenty or more years, and sixteen were first measured in 1930, thus recording the effect of the drouth of the 1930's on ground water levels. The 1968 measurements indicate downward trends of water levels in local areas of irrigation well concentration.

Water levels in 1968 compared to the assumed normal (pre-irrigation development water level) were 19 to 33.5 feet lower in the heavily pumped area north of Alliance in Box Butte County; 4.5 to 15 feet lower in northeastern Adams County, the uplands of Hamilton County, western York County, southern Polk County, and north-central Clay County; declines of 10 to 20 feet have occurred in central and northern Fillmore County. Smaller declines have occurred in the lower Platte River valley, the greatest, less than 9 feet, in the area north of the Wood River between Gibbon and Cairo.

Conversely, ground-water levels in much of Phelps, Gosper, and west-central Kearney County have risen to as much as 69 feet about 6 miles northwest of Holdrege. Rises of more than 25 feet are common since the Central Nebraska Public Power and Irrigation District began to divert surface water into the area in 1940. The amount of water that thus has been added to ground-water storage is estimated to be more than five million acre-feet.

The number of irrigation well registrations in each of the counties of the state, as of January 1, 1969, is shown on the irrigation well map and indicates in general the present development of irrigation from ground water sources. Currently, more than 32,000 irrigation wells have been registered with the state Department of Water Resources, and more than 2,500,000 acres are irrigated by these wells.

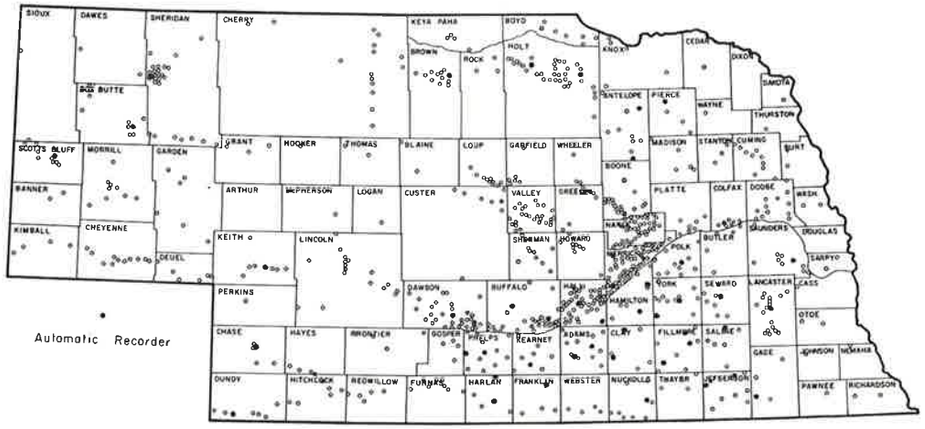
PLATE 3 GROUND WATER SURVEY TEST HOLES, OBSERVATION WELLS, AND DISTRIBUTION OF IRRIGATION WELLS.



GROUND—WATER SURVEY TEST HOLES

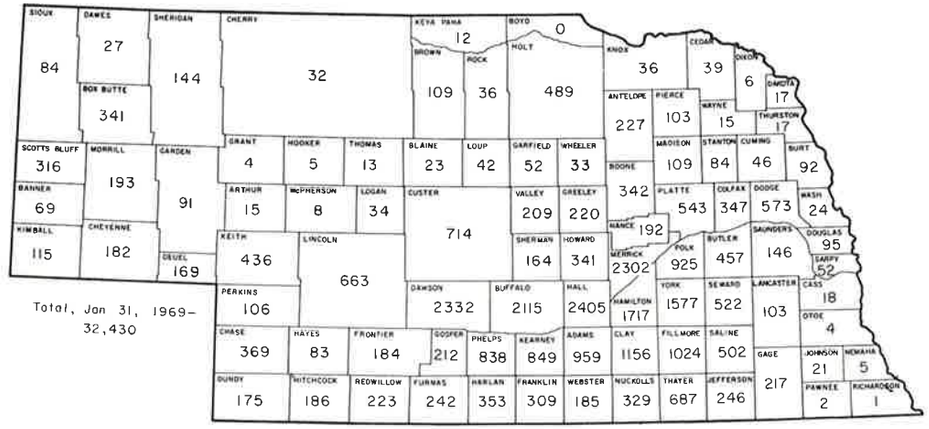
0 10 20 30 40 50 60 70 80 90 100 Miles

SCALE



Automatic Recorder

GROUND—WATER SURVEY OBSERVATION WELLS



Total, Jan 31, 1969— 32,430

NUMBER OF IRRIGATION WELLS REGISTERED IN EACH COUNTY

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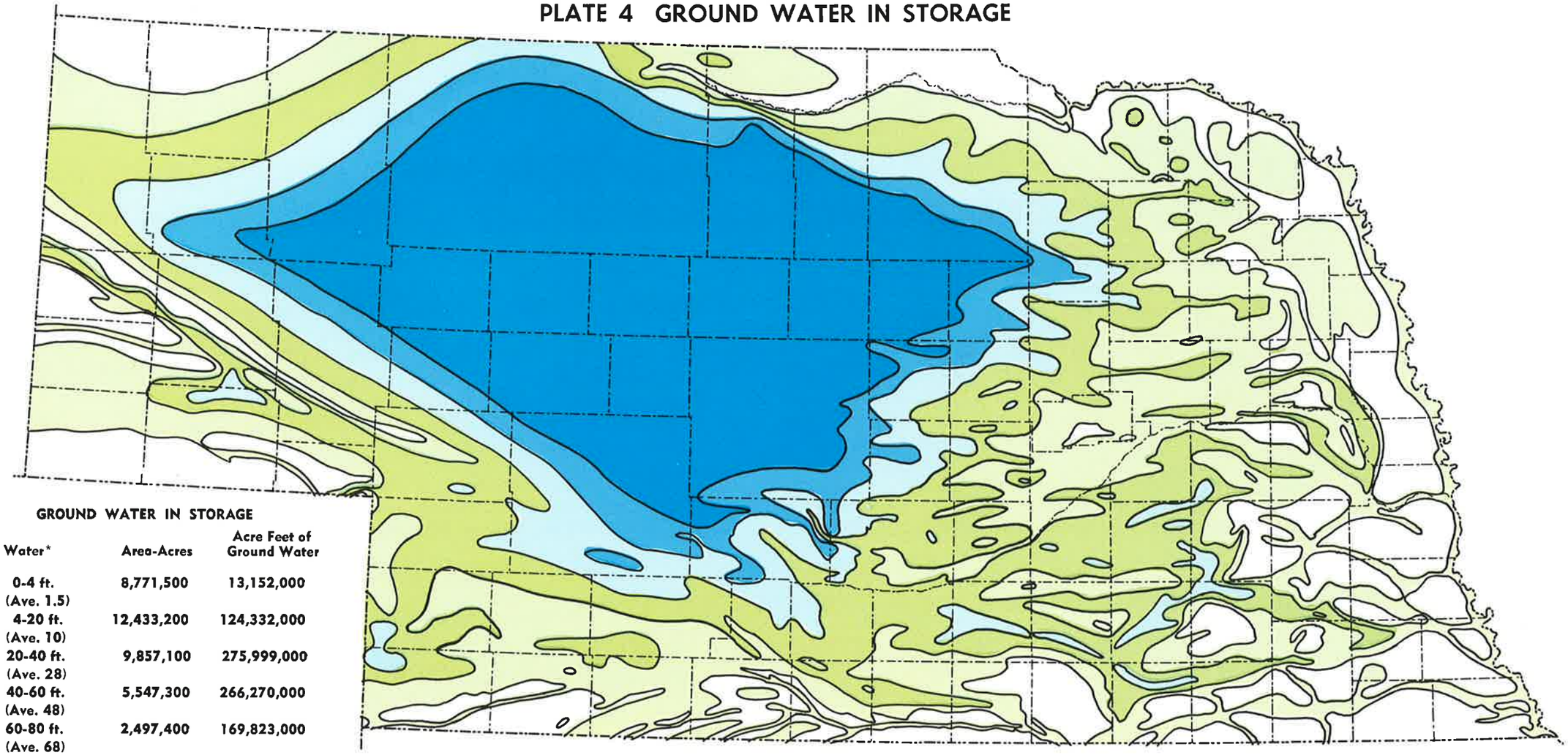
PLATE 4

The amount of good-quality ground water in storage in permeable materials at reasonable depths below land surface is estimated as more than 1,678,800,000 acre-feet, or enough water to cover the state to a depth of about 39 feet. This does not take into consideration ground water in storage in the older bedrock formations which may be of questionable quality, nor does it include ground water in storage in the finer textured materials which are interbedded with the more permeable water-bearing materials. It is based on the amount of recoverable water, assuming an average specific yield of the permeable materials of two-tenths of their thickness.

Nebraska has an unusually large amount of good-quality ground water that can be recovered by wells of moderate depth (generally less than 400 feet) and is more favorably constituted in this respect, per unit area, than any other state in the central part of the country. This represents a reserve that may be effectively utilized for many purposes. However, it should be realized that significant use of this resource in excess of the amount of water returned to the water-bearing formations from precipitation sources (ground water recharge) will result in progressive lowering of ground water levels. Areas adjacent to streams where they can be recharged from surface water sources will be less dependent on recharge from precipitation to replenish the ground water.

It is estimated that the average annual recharge to ground water from precipitation in Nebraska is about eight million acre-feet. Local overdevelopment of ground water (in excess of total recharge) does not result in moving appreciable amounts of additional water into the overdeveloped area from outside sources. The rate of lateral movement of ground water under natural conditions is very slow and cannot be expected to keep up with large withdrawals. In general, overdevelopment of ground water will be evidenced within the local area by declining water levels and will reduce the amount of ground water in storage in these areas, but will have very little effect on ground water stored or the amount discharged by streams outside of the overdeveloped areas.

PLATE 4 GROUND WATER IN STORAGE



GROUND WATER IN STORAGE

Feet of Water*	Area-Acres	Acre Feet of Ground Water
0-4 ft. (Ave. 1.5)	8,771,500	13,152,000
4-20 ft. (Ave. 10)	12,433,200	124,332,000
20-40 ft. (Ave. 28)	9,857,100	275,999,000
40-60 ft. (Ave. 48)	5,547,300	266,270,000
60-80 ft. (Ave. 68)	2,497,400	169,823,000
80-100 ft. (Ave. 80 +)	10,365,500	829,240,000
TOTALS (Ave. 33.9)	49,472,000	1,678,816,000

* Each foot of water represents five feet permeable water-bearing material.

SCALE
10 0 10 20 30 40 Miles

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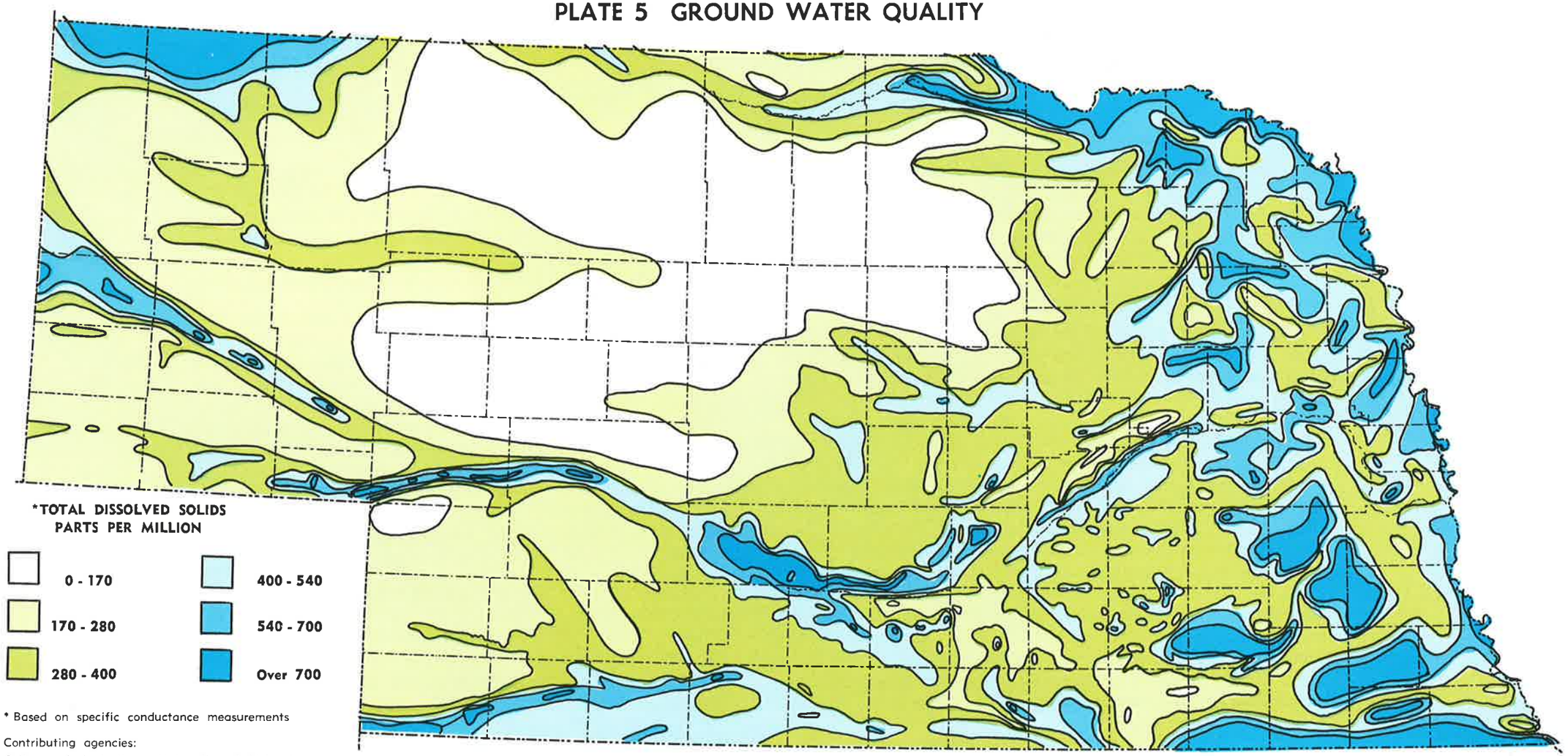
PLATE 5

Ground water which occurs at comparatively shallow depths in Nebraska is of good quality for almost all uses, but is moderately hard and averages about 400 parts per million of total dissolved solids. The chemical quality of ground water is related to the amount and quality of recharge water and the nature of the saturated and unsaturated materials through which it moves and is stored. Concentration of salts is lowest in the Sand Hills region of the state (less than 200 parts per million), and the highest in parts of eastern Nebraska where wells are either developed in materials of lower permeability or in some of the Cretaceous bedrock formations, as for example the Dakota sandstone. Other areas of poorer quality water occur in the valleys of western Nebraska as a result of poorer quality surface water moving in from Wyoming and Colorado, and as a result of the concentration of salts by evapotranspiration in shallow water-table areas. Generally poor quality water occurs in the shale and clay land of the extreme northwestern part of the state.

There is a tendency for an increase in iron and manganese content in the eastern part of the state and treatment may be required for their removal. Locally, a high concentration of salts occur in some shallow wells in the Salt Creek Valley above Lincoln and in the Blue River Valley between DeWitt and Wilber. Water from deep wells in southeastern Nebraska, producing from zones in the Pennsylvanian and Permian formations, generally has such a high concentration of salts that it is not satisfactory for most uses.

A slight deterioration in the quality of the ground water in Phelps and Kearney counties can be noted and is attributed to the transportation and use of surface water for irrigation.

PLATE 5 GROUND WATER QUALITY



* Based on specific conductance measurements

Contributing agencies:

College of Agriculture, University of Nebraska

Conservation and Survey Division, University of Nebraska

Water Resources Division, U. S. Geological Survey
Division of Laboratories, Nebraska Department of Health

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PLATE 6

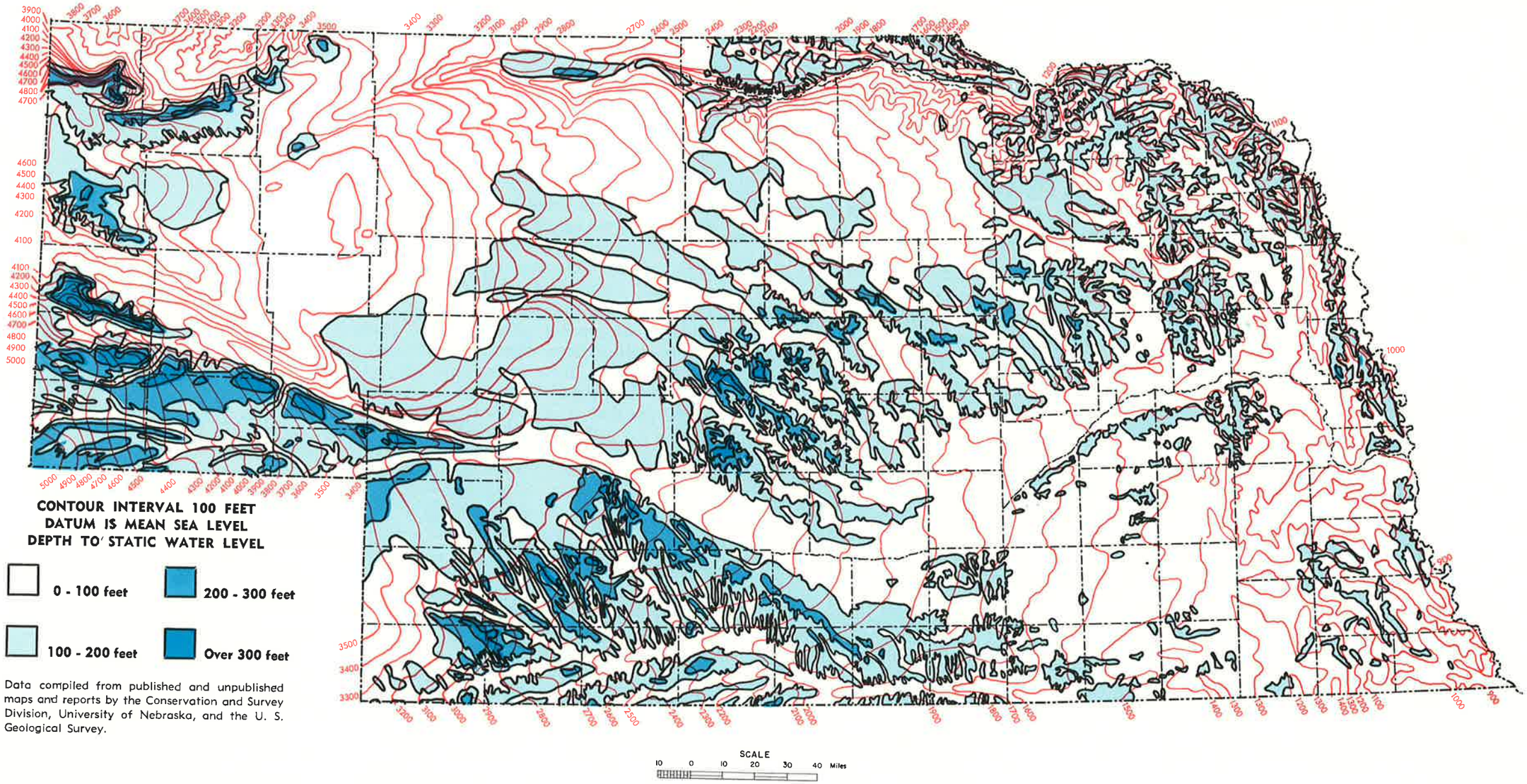
The water table marks the top of the zone of saturation and is shown by contour lines connecting points of equal elevations of water levels which are adjusted to mean sea level. Water levels represent the depth to water measured in wells, or the surface level of flowing streams.

Ground water moves slowly down the slope of the water table and at right angles to the contours, indicating directions of ground water movement throughout the state. Although the general direction of movement is southeastward, it should be noted that ground water, in local areas, may move in almost all directions. The slope down which the water moves does not change except as climate changes, or as man alters natural conditions by heavy withdrawals of water, and then only slightly. Because the slope is so slight, the most important influence on rate of movement is the size of the pore or the crevice openings. Water will move faster in certain kinds of rocks. For example, water may travel through coarse gravel, as in the Platte Valley, at estimated rates of several feet per day. Through fine sands, water may move only a few inches per day. Clays and clayey silts which have only minute pore spaces will allow water to move at rates of only inches per year. This slow rate of ground water movement precludes the possibility that ground water will readily replace the amount withdrawn in a local area. Moreover, there is generally more water moving out of a specific area under natural conditions than is moving into the area, and this difference represents the amount of recharge within the area from precipitation sources.

Detailed water-table contours generally reflect the subsurface conditions in the area. Closely spaced contours represent conditions where the subsurface materials are generally fine-textured and have low permeability; widely spaced contours represent conditions where the subsurface materials are coarse-textured and have high permeability. More than one water table may occur in a given area, including perched water tables where ground water is held up above regional levels by impervious materials (a common feature in eastern Nebraska), and piezometric surfaces where ground water in the deeper permeable horizons is under artesian head as a result of being confined below an impervious horizon.

Depths to static water levels are indicated on the map in increments of 100 feet and are determined by superimposing the water-table contours on topographic maps showing surface elevations. These depths indicate unsaturated intervals where wells will need to be drilled to greater depths to secure supplies of ground water.

PLATE 6 CONTOURS OF WATER TABLE AND DEPTH TO STATIC WATER LEVEL



CONTOUR INTERVAL 100 FEET
DATUM IS MEAN SEA LEVEL
DEPTH TO STATIC WATER LEVEL

- 0 - 100 feet
- 100 - 200 feet
- 200 - 300 feet
- Over 300 feet

Data compiled from published and unpublished maps and reports by the Conservation and Survey Division, University of Nebraska, and the U. S. Geological Survey.

SCALE
10 0 10 20 30 40 Miles

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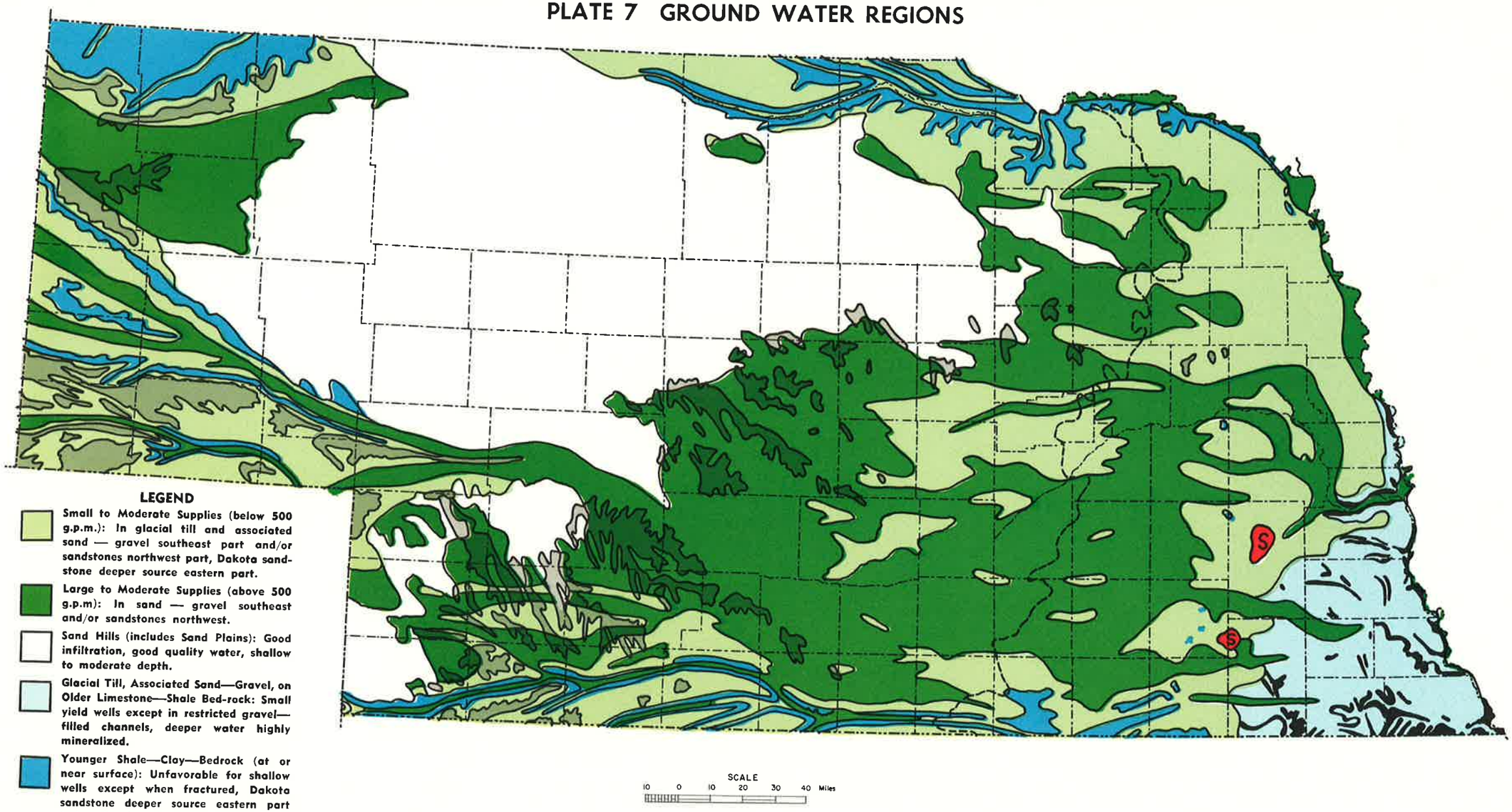
PLATE 7

Nebraska is divided into regions where ground water conditions are believed to be essentially similar. The ground water regions map is a generalized synthesis of all of the most significant ground water data for the state and has been prepared from a study of all of the records available. It is of considerably greater accuracy within that part of the state where systematic test drilling has been completed as a part of the cooperative ground water survey, and is subject to future revision in other areas where accurate test drilling is not complete.

The ground water regions map can be of considerable assistance to those in search of ground water supplies, but it must be kept in mind that there are local variations within regions and the use of the map is not a substitute for test drilling that is required to locate the most favorable locations within the region. Moreover, many of the larger water supplies are developed from sands and gravels that were deposited by streams in channels and valleys that may have little resemblance to the present valley systems. There are channel areas in these old valleys where the sediments are coarse-textured, and back-water areas where finer textured materials were deposited. As a result, wells may have considerable variation in yields per foot of drawdown.

PLATE 7 GROUND WATER REGIONS



LEGEND

- Small to Moderate Supplies (below 500 g.p.m.): In glacial till and associated sand — gravel southeast part and/or sandstones northwest part, Dakota sandstone deeper source eastern part.
- Large to Moderate Supplies (above 500 g.p.m): In sand — gravel southeast and/or sandstones northwest.
- Sand Hills (includes Sand Plains): Good infiltration, good quality water, shallow to moderate depth.
- Glacial Till, Associated Sand—Gravel, on Older Limestone—Shale Bed-rock: Small yield wells except in restricted gravel—filled channels, deeper water highly mineralized.
- Younger Shale—Clay—Bedrock (at or near surface): Unfavorable for shallow wells except when fractured, Dakota sandstone deeper source eastern part (mineralization increases westward), local channel-sand deeper source northwestward (sodium bicarbonate water).
- Older Limestone — Shale Bedrock (at or near surface): Unfavorable except when fractured, deeper water highly mineralized.
- Salt Water Vulnerable. Highly mineralized water in lower Dakota sandstone and gravel—filled channels.
- Water lift over 200 feet.
- Dakota 500 foot line: Progressively

SCALE
10 0 10 20 30 40 Miles

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