PREPARED IN COOPERATION WITH THE
COLORADO DEPARTMENT OF NATURAL RESOURCES, DIVISION OF WATER RESOURCES,
OFFICE OF THE STATE ENGINEER; THE DENVER BOARD OF WATER COMMISSIONERS;
AND ADAMS, ARAPAHOE, DOUGLAS, ELBERT, AND EL PASO COUNTIES

INTRODUCTION

The Denver ground-water basin underlies a 6,700-square-mile area extending from Greeley in the north to Colorado Springs in the south, and from the Front Range in the west to near Limon in the east. The four major bedrock aquifers that occur in the basin are the Laramie-Fox Hills aquifer (the deepest aquifer), the Arapahoe aquifer, the Denver aquifer, and the Dawson aquifer (the uppermost aquifer). The Denver aquifer, which is the subject of this report, underlies an area of about 3,100 square miles in east-central Colorado (index map, fig. 1) and is a primary source of water for rural residents of north-central El Paso County, central Elbert County and the western one-half of Arapahoe County. Of the estimated 3,700 wells completed in the aquifer, almost all supply water to residents and livestock, as little water for irrigation of commercial crops is supplied from the aquifer.

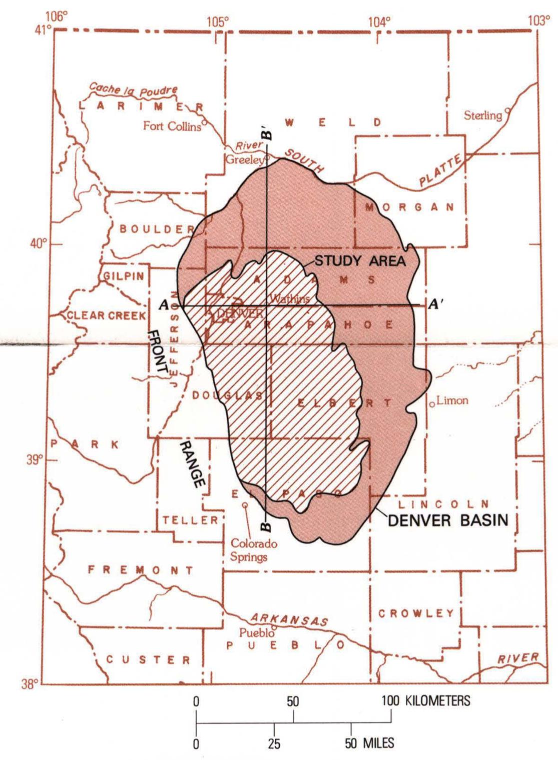

FIGURE 1.—INDEX MAP SHOWING LOCATION OF DENVER BASIN, STUDY AREA, AND GENERALIZED GEOLOGIC SECTION

This study was undertaken to better define the water-supply potential of the four major bedrock aquifers in the Denver basin. The Denver aquifer is one of the shallower aquifers in this group. Findings relating to the Denver aquifer made during the first 2 years of the investigation are presented in this report to provide water users with timely ground-water resource information that can be used to better manage and develop the water supply of the aquifer. A similar report for the Dawson aquifer has been completed (Robson and Romero, 1981). The hydrologic data used in preparing these reports are available in T. J. Major, S. G. Robson, J. C. Romero, and Stanley Zawistowski (written commun., 1980), and McConaghy and others (1964), and in the Colorado District Office of the U.S. Geological Survey in Lakewood, Colo. Similar study results pertaining to the two other aquifers in the basin are being compiled.

Funding for the study was provided jointly by the U.S. Geological Survey; the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer; the Denver Board of Water Commissioners; and Adams, Arapahoe, Douglas, Elbert, and El Paso Counties.

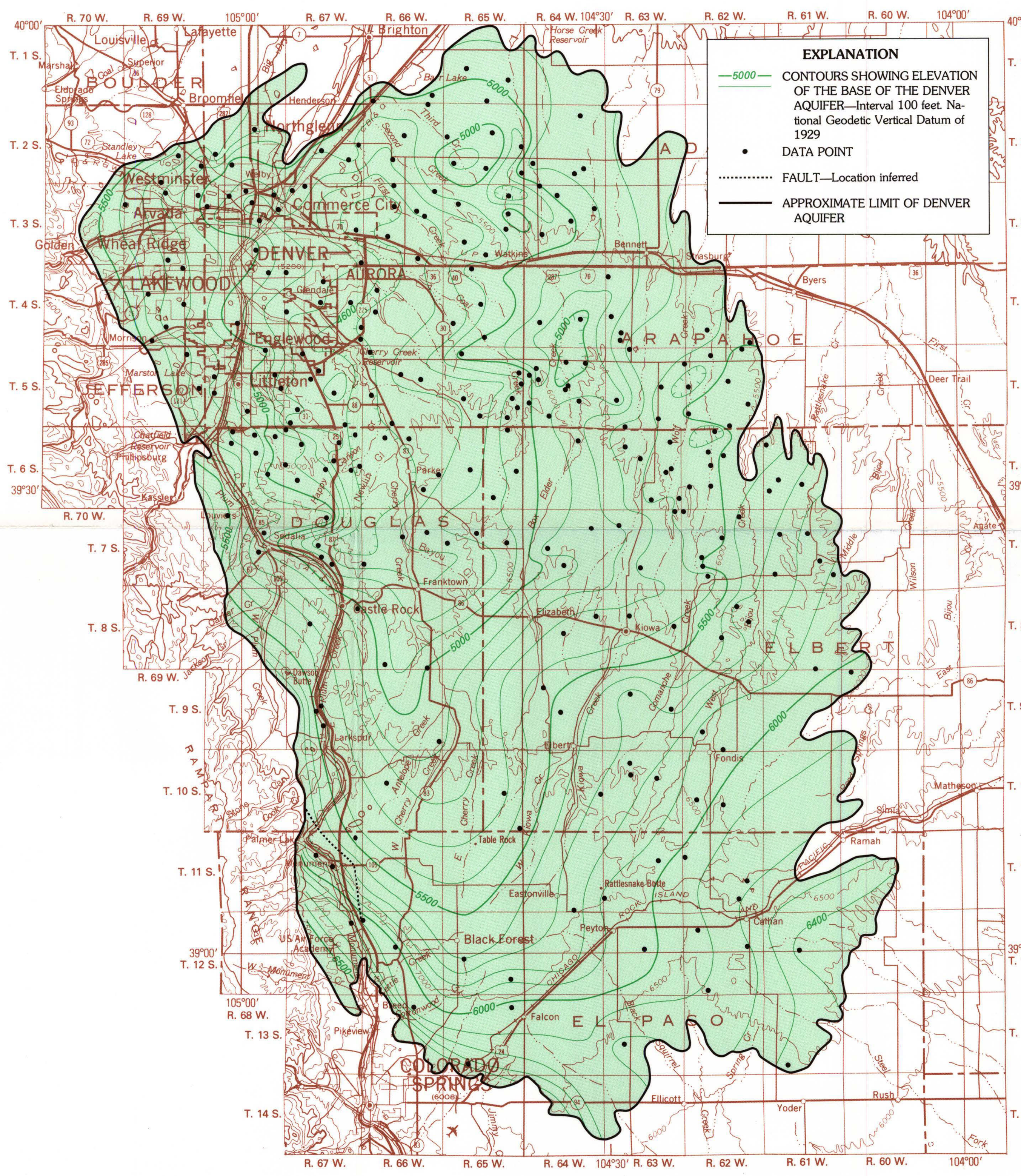

FIGURE 3.—MAP SHOWING ELEVATION AND CONFIGURATION OF THE BASE OF THE AQUIFER

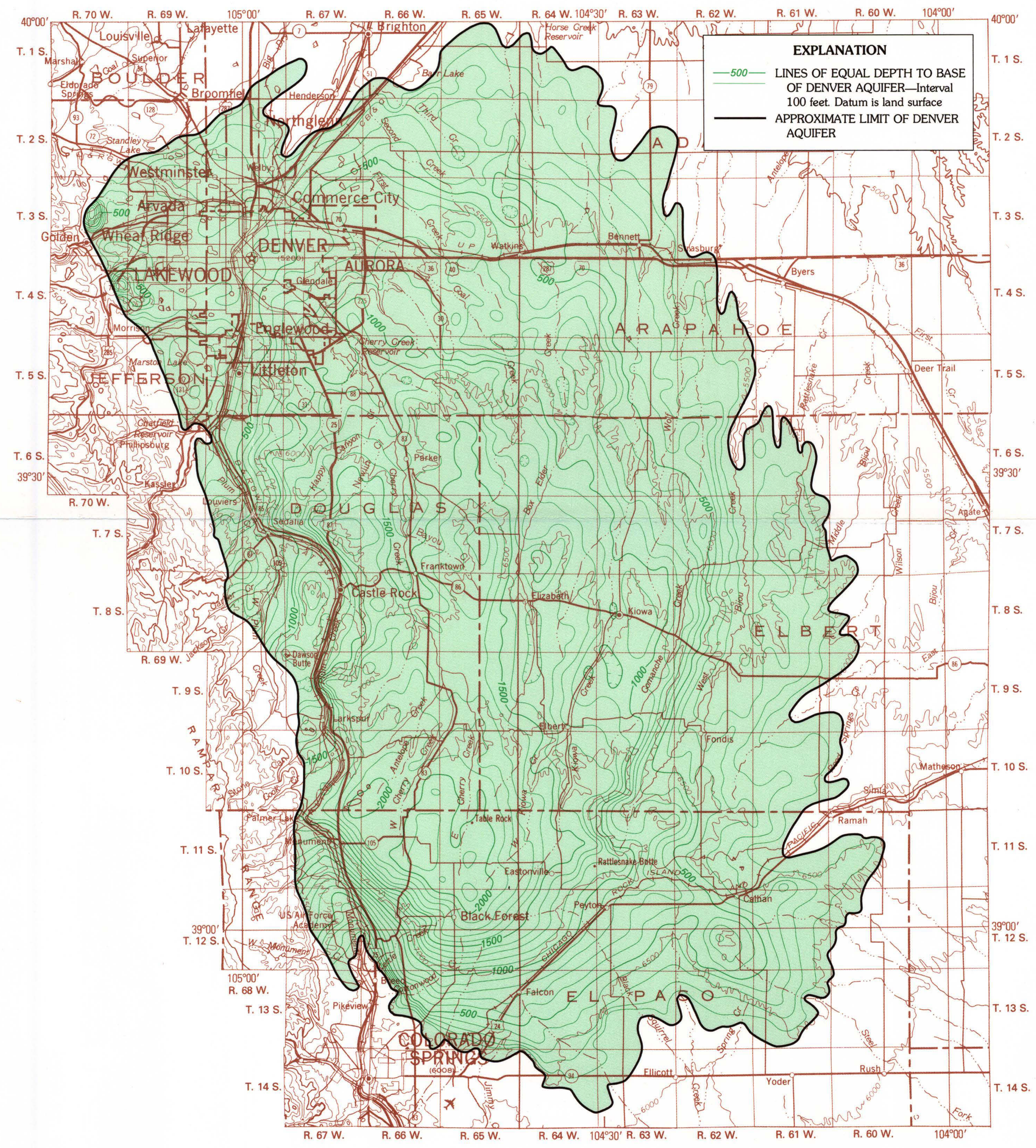

FIGURE 4.—MAP SHOWING DEPTH TO BASE OF THE AQUIFER

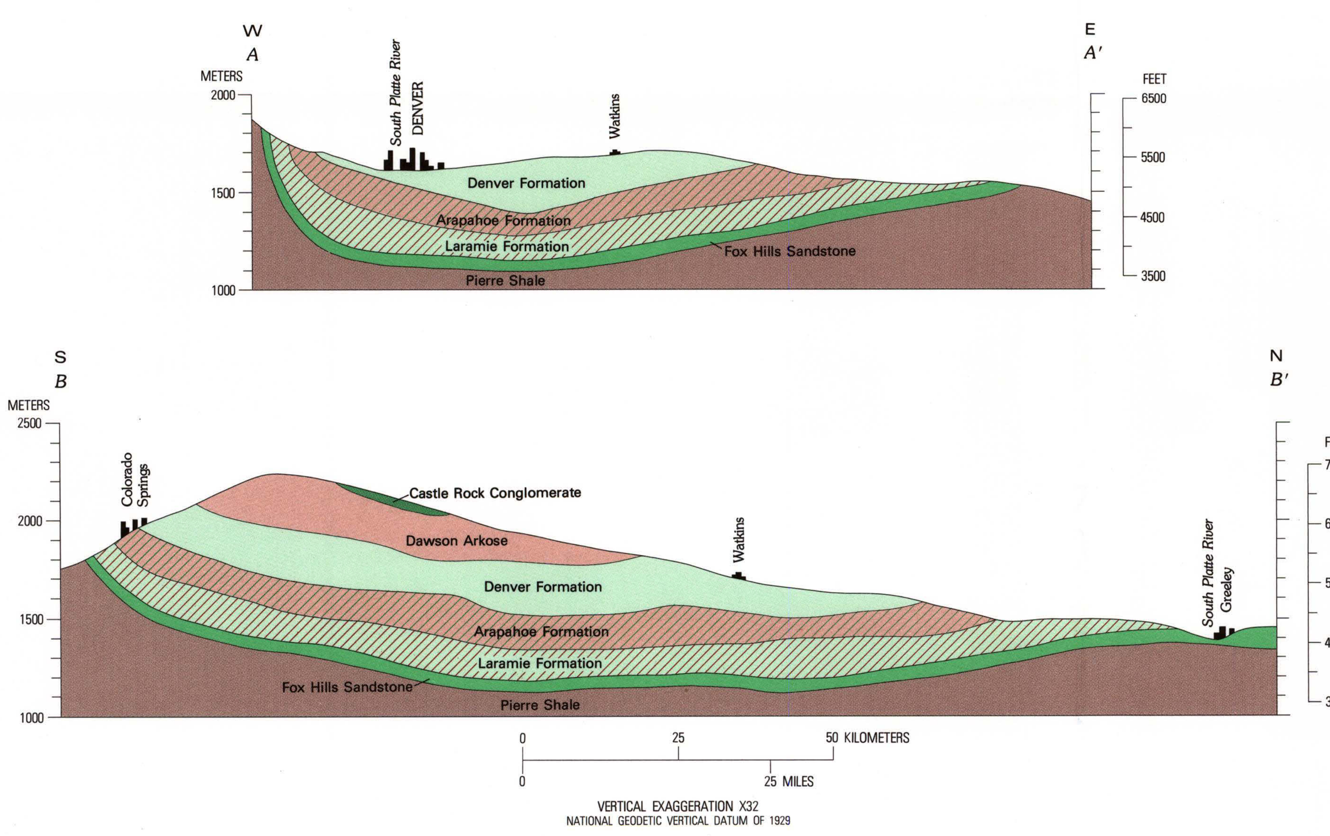

FIGURE 2.—GENERALIZED GEOLOGIC SECTION THROUGH THE DENVER BASIN
(Trace of sections located in figure 1)

GEOLOGIC CHARACTERISTICS

The geologic formations containing the four aquifers of the Denver basin are the Fox Hills Sandstone, the Laramie, and Arapahoe Formations of Late Cretaceous age, the Denver Formation of Late Cretaceous and early Tertiary age, and the Dawson Arkose of Tertiary age (Romero, 1976). These formations occur in a sequence of layers as shown by the generalized geologic sections drawn from west to east and from south to north through the basin (fig. 2). The northern, eastern, and southern parts of the basin form a shallow bowl, the sides of which dip gently toward the west-central part of the basin. Along the western edge of the basin, sedimentary formations are upturned along the Precambrian crystalline rocks of the Front Range and dip steeply to the east as a result of faulting and the gradual upward movement of the Rocky Mountains. The Pierre Shale of Late Cretaceous age underlies the Fox Hills Sandstone and is considered to be the base of the major bedrock-aquifer system due to its great thickness (as much as 8,000 feet) and its minimal permeability.

The Denver Formation consists of a 600 to 1,000-foot thick series of interbedded shale, claystone, siltstone, and sandstone in which coal and fossilized plant remains are common (Romero, 1976). Distinguishing characteristics of the formation are its olive, green-gray, brown, and tan colors; the presence of coal; and a preponderance of shale and claystone with respect to other rock types. The predominant olive and green-gray colors in the formation are due to the presence of sediments derived from erosion of basaltic and andesitic lavas and distinguish Denver rocks from the generally lighter colored rocks found in the overlying Dawson Arkose and the underlying Arapahoe Formation. In most of the outcrop area along the margins of the aquifer, the formation is exposed at the surface or buried under a thin layer of soil. In other parts of this area, the formation is buried under 20 to 100 feet of sand and gravel deposited in the valleys of the South Platte River and many of the smaller streams crossing the area.

The water-bearing layers of sandstone and siltstone occur in poorly defined irregular beds that are dispersed within relatively thick sequences of claystone and shale. Individual sandstone and siltstone layers commonly are lens shaped and range in thickness from a few inches to as much as 50 feet. Sandstone and siltstone layers that are penetrated by a well may be of a different thickness or absent in an adjacent well because of this lens-shaped layering. The sandstone and siltstone generally are only moderately consolidated and are more coarse grained than the claystone and shale. This allows ground water to flow through the void spaces between the grains of sand and silt in these rocks while little water is able to flow through the claystone and shale. The aquifer thus consists of a complex pattern of interconnected beds of permeable and relatively impermeable sediments that differ in their ability to store water and transmit water from one area to another.

The saturated part of the Denver Formation forms the Denver aquifer. Near the margin of the aquifer, the ground-water level is below the top of the formation, and the formation is only partially saturated. In these partially saturated areas, the aquifer is assumed to extend from near the base of the formation to the potentiometric surface (a surface that shows the elevation of the standing water level in wells completed in the aquifer). Where the Denver Formation is overlain by the Dawson Arkose, the entire thickness of the Denver generally is saturated. However, because the geologic contacts between the Denver Formation and the overlying and underlying formations are not always easily discernible, the upper and lower limits of the aquifer may not always coincide with the formational contacts. As a result, the size, shape, and thickness of the Denver aquifer may not always correspond to the size, shape, and thickness of the Denver Formation.

The map showing the elevation and configuration of the base of the Denver aquifer (fig. 3) indicates that the base is bowl shaped and ranges in elevation from a high of about 6,500 feet near Colorado Springs to a low of about 4,600 feet in the area between Castle Rock and Aurora. The aquifer limit shown on the map is the approximate extent of saturated sediments in the Denver Formation. Beyond this limit, it is unlikely that a well completed in the Denver Formation would yield usable quantities of water, although adequate quantities of water may be found in deeper bedrock aquifers.

The depth to the base of the aquifer may be determined by subtracting the elevation of the base of the aquifer from the elevation of the land surface. The depths shown on figure 4 were calculated for each section (1 square mile) of land in the area using the average land surface and structural elevations in each section. The depth to the base of the aquifer is as much as 2,100 feet near Colorado Springs and is in excess of 1,000 feet throughout much of the west-central part of the aquifer. This map provides a quick means of estimating the depth to the base of the aquifer but is somewhat generalized due to the use of average elevations. If, for example, a water well is to be drilled into the Denver aquifer, this map shows the approximate well depth required to fully penetrate the aquifer. A more accurate depth estimate can be made by subtracting the elevation of the base of the aquifer at the well site from the land-surface elevation at the well site.

The extent, elevation, and configuration of the geologic structure at the top of the Denver aquifer is shown on the accompanying map (fig. 5). The top of the aquifer has a bowl shape similar to the base of the aquifer and ranges in elevation from about 6,800 feet near Colorado Springs to about 5,200 feet near Castle Rock. The thickness of the aquifer can be determined by one of two methods, depending on the location of the point of interest. If the point of interest is (1) within the limit of the geologic structure forming the top of the aquifer, the thickness is the difference between the elevations of the top and base of the aquifer. If the point of interest is (2) located in the partially saturated zone, the difference between the elevation of the potentiometric surface (fig. 8, shown on the second map sheet) and the elevation of the base of the aquifer must first be determined. If the point of interest is not located over an alluvial aquifer, this difference is the thickness of the Denver aquifer. If the point of interest is over an alluvial aquifer, the thickness of the alluvial aquifer must be subtracted from the difference to determine the thickness of the Denver aquifer. Because alluvial aquifers 20 to 100 feet thick commonly occur in the valleys of larger streams in the area, the thickness of the Denver aquifer under an alluvial aquifer will be 20 to 100 feet less than the above difference.

The bedrock-aquifer thickness calculated by either of the above methods includes the thickness of the water-yielding sandstone and siltstone as well as the thickness of the nonwater-yielding claystone and shale. Because the thickness of the water-yielding beds are of particular interest, the map of total sandstone and siltstone thickness (fig. 6) was prepared to show the thickness of only these materials. Near the margins of the aquifer there is less than 50 feet of water-yielding material in the aquifer, but near Larkspur there is more than 350 feet of sandstone and siltstone. A comparison of total aquifer thickness to total sandstone and siltstone thickness within the aquifer indicates that the Denver aquifer contains about 30 percent sandstone and siltstone and 70 percent claystone and shale. By comparison, the overlying Dawson aquifer contains about 45 percent conglomerate and sandstone and 55 percent shale.

METRIC CONVERSION FACTORS

The inch-pound units used in this report may be converted to metric units by use of the following conversion factors:

To convert inch-pound units	Multiply by	To obtain metric units
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
gallon per minute	0.06309	liter per second
gallon per minute per foot	0.2070	liter per second per meter

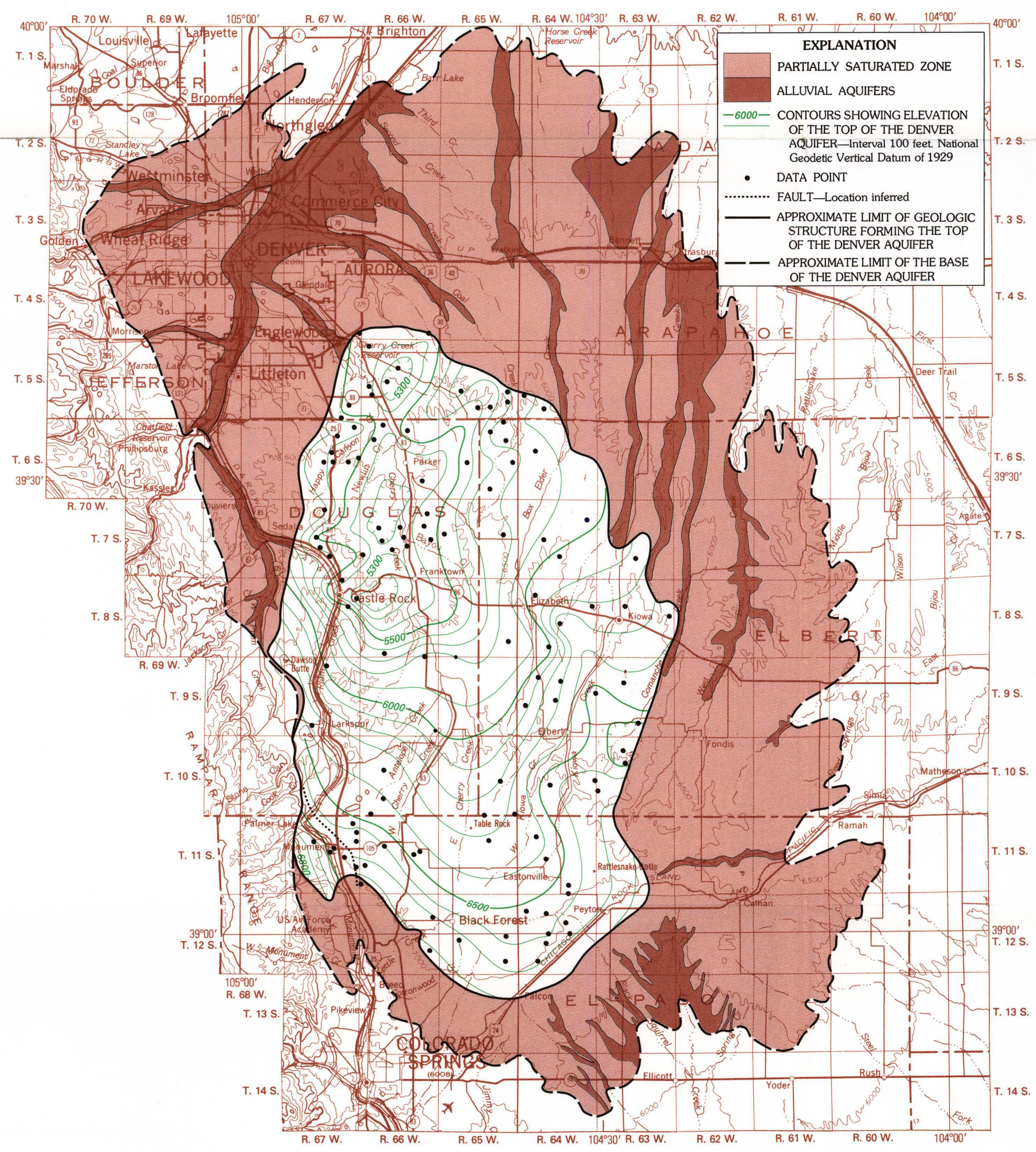

FIGURE 5.—MAP SHOWING ELEVATION AND CONFIGURATION OF THE TOP OF THE DENVER AQUIFER AND LOCATION OF ALLUVIAL AQUIFERS IN THE PARTIALLY SATURATED ZONE

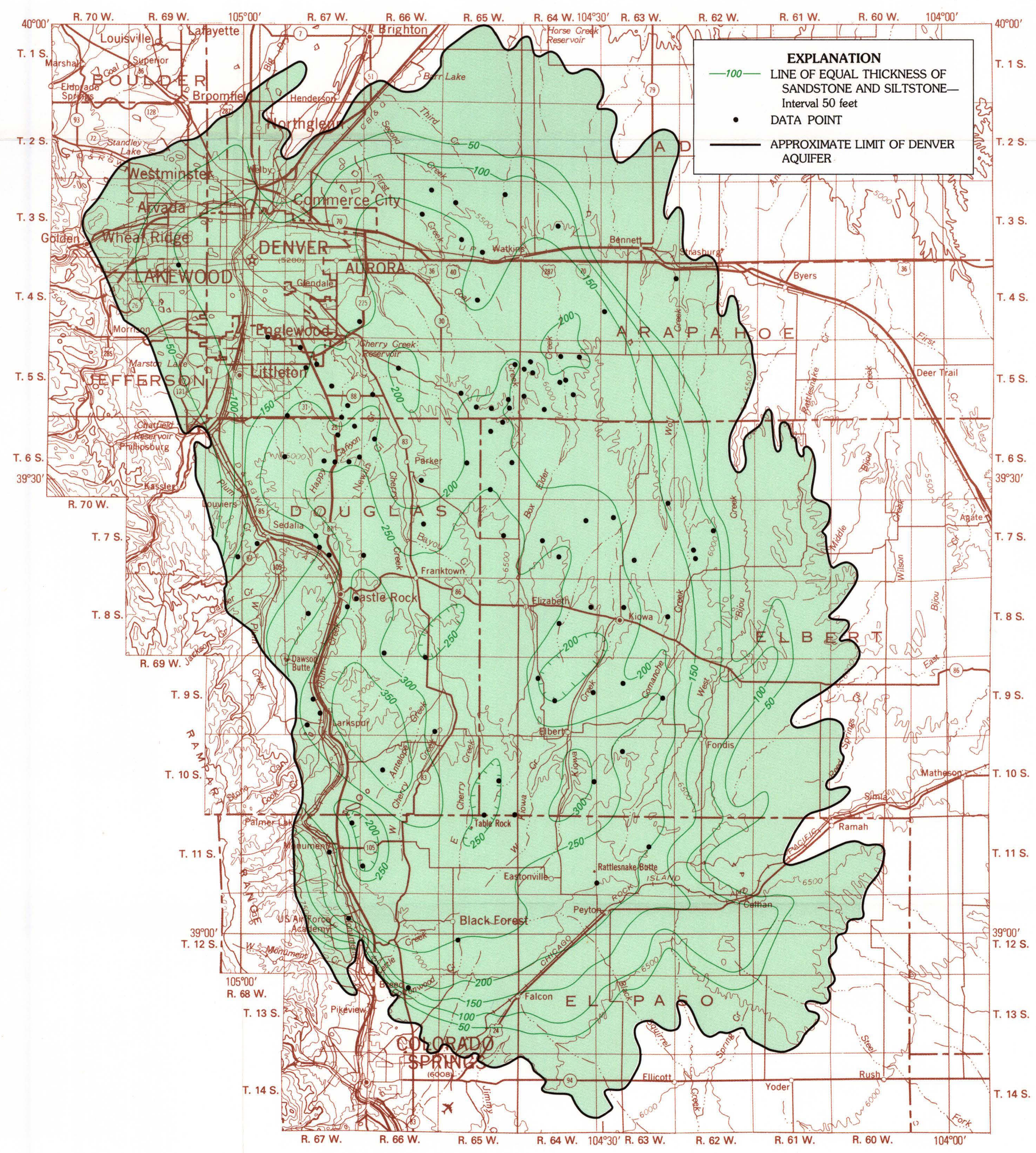

FIGURE 6.—MAP SHOWING TOTAL THICKNESS OF SANDSTONE AND SILTSTONE IN THE AQUIFER

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1981—W80585

Base from U.S. Geological Survey
State base map, 1969

SCALE 1:500 000
10 0 10 20 30 40 50 MILES
10 0 10 20 30 40 50 KILOMETERS
CONTOUR INTERVAL 500 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

GEOLOGIC STRUCTURE, HYDROLOGY, AND WATER QUALITY OF THE DENVER AQUIFER IN THE DENVER BASIN, COLORADO

By
S. G. Robson, U.S. Geological Survey, and
John C. Romero, Colorado Division of Water Resources
1981

For sale by Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225