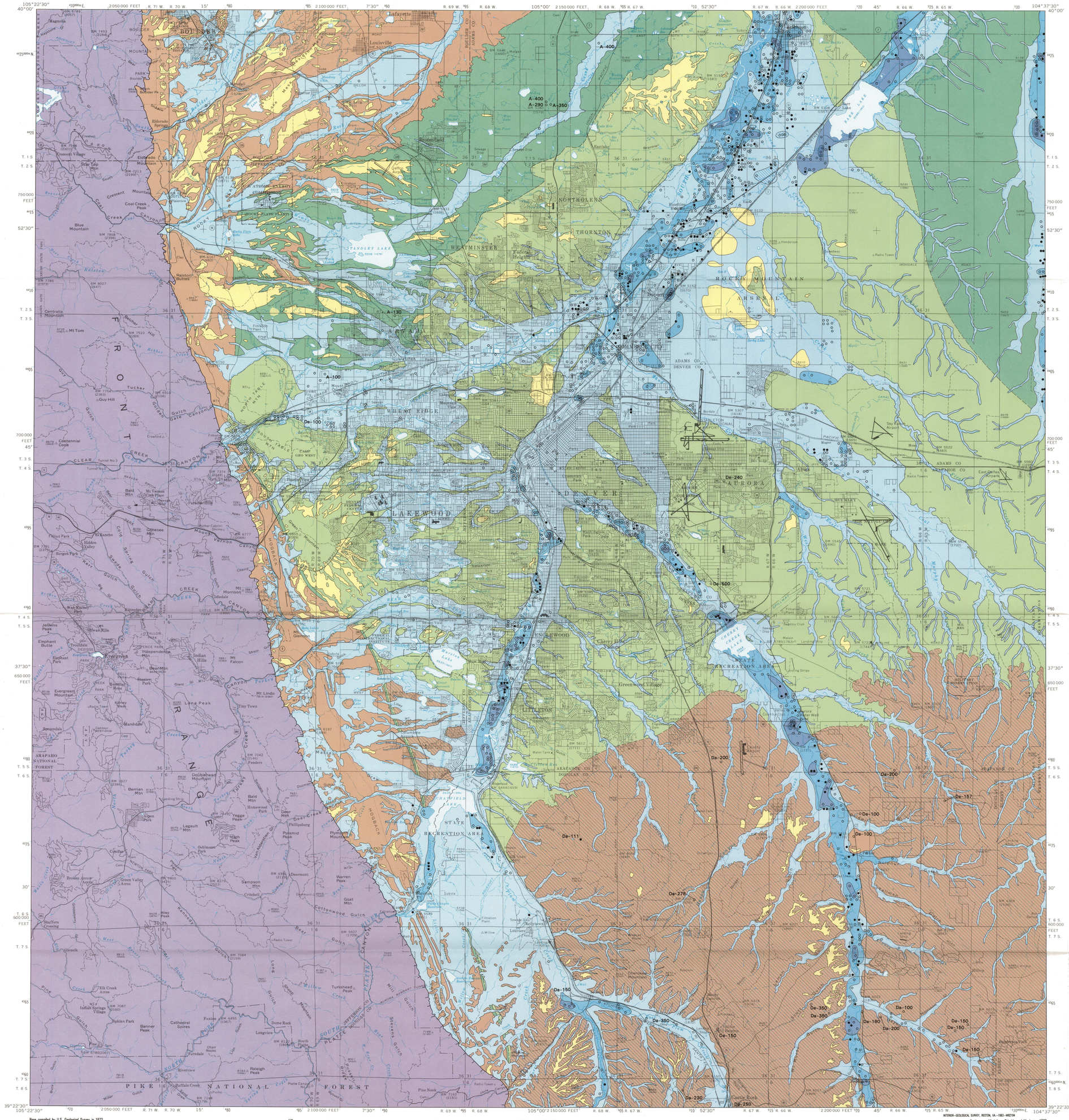


Base compiled by U.S. Geological Survey in 1972 from 1:24,000 quadrangles dated 1954–1966
Limited revision from aerial photographs taken 1969
50,000-foot grid based on Colorado coordinate system, north zone
5000 Universal Transverse Mercator grid ticks, zone 13, shown in blue
Metric elevations are shown in parentheses

APPROXIMATE MEAN DECLINATION, 1983

SCALE 1:100 000

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1983—W82194

Geology modified from Trimble and Machette, 1979 and Shroba, 1980

EXPLANATION

PROBABLE WELL YIELDS FROM UNCONSOLIDATED ALLUVIAL DEPOSITS[1], IN GALLONS PER MINUTE

- Less than 500; pattern indicates area where yields of existing irrigation or public-supply wells are less than 100 gallons per minute
- 500 to 1000
- 1000 to 1500
- Greater than 1500; maximum measured yield = 1640 gallons per minute; maximum reported yield = 3500 gallons per minute

- AREA WHERE WELL YIELDS PROBABLY CANNOT BE SUSTAINED THROUGHOUT THE YEAR BECAUSE UNCONSOLIDATED ALLUVIAL DEPOSITS ARE DRAINED FOR PART OF YEAR
- AREA WHERE WATER-TABLE CONDITIONS PREDOMINATE IN THE DAWSON AQUIFER; WELL YIELDS GENERALLY ARE LESS THAN 200 GALLONS PER MINUTE; MAXIMUM REPORTED WELL YIELD HAS BEEN 350 GALLONS PER MINUTE.—Well yields are sufficient for domestic use; locally well yields are sufficient for uses associated with urban development
- AREA WHERE WATER-TABLE CONDITIONS PREDOMINATE IN THE DENVER AQUIFER; WELL YIELDS GENERALLY ARE LESS THAN 200 GALLONS PER MINUTE; MAXIMUM REPORTED WELL YIELD HAS BEEN 500 GALLONS PER MINUTE.—Well yields are sufficient for domestic use; locally well yields are sufficient for uses associated with urban development
- AREA WHERE WATER-TABLE CONDITIONS PREDOMINATE IN THE ARAPAHOE AQUIFER; WELL YIELDS GENERALLY ARE LESS THAN 200 GALLONS PER MINUTE; MAXIMUM REPORTED WELL YIELD HAS BEEN 400 GALLONS PER MINUTE.—Well yields are sufficient for domestic use; locally well yields are sufficient for uses associated with urban development
- AREA WHERE WELL YIELDS GENERALLY ARE LESS THAN 50 GALLONS PER MINUTE FROM LOCALLY SATURATED COLLUVIAL, LANDSLIDE, AND WINDBLOWN DEPOSITS, AND FROM CONSOLIDATED-SEDIMENTARY ROCKS WHERE UPPER WEATHERED AND FRACTURED ZONE IS SATURATED.—Well yields generally are sufficient for domestic use and some commerical enterprises
- AREA WHERE WELL YIELDS GENERALLY ARE LESS THAN 5 GALLONS PER MINUTE FROM LOCALLY FRACTURED CRYSTALLINE ROCKS.—Well yields generally are sufficient only for domestic use

CONTACT.—Dashed where approximately located

EASTERN OUTCROP LIMIT OF FRACTURED-CRYSTALLINE ROCKS

● INDUSTRIAL, IRRIGATION, OR PUBLIC-SUPPLY WELL; YIELD MEASURED BY U.S. GEOLOGICAL SURVEY

○ INDUSTRIAL, IRRIGATION, OR PUBLIC-SUPPLY WELL; YIELD REPORTED BY DRILLER.—Da indicates well completed in Dawson aquifer; De indicates well completed in Denver aquifer; A indicates well completed in Arapahoe aquifer. Number following symbol is well yield, in gallons per minute

[1]Well yields generally less than 500 gallons per minute from localized areas of unconsolidated alluvial deposits (not shown on map) occurring in stream valleys traversing fractured crystalline rocks. Well yields generally are sufficient for domestic use and may be sufficient for some community water supplies and commercial enterprises.

INTRODUCTION

Knowledge of the well yields and chemical quality of water from water-table aquifers is useful to State and local officials in making decisions on land use and in locating water supplies in the rapidly urbanizing greater Denver area (index map). This report presents the results of a 2-year investigation to obtain this knowledge and to relate the results to urban planning in the greater Denver area. The report is one of a series of geologic and hydrologic reports prepared by the U.S. Geological Survey to demonstrate the usefulness of Earth-science information in urban planning.

In the greater Denver area, the principal water-table aquifers are found in unconsolidated alluvial deposits of Quaternary age and in three groups of consolidated sedimentary rocks—the Dawson, Denver, and Arapahoe Formations—of Paleocene to Late Cretaceous age. The alluvial aquifers, which principally consist of saturated, permeable sand and gravel, occur in present stream valleys, ancestral stream valleys, and terraces both along present stream valleys and on slopes of the foothills east of the Front Range. The Dawson, Denver, and Arapahoe aquifers, which principally consist of saturated, permeable conglomerate and sandstone interbedded with less permeable shale and siltstone (Trimble and Machette, 1979), underlie most of the area east of the Front Range. Most of the conglomerate and sandstone beds are lenticular and generally do not extend laterally for appreciable distances.

Although both water-table (unconfined) and artesian (confined) conditions occur within the Dawson, Denver, and Arapahoe aquifers, water-table conditions generally predominate where the aquifers crop out or are overlain by: (1) Alluvial deposits, (2) windblown deposits, (3) isolated areas of extrusive igneous rocks (North and South Table Mountains), and (4) isolated areas of consolidated sedimentary rocks (Green Mountain and areas in Douglas County) (Trimble and Machette, 1979). Artesian conditions generally predominate where the Arapahoe is overlain by the Denver and where the Denver is overlain by the Dawson. For the purposes of this investigation, it was assumed that only water-table conditions existed where the Dawson, Denver, and Arapahoe aquifers crop out or are overlain by alluvial deposits, windblown deposits, and isolated areas of igneous and sedimentary rocks. It also was assumed that only artesian conditions existed where the Arapahoe is overlain by the Denver and where the Denver is overlain by the Dawson.

The Laramie-Fox Hills aquifer, which is older than the Arapahoe aquifer, consists of the basal sandstones of the Laramie Formation of Late Cretaceous age and the Fox Hills Sandstone of Late Cretaceous age and is the principal artesian aquifer in the area. Although water-table conditions locally exist where this aquifer crops out or is overlain by alluvial and windblown deposits in northern Jefferson and southern Boulder Counties, the extensive faulting in the area (Trimble and Machette, 1979) precluded accurate delineation of areas of water-table conditions. For this reason, the aquifer was considered to be artesian throughout the study area.

Locally, saturated permeable materials that yield water to wells also occur in: (1) Upper weathered and fractured zone of other consolidated sedimentary rocks older than the Laramie-Fox Hills aquifer that form the foothills east of the Front Range; (2) colluvial and landslide deposits that occur on the slopes of the consolidated sedimentary rocks; and (3) windblown deposits that occur throughout the area east of the mountain front. In the crystalline rocks that form the Front Range in the western part of the area, water occurs locally in fractures. Because of the localized occurrence of these saturated permeable materials and fractures in the crystalline rock and because some of the materials and fractures are drained for part of the year, these water-table aquifers were not studied in detail during this investigation.

Yield data from industrial, irrigation, and public-supply wells measured by the U.S. Geological Survey (McConaghy and others, 1964), and yield data reported by drillers for the same types of wells were used to compile the well-yield map. The reported data were obtained from the files of the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer.

Chemical analyses of water samples from 316 wells and 14 springs (Hillier, Schneider, and Hutchinson, 1979; McConaghy and others, 1964; and Robson, 1977) were used to compile the water-quality map. Samples of water from 108 wells and 11 springs were collected during this investigation; in addition, samples of water from 208 wells and 3 springs had been collected by other investigators since the middle 1950's.

The emphasis of the water-quality phase of the investigation was to locate water-table aquifers containing water with less than 500 mg/L (milligrams per liter) of dissolved solids, as these aquifers may be potential sources of water supplies for urban development. Sampling was concentrated in areas where previous investigators had not determined the chemical quality of the water.

Appreciation is extended to the many owners of wells and springs in the greater Denver area for permitting access to and collection of water data from their wells and springs.

RELEVANCE TO URBAN PLANNING

Industrial, irrigation, or public-supply wells yielding 100 gallons per minute or more have been completed in water-table aquifers in many parts of the study area. Yields of 100 gallons per minute or more generally are sufficient for various uses associated with urban development. Construction costs of wells completed in the water-table aquifers make the initial costs of obtaining water from these aquifers less expensive than obtaining water from deeper aquifers or from new surface-water storage and distribution systems.

In addition to potentially being the sole source of water for some residential, commercial, and industrial uses, ground water that is chemically suitable may be used as a secondary or emergency source of water—especially during droughts—for those communities, cities, and industries that now (1983) rely only on surface water. Where available, ground water that is chemically suitable also may be mixed with surface water used for public supplies, thereby increasing the total volume of water available for a specific use. In mixing ground and surface waters, it theoretically would be possible to use ground water containing several thousand milligrams per liter of dissolved solids provided the delivered mix was suitable for the intended use. Volumes as well as total water-quality characteristics of ground and surface waters need to be considered if mixing is used.

Where ground water is not mixed with surface water or is not chemically suitable for public supplies, ground water may be used conjunctively with surface water. This would reserve surface water for public supplies. For example, depending on the degree of salinity, ground water could be used for:

1. Irrigation of parks, golf courses, cemeteries, and other types of open space.
2. Industrial and commercial activities, such as cooling, air conditioning, washing of agricultural products prior to processing, watering livestock in feedlots, and washing of vehicles.
3. Community services, such as fire protection and street cleaning.

WELL YIELDS

Well yields shown on the well-yield map only may be considered as indicators of the maximum long-term yields of individual wells completed in the aquifers, especially the alluvial aquifers. Maximum long-term yields may be larger or smaller than those shown because yields are affected by many hydrologic and well-construction factors that were not determined during this investigation, such as: (1) Volume of recharge to and discharge (including pumpage) from the aquifers that affects the saturated thickness and transmissive characteristics of the aquifers both in large areas and in the vicinity of pumping wells; (2) changes in lithology of the aquifers that affect the transmissive characteristics; (3) duration of sustained pumping; (4) hydraulic connection with surface-water features; (5) volume of water in storage; (6) spacing of wells; (7) well diameter, casing, and development; and (8) pump capacity and efficiency.

Most industrial, irrigation, and public-supply wells completed in alluvial aquifers yield from 100 to 1,000 gallons per minute. Wells yielding more than 1,000 gallons per minute are located along the South Platte River, Cherry Creek, and in the vicinity of Barr Lake. In six small areas east of the South Platte River between Denver and Brighton and in three small areas near the mouth of Cherry Creek, data indicate that the alluvial aquifers yield less than 100 gallons per minute to wells installed for irrigation purposes.

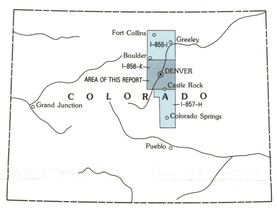
Measured yields from 3 wells exceeded 1,500 gallons per minute; the maximum measured yield was 1,640 gallons per minute from a well completed in the alluvium east of the South Platte River and north of Dupont (sec. 21, T. 2 S., R. 67 W.). Reported yields of 47 wells were 1,500 gallons per minute or larger; the maximum reported yield was 3,500 gallons per minute from a well completed in the alluvium east of the South Platte River at Dupont (sec. 32, T. 2 S., R. 67 W.).

Recharge to the alluvial aquifers principally is from precipitation and snowmelt during the spring and early summer and, where irrigation is extensive, from water applied during the growing season. A factor in planning for urban development that needs investigation is how much recharge and well yields would be decreased if large tracts of irrigated farmland were converted to other land uses where recharge would be derived only from precipitation and snowmelt.

Yields of 100 gallons per minute or more were reported for 29 wells completed in the Dawson, Denver, and Arapahoe aquifers where water-table conditions were assumed to exist. Maximum reported yields were 350 gallons per minute for the 20 wells completed in the Dawson; 500 gallons per minute for the 3 wells completed in the Denver; and 400 gallons per minute for the 6 wells completed in the Arapahoe.

CONVERSION FACTORS

Multiply	By	To obtain
foot	0.3048	meter
mile	1.609	kilometer
gallon per minute	0.06309	liter per second



MAP SHOWING AREA OF FRONT RANGE URBAN CORRIDOR

Map showing well yields

WELL YIELDS AND CHEMICAL QUALITY OF WATER FROM WATER-TABLE AQUIFERS IN THE GREATER DENVER AREA, FRONT RANGE URBAN CORRIDOR, COLORADO

By
Donald E. Hillier, Paul A. Schneider, Jr., and E. Carter Hutchinson

1983

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