EXPLANATION

Areas where properly located and constructed

wells are generally capable of yielding quan-

tities of water in the limits specified, based

Yield, in gallons per minute

1 to 10

5 to 50

Pattern indicates areas where some wells yield

50 to more than 500 gallons per minute

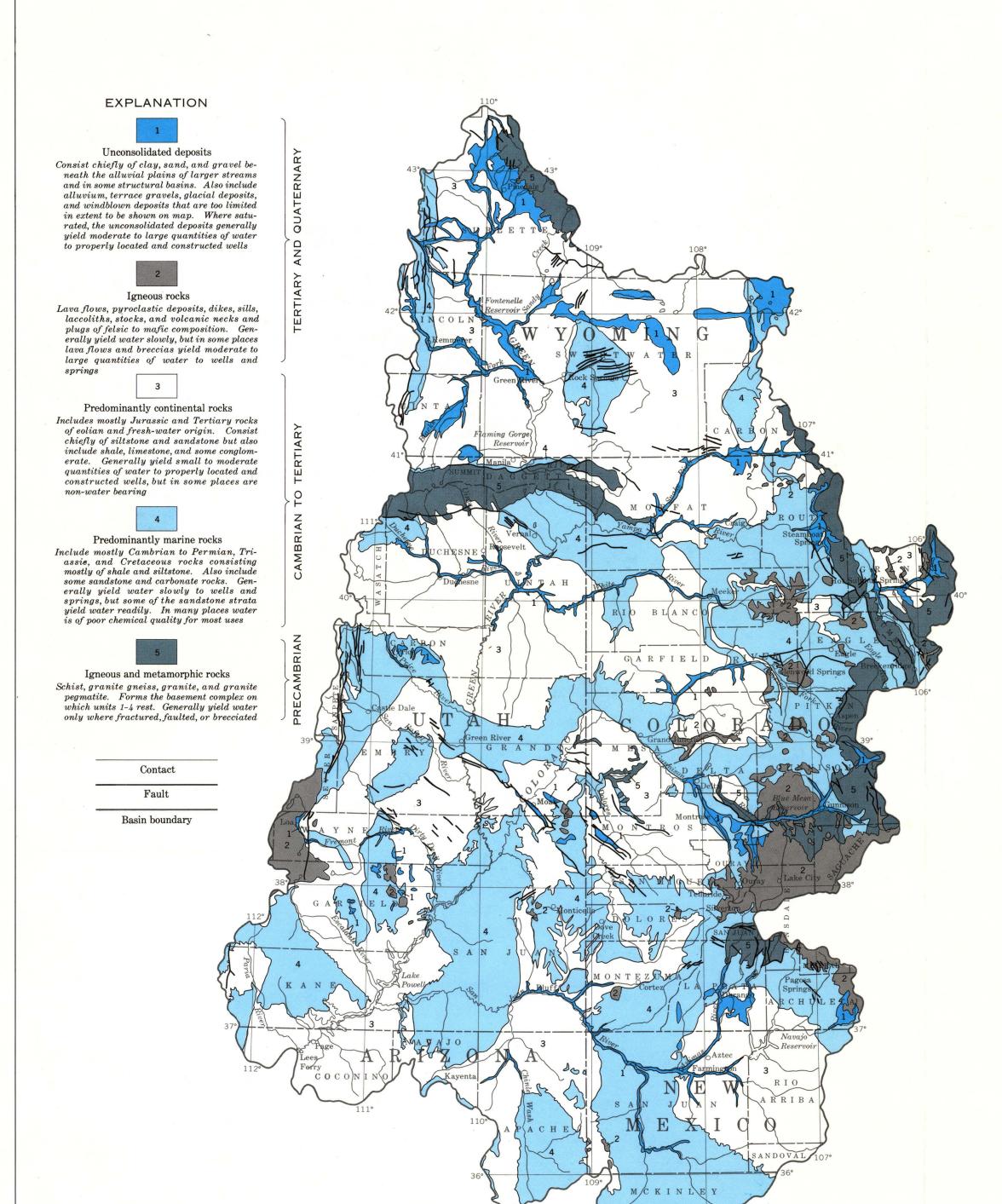
Pattern indicates areas where some wells yield

500 to more than 1000 gallons per minute

Basin boundary

in part on geology

## PHYSICAL SETTING AND GENERAL AVAILABILITY OF GROUND WATER



GEOHYDROLOGIC MAP

MAP SHOWING GENERAL AVAILABILITY OF GROUND WATER

INTRODUCTION Most of the information in this atlas pertains to the ground-water resources of the basin. The surface-water resources, climate, and geohydrologic framework have been described in considerable detail by Iorns and others (1964,

The maps in this atlas are highly generalized, and are intended to provide the reader with only a general understanding of the geology, ground-water conditions, and chemical quality of water in the basin as a whole. In most instances, the availability, depth to, and chemical quality of ground water at a given well site can be determined only by special investigations. Only previously collected data were used to compile the maps in this atlas. More detailed information for specific parts of the basin can be found in the reports and maps in the list of references.

GEOHYDROLOGIC UNITS Rocks ranging in age from Precambrian to Holocene are exposed in the Upper Colorado River basin. The rocks have been grouped into five basic geohydrologic units on the basis of age and general lithologic characters. Alluvium in geohydrologic unit 1 and volcanic rocks in geohydrologic unit 2 contain aquifers that have the highest hydraulic conductivities (ease with which rocks transmit or yield water) in the basin, but these two units underlie less than 5 percent

of the basin. Rocks of geohydrologic units 3 and 4 underlie almost 90 percent of the basin area. Most of these rocks are consolidated and their water-bearing properties are dependent largely on secondary porosity, such as faults, fractures, joints, and solution cavities; their ability to yield water varies considerably from place to place. Both units 3 and 4, as a whole, have low hydraulic conductivities; however, the hydraulic conductivity of geohydrologic unit 3. which includes considerable sandstone, is somewhat higher than that of geohydrologic unit 4, which consists mostly of shale and siltstone. The most extensively developed aquifers in geohydrologic unit 3 are in the Wasatch Formation, the Glen Canyon Group, the Dakota Sandstone, and sandstones

of Jurassic age.

lorns and others, 1965

The Upper Colorado River basin includes the area drained by the Colorado River and its tributaries (including the Paria River) upstream from Lees Ferry, Ariz. The basin covers approximately 110,000 square miles in parts of the Rocky Mountain System and Intermontane Plateaus physiographic divisions of the United States. Physiographic subdivisions that lie partly or wholly in the basin are the Wyoming Basin and Southern and Middle Rocky Mountain provinces (of the Rocky Mountain System), and the High Plateaus of Utah, Canyon Lands, Uinta Basin, and Navajo sections of the Colorado Plateaus province (of the Intermontane

Colorado River basin into three main drainage divisions. They are the Grand, Green, and San Juan divisions. The Green division includes the area drained by the Green River, the largest tributary to the Colorado River, and a closed basin (Great Divide Basin) in Wyoming. The area of the Green division is approximately 45,000 square miles, or about 41 percent of the Upper Colorado River basin. The largest tributaries of the Green River are the Yampa, White, and Duchesne Rivers. The Grand division includes the area drained by the Colorado River above its confluence with the Green River; its area is about 26,500 square miles. The largest tributaries in the Grand division are Roaring Fork and the Gunnison, Dolores, and Eagle Rivers. The San Juan division includes the area drained by the Colorado River between its confluence with the Green River and Lees Ferry, Ariz. Its area is about 38,300 square miles. The largest tributaries are the San Juan, Dirty Devil, Escalante, and Paria Rivers. Average annual discharge of the Colorado River at the Lees Ferry, Ariz. gaging station, for 51 years prior to beginning of

The major tributary streams above Lees Ferry and their approximate average annual discharges near their mouths are

			Average annual discharge	
Stream	Years of record	Period	Cfs (rounded)	Thousands of acre-feet (rounded)
Green River (at Green River, Utah)	68	Oct. 1894 –Oct. 1899, Oct. 1904 –Sept. 1967	6,400	4,600
San Juan River (near Bluff, Utah).	53	Oct. 1914 -Sept. 1967	2,600	1,900
Gunnison River (near Grand Junction, Colo.)	59	1896–99, 1901–06, 1916–67	2,600	1,900
Yampa River (below mouth of Little Snake River, Colo.)	46	Oct. 1921 -Sept. 1967	2,000	1,400
Roaring Fork River (at Glenwood Springs, Colo.)	61	Oct. 1905 —Sept. 1909, Sept. 1910—Sept. 1967	1,400	1,000

geohydrologic unit 5 are generally not water bearing except where faulted, fractured, jointed, or deeply weathered. They generally yield water slowly to wells and springs.

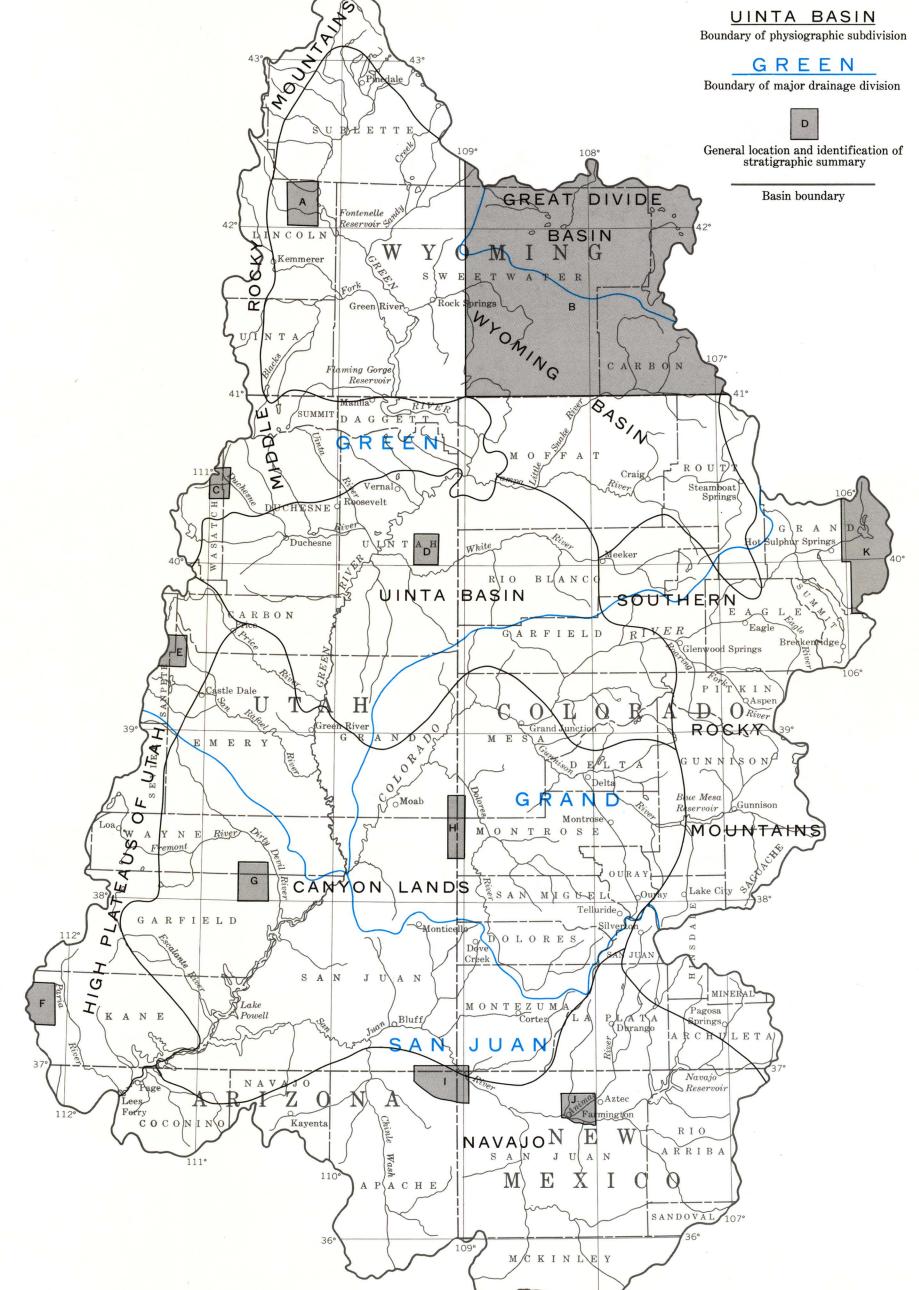
PHYSIOGRAPHY AND DRAINAGE

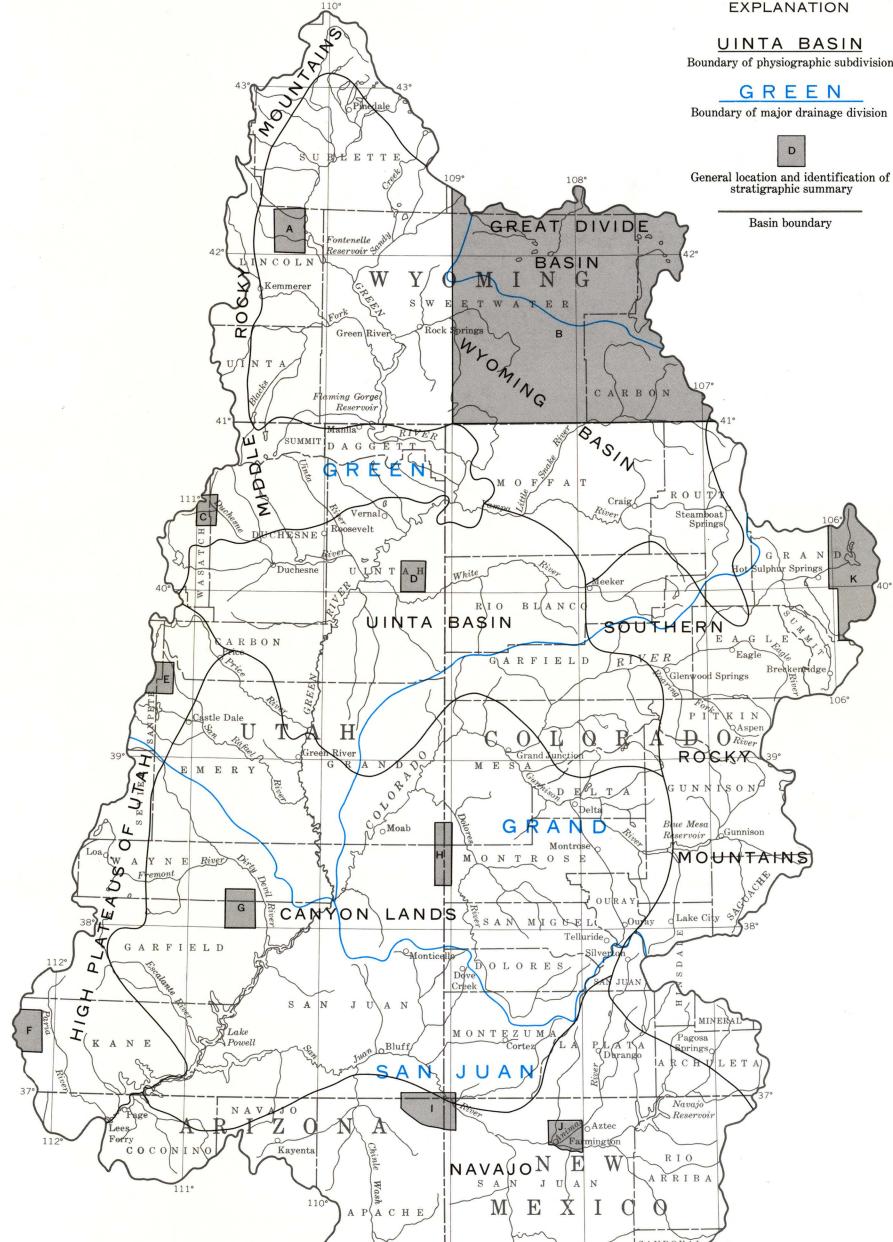
Plateaus) (Fenneman, 1931, 1946). Perhaps the most striking physiographic features in the Upper Colorado River basin are the deep, narrow, intricate canyons carved by the Colorado River and its tributaries in the Canyon Lands and Navajo

Iorns and others (1964, 1965) subdivided the Upper storage in Lake Powell in 1962, was about 18,000 cfs (cubic feet per second) or about 13 million acre-feet a year.

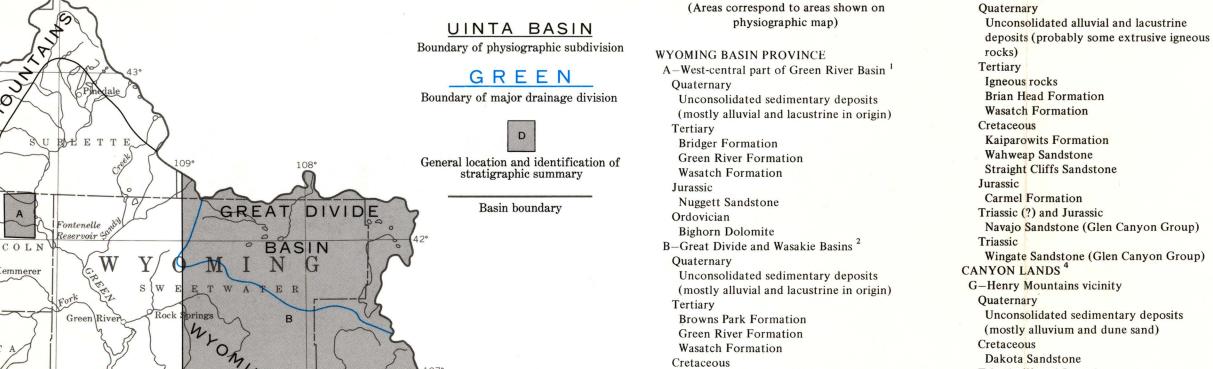
norphic and igneous rocks of Precambrian age in	listed	l in the following table:			
		_	Average annual discharge		
Stream	Years of record	Period	Cfs (rounded)	Thousands of acre-feet (rounded)	
en River (at Green River, Utah)	68	Oct. 1894 –Oct. 1899, Oct. 1904 –Sept. 1967	6,400	4,600	
Juan River (near Bluff, Utah)	53	Oct. 1914 -Sept. 1967	2,600	1,900	
nison River (near Grand Junction, Colo.)		1896–99, 1901–06, 1916–67	2,600	1,900	
pa River (below mouth of Little Snake River, Colo.)	46	Oct. 1921 -Sept. 1967	2,000	1,400	
ring Fork River (at Glenwood Springs, Colo.)		Oct. 1905 —Sept. 1909, Sept. 1910—Sept. 1967	1,400	1,000	

Other tributary streams having an average annual discharge of more than 500 but less than 1,000 cfs are the White, Dolores. Eagle, and Duchesne Rivers.





MAP SHOWING PHYSIOGRAPHIC SUBDIVISIONS, DRAINAGE DIVISIONS, AND LOCATIONS OF STRATIGRAPHIC SUMMARIES



Unconsolidated sedimentary deposits (mostly alluvium and dune sand) Triassic (?) and Jurassic Ericson Formation Navajo Sandstone (Glen Canyon Group) **Rock Springs Formation** Mesaverde Formation (east part of area) Wingate Sandstone (Glen Canyon Group) H-La Sal Mountains vicinity 5

F-Southern part

PRINCIPAL WATER-BEARING FORMATIONS

Pennsylvanian

(mostly alluvium)

Uinta Formation

Cretaceous

Permian

Pennsylvanian

<sup>1</sup> Oriel (1963).

EXPLANATION

Areas where the depths to ground water gen-

in part on topography and geology

Mowry Shale

Wasatch Formation

Dakota Sandstone

Park City Formation

Duchesne River Formation

Mississippian Madison Limestone MIDDLE ROCKY MOUNTAINS PROVINCE Unconsolidated sedimentary deposits C-South Flank of Uinta Mountains 3 (mostly alluvium and dune sand) Quaternary Cretaceous Unconsolidated sedimentary deposits Dakota Sandstone (mostly alluvium) Burro Canyon Formation Cretaceous Dakota Sandstone Entrada Sandstone Traiassic (?) and Jurassic Nugget Sandstone Navajo Sandstone (Glen Canyon Group)

Park City Formation Wingate Sandstone (Glen Canyon Group) Weber Quartzite Cutler Formation Morgan Formation NAVAJO SECTION UINTA BASIN SECTION I-North-central part D-Eastern and central parts Quaternary Unconsolidated alluvium and dune sand Unconsolidated sedimentary deposits (some igneous rocks)

Chuska Sandstone

Triassic (?) and Jurassic

Voegeli (1965) and Hall (1968).

Cretaceous

Dakota Sandstone Green River Formation Recapture Shale Member of Morrison Frontier Sandstone Member of Mancos Shale Salt Wash Sandstone Member of Morrison Formation Summerville Formation Triassic (?) and Jurassic Cow Springs Sandstone Glen Canyon Sandstone Bluff Sandstone

Phosphoria Formation Triassic (?) Moenave Formation Round Valley Limestone Owl Rock Member of Chinle Formation HIGH PLATEAUS OF UTAH E-Northern part Unconsolidated sedimentary deposits Formation

(mostly alluvium) J-Northeast part<sup>7</sup> Ouaternary Crazy Hollow Formation Unconsolidated sedimentary deposits Flagstaff Limestone (mostly alluvium) Cretaceous and Tertiary North Horn Formation San Jose Formation Cretaceous Emery Sandstone Member of Mancos Shale Dakota Sandstone Ferron Sandstone Member of Mancos Shale

Entrada Sandstone Carmel Formation SOUTHERN ROCKY MOUNTAIN PROVINCE<sup>8</sup> Triassic (?) and Jurassic K-North Park and Middle Park vicinity Navajo Sandstone (Glen Canyon Group) Unconsolidated sedimentary deposits Wingate Sandstone (Glen Canyon Group)

(mostly alluvium and glacial deposits) Water-bearing formations from geologic columns <sup>4</sup> Hunt and others (1953). <sup>5</sup> Carter and Gualtieri (1965). <sup>2</sup>Welder and McGreevy (1966). Feltis (1966) and McGavock and others (1966). <sup>7</sup> Baltz (1967) and McGavock and others (1966).

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several hundred feet in these areas, but artesian pressures in the aquifers are sufficient to raise water in the wells to or

Yields to individual wells and springs generally are small in most parts of the basin. Wells that tap the consolidated rocks of geohydrologic units 3 and 4, which underlie most of the basin, generally yield less than 50 gpm (gallons per minute), although a few widely scattered wells produce as much as 1,000 gpm from these rocks. Yields of 50 to 500 gpm are generally available from large-diameter wells that tap alluvium in the larger stream valleys and in some structural basins. Properly located and constructed wells in the thicker (100 ft or more) alluvial deposits yield 500 to more than 1,000 gpm, and some of the most productive wells in the entire basin tap both alluvium and volcanic rocks in the upper Fremont River valley, where several wells yield more than 1,000 gpm. Springs are numerous throughout the Upper Colorado River basin; they most commonly discharge from alluvium along the channels of deeply incised streams and from

GENERAL AVAILABILITY OF GROUND WATER

fractures, joints, and bedding planes in the consolidated rocks. Most of the largest springs discharge from alluvium adjacent to streams and from calcareous and volcanic rocks. Springs discharging several hundred to several thousand gallons per minute are common in the watershed areas of the larger streams, but most of the springs in the arid plateau and basin areas, especially in the Canyon Lands and Navajo sections, discharge only a few gallons per minute. In these sections a small isolated spring may serve a large area as the only source of domestic and stock supply. Depths to ground water exceed 500 feet in much of the Canyon Lands and Navajo sections. Ground-water levels are generally less than 50 feet beneath the land surface along alluvial plains of the larger perennial streams and 500 to more than 1,000 feet beneath the land surface on higher plateaus of the Canyon Lands and Navajo sections. In the Canyon Lands and Navajo sections, and elsewhere throughout the basin, local perched ground-water bodies are only a few feet to a few tens of feet below land surface. Generally, however, the perched water bodies probably would not sustain large perennial withdrawals from wells. In some areas such as the Green River, Uinta, and San Juan Basins and in the Grand Junction, Colo., area, confined (artesian) conditions are common. Many wells tap confined aquifers at depths of

above land surface. UTILIZATION OF GROUND WATER The use of ground water by man in the basin is small compared to natural discharge. The following table shows the estimated average annual withdrawal and use of ground water in the basin for the period 1961-65.

phreatophytes and hydrophytes (water-loving plants). However, according to Robinson (1968), more than 2 million acre-feet of water is consumed by phreatophytes and hydrophytes each year in the Colorado and Utah parts of the GROUND-WATER STORAGE

Only about 5 percent of the maximum estimated volume of ground water stored in the basin is in unconsolidated deposits that have high hydraulic conductivities. Ground-water storage, as used here, is the volume of water, regardless of chemical quality, that will drain by gravity from the rocks in which it occurs; it is the product of the specific yield and the volume of the saturated rocks. The following table shows the estimated volumes of water stored in the upper 100 feet (50 feet in geohydrologic unit 1) of rocks in the main zone of saturation. The estimates are based entirely on estimated specific yields of the representative rock types in each geohydrologic unit, and the figures indicate only a general order of magnitude. About 85 percent of the naximum estimated volume of stored water occurs in the rocks of geohydrologic units 3, 4, and 5, which generally yield the water slowly; and much of that water is moderately to highly mineralized.

		G	round-water	storage		
Geohy- dro- logic unit	Ar (square miles)	ea (thou- sands of	Specific yield (percent)	Saturated thickness used	Amount stor (thousa acre-f	red ands of
unit		acres)		(feet)	Minimum	Maximun
1	1,300	830	5-15	50	2,100	6,200
2	3,500	2,240	2-5	100	4,500	11,200
3	62,400	39,930	1-2	100	39,900	79,800
4	37,400	23,900	0.16-0.7	100	3,800	16,700
5	7,900	5,056	0-0.32	100		1,600
Total						115,500

Hydrographs of wells indicate that there have been no

significant depletions of storage in the basin owing to ground-water development. Long-term water-level bservations have been made in only a few widely scattered wells in the basin, but most of the observation wells are in areas where withdrawals of ground water have increased significantly in the past 30 years and where significant declines in water levels owing to development might be expected. The hydrographs were constructed from levels measured in wells in several of the more heavily pumped parts of the basin. The hydrographs reflect seasonal or periodic changes in ground-water storage owing chiefly to

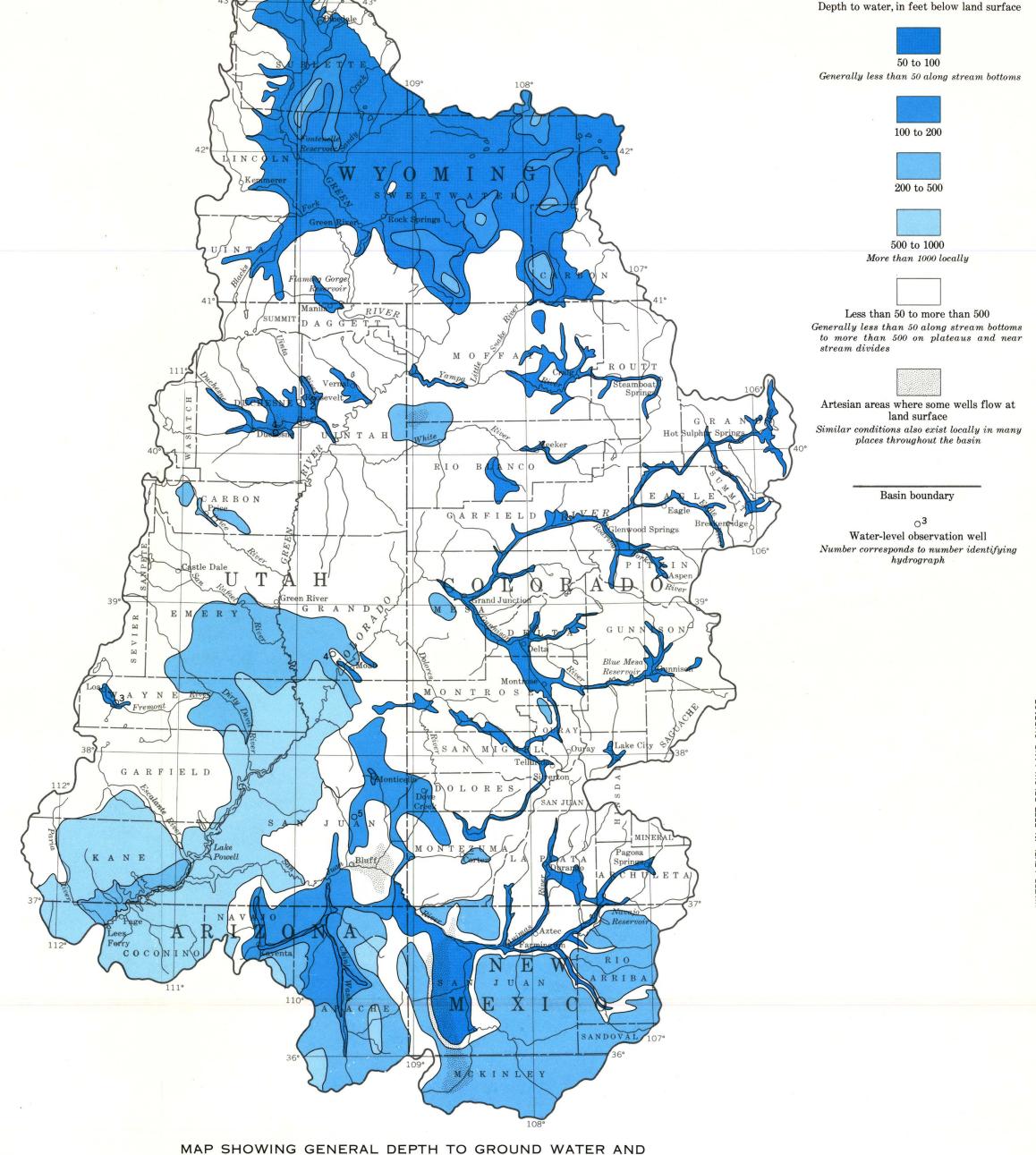
Use	Arizona	Colorado	New Mexico	Utah	Wyoming	Total (rounded)
Irrigation		-				
Acres irrigated	0	3,000	0	4,000	1,300	8,300
Withdrawal (acre-ft)	0	9,000	0	15,900	4,600	29,500
Consumptive use (acre-ft)	0	8,600	0	10,700	2,300	21,600
Industrial <sup>1</sup>						
Withdrawal (acre-ft)	12	56,000	340	600	4,400	61,400
Consumptive use (acre-ft)	.6	<sup>2</sup> 5,600	310	<sup>2</sup> 60	<sup>2</sup> 440	6,400
Public supplies <sup>3</sup>		,				
Persons served	0	29,900	0	41,000		70,900
Withdrawal (acre-ft)	0	11,200	0	13,800	335	25,300
Consumptive use (acre-ft)	0	2,500	0	3,400	85	6,000
Domestic and stock						
Persons served	8,300	83,700	19,000	47,000	19,400	177,400
Withdrawal (acre-ft)	650	9,400	1,600	3,900	1,600	17,200
Consumptive use (acre-ft)	4160	42,400	830	4975	4400	4,800

Ground-water use

not include rural public supplies, such as those for schools, churches, and trading posts. Assumed to average about 25 percent of withdrawal.

An estimated total of about 133,000 acre-feet of ground water per year was withdrawn, of which about 40,000 acre-feet per year was actually consumed. No estimate was made of nonbeneficial ground-water discharge by

natural causes. They do not indicate any significant permanent depletions of ground water owing to pumping. However, there may be some local aquifer depletion owing to pumping as in the vicinity of well 2 in the Uinta Basin.



LOCATION OF SELECTED OBSERVATION WELLS

(1) Well taps alluvium at depths of 5-32 and 37-61 feet, and sandstone at depths of 160-166 feet in Uinta Basin (3) Well taps alluvium at depth of 112 feet in Central High Plateaus (4) Well taps alluvium at depth of 52 feet in Canyon Lands (5) Well taps sandstone at depth of 150 feet in Canyon Lands HYDROGRAPHS OF SELECTED OBSERVATION WELLS

Base from U.S. Geological Survey, 1961

## SELECTED HYDROLOGIC DATA IN THE UPPER COLORADO RIVER BASIN

1973

Don Price and K. M. Waddell

For sale by U.S. Geological Survey, price \$1.00 per set

INTERIOR-GEOLOGICAL SURVEY, WASHINGTON, D.C.-1974-W72110