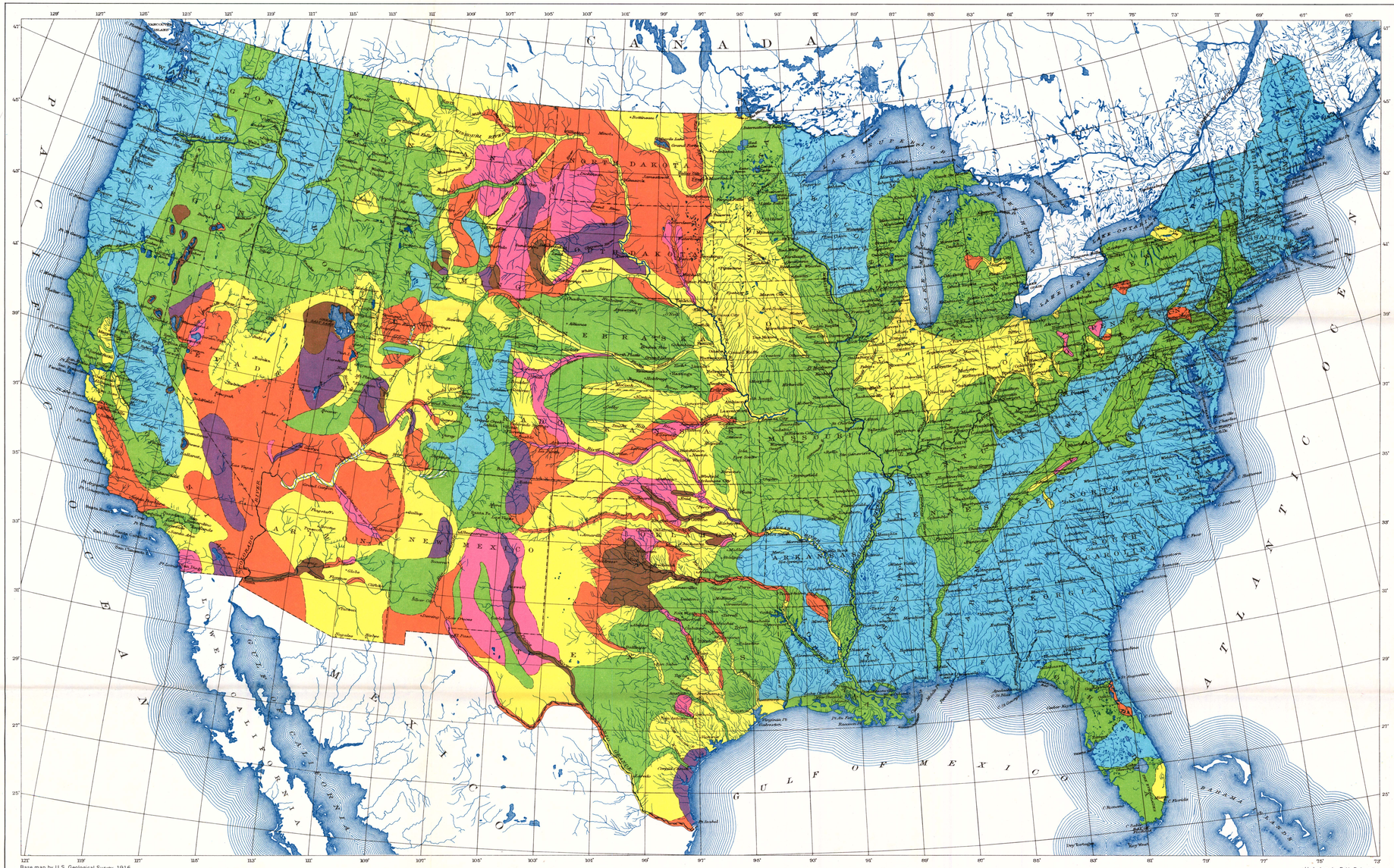
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

HYDROLOGIC INVESTIGATIONS
ATLAS HA-61
PLATE 1 OF 3



EXPLANATION

100 300 500 700 1000 1200 1500 1800 2000 2300 2600

PARTS PER MILLION

Striped patterns are anticipated composition on completion of current reservoir construction

Boundary lines
Dashed where data are sparse

100 0 100 200 MILES

COMPOSITION OF RIVERS OF THE CONTERMINOUS UNITED STATES

By F. H. Rainwater

This atlas is comprised of three maps of the conterminous United States which show separately the prevalent dissolved-solids concentrations, prevalent chemical type, and average sediment concentration of rivers. The river-composition data shown on plates 1-3 provide a starting point for evaluating our surface-water resources on a nationwide scale, indicate regions where acceptable supplies might be found and delineate some of the principal trouble spots throughout the country.

The maps show the composition of water in major rivers and well-developed waterways. River composition is shown as it is, regardless of the source of dissolved materials and sediment. Runoff from dry washes, ephemeral streams, and rills often is quite different from that of major rivers because the rivers commonly are composed of waters from many diverse sources.

The traits selected for mapping, that is, dissolved solids concentration, chemical type, and sediment concentration, probably are of more interest to water users than any others.

Plates 1 and 2 depict the prevalent or modal dissolved-solids concentrations and chemical types, respectively. The maps show the prevalent conditions with respect to both time and location.

Prevalent dissolved-solids concentrations and chemical types usually coincide with low-flow conditions. During low-flow periods water reaches streams after it has seeped through the soil to the ground-water reservoir, where it moved slowly and in contact with subsurface rocks, often for very great distances. In its passage through soil and rocks, underground water dissolves a large variety of chemical constituents. Thus, the river's chemical composition tells something about the composition of the soil and rocks through which the water has flowed and about their reactions with water. During high flow or storm runoff most of the water moves overland or through the upper soil layer to the streams. Storm runoff usually is much more dilute than low-flow because its contact with soil and rock is for a shorter period of time.

Streams are subjected constantly to changes in environment that cause changes in the chemical quality of the water. The variations with time may be small in areas subjected to intense weathering over long periods of geologic time or in areas where the quantity of rainfall is distributed uniformly throughout the year. Maximum concentrations of dissolved solids in such areas commonly are two or three times the minimum concentrations. Conversely, the younger, incompletely leached rocks and the scattered, infrequent, and often intense rainfall characteristic of the arid and semiarid Western States make up an environment that produces erratic and often extreme changes in the composition of the water. Maximum and minimum concentrations of dissolved solids at a specific location often differ by a factor of 5 or 6 and sometimes 10, or an even larger factor.

The designation of chemical type (plate 2) means that most of the dissolved solids are of the substances specified. Water in about 87 percent of the country is of the calcium-magnesium type. Hardness of water is directly related to calcium and magnesium, therefore it may generally be stated that waters with dissolved-solids concentrations less than about 120 ppm (parts per million) are soft; from 120 to 350 ppm of dissolved solids are moderately hard to hard; and those greater than 350 ppm of dissolved solids are very hard. The sodium-potassium type water is prevalent in about 13 percent of the country. Dissolved-solids concentration for this type of water usually is higher than for the calcium-magnesium type. The fact that water is of the sodium-potassium type does not necessarily imply that it is soft. In fact, a sodium-potassium type water with a concentration greater than about 800 ppm dissolved solids may contain concentrations of calcium and magnesium that would make it very hard.

Chemical types also change with time. In general, the prevalent type is characteristic of low flows. On unregulated streams the tendency is toward a calcium-bicarbonate type of water as discharge increases, but there are many exceptions.

The map of sediment concentration (plate 3) shows the average annual discharge-weighted means. The discharge-weighted mean concentration is the quantity of suspended sediment that passes a section on a stream in a given time divided by the volume of water discharge for the period. The average annual discharge-weighted mean sediment concentration is selected for two reasons. First, it provides a common base for comparing the average sediment concentrations from different drainage basins. Second, this concentration is converted easily to annual sediment discharge. Annual sediment discharges are used to predict the life of reservoirs and to study erosion rates.

The range of sediment concentrations of a river throughout the year usually is much greater than the range of dissolved-solids concentrations. Maximum concentrations may be 10 to more than 1,000 times the minimum concentrations. Usually the sediment concentration is higher during high flow than during low flow. This differs from dissolved-solids concentration which is usually lower during high flows.

Concentrations shown on plate 3 represent suspended sediment carried by the major flowing part of the stream. Suspended-sediment discharge differs from total-sediment discharge by the amount of sediment that bounces or slides along the streambed. This amount is called bedload, and it depends mostly on water velocity and particle size of the bed material. In a stream with a sand bottom the bedload may be from 5 to 60 percent of the total sediment discharge. The presence of a hard-rock bottom is evidence that almost all of the sediment moves in suspension.

Limited investigation of mud-bottom streams indicates that bed movement is slight. The cohesiveness of clays tends to bind the fine particles together and prevent their movement as bedload. If the turbulence is sufficient to separate the particles from the bed, it is more than sufficient to keep them in suspension and transport them as suspended load. Probably less than 10 percent of the total sediment discharge is bedload.

Sediment transport is a complicated process, and the foregoing generalizations are presented only as broad guides for using plate 3.

Considerations of broad national coverage show some interesting facts about river composition. In 50 percent of the country the prevalent concentration of dissolved solids is less than 230 ppm and the discharge-weighted sediment concentration is less than 600 ppm. In 90 percent of the country the prevalent concentration is less than 900 ppm and 8,000 ppm respectively. Dissolved and sediment concentrations correlate very well, geographically, low dissolved-solids concentrations tend to coincide with low sediment concentrations.

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MAP OF CONTERMINOUS UNITED STATES SHOWING PREVALENT DISSOLVED-SOLIDS CONCENTRATION OF RIVERS

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—62202 1962

For sale by U. S. Geological Survey, price 1.50 per set