CALCIUM, SODIUM, SULFATE AND CHLORIDE IN STREAM WATER OF THE WESTERN CONTERMINOUS UNITED STATES TO 1957

By J. H. Feth

INTRODUCTION

This Hydrologic Atlas shows concentrations of calcium, sodium (or sodium plus potassium), sulfate, and chloride in stream water of 11 of the Western States, regardless of the sources from which the mineral constituents came. The maps are, in a sense, a historical summary, showing concentrations observed to 1957 and reported in published references. Data on chemical quality of stream water has been obtained at various times and at various places; for no single year does the record even approach complete coverage of the areas shown on the maps. It was necessary, therefore, to combine the records of many years in order to achieve this summary.

Concentrations of the mineral substances in stream water change with time. These changes reflect the influence of variations in precipitation in the drainage basin of the stream, impoundment, introduction of waste products, and other use and re-use of the water by man. With these considerations in mind, the ranges in concentration selected for illustration on the maps have purposely been kept broad. Despite persistent trends in some streams over the years, and transient changes that occur from time to time in all streams, the maps show the general distribution of mineral concentration reported to 1957. They supplement—for the western conterminous United States—data on the general chemical quality of stream water shown in a series of maps published by the U.S. Geological Survey (Rainwater, 1962).

The information on the four maps is intended primarily for planners who must provide water supply of chemical character suited for use in many categories. Virtually at a glance a reader may select or reject broad areas in the Western States for more detailed study of individual localities according to the chemical restrictions upon uses to which the water supply may be put. Although useful in planning, the maps do not define changes in the chemical character of water in an individual stream at a particular location. They provide points of departure for more detailed studies.

WATER-QUALITY DATA

Much of the information on stream-water quality appears in publications of the U.S. Geological Survey, particularly the annual compilations titled "Quality of Surface Water of the United States," a series which began in 1941. Other useful compilations appear in publications of various State universities and Federal agencies (see bibliography at end of text). Many individual analyses were obtained from reports of water-supply investigations in specific areas.

Historically, the drought years of the 1950's provide the greatest number of stations having continuous records. Because of the drought and the accompanying greater withdrawal and use of water, these are also the years in which many maximum concentrations probably occurred. The records of 25 long-established major-river stations were examined for the drought years, showing that maximum concentrations occurred in 1954 or 1955 at 17 of the 25 stations. In those places where maximum concentrations occurred in other of the years surveyed, the maximums recorded did not change the order of magnitude in which the 1954-55 maximums appeared. The records of 1954–55, therefore, were taken as the key data in compiling the continuous-station records on the maps. The records from stations not operative in 1954–55 were sought in other compilations and plotted. Where no continuous records are available, the maximum individual value was used, or the range in concentration plotted where 10 or more analyses were shown from a sample point.

Unfortunately, the data are unevenly distributed, and there are large areas in the Western States—especially where the surface drainage is by smaller streams, or in the headwater areas of major river drainage basins—where information regarding chemical quality is scanty or entirely lacking. Unquestionably there are many areas within the Western States—especially in mountainous areas—where concentrations of individual constituents are 10 ppm (parts per million) or less, but which cannot be identified and illustrated from existing information. The areas having virtually no runoff, or where neither upstream nor downstream sampling points provide reasonable clues to stream-water quality are indicated on the maps in this atlas.

VARIATIONS IN CONCENTRATIONS

A few of the geochemical implications of the data shown on the maps may be mentioned in passing. One such implication has to do with the commonly held idea that in the semiarid Southwest, water of high concentration occurs because the climate is semiarid. This concept is only partly valid. Consider, for example, the Little Colorado River and the Bill Williams River, both in Arizona. Weather Bureau records show that in the drainage basin of the Little Colorado the mean yearly precipitation is roughly twice as much as that in the drainage basin of the Bill Williams River. Yet, for the most part, the water of the Little Colorado River is more highly mineralized than that of the Bill Williams. The principal explanation for the difference observed between the two lies in the abundance of readily soluble minerals in the sedimentary rocks that make up most of the drainage basin of the Little Colorado, and their relative absence in the rocks composing the drainage basin of the Bill Williams River.

The record of the Sevier River in Utah is likewise impressive. Rising in volcanic terrane in southern Utah, the Sevier flows northward, gaining only modest amounts of mineralization until it nears Richfield, Utah. In this part of the drainage basin changes in the chemical character of the water almost immediately reflect the presence of bedded salt and bedded gypsum from which surface drainage and ground-water inflow carry large quantities of mineral matter to the stream. There is no abrupt climatic change in the vicinity of Richfield; instead, there is a marked change in the rock types making up the drainage basin. Similar examples of the well-known influence of readily soluble rock materials upon surface-water quality are abundant throughout the West.

The high concentrations of sodium and chloride that appear well upstream in the course of the Salt River in south-central Arizona depend mainly upon the inflow of water from saline springs. The origin of the salt in the spring water remains unknown, but its effect upon the chemical quality of the water in the Salt River is immediately and abundantly apparent. Within a reach less than a mile long, the river water changes in character from that of a dilute mountain stream to one having enough mineralization to be distinctly salty to the taste.

The influence of heavy precipitation in maintaining a low dissolved-solids content in stream waters is seen in the areas having less than 10 ppm of the several constituents, along and adjacent to the northwest coast of the United States. Similar dilute waters characteristically flow from areas such as those underlain by the Sierra Nevada and Idaho batholiths, where the rate of precipitation is high and the rocks relatively insoluble.

The concentration of calcium is more nearly uniformly distributed in the range 11 to 100 ppm than is true of any of the other three constituents illustrated. There are few areas known in which the concentration of calcium is consistently 10 ppm or less, and there were none found in which the concentration exceeds 1,000 ppm. In those places where the concentration of calcium lies in the range 101 to 1,000 ppm the sulfate content of the water also is high. In these areas the higher concentrations of calcium are controlled mostly by the presence of bedded or disseminated gypsum in sedimentary rocks underlying the drainage basins of the streams.

Some areas show significant changes in dissolved mineral contents over relatively short periods of record. Increasing use, particularly use which tends to increase water loss by evaporation, is a common cause of such quality change. Climatic effects on concentration also are possible, but are less likely sources of noticeable change.

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MAP SHOWING CONCENTRATIONS OF CALCIUM IN STREAM WATER OF THE WESTERN CONTERMINOUS UNITED STATES, BASED ON HISTORIC RECORDS TO 1957

By

J. H. Feth

SCALE 1:2 500 000

50 0 50 100 150 200 250 MILES

50 0 50 100 150 200 250 KILOMETERS

1965

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