PREPARED IN COOPERATION WITH THE
NORTH CAROLINA DEPARTMENT OF WATER AND AIR RESOURCES

CHEMICAL QUALITY OF WATER IN STREAMS OF NORTH CAROLINA

INTRODUCTION

The collection of data on the chemical quality of stream water of North Carolina was started in 1943 by the U.S. Geological Survey in cooperation with the State of North Carolina. This program was continued through September 1967, at which time it was superseded by a more specialized program designed to obtain supporting data for the State's water-pollution monitoring activities. Basic-data reports were published annually to furnish current information to users of water-quality data. A summary compilation of all the data collected through 1967 is contained in U.S. Geological Survey Water-Supply Paper 1895-B.

This atlas provides an interpretive summary of the important aspects of water quality for those who utilize and manage the streams. More detailed information concerning the sites at which data were collected, water-quality variations at these sites, and methods of investigation are contained in Water-Supply Paper 1895-B

QUALITY OF WATER

The minerals dissolved in water are derived both from natural sources and from various human activities. Natural sources include the atmosphere, the land surface, and the rocks below the surface. Human activities that affect chemical quality include those related to the disposal of domestic, industrial, and livestock wastes and farming.

NATURAL QUALITY

Water reaching the land surface as precipitation is relatively free of dissolved minerals. However, as the water moves over the surface and through the underground openings, it dissolves small amounts of the soil, rocks, and other natural substances with which it comes in contact. Because the amount dissolved depends on the path followed by the water on its journey to streams, the movement of water over and under the land surface is the most important factor in determining its natural chemical quality. As shown

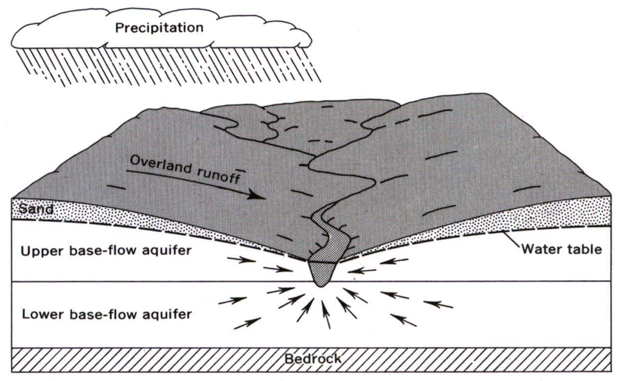

FIGURE 1.—*Diagrammatic cross section of Trent River near Trenton, N.C., showing principal paths by which water enters the stream channel.*

in figure 1 water moves to streams along two principal routes: (1) overland (runoff), and (2) underground as ground water. Overland runoff occurs only during precipitation and for brief periods afterwards. If the precipitation is intense and lasts long enough, floods result. During fair weather, the water in streams is composed of water that has seeped slowly through the ground. Streamflow during these periods is referred to as base flow. Thus, during brief periods most or all the water in streams is derived from overland runoff; during somewhat longer periods most or all the water is derived from ground-water discharge, and during intervening periods the water consists of varying mixtures of these. It is possible, using various techniques, to separate streamflow into its overland-runoff and ground-water components. Figure 2 shows such a separation for the upper part of the Trent River basin. During the 1957 water year, for example, the precipitation on the basin was about 19 billion cubic feet, and the total flow of the river was equivalent to 2.6 billion cubic feet, of which 1.9 billion reached the stream as overland runoff, and 0.7 billion as ground water.

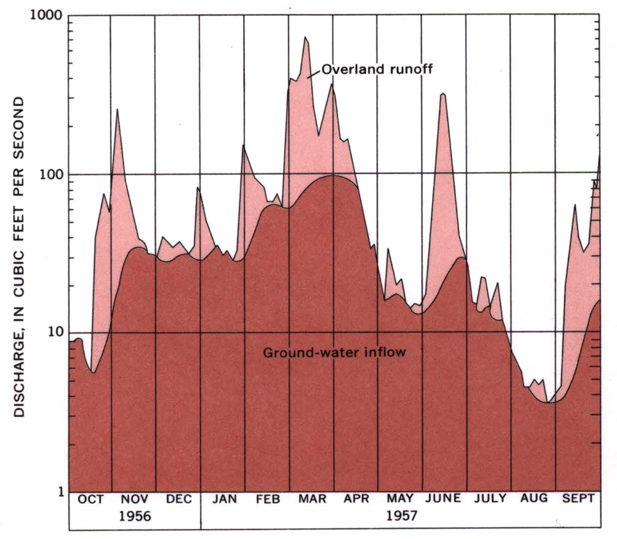

FIGURE 2.—*Example of separation of streamflow hydrograph into components of overland runoff and ground-water inflow using data for the 1957 water year for Trent River near Trenton.*

Figure 2 shows that, while flow in the stream is sustained primarily by base flow much of the time, most of the total volume of flow for the year is made up of overland runoff during floods. This preponderance in volume of overland runoff over ground-water discharge may not be immediately obvious on figure 2 because of the tendency of the logarithmic scale to subdue the height of peak discharges, but it is apparent from the fact that overland runoff ranges up to 700 cfs (cubic feet per second) whereas ground-water discharge is always less than 100 cfs.

The amount of dissolved material found naturally in streams varies from place to place because the natural quality of overland runoff and ground-water inflow are not the same for all locales. The areal variations in natural dissolved-solids concentration in North Carolina are slight compared with many areas, but significant differences do exist in some river basins.

Precipitation reaching the land surface contains less than 5 mg/l (milligrams per liter) dissolved solids. (One mg/l equals about 0.00014 ounces per gallon of water.) Estimated dissolved solids in overland runoff not affected by human activities is shown in figure 3A to range from about 15 mg/l in the western Piedmont and mountains to about 70 mg/l in a part of the Coastal Plain. The dissolved-solids content of ground-water inflow is shown in figure 3B to range from about 20 mg/l in the western part of the State to about 150 mg/l along a part of the southeastern coast. It is apparent from these values that ground water is somewhat more mineralized than overland runoff. Figures 3A and 3B

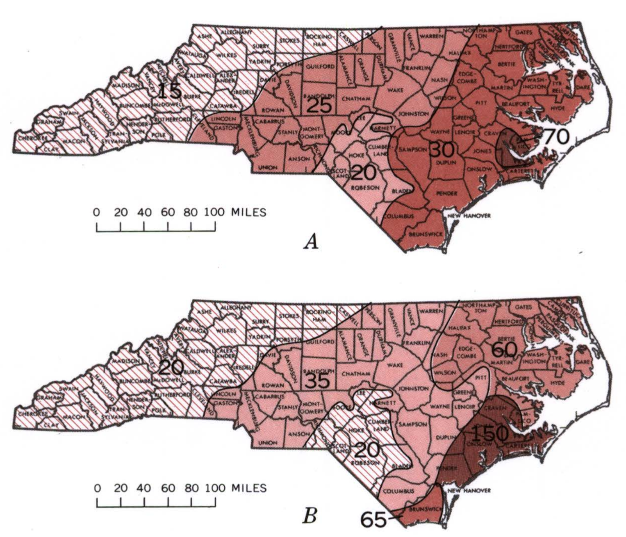

FIGURE 3.—*Estimated dissolved solids concentrations for unpolluted overland runoff (A), and ground-water inflow (B) for streams in North Carolina.*

are based on chemical analyses of water samples collected under both high-flow and low-flow conditions on small streams draining forested and other relatively undeveloped areas. They are, therefore, the best data presently available on the natural dissolved-solids content of streamflow, which is the natural water-quality base.

Referring to figure 2, and recognizing that the dissolved solids in overland runoff differs in amount from that in ground water, it is possible to estimate, in those areas where the differences are significant, what proportion of the dissolved solids in an unpolluted stream at any time is derived from overland runoff and what proportion is derived from ground water. This has been done for the upper Trent River in figure 4. Water in this river is derived from overland runoff and from two distinctly different ground-water aquifers. The dissolved solids in overland runoff contains about 30 mg/l dissolved solids, which probably includes minor amounts of agricultural pollution. Water from one of the ground-water aquifers, probably the uppermost of the two, contains about 117 mg/l of dissolved solids, whereas that from the second aquifer contains about 150 mg/l.

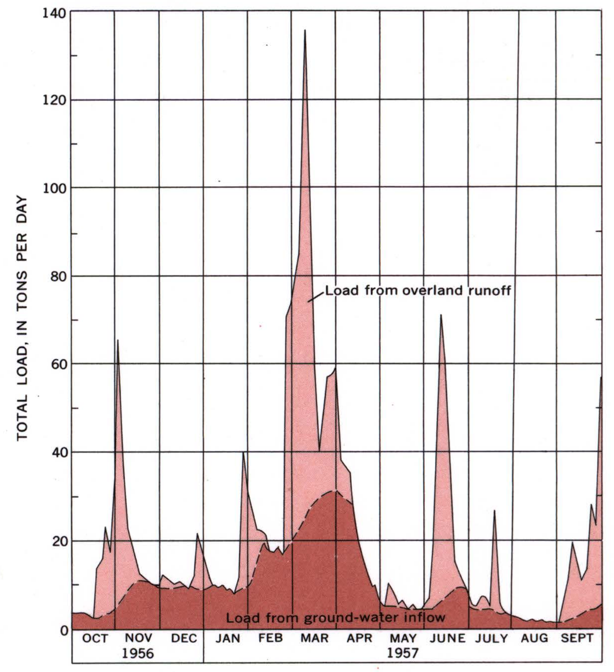

FIGURE 4.—*Amounts and origin dissolved-solids loads for Trent River near Trenton for the 1957 water year*

Figure 4 was prepared using values of 30 mg/l for overland runoff, 117 mg/l for ground-water inflow of 10 cfs or greater, 150 mg/l for ground-water inflow of less than 10 cfs, and the flow separation in figure 2. A comparison of figures 2 and 4 shows that whereas only about 25 percent of the total volume of streamflow is made up of ground-water inflow, almost half the dissolved-solids load was derived from solution of underground materials. (In comparing these two figures it is important to note that the flow volumes on figure 2 are plotted on a logarithmic scale, and the peaks are much more subdued than they would be on an arithmetic scale, such as used for dissolved-solids loads on figure 4).

EFFECT OF HUMAN ACTIVITIES

Many human activities add dissolved substances to water. Such addition is usually referred to as pollution. These activities include agricultural practices that require the use of water-soluble fertilizers, most of which are used by vegetation or retained in the soil zone, but a part of which is carried away in overland runoff and in ground water. Because farming is practiced in nearly all parts of the State, agricultural pollution is widespread. The amount varies seasonally and probably differs markedly between those parts of the Coastal Plain that are intensively farmed and those areas in the mountains in which farming is relatively limited. It would be exceedingly difficult, if not impossible, to estimate with the data now available the quantity of dissolved substances derived from farming.

Man's major additions of dissolved solids to stream water result from the disposal of domestic and industrial wastes. Because such wastes are generally discharged to streams at readily identifiable points, in contrast to the diffused agricultural pollution, their effect on water quality can be determined more easily. However, because the points at which domestic and industrial wastes are discharged number into the thousands, determining the effect of each would be a virtually impossible undertaking. It is possible along some streams where water-quality sampling stations were relatively closely spaced to estimate the amount of dissolved solids added by pollution. Such estimates for the upper part of the Neuse River are presented in figure 5. It may be observed that dissolved solids increase rather markedly at certain points where polluted tributaries enter the main stream and at places on the main stream where large amounts of wastes are discharged. Between these points the concentrations of dissolved solids gradually decrease as less polluted water enters the stream.

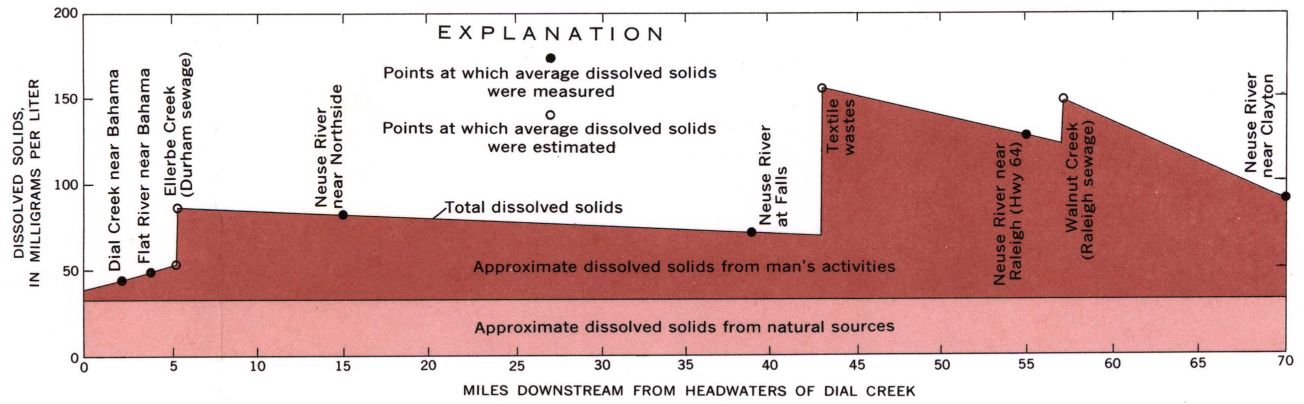

FIGURE 5.—*Downstream changes in concentrations and sources of dissolved solids for the upper Neuse River and selected tributaries.*

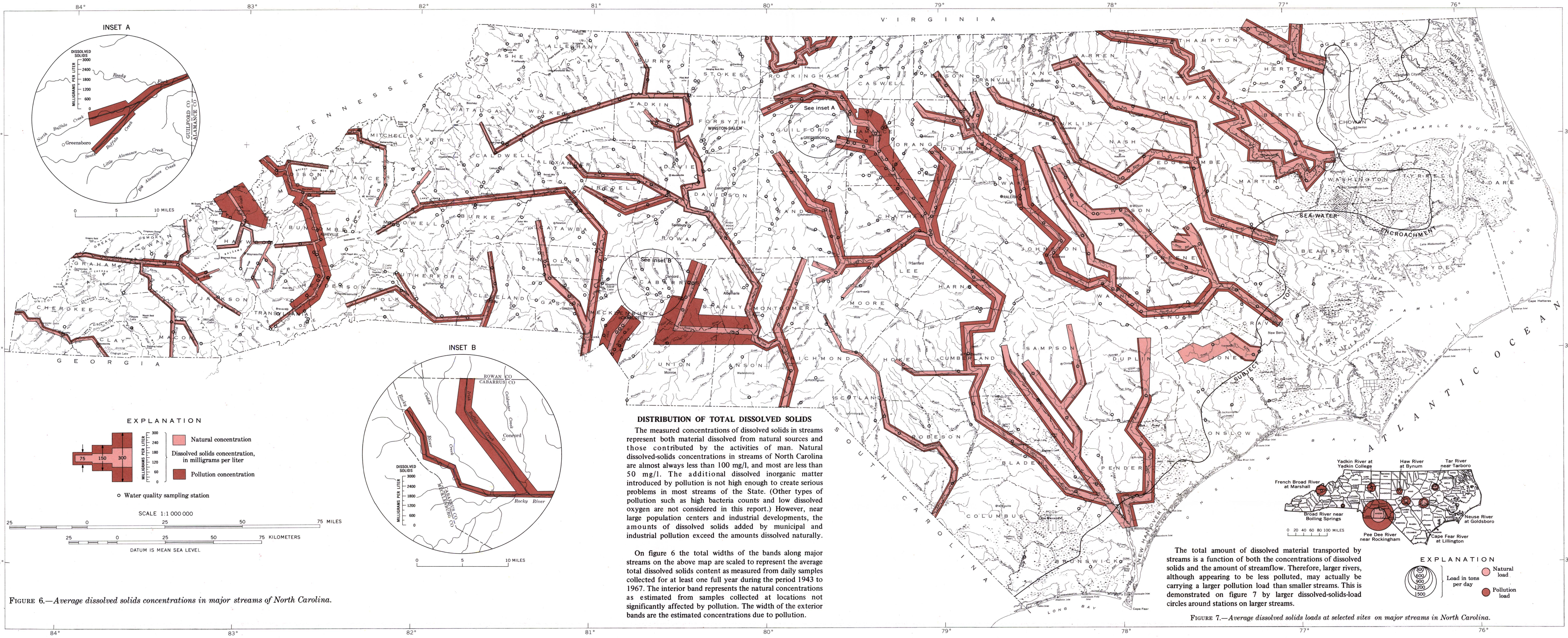

FIGURE 6.—*Average dissolved solids concentrations in major streams of North Carolina.*

DISTRIBUTION OF TOTAL DISSOLVED SOLIDS

The measured concentrations of dissolved solids in streams represent both material dissolved from natural sources and those contributed by the activities of man. Natural dissolved-solids concentrations in streams of North Carolina are almost always less than 100 mg/l, and most are less than 50 mg/l. The additional dissolved inorganic matter introduced by pollution is not high enough to create serious problems in most streams of the State. (Other types of pollution such as high bacteria counts and low dissolved oxygen are not considered in this report.) However, near large population centers and industrial developments, the amounts of dissolved solids added by municipal and industrial pollution exceed the amounts dissolved naturally.

On figure 6 the total widths of the bands along major streams on the above map are scaled to represent the average total dissolved solids content as measured from daily samples collected for at least one full year during the period 1943 to 1967. The interior band represents the natural concentrations as estimated from samples collected at locations not significantly affected by pollution. The width of the exterior bands are the estimated concentrations due to pollution.

The total amount of dissolved material transported by streams is a function of both the concentrations of dissolved solids and the amount of streamflow. Therefore, larger rivers, although appearing to be less polluted, may actually be carrying a larger pollution load than smaller streams. This is demonstrated on figure 7 by larger dissolved-solids-load circles around stations on larger streams.

FIGURE 7.—*Average dissolved solids loads at selected sites on major streams in North Carolina.*

Base from U.S. Geological Survey

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