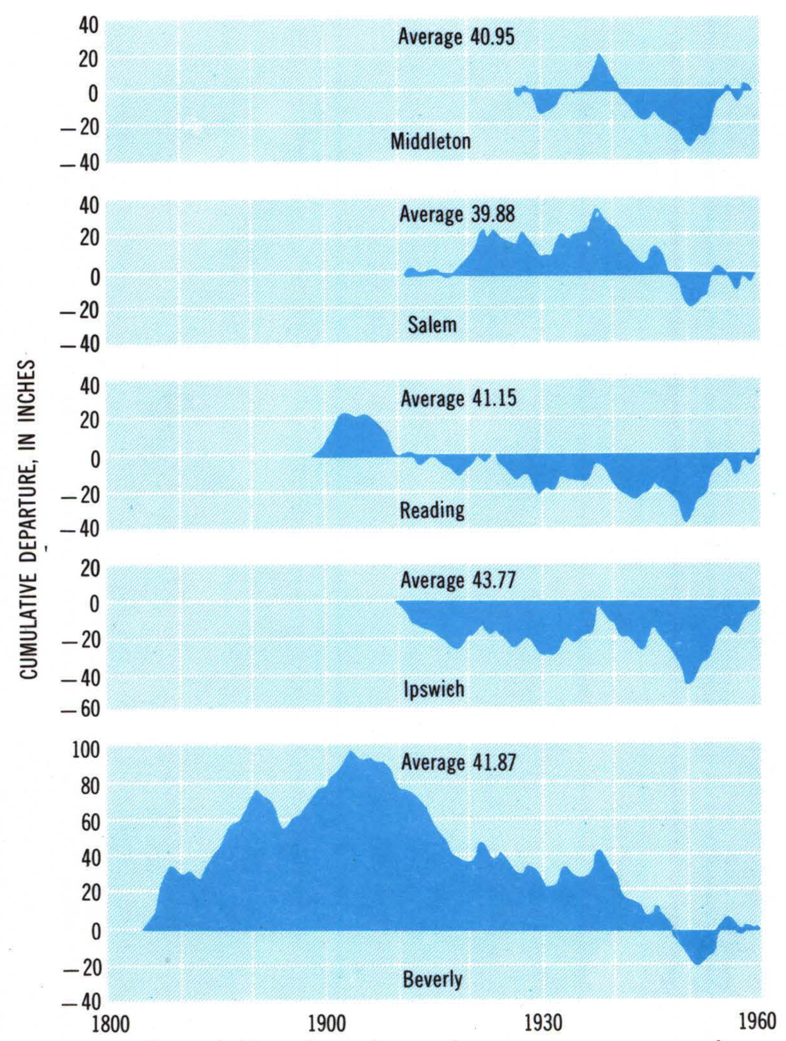
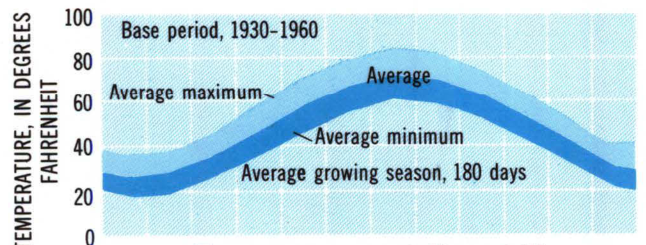
PREPARED IN COOPERATION WITH
MASSACHUSETTS WATER RESOURCES COMMISSION

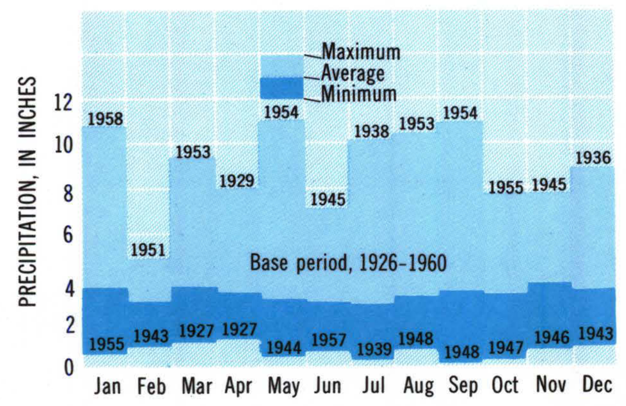


Cumulative departures from average annual precipitation

Precipitation at Beverly was greater during 1875-1903 and 1950-60 than during 1903-50. Precipitation at the other four stations was similar to the Beverly station.



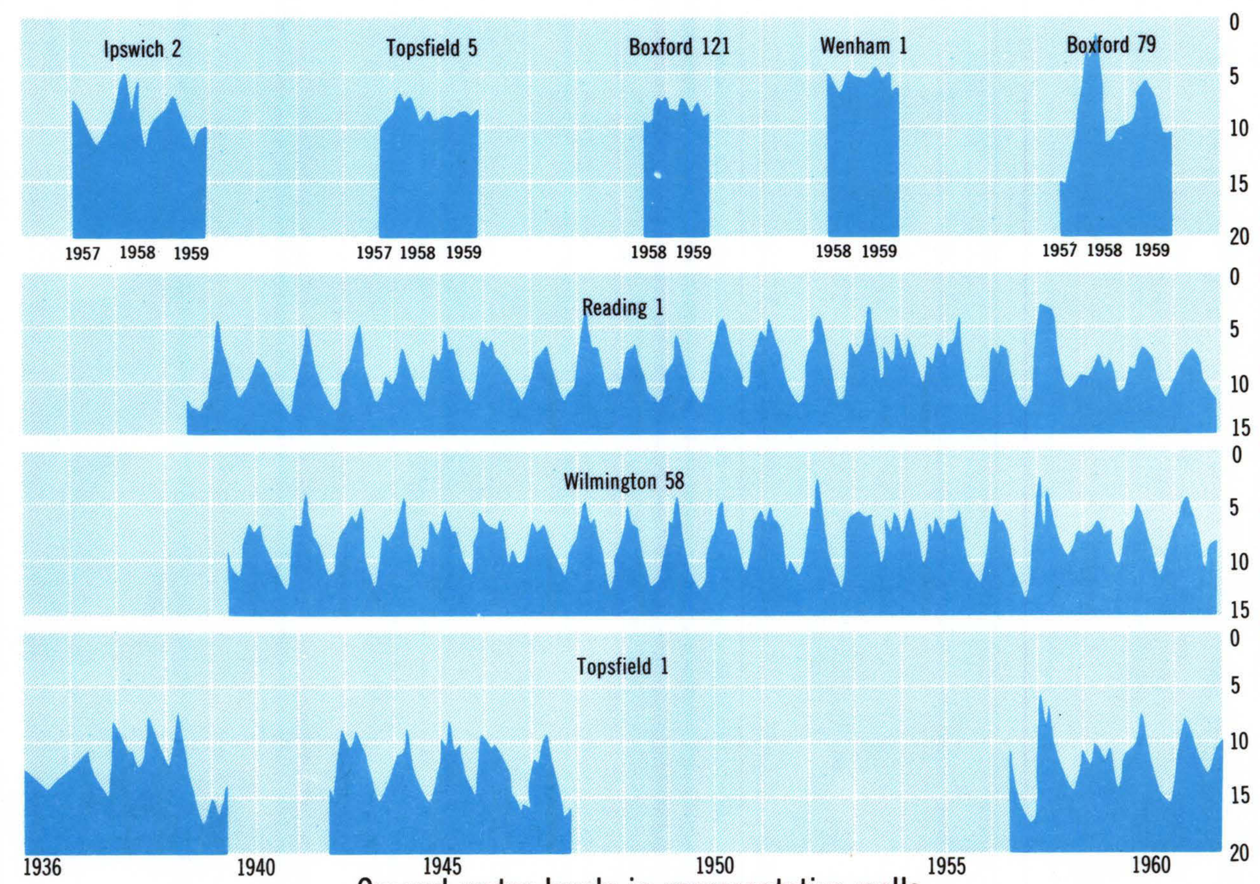
Temperatures at Haverhill



Precipitation at Middleton

Average temperatures in much of the basin are similar to those at Haverhill, a few miles north of the basin. The average growing season is about 180 days. The average monthly precipitation for the basin is represented by the precipitation at Middleton.

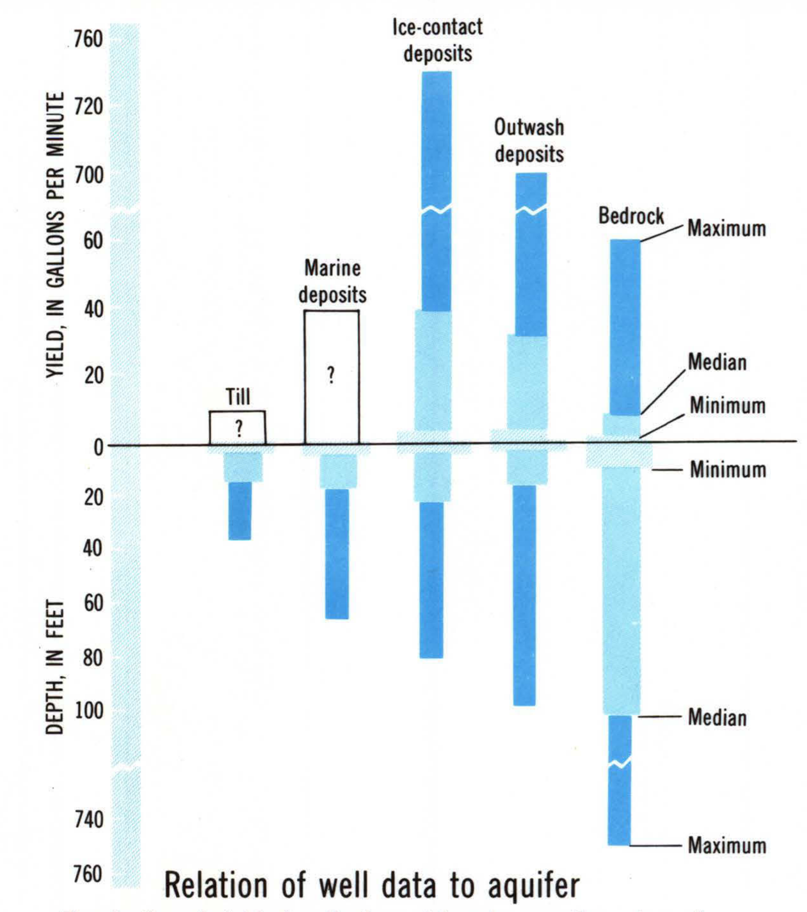
PRECIPITATION—The Primary Source Of Water



Ground-water levels in representative wells

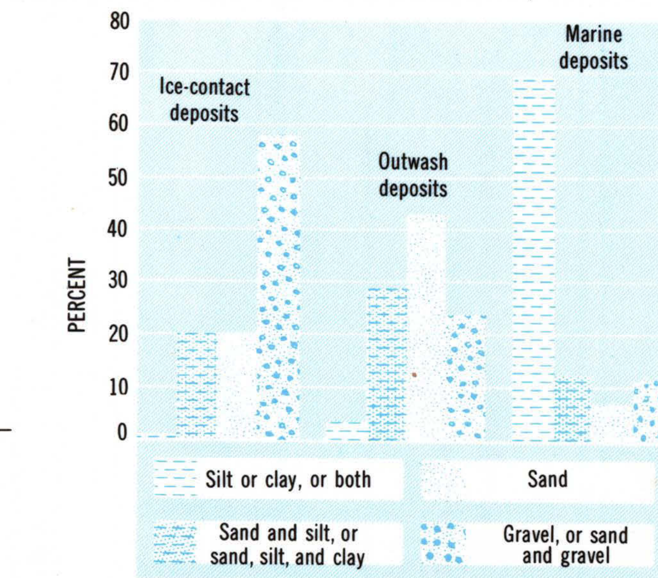
Water levels in wells in the Ipswich River basin fluctuate in an annual cycle, declining during the growing season each year and returning to approximately the same high levels during each winter. The longest records indicate that there is no long-term trend in water levels that corresponds to the long-term trend in annual precipitation.

Fluctuations in ground-water levels result from changes in the ratio of recharge to discharge within the ground-water body and provide a readily measurable index to changes in ground-water storage. The range of annual fluctuations varies from well to well depending upon the nature of the materials penetrated and upon the topographic position of the well. The water levels in wells in fine-grained materials on hilltops fluctuate more than in those penetrating coarser materials or in valleys.



Relation of well data to aquifer

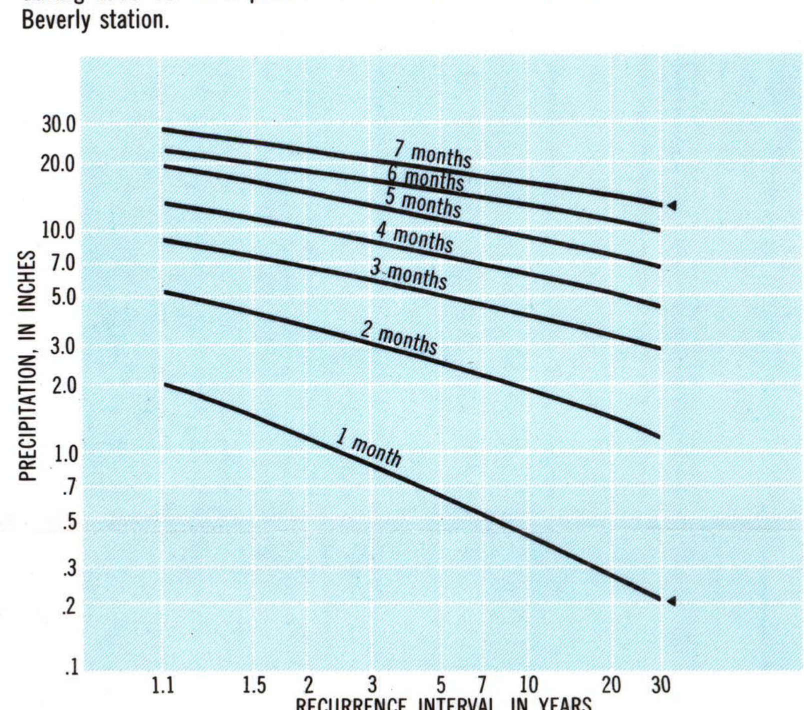
The depth and yield of wells depend largely upon the nature of the materials penetrated. Wells, especially bedrock wells, are deepened beyond the level at which water is encountered to provide storage. Ice-contact and outwash deposits, because of their greater permeability, furnish greater amounts of water than other materials.



Grain-size distribution based on driller's logs

Hydrologic properties of unconsolidated deposits are strongly dependent on grain-size distributions. Large grains of predominantly one size allow maximum permeability. Permeabilities of ice-contact deposits are generally greater than those of outwash deposits, and the permeability of either is greater than that of marine deposits. Glacial till, not shown, is relatively impermeable. The most favorable areas for the large development of ground-water supplies are those underlain by ice-contact and outwash deposits.

AQUIFERS And WELLS—Guides To Ground-Water Availability



Precipitation recurrence

During the 30-year period of record at Middleton, 0.21 inch of precipitation occurred in the driest month, and less than 15 inches of precipitation occurred during the driest 7-month period. Therefore, the probability of recurrence of each of these minimums is 1/30 for the given period of record. On the assumption that existing conditions continue, the probability of 1/30 may be applied in estimating the probability that these minimums will occur during any given year. A similar procedure will provide estimates of probability for other consecutive-month periods and other amounts of precipitation.

SUMMARY OF HYDROLOGY

The Ipswich River drains about 155 square miles in Middlesex and Essex counties, northeastern Massachusetts. The basin is an area of poorly-drained lowlands, many underlain by glacial deposits of sand and gravel, and hills of bedrock and glacial till. It is a major source of water for about 379,000 persons (1960) in 16 towns and cities in or near the river basin. The surplus water that leaves the basin as runoff is a potential source of supply for a number of other communities in the region.

Precipitation, the primary source of water, averages 42.5 inches annually and is distributed evenly throughout the year. Almost half of the precipitation is transpired by plants or evaporates directly from the land surface. The remainder, about 22 inches a year, drains to the ocean as runoff. Runoff reaches the Ipswich River and its tributaries rapidly overland or more slowly through the ground. Base-flow of the streams, amounting to about 14.5 inches each year, is derived mainly from the discharge of ground water to the streams, but an unknown amount is contributed by swamps.

The rate of runoff, which ranges widely during the year, limits the rate of surface-water use. Pumpage from streams could be increased greatly during times of high flow and the water either used immediately or stored for use in times of low flow.

Large supplies of ground water may be obtained from stratified drift deposits, the principal ground-water reservoirs, which underlie about 30 percent of the basin and store about 130 billion gallons of water. These deposits generally are less than 50 feet but may be as much as 200 feet thick. Small supplies of water may be withdrawn from the bedrock almost anywhere in the basin.

Ground-water levels show no long-term trend, and though large fluctuations occur each year, the ground-water reservoirs generally are refilled to capacity annually. During parts of most years, potential recharge, unable to enter the already filled ground-water reservoirs, runs off in streams and is not stored in the basin.

An average of 22 billion gallons of water are recharged to the stratified drift aquifers each year. At this rate ground-water withdrawal could be sustained at about 25 million gallons a day, or about 5 times the 1960 withdrawal rate.

The surface- and ground-water resources of the basin are closely related. For example, large ground-water withdrawals adjacent to streams will reduce streamflows, particularly during low-flow periods. The amount of streamflow reduction will depend on whether the ground water, after being used, is returned to a stream from a central point, returned to the ground at numerous points, or diverted outside the basin. Conversely, increased surface-water use during low-flow periods may reduce the amount of water available to wells near the stream. Draining and dredging of swamps will further reduce low streamflows and ground-water withdrawals.

Diversions of both ground and surface water from the basin, mainly above the South Middleton gaging station, amount to about 5 percent of annual runoff and reduce normal streamflow by 50 percent during some low-flow periods. In 1956 and 1957 this pumpage diverted the entire flow of the river for short periods near the Reading municipal well field.

The chemical quality of both ground and surface water in the basin generally is satisfactory for most uses although some water may contain excessive amounts of iron and manganese.

This report was prepared in cooperation with the Massachusetts Water Resources Commission, Malcolm E. Graf, Director and Chief Engineer. William Everberg, of the Commission, assisted in the preparation of the illustrations. The detailed studies on which this summary is based were made in cooperation with the Massachusetts Department of Public Works, James D. Fitzgerald, Commissioner.

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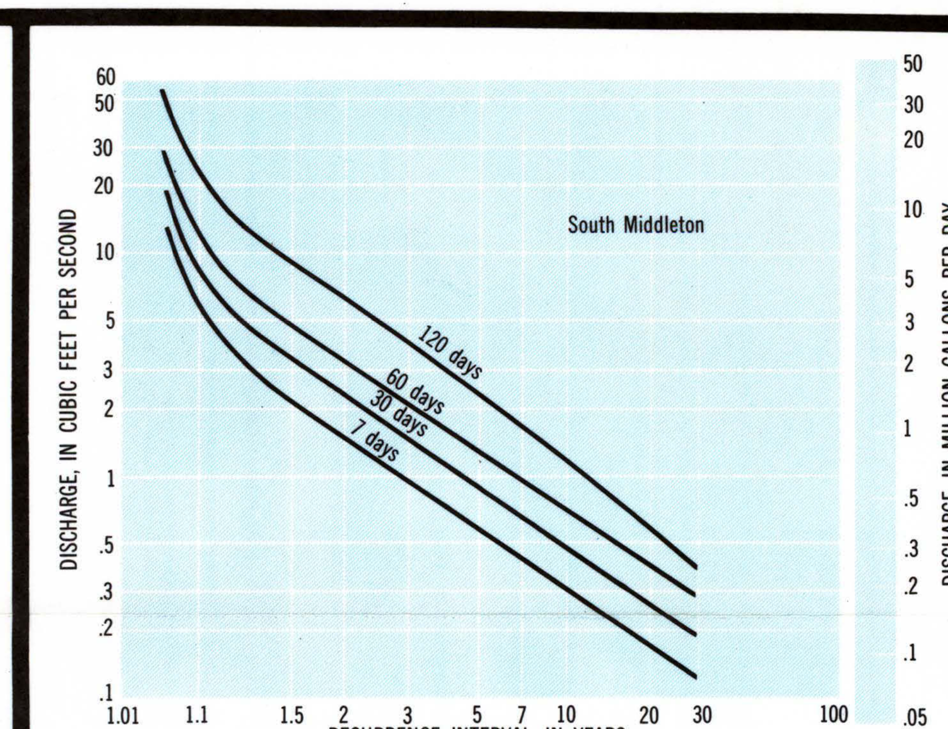
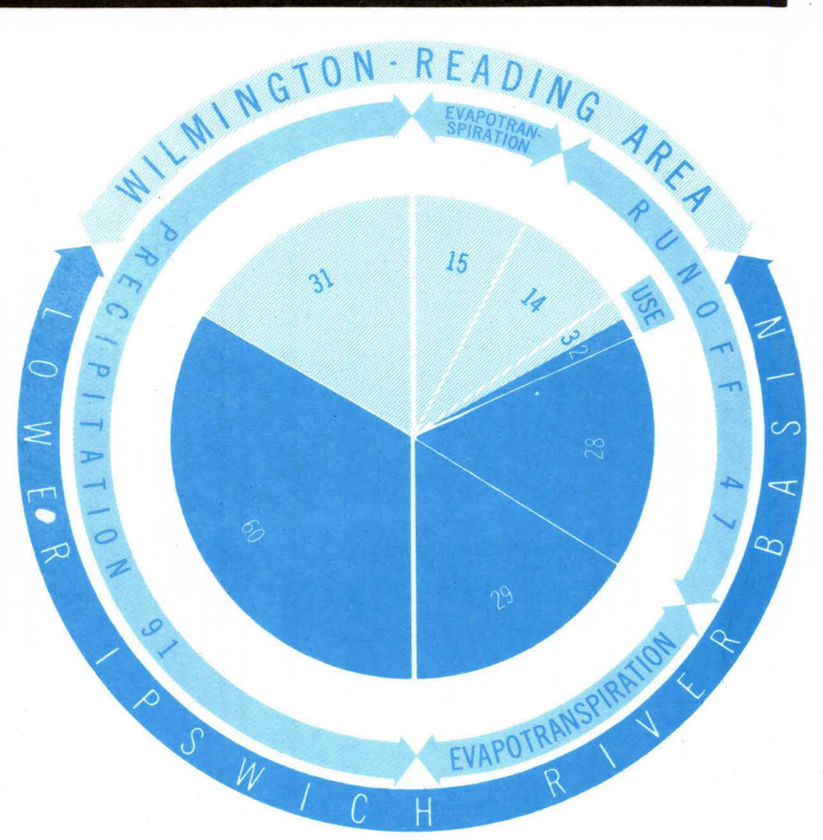
*Available in duplicated form from U.S. Geol. Survey, Boston, Mass.



Frequency of low flows

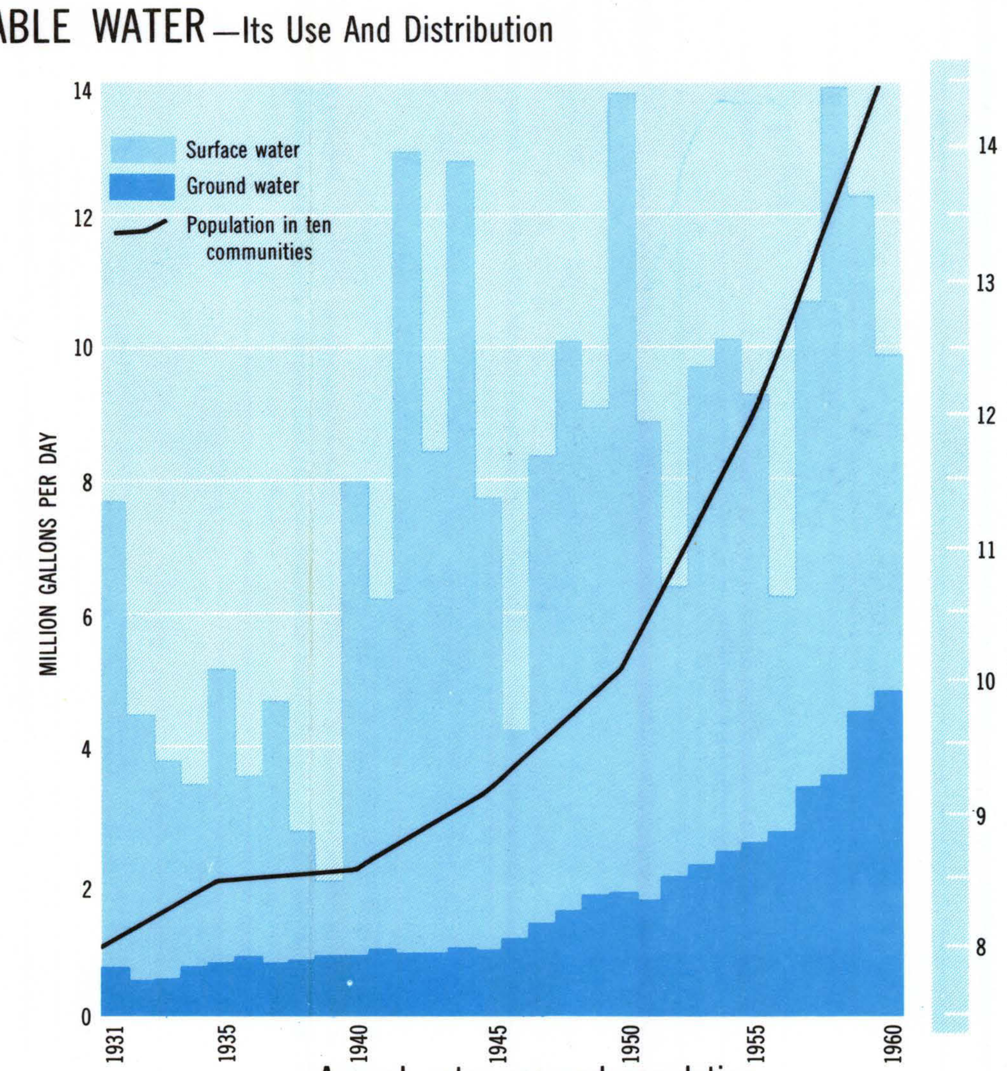
AVAILABLE WATER—Its Use And Distribution



Annual Water budget
(Billion gallons)

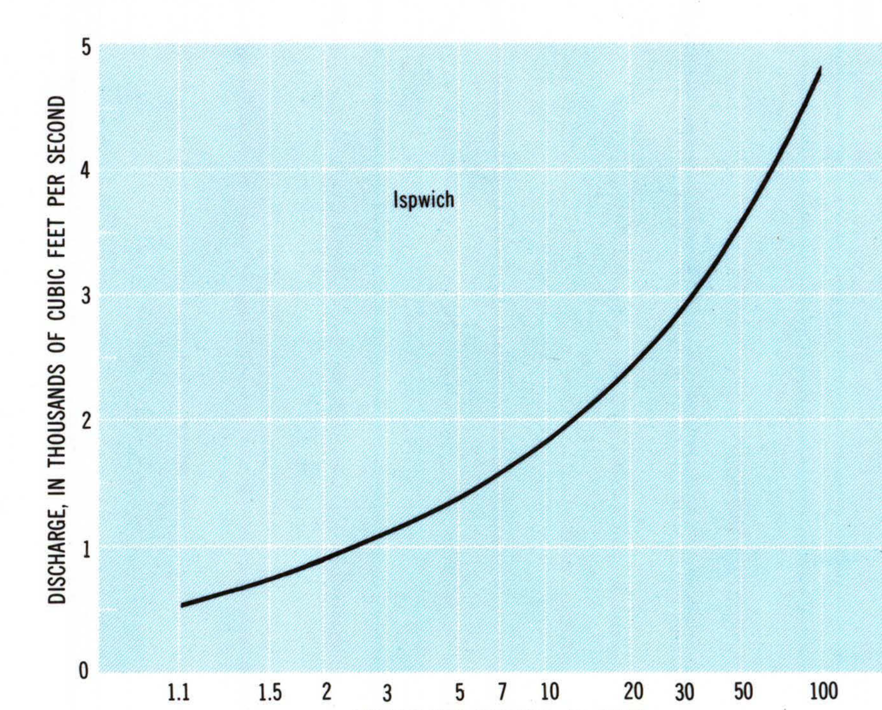
Average runoff in the Ipswich River basin is about half of the water that enters the basin as precipitation. Runoff from a river basin represents the water available for man's use. The rest returns to the atmosphere by evapotranspiration.

In the period 1958-60 only 9 percent of the water available in the entire basin was used. In the upper part of the basin (the Wilmington-Reading area) about 16 percent of the available water was used.



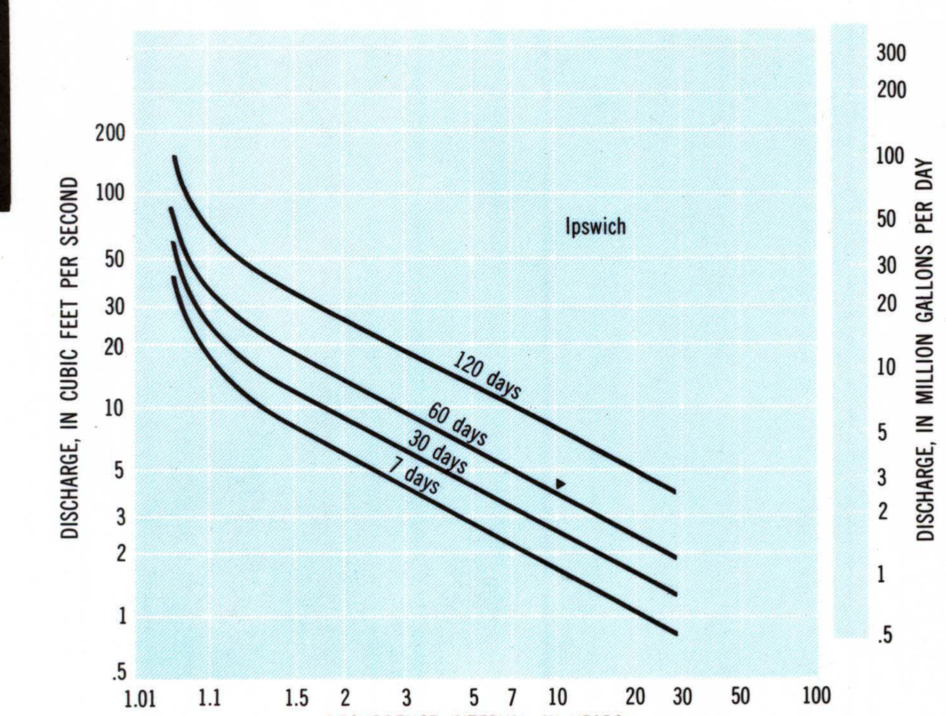
Annual water use and population

Annual withdrawals of water in the Ipswich River basin (1931-60) and the population trend in 10 communities served by water withdrawn in the basin show that a five-fold increase in ground-water use accompanied a doubling of population. Variation in demand, mostly by industry outside the basin, caused a wide range in amount of surface-water use.



Frequency of floods at Ipswich

Flood-frequency curves can be used to predict the probabilities of flood occurence if similar hydrologic conditions continue. Thus, if the recurrence interval of a flood of a given magnitude is 10 years, there is a 10 percent probability of its occurence in any one year.



Frequency of low flows

Low-flow frequency curves can be used to predict the probabilities of low stream flows assuming no change in hydrologic regimen. For example, an average flow of 2.5 million gallons a day for 60 consecutive days has occured at Ipswich at a rate of once every 10 years, indicating a 10 percent probability that the same event will occur in any year.

FLOODS And LOW FLOWS—Extremes Of Streamflows

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1965—W65021

SYNOPSIS OF WATER RESOURCES OF THE IPSWICH RIVER BASIN, MASSACHUSETTS

By
E. A. Sammel, R. A. Brackley, and W. N. Palmquist, Jr.

1964

For sale by U.S. Geological Survey, price 75 cents per set