INTRODUCTION

LOCATION OF THE STUDY AREA.—The Shawsheen River basin includes parts of 12 municipalities in Essex and Middlesex counties and drains a 77 mi^2 area northwest of the Boston Metropolitan area in eastern Massachusetts. It is bordered on the west by the Concord River basin, on the south by the Charles River basin, and on the east by the Mystic and Ipswich River basins and discharges into the Merrimack River to the north. In its upstream half, the Shawsheen River flows in a well-defined channel that meanders over a 200 to 600-foot-wide grassy flood plain. In its downstream half, it flows through a gently curving pool and riffle channel interrupted by five dams. Topographic relief is low; altitudes range from 10 feet at its mouth to between 250 to 300 feet at the tops of many small rounded hills along the drainage divide.

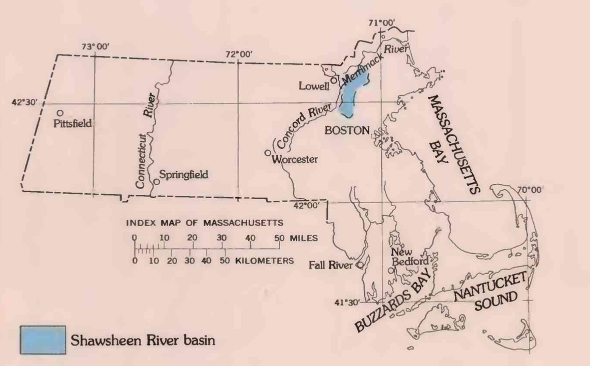
The streams have low gradients; for example, the Shawsheen River loses about 100 feet of altitude in 26 river miles from Kiln Brook in Bedford to its mouth at the Merrimack River in Lawrence. The low relief and poor drainage result in numerous wetlands.

Amount and availability of ground water are determined largely by variations in the type and thickness of unconsolidated deposits overlying bedrock. The bedrock aquifer is capable of supplying only a few gallons per minute to wells, the amount needed for domestic supplies. The most productive aquifers, capable of sustaining well yields of several hundred gallons per minute, are composed of sand and gravel deposited during Pleistocene glaciation. These aquifers are adjacent to and beneath Elm, Heath, Strong Water, and Vine Brooks, and scattered areas along the Shawsheen River.

The population, estimated at 106,000 in 1974, is fairly evenly dispersed throughout the basin but is slightly more dense and more urbanized at the north and south ends.

This atlas provides information on the quantity, quality, and availability of water in the Shawsheen River basin, Massachusetts. The atlas was prepared by the U.S. Geological Survey in cooperation with the Commonwealth of Massachusetts, Water Resources Commission, as part of a statewide program of river-basin studies. It is based on field investigations from 1972 to 1974.

Well logs, chemical data, and water-use data supplied by the Massachusetts Department of Public Works, Massachusetts Department of Public Health, town officials, local well drillers, and individuals are gratefully acknowledged. The authors appreciated the contributions of the Massachusetts Division of Water Pollution Control during the time-of-travel studies on the Shawsheen River.



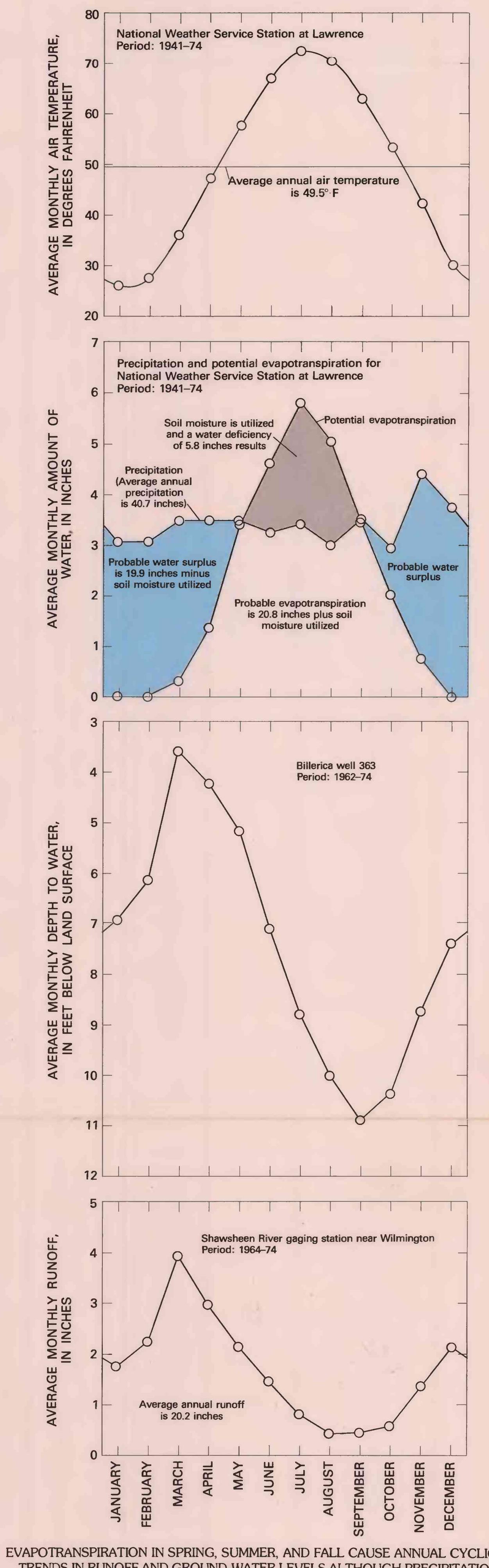
Shawsheen River basin

METRIC CONVERSION FACTORS

TABLE 1.—FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM OF UNITS (SI), WITH ABBREVIATIONS

Multiply inch-pound units	By	To obtain SI Units
	Length	
inches (in)	25.4	millimeters (mm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
	Area	
square miles (mi^2)	2.590	square kilometers (km^2)
acres	4047	square meters (m^2)
	0.4047	hectometers (hm^2)
	Volume	
million gallons (Mgal)	0.003785	cubic hectometers (hm^3)
million gallons per square mile (Mgal/mi^2)	0.001461	cubic hectometers per square kilometer (hm^3/km^2)
	Flow	
cubic feet per second (ft^3/s)	0.02832	cubic meters per second (m^3/s)
cubic feet per second per square mile [(ft^3/s)/mi^2]	0.01093	cubic meters per second per square kilometer [(m^3/s)/km^2]
gallons per minute (gal/min)	0.06309	liters per second (L/s)
	6.309×10^{-5}	cubic meters per second (m^3/s)
gallons per day (gal/d)	3.785	liters per day (L/d)
	3.785×10^{-3}	cubic meters per day (m^3/d)
million gallons per day (Mgal/d)	43.81	liters per second (L/s)
	0.04381	cubic meters per second (m^3/s)
million gallons per day per square mile [(Mgal/d)/mi^2]	16.91	liters per second per square kilometer [(L/s)/km^2]
	0.01691	cubic meters per second per square kilometer [(m^3/s)/km^2]
	Hydraulic units	
feet per second (ft/s)	0.3048	meters per second (m/s)
square feet per day (ft^2/d)	0.0929	square meters per day (m^2/d)
	Temperature	
degrees Fahrenheit (°F)	5/9 (°F–32)	degrees Celsius (°C)

GENERALIZED HYDROLOGIC BUDGET



EVAPOTRANSPIRATION IN SPRING, SUMMER, AND FALL CAUSE ANNUAL CYCLICAL TRENDS IN RUNOFF AND GROUND-WATER LEVELS ALTHOUGH PRECIPITATION IS DISTRIBUTED EVENLY THROUGHOUT THE YEAR.—Five elements of the hydrologic cycle are portrayed in a column to compare their cyclical patterns.

Declines in ground-water levels and surface-water runoff from a peak in March to a low in September are in direct response to increased evapotranspiration. The rates of evaporation and transpiration vary directly with temperature, wind velocity, and hours of sunlight. During the May through September growing period, most of the precipitation is evaporated or replaces soil moisture removed by transpiring vegetation. Recharge to ground-water bodies becomes negligible, ground water in storage decreases, and base flow in streams, which is sustained by ground-water discharge, gradually declines until October when the growing season ends. After October, the rate of evapotranspiration is greatly reduced and slows to near zero from December through February. During the October to April period, precipitation recharges soil moisture and ground-water bodies, and streamflow increases.

The calculated probable water surplus, 19.9 inches, and the measured average annual runoff, 20.2 inches, shown in the evapotranspiration and runoff diagrams are in close agreement even though the precipitation-temperature station and the stream-gaging station are at different locations. Upstream from the Wilmington gaging station, average annual precipitation is about 1 inch higher, and average air temperature is about 0.5°F lower than values obtained at the Lawrence weather station. Therefore, more precipitation is available to become surface runoff and less is lost to evapotranspiration.

EXPLANATION

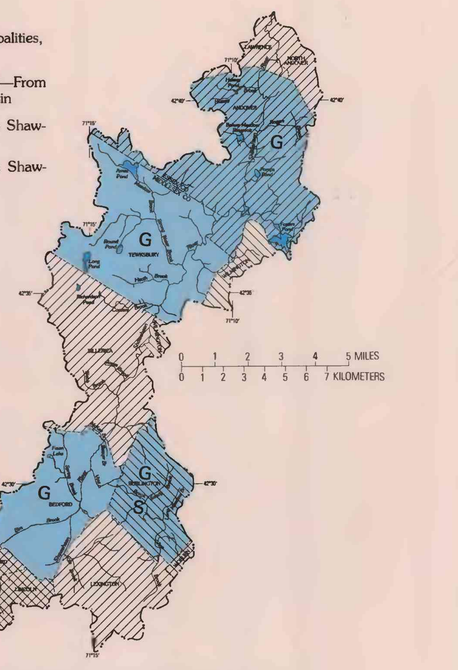
Water-supply sources for municipalities, excluding emergency sources

G S — G, Ground water; S, Surface water—From within the Shawsheen River basin

Ground water—From outside the Shawsheen River basin

Surface water—From outside the Shawsheen River basin

Basin boundary



APPROXIMATELY 85 PERCENT OF THE MUNICIPALITIES WITHIN THE SHAWSHEEN RIVER BASIN OBTAIN PART OR ALL OF THEIR WATER FROM SOURCES OUTSIDE THE BASIN.—Public-supply wells in sand and gravel aquifers are located adjacent to streams, and well yields can be partly sustained by infiltration from the streams. Bedford has wells near Spring and Vine Brooks and the Shawsheen River; Burlington has wells near Vine Brook and its tributaries; Tewksbury has wells near Heath Brook, a tributary to Strong Water Brook, and an unnamed tributary to the Shawsheen River in eastern Tewksbury; and Andover has a well near the Shawsheen River.

One municipality, Burlington, diverts water directly from the Shawsheen River for its public-water supply. (See discussion in "Flow duration" section on sheet 2 for the diversion schedule.)

Per capita usage ranges from 65 to 153 gal/d and depends, in part, on the amount of industrial use and leakage from water mains.

MUNICIPAL WATER USE

TABLE 2.—MUNICIPAL WATER USE IN 1974

Municipality[1]	Total water use[2] (Mgal)	Estimated population[3]	Estimated population served[4] (percentage)	Estimated water use by population served [(gal/d)/capita]	Water-supply sources
Andover	1,210.3	25,580	98	133	Haggetts Pond, diversions from Fish Brook, and gravel-packed well. Emergency: Gravel-packed wells.
Bedford	578.2	12,550	99	128	Gravel-packed wells.
Billerica	1,299.8	34,990	95	108	Diversions from Concord River. Emergency: Gravel-packed wells.
Burlington	1,014.0	23,840	99	118	Diversions from Shawsheen River, gravel-packed wells, and field of driven wells.
Concord	696.0	17,050	94	119	Nagog Pond and gravel-packed wells.
Lawrence	2,637.5	67,400	100	107	Diversions from Merrimack River.
Lexington	1,465.5	32,360	100	125	Metropolitan District Commission (MDC).
Lincoln	140.9	6,610	90	65	Sandy Pond and gravel-packed well.
North Andover	774.5	15,950	97	137	Lake Cochichewick.
Tewksbury	709.6	23,790	94	87	Gravel-packed wells.
Wilmington	933.3	17,550	95	153	Gravel-packed wells and fields of driven wells.
Woburn	1,871.0	35,740	100	144	Gravel-packed wells and MDC. Emergency: Horn Pond.

[1]Data apply to entire municipality. However, each lies partly within Shawsheen River basin.
[2]Data are from Massachusetts Department of Public Health, Metropolitan District Commission, City and Town officials, and Water District officials, and includes only water used from a municipal system.
[3]Data are based on a straight-line interpolation of population figures from the Federal census of 1970 (U.S. Department of Commerce, Bureau of the Census, 1972) and the Commonwealth of Massachusetts census of 1975.
[4]Data are based on the Federal census of 1970 (U.S. Department of Commerce, Bureau of the Census, 1972) and are assumed not to have changed significantly between 1970 and 1974.

GROUND WATER AVAILABILITY

EXPLANATION

TRANSMISSIVITY OF AQUIFER MATERIALS

Transmissivity is the rate at which water of prevailing kinematic viscosity is transmitted through a unit width of aquifer under a unit hydraulic gradient, expressed in feet squared per day (Lohman and others, 1972).

Potential well yields are based on available drawdown, on estimates of transmissivity, and are for properly designed and constructed individual wells at sites that have been located after exploratory drilling. Yield can be higher than estimated from wells located near surface-water sources that have good hydraulic connection with the aquifer tapped.

Areas of stratified glacial deposits

- Transmissivity greater than 4,000 ft^2/d (potential well yield greater than 300 gal/min)
- Transmissivity 1,400 to 4,000 ft^2/d (potential well yield 100 to 300 gal/min)
- Transmissivity less than 1,400 ft^2/d (potential well yield less than 100 gal/min)

Areas of till and bedrock outcrops

Till is a poorly sorted glacial material with a characteristically low transmissivity. Wells in till usually yield only a few gallons per minute but can be suitable sources of domestic supply. These wells, generally 2 to 4 feet in diameter and less than 25 feet deep, are susceptible to contamination if improperly constructed or located close to surface or near-surface contamination sources. Some minor stratified glacial deposits are included in this area because they have little or no saturated thickness and have potential well yields similar to till or bedrock. Distribution of surficial deposits and bedrock is modified from that shown on geologic maps referenced on this sheet and from surficial geologic map of Lowell quadrangle, Massachusetts-New Hampshire (R. H. Jahns, written commun., 1960), surficial geologic map of parts of the Billerica quadrangle, Massachusetts (R. H. Jahns and others, written commun., 1960), and surficial geologic map of parts of the South Groveland quadrangle, Massachusetts (E. A. Sammel and J. E. Cotton, written commun., 1961).

BEDROCK

Bedrock underlies the entire study area. Wells in bedrock yield up to 120 gal/min but generally yield about 10 gal/min. Bedrock wells are deeper, have more available drawdown, and are generally less susceptible to contamination than wells in till.

PUMPING CENTERS IN STRATIFIED DRIFT

Number, if present, is reported pumping capacity, in million gallons per day, of selected well or well field.

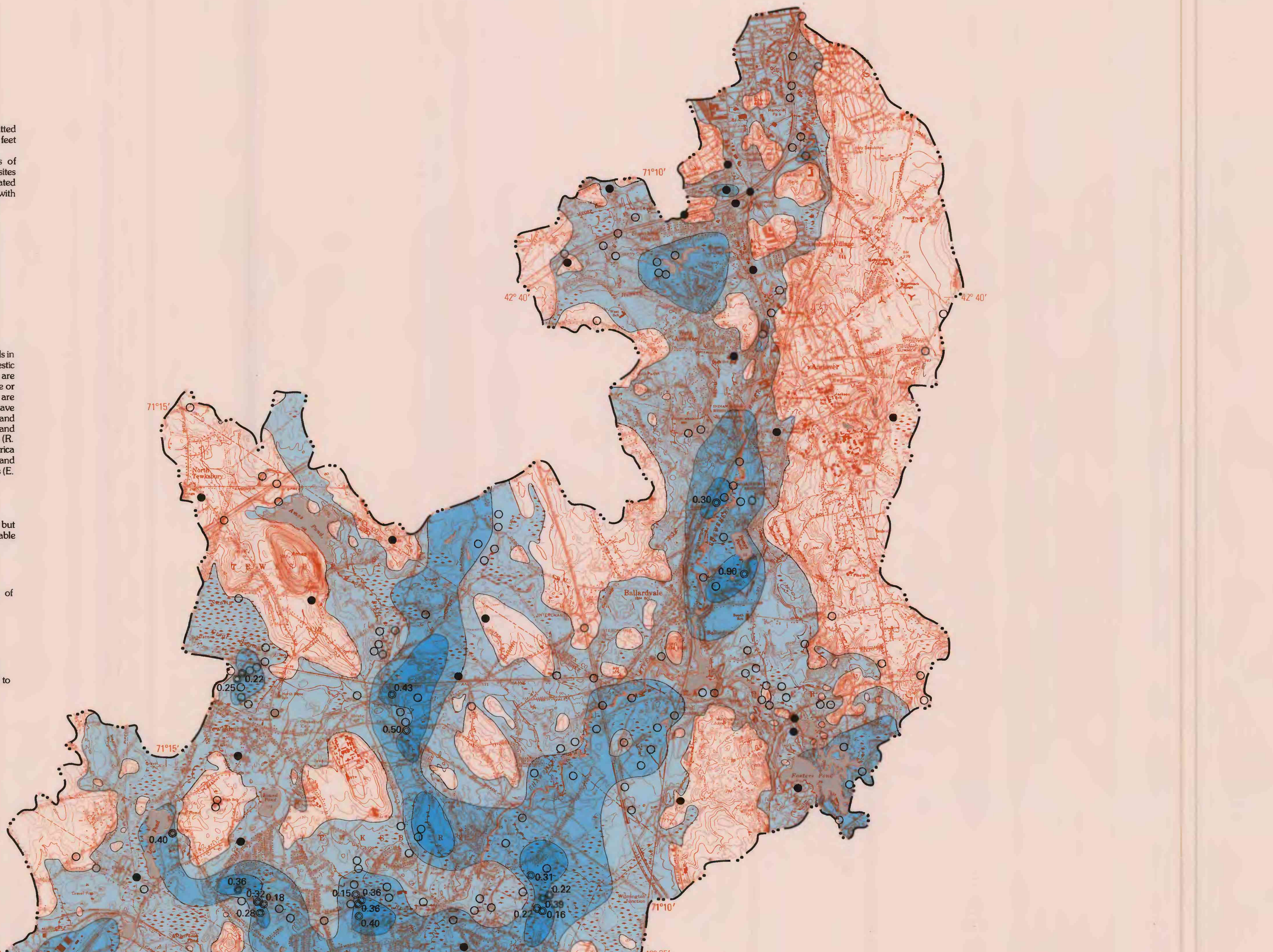
0.50 Municipal or institutional well or well field
0.36 Industrial well or well field

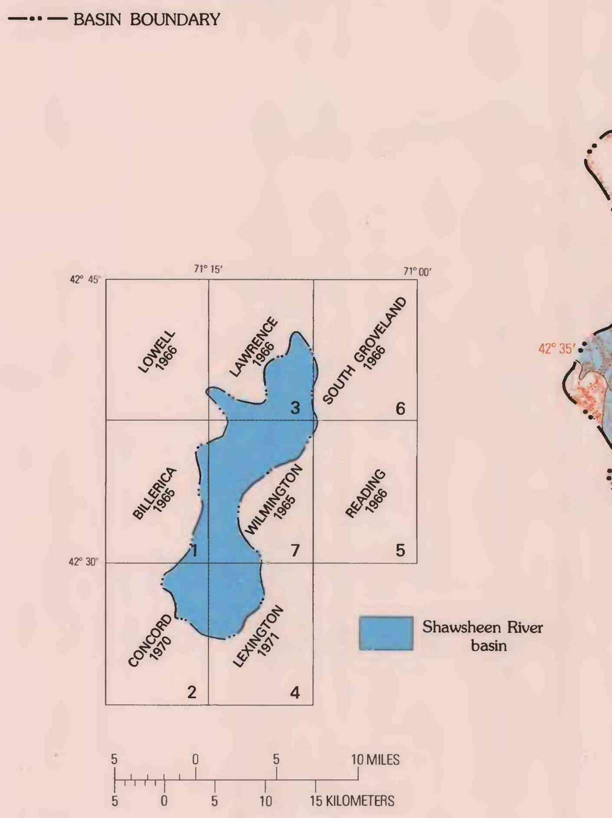
WELLS OR BORINGS USED TO DETERMINE TRANSMISSIVITY

Indicates the extent of municipal and other testing and distribution of data used to estimate transmissivity.

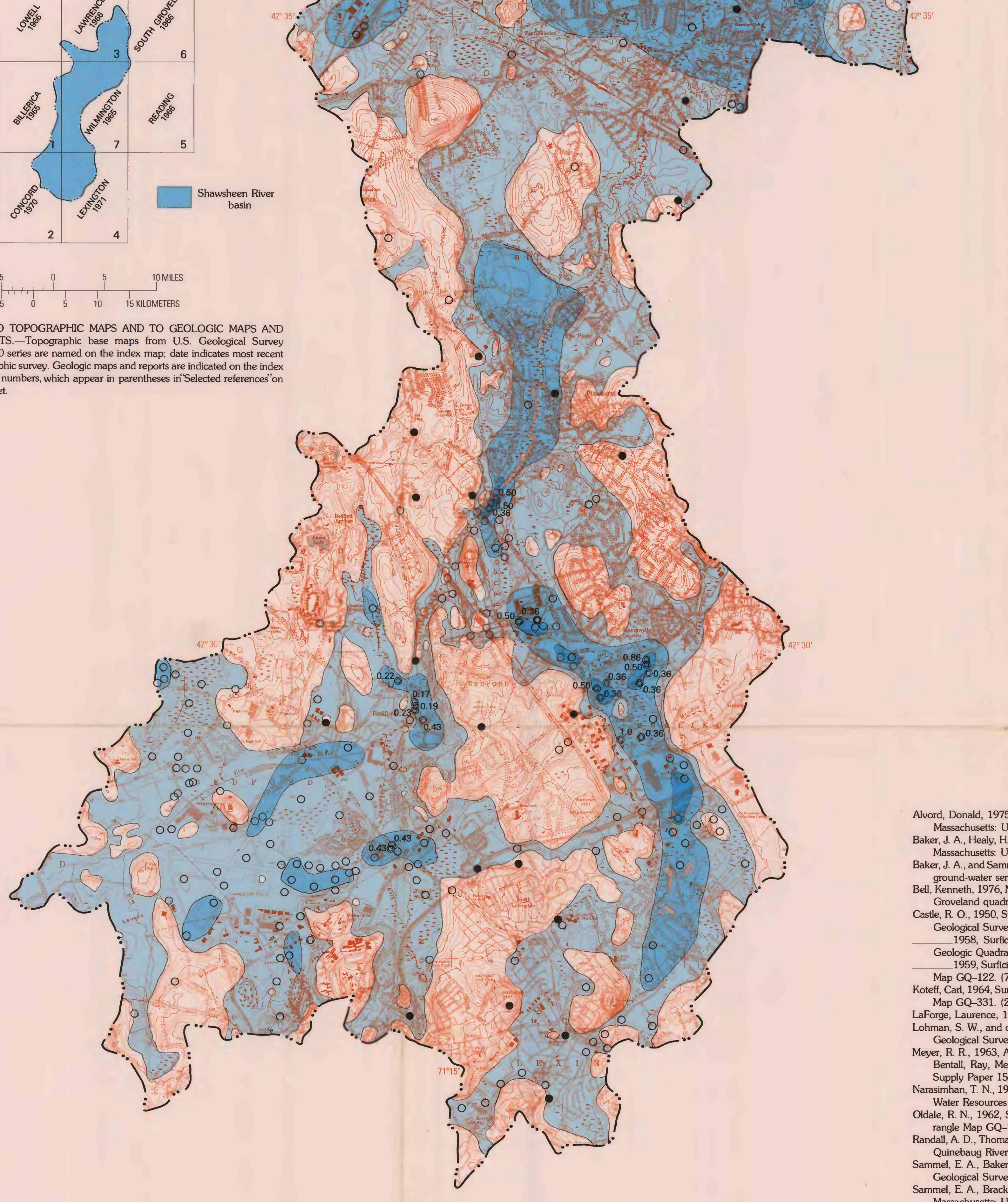
- Well or boring finished in unconsolidated deposits
- Well or boring finished in bedrock

BASIN BOUNDARY





INDEX TO TOPOGRAPHIC MAPS AND TO GEOLOGIC MAPS AND REPORTS.—Topographic base maps from U.S. Geological Survey 1:24,000 series are named on the index map; date indicates most recent topographic survey. Geologic maps and reports are indicated on the index map by numbers, which appear in parentheses in "Selected references" on this sheet.



SCALE 1:48 000
1 0 1 2 3 MILES
1 0 1 2 3 4 5 KILOMETERS
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

TRANSMISSIVITY OF STRATIFIED GLACIAL DEPOSITS OF THE SHAWSHEEN RIVER BASIN.—Continental glaciers, during the Pleistocene Epoch, scoured the bedrock surface of the study area and deposited a discontinuous mantle of till, which is an unconsolidated and unstratified mixture of clay, silt, sand, gravel, cobbles, and boulders. During melting of glacial ice, soil and rock fragments from within the glacier were transported, sorted, and deposited by meltwater as stratified sand and gravel in stream channels and as silt and clay in ponds and lakes. The unconsolidated glaciofluvial deposits of sand and gravel constitute the principal aquifers.

Transmissivities shown on the map are based on analyses of lithologic logs and well specific-capacity data. Transmissivity estimates were made for more than 250 wells and borings penetrating or partly penetrating stratified glacial deposits. Average hydraulic conductivity values were assigned (Thomas and others, 1967; J. R. Williams, written commun., 1974) to materials indicated in lithologic logs. Transmissivity values were calculated from specific-capacity data for 24 well tests by methods devised by Walton, 1962; Meyer, 1963; Narasimhan, 1967. Where possible, the calculated transmissivity values were used to refine those estimated from lithologic logs.

Transmissivity of unconsolidated deposits ranges from less than 10 ft^2/d for till and deposits of lacustrine silt and clay in the headwater area of the Shawsheen River valley to more than 10,000 ft^2/d for deposits of sand and gravel in the Towns of Burlington and Tewksbury. Aquifers that sustain well yields that exceed 300 gal/min lie primarily along the Shawsheen River and its major tributaries. Most of the best aquifers have been located during test drilling by towns searching for ground-water supplies and have been developed for municipal and light industrial use. Glaciofluvial deposits along the Shawsheen River in the Town of Billerica have not been explored. Aquifers that sustain well yields of less than 200 gal/min occur in many stream valleys and swampy areas. These aquifers are generally less than 50 feet thick and are of small areal extent.

Water from bedrock is generally available in quantity and quality suitable for single-family domestic supplies. Bedrock is composed of a variety of igneous and metamorphic rock types. Water in bedrock occurs in secondary pore spaces, such as joints and fractures, which are commonly narrow and represent only a small percentage of total aquifer volume. Consequently, bedrock-aquifer transmissivity varies greatly with location, and overall storage capacity is generally low. Nearly all wells constructed in bedrock intercept some water-bearing fractures; however, bedrock well yields range from a fraction of a gallon per minute, in places where the fractures are small and poorly interconnected, to more than 100 gal/min, where fractures are numerous and well interconnected, as in some fault zones. The median yield of 26 bedrock wells is 10 gal/min.

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Number in parentheses refers to number on "Index to topographic maps and to geologic maps and reports"

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INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1980—

HYDROLOGY AND WATER RESOURCES OF THE SHAWSHEEN RIVER BASIN, MASSACHUSETTS

By
Frederick B. Gay and David F. Delaney

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