GAZETTEER OF HYDROLOGIC CHARACTERISTICS OF STREAMS IN MASSACHUSETTS--THAMES RIVER BASIN

By S.William Wandle, Jr., and Janet A. LeBlanc

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 84-4287

Prepared in cooperation with the

COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

DIVISION OF WATER POLLUTION CONTROL

Boston, Massachusetts

1984

UNITED STATES DEPARTMENT OF THE INTERIOR

WILLIAM P. CLARK, Secretary

GEOLOGICAL SURVEY

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CONVERSION FACTORS

The following factors may be used to convert the inch-pound units published herein to the International System of Units (SI).

Multiply inch-pound units	By	To obtain SI Units
	Length	
inch (in)	25.4*	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]
	Slope	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)

Temperature

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$°C = 5/9\ (°F-32).$$

*Exact.

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ABSTRACT

The Thames River basin includes streams draining the Quinebaug River (141 square miles), French River (99.5 square miles), and Middle River (about 6 square miles) basins in south central Massachusetts. Drainage areas, using the latest available 1:24,000 scale topographic maps, were computed for the first time for ungaged streams draining more than 3 square miles and were re-computed for data-collection sites.

Streamflow characteristics at seven gaging stations were calculated using a new data base with daily flow records through 1980. These characteristics include annual and monthly flow statistics, duration of daily flow values, and the annual 7-day mean low flow at the 2-year and 10-year recurrence intervals. Seven-day low-flow statistics are presented for 32 partial-record sites, and procedures used to determine the hydrologic characteristics of a basin are summarized. Basin characteristics representing 14 commonly used indices to estimate various streamflows are provided for seven gaged streams. This gazetteer will aid in the planning and siting of water-resources related activities and will provide a common data base for governmental agencies and the engineering and planning communities.

INTRODUCTION

Information on hydrologic characteristics, including drainage areas, frequency of low flows, and duration of daily flows, is necessary to plan and manage water-resources related activities. Governmental agencies and the engineering and planning community need streamflow and basin characteristics to satisfy requirements relative to waste assimilation, fisheries management, hydropower, land-use planning, stream-systems analysis, and water-resource development and management. No current hydrologic data base containing a comprehensive list of drainage areas, monthly flows, low-flow frequencies, and duration of daily flows is available for most of the Massachusetts stream systems. Drainage areas are available for selected sites where streamflow data are collected. Streamflow characteristics are presented in various reports, but these data, to be current, need to be re-analyzed using the latest available daily flow records.

In response to this need, a study was begun in 1980, in cooperation with the Massachusetts Division of Water Pollution Control, to analyze available streamflow and river-basin characteristics, and to compute subbasin drainage areas. This report is part of a series of gazetteers on the hydrologic characteristics of the major river basins in the State. Gazetteers are also available for the coastal river basins of the North Shore and Massachusetts Bay (Wandle, 1984a), Connecticut River basin (Wandle, 1984b), Hudson River basin (Wandle, 1984c), Merrimack River basin (Wandle and Fontaine, 1984), Taunton and Ten Mile River basins (Wandle and Keezer, 1984), Housatonic River basin (Wandle and Lippert, 1984), Blackstone River basin (Wandle and Phipps, 1984), and coastal river basins of the South Shore and Buzzards Bay (Wandle and Morgan, 1984). This report provides the first detailed listing of drainage areas and streamflow characteristics derived from daily flow records in the Thames River basin. A detailed summary of drainage areas for the Connecticut part of the Thames River basin is given in Thomas (1972). The daily streamflow characteristics presented are an expansion and an update of those given in (V. A. Eames, U.S. Geological Survey, written commun., 1984).

The Thames River basin in Massachusetts (fig. 1) includes the Quinebaug, French, and Middle River basins in south-central Massachusetts. The study area includes all or part of the following communities: Auburn, Brimfield, Brookfield, Charlton, Douglas, Dudley, East Brookfield, Holland, Leicester, Millbury, Monson, Oxford, Southbridge, Spencer, and Sturbridge, Sutton, Wales, Warren, Webster, and West Brookfield.

Streamflow characteristics presented for seven continuously gaged streams are based upon a new sample of daily flow records in comparison to flow records used by V. A. Eames (U.S. Geological Survey, written commun., 1984), Higgins (1967), Knox and Soule (1949), and Male and Ogawa (1982). Streamflow records through the 1980 water year were available for this analysis. Records were selected for each site to represent a flow regime influenced by fairly constant river basin conditions (Wandle, 1983).

Drainage areas were computed for the first time for ungaged streams draining more than 3 mi^2 and were re-computed for data-collection sites. Drainage divides, as delineated on the latest available 1:24,000 scale topographic quadrangle maps (Brackley and Wandle, 1982; Krejmas, 1982; Krejmas and Wandle, 1982) were used to calculate drainage areas. Drainage areas for most of the long-term gaging stations in earlier reports were computed using the drainage divides as outlined on 1:31,680 or 1:62,500 scale topographic quadrangle maps.

Streamflow data used in this study are a part of the historic streamflow data collected under agreements with State and Federal agencies and the U.S. Geological Survey. Most of the low-flow discharge measurements used in determining low-flow estimates at partial-record sites were collected during the water-resources investigation of the French-Quinebaug River basin (V. A. Eames, U.S. Geological Survey, written commun., 1984) and during the 1960's as part of the Massachusetts low-flow network. The file of basin characteristics was created during an evaluation of available streamflow data in central New England (Johnson, 1970). This file is an expansion of the characteristics abstracted by Langbein and others (1947), and by Benson (1962). Basin characteristics were updated and additional characteristics were entered as part of a study to define floodflow characteristics of small streams (Johnson and Tasker, 1974; Wandle, 1982). The hierarchical stream list was compiled by the Massachusetts Division of Water Pollution Control and the Massachusetts Division of Fisheries and Wildlife (Halliwell and others, 1982).

Data tabulated include drainage areas, basin and streamflow characteristics for gaging stations, including annual and monthly flow statistics, duration of daily flow values, and the annual 7-day mean low flow at the 2-year and 10-year recurrence intervals. Seven-day low-flow statistics for partial-record sites are also presented. An explanation of each procedure to determine the streamflow and basin characteristics is provided.

The authors thank the many persons who have kindly given time, information, and guidance during this study. Particular thanks are given to persons in the Geological Survey who assisted in the data collection and in the preparation of this report.

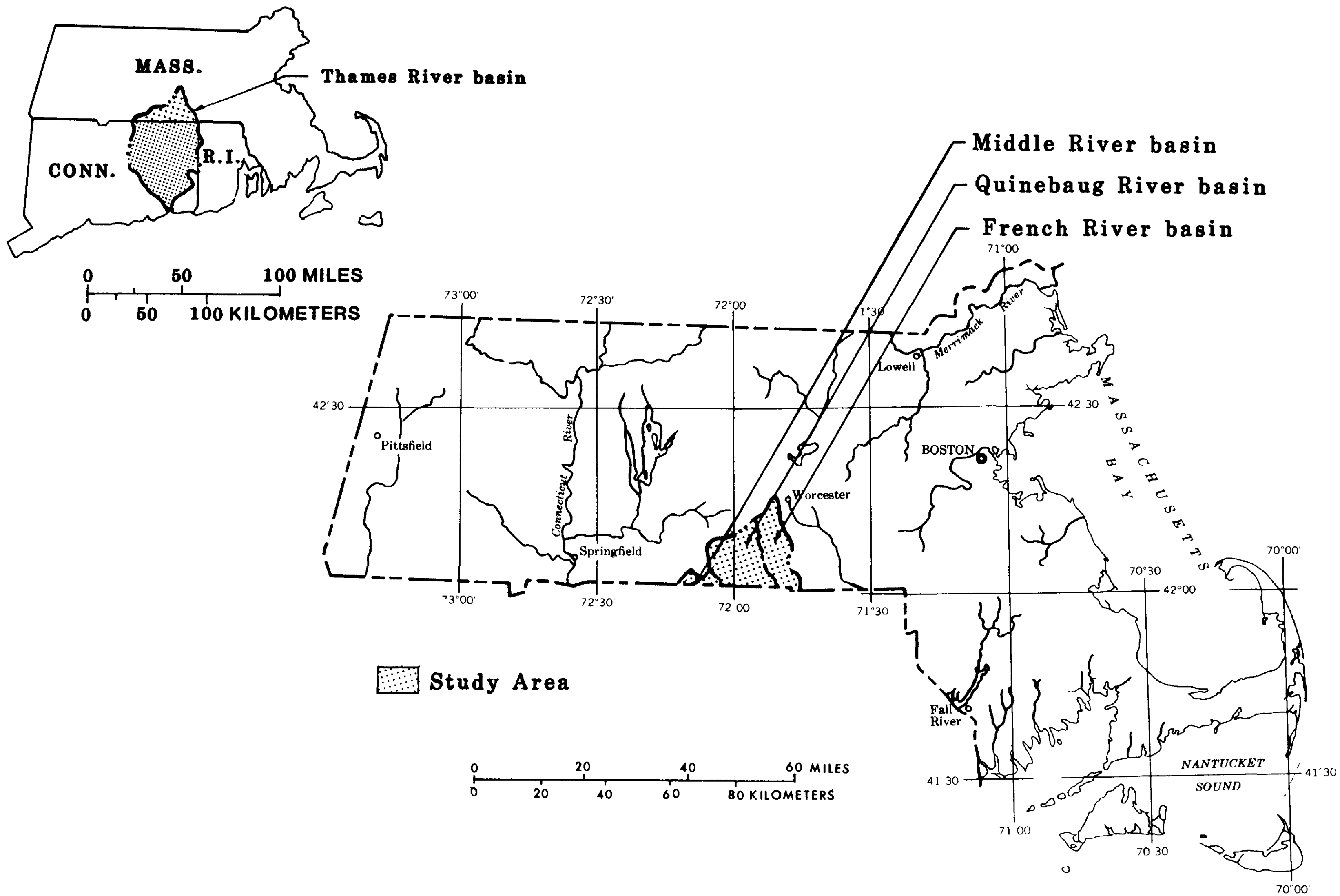


Figure 1.--Location of the Thames River basin

HYDROLOGIC DATA

Hydrologic characteristics are represented by various physical, climatic, and streamflow indices of a river basin. These characteristics can be determined either from available maps by following standardized procedures or from historic streamflow records.

Basin characteristics are indices of the physiography of the basin or of the climate prevailing over the basin and are measured on topographic quadrangle or climatic maps. Streamflow characteristics are computed from continuous records of daily flow or from a set of measurements during the occurrence of a specific event. Streamflow and basin characteristics are used in modeling stream quality, assessing water-resources conditions, analyzing impact of man's activities, and defining relationships to estimate flows or stream-quality parameters at ungaged sites.

Basin Characteristics

Drainage area is one of the most important variables in any hydrologic investigation or in the design of riverine structures because it is the most significant variable in the northeast that influences all streamflow, except perhaps low flow in some regions. The physical boundary for many water-related studies corresponds to the limits for the drainage area upstream from the site.

For this study, drainage areas listed in table 1 (at the end of the report) were determined for the following sites:

1. Survey data-collection sites shown in figure 2. These sites include continuous-record gaging stations given in table 2 (at the end of the report), low-flow partial-record stations, miscellaneous sites, and water-quality stations.

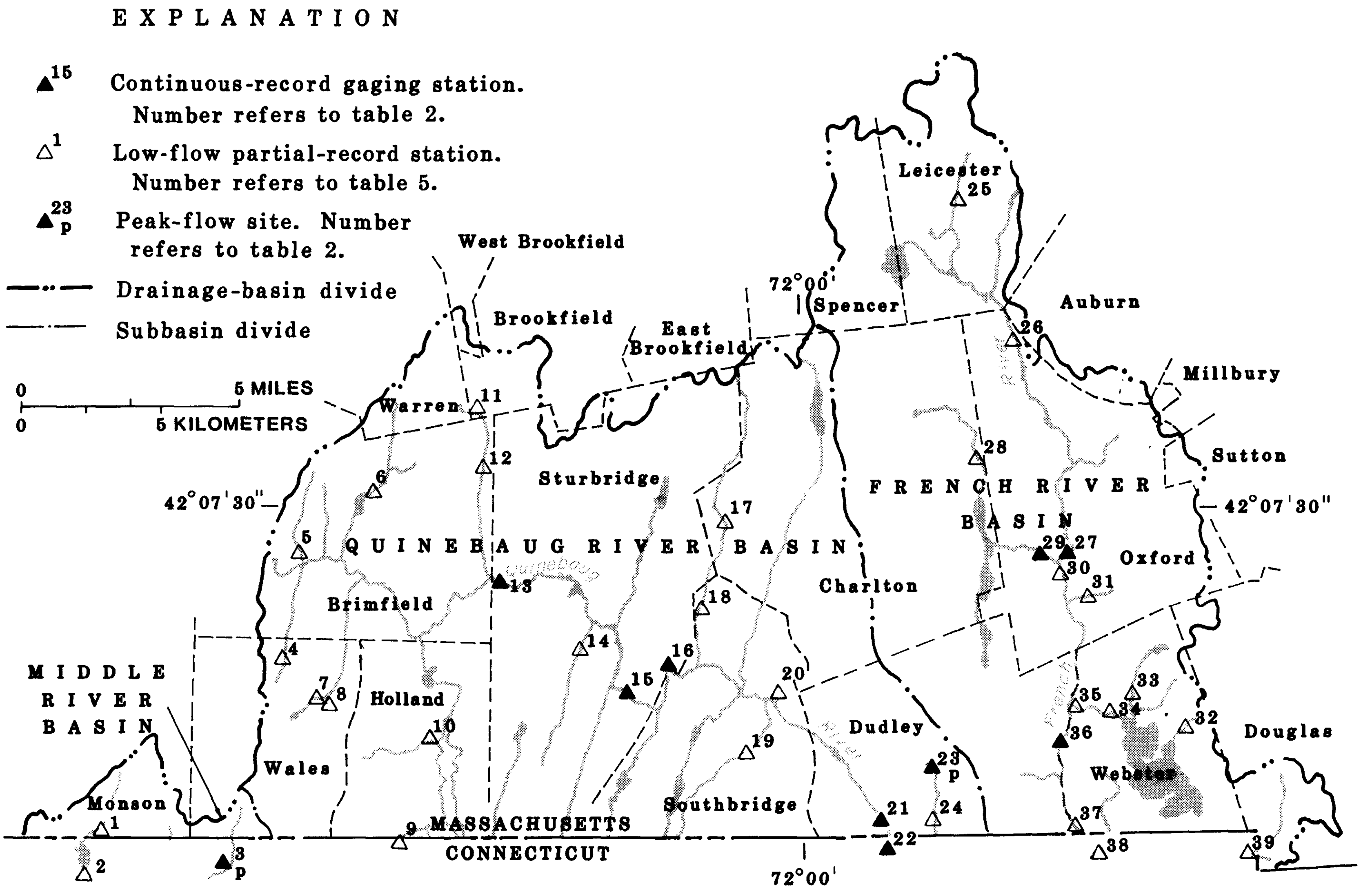
2. Locations where the drainage area is greater than 3 mi^2.

3. Successive sites along a stream where the area between sites is at least 6 mi^2 on tributary streams and 10 mi^2 on the French or Quinebaug River.

The drainage basin divides for these sites were delineated on the latest available 1:24,000 scale topographic quadrangle maps. Subbasin drainage divides are shown in the series of statewide reports, "Drainage Divides, Massachusetts." The Thames River basin is covered by three reports—Blackstone and Thames River basin (Krejmas, 1982), Connecticut River Lowlands and Chicopee River basin (Krejmas and Wandle, 1982), and Nashua and Concord River basins (Brackley and Wandle, 1982).

The subbasin drainage areas given in table 1 are indexed to the Massachusetts stream inventory prepared by the Massachusetts Division of Water Pollution Control and the Massachusetts Division of Fisheries and Wildlife (Halliwell and others, 1982) with some modification. Drainage areas were computed for sites meeting one of the three criteria mentioned above. The entire stream listing is included as a reference for stream order. This hierarchical listing begins at the mouth of a major stream and proceeds upstream with tributary streams indented under the main-stem stream. This order is followed to list all named streams. Unnamed tributaries are included to maintain the hierarchy. The reader is referred to the inventory of rivers and streams report by Halliwell and others (1982) for a more detailed explanation.

The basin characteristics listed below are included because they represent indices that would remain reasonably stable over a planning period. They are useful in predictive surface-water models to assess impacts of proposed developments. The usefulness of these characteristics to explain the variability of various streamflow events has been demonstrated in hydrologic analyses (Thomas and Benson, 1970) and they can be measured readily from available maps. The 14 basin indices given in table 3 (at the end of the report) were computed according to the procedures described below. The indices for elevation, storage, lake area, and forest can be computed by the grid method which is explained after all the procedures are described.



Base from Halliwell and others, 1982

Figure 2.--Location of gaging stations and low-flow partial-record stations in the Thames River basin

1. Drainage area—Area, in square miles, as measured on the most recent 1:24,000 scale topographic quadrangle maps. Drainage area, as defined in the "National Handbook of Recommended Methods for Water-Data Acquisition" (U.S. Geological Survey, 1977), is "...the area of a river basin, measured in a horizontal plane, that is enclosed by a topographic divide such that direct surface runoff from precipitation normally would drain by gravity into the river basin.". Drainage area boundary lines are traced on topographic maps along divides indicated by contour elevations, starting at the point on the stream for which the drainage area is desired. These lines are drawn to cross a contour at right angles. Interpolation between contours may be indicated by reference to trails, old roads, or firebreaks in forested areas, all of which frequently follow drainage divides. Detailed information may also be obtained from highway or street profiles, from examination of aerial photographs, and from ground reconnaissance. Subareas within each quadrangle map were computed with an electronic digitizer using the procedures of the U.S. Federal Inter-Agency River Basin Committee (1951) as a guide. The coefficients to compute square miles from digitizer units were calculated using the known area of each 7.5-minute quadrangle or of the appropriate 2.5-minute quadrilaterals. Drainage areas for the subbasins were computed by summing the contributing areas.
2. Slope--Main-channel slope, in feet per mile, determined from elevations at points 10 percent and 85 percent of the distance along the main channel from the gaging station to the basin divide.
3. Length--Main-channel length, in miles, from the gaging station to the basin divide, as measured with dividers set to 0.1 mile or with a map measurer.
4. Elevation--Mean basin elevation, in feet above sea level, measured on topographic maps by laying a grid over the map.
5. Storage--Area of lakes, ponds, and marshes, in percent of total drainage area, measured by planimetering or by using a transparent grid. The marsh area includes the area of wooded marshes and marshes as defined by the appropriate topographic quadrangle map symbol. Storage area is the total area of all the lakes, ponds, and marshes expressed as a percentage of the total drainage area.
6. Lake area--Area of lakes and ponds, in percent of the drainage area, determined by the grid method.
7. Forest—Area of forest, in percentage of the drainage area, determined from the forest cover as shown on the topographic map with the green woodland overprint using the grid method.
8. Soil--Soil index, in inches, represents the value of potential maximum infiltration, during an annual flood, under average soil-moisture conditions. This characteristic, provided by the U.S. Soil Conservation Service (Dr. Benjamin Isgur, written commun., 1970), is a function of the soil and cover conditions in the basin. The index was computed from the runoff curve number following procedures in U.S. Department of Agriculture (1972).
9. Latitude—Latitude of stream-gaging station, in decimal degrees, determined by manual measurement.
10. Longitude--Longitude of stream-gaging station, in decimal degrees, determined by manual measurement.
11. Precipitation—Mean-annual precipitation, in inches, determined from the isohyetal map in Knox and Nordenson (1955). The variation in mean-annual precipitation is shown in more detail in this map than in more recent sources.
12. Precipitation intensity--Maximum 24-hour rainfall, in inches, having a recurrence interval of 2 years. This characteristic was determined from U.S. Weather Bureau (1959b).
13. Snowfall--Average total seasonal snowfall, in inches, from an isohyetal map in Lautzenheiser (1969).
14. January temperature--Minimum January temperature, in degrees Fahrenheit, determined from U.S. Weather Bureau (1959a).

Several basin characteristics were measured following the grid method by using transparent grids to compute area or an average contour value. Storage area is determined by randomly placing the grid over the water and marsh area and counting squares. If the water and marsh area is large enough (about 30 squares), the number of grid intersections within the storage area are counted. The storage area then is computed as the product of the square size and the number of grid intersections. To measure a contour value such as elevation, the grid spacing is selected to give at least 25 intersections within the basin boundary. The elevation at each grid intersection is determined and an average is computed. The percentage of a variable that is extensive in a drainage basin, such as forest cover, can be easily measured by counting the number of grid intersections occurring over the forested area, multiplying by 100, and dividing by the number of grid intersections within the basin.

Streamflow Characteristics

Historic daily flow records available in the Quinebaug and French River basins were used to compute daily, monthly, and annual flow characteristics. A summary of these records is given in table 2 and the location of streamflow sites is shown in figure 2. These flow data were collected as part of the Survey's nationwide data-collection network through agreements with State and Federal agencies. Records of daily flow are available from the Survey's National Water Data Storage and Retrieval System (WATSTORE). This water-data computer processing system consists of several files containing data grouped by common characteristic and data-collection frequency.

The WATSTORE system includes site identification, daily values files, and computer programs that produce streamflow statistics. Hydrologic-data files are maintained for (1) parameters measured on a daily or continuous basis, such as streamflow values, river stages, water temperatures, specific-conductance values, and ground-water levels; (2) annual peak values for streamflow and stage; (3) chemical analyses for surface- and ground-water sites; and (4) ground-water site inventory, including location, identification and geohydrologic characteristics. The data-processing, storage, retrieval, and analysis capabilities of WATSTORE are described in the system user's guide compiled by Hutchison (1975). Information on the availability of data analyses may be obtained from: U.S. Geological Survey, 150 Causeway Street, Suite 1309, Boston, MA 02114.

A brief description of the streamflow statistics computed using the WATSTORE system is included below. Streamflow characteristics representing annual, monthly, and daily flow statistics were selected for this analysis because they are useful in planning and design studies in this region. The streamflow statistics computed following the procedures given below are listed in table 4 (at the end of the report).

Annual and monthly flow characteristics (means and standard deviations) for seven gaging stations were computed with the "Daily Values Monthly and Annual Statistics" computer program W4422 (Price and Meeks, 1977) using observed daily flow records. The maximum and minimum, monthly means (fig. 3 and table 4) were obtained from output provided by this program. The monthly hydrograph for French River at Webster is shown in figure 3.

Characteristics of the flow-duration curve (the daily flow exceeded 99, 95, 90, 75, 70, 50, 25, and 10 percent of the time) were computed for seven gaging stations by means of computer program A969, "Daily Values Statistics" (Meeks, 1977). An example of a flow-duration curve for Quinebaug River below Westville Dam, near Southbridge is given in figure 4. Low-flow characteristics (annual 7-day mean low flows at the 2-year and 10-year recurrence intervals 7Q2 and 7Q10, respectively) were also calculated for three gaging stations by program A969. In this program, a log-Pearson Type III distribution is fitted to a set of observed annual 7-day mean low flows to obtain coordinates of the computed low-flow frequency curve. If the log-Pearson Type III curve did not adequately fit a plot of the observed data, especially in the low end, then a graphical curve was drawn. The graphical frequency curve was used to interpret the observed data when necessary because a graphical curve is the basic curve to use in analyzing the frequency of annual low flows according to Riggs (1971, 1972). The frequency curve for French River at Webster is shown in figure 5.

Additional flow data, including flood-frequency analyses, are available from WATSTORE. Peak discharges for selected recurrence intervals for 82 sites in Massachusetts are given in Wandle (1982).

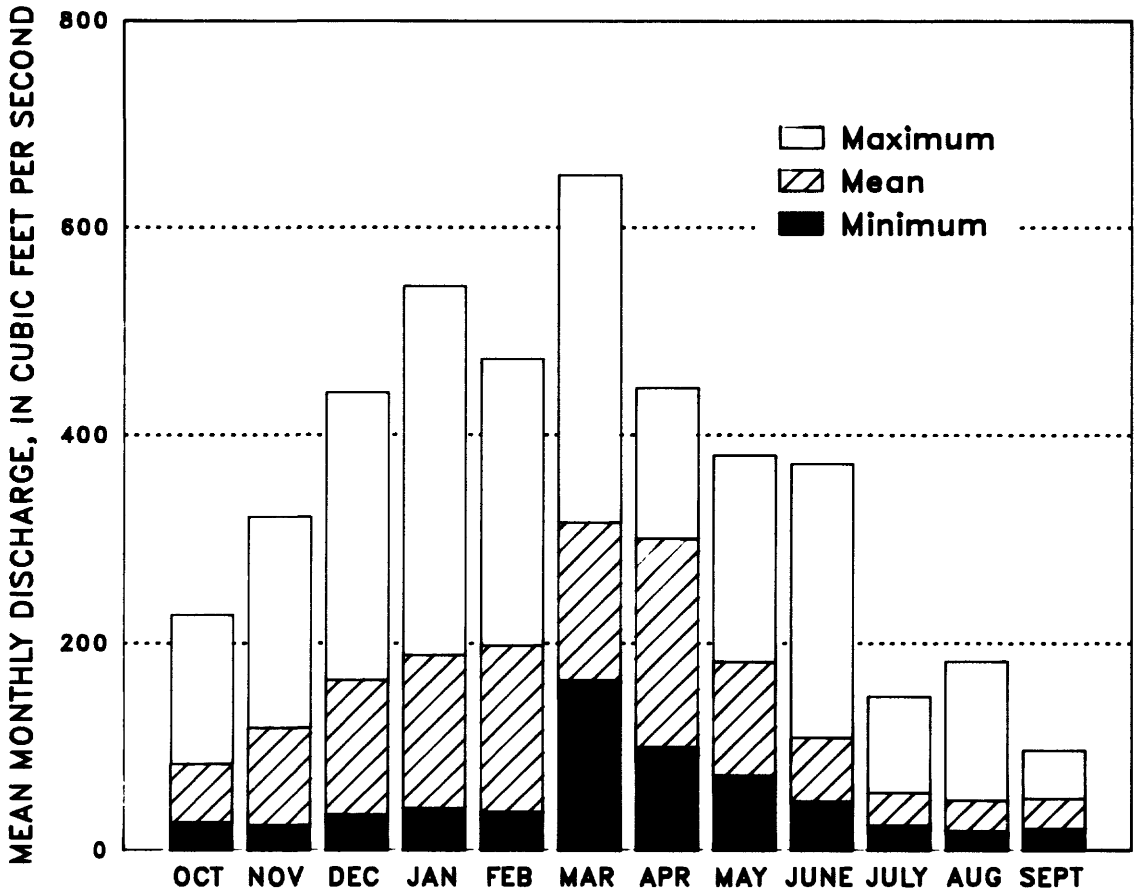


Figure 3.--Monthly discharges and extremes for the French River at Webster, Mass. (site 36), during 1961-80

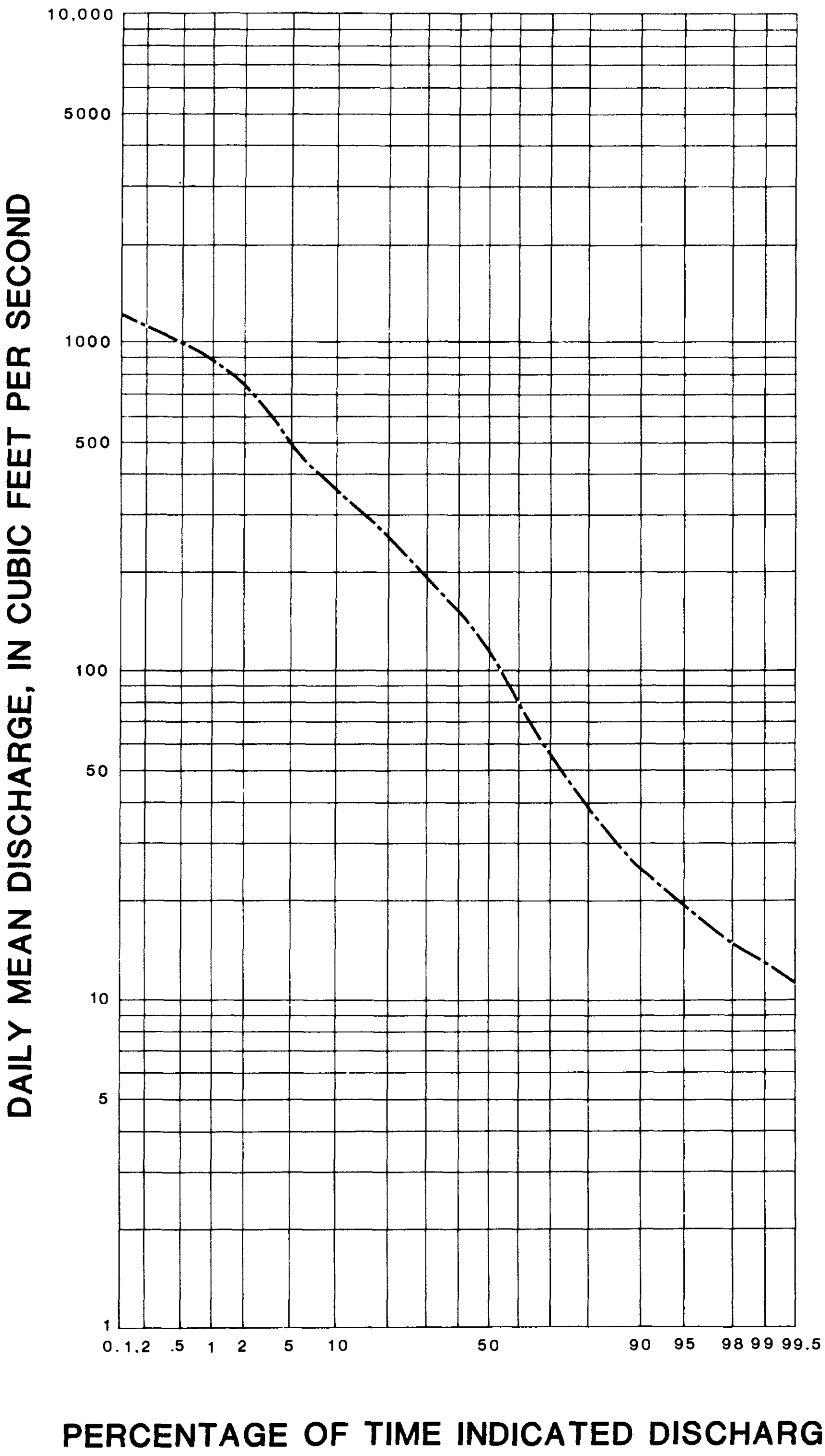


Figure 4.--Flow-duration curve for the Quinebaug River below Westville Dam, near Southbridge, Mass. (site 16), during 1963-80

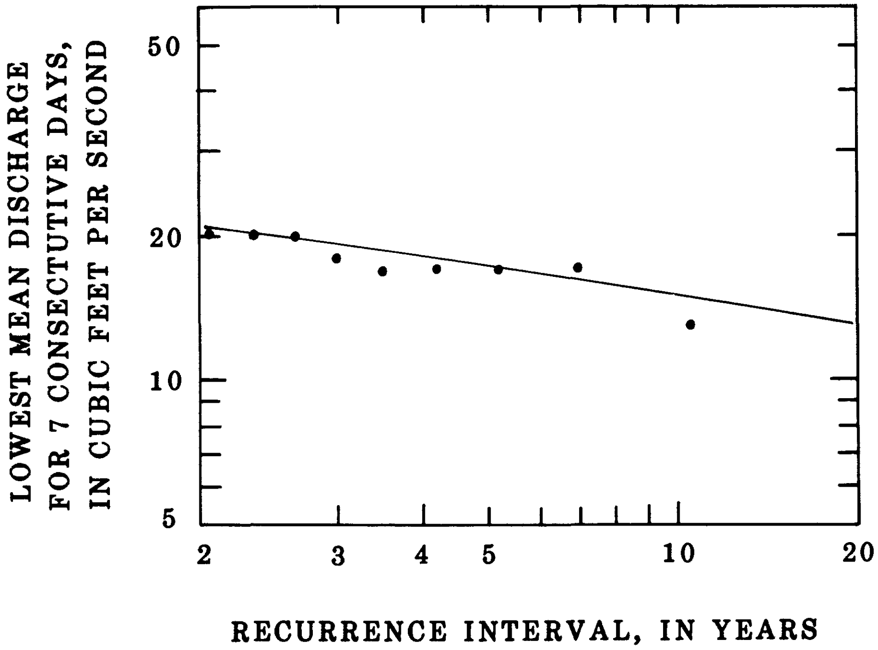


Figure 5.--Low-flow frequency curve for the French River at Webster, Mass. (site 36), during 1961-80

Characteristics of low flow were also determined at low-flow partial-record stations where measurements of discharge, rather than a continuous daily flow record, were available. This estimating technique is briefly described in the section on Streamflow Analysis. The 7-day low-flow statistics were developed from discharge measurements made during periods of base runoff. Base runoff is defined (Langbein and Iseri, 1960) as "the sustained or fair weather runoff. In most streams, base runoff is composed largely of ground-water effluent." Base runoff usually occurs in most Massachusetts streams during the summer or early fall after 5 to 7 consecutive days without rainfall.

STREAMFLOW ANALYSIS

Streamflow Data Base

Systematic records of daily streamflow have been collected since 1932 in the Quinebaug River basin and since 1940 in the French River basin. The location and period of record for these gaging stations are given in table 4. Streams within the Middle River basin are not monitored in Massachusetts. Streamflow records for the Thames River basin in Connecticut, are available from the Survey office in Hartford, Connecticut.

Discharge measurements were made at 20 low-flow partial-record sites during the water-resources investigation of the French and Quinebaug River basins (V. A. Eames, U.S. Geological Survey, written commun., 1984). Measurements were also collected as part of the Massachusetts low-flow network at 10 sites during 1960-62 and 1965-66 and at three sites during 1979-82. Data are available as part of the Connecticut water-resources program in the Middle River and Quinebaug River basin, just south of the state line. Discharge measurements were made for Middle River at Ellithorpe, Delphi Brook near Staffordville, English Neighborhood Brook at North Woodstock, and Muddy Brook at East Woodstock, all of which are in Connecticut.

Flow characteristics are useful in resource management and design studies if these variables represent a particular regulated flow sequence or the natural flow regime that is expected to occur in the future. A valid streamflow analysis is based upon flow records during a period of relatively constant river-basin conditions.

Daily Flow Statistics

Systematic daily flow records from eight sites in the French and Quinebaug River basins were reviewed to select a data base for statistical analysis. Impacts of reservoirs, diversions, regulation, and withdrawals for public supplies were assessed using information on stream regulation found in the series of water-resources data reports issued annually (see U.S. Geological Survey, 1980, for an example) and in Knox and Soule (1949). Streamflow records for seven sites were selected that represent a flow regime influenced by fairly constant river-basin conditions (Wandle, 1983). The record length used in this analysis is given in table 4. Low flow, monthly flow, and flow-duration characteristics given in table 4 were derived from the observed streamflow records at each station and were not adjusted for regulation or diversion. These daily streamflow characteristics were computed following procedures summarized in the section on streamflow characteristics.

Statistics are not included for the Quinebaug River at Westville. These data represent the streamflow prior to the completion of Westville Lake in 1962 and they are not indicative of current conditions.

Low-Flow Statistics

Continuous streamflow records are not necessary to estimate low-flow characteristics at sites. According to Riggs (1972), selected base-flow measurements rather than a continuous daily flow record can define the low-flow characteristics at a site.

Low-flow partial-record stations are operated to collect discharge measurements when streamflow is composed largely of ground-water runoff. These low-flow sites are selected on streams where flow is expected to occur during a significant dry spell and where the flow is not affected by artificial regulation. Base-flow measurements to define a relation with concurrent gaged flows are obtained over several low-flow periods.

A relation is developed with the base-flow measurements and the concurrent daily mean flows at a nearby long-record gaging station (index station). The 7-day low-flow statistics (7Q2 and 7Q10) for the site are determined from this relation using the appropriate low-flow statistics for the gaged stream. This estimating technique is explained in more detail by Riggs (1972).

The 7-day 10 year low-flows for the four sites in Connecticut were computed from a regression equation developed by Cervione and others, 1982. This estimating equation is $7Q10 = 0.67\ A_{sd} + 0.01\ A_{till}$, where A_{sd} is the drainage area, in square miles, underlain by coarse-grained stratified drift; and A_{till} is the drainage area, in square miles, underlain by till-mantled bedrock.

Low-flow statistics for 32 sites in the Thames River basin are summarized in table 5 (at the end of the report). The low-flow statistics are representative of the hydrologic regime during the data-collection period. Seven-day, 2-year, and 10-year low flows ranged from 0 to 0.38 and from 0 to 0.25 $(ft^3/s)/mi^2$, respectively, at these sites. Quaboag River at West Brimfield, Mass., Quinebaug River at Quinebaug, Conn., and Little River near Hanover, Conn., were used as the index stations. These values were computed following the procedures mentioned above.

SUMMARY

Drainage areas were re-computed for data-collection sites and were computed for the first time for ungaged streams draining greater than 3 mi^2. Basin characteristics for drainage area, slope, length, elevation, storage, lake area, forest, soil, latitude, longitude, precipitation, precipitation intensity, snowfall, and January minimum temperature are provided for the seven gaged sites in the Thames River basin. Computer programs A969 and W4422 were used to determine daily flow statistics including annual and monthly flows, duration of daily flows, and 7-day low-flow values. Seven-day, 2-year, and 10-year low flows ranged from 0 to 0.38 and from 0 to 0.25 $(ft^3/s)/mi^2$, respectively, at the 32 partial-record stations.

Techniques used to compute basin and streamflow characteristics of a river basin are summarized. This gazetteer contains a comprehensive listing of hydrologic characteristics that should prove useful to those concerned with water-resources activities.

Table 1.--Stream-order listing, selected drainage areas, and locations of subbasins within the Thames River basin

[Sites with streamflow information listed in tables 2, 4, or 5 are marked with an asterisk. The hierarchical listing is modified from Halliwell and others, 1982. Drainage areas are shown for sites as explained in the section on basin characteristics. These areas are not adjusted for manmade changes in the flow system. Streams entirely in adjacent states are underlined and are included in the list where necessary to maintain the stream order.]

Stream name	Location	Drainage area, in square miles
	THAMES RIVER BASIN	
Thames River (Conn.)--continuation of Shetucket River		
Shetucket River (Conn.)--continuation of Willimantic River		
	QUINEBAUG RIVER BASIN	
Quinebaug River		
Fivemile River (Conn.)		
Rocky Brook	East Thompson Road	*4.97
	FRENCH RIVER BASIN	
French River		
Long Branch Brook	Labby Road	*3.19
Freemans Brook		
French River	Perryville Road	*93.2
Potash Brook		
Unnamed tributary	Low Pond outlet 100 feet downstream from Mill Street	5.76
French River	50 feet upstream from Pleasant Road	*84.0
Mill Brook	Bigelow Road	*10.7
Mill Brook	Lake Chaubunagungamaug outlet	*10.3
Unnamed tributary	100 feet downstream from Club Pond	4.15
Sucker Brook	Mine Brook Road	*2.54
Mine Brook	Mouth	1.03
Sucker Brook	Nipmuc Pond outlet	1.06
Browns Brook	Mouth	1.22
Browns Brook	State Route 16	*.49
French River tributary	Nelson Street	*8.56
Unnamed tributary	Lowes Pond outlet	7.83
Unnamed tributary	Slaters Pond outlet	2.33
Unnamed tributary	Robinson Pond outlet	1.14
French River	Dudley Road	*58.1
Little River	0.6 mile upstream from mouth	*26.0
Little River	Buffum Pond outlet	25.3
Little River	Buffumville Lake outlet	24.5
South Fork	Granite Reservoir outlet	7.80
Unnamed tributary	50 feet downstream from Gore Pond outlet	2.10
Little River	400 feet downstream from Turner Road	10.5

Table 1.--Stream-order listing, selected drainage areas, and locations of subbasins within the Thames River basin (Continued)

Stream name	Location	Drainage area, in square miles
	FRENCH RIVER BASIN (Continued)	
Shetucket River (Conn.) (Continued)		
Quinebaug River (Continued)		
French River (Continued		
Little River	U.S. Route 20	*8.58
French River	240 feet downstream from Hodges Village Dam	*31.2
French River	Hodges Village Dam outlet	31.2
Wellington Brook		
French River	Pond outlet, 1.2 miles upstream from McIntyre Road	24.2
French River	U.S. Route 20	22.3
French River	Cominsville Road	*20.0
Grindstone Brook		
Town Meadow Brook		
Burncoat Brook		
Unnamed tributary	Cedar Meadow Pond outlet	3.28
Unnamed tributary	Sargent Pond outlet	2.78
Bartons Brook	Greenville Pond outlet	8.24
Unnamed tributary	Stiles Reservoir outlet	4.64
Unnamed tributary	Inlet to Stiles Reservoir 0.15 mile upstream from mouth	*2.40
	QUINEBAUG RIVER BASIN	
Quinebaug River		
Tufts Branch	Mouth	4.20
Tufts Branch	State Route 197	*2.40
Tufts Branch	Dudley Southbridge Road	*1.10
Quinebaug River	500 feet upstream from State Route 197	*156
Quinebaug River	State Route 131	*156
Lebanon Brook	Dam 0.15 mile upstream from mouth	10.2
Lebanon Brook	State Route 169	*9.66
Lebanon Brook	Upper unnamed pond outlet	7.12
Quinebaug River trib. no. 2	Road to treatment plant	*9.40
Unnamed tributary	Mouth	4.18
Unnamed tributary	Wells Pond outlet	3.15
Cohasse Brook	Cohasse Brook Reservoir inlet	1.75
Cady Brook	Mouth	11.6
Cady Brook	1.2 miles upstream from mouth	11.3
Unnamed tributary	Sibley Ponds(lower) outlet	2.95
Unnamed tributary	Sibley Ponds(upper) 100 feet downstream from outlet	1.84
Pratt Brook		
Mc Kinstry Brook	Mouth	8.04
Mc Kinstry Brook	Plimpton Street	*7.69
Mc Kinstry Brook	Hill Road	*3.60

Table 1.—Stream-order listing, selected drainage areas, and locations of subbasins within the Thames River basin (Continued)

Stream name	Location	Drainage area, in square miles
	QUINEBAUG RIVER BASIN (Continued)	
Shetucket River (Conn.) (Continued)		
Quinebaug River	200 feet downstream from Westville Dam	*99.0
Quinebaug River	Westville Reservoir outlet	99.0
Hatchet Brook	Mouth	3.94
Quinebaug River	0.45 mile downstream from Breakneck Brook	*93.6
Breakneck Brook	Mouth	4.39
Breakneck Brook	Breakneck Pond outlet	1.67
Unnamed tributary	Mouth	.89
Hobbs Brook	Mouth	7.26
Hobbs Brook	Walker Pond outlet	3.82
Hamant Brook	800 feet upstream from unnamed pond	*3.37
Unnamed tributary	Cedar Pond outlet	3.44
Quinebaug River	Leadmine Road	71.2
Quinebaug River	750 feet downstream from East Brimfield Dam	*67.4
Quinebaug River	East Brimfield Lake outlet	67.4
Quinebaug River tributary		
Unnamed tributary	Alum Pond outlet	.95
Quinebaug River tributary	Sturbridge Road	*5.32
Quinebaug River tributary	Brookfield Road	*2.09
Mill Brook	Mouth	14.2
Wales Brook	Mouth	6.57
Wales Brook tributary	Holland Road	*.73
Wales Brook	0.3 mile downstream from Holland Road	3.83
Wales Brook	Holland Road	*3.64
Wales Brook	Laurel Hill Road	2.21
Wales Brook	Lake George outlet	1.50
Unnamed tributary	Mouth	4.20
East Brook	Bridge 400 feet upstream from Sherman Pond	*2.30
Sessions Brook	Mouth	1.90
West Brook	Mouth	1.41
Mountain Brook	U.S. Route 20	*1.40
Charles Brook	Mouth	.94
Hollow Brook	Mouth	3.26
Hollow Brook	Hollow Road	*.80
Quinebaug River	East Brimfield Road	25.2
Quinebaug River	Hamilton Reservoir outlet	22.8
Stevens Brook	Mashapaug Road	*4.40
Browns Brook	Mouth at Hamilton Reservoir	3.02
Browns Brook	Below May Brook	1.86
May Brook	800 feet south of State Line	*3.02
Leadmine Brook	Mouth	3.06
Leadmine Brook	Leadmine Pond outlet	.88
Wells Brook (Conn.)	Mouth	*2.06a

Table 1.--Stream-order listing, selected drainage areas, and locations of subbasins within the Thames River basin (Continued)

Stream name	Location	Drainage area, in square miles
QUINEBAUG RIVER BASIN (Continued)		
Willimantic River (Conn.)--continuation of Middle River		
MIDDLE RIVER BASIN		
Middle River (Conn.)		
Crow Hill Brook		
Middle River (Conn.)	State Route 32	*[1] 6.46
Sawmill Brook	State Line Pond inlet	2.84
Sawmill Brook	Stafford Hollow Road	*1.49
Alden Brook		
Potash Brook		
Delphi Brook	Mouth	3.37
Delphi Brook	State Route 19	*[1] 2.59

[1] From Thomas, 1972.
a Drainage basin is outside of Massachusetts.

Table 2.--Summary of daily flow records and peak-flow records available in the Thames River basin

Number in figure 2	Station number	Station name	Location	Period of record	Remarks
3	01119255	Delphi Brook near Staffordville, Conn.	State Route 19	1964-76	Peak-flow site discontinued.
8	01123160	Wales Brook tributary near Wales, Mass.	Holland Road	1964-80	Peak-flow site.
13	01123360	Quinebaug River below Brimfield Dam, at Fiskdale, Mass.	750 feet upstream from East Brimfield	1973-80	Regulated by East Brimfield Lake.
15	01123500	Quinebaug River at Westville, Mass.	0.45 mile downstream from Breakneck Brook	1940-62	Regulated by mills and by East Brimfield Lake since 1960. Backwater from Westville Lake since 1962.
16	01123600	Quinebaug River below Westville Dam, near Southbridge, Mass.	200 feet downstream from Westville Dam	1963-80	Regulated by East Brimfield and Westville Lakes and other reservoirs.
21	01123990	Quinebaug River near Dudley, Mass.	State Route 131	1969-80	Water-quality monitor.
22	01124000	Quinebaug River at Quinebaug, Conn.	500 feet upstream from State Route 197	1932-80	Regulated by East Brimfield Lake since 1960 and by Westville Lake since 1962.
23	01124050	Tufts Branch at Dudley, Mass.	Dudley Southbridge Road	1963-80	Peak-flow site.
27	01124350	French River below Hodges Village Dam, at Hodges Village, Mass.	240 feet downstream from Hodges Village	1963-80	Regulated by Hodges River Reservoir.
29	01124500	Little River near Oxford, Mass.	0.6 mile upstream from mouth	1940-80	Regulated by Buffumville Lake since 1958, by other reservoirs, and by mill prior to 1958.
32	01124750	Browns Brook near Webster, Mass.	State Route 16	1963-77	Discontinued.
36	01125000	French River at Webster, Mass.	50 feet upstream from Pleasant Street	1950-80	Regulated by mills, by Lake Chaubunagungamaug, by Buffumville Lake since 1958, by Hodges Village Reservoir since 1960, and by smaller reservoirs.

Table 3.—Basin characteristics for stream-gaging stations in the Thames River basin

Basin characteristics	Station name and site number					
	Delphi Brook near Staffordsville, Conn. (3)	Wales Brook tributary near Wales, Mass. (8)	Quinebaug River below East Brimfield Dam, at Fiskdale, Mass. (13)	Quinebaug River at Westville, Mass. (15)	Quinebaug River below Westville Dam, near Southbridge, Mass. (16)	Quinebaug River at Quinebaug, Conn. (22)
Area, in square miles	[1]2.59	0.73	67.4	93.6	99.0	156
Slope, in feet per mile	67.7	179	—	8.98	—	13.2
Length, in miles	2.6	1.2	—	17.1	—	29.0
Elevation, in feet	1,020	930	—	820	—	800
Storage, in percent	.0	.2	—	3.66	—	3.3
Lake area, in percent	.0	.2	—	2.42	—	2.0
Forest, in percent	87	93	—	86	—	—
Soils index, in inches	—	5.2	—	5.2	—	4.74
Latitude of gage, in decimal degrees	42.0230	42.0800	42.1086	42.0700	42.0828	42.0220
Longitude of gage, in decimal degrees	72.2480	72.1975	72.1242	72.0700	72.0575	71.9560
Precipitation, in inches	45	46	—	46	—	46
Precipitation intensity for 2-year recurrence interval, in inches	2.45	3.30	—	3.20	—	2.50
Snowfall, in inches	—	55	—	52	—	65
January minimum temperature, in degrees Fahrenheit	14	14	—	15	—	13

Table 3.--Basin characteristics for stream-gaging stations in the Thames River basin (Continued)

Basin characteristics	Station name and site number				
	Tufts Branch at Dudley, Mass. (23)	French River below Hodges Village Dam, at Hodges Village, Mass. (27)	Little River near Oxford, Mass. (29)	Browns Brook near Webster, Mass. (32)	French River at Webster, Mass. (36)
Area, in square miles	1.10	31.2	26.0	0.49	84.0
Slope, in feet per mile	169	—	56.8	182	—
Length, in miles	1.1	—	9.6	.99	—
Elevation, in feet	690	—	744	780	—
Storage, in percent	1.7	—	—	2.19	—
Lake area, in percent	.0	—	3.94	.15	—
Forest, in percent	55	—	82	94	—
Soils index, in inches	4.6	—	4.6	5.2	—
Latitude of gage, in decimal degrees	42.0531	42.1183	42.1158	42.0567	42.0508
Longitude of gage, in decimal degrees	71.9394	71.8817	71.8906	71.8308	71.8856
Precipitation, in inches	42	—	43	42	—
Precipitation intensity for 2-year recurrence interval, in inches	3.30	—	2.4	3.50	—
Snowfall, in inches	50	—	55	50	—
January minimum temperature, in degrees Fahrenheit	15	—	7	16	—

[1] From Thomas, 1972.

Table 4.--Streamflow characteristics, in cubic feet per second, at selected stream-gaging stations

Annual and monthly flow characteristics:

QA is the mean annual discharge
SDQA is the standard deviation of mean annual discharge
QM is the mean discharge for M calendar month, M = 1 for January where the top line is the maximum mean; the middle line is the mean; the bottom line is the minimum mean.
SDQM is the standard deviation of mean discharge for M calendar month

Low-flow characteristics:

7Q2 is the annual minimum 7-day mean discharge for 2-year recurrence interval
7Q10 is the annual minimum 7-day mean discharge for 10-year recurrence interval

Flow-duration characteristics:

DPT is the daily discharge, exceeded PT percent of the time, from the flow-duration curve

Years of record:

YRSDAY is the number of years of daily flow record for this analysis
YRSLOW is the number of years of low-flow record for this analysis

Flow	Station name and site number						
	Quinebaug River below Brimfield Dam, at Fiskdale, Mass. (13)	Quinebaug River below Westville Dam, near Southbridge, Mass. (16)	Quinebaug River at Quinebaug, Conn. (22)	French River below Hodges Village Dam, at Hodges Village, Mass. (27)	Little River near Oxford, Mass. (29)	Browns Brook near Webster, Mass. (32)	French River at Webster, Mass. (36)
ANNUAL							
QA	136	168	260	54.6	48.2	1.11	151
SDQA	22.6	49.6	73.9	18.2	13.9	.28	45.2
MONTHLY							
Q10	241 123 53.4	351 109 17.1	495 160 29.2	102 33.8 7.36	80.2 26.1 1.97	1.58 .35 .02	228 84.0 26.5
SDQ10	68.4	89.9	136	29.7	20.1	.45	61.1
Q11	226 112 27.3	330 117 24.4	503 199 40.4	126 47.8 7.04	96.0 37.9 3.90	2.41 1.06 .03	322 119 24.0
SDQ11	72.4	86.7	141	36.1	28.5	.73	85.0
Q12	312 185 46.6	488 200 47.6	738 319 81.4	161 63.9 9.17	124 52.9 11.5	3.42 1.64 .20	442 165 33.9
SDQ12	98.5	135	202	42.4	34.4	.92	109

Table 4.--Streamflow characteristics, in cubic feet per second, at selected stream-gaging stations (Continued)

Flow	Quinebaug River below Brimfield Dam, at Fiskdale, Mass. (13)	Quinebaug River below Westville Dam, near Southbridge, Mass. (16)	Quinebaug River at Quinebaug, Conn. (22)	French River below Hodges Village Dam, at Hodges Village, Mass. (27)	Little River near Oxford, Mass. (29)	Browns Brook near Webster, Mass. (32)	French River at Webster, Mass. (36)
MONTHLY (Continued)							
Q1	371	517	1028	157	154	2.94	544
	217	216	351	68.4	58.9	1.37	189
	40.4	47.9	79	8.90	14.4	.45	39.9
SDQ1	103	141	252	48.6	39.3	.78	133
Q2	308	548	845	171	143	3.24	474
	176	222	334	71.2	62.5	1.47	198
	46.2	62.8	83.0	10.0	13.7	.52	36.7
SDQ2	96.3	140	200	48.2	35.8	.64	120
Q3	361	615	1086	259	195	5.03	651
	255	342	552	117	103	2.51	316
	202	201	317	52.9	55.3	1.25	164
SDQ3	66.5	106	195	50.8	34.4	1.12	115
Q4	252	489	736	167	151	6.44	446
	218	329	493	106	106	2.08	300
	151	126	186	37.6	33.5	.83	99.6
SDQ4	39.7	99.2	150	33.3	30.3	1.40	89.0
Q5	180	349	519	120	112	2.75	381
	141	201	301	63	56.8	1.46	182
	97.4	83.1	135	24.5	25.7	.71	72.3
SDQ5	29.1	67.7	109	26.9	22.0	.58	75.4
Q6	95.4	391	543	145	102	2.52	373
	64.2	122	176	34.8	32.0	.85	109
	43.8	33.7	46	9.88	9.19	.27	46.8
SDQ6	16.9	94.9	138	34.2	23.2	.64	80.2
Q7	85.5	150	211	60.7	67.3	.93	149
	40.3	58.1	85.2	17.6	16.2	.30	55.8
	23.9	12.8	21.7	7.33	2.62	.06	23.8
SDQ7	19.3	38.3	59.8	14.8	17.2	.29	39.9

Table 4.--Streamflow characteristics, in cubic feet per second, at selected stream-gaging stations (Continued)

Flow	Station name and site number						
	Quinebaug River below Brimfield Dam, at Fiskdale, Mass. (13)	Quinebaug River below Westville Dam, near Southbridge, Mass. (16)	Quinebaug River at Quinebaug, Conn. (22)	French River below Hodges Village Dam, at Hodges Village, Mass. (27)	Little River near Oxford, Mass. (29)	Browns Brook near Webster, Mass. (32)	French River at Webster, Mass. (36)
MONTHLY (Continued)							
Q8	97.6	139	259	31.5	55.4	.28	183
	47.0	50.1	70.2	14.0	11.8	.09	47.9
	9.3	16.0	18.1	6.55	1.88	.00	18.3
SDQ8	31.0	37.1	62.2	8.17	13.0	.08	37.5
Q9	122	180	206	48.1	49.2	.31	97.2
	55.5	56.5	79.1	18.8	14.7	.11	50.1
	14.6	16.5	22.9	2.90	1.65	.00	20.5
SDQ9	39.1	46.6	59.0	12.7	11.6	.10	22.7
LOW FLOW							
7Q2	—	—	24.8	—	—	.0	20.9
7Q10	—	—	13.7	—	—	.0	14.8
FLOW-DURATION							
D99	9.0	12.5	17.9	3.8	1.6	.00	7.6
D95	16.2	19.0	25.6	5.9	2.6	.01	21.1
D90	22.3	24.6	33.0	7.3	4.4	.04	26.7
D75	41.1	46.4	67.0	13.0	12.3	.17	43.9
D70	50.3	56.0	82.5	15.6	15.2	.26	51.9
D50	106	116	175	34.2	31.2	.76	101
D25	187	228	352	71.8	64.2	1.6	200
D10	275	372	609	128	117	2.6	345
YEARS							
YRSDAY	8	18	18	19	22	15	20
YRSLOW	—	—	17	—	—	14	20

Table 5.--Summary of 7-day low-flow characteristics, drainage area, and period of record for low-flow partial-record stations

Number in figure 2	Station number	Station name	Location	Period of record	Drainage area, in square miles	Estimated annual minimum 7-day mean low flow, in cubic feet per second, at indicated recurrence interval	
						2-year	10-year
			MIDDLE RIVER BASIN				
1	01119100	Sawmill Brook near South Monson, Mass.	Stafford Hollow Road	1980-82	1.49	0.2	0.1
2	01119150	Middle River at Ellithorpe, Conn.	State Route 32	1962-64	[1]6.46	—	*.7
3	01119255	Delphi Brook near Staffordville, Conn.	State Route 19	1962-75	[1]2.59	—	*.03
			QUINEBAUG RIVER BASIN				
4	01123090	Hollow Brook near Wales, Mass.	Hollow Road	1980-82	.80	.3	.2
5	01123100	Mountain Brook at Brimfield, Mass.	U.S. Route 20	1960-62, 1965-66, 1980-81	1.40	<.1	.0
6	01123150	East Brook near Brimfield, Mass.	Bridge 400 feet upstream from Sherman Pond	1960-62, 1965-66, 1980-82	2.30	.2	.0
7	01123158	Wales Brook at Holland Road near Wales, Mass.	Holland Road	1980-82	3.64	.5	.3
8	01123160	Wales Brook tributary near Wales, Mass.	Holland Road	1965-66, 1980-82	.73	<.1	<.1
9	01123190	May Brook near Union, Conn.	800 feet south of State line	1980-82	3.02	<.1	<.1
10	01123200	Stevens Brook at Holland, Mass.	Mashapaug Road	1960-62, 1965-66, 1979-82	4.40	.3	<.1
11	01123250	Quinebaug River tributary near Brookfield, Mass.	Brookfield Road	1960-62, 1965-66, 1980-82	2.09	<.1	<.1
12	01123300	Quinebaug River tributary near Fiskdale, Mass.	Sturbridge Road	1960-62, 1965-66, 1980-82	5.32	.2	<.1

Table 5.--Summary of 7-day low-flow characteristics, drainage area, and period of record for low-flow partial-record stations (Continued)

Number in figure 2	Station number	Station name	Location	Period of record	Drainage area, in square miles	Estimated annual minimum 7-day mean low flow, in cubic feet per second, at indicated recurrence interval: 2-year	10-year
		QUINEBAUG RIVER BASIN (Continued)					
14	01123450	Hamant Brook near Sturbridge, Mass.	800 feet upstream from unnamed pond	1960-62, 1965-66	3.37	--	--
17	01123695	McKinstry Brook near Charlton City, Mass.	Hill Road	1980-82	3.60	0.0	0.0
18	01123700	McKinstry Brook at Southbridge, Mass.	Plimpton Street	1960-62, 1965-66, 1980-81	7.69	.1	<.1
19	01123800	Lebanon Brook near Southbridge, Mass.	State Route 169	1960-62, 1965-66, 1980-82	9.66	.4	.2
20	01123810	Quinebaug River tributary no. 2 at Sandersdale, Mass.	Road to treatment plant	1980-82	9.40	.2	<.1
24	01124100	Tufts Branch near Dudley, Mass.	State Route 197	1960-62, 1965-66, 1980-82	2.40	<.1	.0
		FRENCH RIVER BASIN					
25	01124250	Town Meadow Brook at Leicester, Mass.	Sargent Pond outlet	1937	--	--	--
26	01124285	French River at Oxford, Mass.	Cominsville Road	1980-82	20.0	2.0	.6
28	01124390	Little River at Richardson Corners, Mass.	U.S. Route 20	1980-82	8.58	1.1	.6
30	01124505	French River at Oxford, Mass.	Dudley Road	1937	58.1	--	--
31	01124515	French River tributary at West Oxford, Mass.	Nelson Street	1980-82	8.56	2.0	1.0
32	01124750	[2]Browns Brook near Webster, Mass.	State Route 16	1963-82	.49	.0	.0

Table 5.—Summary of 7-day low-flow characteristics, drainage area, and period of record for low-flow partial-record stations (Continued)

Number in figure 2	Station number	Station name	Location	Period of record	Drainage area, in square miles	Estimated annual minimum 7-day mean low flow, in cubic feet per second, at indicated recurrence interval	
						2-year	10-year
		FRENCH RIVER BASIN (Continued)					
33	01124800	Sucker Brook near Webster, Mass.	Mine Brook Road	1960-62, 1965-66, 1979-82	2.54	0.1	<0.1
34	01124900	Mill Brook at Webster, Mass.	Lake Chaubuna-gungamaug outlet	1936-37	10.3	—	—
35	01124910	Mill Brook near Webster, Mass.	Bigelow Road	1980-81	10.7	1.9	1.2
37	01125010	French River at Perryville, Mass.	Perryville Road	1913, 1937	93.2	—	—
38	01125020	Long Branch Brook at Wilsonville, Conn.	Labby Road	1980, 1982	3.19	.2	.0
		QUINEBAUG RIVER BASIN (Continued)					
39	01125780	Rocky Brook at East Thompson, Conn.	East Thompson Road	1980-82	4.97	.7	.4
—	01125300	English Neighbor-hood Brook at North Woodstock, Conn.	State Route 93	1960-81	[1]4.66	—	*.07
—	01125400	Muddy Brook at East Woodstock, Conn.	Main Street	1961-81	[1]13.1	—	*.44

*Calculated from equation developed by Cervione and others, 1982.
[1] From Thomas, 1972.
[2] Recording gage, see table 2.

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