PREPARED IN COOPERATION WITH THE
COMMONWEALTH OF MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
DIVISION OF WATER RESOURCES
BOSTON, MASSACHUSETTS

STREAMFLOW-GAGING STATIONS

The U.S. Geological Survey operates streamflow-gaging stations to measure streamflow (table 1). These stations provide data required to describe runoff characteristics in the basins such as high flow, low flow, and flow duration. Locations of these streamflow-gaging stations are shown in figure 5.

HIGH FLOW

A combination of large amounts of rainfall, the steep slope of the river channels, pronounced topographic relief, and low permeability of most of the surficial deposits in the Westfield and Farmington River basins has led to considerable and frequent flooding in the basins. The five greatest floods of record occurred (in descending order of magnitude) August 1955, September 1938, March 1936, November 1927, and December 1948. Flood profiles and high-water marks for the Westfield River and its major tributaries and the West Branch Farmington River have been published for the 1955 flood (Bogart, 1960) and the 1936 flood (Grover, 1937).

Most of the great floods resulted from excessive rainfall, runoff from snowmelt, or a combination of both. The steep slope of the rivers in the upper reaches contributes to high-velocity floodflows. Channel-slope profiles of the West Branch Farmington River, West Branch Westfield River, and Westfield River are shown in figure 6.

As can be seen on the maps on sheets 1 and 2 (fig. 2), very little stratified drift exists in the river basins except along the lower reaches of the Westfield and Little Rivers in Westfield. Because the infiltration of precipitation into the soils is low and there are few surface-water reservoirs in the basins, a very high percentage of the rainfall runs off. This occurs not only during extremely high flow events like the August 1955 flood, but also during lesser events like those of May-June 1984, as shown in figure 7.

It can be seen in figure 7 that the Westfield River near the City of Westfield has a lower percentage of runoff from rainfall than do the other two sites. This lower runoff:rainfall ratio is attributed to relatively lower channel slope and average basin slope, larger amounts of stratified drift, and large flood plain in the lower reach of the river near the City of Westfield. The flood control that exists in the upper reaches also reduces the runoff:rainfall ratio to some extent.

Considerable flood control is provided in the basins by multipurpose lakes and reservoirs. A listing of these is shown in table 2. The West Branch Westfield River is the only totally uncontrolled large river in the Westfield River basin. The West Branch Farmington River is only partially controlled by Otis Reservoir on Fall River, in Massachusetts, but is more fully controlled just beyond the State line by Colebrook River Reservoir in Connecticut.

Probability curves of maximum annual peak discharges and highest average discharges for the indicated number of consecutive days for various streamflow-gaging stations are shown in figure 8. These flood-frequency curves are useful for flood-inundation and flood-control reservoir-capacity studies. The following examples demonstrate use of probability curves for the Valley Brook gaging station (fig. 8G).

Example No. 1: The probability that the highest average discharge for 15 consecutive days of a water year would exceed 100 ft³/s (cubic feet per second) is 20 percent.

Example No. 2: There is a 2-percent chance during any water year that the discharge for the three highest consecutive days will exceed 700 ft³/s.

Flood-insurance studies showing the existence and severity of flood hazards have been published by the Federal Emergency Management Agency for most of the communities in the basin. These studies show the peak discharges, areas of flood inundation, and elevations of the 100-year and 500-year floods for major streams.

Flood information is essential to the economic design of flood-control and riverine structures. Equations for estimating the magnitude and frequency of floods in west-central Massachusetts have been developed by Wandle (1983). The equations apply to ungaged sites where floodflows are unregulated and are within the extremes of the available data for drainage areas of 0.27 mi² to 162 mi². They do not apply to sites where floodflows are significantly affected by diversion, urbanization, and regulation, or where the usable manmade storage is more than 4.5 Mft³/mi² (million cubic feet per square mile) of drainage area above the site. Additional explanation and examples of how to determine flood-frequency estimates are given in Wandle (1983).

The following equations provide estimates of annual peak discharges corresponding to the 0.5, 0.2, 0.1, 0.04, 0.02, and 0.01 annual exceedance probabilities.

	Average standard error (percent)
$Q_{0.5} = 0.933A^{0.990}Sl^{0.198}E^{0.429}$	27
$Q_{0.2} = 1.05A^{0.980}Sl^{0.179}E^{0.469}$	28
$Q_{0.1} = 1.23A^{0.970}Sl^{0.187}E^{0.490}$	31
$Q_{0.04} = 1.31A^{0.969}Sl^{0.200}E^{0.503}$	36
$Q_{0.02} = 1.41A^{0.970}Sl^{0.201}E^{0.522}$	40
$Q_{0.01} = 1.51A^{0.971}Sl^{0.203}E^{0.543}$	45

in which,
Q_t is the peak discharge, in cubic feet per second, for the specified exceedance probability, t (0.5, 0.2, 0.1, 0.04, 0.02, 0.01);
A is the drainage area, in square miles,
Sl is the main-channel slope, in feet per mile, and
E is the mean basin elevation, in feet.

Regression equations for determining the magnitude and frequency of urban floods were developed by Sauer and others (1983). These equations may be applied to the urbanized, ungaged areas of Westfield, West Springfield, and Agawam. The equations use flood-frequency estimates from equations developed by Wandle (1983) in conjunction with topographic and climatic characteristics, land-use variables, and indices of urbanization.

TABLE 1.—Streamflow-gaging stations
[—, no regulation; mi², square miles; ft³/s, cubic feet per second]

Stream and location	Drainage area (mi²)	Period of record	Regulation structure and year completed	Maximum discharge before regulation (ft³/s)	Maximum discharge since regulation (ft³/s)	Average discharge before regulation (ft³/s)	Average discharge since regulation (ft³/s)
Westfield River at Knightville	161	August 1909–September 1986	Knightville Dam 1941	37,900 Sept. 21, 1938	6,660 March 21, 1945	323	335 (through Sept. 1984)
Sykes Brook at Knightville	1.73	June 1945–July 1974	—	680 August 19, 1955	—	2.58	—
Middle Branch Westfield River at Goss Heights	52.7	July 1910–September 1986	Littleville Dam 1965	19,900 Sept. 21, 1938	1,670 March 26, 1980	103	112 (through Sept. 1984)
Walker Brook near Becket Center	2.94	November 1962–September 1977	—	499 August 10, 1976	—	6.67	—
West Branch Westfield River at Huntington	94.0	September 1935–September 1986	—	26,100 August 19, 1955	—	192 (through Sept. 1984)	—
Great Brook near Westfield	22.6	November 1972–September 1982	—	1,930 June 6, 1982	—	35.8	—
Westfield River near Westfield	497	June 1914–September 1986	Cobble Mountain–Borden Brook Dams, 1931; Knightville Dam, and Littleville Dam	42,500 November 4, 1927	70,300 August 19, 1955	885	942 (through Sept. 1984)
Fall River below Otis Res., near Otis	16.5	August 1969–September 1982	Otis Dam 1865	—	422 July 2, 1977	—	37.7
West Branch Farmington River near New Boston	91.7	May 1913–September 1986	Otis Dam	—	34,300 August 19, 1955	—	184 (through Sept. 1984)
Hubbard River near West Hartland, Connecticut	20.8	January 1938–September 1955, September 1956–September 1986	—	10,500 August 19, 1955	—	39.9 (through Sept. 1984)	—
Valley Brook near West Hartland, Connecticut	7.39	February 1940–September 1972	—	5,400 August 19, 1955	—	14.1	—

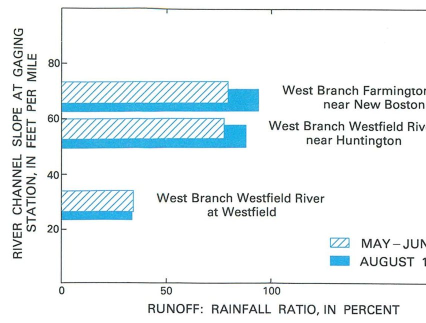
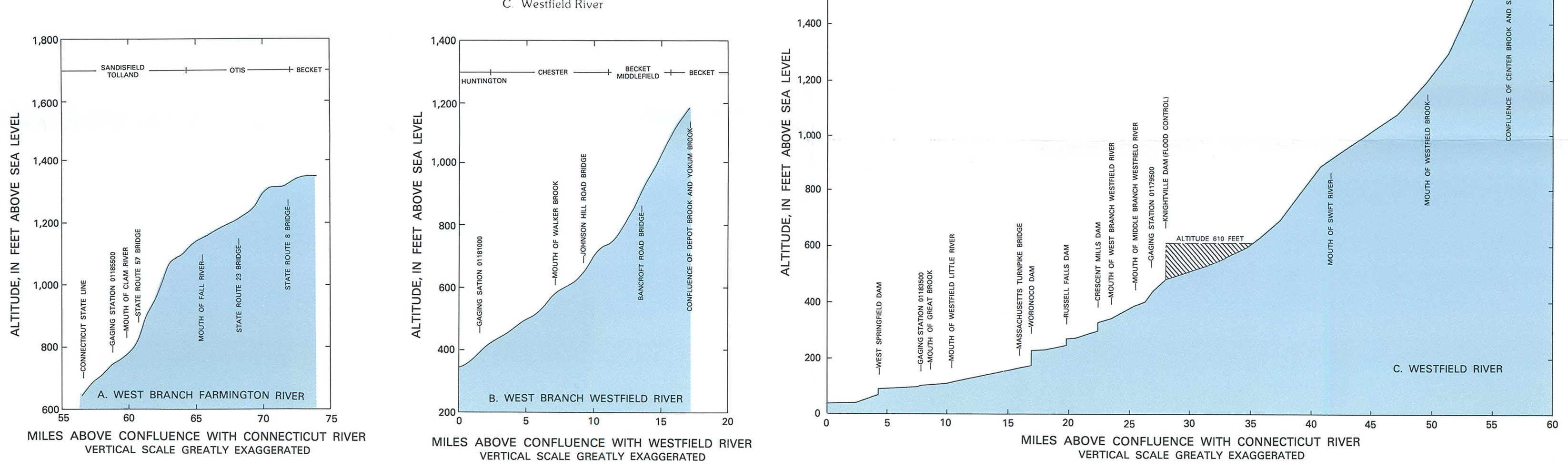


FIGURE 7.—Runoff: rainfall relation for August 1955 and May-June 1984 storms.

FIGURE 6.—Stream channel slope of:
A. West Branch Farmington River
B. West Branch Westfield River
C. Westfield River



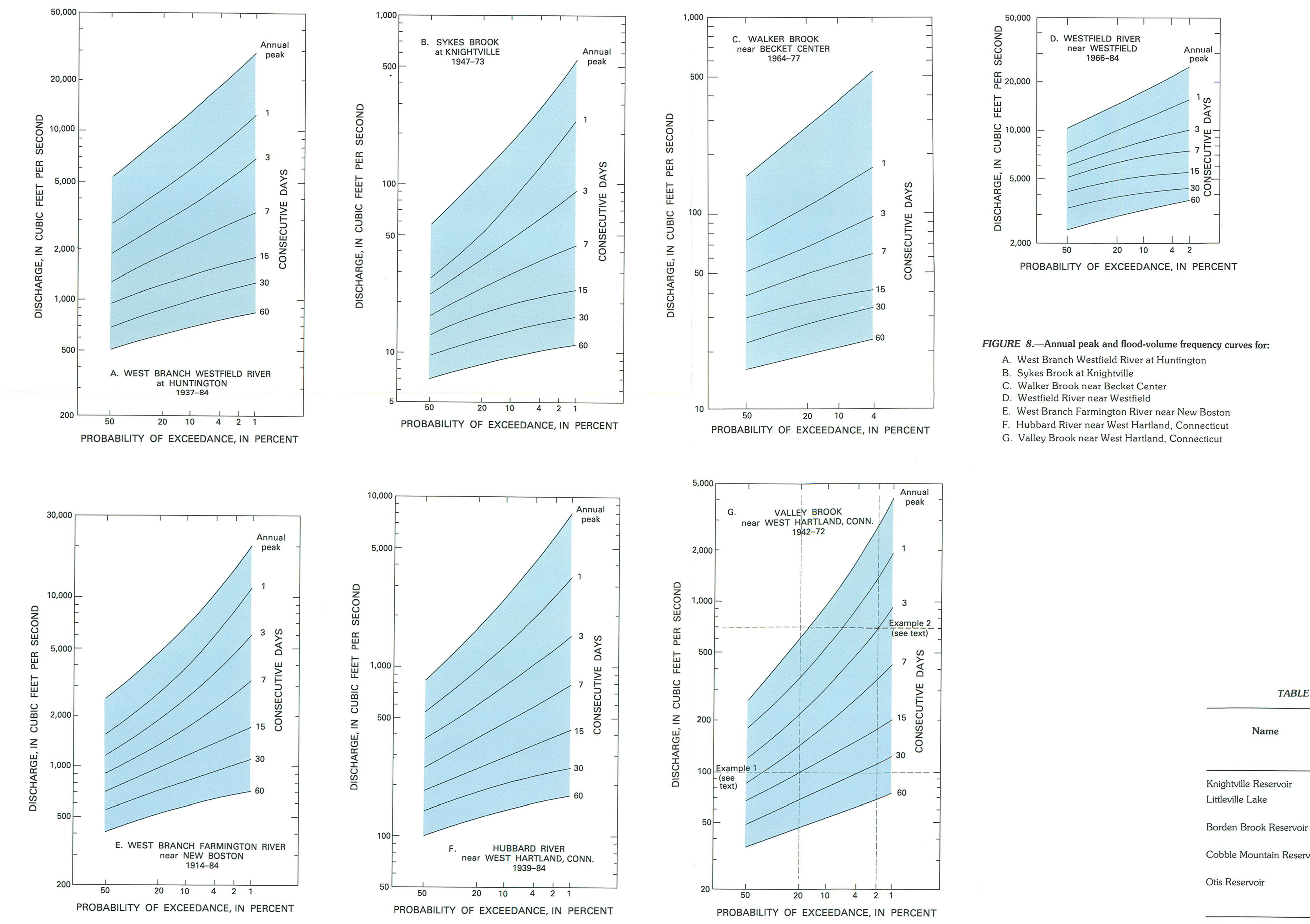
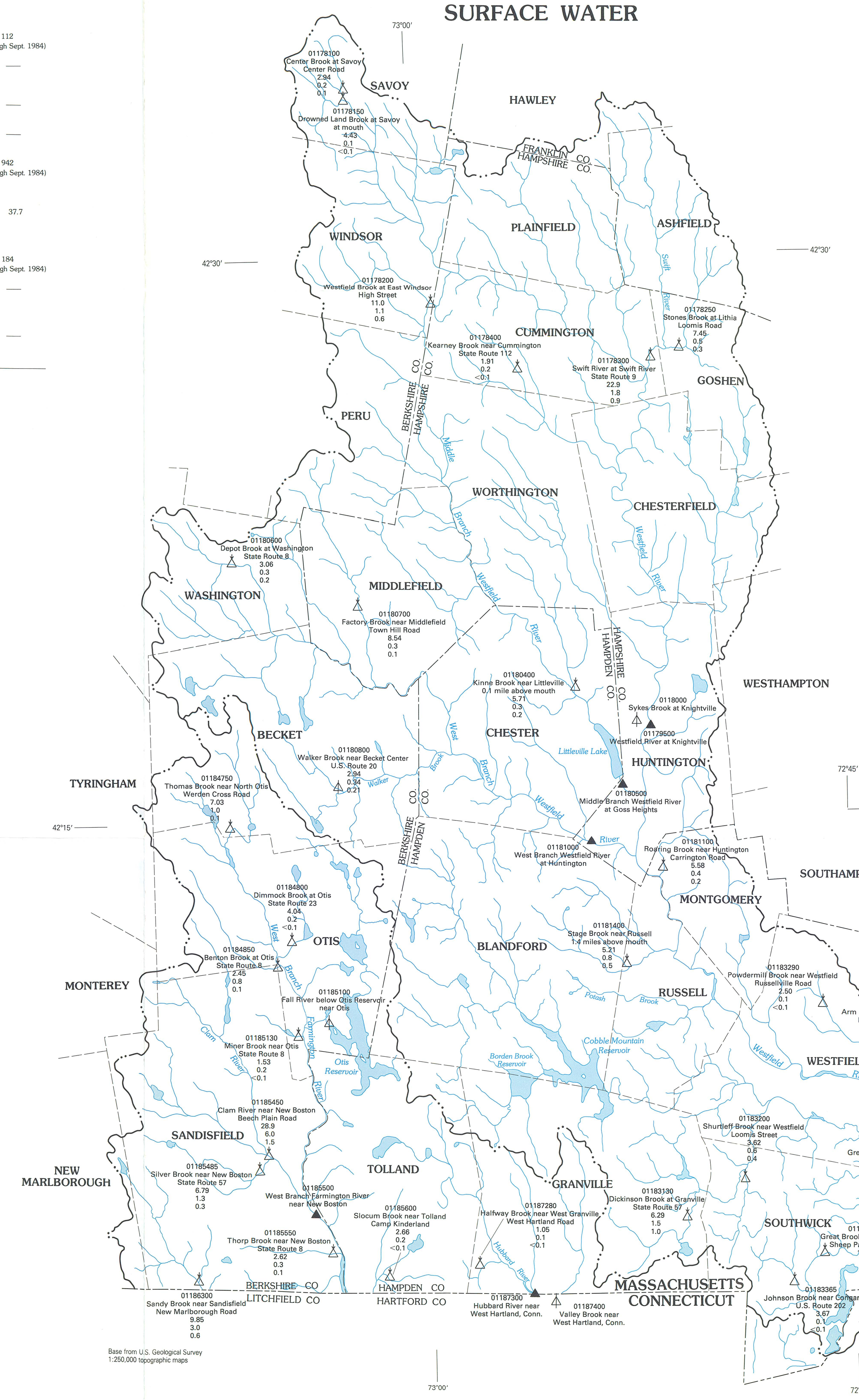


FIGURE 8.—Annual peak and flood-volume frequency curves for:
A. West Branch Westfield River at Huntington
B. Sykes Brook at Knightville
C. Walker Brook near Becket Center
D. Westfield River near Westfield
E. West Branch Farmington River near New Boston
F. Hubbard River near West Hartland, Connecticut
G. Valley Brook near West Hartland, Connecticut

TABLE 2.—Selected manmade lakes and reservoirs

Name	Year completed	Usable capacity, in million gallons	Purpose/use
Knightville Reservoir	1941	15,900	Flood control
Littleville Lake	1965	10,500	Flood control, water supply, recreation
Borden Brook Reservoir	1909	2,570	Water supply, hydroelectric power
Cobble Mountain Reservoir	1931	22,800	Water supply, hydroelectric power
Otis Reservoir	1865	5,830	Hydroelectric power, recreation

SURFACE WATER



Base from U.S. Geological Survey 1:250,000 topographic maps

SCALE 1:125,000
5 4 3 2 1 0 5 MILES
5 4 3 2 1 0 5 KILOMETERS

FIGURE 5.—Stream-measurement sites and low-flow estimates.

EXPLANATION

01184850	Station number, in downstream order, from the data-collection network of the U.S. Geological Survey
Benton Brook at Otis	Station name
State Route 8	Location
2.45	Drainage area, in square miles
0.8	Estimated minimum 7-day mean flow, in cubic feet per second, with an annual 50-percent probability
0.1	Estimated minimum 7-day mean flow, in cubic feet per second, with an annual 10-percent probability
(open triangle with arrow)	Low-flow-measurement station
(solid triangle)	Continuous-record gaging station
(triangle with line)	Discontinued gaging station
(dash-dot line)	Basin boundary
(dashed line)	City or town boundary
(long-short dashed line)	County boundary
(long-double-short dashed line)	State boundary

DIVERSIONS

The Borden Brook and Cobble Mountain Reservoirs located west of the City of Westfield are the second largest water-supply storage system in the State and provide water for the Springfield area southeast of the study area. Together, the reservoirs have a combined storage capacity of 25,400 Mgal (million gallons). Water is diverted underground by way of Wildcat and Springfield Aqueducts for public supply to the City of Springfield and also for Westover Air Force Base and the towns of Agawam, East Longmeadow, Longmeadow, Southwick, and West Springfield, all located about the southeastern corner of the study area. During 1985, an average of 37.21 Mgal/d was diverted from the Westfield River basin through the Springfield water system.

The Littleville Lake is located in the town of Chester and is used as an emergency supply for the Springfield water system. The storage capacity of the reservoir is 14,265 Mgal.

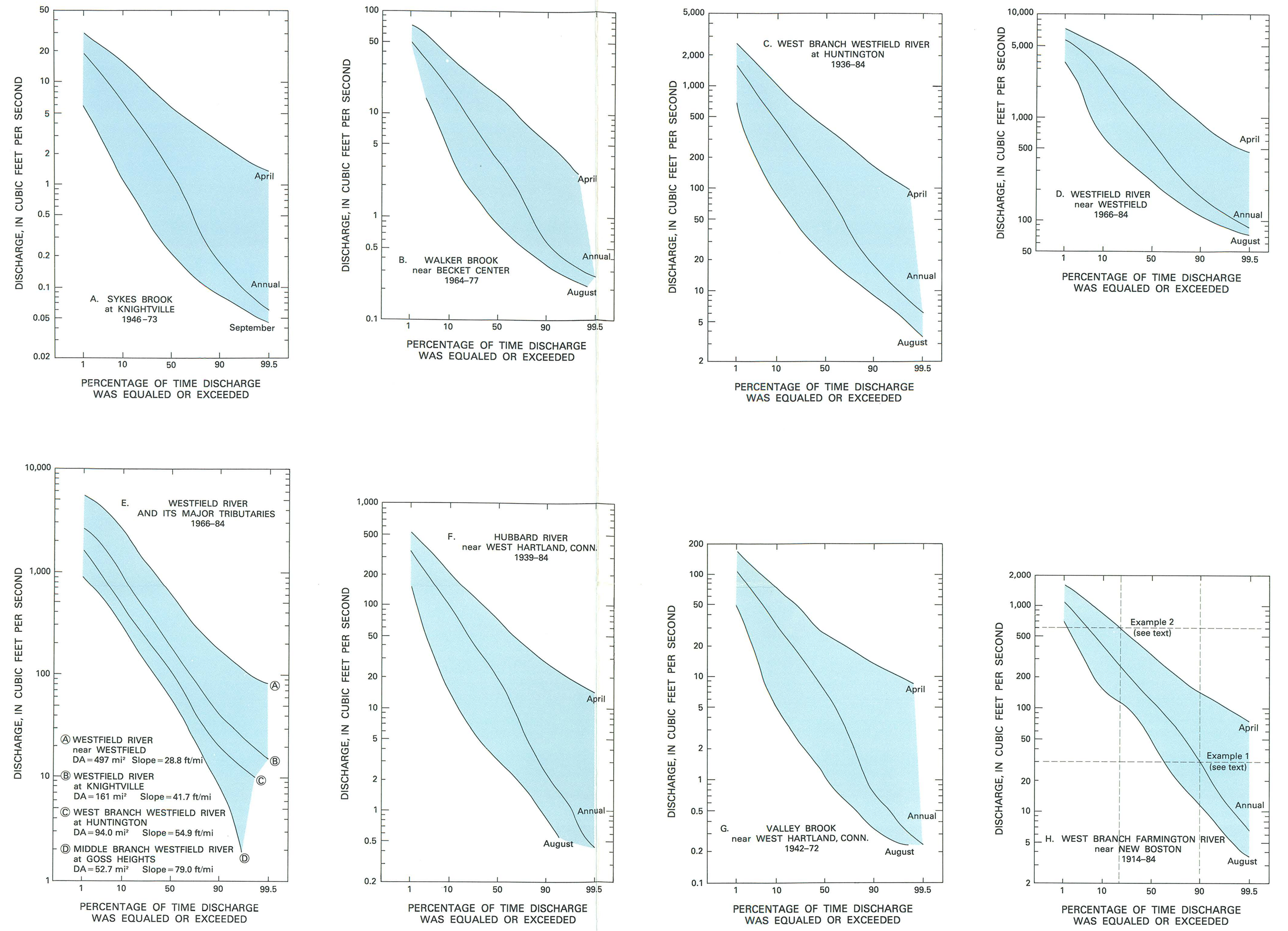


FIGURE 10.—Flow-duration curves for:
A. Sykes Brook at Knightville
B. Walker Brook near Becket Center
C. West Branch Westfield River at Huntington
D. Westfield River near Westfield
E. Westfield River and its major tributaries
F. Hubbard River near West Hartland, Connecticut
G. Valley Brook near West Hartland, Connecticut
H. West Branch Farmington River near New Boston

FLOW DURATION

Flow-duration curves for the streamflow-gaging stations in the Westfield and Farmington River basins (fig. 10) show the percentage of time a particular discharge was equaled or exceeded. The climatic, geologic, and hydrologic characteristics of a basin determine the shape of a duration curve. These characteristics include precipitation, snowmelt, evapotranspiration, topography, channel storage, ground-water storage, and regulation of flow. The curves for Sykes Brook at Knightville, Walker Brook near Becket Center, West Branch Westfield River at Huntington, Westfield River near Westfield, Valley Brook near West Hartland, Connecticut, Hubbard River near West Hartland, Connecticut, and West Branch Farmington River near New Boston also show duration curves of the daily mean flows for the months that had the highest and lowest median flows.

The shape of duration curves for the Westfield River and some of its major tributaries (fig. 10E) show the relations between drainage area, channel slope, and streamflow. Reaches along the river with larger drainage areas and less channel slope about the gaging station permit higher sustained streamflow than do reaches with smaller drainage areas and more channel slope about the gaging station. The annual period used in the duration curves is the water year—the 12-month period beginning October 1 and ending September 30 of the year designated.

The following two examples refer to the flow-duration curve for the West Branch Farmington River near New Boston (fig. 10H):

Example No. 1: A flow of 30 ft³/s is equaled or exceeded 90 percent of the time throughout the year.

Example No. 2: The flow equals or exceeds 600 ft³/s 20 percent of the time during the month of April.

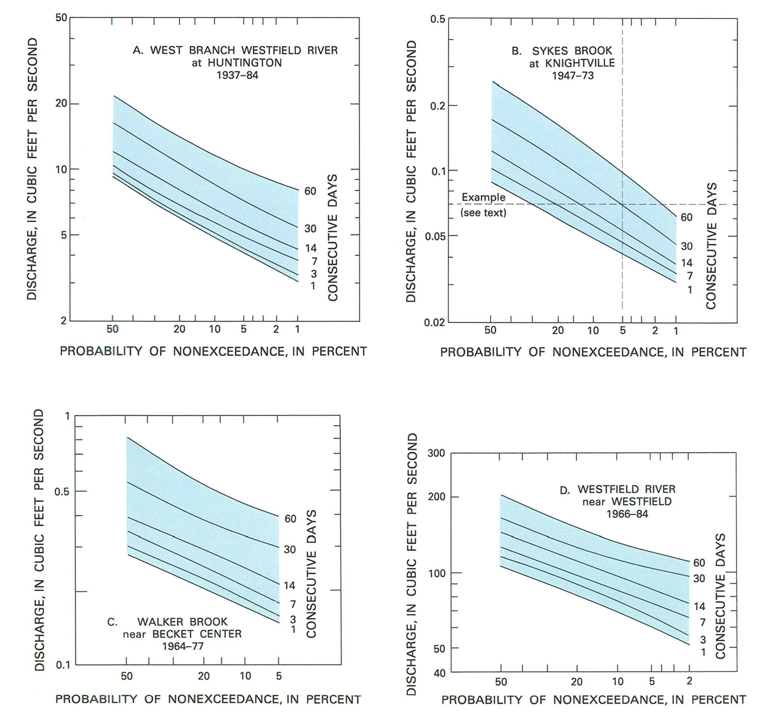
LOW FLOW

Low-flow information is essential to evaluate the potential use of streams for water supply, waste disposal, recreation, and fish habitat. Annual probability curves of the lowest average daily discharges for the indicated number of consecutive days are shown for selected streamflow-gaging stations in figure 9. The annual period used in the analysis of low flows is the climatic year—the 12-month period ending March 31 of the designated year.

Example: For Sykes Brook at Knightville (fig. 9B), the probability that the lowest average discharge for 30 consecutive days of a climatic year would be less than 0.07 ft³/s is 5 percent.

The 7-day, 10-percent-probability flow is used as an index in water-quality standards to ensure that flows of streams are adequate to dilute waste discharges. A graphical correlation method was used to correlate the base-flow measurements at low-flow stations with the long-term gaging-station records of West Branch Westfield River at Huntington in the Westfield River basin and West Branch Farmington River near New Boston and Hubbard River near West Hartland, Connecticut, in the Farmington River basin. Estimates of the annual minimum 7-day low flows having an annual probability of 10 and 50 percent were developed from data collected during 1984–86, and from a drought period (1962–67), and are shown in figure 5. Average 7-day low flows for 29 small tributary streams, with drainage areas that range from 1.05 to 22.9 mi² and average 6.67 mi², are about 0.12 and 0.04 (ft³/s)/mi² (cubic foot per second per square mile) for the 50- and 10-percent annual flow duration, respectively. The 7-day, 10-percent-probability low flow is zero for stream sites with drainage areas less than 1 mi² in central and western Massachusetts (Krejmas and Maevsky, 1986).

During low-flow periods, the relation between streamflow and drainage area differs from one stream to another and between sites on a single stream. The values for the 7-day, 10- and 50-percent probability are site specific and should not be used to estimate values at any other stream sites. The major cause of nonuniformity between natural-flowing streams during low-flow periods is the difference in ground-water level. Other natural causes include differences in surface storage, evaporation, transpiration, geology, and water-table slope. Ground-water pumping, changes in land use, regulation and diversion of streamflow, and other human activities also can cause nonuniformity.



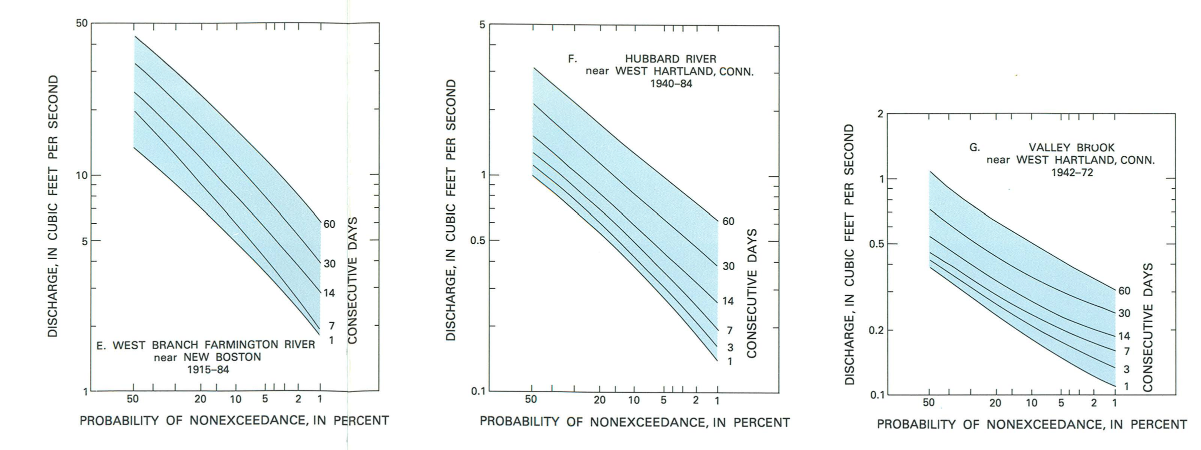


FIGURE 9.—Low-flow frequency curves for:
A. West Branch Westfield River at Huntington
B. Sykes Brook at Knightville
C. Walker Brook near Becket Center
D. Westfield River near Westfield
E. West Branch Farmington River near New Boston
F. Hubbard River near West Hartland, Connecticut
G. Valley Brook near West Hartland, Connecticut

WATER RESOURCES OF THE WESTFIELD AND FARMINGTON RIVER BASINS, MASSACHUSETTS

By
Anthony Maevsky and David G. Johnson
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