Low-Flow Characteristics of Selected Streams in Northern Rhode Island

By JOHN D. KLIEVER

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CONVERSION FACTORS AND VERTICAL DATUM

Conversion Factors

Multiply	By	To obtain
foot	0.3048	meter
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.2832	cubic meter per second
cubic foot per second per sqaure mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer
inch per year (in/yr)	25.4	millimeter per year

VERTICAL DATUM

Sea Level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

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Abstract

Low-flow characteristics were estimated for selected streams in northern Rhode Island. Streamflow was measured at 18 low-flow partial-record gaging stations on rivers and brooks including those contributing to the two largest water supplies in Rhode Island, the Scituate Reservoir and the Pawtucket Reservoir system. Relations were developed between streamflows at the partial-record stations and flows at five continuous-record gaging stations based on the maintenance of variance extension type 1 method and the logistic regression method. Based on these relations, the 7-day, 10-year low flow (7Q10), selected flow durations, and selected monthly mean daily flows for the partial-record stations were estimated.

Low flows of the different streams varied considerably. The 7Q10 ranged from a high of 4.0 cubic feet per second (ft^3/s) at the Chepachet River to a low 7Q10 of 0 ft^3/s at Huntinghouse, Winsor, and Catamint Brooks, and Moosup River. The 99-percent flow duration ranged from a high of 4.3 ft^3/s to a low of 0 ft^3/s on the same streams. The largest tributary to the Scituate Reservoir at low flow is the Ponaganset River with a 7Q10 of 0.56 ft^3/s and a 99-percent flow duration of 0.64 ft^3/s. The next largest tributaries at low flow are the Hemlock Brook with a 7Q10 of 0.36 ft^3/s and the Peeptoad Brook with a 7Q10 of 0.29 ft^3/s. The largest tributary to the Pawtucket Reservoir system at low flow was Ash Swamp Brook with a 7Q10 of 0.31 ft^3/s, the next largest tributary at low flow was Burnt Swamp Brook with a 7Q10 of only 0.006 ft^3/s. The mean daily flow for August was never more than 30 percent different from the 85 percent flow-duration value.

INTRODUCTION

Reservoirs and streams in northern Rhode Island supply most of the drinking water for the entire State. Most of the streams in northern Rhode Island flow into the northern end of Narragansett Bay. The Pawtuxet and Blackstone Rivers are the largest of these streams and drain the Scituate Reservoir and the Pawtucket Reservoir system, respectively (fig. 1). The Moosup River drains a small area in western Rhode Island and flows into the Thames River and Long Island Sound. The Scituate Reservoir supplies 60 percent of the public water supply of Rhode Island including all that of Providence (the largest city and capital of the State) and all or part of the water for several neighboring communities. The Pawtucket Reservoir system is much smaller than the Scituate Reservoir but supplies all of the drinking water for the cities of Pawtucket and Central Falls. Because of expected continued competing demands on the water supplies in Rhode Island, adequate planning and management of water resources will be required to ensure that water-supply shortages and unreasonably low streamflows do not become a problem in the future.

Low-flow characteristics of streams are important in the management and development of water resources because sufficient streamflows are necessary for public water supply, the dilution of effluent, and for the maintenance of aquatic life. Regulations as part of the Water Supply Management Act (46-15.4 of the Rhode Island General Laws) require that water suppliers develop water-management plans that include a calculation of basin yield for surface-water sources.

The purpose of this report is to describe the estimation of low-flow characteristics for selected streams in northern Rhode Island. Most of the streams considered were selected on the basis of their importance for water supply, particularly the major tributaries to the Scituate Reservoir and the Pawtucket Reservoir systems. Several other streams were included in this study to provide broader geographical information on low flows in the northern part of the State. This study was done by the U.S. Geological Survey (USGS) in

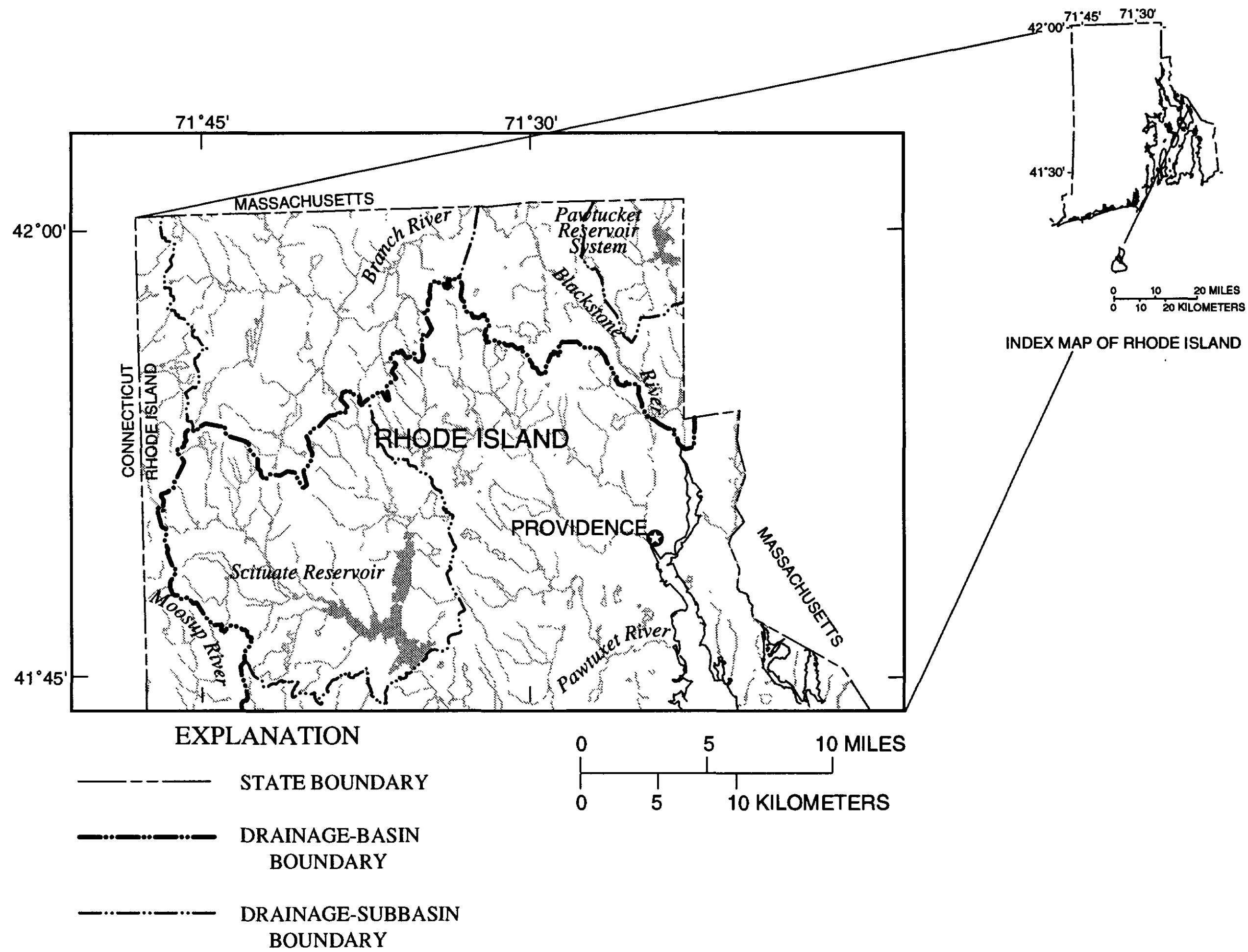

Figure 1. Location of study area in northern Rhode Island.

cooperation with the State of Rhode Island, Department of Environmental Management, and the City of Providence Water Supply Board.

Low-flow characteristics of streams were estimated by correlating streamflow data collected from 18 partial-record stations with streamflow data from continuous-record gaging stations based on the maintenance of variance extension type 1 method (MOVE.1) and logistic regression method. The low-flow characteristics presented in this report are the 7-day, 10-year low flow (7Q10), flow duration, and the mean daily flow for August. The 7Q10 is commonly used to assess the capacity of a river to carry pollutants. Low-flow duration estimates provide an appropriate starting point for formulation of basin-yield estimates. The mean daily flow for August is important for determining the quality of aquatic habitat. In addition, estimates of the mean daily flows for February, April, and May are presented because they are important for assessment of aquatic habitat even though they are not low flows. These estimates can be used to determine the distribution of future flows for water-supply or water-quality studies.

This report contributes to the understanding of low-flow characteristics throughout New England. A similar report of the Pawcatuck and Hunt River Basins in southern Rhode Island was done by Cervione and others (1993). Recent studies of low-flow characteristics in neighboring States have been published by Ries (1994) for Massachusetts, and by Cervione and others (1982) for Connecticut.

The author would like to express his appreciation to the numerous people who helped with the data collection, analyses, and interpretation necessary for this report. In particular, the author thanks Mark Nimiroski, who collected much of the data, and also Kernell Ries who shared his extensive experience with statistical analysis of surface-water data.

DESCRIPTION OF STUDY AREA

The climate in northern Rhode Island is temperate and relatively uniform. Rainfall averages 48 in/yr and does not vary substantially from season to season. In most years, streamflow is highest in the spring and lowest in the late summer when evaporation is high and the growing season is at its peak with vegetation transpiring large quantities of water. In contrast to this general pattern, floods occur in the summer in some years because of hurricanes (National Oceanic and Atmospheric Administration, 1960-94).

Northern Rhode Island is primarily rural with a large amount of forest cover; however, large urban and suburban areas are present in the east. Hills of till-covered bedrock rise as much as 800 ft above sea level. Stream valleys are narrow, and the stratified-drift deposits that underlie the larger valleys are long and sinuous (Trench, 1991). Numerous reservoirs and mill ponds are located throughout the area; however, many are no longer in use or are used only for recreation. Most residents in the study area obtain their water supply from residential wells. Most of this water returns to the ground through individual septage-disposal systems.

STREAMFLOW

Streamflow-Gaging Stations

The streamflow-gaging stations utilized in this study are of two types: (1) index stations, which are part of the USGS continuous-record gaging-station network. Streamflow data have been collected at these stations for 10 or more years to allow accurate and reliable computation of streamflow characteristics; and (2) low-flow partial-record stations, where a limited number of streamflow measurements have been made. Streamflow measured at low-flow partial-record stations can be correlated with streamflow measured at index stations to estimate low-flow characteristics at the partial-record stations.

Five index stations currently operated in Rhode Island were used in this study (fig. 2, table 1). These stations were selected based on proximity to the partial-record stations, length of record, and lack of regulation. Three of the index stations were in southern Rhode Island, outside the study area. Records for these stations have been published in USGS water-data reports, an annual series published under various titles, but presently called "Water Resources Data, Massachusetts and Rhode Island."

A partial-record streamflow-gaging station was established on each of the 18 streams (fig. 2; table 2). Eight of these stations are on streams tributary to the Scituate Reservoir, 3 are on streams tributary to the Pawtucket Reservoir System, and 7 are scattered throughout northern Rhode Island. Streamflow was measured from 9 to 14 times at each station. These data were published as miscellaneous measurements in "Water Resources Data, Massachusetts and Rhode Island" for water years 1993 and 1994 (Gadoury and others, 1994, 1995).

Factors Affecting Streamflow

Generally, the three major factors affecting the low flow of any stream are climate, regulation and withdrawals, and the physical characteristics of the drainage basin contributing water to the stream. Differences in climate account for the large variations in streamflow from region to region and from season to season. Regulation and withdrawals for water supply, flood control, power generation, or dam maintenance also can significantly affect the flows in streams. Physical characteristics of the stream's drainage basin such as geology, topography, and land use, can account for large variations in low flows between nearby streams (Ries, 1994).

In northern Rhode Island, the climate is relatively uniform and, therefore, not a major factor in the large variation in flow characteristics among streams considered in this study. The low-flow characteristics of heavily regulated streams are difficult to estimate because the flows are controlled for human needs of water or power that are difficult to evaluate; therefore, flow characteristics were estimated only for nonregulated streams. The physical characteristics of the drainage basin is the factor that accounts for most of the differences between low-flow characteristics of the streams considered in this study.

Geology is the most important physical characteristic affecting low flow because natural low streamflows are from ground-water sources. Some of the rainfall in Rhode Island seeps into the ground and is stored in aquifers. The water in these aquifers eventually flows to the surface and becomes streamflow. There are three major types of materials that compose aquifers in Rhode Island: stratified drift, till, and bedrock. Coarse-grained stratified drift can store and

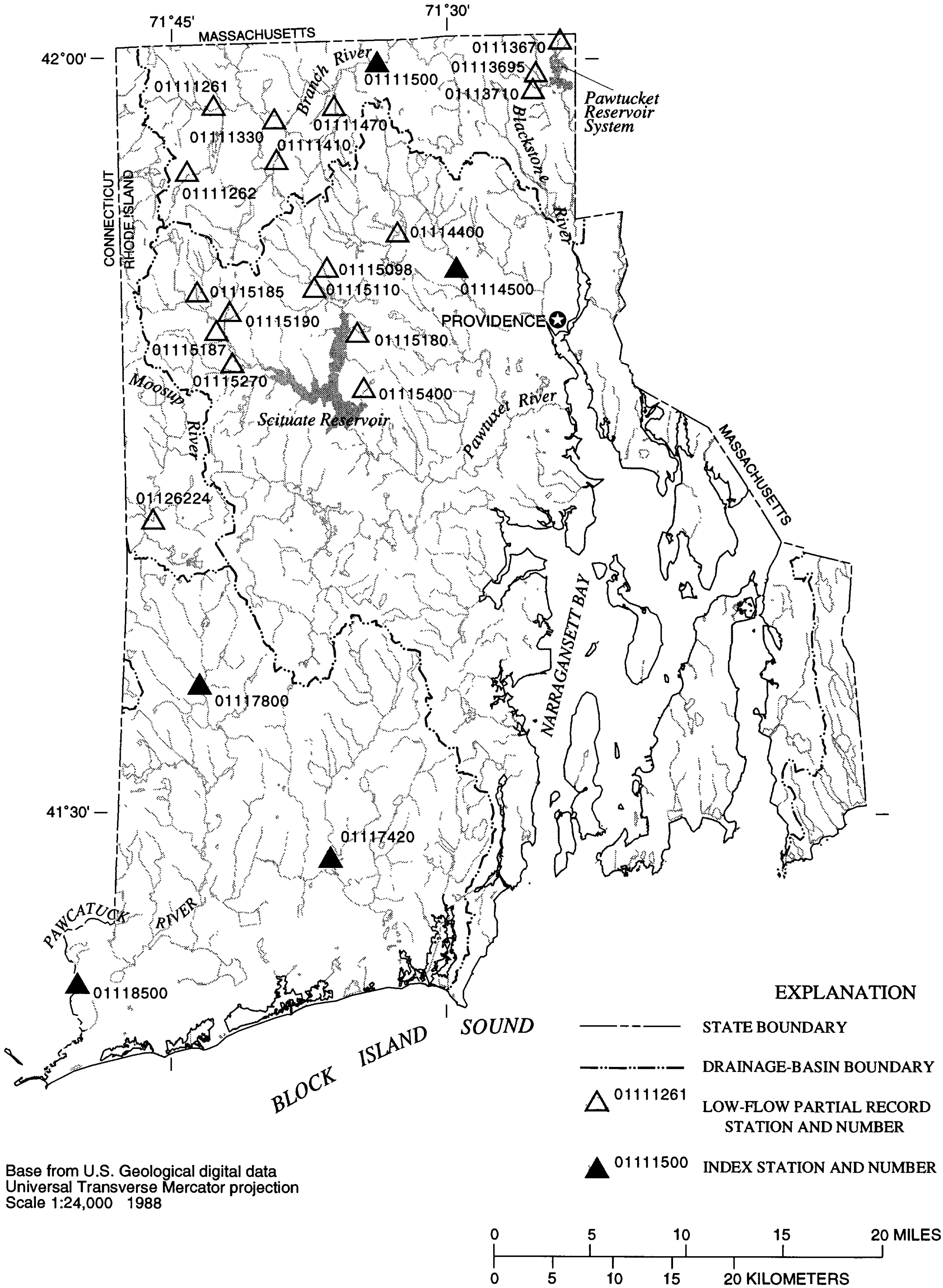

Figure 2. Location of streamflow-gaging stations used in this study.

Table 1. Selected continuous-record gaging stations (index stations) in Rhode Island

[Period of record: Present indicates operating as of 1995. No., number. mi^2, square mile]

Station No.	Station Name	Period of record	Drainage area (mi^2)
01111500	Branch River at Forestdale	Jan. 1940 - present	91.2
01114500	Woonasquatucket River at Centerdale	July 1941 - present	38.3
01117420	Usquepaug River near Usquepaug	Feb. 1958 - July 1960 Dec. 1974 - present	36.1
01117800	Wood River near Arcadia	Jan. 1964 - Sept. 1981 Oct. 1982 - present	35.2
01118500	Pawcatuck River at Westerly	Nov. 1940 -present	295

transmit the largest quantities of water and, consequently, yields the highest streamflows. Thomas (1966) determined that a basin in nearby Connecticut underlain completely by stratified drift yields 100 times more water per square mile of drainage area during dry periods than a basin underlain completely by poorly sorted till.

Low-Flow Characteristics of Streams

The low-flow characteristics of streams presented in this report are (1) 7-day, 10-year low flow (7Q10), (2) flow duration, and (3) mean daily flows for August, February, April, and May. The 7Q10 is the lowest mean streamflow for 7 consecutive days that can be expected to occur on the average of once in 10 years (the 7-day low flow with a 10-year recurrence interval). In Rhode Island, surface-water-quality standards generally are based on the 7Q10 because it is considered to represent low-flow conditions.

Streamflow commonly is presented as a flow duration, which describes a given flow in the stream as a percentage of time that the flow is equaled or exceeded. For example, the 90-percent flow duration is a streamflow that is equaled or exceeded 90 percent of the time; a 99-percent flow duration is smaller than a 90-percent flow duration. The 99-percent flow duration commonly is used for resource assessment and regulatory purposes.

Streamflow variations at a station can be characterized by preparing flow-duration curves, which represent the percentage of time streamflows were equaled or exceeded during a selected period (Searcy, 1959). A flow-duration curve (fig. 3) is a cumulative-frequency curve showing the percentage of time daily flows were equaled or exceeded during a given period. The flow characteristics of a stream throughout the period of interest are combined in a curve, without regard to the sequence of occurrence of the flows. For example, if a water supplier needs to know how much water could be expected to flow into a given reservoir 99 percent of the time, a flow-duration curve can be prepared to estimate the 99-percent flow duration. This flow duration can be used to assess the reliability of the entire water supply.

Table 2. Low-flow partial-record stations in northern Rhode Island

[Period of record: Water year is the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. No., number. mi^2, square mile]

Station identification No.	Station Name	Period of record (water year)	Drainage area (mi^2)
Stations on Streams Tributary to Scituate Reservoir			
01115098	Peeptoad Brook near North Scituate	1993-94	5.02
01115110	Huntinghouse Brook at North Scituate	1993-94	6.31
01115180	Brandy Brook at Saundersville	1993-94	1.59
01115185	Winsor Brook near South Foster	1993-94	4.24
01115187	Ponaganset River at South Foster	1993-94	12.1
01115190	Dolly Cole Brook near Clayville	1993-94	5.07
01115270	Hemlock Brook near Clayville	1993-94	10.7
01115400	Kent Brook at Waterman Four Corners	1993-94	.83
Stations on Streams Tributary to Pawtucket Reservoir System			
01113670	Burnt Swamp Brook at Grants Mills	1986, 1993-94	4.6
01113695	Catamint Brook at Diamond Hill	1993-94	3.5
01113710	Ash Swamp Brook at Diamond Hill	1993-94	4.15
Stations on Other Streams Important for Water Supply			
01111261	Clear River at Laurel Hill	1993-94	12.7
01111262	Brandy Brook near Chepachet	1993-94	3.04
01111330	Clear River at Oakland	1993-94	45.9
01111410	Chepachet River at Gazzaville	1993-94	19.5
01111470	Tarkiln Brook at Oak Valley	1993-94	9.16
01114400	Stillwater Brook at Spragueville	1993-94	12.9
01126224	Moosup River near Fairbanks Corner	1993-94	24.9

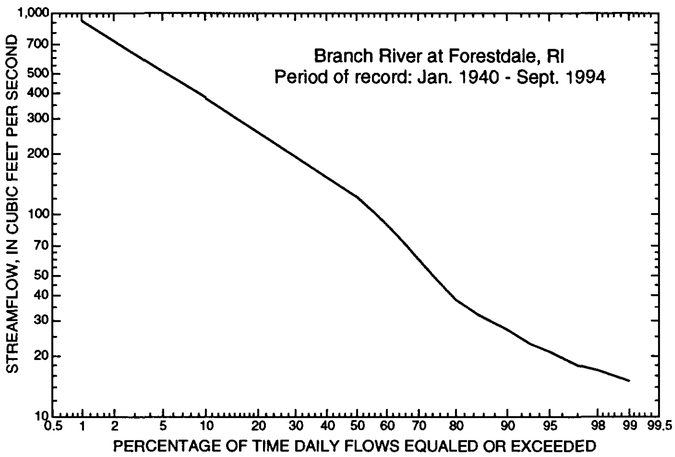

Figure 3. Example of flow-duration curve showing percentage of time daily flows were equaled or exceeded during a given period.

The mean daily flow for August, February, April, and May is the average of all flows during each of these months for the period of record. The flows during these months can affect the population of some aquatic species. When flows are low in the summer, habitat can be damaged because of increased water temperature, decreased dissolved-oxygen concentrations, and decreased water depth. The mean flow for August is indicative of summer flows. Adequate streamflow in the winter is important to prevent the stream from freezing, and streamflow in the spring is important for spawning and incubation. The mean flows in February are indicative of winter flows. The mean flows in April and May are indicative of spring flows (U.S. Fish and Wildlife Service, written commun., 1981).

METHODS TO ESTIMATE LOW-FLOW CHARACTERISTICS

Information on low-flow characteristics of streams is readily available at long-term, continuous-record streamflow-gaging stations (index stations). Only 17 of these stations are currently operating in Rhode Island. Estimates of low-flow characteristics at sites where no recording equipment is present, called partial-record low-flow stations, can be obtained by correlating flows at the partial-record stations with flows at the index stations at which the low-flow characteristics are already known. A correlation establishes a mathematical relation between streamflow measurements made at the partial-record low-flow stations during periods of base flow and streamflows at an index station on the same day (concurrent flows). Once the correlation is established, 7Q10s, flow durations, and monthly means for the partial-record low-flow station are estimated based on the known flows for these characteristics at the index station.

Two different correlation methods were used in this study, the maintenance of variance extension type 1 method (MOVE.1), and the logistic regression method. In the MOVE.1 method (Hirsch, 1982), an equation is developed to describe the relation between concurrent flows at a partial-record station and an index station. The equation takes the form:

$$P = P_{mean} + (\sigma_p/\sigma_i)(I-I_{mean}); \qquad (1)$$

where

P is the logarithm of a given flow at the partial-record station,

P_{mean} is the mean of the logarithms of all flows at the partial-record station,

σ_p is the standard deviation of the logarithms of the flows at the partial-record station,

σ_i is the standard deviation of the logarithms of all concurrent flows at the index station,

I is the logarithm of the concurrent flow at the index station, and

I_{mean} is the mean of the logarithms of all concurrent flows at the index station.

For example, the equation can be used to determine the 7Q10 of Clear River at Laurel Hill (01111261). Concurrent streamflow measurements on the Clear River and the Branch River at Forestdale were made on 10 different days during this study (table 3). The mean and the standard deviation of the logarithm of the flows on the Clear River were 0.297 and 0.419, respectively. The mean and the standard deviation of the logarithm of the flows on the Branch River were 1.44 and 0.189, respectively. The 7Q10 of the Branch River is 14.7 ft^3/s and the logarithm of the 7Q10 is 1.17. Therefore, equation 1 becomes

$$P = 0.297 + (0.419/0.189)(1.17-1.44), \qquad (2)$$

$$P = -0.302. \qquad (3)$$

The logarithm of the 7Q10 of the Clear River at Laurel Hill is -0.302, which corresponds to a 7Q10 of 0.50 ft^3/s.

Table 3. Comparison of concurrent flow at the Branch River at Forestdale (01111500) and the Clear River at Laurel Hill (01111261)

[7Q10 is the lowest mean streamflow for 7 consecutive days that can be expected to occur on the average of once in 10 years (the 7-day low flow with a 10-year recurrence interval). ft^3/s, cubic foot per second. --, not calculated]

Date	Branch River Flow (ft^3/s)	Branch River Logarithm of flow	Clear River Flow (ft^3/s)	Clear River Logarithm of flow
7-09-93	43	1.63	5.00	0.699
7-16-93	23	1.36	.821	-.086
8-11-93	15	1.18	.273	-.564
8-23-93	28	1.45	3.12	.494
9-29-93	68	1.83	8.08	.907
6-22-94	35	1.54	3.79	.579
7-06-94	24	1.38	1.41	.149
8-02-94	21	1.32	2.28	.358
8-11-94	19	1.27	1.86	.270
9-22-94	27	1.43	1.48	.170
Mean	--	1.44	--	.297
Standard deviation	--	.189	--	.419
7Q10	14.7	1.17	.50	-.302

The correlation between the flows at Clear River and Branch River also can be shown graphically. The 10 concurrent measurements are shown in figure 4, as is the MOVE.1 correlation line for these stations that is calculated with equation 1.

In this study, each partial-record station was correlated with several index stations and the flow characteristics derived from the best correlations were averaged. The estimates determined with this method generally are reliable within the range of the measurements; therefore, estimates that are more than twice the highest measurement are considered approximate only. For this study, estimates that were more than 20 times the highest measurement were not reported.

The MOVE.1 method cannot be applied when flow at the partial-record station is zero or when a statistical estimate might be zero. In this study, no flow was observed at four of the partial-record stations (Huntinghouse, Winsor, and Catamint Brooks, and Moosup River) when measurements were made. Therefore, another method had to be applied at these stations. The logistic regression method (Helsel and Hirsch, 1992) is based on a function that relates the

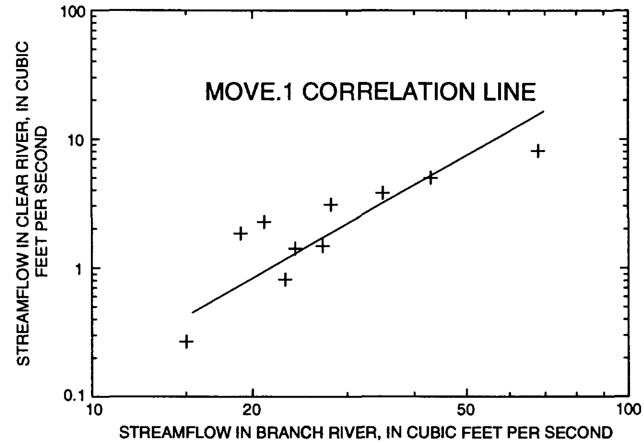

Figure 4. Example of a MOVE.1 correlation line showing relation between flow at a partial-record low-flow station and flow at an index station.

flow at an index station to the probability that the flow at a partial-record station is zero. This function takes the form

$$F = 100(e(a+bI))/(1+e(a+bI)) \quad (4)$$

where

F is the probability, in percent, there is zero flow at the partial-record station,

I is the flow at the index station,

a and b are variables that are selected to make the function fit the data, and

e represents the exponential function.

Variables a and b were calculated by use of the maximum likelihood estimation (MLE), which is an iterative procedure that varies a and b until the version of equation 2 is determined that has the highest likelihood of fitting the measured data. For example, the probability that Winsor Brook has zero flow was correlated with the flow at the Branch River at Forestdale. The MLE procedure calculated a and b as 3.44 and -0.109, respectively, to produce

$$F = 100(e(3.44\text{-}0.109(I)))/(1+e(3.44\text{-}0.109(I))). \quad (5)$$

This equation is presented in graphical form in figure 5. If F is greater than 50 percent, the flow at Winsor Brook is probably zero. Based on equation 5, when the flow at the Branch River is 14.7 ft^3/s (7Q10),

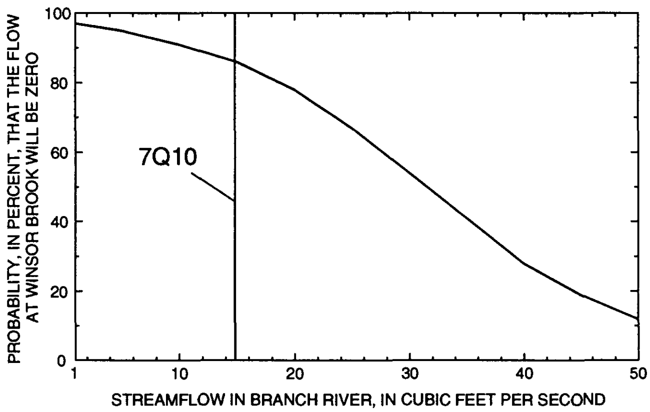

Figure 5. Example of a logistic regression correlation showing relation between the probability, in percent, that a partial-record low-flow site will be flowing and flow at an index site.

there is an 86 percent probability of zero flow at Winsor Brook; therefore, we conclude that the 7Q10 at Winsor Brook is zero.

For the partial-record stations with zero flows observed during this study, logistic regression was done with two or more index stations and a composite result was used. If a given statistic was determined to be non-zero based on logistic regression, then the value of that statistic was calculated with the MOVE.1 method based on the non-zero data only. At all four of these stations, sufficient non-zero measurements were available to perform the calculations.

ESTIMATES OF LOW-FLOW CHARACTERISTICS

Estimates of low-flow characteristics for the low-flow partial-record stations are summarized in table 4. Low flows of different streams in the study varied considerably. The 7Q10 ranged from a high of 4.0 ft^3/s at the Chepachet River (01111410) to a low of 0 ft^3/s at Huntinghouse Brook (01115110), Winsor Brook (01115185), Catamint Brook (01113695), and Moosup River (01126224). The tributary to the Scituate Reservoir with the largest streamflow at low flow is the Ponaganset River (01115187) with a 7Q10 of 0.56 ft^3/s. The next largest tributaries at low flow were Hemlock Brook (01115270) with a 7Q10 of 0.36 ft^3/s, and Peeptoad Brook (01115098) with a 7Q10 of 0.29 ft^3/s. The largest tributary to the Pawtucket Reservoir system at low flow was Ash Swamp Brook (01113710) with a 7Q10 of 0.31 ft^3/s, the next largest tributary at low flow was Burnt Swamp Brook (01113670) with a 7Q10 of only 0.006 ft^3/s.

Estimates of the 99-percent flow duration follow a similar pattern to those of the 7Q10. Flows ranged from a high of 4.3 ft^3/s at the Chepachet River (01111410) to a low of 0 ft^3/s at the same four stations listed above. The Ponaganset River (01115187) had the highest flow to the Scituate Reservoir at the 99-percent flow duration (0.64 ft^3/s) and Ash Swamp Brook (01113710) had the highest flow to the Pawtucket Reservoir at the 99-percent flow duration (0.34 ft^3/s).

The streams with the largest streamflows at low flows were not necessarily the same streams with the largest streamflows during average conditions. The highest median flow (50-percent flow duration) was 130 ft^3/s at Clear River (01111330) and the lowest was 0.78 ft^3/s at Kent Brook (01115400). Tributaries to the Scituate Reservoir with the highest median flows are Dolly Cole Brook (01115190), Ponaganset River (01115187), and Hemlock Brook (01115270) with median flows of 14, 13, and 10 ft^3/s, respectively. The largest tributary to the Pawtucket Reservoir was Burnt Swamp Brook (01113670) with a median flow of 18 ft^3/s.

Mean flows for August followed a somewhat different pattern than those of the 7Q10 and the 99-percent flow duration. The highest mean flow for August was 18 ft^3/s at the Clear River (01111330) to a low of 0.09 ft^3/s at Kent Brook (01115400). The largest tributaries to the Scituate Reservoir were Ponaganset River (01115187) with a mean flow for August of 2.0 ft^3/s and Hemlock Brook (01115187) with a flow of 1.7 ft^3/s. The largest tributaries to the Pawtucket Reservoir were Catamint Brook (01113695) and Ash Swamp Brook (01113710) with mean flows for August of 0.79 and 0.70 ft^3/s, respectively.

Discharge-area-adjusted flow characteristics are shown in table 5. These are the flow characteristics divided by the drainage area contributing to each site. The area-adjusted values indicate less variation than values not adjusted by area, but follow a similar pattern. For example, the area-adjusted 7Q10 ranged from a high of 0.205 $(ft^3/s)/mi^2$ at the Chepachet River (01111410) to a low of 0 $(ft^3/s)/mi^2$ at Huntinghouse Brook (01115110), Winsor Brook (01115185), Catamint Brook (01113695), and Moosup River (01126224). Therefore, differences in drainage basin size do not account for the large variation in flow characteristics.

Table 4. Summary of flow characteristics at low-flow partial-record stations in northern Rhode Island

[Flow characteristics in cubic feet per second. 7Q10 is the lowest mean streamflow for 7 consecutive days that can be expected to occur on the average of once in 10 years (the 7-day low flow with a 10-year recurrence interval). No., number]

Station No.	Station name	7Q10	Equaled or exceeded at indicated percentage of time										Mean daily flows			
			50	60	70	80	85	90	95	97	98	99	Aug.	Feb.	April	May
	STATIONS ON STREAMS TRIBUTARY TO SCITUATE RESERVOIR															
01115098	Peeptoad Brook near North Scituate	0.29	6.7	4.5	2.8	1.6	1.2	0.87	0.57	0.46	0.39	0.33	1.2	14	19	11
01115110	Huntinghouse Brook at North Scituate	0	4.1	2.0	.90	.35	.22	.13	0	0	0	0	.25	17	31	10
01115180	Brandy Brook at Saundersville	.12	[1]3.3	[1]2.2	1.3	.74	.56	.39	.25	.20	.17	.14	.54	[1]6.7	[1]9.7	[1]5.4
01115185	Winsor Brook near South Foster	0	([2])	[1]8.0	[1]1.6	.29	.12	0	0	0	0	0	.13	([2])	([2])	([2])
01115187	Ponaganset River at South Foster	.56	13	8.3	5.1	3.0	2.2	1.5	1.0	.89	.76	.64	2.0	24	37	19
01115190	Dolly Cole Brook near Clayville	.019	[1]14	[1]6.1	[1]2.8	1.1	.65	.34	.16	.096	.054	.028	.85	([2])	([2])	([2])
01115270	Hemlock Brook near Clayville	.36	[1]10	[1]6.1	[1]3.6	2.0	1.5	1.1	.76	.59	.49	.40	1.7	[1]26	([2])	[1]18
01115400	Kent Brook at Waterman Four Corners	.010	[1].78	.45	.25	.13	.085	.054	.031	.024	.018	.013	.09	[1]2.1	[1]3.2	[1]1.4
	STATIONS ON STREAMS TRIBUTARY TO PAWTUCKET RESERVOIR SYSTEM															
01113670	Burnt Swamp Brook at Grants Mills	0.006	[1]18	5.7	1.5	0.36	0.16	0.072	0.022	0.013	0.008	0.004	0.17	([2])	([2])	[1]74
01113695	Catamint Brook at Diamond Hill	0	2.9	2.0	1.3	.84	.68	.58	0	0	0	0	.79	6.7	10	5.1
01113710	Ash Swamp Brook at Diamond Hill	.31	2.3	1.8	1.3	.91	.74	.59	.45	.41	.38	.34	.70	[1]3.4	[1]4.5	3.0
	STATIONS ON OTHER STREAMS IMPORTANT FOR WATER SUPPLY															
01111261	Clear River at Laurel Hill	0.40	[1]59	[1]31	15	6.8	4.4	3.0	1.6	1.1	0.77	0.52	4.9	([2])	([2])	[1]140
01111262	Brandy Brook near Chepachet	.006	([2])	[1]88	[1]17	3.0	1.1	.35	.093	.048	.023	.011	1.3	([2])	([2])	([2])
01111330	Clear River at Oakland	2.4	[1]130	[1]78	44	23	17	12	7.2	5.5	4.1	3.0	18	[1]340	[1]590	[1]250
01111410	Chepachet River at Gazzaville	4.0	[1]31	24	17	12	10	8.1	6.2	5.4	4.9	4.3	9.9	[1]49	[1]60	[1]43
01111470	Tarkiln Brook at Oak Valley	1.1	[1]15	11	7.5	4.9	3.9	3.2	2.3	1.9	1.6	1.3	4.1	[1]28	[1]41	[1]23
01114400	Stillwater River at Spragueville	1.7	[1]17	12	8.6	5.8	4.7	3.6	2.6	2.3	2.0	1.8	4.6	[1]29	[1]38	[1]24
01126224	Moosup River near Fairbanks Corner	0	[1]69	[1]36	[1]17	8.0	5.5	3.5	2.0	1.5	1.2	0	5.6	([2])	([2])	([2])

[1]Estimates are more than twice the value of the highest measurement made and are approximate only.

[2]Estimates were discarded because they were more than 20 times the highest measurement made and therefore considered unreliable

Table 5. Summary of area-adjusted flow characteristics at low-flow partial-record stations in northern Rhode Island

[Flow characteristics in cubic feet per second per square mile. 7Q10 is the lowest mean streamflow for 7 consecutive days that can be expected to occur on the average of once in 10 years (the 7-day low flow with a 10-year recurrence interval). No., number]

Station No.	Station name	7Q10	Equaled or exceeded at indicated percentage of time										Mean daily flows			
			50	60	70	80	85	90	95	97	98	99	Aug.	Feb.	April	May
	STATIONS ON STREAMS TRIBUTARY TO SCITUATE RESERVOIR															
01115098	Peeptoad Brook near North Scituate	0.058	1.34	0.896	0.558	0.319	0.239	0.173	0.114	0.092	0.078	0.066	0.239	2.79	3.78	2.19
01115110	Huntinghouse Brook at North Scituate	0	.650	.317	.143	.055	.035	.021	0	0	0	0	.040	2.69	4.91	1.59
01115180	Brandy Brook at Saundersville	.075	[1]2.08	[1]1.38	.818	.465	.352	.245	.157	.126	.107	.088	.340	[1]4.21	[1]6.10*	[1]3.40
01115185	Winsor Brook near South Foster	0	([2])	[1]1.89	[1].377	.068	.028	0	0	0	0	0	.031	([2])	([2])	([2])
01115187	Ponaganset River at South Foster	.046	1.07	.686	.421	.248	.182	.124	.083	.074	.063	.053	.165	1.98	3.06	1.57
01115190	Dolly Cole Brook near Clayville	.004	[1]2.76	[1]1.20	[1].552	.217	.128	.067	.032	.019	.011	.006	.168	([2])	([2])	([2])
01115270	Hemlock Brook near Clayville	.034	[1].935	[1].570	[1].336	.187	.140	.103	.071	.055	.046	.037	.159	[1]2.43	([2])	[1]1.68
01115400	Kent Brook at Waterman Four Corners	.012	[1].940	.542	.301	.157	.102	.065	.037	.029	.022	.016	.108	[1]2.53	[1]3.86	[1]1.69
	STATIONS ON STREAMS TRIBUTARY TO PAWTUCKET RESERVOIR SYSTEM															
01113670	Burnt Swamp Brook at Grants Mills	0.001	[1]3.91	1.24	0.326	0.078	0.035	0.016	0.005	0.003	0.002	0.001	0.037	([2])	([2])	[1]16.1
01113695	Catamint Brook at Diamond Hill	0	.829	.571	.371	.240	.194	.166	0	0	0	0	.226	1.91	2.86	1.46
01113710	Ash Swamp Brook at Diamond Hill	.075	.554	.434	.313	.219	.178	.142	.108	.099	.092	.082	.169	[1].819	[1]1.08	.723
	STATIONS ON OTHER STREAMS IMPORTANT FOR WATER SUPPLY															
01111261	Clear River at Laurel Hill	0.031	[1]4.65	[1]2.44	1.18	0.535	0.346	0.236	0.126	0.087	0.061	0.041	0.386	([2])	([2])	[1]11.0
01111262	Brandy Brook near Chepachet	.002	([2])	[1]28.9	[1]5.59	.987	.362	.115	.031	.016	.008	.004	.428	([2])	([2])	([2])
01111330	Clear River at Oakland	.052	[1]2.83	[1]1.70	.959	.501	.370	.261	.157	.120	.089	.065	.392	[1]7.41	[1]12.8	[1]5.45
01111410	Chepachet River at Gazzaville	.205	[1]1.59	1.23	.872	.615	.513	.415	.318	.277	.251	.220	.508	[1]2.51	[1]3.08	[1]2.21
01111470	Tarkiln Brook at Oak Valley	.120	[1]1.64	1.20	.819	.535	.426	.349	.251	.207	.175	.142	.448	[1]3.06	[1]4.48	[1]2.51
01114400	Stillwater River at Spragueville	.132	[1]1.32	.930	.667	.450	.364	.279	.202	.178	.155	.140	.357	[1]2.25	[1]2.95	[1]1.86
01126224	Moosup River near Fairbanks Corner	0	[1]2.77	[1]1.45	[1].683	.321	.221	.141	.080	.060	.048	0	.225	([2])	([2])	([2])

[1]Estimates are more than twice the value of the highest measurement made and are approximate only.

[2]Estimates were discarded because they were more than 20 times the highest measurement made and therefore considered unreliable.

Although the flows at these stations vary greatly, three generalizations can be made. First, the 7Q10 at all sites except Burnt Swamp Brook was always less than the 99-percent flow duration but was never more than 40 percent less than the 99-percent flow duration. Second, the difference between the mean daily flow for August and the 85-percent flow duration was never more than 30 percent. And third, the mean daily flows for February, April, and May were always greater than the 50-percent flow duration. These patterns are consistent and probably can be used to assess naturally flowing streams throughout northern Rhode Island.

SUMMARY

Rhode Island is dependent on streams in the northern part of the State for water supply. Streamflow data were collected at 18 stations on these streams. Low-flow characteristics were estimated for 18 of these stations by correlating them with index stations using the MOVE.1 and logistic regression methods. The 7Q10; flows ranging from 50- to 99-percent duration; and mean daily flows for August, February, April, and May are presented for the 18 stations. The largest tributary to the Scituate Reservoir at low flow was the Ponaganset River with a 7Q10 of 0.56 ft^3/s. The largest tributary to the Pawtucket Reservoir system at low flow was Ash Swamp Brook with a 7Q10 of 0.31 ft^3/s. Although the low-flow characteristics varied greatly from station to station, the 99-percent flow duration generally is similar to the 7Q10, and the 85-percent flow duration is similar to the mean daily flow for August. The mean daily flows for February, April, and May were always greater than the 50-percent flow duration.

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