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Flow-Frequency Characteristics of Vermont Streams

Water-Resources Investigations Report 02-4238

U.S. Department of the Interior
U.S. Geological Survey

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By Scott A. Olson

U.S. GEOLOGICAL SURVEY

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Pembroke, New Hampshire
2002

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CONVERSION FACTORS

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Area	
square mile (mi^2)	2.589	square kilometer (km^2)
	Volume	
cubic feet (ft^3)	0.02832	cubic meter (m^3)
	Volume per unit time (includes flow)	
cubic feet per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic feet per square mile (ft^3/mi^2)	0.01094	cubic meter per square kilometer (m^3/km^2)

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

$$^{o}C=(^{o}F-32)/1.8.$$

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

The safe and economical design of infrastructure in and near waterways and the effective management of flood-hazard areas require information on streamflow that may not be readily available. This report provides estimates of flow-frequency characteristics for gaged streams in Vermont and describes methods for estimating flow-frequency characteristics for ungaged streams. The flow-frequency characteristics investigated are the magnitude of peak discharges at recurrence intervals of 2, 5, 10, 25, 50, 100, and 500 years, and the magnitude of daily-mean discharges exceeded 25, 50, and 75 percent of the time.

Peak-flow frequency characteristics for gaged streams were computed following the guidelines in Bulletin 17B of the U.S. Interagency Advisory Committee on Water Data. To determine the peak-flow exceedance probabilities at stream-gaging stations in Vermont, a new generalized skew coefficient map for the State was developed. This new map has greater resolution and more current data than the existing National map. The standard error of the new map is 0.269.

Two methods of extending streamflow record were applied to improve estimates of peak-flow frequency for streams with short flow records (10 to 15 years) in small drainage areas (sites less than 15 square miles). In the first method, a two-station comparison, data from a long-record site was used to adjust the frequency characteristics at the short-record site. This method was applied to 31 crest-stage gages—stations at which only instantaneous peak discharges are determined—in Vermont. The second method used rainfall-runoff modeling. Precipitation and evapotranspiration data from 1948 to 1999 for numerous climate data-collection sites were used as input to a model to simulate flows at 10 stream-gaging stations in Vermont.

Also, methods are described to estimate flow-frequency characteristics for ungaged and unregulated rural streams in Vermont. The peak-flow estimating methods were developed by generalized-least-squares regression procedures with data from 138 U.S. Geological Survey stream-gaging stations in Vermont and in adjacent areas of New York, New Hampshire, Massachusetts, and Quebec. The flow-duration (daily flow exceeded a given percentage of the time) estimating methods were developed by ordinary-least-squares regression procedures with data from 81 stream-gaging stations in Vermont and adjacent states.

INTRODUCTION

Estimates of the magnitude and frequency of streamflow are needed to safely and economically design bridges, culverts, and other structures in or near streams. These estimates also are used for managing floodplains, identifying flood-hazard areas, and establishing flood-insurance rates, but these estimates often are required at ungaged sites where no observed flood data are available for frequency analysis. To address this need, the U.S. Geological Survey (USGS), in cooperation with the Vermont Agency of Transportation (VTrans), developed a study to estimate the peak-flow and selected flow-duration characteristics for ungaged streams in Vermont.

This report (1) provides estimates of peak-flow magnitudes for recurrence intervals of 2, 5, 10, 25, 50, 100, and 500 years, and estimates of the 25-, 50-, and 75-percent-flow duration (daily discharges exceeded 25, 50, and 75 percent of the time) for gaged streams in Vermont; and (2) describes equations developed from regression analyses for estimating these flow magnitudes on ungaged, unregulated, rural Vermont streams.

Several investigations that provide equations for estimating peak-flow characteristics applicable to Vermont have been published. These include Benson (1962), Potter (1957a and b), Johnson and Tasker (1974), and Dingman and Palaia (1999). The estimates and estimating methods described in this report provide more accurate estimates of flow frequency than previous studies because of the additional flow data now available and improved statistical procedures.

The author thanks the following USGS colleagues for their help or guidance in analyzing and reviewing the data used in this study: Gary D. Tasker, William H. Kirby, Craig M. Johnston, and Laura Hayes.

STREAMFLOW DATA USED IN THIS STUDY

All streamflow data in Vermont and adjacent, physiographically similar areas of New Hampshire, New York, Massachusetts, and Quebec, collected by the USGS, the U.S. Forest Service, the U.S. Army Cold Regions Research and Engineering, and Environment Canada were considered for this study. These data included records from continuously recording stream-gaging stations and partial-record crest-stage gages, both current (2002) and discontinued.

Of the many sites considered, 138 stream-gaging stations were selected for use in this study (fig. 1; table 1, back of report). The selection criteria included a requirement of a minimum of 10 years of unregulated streamflow record unaffected by hydrologic or climatic trends or urbanization. Whether or not a station met the regulation criterion depended on the flow-frequency characteristics being investigated. For the purposes of the peak-flow frequency analysis, regulation was assumed to have a negligible effect on flood flows if the usable storage in the basin was less than 4.5 million ft^3/mi^2 of drainage area (Benson, 1962). Peak-flow data from sites that had usable storage greater than 4.5 million ft^3/mi^2 of drainage area were not used. Site selection for the flow-duration (daily flows exceeded a given percentage of the time) analyses was more restrictive when considering regulation. For the flow-duration analyses, regulated sites were not included except in cases where the regulation was slight, such as regulation that may cause only diurnal fluctuations.

To maximize the number of stream-gaging stations included in the analyses, data from a station on a regulated stream was used if the station record included a period of at least 10 years when flows were unregulated. In these cases, only the data for the unregulated period were used to estimate flow frequencies. Thus, the flow-frequency estimates for several stations (tables 2 and 3, back of report) do not represent current regulated-flow conditions, but still provide valuable data for the regression analyses.

In addition to the unregulated streamflow data from sites that are now regulated, some peak discharges were estimated for sites currently affected by flood control. These sites were computed as if flood-control operations did not exist and were included as “historical” peaks in the peak-flow frequency analysis (table 2). These peak-flow estimates, provided by Greg Hanlon (U.S. Army Corps of Engineers, written commun., 1999), were based on the rate a flood reservoir filled during a major flood, such as the 1973 or 1987 floods.

Crest-stage gages are sites at which only the instantaneous peak discharge is determined. In Vermont, crest-stage gages are commonly located on streams with drainage areas of 10 mi^2 or less, thus providing annual peak-flow data for basins with sizes not represented by the continuously recording gages. Furthermore, 29 discontinued gages, used in the analysis by Johnson and Tasker (1974), were re-established as crest-stage gages for this study, and 2 additional years of peak-flow data were collected. Because only the instantaneous peak discharge is available at crest-stage gages, they cannot be used for determining flow duration, which is computed from daily discharge data. With this limitation, plus the more restrictive criteria on regulation, the number of stations used in the flow-duration analyses were limited to 81 of the 138 stations used in the peak-flow analyses (table 3).

Figure 1. Distribution of stream-gaging stations used to determine flow characteristics for Vermont streams.

To ensure that increasing or decreasing trends in the streamflow data did not exist, a two-sided Kendall Tau trend test (Helsel and Hirsch, 1992) was completed. The trend test was done with a program developed by the USGS called SWSTAT, a Computer Program for Interactive Computation of Surface-Water Statistics (A.M. Lumb, W.O. Thomas, Jr., and K.M. Flynn, U.S. Geological Survey, written commun., 1994). Trends were not tested on stream-gaging stations with less than 15 years of annual peak-flow data because a trend over a period of record this short cannot be distinguished from serial correlation. No significant trends were found for the stream-gaging station data utilized in this study.

RECORD EXTENSION

Two record-extension methods were used to improve the estimates of the peak-streamflow statistics at sites with relatively short record (10 to 15 years). In the first method, the frequency characteristics of data from a stream-gaging station with a short record were adjusted by use of statistics from a nearby, hydrologically similar, station with a longer period of record (U.S. Interagency Advisory Committee on Water Data, 1982). The second method used a rainfall-runoff model to focus on high-intensity storms that are generally the major causes of flood peaks on small upland drainage basins in Vermont. Rainfall-runoff models were developed for 10 Vermont drainage basins in which 15-minute rainfall was simultaneously recorded with streamflow by the USGS from 1964 to 1974 (fig. 2). These simultaneous records allowed calibration of the models. The calibrated models were then used to simulate streamflow record from 1948 to 1964, and from 1974 to 1999, at these 10 stations by use of climate data from hydrologically appropriate rain gages and pan-evaporation sites.

Record Extension Using Two-Station Comparison

By using a two-station comparison (U.S. Interagency Advisory Committee on Water Data, 1982), records were extended for 31 short-record crest-stage gages. Application of the two-station comparison method of record extension involves adjusting the logarithmic mean and standard deviation of a short-record stream-gaging station with statistics from a long-record station. The long-record station must be on an unregulated, rural stream. The data for the short- and long-record stream-gaging stations must show a significant correlation during their concurrent period. Minimum allowable correlation coefficients varied depending on the length of the concurrent record. The minimum correlation coefficient ranged from 0.65 for 10 years of concurrent record to 0.54 for 15 years of concurrent record. This is the minimum requirement set by the U.S. Interagency Advisory Committee on Water Data (1982) for improving the standard deviation of peaks from a short-record site. This requirement is more stringent than the requirement for improving the mean of the peaks. Peak-flow characteristics of the 31 stream-gaging stations where this method was applied are in table 2 (back of report).

Record Extension Using Rainfall-Runoff Modeling

The USGS collected simultaneous 15-minute streamflow and precipitation data at 10 stations in Vermont from 1964 to 1974 (fig. 2). Precipitation data were not collected from December to March of these years because of freezing conditions. These data were used to calibrate rainfall-runoff models. The calibrated models then were used to extend the streamflow record beyond the 1964-74 data-collection period. Precipitation and pan-evaporation data from climate data-collection sites (fig. 2) operated by the National Oceanic and Atmospheric Administration (NOAA) were used as model input when simulating the extended streamflow record. The following 10 modeled sites were well distributed around Vermont: (1) Kirby Brook at Concord, (2) Kent Brook near Killington, (3) Sacketts Brook near Putney, (4) Flood Brook near Londonderry, (5) Beaver Brook at Wilmington, (6) Mettawee River Tributary near Pawlet, (7) Lewis Creek Tributary at Starksboro, (8) Sunny Brook near Montpelier, (9) Stony Brook near Eden, and (10) Brownington Branch near Evansville. All modeled sites were in rural, upland drainage basins. Drainage areas for the 10 sites ranged from 2.1 to 10.1 mi^2, mean-basin altitudes ranged from 990 to 2,340 ft, main channel slopes ranged from 115 to 432 ft/mi, and mean-annual precipitation ranged from 40 to 55 in.

Figure 2. Location of the U.S. Geological Survey (USGS) stream-gaging stations, where streamflow and precipitation data were simultaneously collected, and the National Oceanic and Atmospheric Administration (NOAA) climate data-collection stations that were used for modeling the extended streamflow record.

Observed Data Used for Model Calibrations

Daily-mean discharge and precipitation data from the 11-year period of data collection by the USGS were used as input to the model for non-storm periods. Instantaneous 15-minute discharge and precipitation data were used for storms. A rain event was considered to be a storm if 1 in. or more of rain fell in 24 hours. Some storms were not used in the calibration if the rainfall data from the storm were not representative of the rain over the basin. For example, data for a particular storm were not used if runoff exceeded the rainfall, or if rainfall was greater than 10 times the runoff. The 15-minute and daily rainfall data were compared to data at nearby climate stations for quality assurance. Missing daily-rainfall totals were estimated with data from nearby rain gages.

Daily-evaporation data also were required input for calibrating the rainfall-runoff models. Continuous evaporation data for Vermont from 1964 to 1974 are not available. Instead, daily evaporation data from the three closest pan-evaporation stations operated by NOAA—Massebesic Lake, N.H.; Lakeport, N.H.; and Alcove Dam, N.Y.—were averaged and used for model calibration.

Table 4. Precipitation-runoff modeling system modules used in rainfall-runoff modeling

Module name	Function
Precip_prms	Distributes precipitation over basin
Smbal_prms	Soil moisture accounting including infiltration, evapotranspiration, and seepage
Grnampt_infil_prms	Computes infiltration during storms using a modified Green and Ampt equation
Intcp_prms	Computes the amount of precipitation intercepted by vegetation and the evaporation from intercepted precipitation
Potet_ep_not_prms	Computes potential evapotranspiration using the pan-evaporation data
Srunoff_smidx_prms	Computes surface runoff and infiltration
Ssflow_prms	Computes subsurface flow including inflow and outflow to ground water and streamflow
Gwflow_prms	Computes ground-water flow including inflow and outflows
Krout_ofpl_prms	Kinematic flow routing of overland flow
Krout_chan_prms	Kinematic flow routing of channel flow
Strmflow_st_prms	Calculates daily streamflow and individual storm flows

Rainfall-Runoff Model and Input Parameters

The rainfall-runoff modeling program used to simulate streamflow records was the Modular Modeling System (MMS) (Leavesley and others, 1996). The MMS is not a model, but a framework and graphical-user interface for any model. Given a specific hydrologic problem, the MMS user can select established modules or subroutines that are hydrologically appropriate. In this study, the selected modules are primarily from the Precipitation-Runoff Modeling System (PRMS) (Leavesley and others, 1983). Some of the principal subroutines used for modeling are listed in table 4. The model will be referred to as PRMS in this report.

The PRMS is a deterministic, physical-process modeling system designed to reproduce the hydrologic system as realistically as possible. It simulates basin response to normal and extreme precipitation through water-balance relations including base flow, storm runoff, evapotranspiration, ground-water recharge, and other components of the hydrologic cycle. Each component of the hydrologic cycle is expressed in the form of known physical laws or empirical relations that have some physical interpretation based on measurable drainage-basin characteristics. Variations in drainage-basin characteristics, such as slope, aspect, vegetation, altitude, and soil type, also are accounted for in PRMS. In addition, kinematic routing of the runoff through a network of channel reaches is simulated when the model is in storm mode (Leavesley and others, 1983).

The drainage-basin characteristics used as input into the model were determined with a computer software called GIS Weasel (R.J. Viger, S.L. Markstrom, G.H. Leavesley, and D.W. Stewart, U.S. Geological Survey, written commun., 1996). The GIS Weasel, a graphical-user interface for a geographical information system (GIS), aids in the delineation of basin characteristics required by PRMS. The GIS Weasel also divides the modeled basin into subbasins called hydrologic-response units. The GIS Weasel requires a digital-elevation model (DEM) of the basin. The DEM used in this application is the USGS National Elevation Dataset (U.S. Geological Survey, 2001b). Grids of attribute data also are needed to determine other basin characteristics required by the model. The attribute data used were the State Soil Geographic Database (STATSGO) soil characteristics for the conterminous United States (U.S. Geological

Survey, 1997), the Forest Land Distribution Data for the United States (U.S. Forest Service, 1992), and the Global Land Cover Characterization (U.S. Geological Survey, 2001a).

Once determined, the basin characteristics were entered into the models. Models were calibrated by adjusting some of these characteristics or parameters. The modeling system contains subroutines for calibration, which automatically optimizes selected parameters to correlate the observed and simulated streamflow. Selected optimized basin characteristics for use in the calibrated models are listed in table 5 (back of report). The standard error of estimate for each calibrated model, computed from the observed and simulated storm peaks, is shown in table 6.

Simulation of Streamflow Record

Streamflow was simulated for the 10 modeled stream-gaging stations by use of the calibrated models. The optimized parameter sets were used with the NOAA rainfall and evaporation data as model input to generate daily streamflow data and stormflow hydrographs. The annual instantaneous peak discharge was selected from the output. The simulated periods of record were water years 1948-63 and 1975-99.

The rainfall data used as model input for the simulation were from selected NOAA climate data-collection stations. The station selected to represent rainfall in a particular modeled basin was based on how well its daily rainfall data correlated with the concurrent daily rainfall data from the rain gage operated by the USGS at the station location being modeled. Correlation coefficients ranged from 0.61 to 0.86. If data from more than one NOAA rain gage correlated well with this USGS rain gage, the final selection for inclusion in the simulation was based on similarities between altitudes and between the mean-annual precipitations from an isohyets map (Randall, 1996) at the location of the NOAA rain gage and the location of the basin that required record extension (table 7).

Selected NOAA rain gages were not in the modeled basin they were representing; therefore, adjustments were necessary to accurately represent the rainfall on the modeled basin. Because each selected NOAA rain gage had a record that correlated well with concurrent rainfall data from a USGS station, a simple linear regression was considered a possibility for adjusting the NOAA data. Forcing the *y*-intercept to be zero (no rain at either gage) resulted, however, in unreasonable relations between the gages and was not considered an acceptable adjustment. An alternative method similar to a double-mass analysis (Dingman, 1994) was used with rainfall from the concurrent period of record accumulated at a daily time step. This adjustment was computed as the average ratio of accumulated rainfall for all days of concurrent record. Final adjustments and the NOAA rain gages selected for each modeled basin are shown in table 7. The adjustments were applied to daily and storm data.

Because NOAA rain-gage data previous to 1948 were not available in an electronic format, which was necessary to accommodate the model, the start of simulation period was limited to that date. Most of the NOAA rainfall data were available at an hourly time step. A 15-minute time step, however, was desired for model input. A disaggregation model (Ormsbee, 1989) was coded in FORTRAN, a computer-programming language, to convert the hourly rainfall data to 15-minute data during storms.

Daily-evaporation data for the simulation also were required input for the models. Because continuous evaporation data from Vermont are limited, available daily data from the five closest pan-evaporation stations operated by NOAA were averaged

Table 6. Accuracy of rainfall-runoff models for the 10 stream-gaging stations where the models were used

[No., number]

Stream-gaging station No.	Station name	No. of peaks	Standard error of estimate (logarithmic units)
01134800	Kirby Brook at Concord, Vt.	16	0.503
01150800	Kent Brook near Killington, Vt.	30	.249
01155200	Sacketts Brook near Putney, Vt.	22	.449
01155300	Flood Brook near Londonderry, Vt.	19	.326
01167800	Beaver Brook at Wilmington, Vt.	17	.416
04280300	Mettawee River Tributary near Pawlet, Vt.	19	.368
04282700	Lewis Creek Tributary at Starksboro, Vt.	15	.477
04287300	Sunny Brook near Montpelier, Vt.	20	.312
04292100	Stony Brook near Eden, Vt.	19	.347
04296200	Brownington Branch near Evansville, Vt.	17	.352

Table 7. Rain gages used for record extension of each modeled U.S. Geological Survey stream-gaging station

[USGS, U.S. Geological Survey; NOAA, National Oceanic and Atmospheric Administration]

Modeled USGS streamgage	NOAA rain gage (period of record)	Mean-annual precipitation from isohyets map, in inches		Computed coefficient for adjusting NOAA data
		USGS site	NOAA site	
Kirby Brook at Concord, Vt.	St. Johnsbury, Vt.	37	37	1.155
Kent Brook at Killington, Vt.	Stockbridge, Vt. (1948-92)	50	43	1.170
	Pittsfield, Vt. (1992-99)	50	46	1.170
Sacketts Brook near Putney, Vt.	Grafton, Vt.	42	43	1.0
Flood Brook near Londonderry, Vt.	Stockbridge, Vt. (1948-92)	43	43	0.888
	Pittsfield, Vt. (1992-99)	43	46	.888
Beaver Brook at Wilmington, Vt.	Searsburg, Vt.	52	54	1.0
Mettawee River Tributary near Pawlet, Vt.	Whitehall, N.Y.	36	36	1.081
Lewis Creek Tributary at Starksboro, Vt.	Morrisville, Vt.	40	41	.973
Sunny Brook near Montpelier, Vt.	Morrisville, Vt.	38	41	.938
Stony Brook near Eden, Vt.	Morrisville, Vt.	50	41	1.121
Brownington Branch near Evansville, Vt.	Newport, Vt.	40	40	1.124

and used as input. These stations include Massebesic Lake, N.H. (1948-99); Lakeport, N.H. (1952-99); Alcove Dam, N.Y. (1948-77); Valatie, N.Y. (1978-92); and Essex Junction, Vt. (1972-99).

One disadvantage of the PRMS model, and all other models available at the time of this study, is that snowmelt cannot be computed when the model is in storm mode. Only a daily-time step can be solved for events involving snowmelt. Consequently, instantaneous peak flows associated with snowmelt could not be modeled, and the simulated peak-flow record was limited to events related to rainfall only. Even if snowmelt could be modeled at shorter intervals, the data needed for calibration—winter precipitation, temperature, and solar radiation—were incomplete.

Snowmelt-related events, however, may be left out of the frequency analysis without affecting the flood-frequency curves equal to or greater than a 10-year recurrence interval at unregulated stations in Vermont. This fact was discovered when comparing the exceedance-probability curves of annual peak discharges to annual non-snowmelt peak discharges of 22 unregulated stream-gaging stations in Vermont with drainage areas ranging from 2 to 310 mi^2. The exceedance-probability curves were estimated with the Weibull plotting position formula (Maidment, 1992). An example of how the probability curves compared is shown in figure 3. The curves in figure 3, and the curves from all but 1 of the 22 stations, converged at a recurrence interval of 25 years or less (exceedance probability of 4 percent or greater). At 18 of the 22 stations, the probability curves converged at a recurrence interval of 10 years or less (exceedance probability of 10 percent or greater).

Although most annual peaks on Vermont streams are snowmelt related, non-snowmelt peaks generally dominated the flood-frequency curve at recurrence intervals of 25 years and greater. Thus, the rainfall-runoff model results, without snowmelt floods, could be used to define the frequency curve. The average ratio between the annual maximum-discharge curve and annual maximum-non-snowmelt-discharge curve at the 2-, 5-, and 10-year recurrence intervals were 1.35, 1.15, and 1.00, respectively, when rounded to the nearest 0.05. The peakflow frequency curves for the 10 modeled sites were computed with observed and modeled non-snowmelt peaks. The 2- and 5-year flood discharges then were adjusted with the appropriate ratio to correct for the lack of snowmelt peaks.

FLOW-FREQUENCY CHARACTERISTICS AT STREAM-GAGING STATIONS

The 2-, 5-, 10-, 25-, 50-, 100-, and 500-year discharges for 138 streamflow-gaging stations used in this study (table 2) were computed using the guidelines in Bulletin 17B (U.S. Interagency Advisory Committee on Water Data, 1982). Bulletin 17B recommends the use of a log-Pearson Type III distribution for

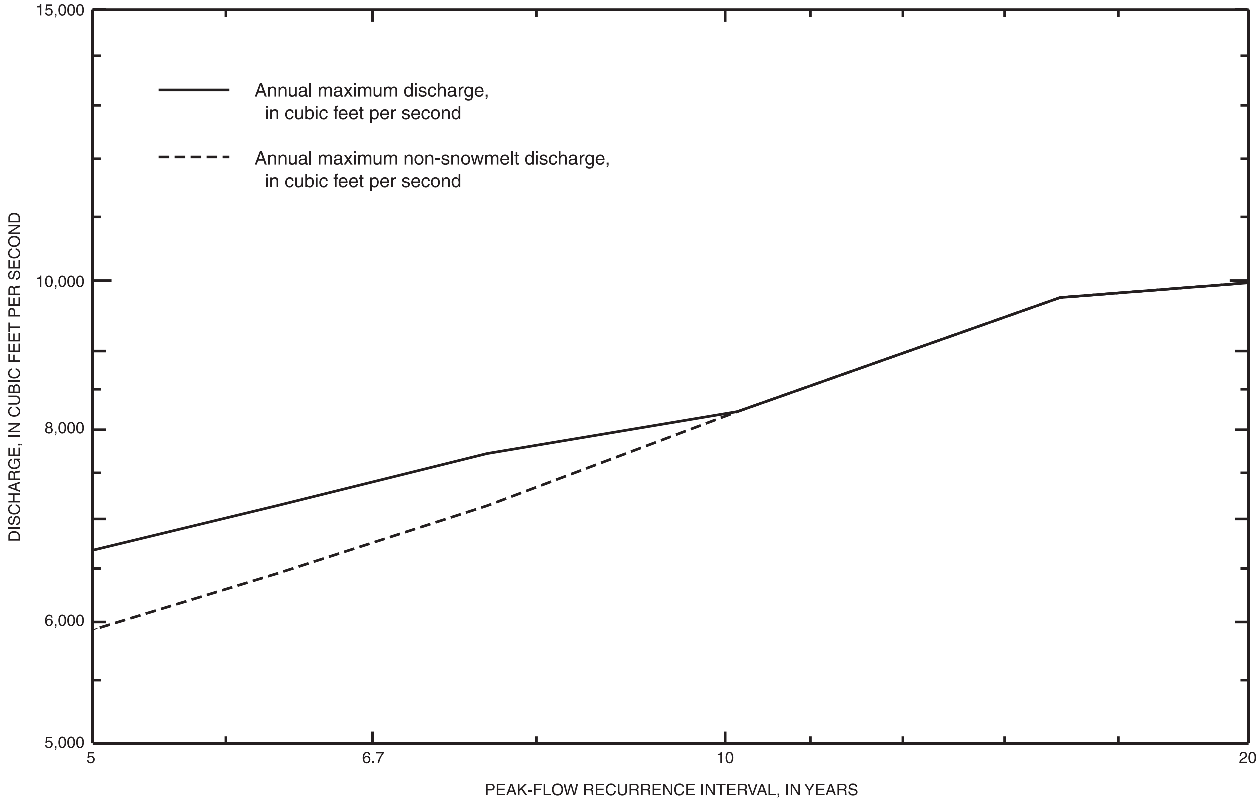


Figure 3. Annual maximum and non-snowmelt maximum frequency curves for Dog River at Northfield Falls, Vermont (stream-gaging station number 4287000).

estimating flow frequency, and provides procedures for weighting station skews, historical peaks, and detecting and treating outliers. Software developed by the USGS to analyze peak-flow frequency (PEAKFQ) was used for these computations (W.O. Thomas, Jr., A.M. Lumb, K.M. Flynn, and W.H. Kirby, U.S. Geological Survey, written commun., 1997).

Peak-flow frequency estimates are sensitive to skew—the measure of the lack of symmetry in a frequency distribution. Extreme floods commonly affect skews computed from a station record and the effect of an extreme flood on skew is greater the shorter the length of the record. To correct for this effect, the skew used in estimating peak-flow frequency characteristics at a stream-gaging station is weighted with a generalized skew estimated by pooling the information from nearby stations. The generalized skew can be taken from the generalized skew map in Bulletin 17B. That map, however, was prepared in 1976, so it lacks data from the past quarter century, and the resolution desired for the study area. Consequently, a new method for obtaining a generalized skew was developed.

Several methods were used to determine the most accurate generalized skew for Vermont, including statewide averages of skew and a multiple-regression analysis between skew and basin characteristics. The most accurate generalized skew was found after developing a new generalized skew map by use of a GIS software ARC/INFO TREND command (Environmental Systems Research Institute, Inc., 1994). This ARC/INFO command interpolates trends on a dataset of points and provides results that can be converted into a contour map. This point dataset contained skews of stream-gaging stations with greater than 30 years of record. The skews were adjusted for bias (Tasker and Stedinger, 1986) and located at the centroid of the respective basin. The resulting map was then manually smoothed to remove unrealistic changes in the contours representing generalized skew. The final generalized skew map (fig. 4) has a standard error of prediction of 0.269, a small improvement over the standard error of prediction (0.283) of the National isoline skew map for Vermont (U.S. Interagency Advisory Committee on Water Data, 1982).

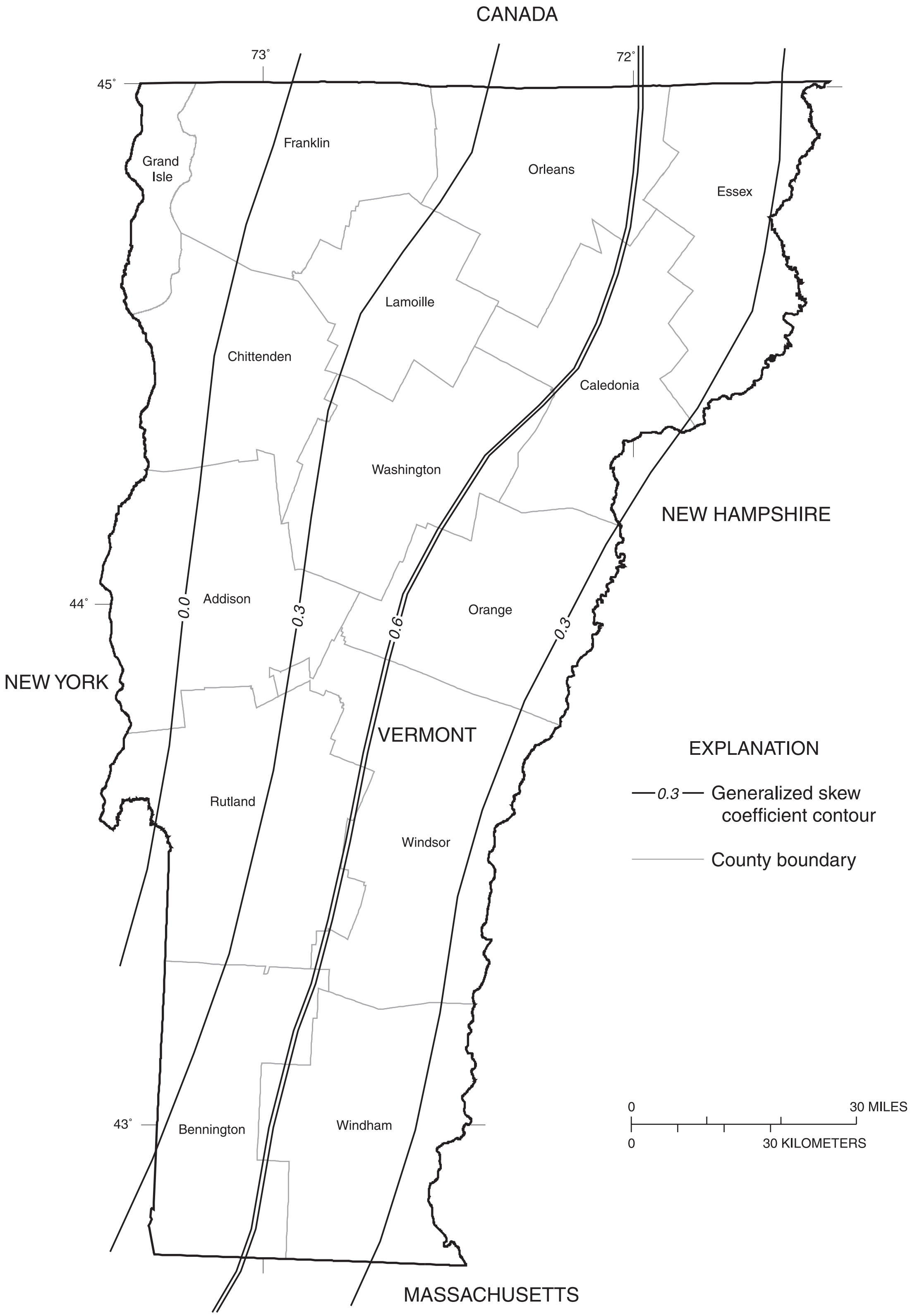


Figure 4. Generalized skew coefficients of logarithms of annual maximum streamflow in Vermont.

The daily discharges exceeded 25, 50, and 75 percent of the time at 81 stream-gaging stations (table 3) were computed by use of the software program SWSTAT (A.M. Lumb, W.O. Thomas, Jr., and K.M. Flynn, U.S. Geological Survey, written commun., 1994). The SWSTAT program does flow-duration analyses by counting occurrences of all daily-discharge values within flow intervals. All data used in the flow-duration analyses were from sites with unregulated discharge.

DRAINAGE-BASIN CHARACTERISTICS

In flow-frequency analysis, the variations in flow-frequency characteristics are related to variations in drainage-basin characteristics through regression analysis. In this study, the flows are the dependent variables and the basin characteristics are the independent, or explanatory, variables. For this study, more than 100 basin characteristics were determined for each stream-gaging station. These included dimensional characteristics such as drainage area, channel slope, channel length, lake area, and altitude; physical properties such as forest cover and permeability; and climatic characteristics such as precipitation and temperature.

When appropriate GIS datasets were available, basin characteristics were delineated with scripts written in Avenue computer programming language or Arc Macro Language (Environmental Systems Research Institute, Inc., 1994), with the computer software GIS Weasel (R.J. Viger, S.L. Markstrom, G.H. Leavesley, and D.W. Stewart, U.S. Geological Survey, written commun., 1996) or Basinsoft (Harvey and Eash, 1995). Basinsoft is a computer program written by the USGS in Arc Macro Language to use digital cartographic data for quantifying useful morphometric characteristics. The source datasets for computing dimensional basin characteristics were the National Elevation Dataset (U.S. Geological Survey, 2001b) and the National Hydrography Dataset (U.S. Geological Survey, 2001c). The National Land Cover Dataset (U.S. Geological Survey, 2000) and STATSGO soil characteristics (U.S. Geological Survey, 1997) were the source datasets for land-surface properties. The data source for climate data was PRISM (Parameter-elevation Regressions on Independent Slopes Model) (Daly, 2000). Several basin characteristics that had no GIS coverage, such as the 24-hour rainfall with a 2-year recurrence interval (Wilks and Cember, 1993), were delineated manually.

FLOW-FREQUENCY CHARACTERISTICS AT UNGAGED STREAMS

Multiple-regression methods, employing generalized least squares, were used to define relations between basin characteristics and flood peaks at the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval and to develop the equations to estimate peak-flow characteristics at ungaged streams. The use of generalized least squares allows for weighting of streamflow data to compensate for the differences in record length and the cross-correlation of concurrent record among stream-gaging stations. Furthermore, Stedinger and Tasker (1985) showed that generalized least-squares regression equations are more accurate and provide better estimates of model error than ordinary least-squares regression equations.

Regression Analyses

More than 100 drainage-basin characteristics were determined for each stream-gaging station used in the regression analysis. Logarithmic transformations of each basin characteristics doubled this number. In the first step of the peak-flow regression analysis, stepwise linear regression (Mathsoft, Inc., 1999) was used to reduce about 200 characteristics to approximately 12 basin characteristics. Next, generalized least-squares-regression methods were used to determine the final basin characteristics and to compute the final regression equations. The generalized least-squares-regression analysis was completed with GLSNET, a hydrologic regression and streamflow-network analysis computer program that uses generalized least squares (G.D. Tasker, K.M. Flynn, A.M. Lumb, W.O. Thomas, Jr., U.S. Geological Survey, written commun., 1995). The basin characteristics used in the final regression equations for estimating peak-flow characteristics are included in table 8 (back of report). Regression equations used with metric units are listed in appendix 1. The final regression equations (equations 1-7) for estimating peak flows on ungaged, unregulated streams in rural drainage basins in Vermont are as follows:

$$Q_2 = 38.1A^{0.914}L^{-0.294}E^{0.0776}Y^{-0.180}, \quad (1)$$

$$Q_5 = 61.8A^{0.902}L^{-0.295}E^{0.0835}Y^{-0.253}, \quad (2)$$

$$Q_{10} = 79.7A^{0.897}L^{-0.302}E^{0.0890}Y^{-0.298}, \quad (3)$$

$$Q_{25} = 106A^{0.883}L^{-0.316}E^{0.104}Y^{-0.349}, \quad (4)$$

$$Q_{50} = 129A^{0.874}L^{-0.327}E^{0.115}Y^{-0.385}, \quad (5)$$

$$Q_{100} = 153A^{0.865}L^{-0.336}E^{0.125}Y^{-0.420}, \text{ and} \quad (6)$$

$$Q_{500} = 217A^{0.846}L^{-0.355}E^{0.148}Y^{-0.497}. \quad (7)$$

where

Q_n is the calculated peak flow for recurrence interval n, in cubic feet per second;

A is the drainage area of the basin, in square miles, delineated with a GIS (boundaries for the drainage areas were from a 14-digit hydrologic unit coverage (Natural Resources Conservation Service, 1996) or digitized when a basin's boundary was not defined by this GIS coverage);

L is the area of lakes and ponds in a basin as a percentage of drainage area, plus 1 percent, determined with a GIS from the 1:24,000 scale National Hydrography Dataset (U.S. Geological Survey, 2001c) and includes all features in the dataset having lake or pond boundaries, even ones as small as several hundreths of an acre and pooled areas of streams;

E is the percent of the basin at or greater than 1,200 ft in altitude, plus 1 percent, computed from the National Elevation Dataset (U.S. Geological Survey, 2001b) with a GIS; and

Y is the northing of the centroid of the drainage basin determined with a GIS, in the Vermont State Plane coordinate system, divided by 100,000, then increased by 1.0.

An attempt was made to group stream-gaging stations into subregions having similar geographic, peak-flow, or drainage-basin characteristics to reduce the standard error of the regression equations for each region. Residuals, the difference between observations and predictions, were determined for each station and plotted spatially in relation to flow and basin characteristics. No trends or patterns were found; therefore, the stations were not divided into subregions and the equations described in this report are intended for statewide use.

The regression analysis for the daily flows exceeded 25, 50, and 75 percent of the time was completed following the same procedures used to develop the peak-flow regression equations. The final regression equations, however, were determined with ordinary least-squares-regression methods (SAS Institute Inc., 1990). The final regression equations (equations 8-10) for estimating flow duration on ungaged, unregulated streams in rural drainage basins in Vermont are as follows:

$$D_{75} = 0.000627A^{1.08}P^{1.55}E^{0.101}, \quad (8)$$

$$D_{50} = 0.00152A^{1.04}P^{1.58}E^{0.0603}, \text{ and} \quad (9)$$

$$D_{25} = 0.00431A^{1.01}P^{1.55}E^{0.0438}. \quad (10)$$

where

D_n is the estimated daily discharge exceeded n percent of the time, in cubic feet per second;

A is the drainage area of the basin, in square miles, delineated with a GIS (boundaries for the drainage areas were from a 14-digit hydrologic-unit coverage (Natural Resources Conservation Service, 1996) or digitized when a basin's boundary was not defined by this GIS coverage);

P is the basinwide mean of the mean-annual precipitation, in inches, determined with a GIS and the PRISM dataset (Daly, 2000), resampled with bilinear interpolation to a 30-m-cell resolution with the GIS, ARC/INFO RESAMPLE command (Environmental Systems Research Institute, Inc., 1994). Precipitation data from Canada (Ghislain Jacques, Environment Quebec, written commun., January 17, 2002) were used along the northern Vermont border where the PRISM data are not available); and

E is the percentage of the basin that is equal to or greater than 1,200 ft in altitude, plus 1 percent, computed from the National Elevation Dataset (U.S. Geological Survey, 2001b) with a GIS.

Accuracy and Limitations

The standard error of residuals (the difference between actual and predicted values) for each regression equation is shown in table 9. The standard error of residuals is a measure of how the observed data deviate from the regression results and is an approximation of how well the regression equations will estimate streamflow. The probability that the discharge value of streamflow at a given recurrence interval is between the positive-percent and negative-percent standard error of residuals estimate is approximately 68 percent. For example, there is a 68-percent chance that the true 10-year discharge at a site is between +49.7 percent and –33.2 percent of the estimated 10-year discharge.

Basin characteristics used to develop equations 1 through 10 were determined with a GIS (table 8, back of report). Basin characteristics that had been determined manually, without a GIS, were eliminated during the stepwise linear-regression step because they were insignificant as explanatory variables. Determining the basin characteristics with alternative data sources, or without a GIS for use in the regression equations, may introduce bias and produce flow estimates that have errors outside the ranges shown in table 9. Appendixes 2-4 show areas of Vermont equal to or greater than 1,200 ft, the northing of the Vermont State Plane coordinate system used in GIS, and the mean-annual precipitation.

The regression equations are applicable only to sites on ungaged, unregulated streams in rural Vermont drainage basins. Use of the equations should also be limited to sites with basin characteristics that are within the range of explanatory variables used in the development of the equations. The ranges of basin characteristics used in the analysis are shown in table 10. If explanatory variables used in the regression equations were outside of these ranges, the accuracy of the predictions of flow frequency decreased.

Table 9. Standard error or residuals of the regression equations for estimating flow frequencies on ungaged, unregulated streams in rural drainage basins in Vermont

Flow-frequency characteristic	Standard error of estimate	
	(in log units)	(in percent)
Peak flow with 2-year recurrence interval	0.171	48.4 to –32.6
Peak flow with 5-year recurrence interval	.170	48.0 to –32.4
Peak flow with 10-year recurrence interval	.175	49.7 to –33.2
Peak flow with 25-year recurrence interval	.182	52.0 to –34.2
Peak flow with 50-year recurrence interval	.190	54.9 to –35.4
Peak flow with 100-year recurrence interval	.200	58.4 to –36.9
Peak flow with 500-year recurrence interval	.227	69.0 to –40.8
Daily discharge exceeded 75 percent of the time	.0540	13.2 to –11.7
Daily discharge exceeded 50 percent of the time	.0832	21.1 to –17.4
Daily discharge exceeded 25 percent of the time	.124	33.2 to –24.9

Table 10. Range of explanatory variables used in the development of the regression equations for estimating flow-frequency characteristicis of ungaged, unregulated streams in Vermont

Equation and explanatory variable	Minimum	Maximum	Mean
Peak flow, drainage area (square miles)	0.211	850	96.8
Peak flow, percent lake area	0	6.86	.641
Peak flow, percent of basin greater than 1,200 feet in altitude	0	100	58.9
Peak flow, centroid northing (Vermont State Plane)	-87	296,194	151,420
Flow duration, drainage area (square miles)	2.09	850	148
Flow duration, mean-annual precipitation (inches)	32.8	63.8	44.5
Flow duration, percent of basin greater than 1,200 feet in altitude	0	100	63.8

SUMMARY AND CONCLUSIONS

This report, prepared by the U.S. Geological Survey in cooperation with the Vermont Agency of Transportation, describes flow-frequency characteristics of rural Vermont streams. The magnitudes of daily-mean discharges exceeded 25, 50, and 75 percent of the time were computed at 81 stream-gaging stations in and adjacent to Vermont. The magnitude of peak flows at recurrence intervals of 2, 5, 10, 25, 50, 100, and 500 years were determined for 138 stream-gaging stations with unregulated streamflow data. Record-extension methods were applied to improve the peak-flow frequency characteristics on 41 short-record length (10 to 15 years) stream-gaging stations in small basins (less than 10 mi^2). Two-station comparisons were used to extend the peak-streamflow record at 31 crest-stage gages, and rainfall-runoff modeling simulated 42 years of additional streamflow record at 10 stream-gaging stations that had only 10 years of record.

Equations for estimating peak flows at the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals and daily discharges exceeded 25, 50, and 75 percent of the time on ungaged, unregulated streams in Vermont are presented. These equations were developed by regression procedures between basin characteristics and flow-frequency characteristics of unregulated gaged streams.

SELECTED REFERENCES

Beard, L.R., 1960, Probability estimates based on small normal-distribution samples: Journal of Geophysical Research, v. 65, no. 7, p. 2,143-2,148.

Bedient, P.B., and Huber, W.C., 1988, Hydrology and floodplain analysis: Reading, Mass., Addison-Wesley Publishing Co., 650 p.

Benson, M.A., 1962, Factors influencing the occurrence of floods in a humid region of diverse terrain: U.S. Geological Survey Water-Supply Paper 1580-B, 64 p.

Daly, Christopher, 2000, PRISM (Parameter-elevation Regressions on Independent Slopes Model), U.S. Department of Agriculture and Natural Resources Conservation Service Climate Mapping Project: National Water and Climate Center, Oregon State University Partnership.

Dingman, S.L., 1994, Physical hydrology: New York, Macmillan Publishing Co., 575 p.

Dingman, S.L., and Palaia, K.J., 1999, Comparison of models for estimating flood quantiles in New Hampshire and Vermont: Journal of the American Water Resources Association, v. 35, no. 5, p. 1,233-1,243.

Environmental Systems Research Institute, Inc. (ESRI), 1994, ARC/INFO users guide, version 7.0: Redlands, Calif.

Harbeck, G.E., 1966, Reservoirs in the United States: U.S. Geological Survey Water-Supply Paper 1838, 115 p.

Hardison, C.H., 1971, Prediction error of regression estimates of streamflow characteristics at ungaged sites: U.S. Geological Survey Professional Paper 750-C, p. 228-236.

Hardison, C.H., and Jennings, M.E., 1972, Bias in computed flood risk, Proceedings: Journal of the Hydraulics Division, American Society of Civil Engineers, v. 98, no. HY3, p. 415-427.

Harvey, C.A., and Eash, D.A., 1995, Description, instructions, and verification for Basinsoft, a computer program to quantify drainage-basin characteristics: U.S. Geological Survey Water-Resources Investigations Report 95-4287, 25 p.

Helsel, D.R., and Hirsch, R.M., 1992, Statistical methods in water resources: New York, Elsevier Science Publishing Co., 522 p.

Jennings, M.E., Thomas, W.O., Jr., and Riggs, H.C., 1993, Regional regression equations for estimating magnitude and frequency of floods for ungaged sites: U.S. Geological Survey Water-Resources Investigations Report 94-4002, 189 p.

Johnson, C.G., and Tasker, G.D., 1974, Progress report on flood magnitude and frequency of Vermont streams: U.S. Geological Survey Open-File Report 74-130, 37 p.

Kirby, W.H., 1975, Model smoothing effect diminishes simulated flood peak variances: American Geophysical Union Transactions, v. 56, no. 6, p. 361.

Leavesley, G.H., Lichty, R.W., Troutman, B.M., and Saindon, L.G., 1983, Precipitation-runoff modeling system: User's manual: U.S. Geological Survey Open-File Report 83-4238, 207 p.

Leavesley, G.H., Restrepo, P.J., Markstrom, S.L., Dixon, M., and Stannard, L.G., 1996, The modular modeling system (MMS): User's manual: U.S. Geological Survey Open-File Report 96-151, 175 p.

Lichty, R.W., and Liscum, F., 1978, A rainfall-runoff modeling procedure for improving estimates of t-year (annual) floods for small drainage basins: U.S. Geological Survey Water-Resources Investigations Report 78-7, 44 p.

Maidment, D.R., 1992, Handbook of hydrology: New York, McGraw-Hill, Inc., 29 chap., variously paged.

Mathsoft, Inc., 1999, Guide to statistics, volume 1: Seattle, Wash., Data Analysis Products Division, v. 1, May, 638 p.

Natural Resources Canada, 2002, National Topographic Data Base, 1:50,000 scale, accessed May 13, 2002, at URL http://www.cits.rncan.gc.ca/.

Natural Resources Conservation Service, 1996, Watershed boundaries of Vermont based on U.S. hydrologic units, accessed December 21, 2001, at URL http://www.vcgi.org/pub/dataware/gisdata/layers_vcgi/WaterHydro_WATSHED.exe

Ormsbee, L.E., 1989, Rainfall disaggregation model for continuous hydrologic modeling: Journal of Hydraulic Engineering, v. 115, no. 4, p. 507-525.

Potter, W.D., 1957a, Peak rates of runoff in the Adirondack, White Mountains, and Maine Woods area: Bureau of Public Roads.

———1957b, Peaks rates of runoff in the New England hills and lowland area: Bureau of Public Roads.

Randall, A.D., 1996, Mean-annual runoff, precipitation, and evapotranspiration in the glaciated northeastern United States, 1951-80: U.S. Geological Survey Open-File Report 96-395, 2 pls.

Riggs, H.C., 1968a, Some statistical tools in hydrology: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, chap. A1, 39 p.

———1968b, Frequency curves: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, chap. A2, 15 p.

———1968c, Regional analyses of streamflow characteristics: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, chap. B3, 15 p.

SAS Institute Inc., 1990, SAS/STAT User's guide: Cary, N.C., version 6, 4th ed., v. 1 and v. 2, 1,686 p.

Stedinger, J.R., and Tasker, G.D., 1985, Regional hydrologic analysis 1. Ordinary, weighted, and generalized least squares compared: Water Resources Research, v. 21, no. 9, p. 1,421-1,432.

Tasker, G.D., and Stedinger, J.R., 1986, Regional skew with weighted LS regression: Journal of Water-Resources Planning and Management, v. 112, no. 2, p. 225-237.

Thomas, W.O., Jr., 1982, An evaluation of flood frequency estimates based on rainfall/runoff modeling: Water Resources Bulletin, v. 18, no. 2, p. 221-230.

Thomson, M.T., Gannon, W.B., Thomas, M.P., and Hayes, G.S., 1964, Historical floods in New England, U.S. Geological Survey Water-Supply Paper 1779-M, 105 p.

U.S. Forest Service, 1992, Forest Land Distribution Data for the United States, accessed December 21, 2001, at URL http://www.srsfia.usfs.msstate.edu/rpa/rpa93.htm/

U.S. Geological Survey, 1997, STATSGO soil characteristics for the conterminous United States: U.S. Geological Survey Open-File Report 656, accessed December 21, 2001, at URL http://water.usgs.gov/GIS/metadata/usgswrd/muid.html/.

———2000, National land cover dataset: U.S. Geological Survey Fact Sheet 108-00, accessed December 21, 2001, at URL http://mac.usgs.gov/mac/isb/pubs/factsheets/fs10800.html/.

———2001a, Global land cover characterization, accessed December 21, 2001, at URLhttp://edcdaac.usgs.gov/glcc/glcc.html/.

———2001b, National elevation dataset, accessed December 21, 2001, at URL http://edcnts12.cr.usgs.gov/ned/.

———2001c, National hydrography dataset, accessed December 21, 2001, at URL http://nhd.usgs.gov/.

U.S. Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency: Reston, Va., U.S. Geological Survey, Office of Water Data Coordination, Bulletin of the Hydrology Committee, no. 17B, 183 p.

Wilks, D.S., and Cember, R.P., 1993, Atlas of precipitation extremes for the northeastern United States and southeastern Canada: Northeast Regional Climate Center Research Series RR 93-5, 40 p.

Table 1. Location descriptions of stream-gaging stations used to determine flow characteristics of Vermont streams

[All streamgages are located on figure 1; USGS, U.S. Geological Survey; No., number; lat, latitude; long, longitude; °, degrees; ', minutes; ", seconds; mi, mile; ft, foot]

USGS stream-gaging station No.	Station name	Station location
01052500	Diamond River near Wentworth Location, N.H.	Lat 44°52'39", long 71°03'28", Coos County, on left bank, 0.8 mi downstream of the confluence of the Swift Diamond River and Dead Diamond River, 0.8 mi upstream from mouth, 1.3 mi north of Wentworth Location, and 7.7 northeast of Errol.
01127880	Big Brook near Pittsburg, N.H.	Lat 45°08'06", long 71°12'23", Coos County, on left bank, 10 ft downstream from culvert on US Highway 3, 0.3 mi upstream from mouth, 8.2 mi south of the US Highway 3 border crossing at the US and Canada Border, and 10.7 mi northeast of US Highway 3 and State Highway 145 intersection in Pittsburg.
01129300	Halls Stream near East Hereford, Quebec	Lat 45°02'41", long 71°29'54", Compton County, on right bank, opposite Alain's farm, 2.3 mi south of East Hereford, Quebec, Canada, 2.5 mi north of Post Office in Beecher Falls, 3.7 mi upstream from mouth, and 5.2 mi west of US Highway 3 and State Highway 145 intersection in Pittsburg.
01129400	Black Brook at Averill, Vt.	Lat 45°00'14", long 71°41'34", Essex County, at culvert on State Highway 114, at Averill-Canaan town line, 0.6 mi south of the US-Canada Border Monument #530, 1.1 mi northeast of Averill, 1.3 mi upstream of mouth on Leach Creek, 3.3 mi west of Wallace Pond, and 7.6 mi west of Canaan.
01129440	Mohawk River near Colebrook, N.H.	Lat 44°52'28", Long 71°24'38", Coos County, on right bank, upstream of Bungy Road bridge, south of the intersection of State Highway 26 and Bungy Road, 0.8 mi upstream of Read Brook, 1.7 mi downstream of Roaring Brook, 5 mi east of Colebrook, and 5.5 mi west of Dixville Notch.
01129700	Paul Stream Tributary near Brunswick, Vt.	Lat 44°41'06", long 71°37'18", Essex County, at culvert on Maidstone Lake Road, 400 ft upstream of mouth at Paul Stream, 1.7 mi west of Mason, N.H., 1.9 mi northeast of Maidstone Lake outlet, 3.5 mi south of Brunswick Springs, and 4.6 mi south of North Stratford, N.H.
01130000	Upper Ammonoosuc River near Groveton, N.H.	Lat 44°37'30", long 71°28'10", Coos County, on left bank, 75 ft upstream from Emerson Road bridge, 0.2 mi downstream from Nash Stream, 2.8 mi northeast of Groveton, and 3.4 mi northwest of Stark, N.H.
01133000	East Branch Passumpsic River near East Haven, Vt.	Lat 44°38'02", long 71°53'53", Caledonia County, on right bank, in Town of Burke, downstream of Watkins Road, 0.5 mi upstream from Flower Brook, 0.9 mi south of Hartwellville, 2.1 mi south of East Haven, 4.2 mi east of Post Office in West Burke, and 8.4 mi upstream from mouth.
01133200	Quimby Brook near Lyndonville, Vt.	Lat 44°34'52", long 71°59'11", Caledonia County, at culvert on Sutton Road, 0.1 mi north of Sutton Road and US 5 intersection, 2.0 mi west of Post Office in East Burke, and 3.3 mi north of Lyndon Town Hall in Lyndonville.
01133300	Cold Hill Brook near Lyndon, Vt.	Lat 44°31'47", long 72°02'57", Caledonia County, at culvert on Brown Brady Road that runs along Cold Hill Brook, 100 ft east of Brown Bradley Road and Penton Chester Road intersection, 0.3 mi upstream of junction with South Wheelock Branch, 2.1 mi northwest of Interstate 91 and US Highway 5 intersection in Lyndon, 2.3 mi west of Lyndon Town hall in Lyndonville, and 2.3 mi southeast of South Wheelock.
01133500	Passumpsic River near St. Johnsbury, Vt.	Lat 44°29'10", long 72°00'35", Caledonia County, on right bank, 200 ft below Pierce Dam, 0.5 mi upstream of Pierce Mill Road Bridge, 2.2 mi downstream of Sheldon Brook, 4.6 mi north of Post Office in St. Johnsbury, and 5.2 mi above mouth of Moose River.
01134500	Moose River at Victory, Vt.	Lat 44°30'42", long 71°50'13", Essex County, on right bank, 0.5 mi northeast of Victory, 0.8 mi downstream from Cold Brook, 1.1 mi upstream from Stanley Brook, 3.1 mi north of North Concord, and 5.0 mi southwest of Burke Road and River Road intersection in Gallup Mills.
01134800	Kirby Brook at Concord, Vt.	Lat 44°26'32", long 71°52'44", Essex County, at culvert on US 2, 600 ft southwest of Kirby Road and US 2 intersection, 700 ft upstream from mouth, 1.1 mi northeast of High Street and US 2 intersection in Concord, 2.1 mi southwest of Victory Road and US 2 intersection in North Concord, and 7.2 mi east of Town Hall in St. Johnsbury.
01135000	Moose River at St. Johnsbury, Vt.	Lat 44°25'22", long 72°00'02", Caledonia County, on left bank, 750 ft downstream of US Highway 2 bridge, 0.5 mi upstream from mouth, and 1.1 mi east of Town Hall in St. Johnsbury.

Table 1. Location descriptions of stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Station location
01135150	Pope Brook near N. Danville, Vt.	Lat 44°28'35", long 72°07'31", Caledonia County, on left bank, 200 ft upstream of Morrill Flat Road, 0.3 mi north of Pope Cemetery, 1.1 mi upstream of North Brook, 1.7 mi northwest of North Danville, 4.5 mi north of Danville, and 6.4 mi northwest of Court House in St. Johnsbury.
01135300	Sleepers River near St. Johnsbury, Vt.	Lat 44°26'07", long 72°02'20", Caledonia County, on left bank, just upstream of Emerson Falls, 0.6 mi upstream of US 2 bridge, 1.5 mi northwest of Post Office in St. Johnsbury, and 2.7 mi above mouth.
01135500	Passumpsic River at Passumpsic, Vt.	Lat 44°21'56", long 72°02'23", Caledonia County, on right bank, 0.7 mi upstream from Water Andric, 1.1 mi downstream from dam, bridge, and village of Passumpsic, 3.8 mi south of Town Hall in St. Johnsbury, 4.0 mi upstream from mouth, and 4.8 mi north of Post Office in Barnet.
01135700	Joes Brook Tributary near East Barnet, Vt.	Lat 44°20'40", long 72°03'52", Caledonia County, at culvert on Joes Brook Road, just southeast of Warden Pond Road and Joes Brook Road intersection, 100 ft upstream of mouth, 1.8 mi northwest of East Barnet, 2.9 mi southwest of Passumpsic, 3.4 mi north of Post Office in Barnet, 5.3 mi east of Peacham.
01137500	Ammonoosuc River at Bethlehem Junction, N.H.	Lat 44°16'08", long 71°37'52, Grafton County, on left bank, 0.2 mi upstream from Pierce Bridge and Bethlehem Junction, 0.8 mi upstream from unnamed tributary entering from left, 3.0 mi east of US 302 and State Highway 142 intersection in Bethlehem, 3.4 mi downstream from Little River, 4.5 mi west of US 3 and 302 intersection in Twin Mountain, and at mi 35.0.
01138000	Ammonoosuc River near Bath, N.H.	Lat 44°09'14", long 71°59'10", Grafton County, on left bank, 0.4 mi downstream from Wild Ammonoosuc River, 1.4 mi southwest of Bath, 2.5 mi east of US 302 and State Highway 135 intersection in Woodsville, and 3.1 mi upstream from mouth.
01138800	Keenan Brook at Groton, Vt.	Lat 44°12'08", long 72°12'03", Caledonia County, at downstream culvert on Topsham Road, 0.6 mi south of US 302 and Topsham Road intersection in Groton, 1.1 mi upstream of mouth on Wells River, and 3.0 mi west of South Ryegate.
01139000	Wells River at Wells River, Vt.	Lat 44°09'03", long 72°03'55", Orange County, on right bank, 0.8 mi west of village of Wells River, 1.3 mi southeast of I-91 and US 302 intersection in Four Corners, and 1.5 mi upstream from mouth.
01139700	Waits River Tributary near West Topsham, Vt.	Lat 44°08'29", long 72°18'52", Orange County, at culvert on US Highway 302, 800 ft upstream of Waits River, 0.3 mi east of US Highway 302 and State Highway 25 intersection, 2.0 mi north of West Topsham, and 7.6 mi southwest of Groton.
01139800	East Orange Branch at East Orange, Vt.	Lat 44°05'34", long 72°20'10", Orange County, on left bank, 0.3 mi east of East Orange Road and Fish Pond Road intersection in East Orange, 1.7 mi upstream from mouth, 2.0 mi southwest of West Topsham, 5.0 mi southwest of Orange, and 11.0 mi southeast of Barre.
01140000	South Branch Waits River near Bradford, Vt.	Lat 44°01'05", long 72°12'28", Orange County, on left bank, 50 ft downstream from Cookville Road bridge, 1.2 mi upstream from mouth, 3.2 mi south of East Corinth, and 4.2 mi west of Bradford.
01140100	South Branch Waits River Tributary near Bradford Center, Vt.	Lat 44°01'14", long 72°12'14", Orange County, at culvert on Cookville Road, 300 ft upstream of South Branch Waits River, 0.3 mi northeast of USGS Station 01140000, 1.7 mi west of Bradford Center, 4.1 mi northeast of Bradford Town Hall, and 4.3 mi east of Corinth.
01140800	West Branch Ompompanoosuc River Tributary at South Strafford, Vt.	Lat 43°49'56", long 72°22'20", Orange County, at culvert on Prestonville Road, 500 ft north of Prestonville Road intersection with State Highway 132, 0.4 mi southwest of Tunbridge Road and State Highway 132 intersection in South Strafford, 0.6 mi upstream of West Branch Ompompanoosuc River, 2.4 mi south of Strafford, and 5.3 mi northeast of State Highway 14 and 132 intersection in Sharon.
01141500	Ompompanoosuc River at Union Village, Vt.	Lat 43°47'24", long 72°15'19", Orange County, on right bank, 400 ft downstream from Avery Brook, 600 ft upstream from covered bridge at Union Village, 0.2 mi downstream from Union Village Reservoir, 3.5 mi upstream from mouth, and 3.7 mi southwest of State Highway 113 and US 5 intersection in East Thetford.
01141800	Mink Brook near Etna, N.H.	Lat 43°42'08", long 72°11'l5", Grafton County, on left bank, 0.1 mi west of Three Mile Road and Ruddsboro Road intersection, 1.6 mi northeast of Etna Road and King Road intersection in Etna, 4.8 mi northwest of City Hall in Enfield, and 5.1 mi east of Post Office in Hanover.

Table 1. Location descriptions of stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Station location
01142000	White River near Bethel, Vt.	Lat 43°48'45", long 72°39'25", Windsor County, on right bank, 0.3 mi upstream from Locust Creek, 0.3 mi northwest of the State Highway 12S and 107W intersection, 1.8 mi southwest of State Highway 12N and 107E intersection in Bethel, and 3.1 mi northeast of Gaysville.
01142400	Third Branch White River Tributary at Randolph, Vt.	Lat 43°55'54", long 72°40'54", Orange County, at culvert on State 12A, 0.3 mi upstream of mouth, 0.8 mi west of junction of State Highways 12 and 12A in Randolph, and 0.8 mi northwest of Town Hall in Randolph.
01142500	Ayers Brook at Randolph, Vt.	Lat 43°56'04", long 72°39'30", Orange County, on right bank, 135 ft upstream from bridge on State Highway 12, 0.4 mi upstream from Adams Brook, 0.7 mi upstream from mouth, and 0.9 mi northeast of Town Hall in Randolph.
01144000	White River at West Hartford, Vt.	Lat 43°42'51", long 72°25'07", Windsor County, on left bank, 700 ft upstream from Quechee West Hartford Road bridge at West Hartford, 0.2 mi south of the State Highway 14 and Tigertown Road intersection in West Hartford, 5.1 mi south of State Highways 14 and 132 intersection in Sharon, 5.5 mi west of Post Office in Norwich, and 7.4 mi upstream from mouth.
01145000	Mascoma River at West Canaan, N.H.	Lat 43°39'04", long 72°05'07", Grafton County, on right bank, 45 ft downstream from Boston and Maine Railroad bridge, 0.6 mi east of US Route 4 and South Road intersection in West Canaan, 1.4 mi downstream from Indian River, 3.0 mi east of City Hall in Enfield, 3.7 mi west of Post Office in Canaan, and at mi 19.3.
01150800	Kent Brook near Killington, Vt.	Lat 43°40'24", long 72°48'33", Rutland County, at culvert on State Highway 100, 0.4 mi north of junction of State Highway 100 and US Route 4, 1.6 mi upstream from mouth, 2.0 mi northwest of River Road and US 4 intersection in Killington, 9.3 mi east of US 4E and 7N intersection in Rutland.
01150900	Ottauquechee River near West Bridgewater, Vt.	Lat 43°37'20", long 72°45'34", Rutland County, on right bank, 50 ft upstream from Mission Chapel Road bridge, 1.6 mi north of State Highway 100 and US Route 4 intersection in West Bridgewater, and 2.6 mi south of River Road and US 4 intersection in Sherburne Center.
01151200	Ottauquechee River Tributary near Quechee, Vt.	Lat 43°39'37", long 72°25'55", Windsor County, at culvert on West Hartford-Quechee Road, 0.2 mi upstream of mouth, 1.2 mi northwest of Quechee Main Street, Deweys Mills Road and Waterman Hill Road intersection in Quechee, and 2.8 mi northeast of Happy Valley Road and US 4 intersection in Taftsville.
01151500	Ottauquechee River at North Hartland, Vt.	Lat 43°36'09", long 72°21'17", Windsor County, on left bank, 100 ft upstream from US 5 bridge, 0.3 mi downstream from North Hartland Dam, 0.7 mi north of Depot Road and US 5 intersection in North Hartland, 1.2 mi upstream from mouth, and 3.7 mi southwest of Courthouse in White River Junction.
01152500	Sugar River at West Claremont, N.H.	Lat 43°23'15", long 72°21'45", Sullivan County, on right bank, 0.2 mi downstream from Redwater Brook, 0.7 mi southeast of Clay Hill Road and Paddy Hollow Road intersection in West Claremont, 1.6 mi northwest of City Hall in Claremont, and 2.4 mi upstream from mouth.
01153000	Black River at North Springfield, Vt.	Lat 43°20'00", long 72°30'55", Windsor County, on right bank, 600 ft upstream of State Highway 106, 0.3 mi upstream from Great Brook, 0.6 mi downstream from North Springfield Dam, 0.9 mi east of State Highway 10 and 106 intersection in North Springfield, 2.9 mi northwest of State Highways 11 and 143 intersection in Springfield, and 7.8 mi upstream of mouth.
01153300	Middle Branch Williams River Tributary at Chester, Vt.	Lat 43°16'13", long 72°36'32", Windsor County, at culvert on Lover Lane Road, 0.2 mi south of Lover Lane Road and State Highway 11 intersection, 0.8 mi northeast of intersection of State Highways 11 and 35 in Chester, 1.5 mi upstream of mouth, and 6.7 mi west of Springfield.
01153500	Williams River at Brockways Mills, Vt.	Lat 43°12'31", long 72°31'05", Windham county, on left bank, 25 ft upstream from road bridge at Brockways Mills, 1.0 mi downstream of Stream Brook, 2.2 mi upstream of Station 01153550, “Williams River near Rockingham”, 3.9 mi downstream from Hall Brook, 4.4 mi upstream from mouth and 6.2 mi northwest of Bellows Falls.

Table 1. Location descriptions of stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Station location
01153550	Williams River near Rockingham, Vt.	Lat 43°11'30", Long 72°29'08", Windham county, on left bank, 50 ft downstream from Parker Hill Road bridge, 0.2 mi downstream from Divoll Brook, 0.3 mi northeast of Rockingham, 2.2 mi upstream from mouth, 2.2 mi downstream of Station 01153500, “Williams River at Brockways Mills”, and 4.5 mi northwest of City Hall in Bellows Falls.
01154000	Saxtons River at Saxtons River, Vt.	Lat 43°08'15", Long 72°29'19", Windham County, on right bank, 130 ft upstream from Hall Bridge Road bridge, 1.1 mi east of Saxtons River, 1.3 mi upstream from Bundy Brook, 2.2 mi west of City Hall in Bellow Falls, and 3.9 mi upstream from mouth.
01155000	Cold River at Drewsville, N.H.	Lat 43°07'54", long 72°23'23", Cheshire County, on left bank, 50 ft upstream from bridge on State Highway 123 at Drewsville, 0.9 mi upstream from Great Brook, 1.9 mi southwest of Alstead, 2.7 mi east of Bellows Falls, Vt., 3.0 mi east of North Walpole, and 3.2 mi upstream from mouth.
01155200	Sacketts Brook near Putney, Vt.	Lat 42°59'57", long 72°31'59", Windham County, on left bank, 50 ft upstream from highway bridge on the Westminster West Road, 1.8 mi north of Westminster West Road and US Route 5 intersection in Putney, and 7.5 mi southeast of State Highway 30 and 35 intersection in Townshend.
01155300	Flood Brook near Londonderry, Vt.	Lat 43°14'11", long 72°51'23", Windham County, on left bank, 20 ft downstream from bridge on State Highway 11, 0.9 mi upstream from Burnt Meadow Brook, 2.5 mi west of State Highway 11E and 100N intersection in Londonderry, 3.6 mi northwest of Main Street and State Highway 100 intersection in South Londonderry, 7.8 mi east of Mad Tom Road and US Route 7 intersection in East Dorset.
01155350	West River Tributary near Jamaica, Vt.	Lat 43°07'33", long 72°48'46", Windham County, at culvert on State Highway 30/100, 800 ft north of Stratton Gate Road and State Highway 100 intersection, 0.5 mi upstream of mouth, 1.9 mi west of Ball Mountain Dam, 2.0 mi southeast of State Highway 30W and 100N intersection in Rawsonville, and 2.5 mi northwest of Depot Street and State Highway 30/100 intersection in Jamaica.
01155500	West River at Jamaica, Vt.	Lat 43°06'32", long 72°46'33", Windham County, on left bank, 0.3 mi upstream from Depot Street bridge, 0.4 mi upstream from Ball Mountain Brook, 0.7 mi north of Depot Street and State Highway 30/100 intersection in Jamaica, 2.5 mi downstream from Ball Mountain Dam, and 7.0 mi northwest of State Highways 30 and 35 intersection in Townshend.
01156000	West River at Newfane, Vt.	Lat 42°59'43", long 72°38'13", Windham County, on left bank, 400 ft downstream from Grassy Brook Road bridge, 1.2 mi northeast of West Road and State Highway 30 intersection in Newfane, 3.9 mi southeast of State Highways 30 and 35 intersection in Townshend, and at mi 12.7.
01156300	Whetstone Brook Tributary near Marlboro, Vt.	Lat 42°52'42", long 72°42'32", Windham County, at culvert on State Highway 9, 600 ft southwest of Sunset Lake Road and State Highway 9 intersection, 800 ft upstream of mouth, 0.5 mi southeast of mouth of Hidden Lake, 1.5 mi northeast of Marlboro, and 7.6 mi west of Town Hall in Brattleboro.
01156450	Connecticut River Tributary near Vernon, Vt.	Lat 42°47'01", long 72°31'57", Windham County, at downstream culvert on Tyler Hill Road, 0.3 mi west of Tyler Hill Road and State Highway 142 intersection, 0.6 mi upstream of mouth, 1.3 mi northwest of Vernon Dam, and 1.8 mi northwest of West Road and State Highway 142 intersection in Vernon.
01157000	Ashuelot River near Gilsum, N.H.	Lat 43°02'21", long 72°16'14", Cheshire County, on right bank, 50 ft downstream from White Brook, 60 ft upstream from stone-arch bridge on Surry Road, 200 ft west of Surry Road and State Highway 10 intersection, 0.8 mi southwest of Post Office in Gilsum, 7.2 mi north of Courthouse in Keene, and at mi 43.4.
01158500	Otter Brook near Keene, N.H.	Lat 42°57'55", long 72°14'00", Cheshire County, on left bank, 10 ft downstream from unnamed road bridge, 0.2 mi south of unnamed road and State Highway 9 intersection, 1.3 mi north of Otter Brook Flood Control Dam, 1.4 mi east of State Highways 9 and 10 intersection, 1.5 mi upstream of station 01158600, Otter Brook below Otter Brook Dam, near Keene, 3.1 mi northeast of City Hall in Keene, and 3.8 mi upstream from confluence with Minnewawa Brook to form The Branch.
01160000	South Branch Ashuelot River at Webb, near Marlborough, N.H.	Lat 42°52'20", long 72°12'51", Cheshire County, on right bank, 15 ft downstream from bridge (destroyed) at Webb, 400 ft upstream of State Highway 12 bridge, 2.3 mi south of Town Hall in Marlborough, 3.5 mi northwest of Town Hall in Troy, and at mi 10.9.

Table 1. Location descriptions of stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Station location
01161000	Ashuelot River at Hinsdale, N.H.	Lat 42°47'09", long 72°29'12", Cheshire County, on left bank, 40 ft upstream from State Highway 63 bridge in Hinsdale, 200 ft south of State Highway 63 and 119 intersection in Hinsdale, 0.2 mi downstream from dam, and 1.3 mi upstream from mouth.
01161300	Millers Brook at Northfield, Mass.	Lat 42°41'07", long 72°27'11", Franklin County, at culvert on Beers Plain Road, 0.8 mi south of Northfield.
01165000	East Branch Tully River near Athol, Mass.	Lat 42°38'32", long 72°13'34", Worcester County, on right Bank 300 ft downstream of Tully Dam, 1.3 mi downstream from Lawrence Brook, 3.5 mi north of Athol, and 4.9 mi upstream from mouth.
01165500	Moss Brook at Wendell Depot, Mass.	Lat 42°36'10", long 72°21'36", Franklin County, on left bank 0.2 mi upstream from mouth, 0.2 mi north of Wendell Depot, and 2.5 mi west of Orange.
01167800	Beaver Brook at Wilmington, Vt.	Lat 42°51'38", long 72°51'06", Windham County, on right bank 20 ft downstream from bridge on State Highway 9, 0.1 mi east of State Highway 9E and 100S intersection, 1.2 mi southeast of State Highway 9W and 100N intersection in Wilmington, and 1.6 mi upstream from mouth.
01169000	North River at Shattuckville, Mass.	Lat 42°38'18", long 72°43'32", Franklin County, on right bank in Shattuckville, 1.2 mi south of Griswoldville and 1.3 mi upstream from mouth.
01169900	South River near Conway, Mass.	Lat 42°32'31", long 72°41'39", Franklin County, on left bank at upstream side of Reeds Bridge just off Bardwell Road, 2.2 mi north of Conway, and 2.6 mi upstream from mouth.
01170100	Green River near Colrain, Mass.	Lat 42°42'12", long 72°40'16", Franklin County, on right bank 0.5 mi upstream from bridge on West Leyden Road and 2.5 mi northeast of Colrain.
01170200	Allen Brook near Shelburne Falls, Mass.	Lat 42°36'46", long 72°40'02", Franklin County, at culvert on Peckville Road, 3.5 mi east of Shelburne Falls.
01170900	Mill River near South Deerfield, Mass.	Lat 42°28'09", long 72°38'31", Franklin County, at culvert on North Street, 2.0 mi southwest of South Deerfield.
01178230	Mill Brook at Plainfield, Mass.	Lat 42°30'57", long 72°55'30", Hampshire County, at culvert on High Street, 0.4 mi west of Plainfield.
01196990	Windsor Brook Tributary at Windsor, Mass.	Lat 42°30'41", long 73°04'37", Berkshire County, at culvert on State Highway 9, 0.9 mi west of Windsor.
01328000	Bond Creek at Dunham Basin, N.Y.	Lat 43°18'22", long 73°32'56", Washington County, on left bank, approximately 400 ft upstream from bridge on State Route 196, 1,000 ft upstream of mouth, 0.8 mi east of intersection of State Routes 196 and 32, and 1.8 mi east of Hudson Falls, N.Y.
01328900	Tanner Brook near Sunderland, Vt.	Lat 43°07'48", long 73°05'44", Bennington County, at culvert on State Highway 7A, 400 ft south of State Highway 7A and Muddy Lane intersection, 1.3 mi northeast of Sunderland Borough Road and North Road intersection in Sunderland, 2.5 mi southwest of Courthouse in Manchester.
01329000	Batten Kill at Arlington, Vt.	Lat 43°04'34", long 73°09'26", Bennington County, on left bank, 5 ft upstream (destroyed in new bridge construction) from bridge on State Highway 313, 0.2 mi northwest of State Highway 7A and 313 intersection in Arlington, 0.9 mi downstream from Warm Brook, 7.4 mi southwest of Courthouse in Manchester.
01329154	Steele Brook at Shushan, N.Y.	Lat 43°05'35", long 73°19'38", Washington County, at bridge on county road, 1.1 mi upstream from mouth, and 0.8 mi east of Shushan.
01329500	Batten Kill at Battenville, N.Y.	Lat 43°06'05", long 73°25'55", Washington County, on left bank 1.2 mi upstream from Trout Brook and 1.0 mi southwest of Battenville.
01331400	Dry Brook near Adams, Mass.	Lat 42°35'20", long 73°06'48", Berkshire County, on right bank 20 ft upstream from bridge on State Highway 116, just south of junction of Wells Road and State Highway 116, and 2.5 mi south of Adams.
01331500	Hoosic River at Adams, Mass.	Lat 42°36'37", long 73°07'32", Berkshire County, on right bank at Adams, just downstream from Dry Brook and 0.5 mi upstream from Pecks Brook.

Table 1. Location descriptions of stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Station location
01332000	North Branch Hoosic River at North Adams, Mass.	Lat 42°42'08", long 73°05'37", Berkshire County, on left bank at North Adams, 0.4 mi downstream from Hudson Brook, and 1.5 mi upstream from mouth.
01332500	Hoosic River near Williamstown, Mass.	Lat 42°42'21", long 73°10'50", Berkshire County, on left bank 1.0 mi upstream from Green River and 1.2 mi east of Williamstown.
01333000	Green River at Williamstown, Mass.	Lat 42°42'32", long 73°11'50", Berkshire County, on left bank 0.1 mi upstream from bridge on State Highway 2 at Williamstown and 0.8 mi upstream from mouth.
01333500	Little Hoosic River at Petersburg, N.Y.	Lat 42°45'50", long 73°20'16", Rensselaer County, on left bank 100 ft downstream from highway bridge on dirt road, 1.0 mi downstream from Petersburg, and 4.9 mi upstream from mouth.
01333800	South Stream near Bennington, Vt.	Lat 42°49'53", long 73°10'04", Bennington County, at culvert on South Stream Road, 900 ft southeast of South Stream Road and Maple Grove Road intersection, 0.4 mi upstream of mouth of Roaring Brook, and 3.5 mi southeast of Town Hall in Bennington.
01333900	Paran Creek near South Shaftsbury, Vt.	Lat 42°58'13", long 73°11'19", Bennington County, at culvert on Hallow Road, 400 ft upstream of right bank tributary, 400 ft north of Hallow Road and Airport Road intersection, 1.3 mi southeast of State Highway 7A and West Mount Road intersection in Shaftsbury Center, and 1.8 mi northeast of State Highways 7A (north) and 67N intersection in South Shaftsbury.
01334000	Walloomsac River near North Bennington, Vt.	Lat 42°54'47", long 73°15'25", Bennington County, on left bank, 500 ft downstream of River Road Covered bridge, 700 ft downstream of old mill dam, 0.6 mi downstream from Paran Creek, 1.4 mi southwest of State Highway 67 and 67A intersection in North Bennington, and 3.9 mi northwest of Town Hall in Bennington.
01334500	Hoosic River near Eagle Bridge, N.Y.	Lat 42°56'19", long 73°22'39", Rensselaer County, on right bank 0.5 mi upstream from Case Brook, 1.2 mi downstream from Walloomsac River, and 1.2 mi southeast of Eagle Bridge.
04270800	English River near Mooers Forks, N.Y.	Lat 44°58'32", long 73°39'49", Clinton County, on right bank at downstream side of highway bridge, 1.6 mi upstream from unnamed tributary, 1.7 mi northwest of Mooers Forks, and 2.5 mi upstream of the international boundary.
04271815	Little Chazy River near Chazy, N.Y.	Lat 44°54'08", long 73°24'56", Clinton County, on right bank at downstream side of bridge on Stetson Road, 0.2 mi upstream from abandoned dam, 1.4 mi northeast of Chazy, and 2.2 mi upstream from mouth.
04273500	Saranac River at Plattsburgh, N.Y.	Lat 44°40'54", long 73°28'18", Clinton County, on right bank at Plattsburgh, 600 ft downstream from Imperial Paper and Color Corporation dam, 3.0 mi upstream from mouth, and 5.5 mi downstream from Mead Brook.
04273700	Salmon River at South Plattsburgh, N.Y.	Lat 44°38'24", long 73°29'43", Clinton County, on left bank at South Plattsburgh, 32 ft upstream from bridge on Salmon River Road, 0.4 mi west of State Highway 22, and 3.9 mi upstream from mouth.
04276200	Bouquet River at New Russia, N.Y.	Lat 44°09'51", long 73°36'30", Essex County, on right bank at bridge on Simonds Hill Road in New Russia, 0.2 mi northeast of the intersection of Simonds Hill Road and US Route 9, 4.5 mi south of Elizabethtown, N.Y.
04276500	Bouquet River at Willsboro, N.Y.	Lat 44°21'30", long 73°23'50", Essex County, on right bank at Willsboro, 0.5 mi upstream from bridge on State Highway 22, 2.5 mi downstream from North Branch Bouquet River, and 3.0 mi upstream from mouth.
04276770	Mill Brook at Port Henry, N.Y.	Lat 44°03'09", long 73°28'47", Essex County, on left bank at Port Henry, 30 ft downstream from bridge on Forge Hollow Road, and 2.0 mi upstream from mouth.
04276842	Putnam Creek East of Crown Point Center, N.Y.	Lat 43°56'31", long 73°27'54", Essex County, on right bank 200 ft upstream from bridge at Fish Hatchery, 200 ft downstream from Rennie Brook, and 0.2 mi east of Crown Point Center.
04278300	Northwest Bay Brook near Bolton Landing, N.Y.	Lat 43°39'48", long 73°36'14", Warren County, on left bank 10 ft downstream from county bridge on Padanarum Road and 7.7 mi north of Bolton Landing.

Table 1. Location descriptions of stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Station location
04279400	Poultney River Tributary at East Poultney, Vt.	Lat 43°32'13", long 73°12'33, Rutland County, at culvert on Lewis Road, 0.5 mi west of Town Hill, 0.5 mi northwest of Lewis, Thrall and Hillside Roads intersection, 0.8 mi north of State Highway 140 and Thrall Road intersection in East Poultney, and 1.8 mi northeast of Town Hall in Poultney.
04280000	Poultney River below Fair Haven, Vt.	Lat 43°37'27", long 73°18'43", Rutland County, on right bank, 0.4 mi downstream from Carver Falls and Dam, 2.0 mi upstream from Hubbardton River, 3.0 mi northwest of Town Hall in Fair Haven, and 6.6 mi northeast of Whitehall, N.Y.
04280200	Mettawee River Tributary #2 at East Rupert, Vt.	Lat 43°16'16", long 73°07'23", Bennington County, at culvert on State Highway 30, 400 ft upstream of junction with Mettawee River, 0.1 mi east of State Highway 30 and 315 intersection in East Rupert, 1.7 mi northwest of State Highway 30 and Church Street intersection in Dorset, and 5.9 mi southeast of State Highway 30 and 133 intersection in Pawlet.
04280300	Mettawee River Tributary near Pawlet, Vt.	Lat 43°19'35", long 73°10'20", Rutland County, on left bank, 20 ft downstream from culvert on State Highway 30, 200 ft upstream from mouth, 1.4 mi south of State Highway 30 and 133 intersection in Pawlet, and 7.1 mi southeast of New York State Highways 31 and 149 intersection in Granville, N.Y.
04280350	Mettawee River near Pawlet, Vt.	Lat 43°22'14", long 73°13'00", Rutland County, on left bank, 10 ft downstream from Betts Bridge Road bridge, 20 ft southwest of Betts Bridge Road and Offesend Road intersection, 0.8 mi upstream of State Highway 153 bridge, 1.0 mi southwest of Offesend Road and State Highway 30 intersection at Butternut Bend, and 2.6 mi northwest of State Highways 30 and 133 intersection in Pawlet.
04280450	Mettawee River near Middle Granville, N.Y.	Lat 43°27'50", long 73°17'05", Washington County, on right bank 110 ft downstream from bridge on County Highway 21 and 2.2 mi north of Middle Granville, N.Y.
04280900	Moon Brook at Rutland, Vt.	Lat 43°36'33", long 72°57'25", Rutland County, at culvert on Stratton Road, 0.6 mi south of Stratton Road and US Route 4 intersection, and 0.8 mi east of US Routes 7 and 4 intersection in Rutland.
04282000	Otter Creek at Center Rutland, Vt.	Lat 43°36'13", long 73°00'49", Rutland County, on right bank 200 ft downstream from dam, 500 ft upstream from bridge on US Route 4 (Business) in Center Rutland, 0.3 mi upstream of Clarendon River, 1.2 mi downstream from East Creek, and 2.1 mi west of US Routes 7 and 4 intersection in Rutland.
04282200	Neshobe River at Brandon, Vt.	Lat 43°48'37", long 73°04'36", Rutland County, at bridge on Stone Mill Dam Road, 300 ft north of Stone Mill Dam Road and State Highway 73 intersection, 1.0 mi northeast of Town Hall in Brandon, 1.7 mi southwest of State Highways 53 and 73 intersection in Forest Dale, and 3.1 mi upstream of mouth on Otter Creek.
04282300	Brandy Brook at Bread Loaf, Vt.	Lat 43°57'19", long 72°59'47", Addison County, at culvert on State Highway 125, 300 ft southeast of Kirby Road and State Highway 125 intersection, 0.2 mi west of Bread Loaf, 0.3 mi upstream of South Branch Middlebury River, 2.3 mi southeast of National Turnpike and State Highway 125 in Ripton, and 9.5 mi southeast of Town Hall in Middlebury.
04282500	Otter Creek at Middlebury, Vt.	Lat 44°00'47", long 73°10'06", Addison County, on right bank 150 ft upstream from State Highway 125 bridge in Middlebury, 0.1 mi southwest of US Route 7 and State Highway 125 intersection, and 3.6 mi downstream from Middlebury River.
04282525	New Haven River at Brooksville near Middlebury, Vt.	Lat 44°03'42", long 73°10'16", Addison County, on left bank at downstream side of Dog Team Road bridge, 0.2 mi south of Brooksville, 0.6 mi upstream from mouth, 1.5 mi downstream of Muddy Branch, 3.3 mi north of US Route 7 and State Highway 125 intersection in Middlebury.
04282550	Beaver Brook at Cornwall, Vt.	Lat 43°57'29", long 73°12'51", Addison County, at culvert on State Highway 74, 0.2 mi southwest of State Highway 30 and 74 intersection in Cornwall, 1.5 mi northeast North and South Bingham Roads and State Highway 74 intersection in West Cornwall, and 4.5 mi southwest of US Route 7 and State Highway 125 intersection in Middlebury.
04282600	Little Otter Creek Tributary near Bristol, Vt.	Lat 44°08'35", long 73°07'03", Addison County, at culvert on Plank Road, 300 ft east of East Road and Plank Road intersection, 2.0 mi northwest of Town Hall in Bristol, 2.2 mi northeast of North Street, South Street, and State Highway 17 intersection in New Haven, and 9.1 mi northeast of State Highway 125 and US Route 7 intersection in Middlebury.

Table 1. Location descriptions of stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Station location
04282650	Little Otter Creek at Ferrisburg, Vt.	Lat 44°11'53", long 73°14'58", Addison County, on left bank at downstream side of US Route 7 Highway bridge, 0.5 mi south of Middle Brook Road and US Route 7 intersection in Ferrisburg, 2.0 mi north of Town Hall in Vergennes, and 2.4 mi downstream of Mud Creek.
04282700	Lewis Creek Tributary at Starksboro, Vt.	Lat 44°13'00", long 73°03'21", Addison County, at culvert on State Highway 116, 0.4 mi upstream of mouth, 0.7 mi south of Big Hollow Road and State Highway 116 intersection in Starksboro, 0.9 mi west of East Mountain, and 5.9 mi north of Town Hall in Bristol.
04282750	Lewis Creek Tributary #2 near Rockville, Vt.	Lat 44°15'54", long 73°04'02", Addison County, at culvert on State Highway 116, 50 ft south of unnamed road intersection with State Highway 116, 500 ft upstream of mouth, 1.3 mi north of State Prison Hollow Road and Cemetery Road intersection in Rockville, 1.9 mi south of Hollow Road and State Highway 116 intersection in South Hinesburg, and 4.8 mi southeast of Silver Road and State Highway 116 intersection in Hinesburg.
04282780	Lewis Creek at North Ferrisburg, Vt.	Lat 44°14'57", long 73°13'44", Addison County, on right bank 100 ft upstream of US Route 7 Highway bridge, 1.1 mi southwest of Four Winds Road and Hollow Road intersection in North Ferrisburg, 1.2 mi south of Mount Philo peak, and 5.7 mi north of Town Hall in Vergennes.
04282795	Laplatte River at Shelburne Falls, Vt.	Lat 44°22'12", long 73°13'00", Chittenden County, on left bank 150 ft upstream of small right bank tributary, 300 ft upstream of Falls Road bridge, 500 ft southwest of Falls Road and Thomas Road intersection in Shelburne Falls, 0.8 mi southeast of Town Hall in Shelburne, and 3.4 mi above mouth.
04282850	Winooski River Tributary #2 near Cabot, Vt.	Lat 44°25'53", long 72°18'11", Washington County, at culvert on South Walden Road, 200 ft upstream of mouth, 600 ft south of South Walden Road and Walbridge Road intersection, 2.1 mi north of Elm Street and State Highway 215 intersection in Cabot, 6.0 mi southeast of Town Hall in Hardwick, and 6.1 mi north of Calais Road and US Route 2 intersection in Marshfield.
04283470	Stevens Branch Tributary at South Barre, Vt.	Lat 44°10'51", long 72°31'11", Washington County, at culvert on abandoned Lower Usle Road (road has been moved downstream), 1,200 ft west of Lower Usle Road and Jensen Road intersection, 0.7 mi west of Post Office in South Barre, 1.4 mi southeast of Post Office in Barre.
04286000	Winooski River at Montpelier, Vt.	Lat 44°15'23", long 72°35'36", Washington County, on right bank, 0.4 mi upstream from Dog River, 0.6 mi downstream of Bailey Road Bridge, 0.8 mi southwest of the Vermont State Capitol Building in Montpelier, and 1.0 mi downstream of the North Branch Winooski River.
04286500	Dog River at Northfield, Vt.	Lat 44°08'19", long 72°40'02", Washington County, on left bank downstream of Dole Hill Road Bridge, 0.4 mi west of Dole Hill Road and State Highway 12 intersection at Norwich University, 0.8 mi southwest of Town Hall in Northfield, 0.9 mi upstream of Union Brook, 1.3 mi downstream of Sunny Brook, and 4.2 mi upstream of Station 04287000, Dog River at Northfield Falls.
04287000	Dog River at Northfield Falls, Vt.	Lat 44°10'58", long 72°38'27", Washington County, on right bank just downstream of New England Central Railroad bridge, 0.9 mi northeast of Cox Brook Road and State Highway 12 intersection in Northfield Falls, 1.1 mi downstream from Cox Branch, and 4.2 mi downstream of Station 04286500, Dog River at Northfield.
04287300	Sunny Brook near Montpelier, Vt.	Lat 44°16'05", long 72°37'28", Washington County, at culvert on US Highway 2, 600 ft northeast of Interstate 89 overpass over US Route 2, 0.3 mi upstream from mouth, 0.7 mi east of the mouth of Jones Brook, and 2.2 mi west of Vermont State Capitol Building in Montpelier.
04288000	Mad River near Moretown, Vt.	Lat 44°16'38", long 72°44'35", Washington County, on left bank, at downstream side of Munns Road bridge, 0.4 mi downstream of Welder Brook, 2.0 mi northeast of Moretown Mountain Road and State Highway 100B intersection in Moretown, 3.2 mi west of State Highway 100B bridge across Winooski River in Middlesex, and 3.8 mi upstream from mouth.
04288400	Bryant Brook at Waterbury Center, Vt.	Lat 44°22'41", long 72°43'29", Washington County, at culvert on State Highway 100, 100 ft north of Howard Road and State Highway 100 intersection, 0.4 mi west of Maple Road and Loomis Hill Road intersection in Waterbury Center, 3.0 mi north of US Route 2 and State Highway 100 intersection in Waterbury.

Table 1. Location descriptions of stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Station location
04289600	Winooski River Tributary near Richmond, Vt.	Lat 44°26'09", long 72°58'46", Chittenden County, at culvert on Browns Trace Road, 1400 ft north of Jerico-Richmond Town Line, 0.3 mi south of Browns Trace Road and Governor Peck Road intersection, 2.2 mi north of Jerico Road and US Highway 2 intersection in Richmond, and 2.3 mi south of Browns Trace Road and Bolger Hill Road intersection in Jerico Center.
04290700	Bailey Brook at East Hardwick, Vt.	Lat 44°31'41", long 72°18'16", Caldonia County, at culvert on Hardwick Street, 800 ft north of railroad crossing, 0.4 mi upstream of mouth, 0.5 mi northeast of Brochu Road and Church Street intersection in East Hardwick, and 3.6 mi northeast of Town Hall in Hardwick.
04291000	Green River at Garfield, Vt.	Lat 44°36'10", long 72°32'08", Lamoille County, on left bank in pool of dam, 200 ft west of Garfield Road and Green River Dam Road intersection in Garfield, 1.6 mi downstream of Green River Reservoir Dam, and 3.4 mi northeast of State Highways 15 and 100 intersection in Morrisville.
04292000	Lamoille River at Johnson, Vt.	Lat 44°37'22", long 72°40'36", Lamoille County, on right bank, above falls, 0.8 mi south of State Highways 15 and 100C intersection in Johnson, 0.8 mi upstream from Railroad Street bridge in Johnson, 0.9 mi upstream from Gihon River, and 1.0 mi downstream of Waterman Brook.
04292100	Stony Brook near Eden, Vt.	Lat 44°41'37, long 72°34'58", Lamoille County, at culvert on State Highway 100, 500 ft upstream of mouth, 2.0 mi southwest of State Highways 100 and 118 intersection in Eden, 2.2 mi northeast of State Highway 100 and 100C intersection in North Hyde Park, and 6.2 mi northeast of State Highways 15 and 100C intersection in Johnson.
04292150	Gihon River Tributary near Johnson, Vt.	Lat 44°39'36", long 72°37'44", Lamoille County, at culvert on State Highway 100C, at intersection of Ober Hill Road and State Highway 100C, 2,000 ft upstream of mouth, 1.2 mi southwest of State Highways 100 and 100C intersection in North Hyde Park, and 3.0 mi northeast of State Highways 15 and 100C intersection in Johnson.
04292200	Lamoille River Tributary at Jeffersonville, Vt.	Lat 44°39'13", long 72°49'42", Lamoille County, at culvert on State Highway 108, 200 ft north of State Highways 108 and 109 intersection, 1,800 ft upstream of mouth, 0.6 mi north of Town Hall in Jeffersonville, and 0.8 mi west of Junction Hill Road and State Highway 15 intersection in Cambridge Junction.
04292500	Lamoille River at East Georgia, Vt.	Lat 44°40'45", long 73°04'23", Franklin County, on right bank 0.5 mi upstream from New England Central Railroad bridge at East Georgia, 0.9 mi downstream from Beaver Meadow Brook, and 3.3 mi northeast of Main Street and US Route 7 intersection in Milton.
04292700	Stone Bridge Brook near Georgia Plains, Vt.	Lat 44°42'14", long 73°10'55", Franklin County, on left bank 20 ft upstream from Lake Road culvert, 0.1 mi downstream of small left bank tributary, 1.0 mi upstream of large right bank tributary, 1.3 mi west of Sodom Road and Sandy Birch Road intersection in West Georgia, 1.4 mi southwest of Stone Bridge Road and Plains Road intersection in Georgia Plains, 2.6 mi upstream of mouth, and 5.6 mi northwest of Main Street and US Route 7 intersection in Milton.
04293000	Missisquoi River near North Troy, Vt.	Lat 44°58'22", long 72°23'09", Orleans County, on right bank 200 ft upstream from Big Falls, 1.5 mi downstream from Jay Branch, 1.8 mi southeast of Town Hall in North Troy, 2.2 mi upstream from State Highway 105 bridge in North Troy, and 8.8 mi west of State Highway 105 and US Route 5 intersection in Newport.
04293400	Whittaker Brook at Richford, Vt.	Lat 44°59'14", long 72°39'15", Franklin County, at culvert on State Highway 105, 100 ft upstream of mouth, 0.3 mi east of Canadian Pacific Railroad and State Highway 105 crossing, 1.0 mi southeast of the junction of State Highways 105 and 139 in Richford.
04293500	Missisquoi River near East Berkshire, Vt.	Lat 44°57'36", long 72°41'49", Franklin County, on left bank, 0.4 mi upstream of State Highway 105 bridge, 1.9 mi north of intersection of State Highways 105 and 118 in East Berkshire, 1.9 mi upstream from Trout River, 2.6 mi southwest of Town Hall in Richford, and 3.6 mi downstream from North Branch.
04293800	Missisquoi River Tributary at Sheldon Junction, Vt.	Lat 44°54'01", long 72°57'40", Franklin County, at culvert on State Highway 105, 40 ft west of the State Highway 105 and Bergeron Road intersection, 0.5 mi upstream of mouth, 0.8 mi west of State Highways 78 and 105 intersection in Sheldon Junction, and 0.9 mi east of Catholic Church Road and Mill Road intersection in Sheldon Springs.

Table 1. Location descriptions of stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Station location
04294000	Missisquoi River at Swanton, Vt.	Lat 44°55'00", long 73°07'44", Franklin County, on left bank, at old railroad abutment, 0.3 mi upstream of dam and Depot Street (State Highway 78) bridge, 0.3 mi southwest of Post Office in Swanton, 1.1 mi west of State Highway 78 and Interstate 89 interchange, and 7.9 mi upstream of mouth.
04294200	Saxe Brook near Highgate Springs, Vt.	Lat 44°59'38", long 73°03'59", Franklin County, at culvert on Ballard Road, 100 ft north of Ballard Road and St. Armand Road intersection, 0.4 mi upstream of mouth at Rock River, 1.5 mi south of US-Canada Border Bench Mark 629A, 2.4 mi northeast of US Route 7 and Tyler Road intersection in Highgate Springs, and 4.0 mi north of State Highways 78 and 207 intersection in Highgate Center.
04295900	Ware Brook near Coventry, Vt.	Lat 44°51'02", long 72°17'30", Orleans County, at culvert on Metcalf Flat Road, 1.1 mi southwest of Metcalf Flat Road covered bridge over the Black River, 1.4 mi upstream of mouth, 1.7 mi southwest of Metcalf Flat Road and Loop Road intersection in Coventry, and 3.3 mi north of State Highways 14 and 58 intersection in Irasburg.
04296000	Black River at Coventry, Vt.	Lat 44°52'08", long 72°16'14", Orleans County, on right bank, 15 ft downstream from Loop Road bridge, 800 ft upstream from Stony Brook, 0.3 mi northwest of Loop Road and Main Street intersection in Coventry, and 4.6 mi north of State Highways 14 and 58 intersection in Irasburg.
04296150	Lord Brook near Evansville, Vt.	Lat 44°46'59", long 72°07'08", Orleans County, at culvert on State Highway 16, 0.2 mi east of Fisk Road and State Highway 16 intersection, 1.2 mi upstream of mouth, 1.5 mi south of Chase Road and State Highway 58 intersection in Evansville, and 3.7 mi northeast of US Route 5 and State Highway 16 intersection in Barton.
04296200	Brownington Branch near Evansville, Vt.	Lat 44°50'02", long 72°04'00", Orleans County, at culvert on State Highway 5A, 0.5 mi upstream of mouth of Moody Brook, 2.8 mi north of State Highways 5A and 58 intersection, 3.8 mi northeast of Chase Road and State Highway 58 intersection in Evansville, and 10.0 mi east of Loop Road and Main Street intersection in Coventry.
04296300	Pherrins River Tributary near Island Pond, Vt.	Lat 44°50'34", long 71°54'31", Essex County, at culvert on State Highway 114, 200 ft upstream of mouth, 800 ft south of State Highway 111 and 114 junction, 2.3 mi northwest of State Highways 105 and 114 intersection in Island Pond, and 4.0 mi east of Echo Pond Road and State Highway 105 intersection in East Charleston.

Table 2. Magnitude and frequency discharges at stream-gaging stations used to determine flow characteristics of Vermont streams

[All streamgages are located on figure 1; USGS, U.S. Geological Survey; ft^3/s, cubic feet per second; No., number; mi^2, square miles; Frequency-analysis comments: 1, Frequency curve computed using complete period of record; 2, Frequency curve computed using complete period of record plus historical peak(s); 3, Frequency curve adjusted using two-station comparison record extension; 4, Frequency curve computed using observed peaks from period of record, plus peaks simulated by rainfall-runoff modeling; 5, Frequency curve computed using unregulated peaks only and does not represent current conditions at this stream-gaging station; 6, Frequency curve computed using unregulated peaks plus peaks estimated by the U.S. Army Corp of Engineers (written commun., 1999) based upon the rate the flood reservoir filled. Frequency curve does not represent current conditions at this stream-gaging station; 7, Frequency curve for Williams River at Brockways Mills was computed using its complete period of record plus the 1987-2000 record from Williams River at Rockingham adjusted for drainage area]

USGS stream-gaging station No.	Station name	Drainage area (mi^2)	Peak flow for given recurrence intervals (ft^3/s)							Period of record with unregulated peaks, in water years	Frequency analysis comments
			2-year	5-year	10-year	25-year	50-year	100-year	500-year		
01052500	Diamond River near Wentworth Location, N.H.	153	4,790	6,320	7,310	8,550	9,460	10,400	12,500	1942-2000	1
01127880	Big Brook near Pittsburg, N.H.	6.52	264	341	389	447	489	530	621	1964-84	1
01129300	Halls Stream near East Hereford, Quebec	84.8	3,130	4,420	5,480	7,090	8,500	10,100	14,900	1943, 1963-94	2
01129400	Black Brook at Averill, Vt.	.88	30.1	39.5	46.3	55.3	62.3	69.7	88.6	1964-78	3
01129440	Mohawk River near Colebrook, N.H.	35.3	2,310	3,500	4,360	5,510	6,410	7,350	9,690	1987-2000	1
01129700	Paul Stream Tributary near Brunswick, Vt.	1.48	46.1	61.6	72.2	85.9	96.4	107	133	1966-78, 1999-2000	3
01130000	Upper Ammonoosuc River near Groveton, N.H.	230	4,840	6,530	7,600	8,890	9,830	10,700	12,800	1941-80, 1983-2000	1
01133000	East Branch Passumpsic River near East Haven, Vt.	51.3	1,320	1,920	2,380	3,050	3,610	4,230	5,920	1940-45, 1949-79, 1998-2000	1
01133200	Quimby Brook near Lyndonville, Vt.	2.15	73.2	121	160	219	271	329	498	1964-74, 1999-2000	3
01133300	Cold Hill Brook near Lyndon, Vt.	1.64	58.3	94.2	124	171	213	262	407	1964-78	3
01133500	Passumpsic River near St. Johnsbury, Vt.	232	3,830	5,530	7,010	9,370	11,500	14,100	22,200	1910-19, 1927, 1936	2
01134500	Moose River at Victory, Vt.	75.2	2,070	2,770	3,260	3,920	4,440	4,980	6,340	1947-2000	1
01134800	Kirby Brook at Concord, Vt.	8.13	225	371	464	688	892	1,130	1,850	1964-74, 1999-2000	4
01135000	Moose River at St. Johnsbury, Vt.	129	2,650	3,790	4,610	5,730	6,630	7,570	9,980	1929-83	1
01135150	Pope Brook near N. Danville, Vt.	3.27	146	188	216	254	283	314	389	1991-2000	1
01135300	Sleepers River near St. Johnsbury, Vt.	42.5	1,430	2,390	3,260	4,670	6,010	7,620	12,800	1960-73, 1991-2000	1
01135500	Passumpsic River at Passumpsic, Vt.	434	7,600	10,100	11,700	13,800	15,400	16,900	20,700	1929-2000	1
01135700	Joes Brook Tributary near East Barnet, Vt.	.7	25.1	38.3	49	65.2	79.3	95.3	142	1964-74, 1999	3
01137500	Ammonoosuc River at Bethlehem Junction, N.H.	88.2	4,270	6,230	7,680	9,680	11,300	13,000	17,600	1940-2000	1
01138000	Ammonoosuc River near Bath, N.H.	396	10,600	15,700	19,600	25,200	29,700	34,700	48,100	1936-80	1

Table 2. Magnitude and frequency discharges at stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Drainage area (mi^2)	Peak flow for given recurrence intervals (ft^3/s)							Period of record with unregulated peaks, in water years	Frequency analysis comments
			2-year	5-year	10-year	25-year	50-year	100-year	500-year		
01138800	Keenan Brook at Groton, Vt.	4.72	93.5	161	216	298	369	449	674	1964-74	3
01139000	Wells River at Wells River, Vt.	98.7	1,700	2,520	3,130	3,980	4,670	5,400	7,340	1941-2000	1
01139700	Waits River Tributary near West Topsham, Vt.	1.21	47.7	75.7	96.9	127	151	177	246	1964-74, 1999-2000	3
01139800	East Orange Branch at East Orange, Vt.	8.79	245	388	498	657	789	933	1,320	1959-2000	1
01140000	South Branch Waits River near Bradford, Vt.	43.8	961	1,410	1,740	2,210	2,590	2,990	4,060	1940-51	1
01140100	South Branch Waits River Tributary near Bradford Center, Vt.	.21	5.4	7.3	8.6	10.2	11.5	12.8	16.1	1964-74	1
01140800	West Branch Ompompanoosuc River Tributary at South Strafford, Vt.	1.35	76.4	98.8	115	138	156	175	225	1964-77	3
01141500	Ompompanoosuc River at Union Village, Vt.	131	2,620	3,790	4,660	5,870	6,860	7,910	10,700	1941-49, 1973, 1987	6
01141800	Mink Brook near Etna, N.H.	4.88	216	367	485	657	800	957	1,380	1963-98	1
01142000	White River near Bethel, Vt.	239	10,100	15,400	19,600	25,800	31,000	36,800	53,200	1932-55	1
01142400	Third Branch White River Tributary at Randolph, Vt.	.83	46.7	68.3	86	113	136	162	239	1964-74, 1998-2000	3
01142500	Ayers Brook at Randolph, Vt.	30.5	703	1,070	1,380	1,850	2,270	2,750	4,190	1940-75, 1977-2000	1
01144000	White River at West Hartford, Vt.	689	17,300	25,300	31,800	41,600	50,100	59,800	87,600	1916-2000	1
01145000	Mascoma River at West Canaan, N.H.	80.4	1,630	2,310	2,770	3,350	3,790	4,220	5,260	1938, 1940-78, 1985-2000	1
01150800	Kent Brook near Killington, Vt.	3.26	117	150	167	224	275	335	517	1964-74, 1999-2000	4
01150900	Ottauquechee River near West Bridgewater, Vt.	23.3	944	1,340	1,630	2,050	2,390	2,750	3,730	1985-2000	1
01151200	Ottauquechee River Tributary near Quechee, Vt.	.77	14.7	25	34.1	48.6	61.9	77.7	127	1964-74, 1999-2000	3
01151500	Ottauquechee River at North Hartland, Vt.	222	7,760	12,500	16,600	23,300	29,400	36,600	59,200	1928, 1931-60, 1973	6
01152500	Sugar River at West Claremont, N.H.	270	4,630	6,510	7,870	9,720	11,200	12,700	16,700	1929-2000	1
01153000	Black River at North Springfield, Vt.	158	5,590	8,920	11,600	15,600	19,100	23,000	34,100	1930-60, 1973	6
01153300	Middle Branch Williams River Tributary at Chester, Vt.	3.18	148	204	244	298	342	387	505	1964-78, 1999-2000	3
01153500	Williams River at Brockways Mills, Vt.	102	4,380	6,440	7,910	9,890	11,400	13,100	17,200	1941-84	7

Table 2. Magnitude and frequency discharges at stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Drainage area (mi^2)	Peak flow for given recurrence intervals (ft^3/s)							Period of record with unregulated peaks, in water years	Fre-quency analysis com-ments
			2-year	5-year	10-year	25-year	50-year	100-year	500-year		
01153550	Williams River near Rockingham, Vt.	112	6,190	8,580	10,200	12,300	14,000	15,700	19,700	1987-2000	1
01154000	Saxtons River at Saxtons River, Vt.	72.1	2,640	4,180	5,420	7,270	8,860	10,600	15,700	1936, 1941-82	2
01155000	Cold River at Drewsville, N.H.	83.4	1,970	3,020	3,830	5,000	5,990	7,060	10,000	1941-78	1
01155200	Sacketts Brook near Putney, Vt.	10.2	140	235	296	446	586	753	1,270	1964-74	4
01155300	Flood Brook near Londonderry, Vt.	9.28	217	357	454	703	947	1,250	2,280	1964-74	4
01155350	West River Tributary near Jamaica, Vt.	.93	46.6	83	117	177	235	307	553	1964-78, 1999-2000	3
01155500	West River at Jamaica, Vt.	177	8,180	13,800	18,800	27,100	35,000	44,500	75,100	1936, 1938, 1947-60, 1973, 1987	2, 6
01156000	West River at Newfane, Vt.	306	12,800	20,800	28,000	39,600	50,500	63,500	105,000	1920-23, 1928-60	5
01156300	Whetstone Brook Tributary near Marlboro, Vt.	1.08	107	184	246	337	414	498	728	1963-74, 1999-2000	3
01156450	Connecticut River Tributary near Vernon, Vt.	1.1	52.7	79.8	100	128	151	176	241	1964-74, 1999-2000	3
01157000	Ashuelot River near Gilsum, N.H.	70.9	1,610	2,420	3,040	3,930	4,660	5,460	7,630	1923-80	1
01158500	Otter Brook near Keene, N.H.	41.9	1,150	2,020	2,770	3,960	5,040	6,310	10,200	1924-57	1
01160000	South Branch Ashuelot River at Webb, near Marlborough, N.H.	35.8	961	1,690	2,340	3,420	4,420	5,630	9,470	1921-78	1
01161000	Ashuelot River at Hinsdale, N.H.	421	6,350	8,890	10,800	13,500	15,700	18,100	24,600	1907-11, 1915-42	5
01161300	Millers Brook at Northfield, Mass.	2.31	108	190	266	393	514	661	1,140	1964-83	1
01165000	East Branch Tully River near Athol, Mass.	50.6	754	1,320	1,840	2,710	3,550	4,580	7,980	1917-48	5
01165500	Moss Brook at Wendell Depot, Mass.	12.2	261	432	573	784	967	1,170	1,760	1917-82	1
01167800	Beaver Brook at Wilmington, Vt.	6.36	360	633	805	1,210	1,580	2,010	3,280	1963-77	4
01169000	North River at Shattuckville, Mass.	89.6	4,690	7,380	9,440	12,400	14,800	17,400	24,400	1940-2000	1
01169900	South River near Conway, Mass.	24.1	1,830	2,830	3,600	4,710	5,630	6,650	9,390	1967-2000	1
01170100	Green River near Colrain, Mass.	41.3	2,480	3,330	3,890	4,580	5,100	5,610	6,810	1968-2000	1
01170200	Allen Brook near Shelburne Falls, Mass.	.72	25.1	46.6	64.2	90.4	113	137	205	1964-74	1
01170900	Mill River near South Deerfield, Mass.	6.4	140	198	238	293	335	379	490	1963-74	1
01178230	Mill Brook at Plainfield, Mass.	4.43	181	302	396	528	636	751	1,050	1964-83	1
01196990	Windsor Brook Tributary at Windsor, Mass.	.3	24.3	35.9	45	58.5	70	82.9	119	1964-74	1

Table 2. Magnitude and frequency discharges at stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Drainage area (mi^2)	Peak flow for given recurrence intervals (ft^3/s)							Period of record with unregulated peaks, in water years	Frequency analysis comments
			2-year	5-year	10-year	25-year	50-year	100-year	500-year		
01328000	Bond Creek at Dunham Basin, N.Y.	14.4	691	938	1,090	1,270	1,400	1,520	1,780	1948-82	1
01328900	Tanner Brook near Sunderland, Vt.	2.34	33.4	49.9	62.7	81.2	96.7	114	161	1964-74, 1999-2000	1
01329000	Batten Kill at Arlington, Vt.	150	3,220	4,520	5,500	6,870	8,000	9,230	12,500	1929-84	1
01329154	Steele Brook at Shushan N.Y.	2.81	67.1	103	128	160	185	209	267	1979-2000	1
01329500	Batten Kill at Battenville, N.Y.	397	5,930	8,770	11,000	14,200	16,900	20,000	28,400	1904, 1913, 1923-68, 1977, 1984, 1987-2000	2
01331400	Dry Brook near Adams, Mass.	7.68	476	693	848	1,050	1,220	1,390	1,810	1963-74	1
01331500	Hoosic River at Adams, Mass.	46.7	1,120	1,710	2,190	2,930	3,570	4,320	6,500	1932-2000	1
01332000	North Branch Hoosic River at North Adams, Mass.	41.1	2,390	3,920	5,230	7,260	9,100	11,200	17,700	1928, 1932-90	2
01332500	Hoosic River near Williamstown, Mass.	132	3,810	5,690	7,210	9,510	11,500	13,800	20,300	1941-2000	1
01333000	Green River at Williamstown, Mass.	42.4	1,500	2,200	2,720	3,440	4,020	4,640	6,260	1950-2000	1
01333500	Little Hoosic River at Petersburg, N.Y.	55.3	2,000	2,990	3,790	4,950	5,950	7,060	10,200	1949, 1952-2000	2
01333800	South Stream near Bennington, Vt.	7.71	85	119	143	175	199	224	287	1963-74	3
01333900	Paran Creek near South Shaftsbury, Vt.	2.38	76.5	124	159	209	249	292	403	1964-74, 1999-2000	3
01334000	Walloomsac River near North Bennington, Vt.	116	3,310	4,870	5,980	7,480	8,660	9,890	13,000	1932-2000	1
01334500	Hoosic River near Eagle Bridge, N.Y.	515	11,400	16,900	21,400	28,300	34,300	41,200	61,500	1911-22, 1924-2000	1
04270800	English River near Mooers Forks, N.Y.	39.4	913	1,270	1,510	1,830	2,080	2,330	2,960	1961-69, 1970-77	1
04271815	Little Chazy River near Chazy, N.Y.	50.4	737	1,270	1,720	2,420	3,030	3,730	5,790	1990-2000	1
04273500	Saranac River at Plattsburgh, N.Y.	608	5,580	7,780	9,240	11,100	12,500	13,900	17,200	1928, 1944-2000	1
04273700	Salmon River at South Plattsburgh, N.Y.	63.4	882	1,560	2,110	2,940	3,650	4,450	6,660	1960-86, 1990-2000	1
04276200	Bouquet River at New Russia, N.Y.	37.6	1,460	2,080	2,550	3,180	3,700	4,250	5,690	1949-79	1
04276500	Bouquet River at Willsboro, N.Y.	272	4,620	6,900	8,410	10,300	11,700	13,000	16,100	1924-68, 1980, 1987-2000	1
04276770	Mill Brook at Port Henry, N.Y.	27.1	692	1,050	1,290	1,590	1,810	2,020	2,510	1990-2000	1
04276842	Putnam Creek East of Crown Point Center, N.Y.	51.7	1,240	1,810	2,200	2,700	3,070	3,440	4,320	1990-2000	1

Table 2. Magnitude and frequency discharges at stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Drainage area (mi^2)	Peak flow for given recurrence intervals (ft^3/s)							Period of record with unregulated peaks, in water years	Frequency analysis comments
			2-year	5-year	10-year	25-year	50-year	100-year	500-year		
04278300	Northwest Bay Brook near Bolton Landing, N.Y.	22	1,030	1,390	1,610	1,850	2,020	2,180	2,520	1966-99	1
04279400	Poultney River Tributary at East Poultney, Vt.	1.14	66.2	84.7	95.7	108	117	125	143	1964-78, 1999-2000	3
04280000	Poultney River below Fair Haven, Vt.	188	4,080	6,090	7,490	9,320	10,700	12,200	15,600	1929-2001	1
04280200	Mettawee River Tributary #2 at East Rupert, Vt.	1.66	71	106	131	164	191	220	291	1963-74	1
04280300	Mettawee River Tributary near Pawlet, Vt.	2.09	34.4	55.5	67.1	94.8	118	144	213	1963-74	4
04280350	Mettawee River near Pawlet, Vt.	70.5	2,040	3,400	4,480	6,060	7,380	8,850	12,900	1985-2001	1
04280450	Mettawee River near Middle Granville, N.Y.	167	4,560	7,810	10,400	14,100	17,100	20,500	29,400	1990-2001	1
04280900	Moon Brook at Rutland, Vt.	1.84	76.8	112	137	171	198	227	300	1964-78	3
04282000	Otter Creek at Center Rutland, Vt.	308	5,370	7,490	8,890	10,700	12,000	13,300	16,300	1929-2000	1
04282200	Neshobe River at Brandon, Vt.	17.9	657	807	893	990	1,060	1,120	1,240	1968-78	3
04282300	Brandy Brook at Bread Loaf, Vt.	1.88	105	190	264	384	494	624	1,020	1963-78, 2000	1
04282500	Otter Creek at Middlebury, Vt.	630	4,270	5,840	6,970	8,480	9,680	10,900	14,200	1904-6, 1911-19, 1928-2000	1
04282525	New Haven River at Brooksville near Middlebury, Vt.	116	4,410	6,980	8,870	11,500	13,500	15,700	21,200	1991-2000	1
04282550	Beaver Brook at Cornwall, Vt.	1.06	62.2	69.9	74.4	79.5	82.9	86.2	93.2	1964-74	3
04282600	Little Otter Creek Tributary near Bristol, Vt.	1.52	30.1	46.1	57.5	72.6	84.3	96.4	126	1964-78, 1999-2000	3
04282650	Little Otter Creek at Ferrisburg, Vt.	57.3	1,120	1,640	1,990	2,440	2,790	3,130	3,950	1990-2000	1
04282700	Lewis Creek Tributary at Starksboro, Vt.	5.34	118	207	266	409	543	704	1,210	1963-74, 1999-2000	4
04282750	Lewis Creek Tributary #2 near Rockville, Vt.	1.23	45.8	63.4	75.3	90.8	103	115	144	1964-78	3
04282780	Lewis Creek at North Ferrisburg, Vt.	77.4	2,280	2,990	3,420	3,920	4,270	4,590	5,290	1990-2000	1
04282795	Laplatte River at Shelburne Falls, Vt.	44.3	1,040	1,650	2,120	2,770	3,310	3,880	5,390	1990-2000	1
04282850	Winooski River Tributary #2 near Cabot, Vt.	.58	18.2	28.9	37.4	49.9	60.5	72.4	106	1964-74	3
04283470	Stevens Branch Tributary at South Barre, Vt.	.49	24.3	37.8	48.6	64.3	77.8	92.8	135	1964-74	3
04286000	Winooski River at Montpelier, Vt.	395	9,170	12,500	15,200	19,300	22,900	26,900	38,700	1912-23, 1928-35	5

Table 2. Magnitude and frequency discharges at stream-gaging stations used to determine flow characteristics of Vermont streams--Continued

USGS stream-gaging station No.	Station name	Drainage area (mi^2)	Peak flow for given recurrence intervals (ft^3/s)							Period of record with unregulated peaks, in water years	Frequency analysis comments
			2-year	5-year	10-year	25-year	50-year	100-year	500-year		
04286500	Dog River at Northfield, Vt.	52	1,910	3,060	4,040	5,550	6,910	8,480	13,200	1912-34	1
04287000	Dog River at Northfield Falls, Vt.	76.6	3,100	4,930	6,300	8,200	9,730	11,400	15,600	1935-2000	1
04287300	Sunny Brook near Montpelier, Vt.	2.38	72.9	110	135	199	262	338	588	1964-74, 1999-2000	4
04288000	Mad River near Moretown, Vt.	139	5,780	8,180	10,000	12,700	14,800	17,300	23,800	1928-2000	1
04288400	Bryant Brook at Waterbury Center, Vt.	2.63	146	210	255	313	358	403	516	1964-78, 1999-2000	3
04289600	Winooski River Tributary near Richmond, Vt.	.71	33.1	50.1	63.3	82.2	98	115	163	1964-74, 1999-2000	3
04290700	Bailey Brook at East Hardwick, Vt.	2.55	87.1	135	174	235	289	352	538	1964-78, 1999-2000	3
04291000	Green River at Garfield, Vt.	15.9	429	668	874	1,200	1,490	1,840	2,910	1915-20, 1923-32	1
04292000	Lamoille River at Johnson, Vt.	310	7,190	9,600	11,200	13,300	14,900	16,500	20,300	1912-13, 1929-2000	1
04292100	Stony Brook near Eden, Vt.	4.24	212	365	467	717	952	1,240	2,130	1964-74, 1999-2000	4
04292150	Gihon River Tributary near Johnson, Vt.	.47	44.9	61.6	74.3	92.3	107	123	167	1964-74	1
04292200	Lamoille River Tributary at Jeffersonville, Vt.	.58	33	42.2	48	55.2	60.5	65.7	77.7	1964-74	1
04292500	Lamoille River at East Georgia, Vt.	688	13,200	16,500	18,700	21,400	23,300	25,300	29,900	1930-2000	1
04292700	Stone Bridge Brook near Georgia Plains, Vt.	8.41	168	317	450	663	858	1,090	1,790	1963-74, 1990-2000	1
04293000	Missisquoi River near North Troy, Vt.	133	4,370	5,670	6,540	7,650	8,500	9,350	11,400	1932-2000	1
04293400	Whittaker Brook at Richford, Vt.	.88	62.7	93.1	116	147	172	199	269	1963-78, 1999-2000	1
04293500	Missisquoi River near East Berkshire, Vt.	478	10,100	13,300	15,600	18,600	21,000	23,500	29,800	1912-17, 1919, 1921-23, 1928-2000	1
04293800	Missisquoi River Tributary at Sheldon Junction, Vt.	1.73	61.1	82.6	96.1	113	124	136	161	1963-78, 1999-2000	1
04294000	Missisquoi River at Swanton, Vt.	850	21,300	28,800	33,800	40,100	44,900	49,700	61,200	1990-2000	1
04294200	Saxe Brook near Highgate Springs, Vt.	2.65	66.3	121	164	225	273	325	456	1963-74, 1999-2000	3
04295900	Ware Brook near Coventry, Vt.	2.84	116	139	153	172	185	199	231	1963-74	3
04296000	Black River at Coventry, Vt.	122	2,040	2,670	3,080	3,590	3,980	4,360	5,260	1952-2000	1
04296150	Lord Brook near Evansville, Vt.	4.61	196	303	380	487	571	660	887	1964-78, 1999-2000	3
04296200	Brownington Branch near Evansville, Vt.	2.21	34.6	57	74.1	119	166	227	453	1964-74, 1999-2000	4
04296300	Pherrins River Tributary near Island Pond, Vt.	1.02	45.9	69.5	89.1	119	146	176	267	1964-74, 1999-2000	3

Table 3. Daily discharges exceeded 25, 50, and 75 percent of the time at stream-gaging stations used to determine flow characteristics of Vermont streams

[All streamgages are located on figure 1; USGS, U.S. Geological Survey; ft^3/s, cubic feet per second; No., number; mi^2, square miles]

USGS stream-gaging station No.	Station name	Drainage area, (mi^2)	Daily discharge exceeded *n* percent of the time (ft^3/s)			Period of record used (water years)
			75 percent	50 percent	25 percent	
01052500	Diamond River near Wentworth Location, N.H.	153	83.4	162	358	1941-2000
01127880	Big Brook near Pittsburg, N.H.	6.52	4.2	7.6	17.2	1964-85
01129300	Halls Stream near East Hereford, Quebec	84.8	40.1	81.2	183	1963-92
01129440	Mohawk River near Colebrook, N.H.	35.3	24.7	41.6	73.6	1987-2000
01130000	Upper Ammonoosuc River near Groveton, N.H.	230	143	252	524	1940-81, 1983-2000
01133000	East Branch Passumpsic River near East Haven, Vt.	51.3	42.2	64.6	119	1939-46, 1949-79, 1998-2000
01134500	Moose River at Victory, Vt.	75.2	38.4	73.8	160	1947-2000
01134800	Kirby Brook at Concord, Vt.	8.13	2.4	5.0	12.0	1963-74
01135000	Moose River at St. Johnsbury, Vt.	129	51.9	101	233	1928-83
01135150	Pope Brook near N. Danville, Vt.	3.27	2.4	3.7	6.5	1991-2000
01135300	Sleepers River near St. Johnsbury, Vt.	42.5	23.7	42.3	79.2	1991-2000
01135500	Passumpsic River at Passumpsic, Vt.	434	257	435	853	1929-2000
01137500	Ammonoosuc River at Bethlehem Junction, N.H.	88.2	65.0	109	224	1939-2000
01138000	Ammonoosuc River near Bath, N.H.	396	187	337	730	1935-80
01139000	Wells River at Wells River, Vt.	98.7	47.5	84.2	171	1940-2000
01139800	East Orange Branch at East Orange, Vt.	8.79	4.4	8.7	19.8	1958-2000
01140000	South Branch Waits River near Bradford, Vt.	43.8	20.3	38.2	80.2	1940-51
01141500	Ompompanoosuc River at Union Village, Vt.	131	54.9	112	242	[1]1940-49
01141800	Mink Brook near Etna, N.H.	4.88	1.1	3.1	8.1	1962-98
01142000	White River near Bethel, Vt.	239	134	261	548	1931-55
01142500	Ayers Brook at Randolph, Vt.	30.5	13.9	27.5	56.3	1939-75, 1976-2000
01144000	White River at West Hartford, Vt.	689	330	644	1,360	1915-27, 1929-2000
01150800	Kent Brook near Killington, Vt.	3.26	2.4	4.5	8.9	1964-74
01150900	Ottauquechee River near West Bridgewater, Vt.	23.3	18.4	33.2	64.7	1985-2000
01151500	Ottauquechee River at North Hartland, Vt.	222	104	205	437	[1]1931-60
01153500	Williams River at Brockways Mills, Vt.	102	32.3	74.9	190	1940-84
01153550	Williams River near Rockingham, Vt.	112	48.7	107	214	1987-2000
01154000	Saxtons River at Saxtons River, Vt.	72.1	22.7	54.9	134	1940-82
01155000	Cold River at Drewsville, N.H.	83.4	22.1	52.4	134	1940-78
01155200	Sacketts Brook near Putney, Vt.	10.2	3.9	8.5	20.1	1963-74
01155300	Flood Brook near Londonderry, Vt.	9.28	4.1	9.4	22.0	1963-74
01155500	West River at Jamaica, Vt.	177	60.5	156	384	[1]1947-60
01156000	West River at Newfane, Vt.	306	114	253	625	1920-23, [1]1929-60
01157000	Ashuelot River near Gilsum, N.H.	70.9	24.6	57.7	144	1922-80
01158500	Otter Brook near Keene, N.H.	41.9	14.6	36.7	83.3	1924-58

Table 3. Daily discharges exceeded 25, 50, and 75 percent of the time at stream-gaging stations used to determine flow characteristics of Vermont streams --Continued

USGS stream-gaging station No.	Station name	Drainage area, (mi^2)	Daily discharge exceeded *n* percent of the time (ft^3/s)			Period of record used (water years)
			75 percent	50 percent	25 percent	
01165000	East Branch Tully River near Athol, Mass.	50.6	18.6	46.4	104	[1]1916-48
01165500	Moss Brook at Wendell Depot, Mass.	12.2	3.9	10.6	24.8	1916-82
01167800	Beaver Brook at Wilmington, Vt.	6.36	2.5	6.8	16.9	1963-77
01169000	North River at Shattuckville, Mass.	89.6	41.3	94.8	204	1940-2000
01169900	South River near Conway, Mass.	24.1	13.8	31.0	61.9	1966-2000
01170100	Green River near Colrain, Mass.	41.3	22.1	49.9	103	1968-2000
01328000	Bond Creek at Dunham Basin, N.Y.	14.4	2.3	5.3	15.4	1948-82
01329000	Batten Kill at Arlington, Vt.	150	130	214	400	1929-84
01329500	Batten Kill at Battenville, N.Y.	397	234	426	874	1923-68, 1998-2000
01331400	Dry Brook near Adams, Mass.	7.68	2.8	7.3	16.6	1963-74
01332000	North Branch Hoosic River at North Adams, Mass.	41.1	23.5	49.2	105	1931-90
01332500	Hoosic River near Williamstown, Mass.	132	99.8	171	317	1940-2000
01333000	Green River at Williamstown, Mass.	42.4	23.4	49.3	103	1949-2000
01333500	Little Hoosic River at Petersburg, N.Y.	55.3	19.8	52.7	119	1951-96
01334000	Walloomsac River near North Bennington, Vt.	116	87.7	145	260	1931-2000
01334500	Hoosic River near Eagle Bridge, N.Y.	515	293	573	1,180	1910-2000
04271815	Little Chazy River near Chazy, N.Y.	50.4	11.7	29.3	65.3	1990-2000
04273500	Saranac River at Plattsburgh, N.Y.	608	445	649	1,020	1903-30, 1944-2000
04273700	Salmon River at South Plattsburgh, N.Y.	63.4	18.5	33.0	61.0	1959-68, 1990-2000
04276500	Bouquet River at Willsboro, N.Y.	272	87.6	157	332	1923-68, 1990-2000
04276842	Putnam Creek East of Crown Point Center, N.Y.	51.7	16.5	36.8	86.2	1990-2000
04278300	Northwest Bay Brook near Bolton Landing, N.Y.	22	6.9	17.6	40.2	1966-97
04280300	Mettawee River Tributary near Pawlet, Vt.	2.09	0.7	1.8	4.3	1963-74
04280350	Mettawee River near Pawlet, Vt.	70.5	42.6	80.1	145	1985-2000
04280450	Mettawee River near Middle Granville, N.Y.	167	73.4	168	342	1990-2000
04282500	Otter Creek at Middlebury, Vt.	630	382	646	1,350	1903-07, 1911-20, 1929-2000
04282525	New Haven River at Brooksville near Middlebury, Vt.	116	77.7	129	232	1990-2000
04282650	Little Otter Creek at Ferrisburg, Vt.	57.3	11.0	25.7	60.4	1990-2000
04282700	Lewis Creek Tributary at Starksboro, Vt.	5.34	0.9	2.4	7.5	1963-74
04282780	Lewis Creek at North Ferrisburg, Vt.	77.4	31.8	61.2	120	1990-2000
04282795	Laplatte River at Shelburne Falls, Vt.	44.3	7.2	19.7	48.6	1990-2000
04286500	Dog River at Northfield, Vt.	52	17.5	34.7	80.6	1909-21, 1929-35
04287000	Dog River at Northfield Falls, Vt.	76.6	31.5	64.4	134	1935-2000
04287300	Sunny Brook near Montpelier, Vt.	2.38	0.5	1.1	3.1	1964-74
04288000	Mad River near Moretown, Vt.	139	71.7	140	292	1929-2000

Table 3. Daily discharges exceeded 25, 50, and 75 percent of the time at stream-gaging stations used to determine flow characteristics of Vermont streams --Continued

USGS stream-gaging station No.	Station name	Drainage area, (mi^2)	Daily discharge exceeded *n* percent of the time (ft^3/s)			Period of record used (water years)
			75 percent	50 percent	25 percent	
04291000	Green River at Garfield, Vt.	15.9	9.8	16.7	36.6	1916-21, 1923-32
04291500	Lamoille River at Cadys Falls, Vt.	268	142	229	454	1914-23
04292000	Lamoille River at Johnson, Vt.	310	190	298	566	1910-14, 1929-2000
04292100	Stony Brook near Eden, Vt.	4.24	3.2	5.6	11.0	1963-74
04292500	Lamoille River at East Georgia, Vt.	688	433	722	1,390	1929-2000
04292700	Stone Bridge Brook near Georgia Plains, Vt.	8.41	2.6	4.8	9.0	1963-74, 1990-2000
04293000	Missisquoi River near North Troy, Vt.	133	73.7	132	280	1931-2000
04293500	Missisquoi River near East Berkshire, Vt.	478	255	471	1,060	1915-23, 1929-2000
04294000	Missisquoi River at Swanton, Vt.	850	424	840	1,930	1990-2000
04296000	Black River at Coventry, Vt.	122	63.2	108	225	1952-2000

[1]Statistics computed using only the period of record with unregulated flows and discharge does not represent current conditions.

Table 5. Values of parameters used in the calibrated rainfall-runoff models for selected stream-gaging stations in Vermont

Stream-gaging stations are shown in figure 2.

na, not applicable;

carea_max, Maximum drainage area contributing to surface runoff in decimal percent of basin area;

cecn_coef, Convection condensation energy coefficient, monthly, in calories per degrees Celsius above 0;

chan_type, 1=rectangular open channel, 4=explicit specification of the kinematic parameters;

chan_alpha, Kinematic parameter alpha for routing channel flow;

chan_cmp, Kinematic parameter m for routing channel flow;

chan_rough, Channel roughness parameter;

cov_type, Vegetation cover type, 3=trees;

drnpar, Drainage factor for redistribution of saturated moisture storage to soil recharge as a function of hydraulic conductivity, in inches per hour;

emis_noppt, Emissivity of air on days without precipitation;

epan_coef, Pan-evaporation coefficient;

gwflow_coef, Ground-water routing coefficient for computing ground-water flow contribution to streamflow, in 1 per day;

gwsink_coef, Ground-water sink coefficient to compute seepage from ground-water storage to sink, in 1 per day;

gwstor_init, Initial storage in ground-water reservoir, in inches;

hc, Parametric coefficient in raindrop flow-depth soil detachment relation;

kf, Parametric coefficient in runoff detachment relation;

Kpar, Hydraulic conductivity of the transmission zone, in inches per hour;

kr, Parametric coefficient in raindrop flow-depth soil detachment relation;

nchan, Number of channels;

nhru, Number of hydrologic response units or subbasins;

ofp_alpha, Kinematic parameter alpha for routing overland flow;

ofp_cmp, Kinematic parameter m for routing overland flow;

psp, The product of moisture deficit and capillary drive for soil recharge equal to field capacity, in inches;

rain_adj, Monthly factor to adjust measured precipitation to account for differences in altitude;

sfres_coef, Coefficient to route reservoir storage to streamflow;

sfres_init, Initial storage of each surface reservoir, in cubic feet per second per day;

sfres_qro, Initial outflow from each surface storage reservoir, in cubic feet per second;

smidx_coef, Coefficient in non-linear contributing area algorithm;

smidx_exp, Exponent in non-linear contributing area algorithm;

soil_moist_init, Initial value of available water in soil profile, in inches;

soil_moist_max, Maximum available water holding capacity of soil profile, in inches;

soil_rechr_init, Initial value for soil recharge zone, in inches;

soil_rechr_max, Maximum value for soil recharge zone, in inches;

soil_type, 1=sand, 2=loam, 3=clay;

soil2gw_max, Maximum amount of the soil water excess that is routed directly to the ground-water reservoir each day, in inches;

srain_intcp, Summer rain interception storage, in inches;

ssr2gw_exp, Coefficient in equation used to route water from subsurface to ground-water reservoirs;

ssr2gw_rate, Coefficient in equation used to route water from subsurface to ground-water reservoirs;

ssrcoef_lin, Coefficient to route subsurface storage to streamflow;

ssrcoef_sq, Coefficient to route subsurface storage to streamflow;

ssrmax_ceof, Coefficient to route subsurface storage to ground water;

ssstor_init, Initial storage of subsurface reservoirs, in inches;

strain_adj, Monthly factor to adjust measured precipitation to account for differences in altitude during storm runoff routing.

Table 5. Values of parameters used in the calibrated rainfall-runoff models for selected stream-gaging stations in Vermont--Continued

Parameter	Kirby Brook	Kent Brook	Sacketts Brook	Flood Brook	Beaver Brook	Mettawee River Tributary	Lewis Creek Tributary	Sunny Brook	Stony Brook	Brownington Branch
carea_max	0.96	0.99	0.98	0.7	0.9	0.91	0.91	0.94	0.96	0.96
cecn_coef	4.7	5	5	5.8	5	5.1	5	5	5.7	5
chan_type	4	1	4	4	4	1	1	1	1	1
chan_alpha	99.3	na	51.4-100	1.1-1.4	.2-.9	na	na	na	na	na
chan_cmp	1.8	na	.86	1.6	1.8	na	na	na	na	na
chan_rough	na	.11	na	na	na	.01	.001	.0013	.01	.019
cov_type	3	3	3	3	3	3	3	3	3	3
drnpar	1.13	.3	1	1.87	1.98	1	2	1	2	.13
emiss_noppt	.757	.757	.757	.757	.757	.757	.757	.757	.757	.757
epan_coef	.37-.78	.38-.79	.47-.99	.44-.93	.72-1.51	.63-1.31	.47-.99	.46-.95	.44-.92	.37-.77
gwflow_coef	.046	.056	.025	.0082	.04	.048	.048	.019	.021	.014
gwsink_coef	0	.0037	0	.029	0	0	0	.013	0	.049
gwstor_init	.69	.41	.69	.71	.7	.5	.49	1.2	.5	.5
hc	10	.000001	10.6	9.9	10	10	10	10.5	9.9	10
kf	1	1	.99	.99	1	1	1	.39	1	1
kpar	.59	.011	1.7	19.2	1.32	.5	3	.058	1.1	1.4
kr	1	1	1	1	1	1	1	2.7	.69	1
nchan	5	1	5	3	5	1	1	1	1	1
nhru	10	2	10	6	10	2	2	2	2	2
ofp_alpha	.014-.025	.001	.001-.0016	1.7-2.7	1.4-2.5	.003	.0094	.001	.2	.0011
ofp_cmp	2.3	3	3	2.5	1.9	1.7	1.6	3	1.1	3
psp	.0022	12.3	.11	41.3	0	.5	.46	2.7	.46	.41
rain_adj	1	1.27	1	1	1	1.03	1	1.08	1	1.07
sfres_coef	.1	.1	.1	.1	.1	.1	.1	.12	.1	.1
sfres_init	0	0	1	.01	0	0	0	1.1	0	0
sfres_qro	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
smidx_coef	.0017	.0001	.00056	.031	.0052	.0001	.00053	.00014	.0066	.0055
smidx_exp	.41	.26	.2	.2	.34	.2	.2	.26	.2	.28
soil_moist_init	1	1	1	1.3	1	1	1	1	1	1
soil_moist_max	1	1	1	.8	1	1	1	1	1	1
soil_rechr_init	1	1	1	1.3	1	1	1	1	1	1
soil_rechr_max	1	1.7	1	.8	1	1	1	1	1	1
soil_type	2	2	2	2	2	2	2	2	2	2
soil2gw_max	.082	.15	.15	.15	2.1	.38	.016	.0011	0	.046
srain_intcp	.0018	.0000001	-.049	.21	.051	.015	.45	3.8	.28	.33
ssr2gw_exp	1.2	.53	2.6	2.9	.33	3	.75	.77	2.1	1.3
ssr2gw_rate	.076	.7	.045	.49	.0048	.36	.11	.29	.22	.11
ssrcoef_lin	.00001	1	.031	.0038	.00013	.089	.1	.000024	.0055	.15
ssrcoef_sq	.43	.28	.096	.3	.48	.15	.17	1	.16	.12
ssrmax_coef	.92	.49	.83	1	1	1	1.1	.71	.97	.15
ssstor_init	.6	.01	.59	.6	.6	.001	0	.62	0	.05
strain_adj	.99	1	1	1	1	1	1	1.06	1	3.3

Table 8. Basin characteristics used in the regression-equation development

[All station locations are shown on figure 1; USGS, U.S. Geological Survey; No., number; mi^2, square miles]

USGS stream-gaging station No.	Station name	Drainage area, (mi^2)	Percent of basin area that is lake or pond	Percent of basin area above 1,200 feet	Northing of basin centroid in Vermont State Plane Coordinates	Mean annual precipitation (inches)
01052500	Diamond River near Wentworth Location, N.H.	153	0.336	100	274,367	48.6
01127880	Big Brook near Pittsburg, N.H.	6.52	.965	100	296,194	48.8
01129300	Halls Stream near East Hereford, Quebec	84.8	.040	95.8	293,409	43.6
01129400	Black Brook at Averill, Vt.	0.88	0	100	279,226	44.3
01129440	Mohawk River near Colebrook, N.H.	35.3	.407	100	266,508	47.2
01129700	Paul Stream Tributary near Brunswick, Vt.	1.48	.208	83.7	242,002	40.4
01130000	Upper Ammonoosuc River near Groveton, N.H.	230	.615	87.2	235,261	47.4
01133000	East Branch Passumpsic River near East Haven, Vt.	51.3	.791	89.5	245,264	44.7
01133200	Quimby Brook near Lyndonville, Vt.	2.15	.016	55.1	231,996	39.1
01133300	Cold Hill Brook near Lyndon, Vt.	1.64	.061	76.2	224,877	40.5
01133500	Passumpsic River near St. Johnsbury, Vt.	232	.462	71.4	236,275	42.7
01134500	Moose River at Victory, Vt.	75.2	.202	93.3	230,866	46.3
01134800	Kirby Brook at Concord, Vt.	8.13	.361	74.0	220,716	41.8
01135000	Moose River at St. Johnsbury, Vt.	129	.361	75.3	225,353	43.7
01135150	Pope Brook near N. Danville, Vt.	3.27	.038	98.7	220,797	44.0
01135300	Sleepers River near St. Johnsbury, Vt.	42.5	.095	62.5	219,474	41.9
01135500	Passumpsic River at Passumpsic, Vt.	434	.369	67.9	229,842	42.6
01135700	Joes Brook Tributary near East Barnet, Vt.	.7	.045	14.2	204,569	37.6
01137500	Ammonoosuc River at Bethlehem Junction, N.H.	88.2	.038	100	195,295	63.8
01138000	Ammonoosuc River near Bath, N.H.	396	.263	69.8	190,917	48.1
01138800	Keenan Brook at Groton, Vt.	4.72	.107	86.0	187,270	42.2
01139000	Wells River at Wells River, Vt.	98.7	1.41	64.5	191,057	40.7
01139700	Waits River Tributary near West Topsham, Vt.	1.21	.047	100	184,057	43.4
01139800	East Orange Branch at East Orange, Vt.	8.79	.162	100	177,164	41.7
01140000	South Branch Waits River near Bradford, Vt.	43.8	.172	69.3	169,051	39.8
01140100	South Branch Waits River Tributary near Bradford Center, Vt.	0.21	0	6.0	168,480	37.8
01140800	West Branch Ompompanoosuc River Tributary at South Strafford, Vt.	1.35	.093	83.1	147,717	40.5
01141500	Ompompanoosuc River at Union Village, Vt.	131	.905	56.0	154,356	39.0
01141800	Mink Brook near Etna, N.H.	4.88	.289	90.6	133,909	40.8
01142000	White River near Bethel, Vt.	239	.070	86.4	149,394	47.8
01142400	Third Branch White River Tributary at Randolph, Vt.	0.83	0	55.3	160,525	39.6
01142500	Ayers Brook at Randolph, Vt.	30.5	.199	65.0	167,034	40.6
01144000	White River at West Hartford, Vt.	689	.192	68.9	154,018	43.2
01145000	Mascoma River at West Canaan, N.H.	80.4	1.54	64.6	133,345	41.6
01150800	Kent Brook near Killington, Vt.	3.26	.490	100	128,291	55.0

Table 8. Basin characteristics used in the regression-equation development--Continued

USGS stream-gaging station No.	Station name	Drainage area, (mi^2)	Percent of basin area that is lake or pond	Percent of basin area above 1,200 feet	Northing of basin centroid in Vermont State Plane Coordinates	Mean annual precipitation (inches)
01150900	Ottauquechee River near West Bridgewater, Vt.	23.3	0.841	97.8	128,834	52.6
01151200	Ottauquechee River Tributary near Quechee, Vt.	.77	.126	8.7	130,162	38.8
01151500	Ottauquechee River at North Hartland, Vt.	222	.357	69.8	124,490	45.7
01152500	Sugar River at West Claremont, N.H.	270	4.31	53.4	100,439	41.2
01153000	Black River at North Springfield, Vt.	158	1.08	70.3	103,696	45.9
01153300	Middle Branch Williams River Tributary at Chester, Vt.	3.18	.058	56.4	88,259	43.0
01153500	Williams River at Brockways Mills, Vt.	102	.127	56.7	85,781	44.7
01153550	Williams River near Rockingham, Vt.	112	.129	52.3	85,113	44.4
01154000	Saxtons River at Saxtons River, Vt.	72.1	.208	55.6	72,567	45.7
01155000	Cold River at Drewsville, N.H.	83.4	3.63	65.3	76,618	40.9
01155200	Sacketts Brook near Putney, Vt.	10.2	.486	22.4	57,835	43.3
01155300	Flood Brook near Londonderry, Vt.	9.28	.403	100	83,942	51.2
01155350	West River Tributary near Jamaica, Vt.	.93	.075	100	68,954	47.3
01155500	West River at Jamaica, Vt.	177	.662	93.3	80,594	50.4
01156000	West River at Newfane, Vt.	306	.501	84.6	73,352	49.8
01156300	Whetstone Brook Tributary near Marlboro, Vt.	1.08	1.04	100	40,691	50.3
01156450	Connecticut River Tributary near Vernon, Vt.	1.1	.083	0	31,703	44.7
01157000	Ashuelot River near Gilsum, N.H.	70.9	3.36	90.0	71,144	44.3
01158500	Otter Brook near Keene, N.H.	41.9	2.12	89.1	57,814	43.9
01160000	South Branch Ashuelot River at Webb, near Marlborough, N.H.	35.8	1.79	57.4	38,205	43.6
01161000	Ashuelot River at Hinsdale, N.H.	421	1.99	42.0	48,752	42.0
01161300	Millers Brook at Northfield, Mass.	2.31	.057	21.6	19,597	44.3
01165000	East Branch Tully River near Athol, Mass.	50.6	2.49	14.2	23,921	43.0
01165500	Moss Brook at Wendell depot, Mass.	12.2	1.18	0.50	16,273	42.9
01167800	Beaver Brook at Wilmington, Vt.	6.36	.520	100	39,854	53.0
01169000	North River at Shattuckville, Mass.	89.6	.326	74.6	26,424	49.3
01169900	South River near Conway, Mass.	24.1	.406	42.8	777	45.9
01170100	Green River near Colrain, Mass.	41.3	.450	65.1	32,903	49.0
01170200	Allen Brook near Shelburne falls, Mass.	.72	1.11	0	12,253	43.5
01170900	Mill River near South Deerfield, Mass.	6.4	.033	0	-87	43.1
01178230	Mill Brook at Plainfield, Mass.	4.43	.424	100	3,391	47.9
01196990	Windsor Brook Tributary at Windsor, Mass.	.3	0	100	2,328	52.8
01328000	Bond Creek at Dunham Basin, N.Y.	14.4	.075	0	93,990	37.2
01328900	Tanner Brook near Sunderland, Vt.	2.34	0	72.9	72,432	50.0
01329000	Batten Kill at Arlington, Vt.	150	.342	62.3	69,235	53.0

Table 8. Basin characteristics used in the regression-equation development--Continued

USGS stream-gaging station No.	Station name	Drainage area, (mi^2)	Percent of basin area that is lake or pond	Percent of basin area above 1,200 feet	Northing of basin centroid in Vermont State Plane Coordinates	Mean annual precipitation (inches)
01329154	Steele Brook at Shushan N.Y.	2.81	0	0	68,855	38.5
01329500	Batten Kill at Battenville, N.Y.	397	0.549	40.0	73,684	46.7
01331400	Dry Brook near Adams, Mass.	7.68	.163	98.6	7,591	50.0
01331500	Hoosic River at Adams, Mass.	46.7	2.10	71.5	6,560	46.9
01332000	North Branch Hoosic River at North Adams, Mass.	41.1	.276	84.7	29,678	51.9
01332500	Hoosic River near Williamstown, Mass.	132	.961	69.6	17,604	48.1
01333000	Green River at Williamstown, Mass.	42.4	.072	67.5	15,585	46.2
01333500	Little Hoosic River at Petersburg, N.Y.	55.3	.239	67.5	22,612	44.7
01333800	South Stream near Bennington, Vt.	7.71	1.11	69.4	33,294	48.2
01333900	Paran Creek near South Shaftsbury, Vt.	2.38	0	64.3	53,287	46.6
01334000	Walloomsac River near North Bennington, Vt.	116	.300	59.5	43,892	50.1
01334500	Hoosic River near Eagle Bridge, N.Y.	515	.368	54.4	30,814	45.7
04270800	English River near Mooers Forks, N.Y.	39.4	.105	9.1	273,087	32.1
04271815	Little Chazy River near Chazy, N.Y.	50.4	.431	7.7	260,180	32.8
04273500	Saranac River at Plattsburgh, N.Y.	608	5.68	88.6	220,074	38.3
04273700	Salmon River at South Plattsburgh, N.Y.	63.4	.274	31.3	235,849	33.1
04276200	Bouquet River at New Russia, N.Y.	37.6	.146	82.2	180,544	40.5
04276500	Bouquet River at Willsboro, N.Y.	272	.881	41.6	195,052	36.9
04276770	Mill Brook at Port Henry, N.Y.	27.1	1.61	63.7	174,784	38.3
04276842	Putnam Creek East of Crown Point Center, N.Y.	51.7	2.23	49.2	156,433	39.0
04278300	Northwest Bay Brook near Bolton Landing, N.Y.	22	1.19	54.1	132,885	41.8
04279400	Poultney River Tributary at East Poultney, Vt.	1.14	0	0	116,877	38.0
04280000	Poultney River below Fair Haven, Vt.	188	2.70	21.2	121,848	40.1
04280200	Mettawee River Tributary #2 at East Rupert, Vt.	1.66	0	86.0	84,510	54.4
04280300	Mettawee River Tributary near Pawlet, Vt.	2.09	.018	48.9	93,099	45.8
04280350	Mettawee River near Pawlet, Vt.	70.5	.036	59.1	91,677	48.2
04280450	Mettawee River near Middle Granville, N.Y.	167	1.15	34.6	96,691	43.7
04280900	Moon Brook at Rutland, Vt.	1.84	.268	29.1	124,370	44.4
04282000	Otter Creek at Center Rutland, Vt.	308	.759	72.2	110,502	48.8
04282200	Neshobe River at Brandon, Vt.	17.9	.091	66.3	150,054	45.5
04282300	Brandy Brook at Bread Loaf, Vt.	1.88	.062	100	162,601	48.2
04282500	Otter Creek at Middlebury, Vt.	630	.758	54.4	128,144	44.9
04282525	New Haven River at Brooksville near Middlebury, Vt.	116	.122	63.0	176,729	44.2
04282550	Beaver Brook at Cornwall, Vt.	1.06	.150	0	164,217	35.3
04282600	Little Otter Creek Tributary near Bristol, Vt.	1.52	.041	0	184,921	36.7

Table 8. Basin characteristics used in the regression-equation development--Continued

USGS stream-gaging station No.	Station name	Drainage area, (mi^2)	Percent of basin area that is lake or pond	Percent of basin area above 1,200 feet	Northing of basin centroid in Vermont State Plane Coordinates	Mean annual precipitation (inches)
04282650	Little Otter Creek at Ferrisburg, Vt.	57.3	0.124	0.2	185,175	35.4
04282700	Lewis Creek Tributary at Starksboro, Vt.	5.34	.189	70.5	194,167	45.1
04282750	Lewis Creek Tributary #2 near Rockville, Vt.	1.23	.147	20.7	194,818	39.1
04282780	Lewis Creek at North Ferrisburg, Vt.	77.4	.820	22.4	194,096	39.2
04282795	Laplatte River at Shelburne Falls, Vt.	44.3	1.10	1.8	204,271	36.3
04282850	Winooski River Tributary #2 near Cabot, Vt.	.58	0	100	215,714	44.9
04283470	Stevens Branch Tributary at South Barre, Vt.	.49	.526	16.5	187,615	35.3
04286000	Winooski River at Montpelier, Vt.	395	1.20	62.8	199,451	40.5
04286500	Dog River at Northfield, Vt.	52	.243	81.6	178,943	41.8
04287000	Dog River at Northfield Falls, Vt.	76.6	.192	74.7	181,468	41.3
04287300	Sunny Brook near Montpelier, Vt.	2.38	0	31.1	198,551	39.8
04288000	Mad River near Moretown, Vt.	139	.047	73.4	186,136	46.8
04288400	Bryant Brook at Waterbury Center, Vt.	2.63	.039	33.5	211,456	45.9
04289600	Winooski River Tributary near Richmond, Vt.	.71	0	34.3	215,233	38.2
04290700	Bailey Brook at East Hardwick, Vt.	2.55	1.04	95.8	227,357	42.8
04291000	Green River at Garfield, Vt.	15.9	6.86	97.6	239,564	45.5
04291500	Lamoille River at Cadys Falls, Vt.	268	1.69	67.9	228,695	43.3
04292000	Lamoille River at Johnson, Vt.	310	1.49	63.7	229,198	43.7
04292100	Stony Brook near Eden, Vt.	4.24	.644	82.4	246,254	48.5
04292150	Gihon River Tributary near Johnson, Vt.	.47	.058	20.8	240,796	42.4
04292200	Lamoille River Tributary at Jeffersonville, Vt.	.58	0	5.9	240,171	41.6
04292500	Lamoille River at East Georgia, Vt.	688	.883	46.5	234,270	45.1
04292700	Stone Bridge Brook near Georgia Plains, Vt.	8.41	.478	0	245,095	36.9
04293000	Missisquoi River near North Troy, Vt.	133	0.129	62.0	262,556	45.4
04293400	Whittaker Brook at Richford, Vt.	.88	0	7.6	275,343	48.4
04293500	Missisquoi River near East Berkshire, Vt.	478	.717	35.4	280,419	45.3
04293800	Missisquoi River Tributary at Sheldon Junction, Vt.	1.73	.350	0	264,664	43.8
04294000	Missisquoi River at Swanton, Vt.	850	.614	27.8	272,042	46.0
04294200	Saxe Brook near Highgate Springs, Vt.	2.65	.391	0	274,996	37.7
04295900	Ware Brook near Coventry, Vt.	2.84	1.37	64.7	262,302	42.7
04296000	Black River at Coventry, Vt.	122	1.38	52.8	247,849	43.2
04296150	Lord Brook near Evansville, Vt.	4.61	.013	100	251,504	43.3
04296200	Brownington Branch near Evansville, Vt.	2.21	0	98.2	257,480	44.4
04296300	Pherrins River Tributary near Island Pond, Vt.	1.02	0	100	261,065	42.7

APPENDIXES

APPENDIX 1: USE OF REGRESSION EQUATIONS WITH METRIC UNITS

The equations for estimating peak flow at recurrence intervals of 2, 5, 10, 25, 50, 100, and 500 years, and daily-mean discharges exceeded 25, 50, and 75 percent of the time when using metric units for drainage area and precipitation are as follows:

$$Q_2 = 0.452A^{0.914}L^{-0.294}E^{0.0776}Y^{-0.180}, \qquad (1)$$

$$Q_5 = 0.742A^{0.902}L^{-0.295}E^{0.0835}Y^{-0.253}, \qquad (2)$$

$$Q_{10} = 0.962A^{0.897}L^{-0.302}E^{0.0890}Y^{-0.298}, \qquad (3)$$

$$Q_{25} = 1.30A^{0.883}L^{-0.316}E^{0.104}Y^{-0.349}, \qquad (4)$$

$$Q_{50} = 1.59A^{0.874}L^{-0.327}E^{0.115}Y^{-0.385}, \qquad (5)$$

$$Q_{100} = 1.90A^{0.865}L^{-0.336}E^{0.125}Y^{-0.420}, \qquad (6)$$

$$Q_{500} = 2.75A^{0.846}L^{-0.355}E^{0.148}Y^{-0.497}, \qquad (7)$$

$$D_{75} = (4.28 \text{x} 10^{-8})A^{1.08}P^{1.55}E^{0.101}, \qquad (8)$$

$$D_{50} = (9.73 \text{x} 10^{-8})A^{1.04}P^{1.58}E^{0.0603}, \text{ and} \qquad (9)$$

$$D_{25} = (3.08 \text{x} 10^{-7})A^{1.01}P^{1.55}E^{0.0438}. \qquad (10)$$

where

- Q_n is the calculated peak flow for recurrence interval *n*, in cubic meters per second;
- D_n is the estimated daily discharge exceeded *n* percent of the time, in cubic meters per second;
- A is the drainage area of the basin, in square kilometers, delineated with a GIS (boundaries for the drainage areas were from a 14-digit hydrologic-unit coverage (Natural Resources Conservation Service, 1996) or digitized when a basin’s boundary was not defined by this GIS coverage);
- L is the area of lakes and ponds in a basin as a percentage of drainage area, plus 1 percent, determined using a GIS from the 1:24,000 scale National Hydrography Dataset (U.S. Geological Survey, 2001c) and includes all features in the dataset having lake or pond boundaries even ones as small as several hundreths of an acre and pooled areas of streams;
- E is the percentage of the basin at or greater than 1,200 feet (365.7 meters) in altitude, plus 1 percent, computed from the National Elevation Dataset (U.S. Geological Survey, 2001b) with a GIS.
- Y is the northing of the centroid of the drainage basin determined with a GIS, in the Vermont State Plane coordinate system, divided by 100,000, then increased by 1; and
- P is the basinwide mean of the mean-annual precipitation, in millimeters, determined with a GIS and the PRISM dataset (Daly, 2000), resampled with bilinear interpolation to a 30-m-cell resolution using the GIS, ARC/INFO RESAMPLE command (Environmental Systems Research Institute, Inc., 1994). Precipitation data from Canada (Ghislain Jacques, Environment Quebec, written commun., January 17, 2002) were used along the northern Vermont border where the PRISM data are not available).

REFERENCES CITED

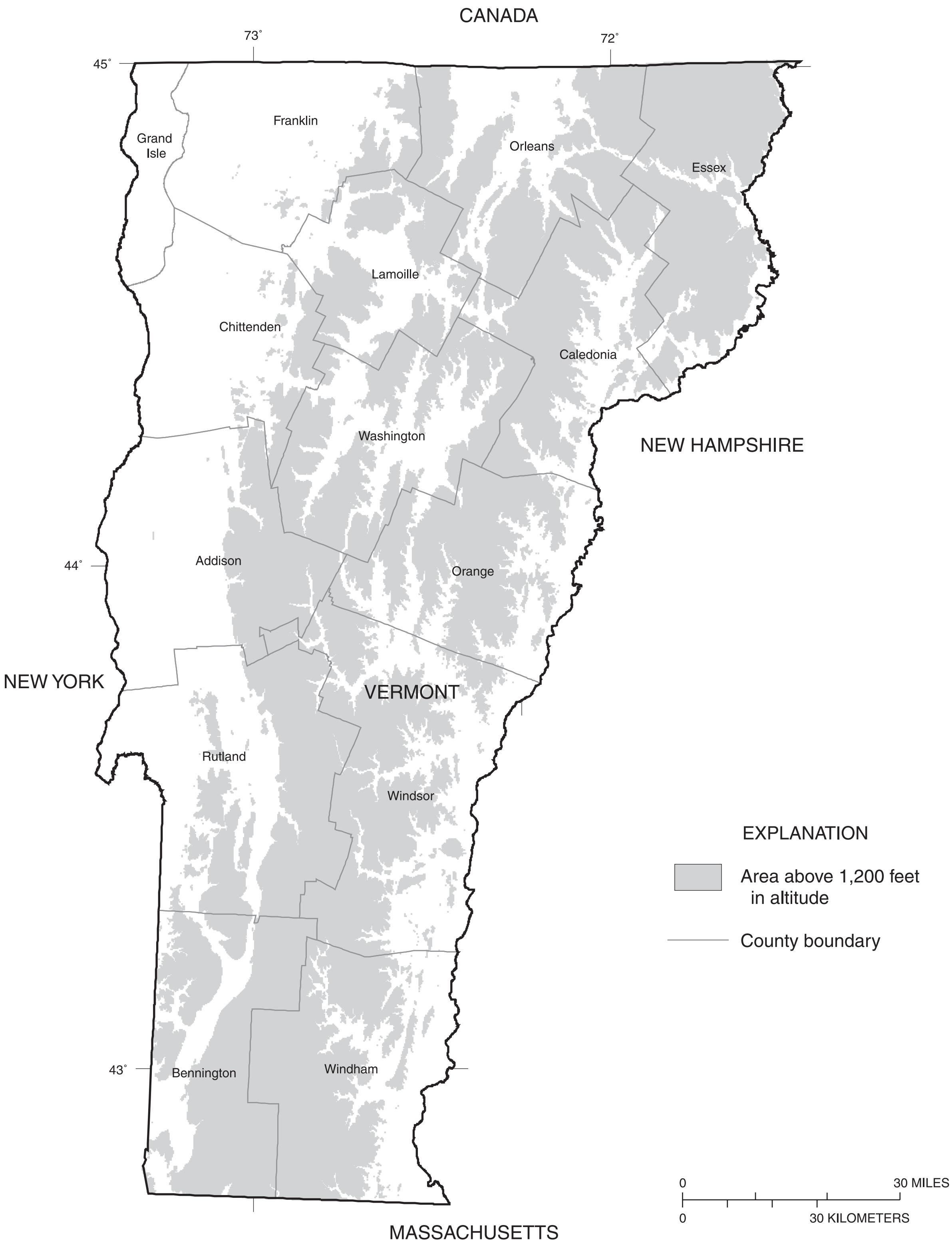
Daly, Christopher, 2000, PRISM (Parameter-elevation Regressions on Independent Slopes Model), U.S. Department of Agriculture and Natural Resources Conservation Service Climate Mapping Project: National Water and Climate Center, Oregon State University Partnership.

Environmental Systems Research Institute, Inc. (ESRI), 1994, ARC/INFO users guide, version 7.0: Redlands, Calif.

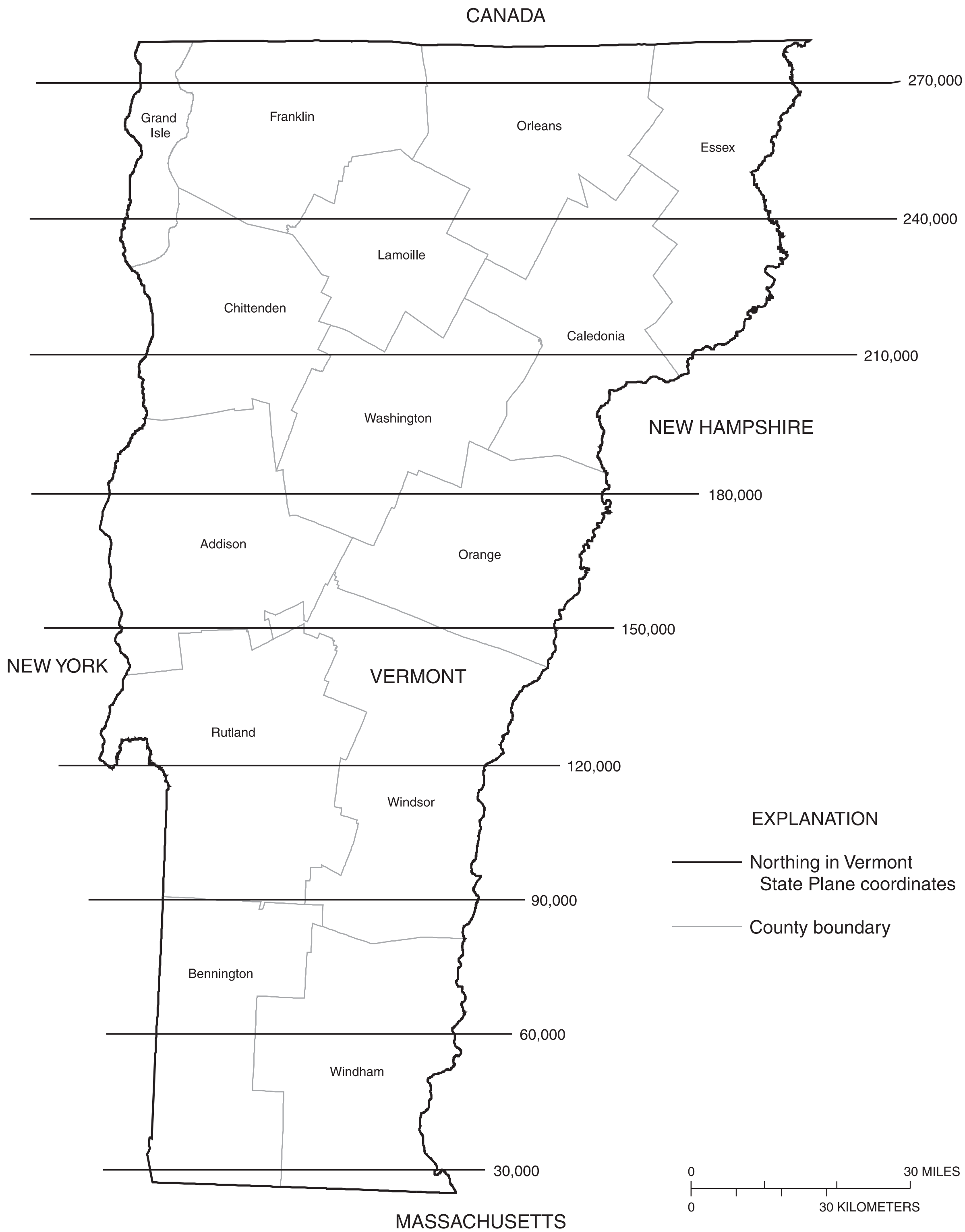
Natural Resources Conservation Service, 1996, Watershed boundaries of Vermont based on U.S. hydrologic units, accessed December 21, 2001, at URL http://geo-vt.uvm.edu/cfdev2/warehouse_new/data/moreinfoquery.cfm?covername=WATSHED/.

U.S. Geological Survey, 2001a, National elevation dataset, accessed December 21, 2001, at URL http://edcnts12.cr.usgs.gov/ned/.

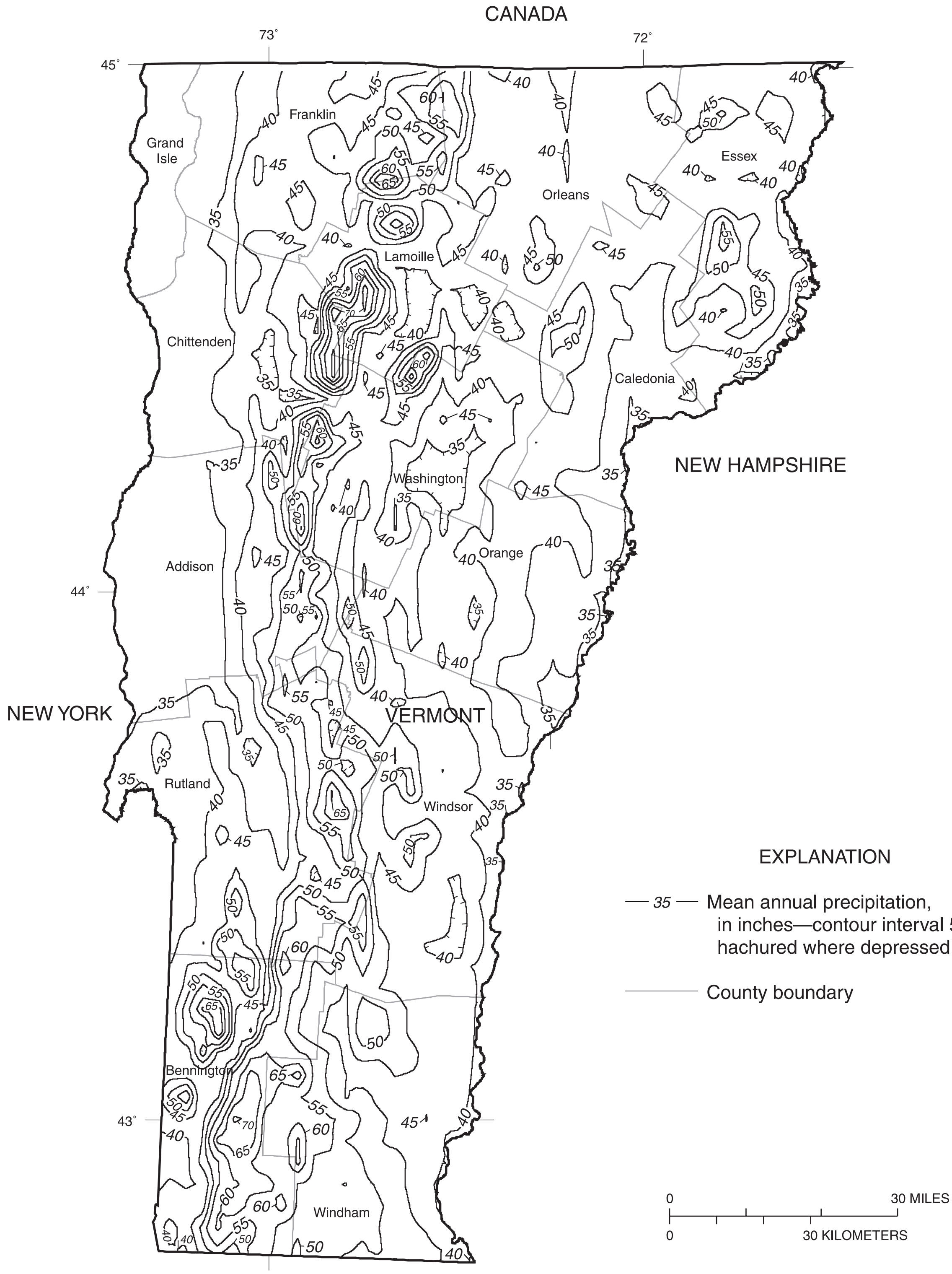
———2001b, National hydrography dataset, accessed December 21, 2001, at URL http://nhd.usgs.gov/.



Appendix 2. Areas of Vermont above 1,200 feet in altitude.



Appendix 3. Northing of the Vermont State Plane coordinate system.



Appendix 4. Mean-annual precipitation in Vermont. (Modified from Daly, 2000)