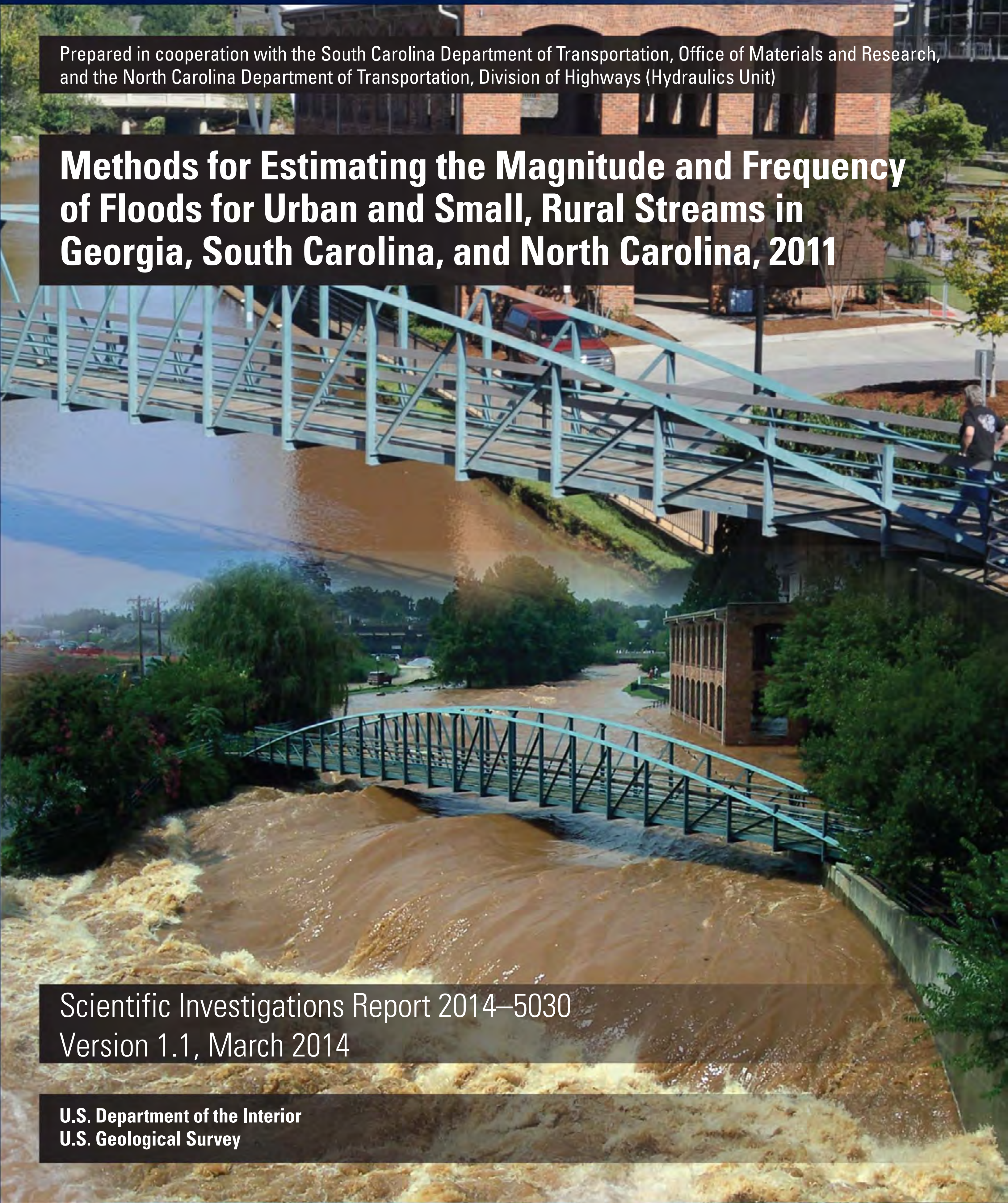
Prepared in cooperation with the South Carolina Department of Transportation, Office of Materials and Research, and the North Carolina Department of Transportation, Division of Highways (Hydraulics Unit)

Methods for Estimating the Magnitude and Frequency of Floods for Urban and Small, Rural Streams in Georgia, South Carolina, and North Carolina, 2011



Scientific Investigations Report 2014–5030
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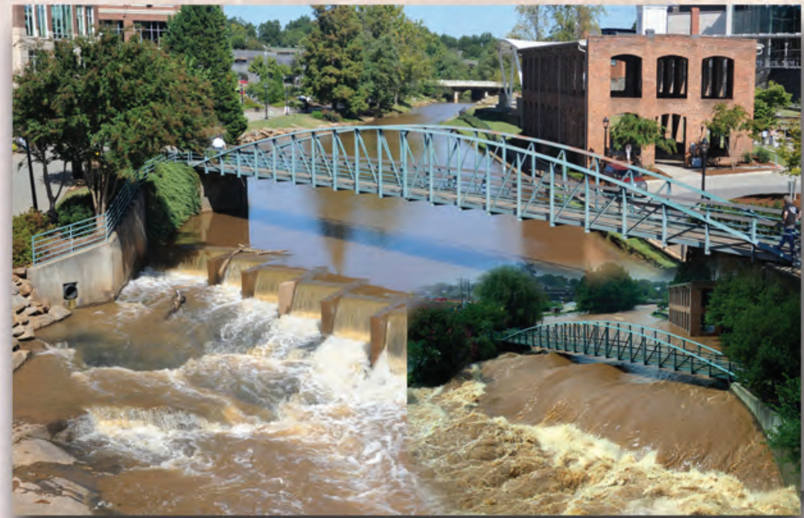

Cover: Photographs showing pedestrian bridge crossing of the Reedy River at South Main Street in downtown Greenville, S.C., during flood conditions on July 29, 2004, and under normal flow conditions on September 23, 2013. Photographs by City of Greenville staff, July 29, 2004, and J. Michael Hall, USGS, September 23, 2013

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U.S. Department of the Interior
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U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

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Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	640.0	acres
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

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

°F=(1.8×°C)+32

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

°C=(°F-32)/1.8

Vertical coordinate information is referenced to North American Vertical Datum of 1988 (NAVD 88) or National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Elevation, as used in this report, refers to distance above the vertical datum.

Abbreviations

AEP	annual exceedance probability
APS	all possible subsets
ARIS	Atlanta Region Information System
AVP	average variance of prediction
BDF	basin-development factor
DEM	digital elevation model
DEVNLCD06	percentage of developed land from 2006 NLCD
DRNAREA	drainage area
EMA	expected moments algorithm
FIS	Flood Insurance Studies
GIS	geographic information system
GLS	generalized least squares
HR	hydrologic region
I24H50Y	24-hour, 50-year maximum precipitation
IA	impervious area
ICP	inner Coastal Plain
IMPNLCD06	impervious area from 2006 NLCD
NED	National Elevation Dataset
NHD	National Hydrography Dataset
NLCD	National Land-Cover Dataset
OCP	outer Coastal Plain
OLS	ordinary least squares
PRISM	Parameter-elevation Regressions on Independent Slopes Model
QAQC	quality assurance and quality control
R^2	coefficient of determination
RQP	equivalent rural regression flood flow
STATSGO	State Soil Geographic
USGS	U.S. Geological Survey
VIF	variance inflation factor
WREG	weighted-multiple-linear regression

Methods for Estimating the Magnitude and Frequency of Floods for Urban and Small, Rural Streams in Georgia, South Carolina, and North Carolina, 2011

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Abstract

Reliable estimates of the magnitude and frequency of floods are essential for the design of transportation and water-conveyance structures, flood-insurance studies, and flood-plain management. Such estimates are particularly important in densely populated urban areas. In order to increase the number of streamflow-gaging stations (streamgages) available for analysis, expand the geographical coverage that would allow for application of regional regression equations across State boundaries, and build on a previous flood-frequency investigation of rural U.S. Geological Survey streamgages in the Southeast United States, a multistate approach was used to update methods for determining the magnitude and frequency of floods in urban and small, rural streams that are not substantially affected by regulation or tidal fluctuations in Georgia, South Carolina, and North Carolina. The at-site flood-frequency analysis of annual peak-flow data for urban and small, rural streams (through September 30, 2011) included 116 urban streamgages and 32 small, rural streamgages, defined in this report as basins draining less than 1 square mile. The regional regression analysis included annual peak-flow data from an additional 338 rural streamgages previously included in U.S. Geological Survey flood-frequency reports and 2 additional rural streamgages in North Carolina that were not included in the previous Southeast rural flood-frequency investigation for a total of 488 streamgages included in the urban and small, rural regression analysis. The at-site flood-frequency analyses for the urban and small, rural streamgages included the expected moments algorithm, which is a modification of the Bulletin 17B log-Pearson type III method for fitting the statistical distribution to the logarithms of the annual peak flows. Where applicable, the flood-frequency analysis also included low-outlier and historic information. Additionally, the application of a generalized Grubbs-Becks test allowed for the detection of multiple potentially influential low outliers.

Streamgage basin characteristics were determined using geographical information system techniques. Initial ordinary least squares regression simulations reduced the number of basin characteristics on the basis of such factors as statistical significance, coefficient of determination, Mallow's Cp statistic, and ease of measurement of the explanatory variable. Application of generalized least squares regression techniques produced final predictive (regression) equations for estimating the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent annual exceedance probability flows for urban and small, rural ungaged basins for three hydrologic regions (HR1, Piedmont–Ridge and Valley; HR3, Sand Hills; and HR4, Coastal Plain), which previously had been defined from exploratory regression analysis in the Southeast rural flood-frequency investigation. Because of the limited availability of urban streamgages in the Coastal Plain of Georgia, South Carolina, and North Carolina, additional urban streamgages in Florida and New Jersey were used in the regression analysis for this region. Including the urban streamgages in New Jersey allowed for the expansion of the applicability of the predictive equations in the Coastal Plain from 3.5 to 53.5 square miles. Average standard error of prediction for the predictive equations, which is a measure of the average accuracy of the regression equations when predicting flood estimates for ungaged sites, range from 25.0 percent for the 10-percent annual exceedance probability regression equation for the Piedmont–Ridge and Valley region to 73.3 percent for the 0.2-percent annual exceedance probability regression equation for the Sand Hills region.

Introduction

Reliable estimates of the magnitude and frequency of floods are essential for flood insurance studies, flood-plain management, and the design of transportation and water-conveyance structures, such as roads, bridges, culverts, dams, and levees. Federal, State, regional, and local officials rely on these estimates to effectively plan and manage land use and water resources, protect lives and property in flood-prone areas, and determine flood-insurance rates.

Reliable flood-frequency estimates are particularly important in densely populated urban areas. Urbanization changes a basin's response to precipitation. The most common effects are reduced infiltration and decreased lag time, which substantially increase peak flows (U.S. Department of Agriculture, 1986). Engineers and planners often need to consider the potential effects on peak flow of urban-development scenarios in their design and planning efforts. Because urbanization can produce substantial changes in flood-frequency characteristics of streams, rural basin flood-frequency relations are not always applicable to urban streams.

Traditionally, regional flood-frequency regression analyses for rural and urban basins have been done separately (Ries, 2007). For urban basins, a lack of urban streamflow data could be supplemented by rainfall-runoff models. Sauer and others (1983) presented a method for estimating urban flood frequency by scaling up regional rural flood frequency estimates by using several urbanization characteristics. The database in that study included a combination of at-site urban flood-frequency estimates based on measured peak flows and peak flows generated from rainfall-runoff models. As additional data have been collected at urban basins, several studies have compared flood-frequency estimates computed from peak flows generated using rainfall-runoff models with those computed from measured peak flows at U.S. Geological Survey (USGS) streamflow gaging stations, hereafter referred to as streamgages.

Urban flood-frequency equations were developed by Inman (1995) for urban streams in Georgia by using simulated peak-flow data from rainfall-runoff modeling. Inman (1997) compared the 50-, 4-, and 1-percent annual exceedance probability (AEP) flows computed from measured data with the urban flood-frequency estimating equations from Inman (1995) and found that peak flows computed by using equations derived from data generated by rainfall-runoff models generally were higher than those computed using measured data. However, the differences were within the range of standard error of prediction for the statewide regression equations from Inman (1995). Feaster and Guimaraes (2004) compared simulated and measured peak-flow data and observed a significant difference. The flood-frequency estimates computed by using simulated data were higher than estimates computed by using only measured data. Because of the bias found in simulated peak-flow data, only measured data collected on urban streams were used in that study. Since the Inman (1995) and Feaster and Guimaraes (2004) studies, the USGS has collected additional peak-flow data on urban streams in the Southeast making dependence on peak flows from rainfall-runoff models unnecessary.

Southard (2010) developed flood-frequency equations for urban areas in Missouri on the basis of measured annual peak-flow data collected from 35 streamgages. Data from 7 of the 35 streamgages were used to compare the flood-frequency estimates for the 1-percent annual exceedance probability floods with those from a previous urban flood-frequency investigation in Missouri by Becker (1986). In the Becker (1986) investigation, 27 urban streamgages were combined with 10 rural streamgages in order to increase the number of streamgages in the statistical analysis and extend the applicability of the regression equations. The streamgage records were extended by using a rainfall-runoff model to simulate runoff using long-term precipitation records. Of the seven streamgages compared by Southard (2010), the results from the Becker (1986) equation were higher at six of the streamgages with the range in percentage differences being from –12 to –255 percent. The seventh streamgage had a percentage difference of 10 percent. These findings are similar to those in the Southeast by Inman (1995) and Feaster and Guimaraes (2004) in which the flood-frequency estimates based on peak-flow data generated from rainfall-runoff models tend to be higher than the estimates from flood-frequency estimates based on measured peak-flow data.

The understanding of urban flood-frequency in the Southeast can continue to be improved in several ways. One way is to expand the database used for estimating the magnitude and frequency of floods on urban streams by continuing to collect streamflow data at existing urban streamgages. Using Monte Carlo simulations representing 25, 50, and 100 sample points, Griffis and Stedinger (2007a) demonstrated that estimates of magnitude and frequency of floods computed using peak flows from streamgages with a shorter record of annual peak-flow data have higher standard errors or uncertainties when compared to estimates computed using peak flows from streamgages with longer annual peak-flow record. Thus, long-term data collection at streamgages is important in the determination of reliable estimates of the magnitude and frequency of floods. Urban flood-frequency estimates also could be improved with additional streamgages in urban areas where the network is sparse, which not only would improve the geographical coverage but also would increase the range of basin characteristics represented in the database. An extended monitoring network and database are likely to provide more accurate flood-frequency equations for use in design and planning.

In this investigation, the U.S. Geological Survey, in cooperation with the South Carolina Department of Transportation, Office of Materials and Research, and the North Carolina Department of Transportation, Division of Highways (Hydraulics Unit), developed regional flood-frequency regression equations to estimate flood magnitudes at the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent AEP flows for urban and small, rural ungaged basins for three hydrologic regions (HR) (HR1, Piedmont–Ridge and Valley; HR3, Sand Hills; and HR4, Coastal Plain) in Georgia, South Carolina, and North Carolina. In this report and when needed for clarity, AEP flows computed from the annual peak-flow data at a streamgage will be referred to as "at-site" AEP flows and the AEP flows computed using regional regression equations will be referred to as "predicted" AEP flows.

This investigation meets the requirements of the Federal Cooperative Water Program by advancing understanding of hydrologic processes, furnishing hydrologic data or information that contribute to protection of life and property, and providing standardized, quality-assured data to national data bases available to the public that will be used to advance the understanding of regional and temporal variations in hydrologic conditions that are useful to multiple parties (U.S. Geological Survey, 2013). This investigation also addresses the water-resources issue of hydrologic hazards, which is a high-priority issue for the Federal Cooperative Water Program. Natural hazards such as floods also have been identified as one of six strategic science directions listed in USGS Circular 1309 “Facing tomorrow’s challenges—U.S. Geological Survey science in the decade 2007–2017” (U.S. Geological Survey, 2007).

Purpose and Scope

The central purpose of this report is to present methods for estimating the magnitude and frequency of floods on urban and small, rural streams in the Southeast United States with particular focus on Georgia, South Carolina, and North Carolina. Consequently, in this report the use of the term “Southeast” refers specifically to Georgia, South Carolina, and North Carolina. The analytical techniques described in the report incorporate both urban and rural streamgages and, therefore, can be applied to urban and small, rural streams. In the Southeast rural flood-frequency investigation by Gotvald and others (2009), Weaver and others (2009), and Feaster and others (2009), the lower limit of drainage area for the rural basins included was 1 square mile (mi^2). The lower limit of drainage area for rural basins included in the current investigation is 0.1 mi^2. Consequently, in this report, small, rural streams refer to those with drainage areas less than 1 mi^2. In addition, the scope of the investigation does not include the Blue Ridge region due to an insufficient number of urban streamgages.

The basins for the streamgages included in this report are considered to be unregulated (or not substantially regulated at medium to high flows) and not tidally influenced. The methods presented were developed by using flood-frequency analyses of annual peak-flow data through September 30, 2011, which is the end of the 2011 water year. The water year is the annual period from October 1 through September 30 and is designated by the year in which the period ends. The report includes (1) the description of techniques used to generate estimates of the magnitude of floods at the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent AEP levels for 148 urban and small, rural streamgages; (2) the description of techniques used to develop regression equations to estimate the magnitude of floods for ungaged, urban and small, rural sites in Georgia, South Carolina, and North Carolina; (3) the resultant regional equations for estimating the magnitude and frequency of peak flows on ungaged, non-regulated urban and small, rural streams from applying the techniques described in step 2; and (4) a discussion of the accuracy and limitations of these equations. For the purposes of this investigation, a basin is considered to be “urban” if the percentage impervious area is greater than 10 percent.

This investigation builds on the previous work by Gotvald and Knaak (2011) and the Southeast multistate rural flood-frequency investigation by Gotvald and others (2009), Weaver and others (2009), and Feaster and others (2009). The analysis includes both urban and rural streamgages, which allows for a larger database for the regression analysis and provides a smoother transition between flood-frequency estimates for ungaged urban streams and ungaged rural streams. Although the flood-frequency estimates for ungaged rural sites generated from the flood-frequency equations in this report will not be exactly the same as those generated from the flood-frequency equations from the Southeast rural investigation, they would be expected to be within the uncertainty of the Southeast rural flood-frequency regression equation estimates. Part of the differences in the estimates for ungaged rural sites is due to the database of rural streamgages included in this study being a subset of the rural streamgages included in the Southeast rural flood-frequency investigation, which will be discussed in more detail later in the report, and including additional streamgages that were not part of the Southeast rural investigation.

Previous Studies

The USGS has completed numerous flood-frequency investigations throughout the Southeast. For the most part, those investigations addressed flood frequency in rural and urban areas separately. In 2009, the USGS completed a flood-frequency investigation that involved a multistate approach to update methods for estimating the magnitude and frequency of floods in rural, ungaged basins in Georgia, South Carolina, and North Carolina (Gotvald and others, 2009; Feaster and others, 2009; and Weaver and others, 2009). Consequently, the reader is referred to those reports for details concerning previous flood-frequency studies in rural basins. The focus of the following information will be on previous studies relating to urban and small, rural streams. Where pertinent to this report, information may be replicated from Feaster and others (2009), Gotvald and Knaak (2011), Gotvald and others (2009), and Weaver and others (2009).

Sauer and others (1983) used data from 269 gaged basins in 56 cities in 31 States to develop flood-frequency relations for urban basins in the United States. Although their study did not include any urban streamgages from South Carolina, it did include five urban streamgages from Atlanta, Georgia, four urban streamgages from Charlotte, North Carolina, and one urban streamgage from Lenoir, North Carolina. Their techniques used the flood magnitude for rural streams as a base by including the estimate for rural streams as an independent variable in the regression analysis. Additional variables reflective of the degree of urban development were used to adjust the flood magnitude from rural to urban conditions.

Along with Gotvald and Knaak (2011), which is further discussed in the following section concerning previous urban flood-frequency investigations in Georgia, other investigators have combined flood-frequency estimates from urban and rural streamgages resulting in regression equations that were applicable for urban and rural basins. Watson and Schopp (2009) used 254 streamgages in New Jersey, Pennsylvania, New York, Delaware, and Maryland to develop flood-frequency relations for urban and rural basins in New Jersey. In that study, the regression analysis was completed by using a mix of urban and rural streamgages. The State was divided into five hydrologic regions, and the regression equations included population density as the urbanization characteristic.

In 2010, the Maryland State Highway Administration and the Maryland Department of the Environment published updated techniques providing guidance on applying hydrologic methods in Maryland (Thomas and Moglen, 2010). In appendix 3 of that report, a mix of 22 streamgages from rural and urban basins was included in a regional flood-frequency regression analysis for the Western Coastal Plain of Maryland. The urbanization factor included in the regression equations was percent impervious area.

Kollat and others (2012) describe an initiative for the Federal Emergency Management Agency to estimate the economic risks associated with climate and land-use changes as part of the U.S. National Flood Insurance Program. Their research focused on how the 1-percent AEP flood (also referred to as a 100-year return interval flood) may change based on climate change and population projections through the year 2100. Basin characteristics and observations of climate indicators from 2,357 USGS streamgages from across the United States were used to develop regression relations to estimate the 1-percent AEP flood. The streamgages included in the regression analysis were a combination of 1,973 rural and 384 urban streamgages and the independent variable representing urbanization was percentage impervious area.

Georgia

Many urban flood-frequency studies have been done in Georgia. Earlier USGS studies describing urban flood-frequency relations applicable to Georgia include reports completed by Lumb (1975), James and Lumb (1975), Golden (1977), Lichty and Liscum (1978), Price (1979), Inman (1983), Sauer and others (1983), and Inman (1988, 1995, 1996, 1997).

Lumb (1975) explained how a flood-simulation model was used to simulate an annual series of flood peaks and perform a flood-frequency analysis at a selected point. James and Lumb (1975) applied the model to eight basins in DeKalb County, Georgia, with limited measured data for verification.

Golden (1977) presented flood-frequency relations for urban streams in metropolitan Atlanta based on the technique used by Sauer (1974) for Oklahoma and included rural flood-frequency and rainfall-frequency characteristics of the Atlanta area. Sauer (1974) adjusted rural flood-frequency relations to urban conditions by using local rainfall-frequency characteristics, percentage of impervious area in the basin, and percent of the basin served by street gutters and storm sewers. Price (1979) used the same technique on a statewide basis for Georgia.

Lichty and Liscum (1978) described a procedure for computing estimates of 2- to 100-year (T-year) recurrence-interval flows that incorporated a rainfall information-transfer mechanism in the form of three maps and a generalized definition of synthetic T-year flood potential as a function of fitted rainfall-runoff model parameters. Impervious area was incorporated in T-year flood equations to account for urban development. This procedure was applicable for most of the Eastern United States.

A method for estimating the magnitude and frequency of floods on small streams in the Atlanta metropolitan area was presented by Inman (1983). This method was based on observed peak-discharge data from 19 streamgages, which were used to calibrate USGS rainfall-runoff models (Dawdy and others, 1972; Alley and Smith, 1982). These models were used to synthesize long-term annual peak flows for the 19 streamgages. The 2- to 100-year recurrence-interval flow estimates were developed for the 19 streamgages from the synthetic, long-term peak flows by fitting a Pearson Type III frequency distribution curve to the logarithms of the annual peak flows. Multiple-regression analyses were used to define relations between flood-frequency data and certain physical characteristics of the basin, of which drainage area, main-channel slope, and measured total impervious area were found to be statistically significant. These relations were used to estimate the magnitude and frequency of floods at ungaged basins in the Atlanta area.

A method for estimating the magnitude and frequency of floods for urban streams on a statewide basis for Georgia was presented by Inman (1988). This method was based on observed data from 45 streamgages, which were used to calibrate a USGS rainfall-runoff model (Dawdy and others, 1972). This model was used to synthesize long-term peak flows for the 45 streamgages. The 2- to 100-year peak-flow estimates were developed for each basin from these synthetic, long-term annual peak-flow records and by fitting a Pearson Type III frequency distribution curve to the logarithms of the annual peak flows. Multiple-regression analyses were used to define relations between the flood-frequency data and certain physical characteristics of the basin, of which drainage area, equivalent rural discharge, and measured total impervious area were found to be statistically significant. These relations were used to estimate the magnitude and frequency of floods at ungaged basins in urban areas on a statewide basis for Georgia. Inman (1995) updated the previous study (Inman, 1988) by including an additional 20 basins in 4 urban areas of south Georgia. Subsequently, Inman (1996, 1997) compared the results of the updated study (Inman, 1995) with flood-frequency estimates computed from measured data.

Gotvald and Knaak (2011) used generalized least squares regression to develop a set of equations for estimating the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent AEP flows for ungaged urban basins in Georgia. In an effort to maintain continuity between flood estimates for urban and rural basins as the basin characteristics pertaining to urbanization approach zero, urban and rural streamgages were combined in the regression analysis. The investigation included 56 urban streamgages and 171 rural streamgages. The flood-frequency estimates for the rural streamgages had been previously published in Gotvald and others (2009), which presented regression equations for rural basins equal to or larger than 1 mi^2. By including both rural and urban basins that were less than 1 mi^2, Gotvald and Knaak (2011) also provided a set of equations that could be used to generate flood-frequency estimates at small, ungaged rural streams in Georgia. The current investigation builds on the work done by Gotvald and Knaak (2011) by expanding the geographical region to include South Carolina and North Carolina and by including additional streamgages from those States.

South Carolina

Whetstone (1982) combined measured data from 49 streamgages that had long-term records with 25 small streams for which streamflow data were synthesized by using a rainfall-runoff model. Multiple-regression techniques were used to develop equations for estimating the magnitude of floods having recurrence intervals of 10, 25, 50, and 100 years on small natural streams. Equations were developed for the Blue Ridge, Piedmont, and Coastal Plain physiographic provinces of South Carolina. The general range of application for the equations was for drainage areas from 1 to 500 mi^2.

Bohman (1992) described methods for determining peak-flow frequency relations, flood hydrographs, average basin lag times, and runoff volumes associated with a given peak flow for ungaged, urban basins by using data from 34 streamgages in 15 cities in South Carolina, North Carolina, and Georgia. A rainfall-runoff model was calibrated for 23 urban drainage basins in South Carolina. The model was then used to synthesize from 50 to 70 annual peaks, depending on the length of the long-term rainfall data from nearby National Weather Service stations. The logarithms of these peaks were fitted to a Pearson Type III distribution to determine the frequency of peak flows having recurrence intervals of 2, 5, 10, 25, 50, 100, and 500 years at each gaged station. The final step in analyzing these data was to develop regression equations that could be used to predict the magnitude and frequency of floods at ungaged, urban sites in South Carolina.

Feaster and Guimaraes (2004) used generalized least squares regression to define the relation of magnitude and frequency of floods on small, unregulated, urban streams in or near South Carolina. Predictive equations were developed to estimate flows at the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence intervals for small, urban streams in the Piedmont, upper Coastal Plain, and lower Coastal Plain of South Carolina. Measured peak flows were compared with simulated peak flows from a rainfall-runoff model that was developed in an earlier investigation. The results indicated statistically significant differences in the variances and means at a number of the urban streamgages included in both investigations and, therefore, only measured data were included in the flood-frequency analyses.

North Carolina

Beginning in 1952, 120 crest-stage stations were established in North Carolina rural basins generally less than 50 mi^2 in size (Gunter and others, 1987). Crest-stage stations are partial-record sites used to measure annual peak flows. Records for these and other gaging stations through 1963 were used by Hinson (1965) to develop statewide flood relations for rural basins less than 150 mi^2 in size. Jackson (1976) used 10 additional years of record, to better define statewide flood-prediction relations, especially for basins less than 50 mi^2 in size. Generally, results of these studies were applicable to rural basins in North Carolina with the exception of streams subject to regulation, tide effect, urbanization, channel improvement, and those streams with basins covering less than 0.5 mi^2.

Putnam (1972) determined that urban development in the Piedmont province of North Carolina significantly affected flood flows and presented relations including indices of lag time and impervious cover to account for the increase in peak flow caused by urbanization. As noted earlier, Sauer and others (1983) developed relations for a nationwide application of urban flood frequency that included urban streamgages from North Carolina. Gunter and others (1987) presented an analysis of the applicability of those nationwide relations to the Coastal Plain and Piedmont provinces of North Carolina.

The most recent study of flood-frequency characteristics in urban basins in North Carolina was completed by Robbins and Pope (1996). In this study, concurrent records of rainfall and runoff data collected in small, urban basins were used to calibrate rainfall-runoff models. Then historic rainfall records were used with the calibrated models to synthesize a long-term record of annual peak flow used for determining the flood-frequency distributions and corresponding statistics. Flood-frequency statistics were developed for 32 small urban basins in the Blue Ridge–Piedmont, Coastal Plain, and Sand Hills hydrologic areas. Drainage areas for the basins range from 0.04 to 41.0 mi^2. A generalized least squares regression analysis was used to develop a relation where drainage area, impervious area, and rural flood discharge were found to be the most significant basin characteristics.

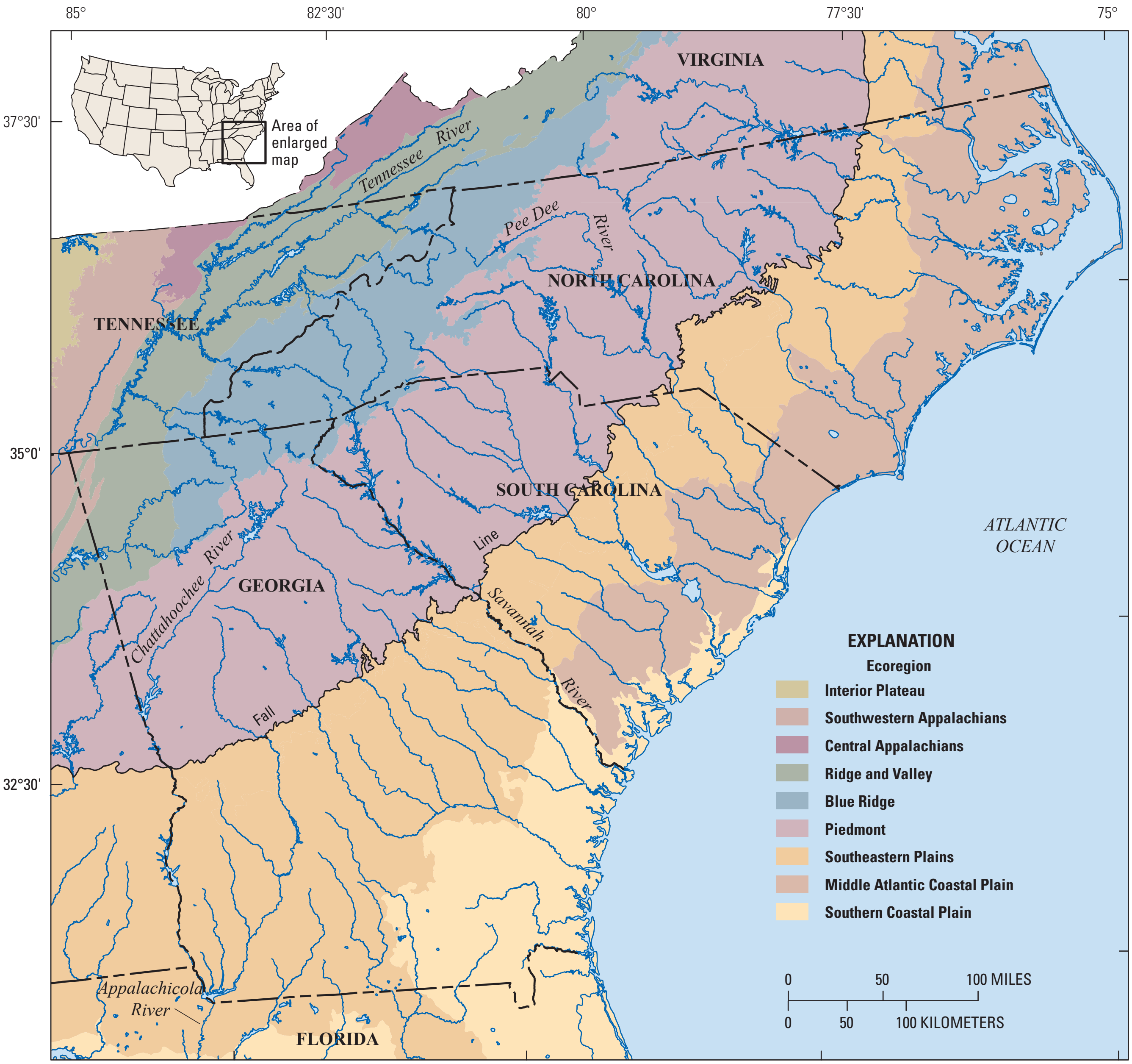
Description of the Study Area

The study area includes all of Georgia, South Carolina, and North Carolina with the exception of the Blue Ridge ecoregion, which lacks a sufficient number of urban streamgages to allow for a regional regression analysis, and the tidally influenced regions of the Coastal Plain. Georgia, South Carolina, and North Carolina encompass seven U.S. Environmental Protection Agency (USEPA) level III ecoregions—Southwestern Appalachians, Blue Ridge, Ridge and Valley, Piedmont, Southeastern Plains, Southern Coastal Plain, and Middle Atlantic Coastal Plain (fig. 1; U.S. Environmental Protection Agency, 2007a). The ecoregions represent areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. The ecoregions provide a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. The ecoregions were determined from an analysis of the spatial patterns and the composition of biotic and abiotic phenomena that include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology (Griffith and others, 2002). The Fall Line separates the higher elevation Southwestern Appalachians, Blue Ridge, Ridge and Valley, and Piedmont ecoregions from the low lying Southeastern Plains, Southern Coastal Plain, and Middle Atlantic Coastal Plain ecoregions.

The Southwestern Appalachians ecoregion is composed of open, low mountains. The eastern boundary of this ecoregion, along the more abrupt escarpment where it meets the Ridge and Valley ecoregion, is relatively smooth and only slightly notched by small, eastward-flowing streams. The Ridge and Valley is composed of roughly parallel ridges and valleys that vary in width, height, and geologic material. Springs and caves are relatively numerous, and present-day forests cover about 50 percent of the Ridge and Valley ecoregion. The Piedmont ecoregion is composed of a transitional area between the mostly mountainous ecoregions of the Appalachians to the northwest and the relatively flat Coastal Plain to the southeast. The Piedmont ecoregion is a complex mosaic of metamorphic and igneous rocks of Precambrian and Paleozoic age, with moderately dissected irregular plains and some hills. The soils tend to be finer textured than in coastal plain regions to the south. Once largely cultivated, much of this ecoregion has reverted to pine and hardwood woodlands, with increasing conversion to urban and suburban land cover (Omernik, 1987).

The Southeastern Plains ecoregion is composed of irregular plains made up of a mixture of cropland, pasture, woodland, and forest. The sands, silts, and clays of this ecoregion contrast geologically with the older rocks of the Piedmont ecoregion. Elevations and relief are greater than in the Southern Coastal Plain, but generally are less than in much of the Piedmont. Streams in this area have relatively low gradient and sandy bottoms. The Southern Coastal Plain ecoregion consists of mostly flat plains, but it is a heterogeneous ecoregion containing barrier islands, coastal lagoons, marshes, and swampy lowlands along the Gulf and Atlantic coasts. This ecoregion is lower in elevation with less relief and wetter soils than the Southeastern Plains ecoregion. The Middle Atlantic Coastal Plain ecoregion consists of low-elevation flat plains, with many swamps, marshes, and estuaries. The low terraces, marshes, dunes, barrier islands, and beaches of the ecoregion are underlain by unconsolidated sediments. Poorly drained soils are common, and the ecoregion has a mix of coarse and finer textured soils compared to the mostly coarse soils in the majority of the Southeastern Plains ecoregion. The Middle Atlantic Coastal Plain ecoregion typically is lower, flatter, and more poorly drained than the Southern Coastal Plain ecoregion (Omernik, 1987).

The average annual precipitation in the study area ranges between 40 to 60 inches per year (National Atlas of the United States, 2013). Precipitation in the study area typically is associated with the movement of warm and cold fronts from November through April and isolated summer thunderstorms from May through October. Occasionally, tropical storms or hurricanes along the Atlantic and Gulf coasts produce unusually large amounts of rainfall throughout the study area. The mean annual air temperature ranges from 55 degrees Fahrenheit (ºF) in northern North Carolina to 68 ºF in southern Georgia (National Oceanic and Atmospheric Administration, 2008).



Base modified from U.S. Geological Survey 1:100,000-scale digital data
Ecoregions from U.S. Environmental Protection Agency 1:7,500,000-scale digital data (2002; revision of Omernik, J.M., 1987)

Figure 1. Study area and ecoregions in Georgia, South Carolina, and North Carolina and surrounding States.

Data Compilation

For this investigation, urban and small, rural streamgages with 10 or more years of annual peak-flow record were considered for inclusion in the analysis. Additional rural flood-frequency data included in the study were based on a subset of the data previously included in the Southeast rural flood-frequency investigation by Gotvald and others (2009), Weaver and others (2009), and Feaster and others (2009), which included annual peak-flow data through water year 2006. Generally, the data from those studies selected for inclusion in the current study were based on the upper limits of the drainage area size for the urban streamgages. This was done to maintain some level of uniformity with respect to the range of drainage area sizes for the urban and rural basins. In the Sand Hills, which has the fewest number of streamgages in the hydrologic regions analyzed, all of the streamgages from the Southeast rural flood-frequency investigation were included.

After compiling the peak-flow data, quality assurance and quality control (QAQC) methods were used to assess homogeneity of the annual peak-flow data for the period being analyzed and to assess other potential issues. The QAQC methods used to review the rural streamgages previously included in the Southeast rural flood-frequency study can be found in the reports by Gotvald and others (2009), Weaver and others (2009), and Feaster and others (2009). The QAQC methods for the urban and small, rural streamgages included in the current study are discussed below.

Peak-Flow Data

Streamgages with annual peak-flow record are either continuous-record streamgages or crest-stage gages. At continuous-record streamgages, the water-surface elevation, or stage, of the stream is recorded at fixed intervals, typically 15 minutes. At crest-stage gages, only the crest (highest) stage that occurs between site visits is recorded. Regardless of the type of streamgage, measurements of stage and flow (discharge) are used to develop a relation between stage and flow for the streamgage. This stage-flow relation, or rating, is used to estimate flow for all recorded stages at this streamgage. The highest peak flow that occurs during a given year is the annual peak flow for the year, and the list of annual peak flows forms a time series referred to as the annual peak-flow record. The peak-flow records for streamgages are available from the USGS National Water Information System (NWIS) database at *http://nwis.waterdata.usgs.gov/usa/nwis/peak/*.

Urban and small, rural streamgages in Georgia, South Carolina, and North Carolina were the focus of this investigation. The percentage of impervious area has long been recognized as an effective indicator of the intensity of urban development and its potential effects on streamflow and the environment (Klein, 1979). The threshold of influence of impervious area on streamflow has been reported in previous studies (Brabec and others, 2002) to be between 5 and 21 percent. Landers and others (2007) reported that basin imperviousness had a well-defined influence on streamflow at levels between 12 and 21 percent. For this study, a streamgage is referred to as "urban" if the percentage of impervious area within the drainage basin is 10 percent or greater. However, because both urban and rural streamgages were included in the investigation, this demarcation between urban and rural basins is not pertinent with respect to the generation of the regional regression equations. Conversely, it does have pertinence with respect to the application of the regression equations. In general, if a drainage basin at an ungaged location is greater than 1 mi^2 and the percentage of impervious area is less than 10 percent, it is recommended that the regional regression equations from the Southeast rural study be used to estimate flood flows for that basin (Gotvald and others, 2009; Weaver and others, 2009; Feaster and others, 2009).

Streamgages were used in the analysis only if 10 or more years of annual peak-flow data were available and if peak flows at the streamgages were not affected substantially by dam regulation, flood-retarding reservoirs, channelization, or tides. The peak-flow data from the urban streamgages in Georgia that were included in this investigation were previously reviewed and analyzed as documented by Gotvald and Knaak (2011). Similar QAQC methods also were used for the additional urban streamgages included in the current investigation. The peak-flow record for urban streamgages that meets these criteria then were compiled and reviewed for QAQC by using the PFReports computer program, as detailed by Ryberg (2008). Kendall's tau was chosen to assess the significance of time trends in the peak-flow record for each streamgage (Helsel and Hirsch, 1992). If it was determined that a streamgage record was not homogeneous, that streamgage was not used in the analysis unless a homogenous portion could be identified. The homogenous portion of the record was considered for this study if the basin characteristics were representative of this portion of record. Topographic maps and aerial photographs were used to help determine if the cause of a positive trend in flood-peak magnitude was a result of increasing urbanization in the basin during the gaged period of record. For the Atlanta area, Gotvald and Knaak (2011) obtained geographic information system (GIS) layers of land-use data for 1999, 2001, 2003, 2005, and 2007 from the Atlanta Regional Commission (Atlanta Regional Commission, 2008) Atlanta Region Information System (ARIS) at *http://www.atlantaregional.com/info-center/gis-data-maps/gis-data*. These land-use data were used to determine changes in urbanization for the streamgages in the Atlanta metropolitan area. The urban streamgages that were used in the previous Georgia urban flood-frequency study by Inman (1995) are located in older, well-established urban areas outside of the Atlanta metropolitan area, and these basins were considered to be stable.

For the urban streamgages in South Carolina and North Carolina, historical aerial photographs from Google Earth were reviewed to assess stable periods of urbanization. Along with the aerial photographs, plots of the annual peak flows also were reviewed. If the Kendall’s tau analysis indicated a trend, all of the available information was used to determine whether there was a sufficient period of record available that indicated a relatively stable period of urbanization. If so, that period of record was used in the at-site flood-frequency analysis. Otherwise, the station was excluded from the analysis.

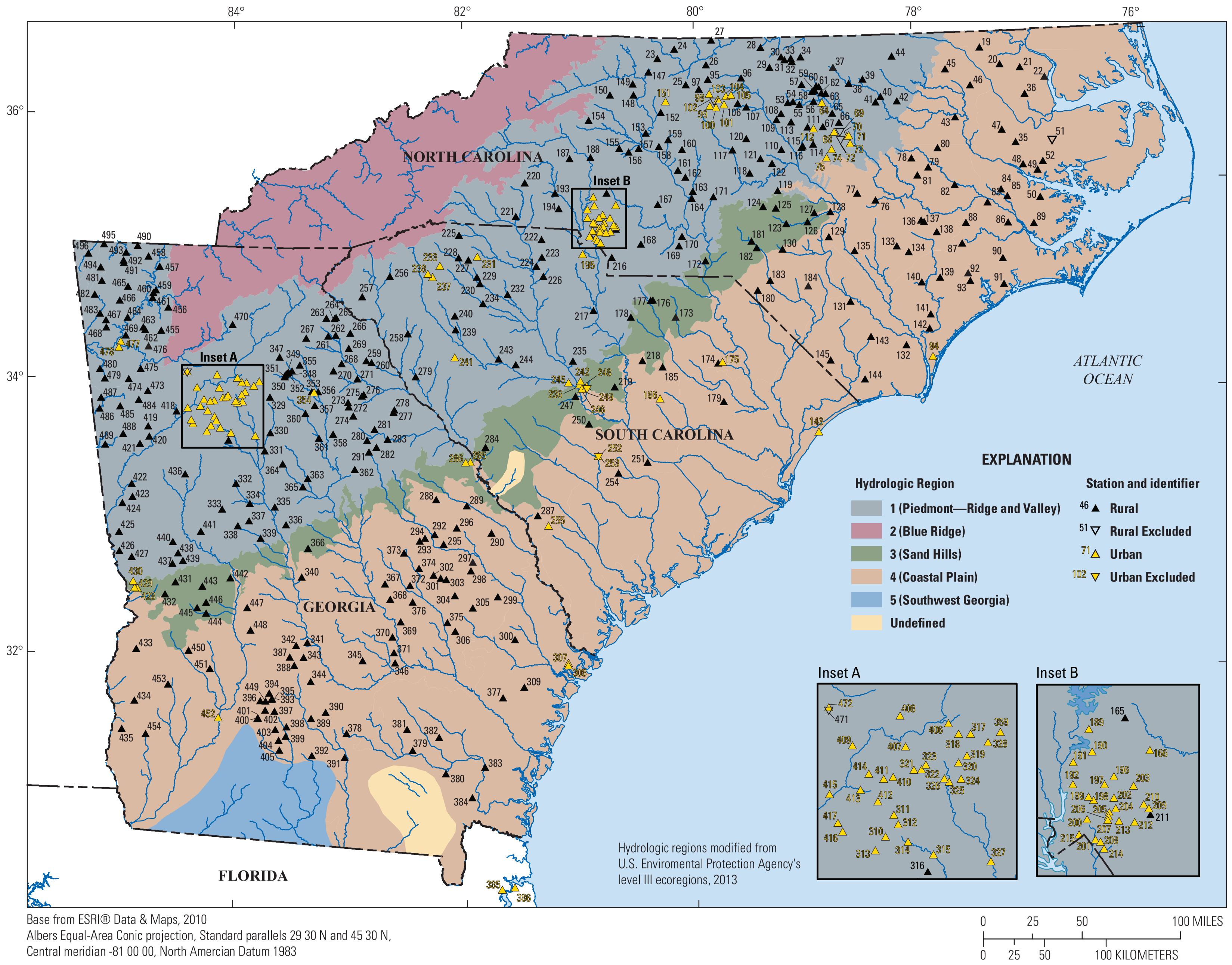
The QAQC and trend analyses resulted in the selection of 116 urban streamgages for use in this study (fig. 2; table 1, p. 52). As noted in table 1, 17 streamgages are listed for which only a portion of the record was considered to be homogenous with respect to urbanization.

New Jersey Inner Coastal Plain

In Gotvald and Knaak (2011), the largest drainage area for the urban streamgages in the Coastal Plain for which sufficient peak-flow data were available for analysis was 3.5 mi^2 (station 02246497, McCoy Creek at Jacksonville, Florida). The additional urban streamgages available in the Coastal Plain of South Carolina and North Carolina were in basins with drainage areas smaller than that of station 02246497. In an effort to increase the range of drainage basin area for the urban streamgages in the Coastal Plain, USGS flood-frequency reports from other States along the Atlantic Coastal Plain (fig. 3) were reviewed in an effort to find additional urban streamgages to include in the regression analysis. In order to verify that the Coastal Plain flood-frequency characteristics were similar to those in Georgia, South Carolina, and North Carolina, the published 1-percent AEP flows for rural basins in Virginia (Austin and others, 2011), Maryland (Ries and Dillow, 2006), Delaware (Ries and Dillow, 2006), and New Jersey (Watson and Schopp, 2009) were graphically compared with published 1-percent AEP flows from the Southeast rural flood-frequency study (Feaster and others, 2009; fig. 4*A* and fig. 4*B*).

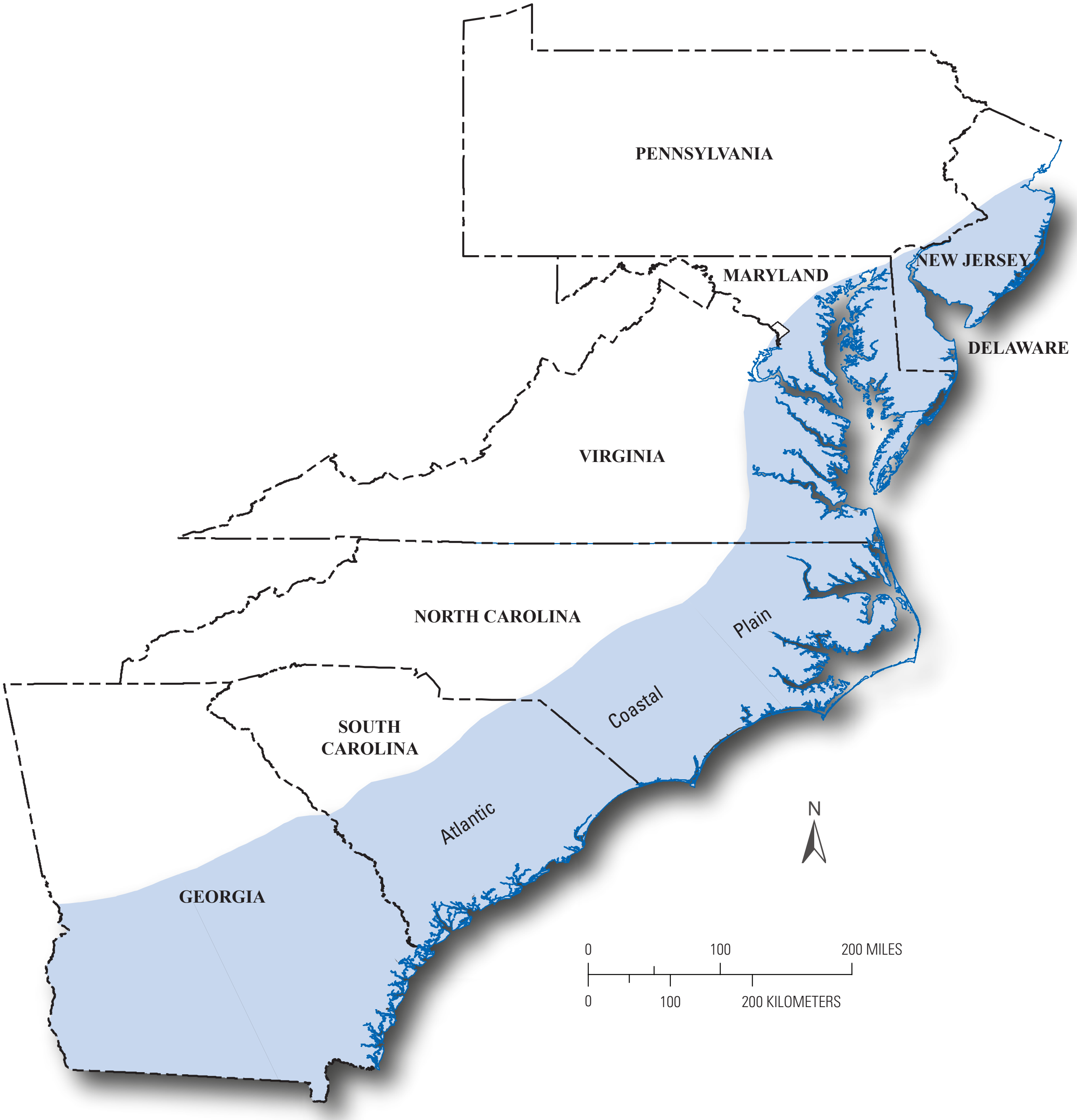
Watson and Schopp (2009) subdivided the New Jersey Coastal Plain into the inner and outer Coastal Plain (ICP and OCP, respectively; fig. 5). They noted that this division of the Coastal Plain roughly follows the topographic high of the underlying sediments. The ICP extends from the Fall Line at the northern reach and the topographic high of the Coastal Plain to the southern reach. The extent of the OCP covers the low-elevation region from the topographic high to the Atlantic Ocean. Although the materials in both the ICP and OCP in New Jersey are marine-deposited sedimentary sands, gravels, and clays overlain with later deposits, the ICP has a larger proportion of clay in its soil than does the OCP making its soils much more fertile than the OCP (Geomorphic provinces and sections of the New York Bight watershed accessed October 2012 at *http://library.fws.gov/pubs5/web_link/text/geolsect.htm*). Similar to the importance of agricultural in the Southeast Coastal Plain, the New Jersey ICP has long been an important agricultural area in New Jersey giving rise to it being known as the Garden State.

As shown in figure 4*B*, the New Jersey ICP 1-percent AEP flows are well within the dataset of the Southeast Coastal Plain streamgages whereas the OCP New Jersey data points fall either below or on the lower edge of the Southeast data as do much of the Delaware data. The Virginia and Maryland data also plot well within the Southeast Coastal Plain data. Because the New Jersey ICP rural data were comparable to the Southeast rural Coastal Plain data, it was concluded that the urban streamgages from Virginia, Maryland, and the New Jersey ICP would be appropriate to include in the Southeast urban flood-frequency analysis. This conclusion assumes that with respect to streamflow, the effect of urbanization in the Virginia, Maryland, and the New Jersey ICP is similar to that in the Southeast Coastal Plain. From a review of previously published peak-flow data for urban streamgages in the Coastal Plain regions of Virginia, Maryland, and the New Jersey ICP, it was determined that only New Jersey had sufficient measured urban peak-flow data that could be included in the Southeast study. Similar QAQC reviews were done for the New Jersey ICP urban streamgages as were done for the Southeast urban streamgages. On the basis of those reviews, a total of 18 streamgages from the New Jersey ICP with drainage areas ranging from 0.43 to 47.2 mi^2 were included in the Southeast regression analysis (fig. 6). Of the 18 streamgages included from the New Jersey ICP, 16 had impervious areas greater than 10 percent and the other two streamgages had impervious areas of 7.6 and 8.0 percent. Although the streamgages with impervious areas of less than 10 percent would be considered rural basins, they were included in the analysis to provide additional streamgages representing the transitional zone between rural and urban basin characteristics.



Base from ESRI® Data & Maps, 2010
Albers Equal-Area Conic projection, Standard parallels 29 30 N and 45 30 N,
Central meridian -81 00 00, North Amercian Datum 1983

Figure 2. Location of hydrologic regions and U.S. Geological Survey streamflow-gaging stations with 10 or more years of record that were included in the Southeast regional-regression analysis for urban and small, rural streams, 2011.



Physiographic data modified from U.S. Geological Survey, N.M. Fenneman and D.W. Johnson, 1946

Figure 3. The Atlantic Coastal Plain from Georgia to New Jersey.

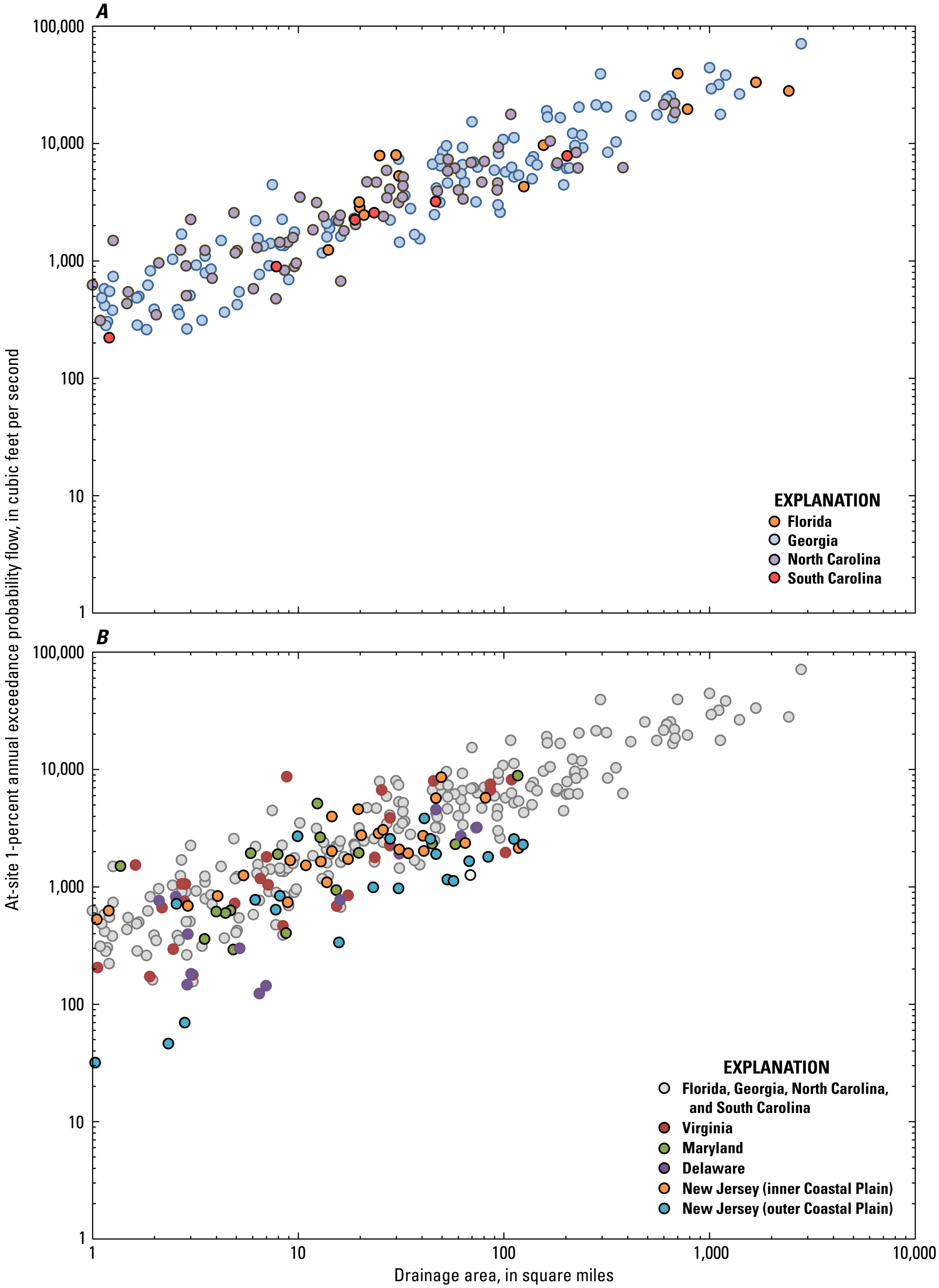
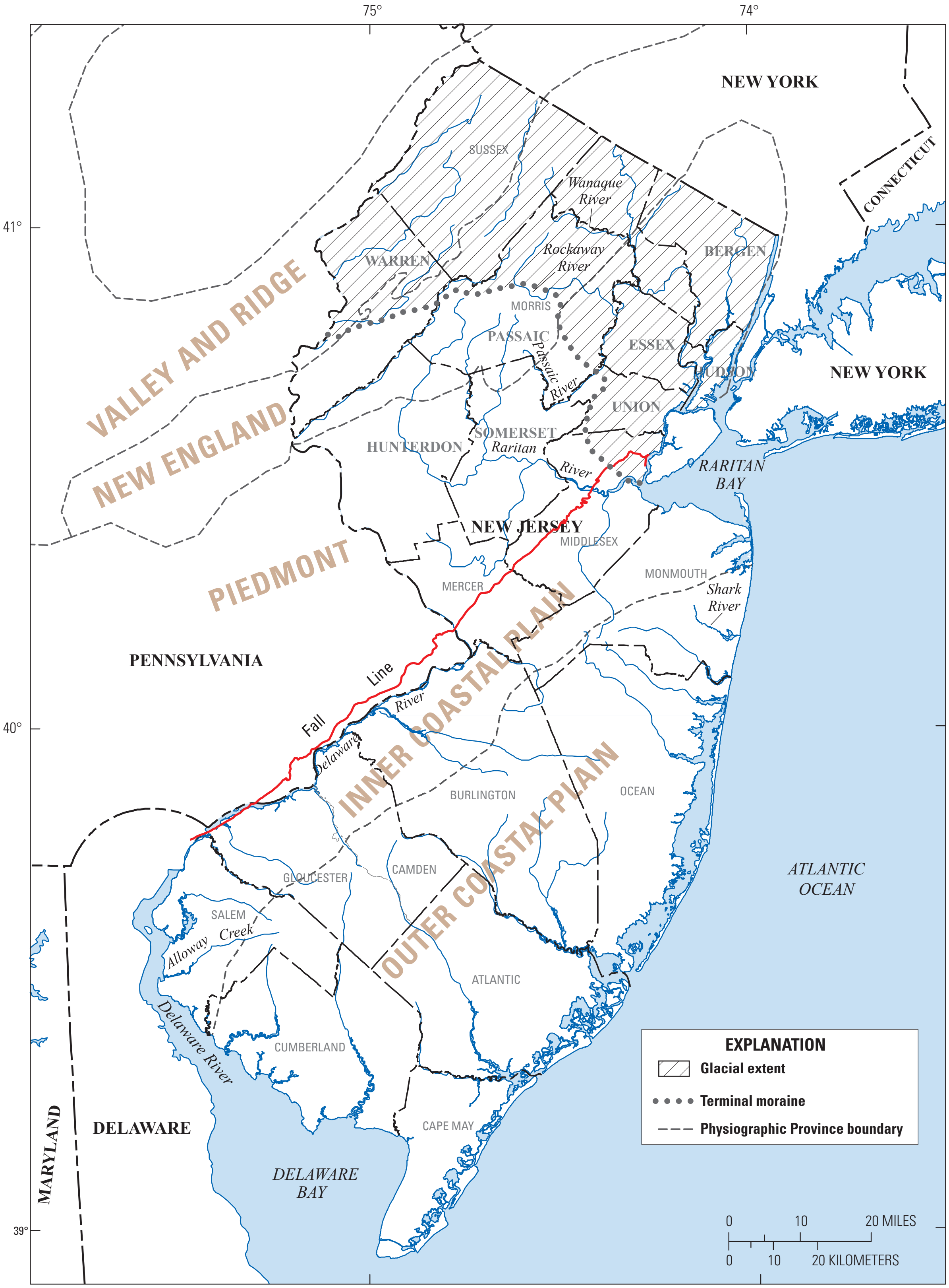
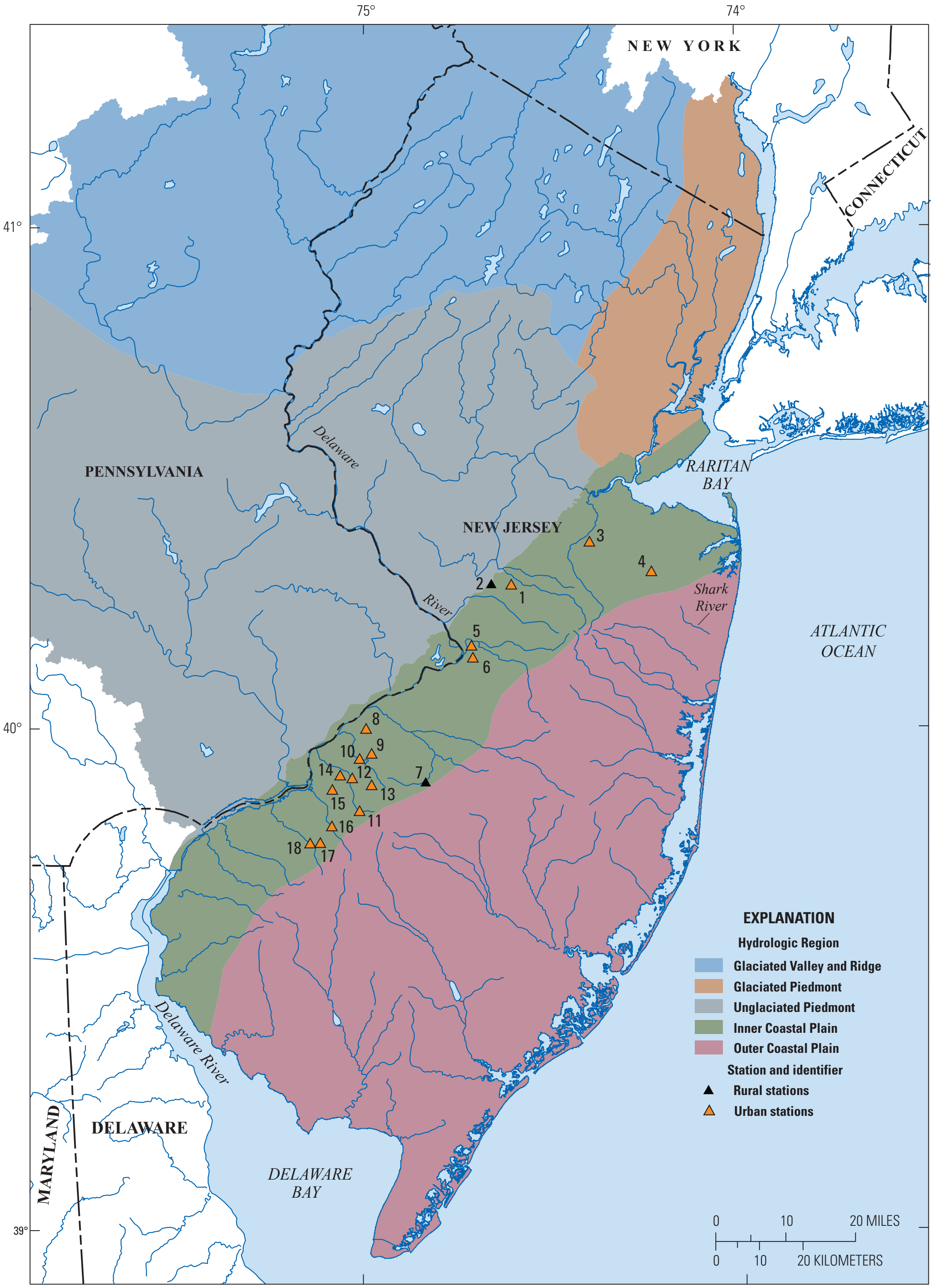


Figure 4. At-site 1-percent annual exceedance probability flow and drainage area for (*A*) U.S. Geological Survey rural streamflow-gaging stations (streamgages) in Florida, Georgia, South Carolina, and North Carolina that were included in the Southeast rural flood-frequency investigation (Feaster and others, 2009) and (*B*) rural streamgages from Virginia, Maryland, Delaware, and New Jersey (Austin and others, 2011; Ries and Dillow, 2006; and Watson and Schopp, 2009).



Modified from Watson and Schoop, 2009

Figure 5. Physiographic provinces in New Jersey (Watson and Schopp, 2009).



Base from ESRI® Data & Maps, 2010
Albers Equal-Area Conic projection, Standard parallels 29 30 N and 45 30 N,
Central meridian -75 00 00, North American Datum 1983

Hydrologic regions modified from
Enviromental Protection Agency's
U.S. level III Ecoregions, 2010

Figure 6. Locations of U.S. Geological Survey streamflow-gaging stations in the New Jersey inner Coastal Plain that were included in the Southeast regression analysis.

Physical and Climatic Basin Characteristics

Peak-flow information can be estimated at ungaged sites by using multiple regression analysis that relates peak-flow characteristics (such as 1-percent AEP flow) to selected physical and climatic basin characteristics for gaged drainage areas. Drainage-basin boundaries are needed for each station to determine basin characteristics. Basin boundaries were generated from National Elevation Dataset (NED) digital elevation models (DEMs) at 30-meter (m) horizontal resolution (or 10-m when available; U.S. Geological Survey, 1999a). To improve boundary delineations, GIS processing was used to make the DEM conform to stream locations defined in the high-resolution National Hydrography Dataset (NHD; U.S. Geological Survey, 1999b).

Basin characteristics were selected for use as potential explanatory variables in the regression analyses on the basis of the theoretical hydrologic relation to flood flows and the ability to measure the basin characteristics using digital datasets and GIS technology. For each of the streamgages included in this study, the following basin characteristics were determined and considered: drainage area; basin perimeter length; mean basin slope; basin shape factor; main channel length; main channel slope; minimum, maximum, and mean basin elevations; percentage of basin imperviousness; percentage of basin developed; percentage of basin forested; percentage of basin storage; soil drainage index; hydrologic soil index; drainage density; mean annual precipitation; 24-hour, 2-, 10-, 25-, 50-, and 100-year maximum precipitation; and population density. For the rural streamgages in Georgia, South Carolina, and North Carolina, the basin characteristics that were not related to urbanization were obtained from the Southeast rural flood-frequency investigation by Feaster and others (2009), Gotvald and others (2009), and Weaver and others (2009). The names, units of measure, methods of measurement, and source data for the measured basin characteristics that were considered for use in this study are listed in table 2.

The drainage areas for the streamgages that were computed by using GIS were compared to previously published drainage areas as a means of quality assurance. The measured and published drainage areas for the urban streamgages agreed closely for most streamgages, but the drainage areas for several streamgages differed by more than 5 percent. In most of these cases, the published drainage areas were determined from older topographic maps with 10-foot (ft) contour intervals. Boundaries determined by the two methods were compared, and those computed by using GIS were considered superior in accuracy to manual delineations. Therefore, the station drainage areas with differences greater than 5 percent were revised using the GIS-measured values. The nine streamgages with revised drainages areas (one in South Carolina and eight in North Carolina) are noted in table 1.

The methods used in previous Georgia, South Carolina, and North Carolina urban flood-frequency studies (Inman, 1995; Robbins and Pope, 1996; and Feaster and Guimaraes, 2004) to compute the percentage of impervious area within a drainage area are documented in Cochran (1963). For this study, however, the impervious cover dataset developed by the USGS as part of the 2001 and 2006 National Land Cover Dataset (NLCD; Yang and others, 2003; U.S. Environmental Protection Agency, 2007b, 2011; Fry and others, 2011) was used to compute the percentage of impervious area within a basin. Computing the impervious area by using GIS tools with the NLCD 2001 and 2006 data layers provides accurate results (Chabaeva and others, 2009) in less time than the previous methods used.

Percentage of developed land is another variable considered in this study to be an indicator of the amount of urbanization in a basin. This variable is computed by dividing the sum of the area of each NLCD land-cover class for developed land by the total drainage area of the basin (table 3 lists the definitions for the four NLCD land-cover classes for developed land). A graph of the relation between the percentage of impervious area and the percentage of developed land for the urban and rural streamgages shows that the two characteristics are correlated but that the variability in the relation increases with increasing values (fig. 7*A*). By adding 1 to each data point and plotting in logarithmic space, there is a relatively strong relation between the two variables but at the extremes, the relation is somewhat curvilinear (fig. 7*B*). Nonetheless, fitting a linear curve to the logarithms of the rural and urban data resulted in a coefficient of determination, R^2, of 0.95.

The basin-development factor (BDF) described in Sauer and others (1983) was not included in this study. The BDF computations are labor-intensive field assessments that are subjective and produce results that cannot necessarily be easily replicated. In Feaster and Guimaraes (2004), the inclusion of the BDF reduced the standard error of prediction by only 4 percent. Thus, the effort required to compute the BDF does not appear to provide a substantial benefit for reducing the uncertainty in flood estimates for the Southeast United States.

Basin storage as included in this investigation is the percentage of the drainage basin occupied by lakes, reservoirs, swamps, and wetlands from the NLCD. For urban basins, detention storage can be used to reduce the effect that urbanization has on peak runoff. However, such storage is not easily quantified and, therefore, was not included as a basin characteristic. Like BDF, assessment of detention storage in the urban basins would entail labor-intensive field assessments and, given the large geographical coverage of this investigation, was not practical. It is likely that detention storage would have the most effect on small urban basins. Hess and Inman (1994) looked at the effect of flood-detention reservoirs on peak flows for six small urban basins ranging in size from 0.10 to 0.37 mi^2 in Gwinnett County, Georgia. A rainfall-runoff model was calibrated by using measured data from 1986 to 1992 and used to simulate long-term peak flows from 1898 to1980 representing various amounts of detention ranging from the conditions as they existed in 1992 to natural conditions (no reservoirs). Results showed that removal of an individual detention reservoir changed peak flows from –1 to 24 percent for the 2-year recurrence-interval flows and from –2 to 31 percent for the 100-year recurrence-interval flow. The cumulative effect of removing all the reservoirs from each of the six basins increased peak flows from 1 to 38 percent for the 2-year recurrence interval and from 3 to 31 percent for the 100-year recurrence interval. Thus, as these results indicate, the influence of detention storage on flood-frequency estimates for a station can vary substantially. For the urban streamgages included in this investigation, it was assumed that the influence of detention storage was not substantially appreciable and that the urban basins are likely to represent a range of detention storage.

Table 2. Basin characteristics considered for use in the regional regression analysis.

[DEM, digital elevation model; USGS, U.S. Geological Survey; NED, National Elevation Dataset; NHD, National Hydrography Dataset; NLCD, National Land-Cover Dataset; %, percent; PRISM, Parameter-elevation Regressions on Independent Slopes Model; STATSGO, State Soil Geographic]

Name	Units	Method	Source data
Drainage area	Square miles	Area within the basin boundary, which is represented as a polygon of cells that flow to the streamgage location based on the primary down-slope flow direction of the DEM	USGS NED DEMs at 10- and 30-m resolution (*http://ned.usgs.gov*), conditioned to conform with NHD streams, 1:24,000 scale (*http://nhd.usgs.gov/*)
Main channel length	Miles	Length of the longest flow path in a drainage area based on steepest descent as defined by the flow direction grid	DEM data used to create the basin boundaries, as defined in the drainage area source data
Basin Perimeter	Miles	Length of basin boundary perimeter	Watershed boundaries, as defined in the drainage area method
Main channel slope	Feet per mile	Difference in the DEM elevation at points corresponding to 10% and 85% of the main channel divided by the main channel length between those two points	DEM data used to create the basin boundaries, as defined in the drainage area source data. Main channel length, as defined in the main channel length method.
Mean basin slope	Percent	Mean of the DEM percentage slope grid values within the basin boundary	DEM data used to create the basin boundaries, as defined in the drainage area source data. Drainage area, as defined in the drainage area method. Main channel length, as defined in the main channel length method.
Basin shape factor	Dimensionless	Main channel length squared divided by drainage area	Drainage area, as defined in the drainage area method. Main channel length, as defined in the main channel length method.
Mean basin elevation	Feet	Area-weighted average	DEM data used to create the basin boundaries, as defined in the drainage area source data
Maximum basin elevation	Feet	Maximum elevation value of the DEM within the basin boundary	DEM data used to create the basin boundaries, as defined in the drainage area source data
Minimum basin elevation	Feet	Minimum elevation value of the DEM within the basin boundary	DEM data used to create the basin boundaries, as defined in the drainage area source data
Percentage of impervious area	Percent	(Impervious Surface area/drainage area)*100	NLCD 2001 and 2006 Impervious Surface, 30-meter resolution (*http://www.mrlc.gov/nlcd.php*)
Percentage of developed land	Percent	(Sum of areas of classes 21–24/ drainage area)*100, where land-use classes are defined at *http://www.epa.gov/mrlc/definitions.html*	NLCD 2001 and 2006, 30-meter resolution (*http://www.mrlc.gov/nlcd.php*)
Percentage of forested land	Percent	(Forested area/drainage area)*100	NLCD 2001 and 2006, 30-meter resolution (*http://www.mrlc.gov/nlcd.php*)
Percentage of storage	Percent	Sum of areas of wetlands and open water/ drainage area)*100	NHD, 1:24,000 scale (*http://nhd.usgs.gov*)
Mean annual precipitation	Inches	Area-weighted average	PRISM (*http://prism.oregonstate.edu/*)
Soil drainage index	Dimensionless	Area-weighted average	STATSGO Data (*http://sdmdataaccess.nrcs.usda.gov/*)
Hydrologic soil index	Dimensionless	Area-weighted average	STATSGO Data (*http://sdmdataaccess.nrcs.usda.gov/*)
Drainage density	Miles per square mile	Total length of all streams divided by drainage area	NHD, 1:24,000 scale (*http://nhd.usgs.gov*)
Population density	Population per square meter	Total number of persons divided by basin area	National Historical Geographic Information System (*http://nhgis.org/*)
24 hour, 2-, 10-, 25-, 50-, and 100-year maximum precipitation	Inches	Area-weighted average	For Georgia and Florida streamgages: Derived from Hershfield (1961). For North Carolina, South Carolina, and New Jersey streamgages: National Oceanic and Atmospheric Administration Atlas 14, Volume 2 (*http://hdsc.nws.noaa.gov/hdsc/pfds/index.html*)

Table 3. 2001 and 2006 National Land Cover Dataset (NLCD) class definitions for developed land.

Class number	Class name	Class definition
21	Developed, Open Space	Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22	Developed, Low Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20–49 percent of total cover. These areas most commonly include single-family housing units.
23	Developed, Medium Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50–79 percent of the total cover. These areas most commonly include single-family housing units.
24	Developed, High Intensity	Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.

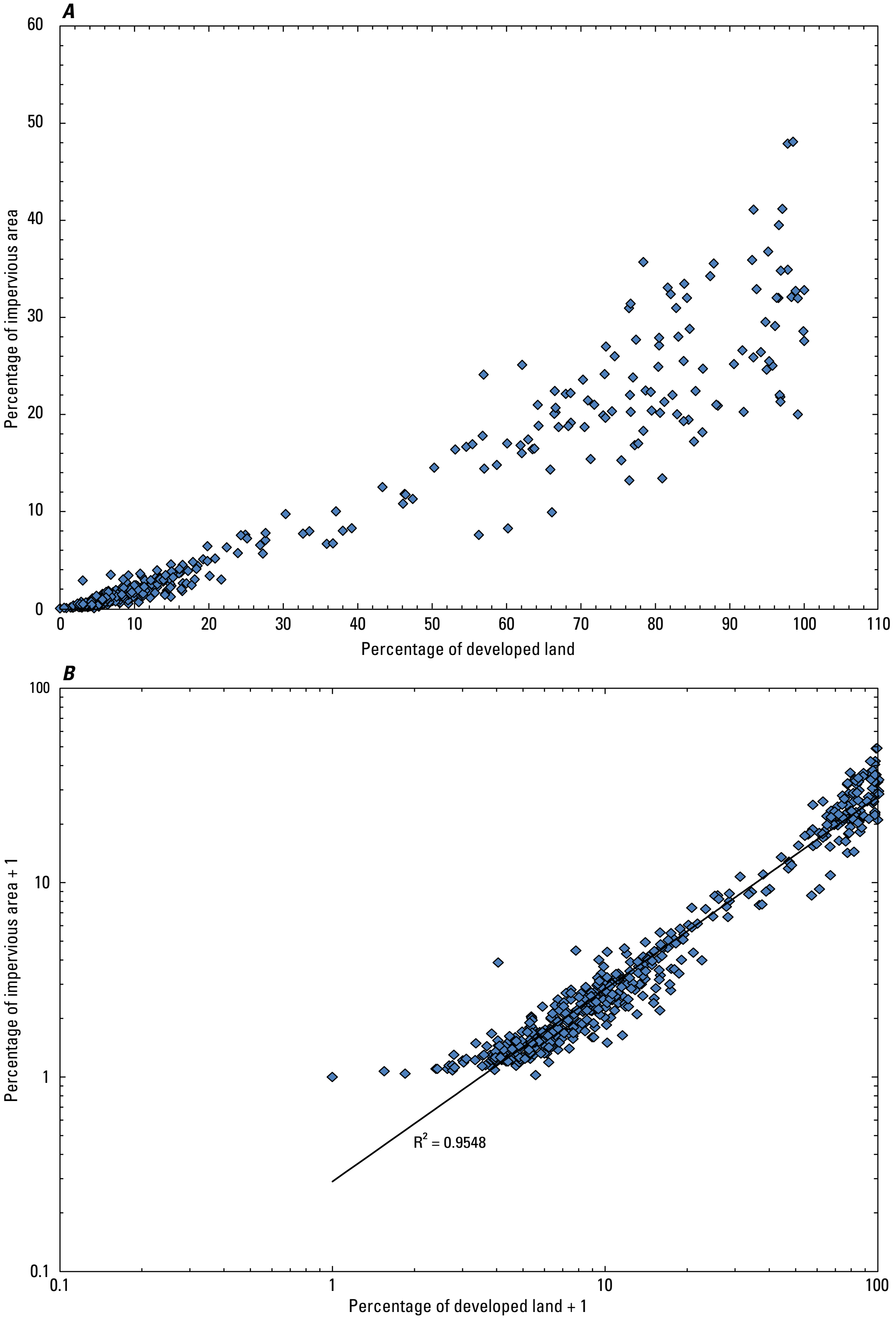


Figure 7. Relation between the percentage of developed land and the percentage of impervious area for the rural and urban streamgages included in the regression analysis using (*A*) arithmetic values and (*B*) logarithms of the values plus 1.

Estimation of Flood Magnitude and Frequency at Urban and Small, Rural Streamgages

A frequency analysis of annual peak-flow data at a streamgage provides an estimate of the flood magnitude and frequency for that specific stream site. Until recently, flood-frequency flows in USGS reports were expressed as T-year floods based on the recurrence interval for that flood quantile (for example, the “100-year flood”). The use of recurrence-interval terminology is now discouraged because it sometimes causes confusion to the general public. The term is sometimes interpreted to imply that there is a set time interval between floods of a particular magnitude, when in fact floods are random processes that are best understood using probabilistic terms. Misunderstandings of the T-year recurrence-interval terminology primarily have to do with the number of times that a peak flow of certain magnitude could occur during the T-year period. While the T-year recurrence-interval flood is statistically expected to be equaled or exceeded, on average, once during the T-year period, floods of this magnitude may occur multiple times during the period or not at all.

The terminology associated with flood-frequency estimates has shifted toward the P-percent annual exceedance probability (AEP) flood. The use of P-percent AEP flood is recommended because it conveys the probability, or odds, of a flood of a given magnitude being equaled or exceeded in any given year. For example, a 1-percent AEP flood (formerly known as the “100-year flood”) corresponds to the flow magnitude that has a probability of 0.01 of being equaled or exceeded in any given year. The P-percent is computed as the inverse of the recurrence interval T multiplied by 100 (for example, 1/100 × 100). T-year recurrence intervals with corresponding annual exceedance probabilities and P-percent chance exceedance probabilities are listed in table 4 (Feaster and others, 2009).

Table 4. T-year recurrence intervals with corresponding annual exceedance probability and P-percent chance exceedance for flood-frequency flow estimates (from Feaster and others, 2009).

T-year recurrence interval	Annual exceedance probability	P-percent annual exceedance probability
2	0.5	50
5	0.2	20
10	0.1	10
25	0.04	4
50	0.02	2
100	0.01	1
200	0.005	0.5
500	0.002	0.2

Flood-frequency estimates for streamgages are computed by fitting the series of annual peak flows to a known statistical distribution. Flood-frequency estimates for streamgages included in this study were computed by fitting logarithms (base 10) of the annual peak flows to a Pearson Type III distribution. This method follows the guidelines and computational methods described in Bulletin 17B of the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data (1982). Fitting the distribution requires calculating the mean, standard deviation, and skew coefficient of the logarithms of the annual peak-flow record, which describe the mid-point, slope, and curvature of the peak-flow frequency curve, respectively. Estimates of the P-percent AEP flows are computed by inserting the three statistics of the frequency distribution into the equation

$$\log Q_{P\%} = X + KS \tag{1}$$

where

$Q_{P\%}$ is the P-percent annual exceedance probability flow, in cubic feet per second;

X is the mean of the logarithms of the annual peak flows;

K is a factor based on the skew coefficient and the given percent annual exceedance probability, which can be obtained from appendix 3 in Bulletin 17B; and

S is the standard deviation of the logarithms of the annual peak flows, which is a measure of the degree of variation of the annual values about the mean value.

A series of annual peak flows at a station may include outliers or annual peak flows that are substantially lower or higher than other peak flows in the series. The station record also may include information about peak flows that occurred outside of the period of regularly collected, or systematic, record. These peak flows are known as historic peaks. Bulletin 17B (Interagency Advisory Committee on Water Data, 1982) provides guidelines for detecting and interpreting outliers and historic data points and provides computational methods for appropriate corrections to the distribution to account for the presence of outliers and historic information. In some cases, outliers may be excluded from the record; thus, the number of systematic peaks may not be equal to the number of years in the period of record.

In terms of annual peak flows, the period of collected record can be thought of as a sample of the entire record, or population. Statistical measures, such as mean, standard deviation, or skew coefficient, can be described in terms of the sample or computed measure and the population or true measure. Statistical measures computed from the sample record are estimates of what the measure would be if the entire population were known and used to compute the given measure. The accuracy of these estimates depends on the specific statistic and the given sample of the population.

For the rural streamgages in Georgia, South Carolina, and North Carolina included in this investigation, the flood-frequency estimates were obtained from those previously published in the Southeast rural flood-frequency investigation (Feaster and others, 2009; Gotvald and others, 2009; Weaver and others, 2009). Two additional rural streamgages from North Carolina that were not included in the Southeast rural flood-frequency investigation due to insufficient length of record were included in this report: streamgages 0209782609 and 0214657975 (table 1). The two streamgages have impervious areas of 7.7 and 8.2 percent, respectively, and therefore, provide impervious area data in the transitional range between rural and urban streamgages. In addition, the flood-frequency estimates for the Georgia urban and small, rural streamgages included in Gotvald and Knaak (2011) were updated by including additional data collected through September 2011 and using the expected moments algorithm (EMA) (Cohn and others, 1997), which will be discussed in the following section. Updating the flood-frequency analyses for the Georgia urban and small, rural streamgages allowed for the inclusion of the historic floods that occurred in northern Georgia during September 2009 (McCallum and Gotvald, 2010). For the streamgages included from the New Jersey ICP, the flood-frequency estimates were updated in consultation with USGS New Jersey Water Science Center hydrologists and included peak-flow data through September 2011.

The USGS computer program PeakFQ version 7.0.29368 was used to compute flood-frequency estimates for the urban and small, rural streamgages considered for this study (Julie Kiang, U.S. Geological Survey, written commun., May 17, 2013). PeakFQ automates many of the analytical procedures recommended in Bulletin 17B (Interagency Advisory Committee on Water Data, 1982), including identifying and adjusting for outliers and historical periods, weighting of station skews with a generalized skew, and fitting a log-Pearson Type III distribution to the annual peak-flow data (Flynn and others, 2006). The PeakFQ program and associated documentation can be downloaded from *http://water.usgs.gov/software/PeakFQ/.* Bulletin 17B (Interagency Advisory Committee on Water Data, 1982) recommends using a weighted average of the station skew coefficient with a generalized or regional skew coefficient. For urban streamgages, this method is problematic because of the limited number of urban streamgages with 25 years or more of peak-flow record from which to develop a generalized skew. In this study, therefore, each urban streamgage was considered individually, and the flood-frequency estimates were computed using their respective station skew. This method is consistent with the methodology used in the previous urban flood-frequency studies in the Southeast (Bohman, 1992; Inman, 1995; Feaster and Guimareas, 2004; and Gotvald and Knaak, 2011) and the approach used in the national urban flood-frequency study by Moglen and Shivers (2006). The final flood-frequency estimates from the Bulletin 17B analysis for the streamgages included in this investigation are listed in table 5, p. 73.

Expected Moments Algorithm (EMA)

Bulletin 17B has been the standard methodology for flood-frequency analysis in the United States since 1981 (Interagency Advisory Committee on Water Data, 1982). However, the authors of Bulletin 17B noted that the guide was designed to "…meet a current, ever-pressing demand that the Federal Government develop a coherent set of procedures for accurately defining flood potentials…" but that additional studies were needed to address a number of items identified in Bulletin 17B as "Future Studies." On the basis of studies made in response to those recommendations, adoption of the EMA is among the changes that have been suggested (Cohn and others, 1997; Tim Cohn, U.S. Geological Survey, written commun., September 27, 2012) and are starting to be applied in USGS flood-frequency studies (Gotvald and others, 2012; Zarriello and others, 2012; Kessler and others, 2013).

The EMA techniques also fit peak-flow data to the log-Pearson Type III distribution and were used in this investigation to determine the log-Pearson Type III at-site estimates for the urban and small, rural streamgages. For streamgages that have systematic annual peak-flow records for complete periods of record with no low outliers or historical flood information, the EMA method calculates identical values of the mean log, standard deviation log, and station skew as obtained from the traditional Bulletin 17B analysis. However, for streamgages with broken records, low outliers, or historical information, the EMA method can incorporate censored and interval peak-flow data into the analysis. During historical periods (periods outside of the systematic data collection), knowledge of peak-flow magnitudes may be incomplete. For example, the peak flows may only be known to be greater than or less than some value. Such data are said to be censored. One such case might be a station that has historical information indicating that a recorded peak flow, Q_{hist}, was the largest since 1908, before the systematic record collection began in 1950. In such a case, the unknown peaks between 1908 and 1949 can be characterized as a censored peak flow for which the value is known not to have exceeded Q_{hist}. The estimates of those bounded peak flows between zero and Q_{hist} can be used in the log-Pearson Type III flood-frequency analysis (Gotvald and others, 2012). So, although the exact values of the peaks from 1908 to 1949 are not known, EMA takes advantage of the information that is known, namely that those peaks did not exceed Q_{hist}. Bulletin 17B also provides techniques for using historic information but the EMA procedures do so with greater efficiency (Cohn and others, 1997).

The EMA techniques also take advantage of interval discharges to characterize peak flows that are known to be greater or less than some specific value or that can only be reliably estimated within a specific flow range. Such interval data can be used for missing data that may occur during a period of systematic data collection. For example, if a peak flow was not determined because the water level did not reach the bottom of the gage, the missing peak can be characterized as an interval discharge with a range that is bounded by zero and the discharge associated with the elevation of the bottom of the gage.

Multiple Grubbs-Beck Test for Detecting Low Outliers

In Bulletin 17B, the Grubbs-Beck test is recommended for detection of low outliers, which can have a substantial influence on the upper end of the frequency curve (large peak flows, small AEP) (Grubbs and Beck, 1972; Interagency Advisory Committee on Water Data, 1982). The Grubbs-Beck test uses the at-site logarithms of the peak-flow data to calculate a one-sided, 10-percent significance-level critical value for a normally distributed sample (Gotvald and others, 2012). Although more than one recorded peak flow for a streamgage may be smaller than the Grubbs-Beck test critical value, usually only one non-zero recorded peak flow is identified from the test as being a low outlier. However, some streamgage peak-flow records may include multiple small peak flows that could unduly influence the upper end of the frequency curve. In that case, Bulletin 17B noted that it may be desirable to test the sensitivity of the results of also treating those values as outliers.

Low outliers and potentially influential low flows likely reflect physical processes that are not relevant to the processes effecting large floods. Consequently, standardized procedures to identify such potentially influential low flows to limit their influence on large flood estimates are desirable. On the basis of the recognition of such a need, a method for statistically detecting multiple potentially-influential low outliers using a generalized Grubbs-Beck test has been developed and incorporated into the USGS PeakFQ program (Cohn and others, 2013). The multiple Grubbs-Beck test also is based on a one-sided, 10-percent significance-level critical value for a normally distributed sample, but the test is constructed so that groups of ordered data are examined (for example, the six smallest values) and excluded from the dataset when the critical value is calculated. For the example noted, if the critical value is greater than the sixth smallest value, then all six values are considered to be low outliers. In addition to the EMA procedures, the multiple Grubbs-Beck test was applied to the log-Pearson Type III analyses for the urban and small, rural streamgages included in this investigation.

Estimation of Flood Magnitude and Frequency at Ungaged Urban and Small, Rural Sites

A regional regression analysis was used to develop a set of equations for use in estimating the magnitude and frequency of floods for ungaged urban and small, rural sites in Georgia, South Carolina, and North Carolina. These equations relate the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent AEP flows (table 4) computed from available peak-flow records for streamgages to measured physical and climatic basin characteristics of the associated drainage basins. For the initial analysis, the upper limit for the drainage area of the rural streamgages included in the regression analysis was established based on the upper limit of the drainage area for the urban streamgages in each hydrologic region (HR; fig. 2) so that reasonable representation of basin characteristics for both urban and rural streamgages would be included in the analysis. Additionally, only the Southeast rural streamgages that drained 100 percent from a single HR were included in the regression analysis (all the urban streamgages drained 100 percent from individual HRs). Some of the benefits of including urban and rural streamgages together in the regression analysis are (1) smoother transition between urban and rural flood-frequency estimates, (2) larger database than would be available with urban streamgages alone, and (3) larger geographical coverage in the HRs, which will represent a broader range of hydrologic conditions likely to occur at ungaged locations (fig. 2; table 1).

Regression Analysis

Hydrologic regions that were determined in the Southeast rural flood-frequency investigation were used as the basis for the HRs in this study (Feaster and others, 2009). In the Southeast rural flood-frequency investigation, exploratory regression analysis was done using ordinary least squares (OLS) regression techniques. From that exploratory analysis, three HRs were defined by combining USEPA level III ecoregions for which flood-frequency characteristics were determined to be similar (figs. 1 and 2): HR1, Piedmont–Ridge and Valley; HR2, Blue Ridge; and HR4, Coastal. The USEPA level IV Sand Hills ecoregion was designated as HR3. Additionally, a unique region in the southwestern corner of the Georgia Southeastern Plains that approximately corresponds to the USEPA level IV Tifton Uplands ecoregion was designated as HR5.

Ordinary least squares regression techniques also were used in the exploratory analysis for this investigation to determine the best regression models for all combinations of basin characteristics. The general model for an OLS regression analysis is of the form

$$Q_{P\%} = aA^{b}B^{c}C^{d}..., \qquad (2)$$

where

$Q_{P\%}$ is as previsously defined:
A,B,C are explanatory (independent) variables; and
$a,b,c,$ and d are regression coefficients.

If the response and explanatory variables are logarithmically transformed, the regression model has the following line form:

$$\log Q_{P\%} = \log a + b(\log A) + c(\log B) + d(\log C) + \ldots, \tag{3}$$

where the variables are as previously defined in equation 2. The logarithmic and arithmetic relation was used in this investigation because the logarithmic transformation of some variables, such as percentage impervious area and percentage development, did not improve the linear relation with $Q_{P\%}$.

Ordinary least squares regression is an efficient way to explore linear relations between the explanatory (basin characteristics) and response (P-percent AEP flows) variables. As previously mentioned, sometimes variables can be transformed in order to create or improve linear relations. For example, the relation between arithmetic values of basin drainage area and P-percent AEP flow is typically curvilinear. However, the relation between the logarithms of basin drainage area and the logarithms of P-percent AEP flow typically is linear, an example of which is shown in figure 8. Homoscedasticity (a constant variance in the response variable over the range of the explanatory variables) about the regression line and normality of the residuals also are requirements for OLS regression. Log transformation of the P-percent AEP flow and some of the explanatory variables enhances the homoscedasticity of the data about the regression line. Homoscedasticity and normality of residuals were examined in residual plots. In addition, partial-regression residual plots were reviewed to assess the linearity of each individual explanatory variable included in the regression model for a specific HR (Larsen and McCleary, 1972).

Selection of the explanatory variables for each HR using OLS regression was based on all-possible-subsets (APS) regression methods (Neter and others, 1985). The final explanatory variables for each HR were selected on the basis of several factors, including standard error of the estimate, Mallow's Cp statistic, statistical significance of the explanatory variables, coefficient of determination (R^2), and ease of measurement of explanatory variables. Multicollinearity in the candidate exploratory variables also was assessed by the variance inflation factor (VIF) and the correlation between explanatory variables. A general rule is that the VIF should not exceed a range of 5 to 10 (Julie Kiang, U.S. Geological Survey, written commun., March 15, 2012). Helsel and Hirsch (1992) note that serious problems are indicated for a VIF greater than 10.

Generalized least squares (GLS) regression methods, as described by Stedinger and Tasker (1985), were used to determine the final regional P-percent AEP flow regression equations with the use of the weighted-multiple-linear regression (WREG) program version 1.06 (Julie Kiang, U.S. Geological Survey, written commun., May 2013). Details about this computer program are available in Eng and others (2009). Stedinger and Tasker (1985) found that GLS regression equations are more accurate and provide a better estimate of the accuracy of the equations than OLS regression equations when annual peak-flow record at streamgages are of different and widely varying lengths and when concurrent flows at different streamgages are correlated. Generalized least square regression techniques give less weight to streamgages that have shorter periods of record than streamgages with longer periods of record. Less weight also is given to streamgages where concurrent peak flows are correlated due to the geographic proximity with other streamgages (Hodgkins, 1999).

As was done for the rural streamgages included in the Southeast rural flood-frequency investigation by Feaster and others (2009), the urban streamgages were assessed for redundancy. Redundancy occurs when the drainage basins of two streamgages are nested, which is when one basin is contained inside the other basin and most or all of the peak-flow data at the two streamgages are concurrent. In order to remove the redundancy from the GLS regression analysis associated with streamgages that represent the same basin, two streamgages on the same stream where the percentage change in drainage area from one station to the second was within 50 percent were considered redundant pair streamgages. If the peak-flow record of the station with the shorter period of record was predominantly captured within the record of the station with the longer period of record and the urbanization characteristics of the two streamgages were relatively similar, the station with the shorter period of record was omitted from the analysis. The following streamgages were excluded from the regional regression analysis due to redundancy: 02087275, 02095181, and 02392950 (table 1).

Regionalization of Flood-Frequency Estimates Using Rural and Urban Streamgages

One of the earliest regional analyses of streamflow was based on the strong relation between drainage area and maximum streamflow (Dawdy and others, 2012). For rural flood-frequency regional regression equations, drainage area is commonly the predominant, if not the single, explanatory variable for estimating the P-percent AEP flows. A number of urban flood-frequency investigations have included an explanatory variable for the equivalent rural regression flood flow (RQP), which is computed using a rural regression equation for an equivalent rural basin in the same HR as the urban basin (Sauer and others, 1983; Bohman, 1992; Inman, 1995; Robbins and Pope, 1996; and Moglen and Shivers, 2006). One concern with including the RQP in an urban flood-frequency analysis is the issue of multicollinearity, which is the situation where the correlations between the explanatory variables are significantly strong (Harrell, 2001). Given that many rural flood-frequency equations are solely a function of drainage area, including the RQP and drainage area as explanatory variables raises the possibility of the variables being highly collinear, which can inflate the standard errors of the regression coefficient estimates. In the national urban flood-frequency investigation by Sauer and others (1983), a separate analysis was done to remove the intercorrelation of such variables as drainage area and the RQP. Their test showed that the resulting regression equations were unchanged, and the tests for significance showed the same or slightly higher significance and, thus, it was concluded that the regression equations were valid.

Another issue with including the RQP in an urban flood-frequency analysis is that of having to extrapolate outside the range of drainage area sizes used in the rural flood-frequency analysis to estimate the RQP for urban basins, which often have a smaller minimum drainage area size than the rural basins included in the rural flood-frequency analysis. For example, the range of drainage-area sizes for the urban streamgages used in the national urban flood-frequency regression analysis by Sauer and others (1983) was 0.2 to 100 mi^2; however, the minimum drainage area size for the South Carolina rural basins included in the rural flood frequency report listed in appendix II of Sauer and others (1983) was 1 mi^2 (Whetstone, 1982).

For the current investigation, many of the urban streamgages have drainage areas less than 1 mi^2, which is outside the limits of the rural equations from Feaster and others (2009); thus, it would not be prudent to compute the RQP for those urban basins. Consequently, another benefit of mixing the urban and rural streamgages together in the flood-frequency analysis is not being limited by drainage-area sizes from the rural flood-frequency investigation. Along with the small, urban drainage basins, rural flood-frequency streamgages with drainage basins less than 1 mi^2 that were not included in Gotvald and others (2009), Weaver and others (2009), and Feaster and others (2009) are included in this analysis. As a result, an additional benefit of the current investigation is the generation of a set of flood-frequency equations that will be applicable for small, rural basins draining less than 1 mi^2.

Influence of Urbanization

Urbanization in a drainage basin results in increased impervious surfaces, such as roads and rooftops, which results in decreased infiltration of precipitation into the soils. As a consequence, urbanization of a natural basin generally results in a more rapid runoff and increased runoff volume than would occur for the natural conditions (Rawls and others, 1980). The changes in the characteristics of the streamflow due to urbanization, however, are dependent on many factors such as the extent and location of the urbanized area, the severity of the storm event, and drainage improvements and alterations in the urban areas. For large basins, if the urbanized area is located closer to the basin outlet, the peak flows could be reduced by urbanization due to rapid removal of floodwaters in the lower part of the basin prior to the arrival of flood flows from the upper part of the basin (Sauer and others, 1983). In addition, the runoff from larger, infrequent storms tends to be less influenced by increased imperviousness than is the runoff from smaller, more frequent storms. The reason for the difference is that as soils become saturated and (or) the rainfall intensity exceeds the soils' infiltration rate, overland flow dominates for both impervious and pervious surfaces. In such cases, increased imperviousness would be expected to have more influence in sandy soils such as in the Sand Hills (HR3) and Coastal Plain (HR4) and a lesser influence in the clayey Piedmont (HR1) soils or the higher gradient slopes and more rugged terrain of the Blue Ridge (HR2), which consist of lower soil depths overlying metaphoric rocks. Finally, with respect to the differences in the flood-frequency estimates from natural and urbanized streams, there is the issue of the natural variability in the flood-frequency flow data from rural basins that is a result of the variety of record lengths and the climatic conditions under which those records were collected (fig. 4*A*). Consequently, it is expected that there will be some degree of overlap in the P-percent AEP flows from urban and rural basins of similar drainage area sizes (fig. 8*A* and *B*).

Regional Regression Equations

For both the OLS and GLS analyses, multiple regression diagnostics were generated and used to identify possible problems with the streamgage data or basin characteristics. Along with reviews to assess that the regression residuals were randomly distributed around zero, other regression diagnostics were reviewed to determine streamgages that had high leverage and (or) high influence. The leverage metric is used to measure how unusual the values of independent variables at one streamgage are compared to the values of the same variables at all other streamgages. The influence metric indicates whether the data at a streamgage had a high influence on the estimated regression metric values (Eng and others, 2009). A streamgage may have a high leverage metric indicating that its independent variables are substantially different from those at all other streamgages, but the same streamgage may not have a high influence on the regression metrics. Conversely, a streamgage with a high influence may not have a high leverage metric. Sometimes, measurement or transposing errors in reported values of some independent variables may produce high leverage or influence metrics. Streamgages with high influence or leverage were given additional review to determine if such errors had been made or if the streamgage should be excluded for other reasons.

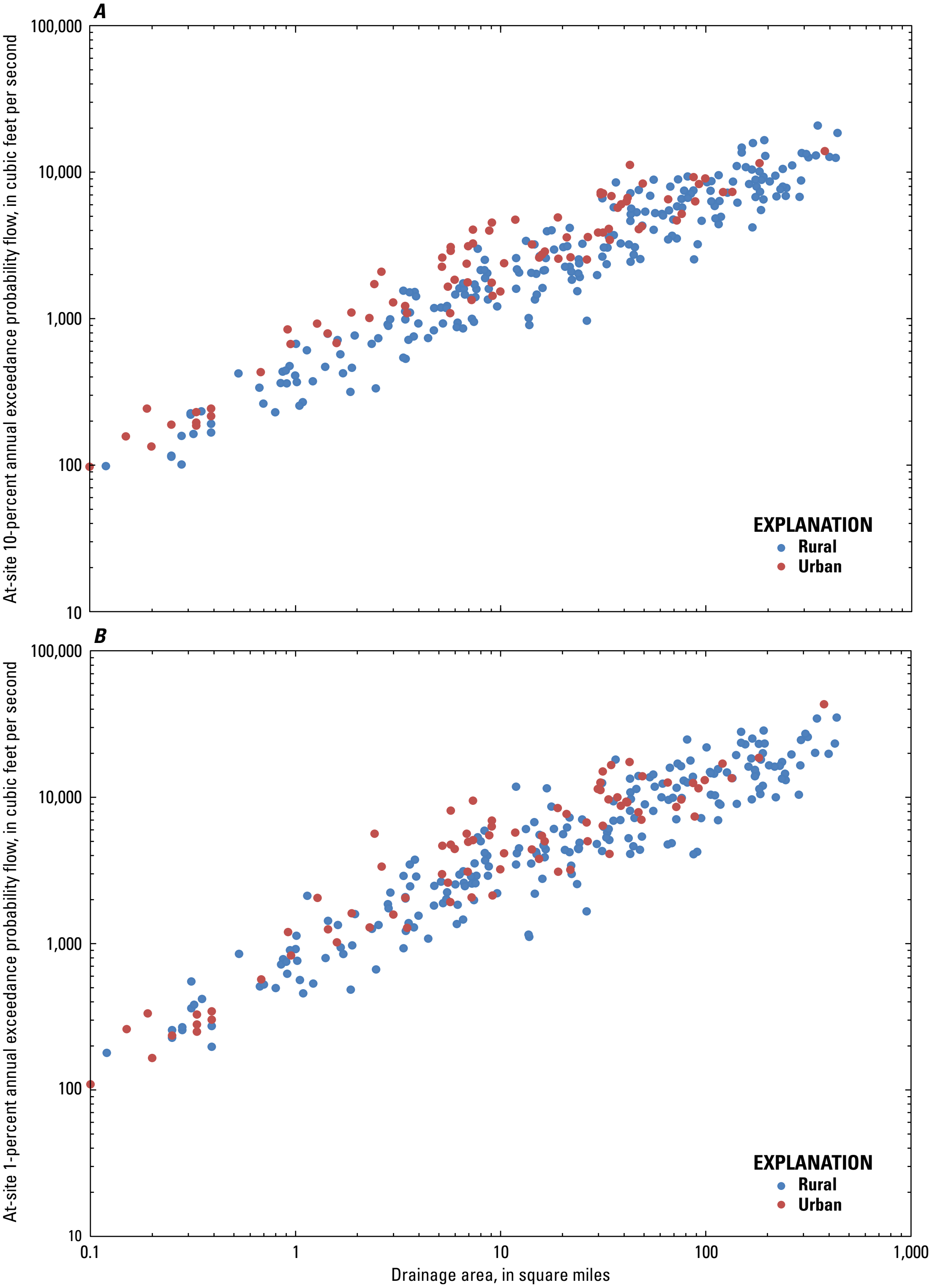


Figure 8. At-site annual exceedance probability flow and drainage area for (*A*) 10-percent annual exceedance and (*B*) 1-percent annual exceedance flows in hydrologic region 1.

Streamgages Excluded on the Basis of Regression Diagnostics

The majority of the streamgages that were identified in the OLS or GLS analysis as having high influence or leverage were not excluded because no known errors associated with the basin characteristics or streamflow data were discovered. However, the following streamgages were excluded on the basis of the regression diagnostics and further review of the streamgages: 02084557, 0208735012, 02166975, 02169570, and 02173495.

In the preliminary OLS analyses, station 02084557 had the highest residual of the streamgages included in the HR4 regression and also had a high influence value. Review of the stage-flow rating for the station indicated that there was a substantial amount of uncertainty with respect to the higher flows due to the possibility of backwater from artificial farm canals located downstream. Consequently, station 02084557 was excluded from the final regression analyses.

In the preliminary OLS analyses, station 0208735012 had both high leverage and high influence values. Additional review of the station indicated that there was substantial uncertainty with the high end of the rating curve due to flashy conditions in the stream, making it difficult to obtain high-stage streamflow measurements. As a result, this streamgage was excluded from the final regression analyses.

Station 02166975 has peak-flow data from 1986 to 2003 and 2005 to 2009. The pattern of the peak flows for 1986 to 2003 was stable, indicating no trends, but the peaks from 2005 to 2009 showed an upward trend. Additional review of the station suggested that rapid upstream development may have begun around 2004. In addition, it was noted in the 2008 station analysis that the station was likely being influenced by varying degrees of backwater from a downstream crossing. Consequently, given the uncertainty in the stationarity of the peak-flow data and the potential issues with backwater, the streamgage was excluded from the regression analysis.

While reviewing observed and predicted plots from the GLS regression, it was noted that the rate of runoff (cubic feet per second per square mile) for station 02169570, which has an impervious area of 15 percent and, therefore, is considered an urban basin, was much more similar to the rural streamgages. Additional review indicated a large number of ponds located throughout the basin, and it was concluded that those ponds are likely causing substantial reduction of peak flows in the basin. Consequently, station 02169570 was excluded from the final regression analysis.

Along with having the highest residual of the HR4 streamgages, preliminary OLS regression diagnostics indicated that station 02173495 had both high influence and high leverage. The 1995 peak flow, which was the peak of record for this station, was based on an extension of the rating curve that was more than two times the maximum measured flow and was three times as large as the mean of the other peak flows for the period from 1986 to 2011. The drainage basin for station 02173491 is adjacent to the basin for station 02173495, and the 1995 peak flow for station 02173491 did not indicate a substantial flood. Inspection records indicate that downstream from 02173495, a large pipe crosses the concrete channel and the bottom of the pipe sometimes becomes clogged with debris, which may be influencing the flood flows. Consequently, given these findings, station 02173495 was excluded from the final regression analysis.

Generalized Least Squares Regression Results

A GLS analysis was completed for hydrologic regions 1, 3, and 4 and included 340 rural, 116 urban, and 32 small, rural streamgages for a total of 488 streamgages (table 1; fig. 2). A regression analysis was not completed for HR2 (Blue Ridge) due to an insufficient number of urban streamgages. Gotvald and Knaak (2011) found that for HR1, the regression curve through the complete range of data over predicted P-percent AEP flows for drainage basins less than 1 mi^2. To account for the difference in slope for the regression curve, Gotvald and Knaak (2011) divided the streamgages into two groups and generated regression curves for sites drainage areas less than 1 mi^2 and sites drainage areas greater than 1 mi^2. For the larger dataset included in this investigation, the regression curve for HR1 generated using the complete range of data tended to over predict the P-percent AEP flows for sites with small drainage areas. Several regressions were tested breaking the data at various drainage-area sizes between 1 and 5 mi^2. Residuals were reviewed, and model accuracy results were compared to determine a reasonable break point. In addition, plots of observed 1-percent AEP flows divided by the drainage area at the streamgages also were reviewed. On the basis of this information, the regional regression analyses for HR1 was based on two groups of streamgages—those with drainage areas less than or equal to 3 mi^2 and those with drainage areas greater than 3 mi^2 (fig. 9*A* and *B*).

For HR1, the final regression equations for drainage area (DRNAREA) less than or equal to 3 mi^2 included 41 rural and 21 urban streamgages (table 6). The independent variables for HR1 for the streamgages less than or equal to 3 mi^2 included DRNAREA and percentage impervious area (IMPNLCD06) (table 7). For the 0.5-percent AEP, IMPNLCD06 was not statistically significant but was included in the regression equation because the regression coefficient was positive and including it insured a smooth transition between the 1- and 0.5-percent AEP regression curves. For the 0.2-percent AEP regression curve, IMPNLCD06 was not statistically significant and the regression coefficient was negative; consequently, IMPNLCD06 was not included in the regression equation. The explanatory variables for the urban and rural streamgages used in the regression analysis are given in table 8, p. 83.

For HR1 streamgages with DRNAREA greater than 3 mi^2, the final regression equations included 175 rural and 60 urban streamgages. The independent variables included DRNAREA and IMPNLCD06 (table 7). For the 0.5- and 0.2-percent AEP flows, IMPNLCD06 was not statistically significant at the 0.05 significance level. However, because the regression coefficient for IMPNLCD06 was positive and to maintain consistency between the 1- to 0.2-percent AEP flows for HR1, IMPNLCD06 was retained in the 0.5- and 0.2-percent AEP flow regression equations.

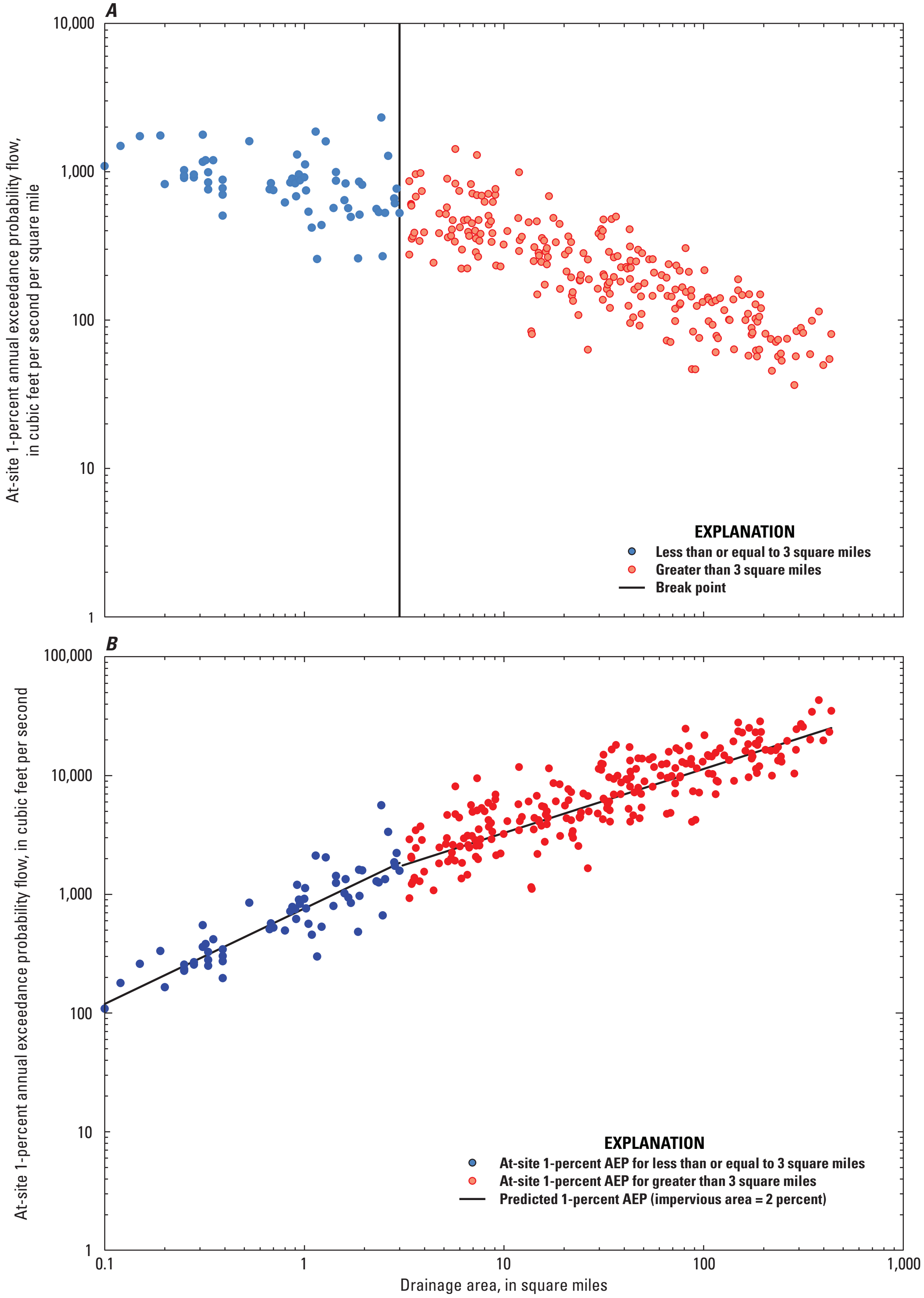


Figure 9. Drainage area for hydrologic region 1 streamgages included in the regional regression analysis and at-site 1-percent annual exceedance probability (AEP) flow, in (*A*) cubic feet per second per square mile, and (*B*) cubic feet per second.

Table 6. Distribution by State of U.S. Geological Survey streamflow-gaging stations included in the regional regression analysis.

[R, rural; SR, small rural; U, urban; HR, hydrologic region; ---, not applicable. Hydrologic regions shown in figure 2]

State	Florida			Georgia			New Jersey			North Carolina			South Carolina			Total		
Type	R	SR	U	R	SR	U	R	SR	U	R	SR	U	R	SR	U	R	SR	U
[a]HR1	---	---	---	13	11	17	---	---	---	8	9	1	0	0	3	21	20	21
[b]HR1	---	---	---	84	---	19	---	---	---	67	---	38	24	---	3	175	---	60
HR3	---	---	---	7	1	4	---	---	---	10	1	0	7	0	4	24	2	8
HR4	0	0	2	65	8	3	2	0	16	48	2	1	5	0	5	120	10	27
															Total	340	32	116

[a] HR1, hydrologic region 1 stations with drainage areas less than or equal to 3 square miles (mi^2).

[b] HR1, hydrologic region 1 stations with drainage areas greater than 3 mi^2.

Table 7. Regional flood-frequency equations for ungaged urban and small, rural streams in Georgia, South Carolina, and North Carolina.

[mi^2, square miles; DRNAREA, drainage area, mi^2; IMPNLCD06, percentage of impervious area from the 2006 National Land Dataset, in percent; I24H50Y, 24-hour, 50-year maximum precipitation, in inches]

Percent annual exceedance probability	Hydrologic Region (shown in fig. 2)		
	1		3
	$0.10\ mi^2 \le DRNAREA \le 3\ mi^2$	$3\ mi^2 < DRNAREA \le 436\ mi^2$	$0.22\ mi^2 \le DRNAREA \le 459\ mi^2$
50	$163(DRNAREA)^{0.7089}10^{(0.0133*IMPNLCD06)}$	$198(DRNAREA)^{0.5735}10^{(0.0101*IMPNLCD06)}$	$30.0(DRNAREA)^{0.6605}10^{(0.0122*DEVNLCD06)}$
20	$284(DRNAREA)^{0.7351}10^{(0.0096*IMPNLCD06)}$	$359(DRNAREA)^{0.5605}10^{(0.0074*IMPNLCD06)}$	$51.4(DRNAREA)^{0.6535}10^{(0.0109*DEVNLCD06)}$
10	$381(DRNAREA)^{0.7536}10^{(0.0076*IMPNLCD06)}$	$484(DRNAREA)^{0.5539}10^{(0.0060*IMPNLCD06)}$	$68.4(DRNAREA)^{0.6507}10^{(0.0102*DEVNLCD06)}$
4	$518(DRNAREA)^{0.7752}10^{(0.0053*IMPNLCD06)}$	$657(DRNAREA)^{0.5470}10^{(0.0046*IMPNLCD06)}$	$93.3(DRNAREA)^{0.6472}10^{(0.0095*DEVNLCD06)}$
2	$632(DRNAREA)^{0.7903}10^{(0.0037*IMPNLCD06)}$	$794(DRNAREA)^{0.5428}10^{(0.0037*IMPNLCD06)}$	$114(DRNAREA)^{0.6451}10^{(0.0090*DEVNLCD06)}$
1	$753(DRNAREA)^{0.8038}10^{(0.0024*IMPNLCD06)}$	$941(DRNAREA)^{0.5386}10^{(0.0028*IMPNLCD06)}$	$138(DRNAREA)^{0.6430}10^{(0.0086*DEVNLCD06)}$
0.5	$884(DRNAREA)^{0.8181}10^{(0.0011*IMPNLCD06)}$	$1096(DRNAREA)^{0.5351}10^{(0.0021*IMPNLCD06)}$	$163(DRNAREA)^{0.6413}10^{(0.0082*DEVNLCD06)}$
0.2	$1045(DRNAREA)^{0.8160}$	$1319(DRNAREA)^{0.5305}10^{(0.0011*IMPNLCD06)}$	$201(DRNAREA)^{0.6386}10^{(0.0077*DEVNLCD06)}$

Percent annual exceedance probability	Hydrologic Region (shown in fig. 2)	
	4	†5
	$0.10\ mi^2 \le DRNAREA \le 53.5\ mi^2$	$0.20\ mi^2 \le DRNAREA \le 10\ mi^2$
50	$26.3(DRNAREA)^{0.5908}10^{(0.0173*IMPNLCD06)}10^{(0.0515*I24H50Y)}$	$165(DRNAREA)^{0.537}$
20	$40.6(DRNAREA)^{0.5958}10^{(0.0125*IMPNLCD06)}10^{(0.0623*I24H50Y)}$	$265(DRNAREA)^{0.583}$
10	$51.8(DRNAREA)^{0.6004}10^{(0.0101*IMPNLCD06)}10^{(0.0666*I24H50Y)}$	$349(DRNAREA)^{0.600}$
4	$67.1(DRNAREA)^{0.6067}10^{(0.0075*IMPNLCD06)}10^{(0.0708*I24H50Y)}$	$473(DRNAREA)^{0.615}$
2	$78.4(DRNAREA)^{0.6111}10^{(0.0058*IMPNLCD06)}10^{(0.0738*I24H50Y)}$	$574(DRNAREA)^{0.624}$
1	$90.5(DRNAREA)^{0.6154}10^{(0.0043*IMPNLCD06)}10^{(0.0762*I24H50Y)}$	$684(DRNAREA)^{0.632}$
0.5	$103(DRNAREA)^{0.6201}10^{(0.0029*IMPNLCD06)}10^{(0.0785*I24H50Y)}$	$804(DRNAREA)^{0.639}$
0.2	$119(DRNAREA)^{0.6261}10^{(0.0012*IMPNLCD06)}10^{(0.0813*I24H50Y)}$	$971(DRNAREA)^{0.649}$

†From Gotvald and Knaak, 2011.

The Sand Hills region (HR3) is the smallest HR in Georgia, South Carolina, and North Carolina and, therefore, has the smallest number of streamgages (fig. 2). The explanatory variables included in the final regression analysis for HR3 were DRNAREA and percentage of developed land (DEVNLCD06) (table 7). At a significance level of 0.05, DEVNLCD06 was found to be statistically significant throughout the full range of P-percent annual exceedance flows (50 to 0.2). Percentage of impervious area also was tested as an explanatory variable, but using DEVNLCD06 reduced the standard error of prediction for the 10- and 1-percent AEP flow equations by more than 5 percent and therefore was selected for inclusion as the urbanization variable.

Because of the limited number of streamgages available in HR3, the criteria that had been initially set for including rural streamgages in the analysis, which was based on the upper limit of the drainage area for the urban streamgages, was relaxed. The final regression analysis for HR3 included all rural streamgages that had been included in the Southeast rural flood-frequency investigation for which at least 90 percent of the drainage area was located in HR3. The DRNAREA for the largest urban watershed in HR3 was 5.67 mi^2. A WREG analysis was made with the upper limit of the rural basins set at 50 mi^2, and a second analysis was made using all the HR3 rural streamgages that had been included in the Southeast rural flood-frequency study and for which at least 90 percent of the DRNAREA was located in HR3 with the upper limit of the rural basins set at 459 mi^2. A comparison of the observed and predicted 1-percent AEP flows indicates that the results are relatively similar and that including the streamgages from the larger DRNAREA rural basins does not appreciably degrade the 1-percent AEP flow predictions for the smaller DRNAREA basins (fig. 10*A*).

Figure 10*B* shows a comparison of the predicted 1-percent AEP flow curves (1) using data from streamgages with DRNAREA less than 50 mi^2 and applying it with DEVNLCD06 of 7.2, which is the average for the rural HR3 streamgages, (2) using data from streamgages with DRNAREA less than 50 mi^2 and applying it with DEVNLCD06 of 98.5, which is the maximum value from the HR3 data, (3) using all HR3 streamgages and applying it with a DEVNLCD06 of 7.2, (4) using all HR3 streamgages and applying it with a DEVNLCD06 of 98.5, and (5) using the Southeast rural equation for HR3 (Feaster and others, 2009). This comparison shows that including the additional rural streamgages with DRNAREA greater than 50 mi^2 does not substantially alter the relation but does provide a broader range of applicability to the relation. It also shows that the regression analysis including both rural and urban streamgages when applied to sites that have rural characteristics (low DEVNLCD06) matches well with the Southeast rural regression relation for HR3, which was based on using only rural streamgages.

For the Coastal Plain (HR4), the explanatory variables included in the final regression equation were DRNAREA, IMPNLCD06, and 24-hour, 50-year maximum precipitation (I24H50Y). Because the actual rainfall intensity value associated with the storm systems causing the annual maximum peak flows varies, the I24H50Y is likely indicating a statistical difference in rainfall patterns across the large Coastal Plain region and not necessarily the actual rainfall variable itself (I24H50Y as opposed to the mean annual precipitation, 24-hour, 100-year maximum precipitation, and so on). For the 1-, 0.5-, and 0.2-percent AEP flows, IMPNLCD06 was not statistically significant at the 0.05 significance level. However, because the regression coefficient for IMPNLCD06 was positive and to maintain consistency between the P-percent AEP flows for HR4, IMPNLCD06 was retained in the 1-, 0.5-, and 0.2-percent AEP flow regression equations.

As noted earlier, various residual plots were generated and reviewed to make sure the regression models reasonably adhered to the assumptions of linear regression (Helsel and Hirsch, 1992). For each hydrologic region, the residuals for the 1-percent and 10-percent AEP predicted flows were plotted against the predicted flows and against each independent variable. The streamgages included in the plots also were distinguished between urban and rural streamgages to assess that no overall bias existed for either type of station. For all of the hydrologic regions, the plots indicated a reasonable variance and distribution of the residuals (fig. 11). The residuals are computed as follows:

$$residual = measured \log Q_{P\%} - estimated \log Q_{P\%} \tag{4}$$

where $Q_{P\%}$ is as previously defined. Consequently, a negative residual indicates that the regression estimate is greater than the observed value, and a positive residual indicates that the regression estimate is less than the observed value.

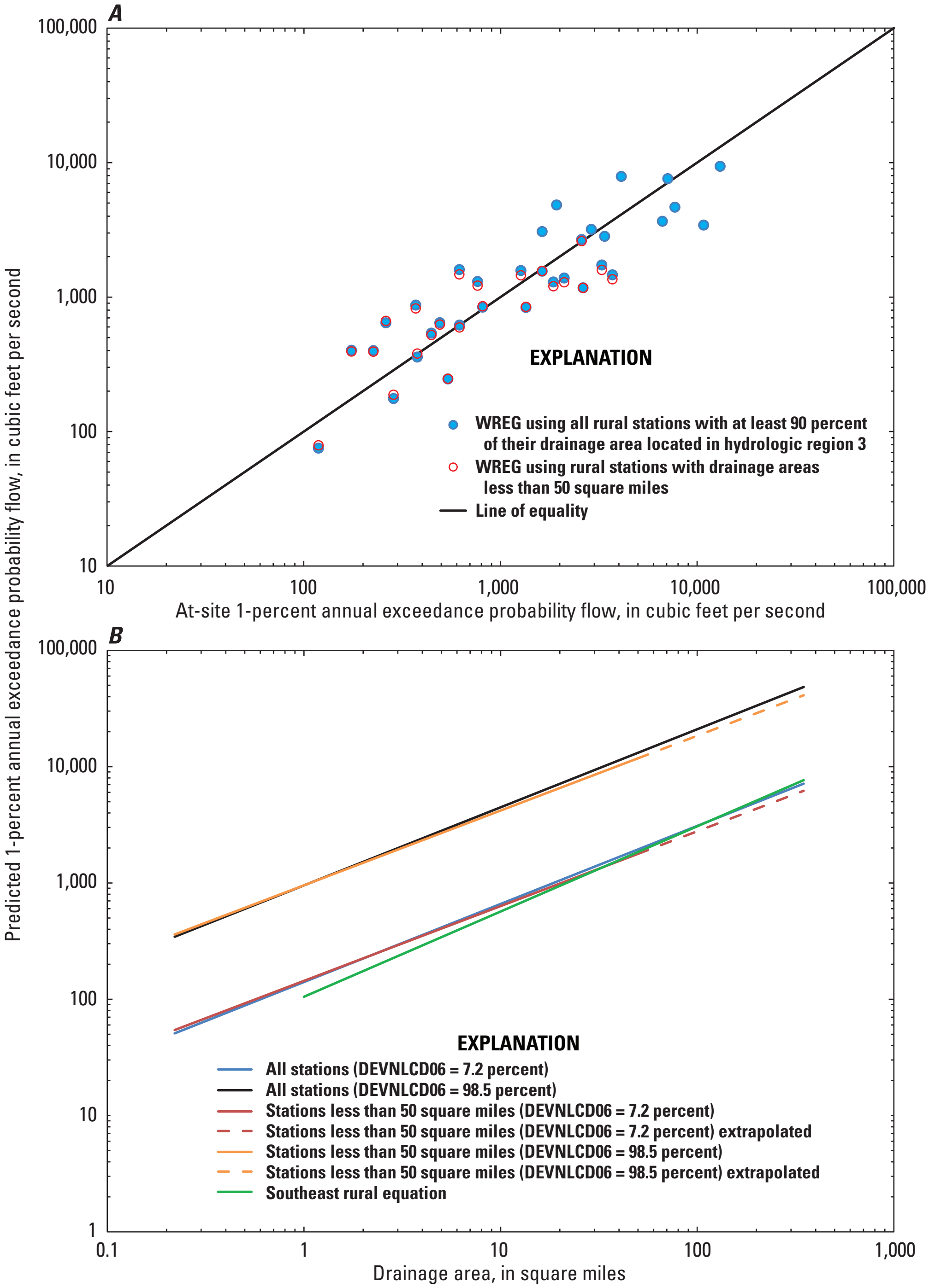


Figure 10. (*A*) Predicted and at-site 1-percent annual exceedance probability flow, in cubic feet per second, from WREG regression analyses using (1) all urban basins located in hydrologic region (HR) 3 and rural basins in HR3 with drainage areas of 50 square miles (mi^2) or less and (2) all urban basins located in HR3 and rural basins with at least 90 percent of the drainage area located in HR3, and (*B*) HR3 regression curves based on (1) streamgages with drainage areas less than 50 mi^2 and applying a percentage of developed land of 7.2 and 98.5, which is the average from the rural streamgages and the maximum of all HR3 streamgages, respectively, (2) all available streamgages for which at least 90 percent of the drainage area is located in HR3 and applying it with a percentage of developed land of 7.2 and 98.5, respectively, and (3) the Southeast rural regression equation from Feaster and others (2009).

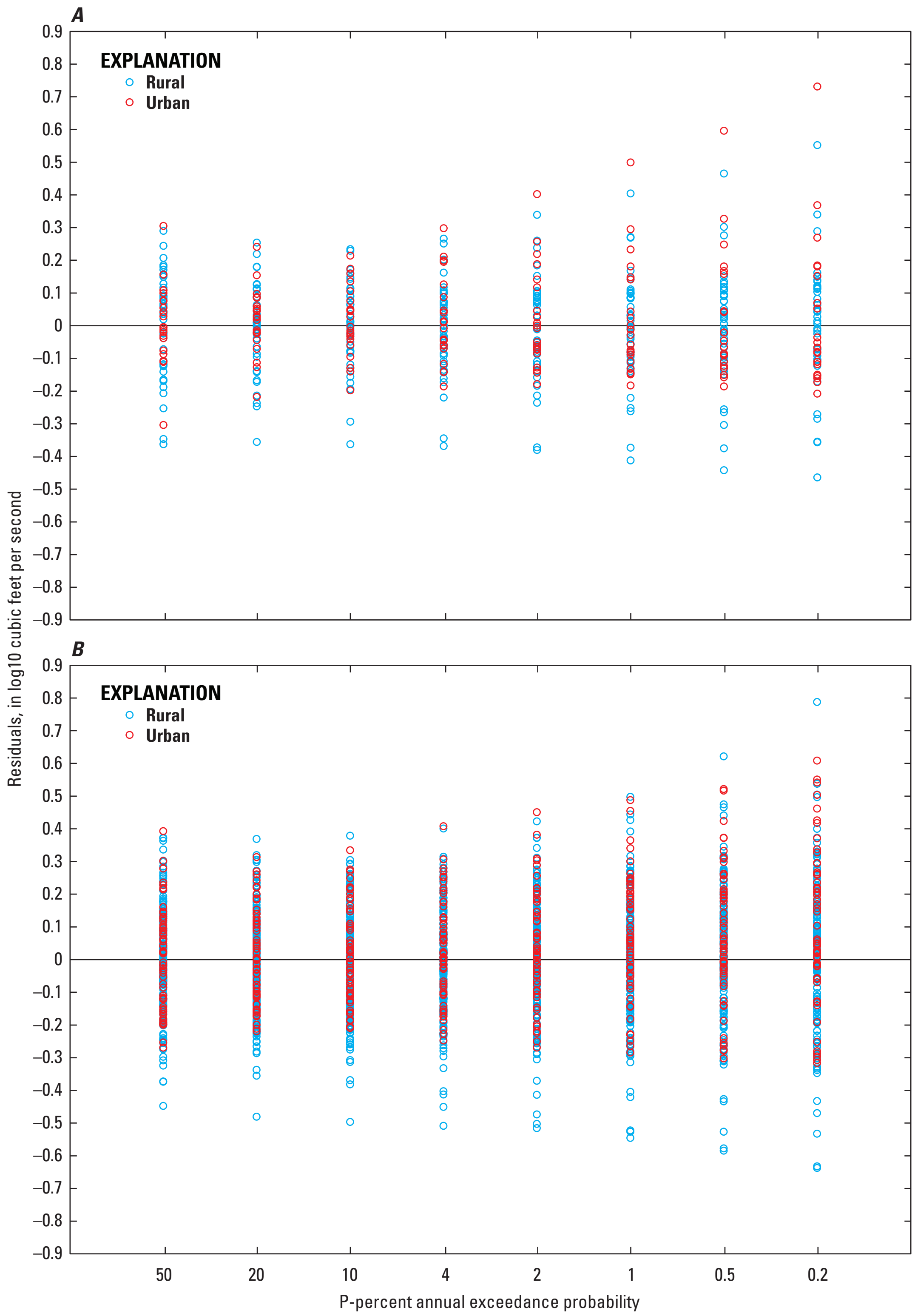


Figure 11. Residuals of generalized least squares (GLS) regional regression of 50- to 0.2-percent annual exceedance probability flows for (*A*) hydrologic regions (HR) 1 for drainage areas less than or equal to 3 square miles, (*B*) HR1 for drainage area greater than 3 square miles, (*C*) HR3, and (*D*) HR4.

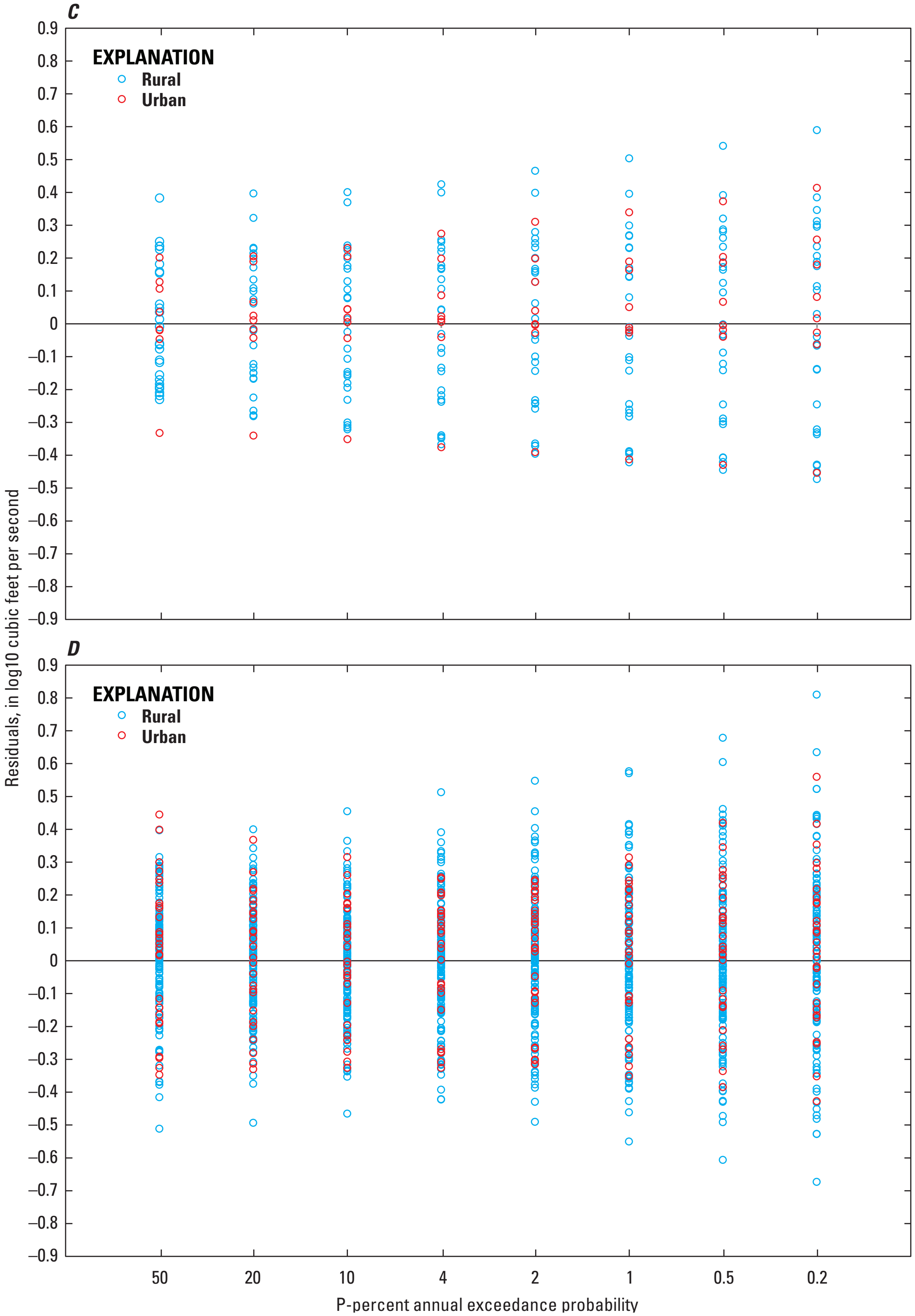


Figure 11. Residuals of generalized least squares (GLS) regional regression of 50- to 0.2-percent annual exceedance probability flows for (*A*) hydrologic regions (HR) 1 for drainage areas less than or equal to 3 square miles, (*B*) HR1 for drainage area greater than 3 square miles, (*C*) HR3, and (*D*) HR4.—Continued

Accuracy and Limitations

When applying regression equations, users are advised not to interpret the empirical results as exact. Regression equations are statistical models that must be interpreted and applied within the limits of the data and with the understanding that the results are best-fit estimates with an associated variance. For a set of data, the variance is the expected value of the squared deviations about the mean and represents the spread of the data (Bedient and others, 2008). For a regression model, the variance of prediction, $V_{p,i}$, can be thought of as a measure of the uncertainty of the regression model predictions. The $V_{p,i}$ can be calculated as

$$V_{p,i} = \gamma^2 + x_i U x_i' \qquad (5)$$

where

γ^2 is the model error variance;

x_i is a row vector of the explanatory variables for site *i*, augmented by 1 as the first element;

U is the covariance matrix for the regression coefficients; and

x_i' is the transpose of x_i (Ludwig and Tasker, 1993).

Assuming that the explanatory variables for the streamgages in a regression analysis are representative of all streamgages in the region, the average accuracy of prediction for a regression equation can be determined by computing the average variance of prediction, *AVP*, for *n* number of streamgages:

$$AVP = \gamma^2 + \left(\frac{1}{n}\right)\sum_{i=1}^{n} V_{p,i} \qquad (6)$$

The average variance of prediction also can be expressed in percent and, with this conversion, would be called the standard error of prediction, S_p. The standard error of prediction can be computed in percentage error using *AVP*, in log units, and the following transformation formula (Aitchison and Brown (1957); modified for use of the common logarithms)

$$S_{p,ave} = 100\left[10^{2.3026(AVP)} - 1\right]^{0.5} \qquad (7)$$

where

$S_{p,ave}$ is the average standard error of prediction, in percent, and

AVP is the average variance of prediction as previously defined.

The $S_{p,ave}$ is a measure of the average accuracy of the regression equations when predicting flood estimates for ungaged sites and is the most common application of the regression equations. About two-thirds of the regression estimates for ungaged sites will have errors less than the average standard error of prediction for the equations (Ries, 2007).

A measure of the proportion of the variation in the response variable explained by the explanatory variables in OLS regressions is the coefficient of determination, R^2 (Montgomery and others, 2001). For GLS regressions, a more appropriate performance metric than R^2 is R^2_{pseudo} described by Griffis and Stedinger (2007b). Unlike the R^2 metric, R^2_{pseudo} is based on the variability in the response variable explained by the regression after removing the effect of the time-sampling error. The R^2_{pseudo} is computed using the following formula:

$$R^2_{pseudo} = 1 - \frac{\gamma^2(k)}{\gamma^2(0)} \qquad (8)$$

where

$\gamma^2(k)$ is the model error variance from a GLS regression with *k* explanatory variables; and

$\gamma^2(0)$ is the model error variance from a GLS regression with no explanatory variables.

The average variance of prediction, average standard error of prediction, and R^2_{pseudo} for the final set of regional regression equations are given in table 9.

Figure 12 shows the number of streamgages used for each hydrologic region in the development of the equations for this study. Hydrologic regions 3 and 4 have a small number of streamgages that are located in urban areas. The small sample of urban streamgage data increases the uncertainties of flood estimates for these regions. Adding more streamgages in urban areas in these regions and continuing to collect data at the current streamgages would likely provide a better understanding of the effects of urbanization in the regions as well as provide more accurate flood-frequency estimates for urban streams within these regions.

Users of the regression models may be interested in a measure of uncertainty at a particular site as opposed to the uncertainty statistics based on station data used to generate the regression models. One such measure of uncertainty at a particular ungaged site is the confidence interval of a prediction, or prediction interval. Prediction interval is the minimum and maximum value between a stated probability for which the true value of the response variable exists. Tasker and Driver (1988) determined that a 100 (1-α) prediction interval for the true value of a streamflow statistic for an ungaged site from the regression equation can be computed as follows:

$$Q / C < Q < CQ \qquad (9)$$

where

Q is the streamflow characteristic for the ungaged site; and

C is computed as

$$C = 10^{t_{(\alpha/2,\, n\text{-}p)} S_{p,i}} \tag{10}$$

where

$t_{(\alpha/2,\, n\text{-}p)}$ is the critical value from the Student's *t*-distribution at a particular alpha-level (α) and degrees of freedom (*n-p*), where n is the number of observations included in the regression analysis for the particular hydrologic region (HR), and *p* is the number of regression variables including the intercept coefficient and is equal to 2.001, 2.000, 1.971, 2.040, 1.977, and 2.040 for HR1 for the 50-, 20-, 10-, 4-, 2-, 1-, and 0.5-percent AEP flows (drainage area less than 3 mi^2), HR1 for the 0.2-per cent AEP flow (drainage area less than 3 mi^2), HR1 (drainage area greater than 3 mi^2), HR3, HR4, and HR5, respectively, for a 95-percent prediction interval (α=0.05); and

$S_{p,i}$ is the standard error of prediction for site *i*, and is computed as

$$S_{p,i} = \left[\gamma^2 + \boldsymbol{x_i U x_i'}\right]^{0.5} \tag{11}$$

where

γ^2 is the model error variance;

$\boldsymbol{x}_i$ is a row vector of the explanatory variables for site *i*, augmented by 1 as the first element;

$\boldsymbol{U}$ is the covariance matrix for the regression coefficients; and

$\boldsymbol{x}_i'$ is the transpose of $\boldsymbol{x}_i$ (Ludwig and Tasker, 1993).

The values for γ^2 and ***U*** are presented in table 10.

The procedure necessary to obtain the prediction intervals for P-percent annual exceedance flow estimates is explained in the following example computation of the 1-percent annual exceedance flow ($Q_{1\%}$) for a hypothetical ungaged site on Unnamed Creek near Unnamed City, South Carolina, located in HR 1:

1. Obtain the drainage area and percentage of impervious area for the ungaged site (*DRNAREA* = 0.50 mi^2, *IMPNLCD06* = 30.0 percent);
2. Compute $Q_{1\%}$ using the equation in table 7. for hydrologic region 1 ($Q_{1\%} = 753*(0.50)^{0.8038}10^{(0.0024*30.0)} = 509$ ft^3/s);
3. Determine the ***xi*** vector (***xi*** = {1, $\log_{10}(0.50)$, 30.0});
4. Compute the standard error of prediction using equation 10 with γ^2 and ***U*** for the 1-percent annual exceedance flow from table 10; $S_{p,i}=(0.017+0.001447)^{0.5}=$ 0.1358,
5. Compute C using equation 9;C=10($^{2.001*0.1358}$)=1.8695,
6. Compute the 95-percent prediction interval using equation 8; (509/1.8695)<$Q_{1\%}$< (509*1.8695) , or, 272<$Q_{1\%}$<952.

The example may not be clear to readers unfamiliar with the matrix algebra computations necessary for solution. To aid users who wish to compute the 95-percent prediction intervals at an ungaged site, a spreadsheet program has been developed and posted at *http://pubs.usgs.gov/sir/2014/5030/*. Instructions for application of the program are provided within the spreadsheet.

Limitations for Applying the Regional Regression Equations

The following limitations need to be recognized when applying the final regional regression equations:

1. The ranges of explanatory variables used to develop the urban and small, rural regional regression equations are listed in table 11. Applying the equations to sites on streams having explanatory variables outside the range of those used in this study may result in prediction errors that are considerably greater than those suggested by the standard error of prediction percentages listed in table 9. In general, if the impervious area is less than 10 percent and the drainage area is 1 mi^2 or greater, then the Southeast rural flood-frequency equations should be used (Feaster and others, 2009; Gotvald and others, 2009; or Weaver and others, 2009).
2. For the equations that were developed using percentage of impervious area from NLCD 2006 or NLCD 2001 (HR1 and HR4), the percentage of impervious area for an ungaged site should be obtained from NLCD 2006. The equations should not be used with percentage of impervious area calculated using NLCD 1992 or other methods, such as the method documented in Cochran (1963). However, future iterations of NLCD that use methods consistent with the NLCD 2001 and 2006 methods can be used to compute the percentage of impervious area for use in the equations for this study.
3. The methods are not appropriate (or applicable) for sites where the peak-flow magnitudes are affected substantially by regulation from impoundments, channelization, levees, or other manmade structures.
4. The methods do not apply where flooding is influenced by extreme ocean storm surge or tidal events.
5. The methods are not applicable to urban streams in the Blue Ridge region (HR2) due to the lack of streamgages with sufficient measured data that could be included in a regres-

sion analysis. The Blue Ridge region occupies approximately 3 percent of Georgia, 2 percent of South Carolina (Wachob and others, 2009), and 16 percent of North Carolina, and does include some urban areas. Given the high degree of basin and channel slopes in Blue Ridge streams combined with low soil depths overlaying metaphoric rocks, the influence of urbanization may not be as substantial in the Blue Ridge region as compared to the other hydrologic regions in the Southeast United States. However, no formal study can be sited to confirm or refute that hypothesis. As noted in the Previous Studies section, Robbins and Pope (1996) used concurrent records of rainfall and runoff data collected in small, urban basins in North Carolina to calibrate rainfall-runoff models. Historic rainfall records were then used with the calibrated models to synthesize long-term records of annual peak flow that were subsequently used for determining the flood-frequency distributions and corresponding statistics. That study combined urban data from the Blue Ridge and Piedmont regions and generated flood-frequency equations that could be used to estimate flood flows in urban streams as a function of drainage area, percentage impervious area, and the rural equivalent peak flow. On the basis of the equations by Robbins and Pope (1996), Mason and others (2002) provided a modified equation for urban streams in the Blue Ridge and Piedmont region of North Carolina that is a function of drainage area and percentage impervious area. On the basis of the consistency of flood-frequency characteristics for rural streams in the Blue Ridge region of Georgia, North Carolina, and South Carolina as demonstrated by Gotvald and others (2009), Weaver and others (2009), and Feaster and others (2009) and until such time that sufficient data are collected to generate a set of urban equations for the Blue Ridge region based on measured annual peak-flow data, it seems reasonable that the urban equations for the Blue Ridge region as presented by Mason and others (2002) could also be applied to urban streams in the Blue Ridge of Georgia and South Carolina. A comparison of the Southeast urban and small, rural regression curves for the Piedmont (HR1) and the North Carolina urban Blue Ridge–Piedmont regression curves as presented by Mason and others (2002) are shown in figure 13*A* and *B* for the 10- and 1-percent AEP flows, respectively. The range of the drainage area and percentage of impervious area (IA) used to generate figure 13 was based on the coincident data from the referenced studies.

Comparison with Southeast Rural Flood-Frequency Equations

The Southeast rural flood-frequency equations were developed from a database that included 828 streamgages from rural basins in Alabama, Florida, Georgia, South Carolina, North Carolina, Tennessee, and Virginia (Feaster and others, 2009; Gotvald and others, 2009; Weaver and others, 2009). The explanatory variables in the regression analysis included DRNAREA and the percentage of the basin in hydrologic regions 1, 2, 3, 4, and 5 (fig. 2). The DRNAREA sizes included in the Southeast rural flood-frequency study ranged from 1 to 9,000 mi^2. As noted earlier, a subset of those rural streamgages (336) was included in the current investigation. Consequently, it would not be expected that the current equations for the urban and small, rural streams when applied under “rural” conditions would exactly match the results from the Southeast rural flood frequency study but the differences would be expected to be within reason.

Graphical comparisons of the 10- and 1-percent AEP regional regression equations developed in this investigation for urban and small, rural basins with the regression equations developed in the Southeast rural flood-frequency (Feaster and others, 2009; Gotvald and others, 2009; Weaver and others, 2009) are presented in this section. For HR1, the urban and small, rural regression equations were applied under rural conditions by setting the IMPNCLD06 to 2 percent, which is the average IMPNCLD06 for the rural basins included in the regression analysis for the urban and small, rural basins. As shown in figure 14, given the uncertainty in both sets of equations, the difference of the number of streamgages included in the two analyses, and the difference in the ranges of DRNAREA included in the regression analyses, the regional regression curves match very well. The observed data are those that were included in the regression analysis for the urban and small, rural streamgages.

For HR3, the urban and small, rural regression equations were applied under rural conditions by setting the DEVNCLD06 to 7.2 percent, which is the average DEVNCLD06 for the rural basins included in the regression analysis for the urban and small, rural basins. The comparison between the regional regression curves shows slightly different slopes but reasonably similar results (fig. 15). Hydraulic region 3 has the least number of streamgages, has the largest standard error of prediction, and as the observed data denote, flows that indicate more sensitivity to urbanization. As noted earlier, this sensitivity is reasonable given the soil conditions in the Sand Hills (HR3) region. For example, increased runoff from paving over sand would be expected to be greater than the increased runoff from paving over the clayey soils of the Piedmont.

For HR4, the urban and small, rural regression equations were applied under rural conditions by setting the IMPNLCD06 to 1 percent and the I24H50Y to 8.2 inches, which are the average IMPNCLD06 and I24H50Y, respectively, for the rural basins included in the regression analysis for the urban and small, rural basins. As shown in figure 16, the results from the two regression curves show little difference throughout most of the range of concurrent DRNAREA.

For HR5, the regional regression curves published in Gotvald and Knaak (2011) and Gotvald and others (2009) are compared. The observed data are not shown because the regression curves for HR5 were not updated in this report. For the range of concurrent DRNAREA for the 10-percent AEP flows, the two curves are parallel with the curve for the urban and small, rural analysis by Gotvald and Knaak (2011) having a slightly higher intercept (fig. 17*A*). For the 1-percent AEP flows, the curves overlap for the concurrent range of DRNAREA (fig. 17*B*). This indicates that the streamgages with DRNAREA less than 1 mi^2 are showing slightly more runoff for the higher AEP flows (more frequent events) but for the lower AEP flows (less frequent events), the runoff characteristics for streamgages with DRNAREA less than 1 mi^2 are the same as

Table 9. Average variance of prediction, average standard error of prediction, and pseudo coefficient of determination for the urban and small, rural regional regression equations.

[mi^2, square miles; AVP, average variance of prediction; SEp, ave, average standard error of prediction; R^2pseudo, pseudo coefficient of determination]

Percent annual exceedance probability	Hydrologic Region (shown in fig. 2)														
	1						3			4			†5		
	0.10 mi^2 <DRNAREA <3 mi^2			3 mi^2<DRNAREA <436 mi^2			0.22 mi^2 <DRNAREA <459 mi^2			0.10 mi^2 <DRNAREA <53.5 mi^2			0.20 mi^2 <DRNAREA <10 mi^2		
	AVP (log units)	$SE_{p, ave}$ (percent)	R^2_{pseudo} (percent)	AVP (log units)	$SE_{p, ave}$ (percent)	R^2_{pseudo} (percent)	AVP (log units)	$SE_{p, ave}$ (percent)	R^2_{pseudo} (percent)	AVP (log units)	$SE_{p, ave}$ (percent)	R^2_{pseudo} (percent)	AVP (log units)	$SE_{p, ave}$ (percent)	R^2_{pseudo} (percent)
50	0.018	31.9	84.3	0.021	34.4	83.2	0.031	42.5	90.9	0.029	40.8	82.4	0.030	41.8	91.9
20	0.012	25.4	89.1	0.018	31.4	84.6	0.039	47.6	88.7	0.024	36.9	85.3	0.021	34.2	95.3
10	0.011	25.0	89.4	0.017	30.7	84.7	0.044	51.2	87.2	0.024	36.7	85.8	0.020	33.9	95.8
4	0.013	27.0	88.3	0.018	31.4	83.6	0.051	56.0	85.1	0.026	38.2	85.4	0.022	35.6	95.8
2	0.016	29.3	86.8	0.019	32.4	82.3	0.058	59.7	83.6	0.028	40.2	84.6	0.025	37.8	95.6
1	0.019	32.1	85.1	0.021	34.2	80.4	0.064	63.5	82.0	0.032	42.7	83.5	0.029	41.0	95.1
0.5	0.022	35.1	83.4	0.023	35.8	78.7	0.071	67.4	80.4	0.035	45.4	82.5	0.034	44.1	94.6
0.2	0.025	37.5	81.7	0.026	38.7	75.9	0.081	73.3	78.1	0.042	49.9	80.4	0.041	49.5	93.6

†From Gotvald and Knaak, 2009.

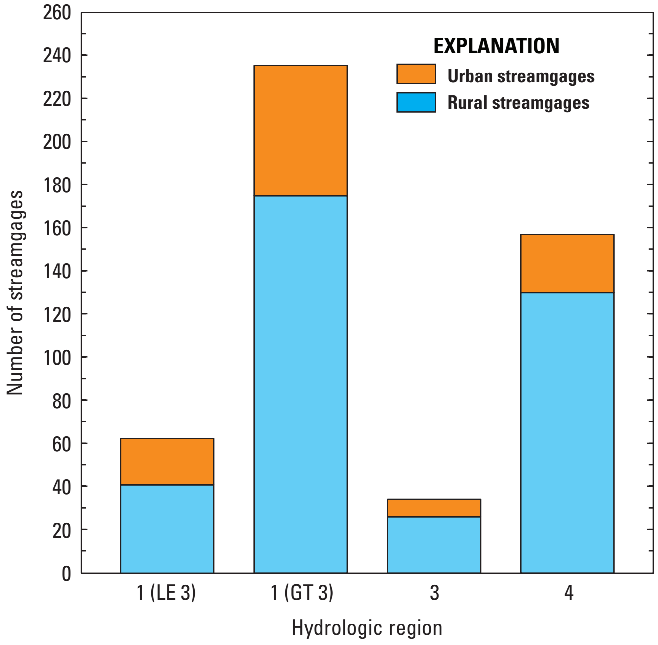


Figure 12. Number of rural and urban streamgages in each hydrologic region that were used in the development of the regional regression equations where 1 (LE 3) represents streamgages from hydrologic region 1 that have drainage areas less than or equal to 3 square miles and 1 (GT 3) represents streamgages from hydrologic region 1 that have drainage areas greater than 3 square miles.

Table 10. Values needed to determine prediction intervals for the regression equations.

[mi^2, square miles; DRNAREA, drainage area, mi^2; γ^2, the regression model error variance used in equation 10; *U*, the covariance matrix used in equation 10]

Percent annual exceedance probability	Hydrologic Region (shown in fig. 2)											
	1								3			
	0.10 mi^2 <DRNAREA <3 mi^2				3 mi^2<DRNAREA <436 mi^2				0.22 mi^2 <DRNAREA <459 mi^2			
	γ^2	***U***			γ^2	***U***			γ^2	***U***		
50	0.017	9.23E-04	1.87E-04	–3.35E-05	0.020	1.51E-03	–6.19E-04	–1.79E-05	0.028	5.29E-03	–2.31E-03	–6.07E-05
		1.87E-04	2.15E-03	3.87E-06		–6.19E-04	3.58E-04	3.53E-06		–2.31E-03	1.46E-03	2.46E-05
		–3.35E-05	3.87E-06	2.93E-06		–1.79E-05	3.53E-06	1.31E-06		–6.07E-05	2.46E-05	1.20E-06
20	0.011	7.87E-04	1.56E-04	–2.73E-05	0.017	1.49E-03	–5.90E-04	–1.69E-05	0.035	6.62E-03	–2.89E-03	–7.57E-05
		1.56E-04	1.54E-03	2.23E-06		–5.90E-04	3.33E-04	3.39E-06		–2.89E-03	1.82E-03	3.06E-05
		–2.73E-05	2.23E-06	2.20E-06		–1.69E-05	3.39E-06	1.27E-06		–7.57E-05	3.06E-05	1.50E-06
10	0.010	8.54E-04	1.71E-04	–2.94E-05	0.016	1.59E-03	–6.19E-04	–1.78E-05	0.040	7.74E-03	–3.37E-03	–8.82E-05
		1.71E-04	1.62E-03	2.18E-06		–6.19E-04	3.45E-04	3.54E-06		–3.37E-03	2.11E-03	3.55E-05
		–2.94E-05	2.18E-06	2.32E-06		–1.78E-05	3.54E-06	1.35E-06		–8.82E-05	3.55E-05	1.74E-06
4	0.012	1.03E-03	2.09E-04	–3.57E-05	0.017	1.81E-03	–7.03E-04	–2.02E-05	0.046	9.36E-03	–4.06E-03	–1.06E-04
		2.09E-04	1.98E-03	2.86E-06		–7.03E-04	3.89E-04	4.02E-06		–4.06E-03	2.54E-03	4.26E-05
		–3.57E-05	2.86E-06	2.80E-06		–2.02E-05	4.02E-06	1.56E-06		–1.06E-04	4.26E-05	2.09E-06
2	0.014	1.20E-03	2.47E-04	–4.19E-05	0.018	2.02E-03	–7.85E-04	–2.26E-05	0.052	1.07E-02	–4.62E-03	–1.21E-04
		2.47E-04	2.36E-03	3.78E-06		–7.85E-04	4.33E-04	4.49E-06		–4.62E-03	2.89E-03	4.83E-05
		–4.19E-05	3.78E-06	3.31E-06		–2.26E-05	4.49E-06	1.75E-06		–1.21E-04	4.83E-05	2.37E-06
1	0.017	1.40E-03	2.90E-04	–4.91E-05	0.020	2.28E-03	–8.90E-04	–2.56E-05	0.057	1.20E-02	–5.21E-03	–1.36E-04
		2.90E-04	2.81E-03	4.96E-06		–8.90E-04	4.91E-04	5.10E-06		–5.21E-03	3.25E-03	5.42E-05
		–4.91E-05	4.96E-06	3.91E-06		–2.56E-05	5.10E-06	1.99E-06		–1.36E-04	5.42E-05	2.66E-06
0.5	0.020	1.61E-03	3.37E-04	–5.69E-05	0.022	2.53E-03	–9.94E-04	–2.86E-05	0.064	1.35E-02	–5.83E-03	–1.51E-04
		3.37E-04	3.31E-03	6.44E-06		–9.94E-04	5.48E-04	5.72E-06		–5.83E-03	3.63E-03	6.04E-05
		–5.69E-05	6.44E-06	4.57E-06		–2.86E-05	5.72E-06	2.23E-06		–1.51E-04	6.04E-05	2.98E-06
0.2	0.023	1.06E-03	5.13E-04		0.025	2.93E-03	–1.16E-03	–3.33E-05	0.073	1.56E-02	–6.75E-03	–1.75E-04
		5.13E-04	3.99E-03			–1.16E-03	6.40E-04	6.71E-06		–6.75E-03	4.20E-03	6.97E-05
						–3.33E-05	6.71E-06	2.60E-06		–1.75E-04	6.97E-05	3.44E-06

Table 10. Values needed to determine prediction intervals for the regression equations. —Continued

[mi^2, square miles; DRNAREA, drainage area, mi^2; γ^2, the regression model error variance used in equation 10; *U*, the covariance matrix used in equation 10]

Percent annual exceedance probability	Hydrologic Region (shown in fig. 2)							
	4					†5		
	0.10 mi^2 <DRNAREA <53.5 mi^2					0.20 mi^2 <DRNAREA <10 mi^2		
	γ^2	*U*				γ^2	*U*	
50	0.028	2.86E-02	–9.45E-04	–1.18E-04	–3.34E-03	0.0277	2.62E-03	–8.95E-04
		–9.45E-04	5.36E-04	1.42E-05	5.76E-05		–8.95E-04	8.46E-04
		–1.18E-04	1.42E-05	4.48E-06	9.08E-06			
		–3.34E-03	5.76E-05	9.08E-06	4.07E-04			
20	0.023	2.71E-02	–8.22E-04	–1.03E-04	–3.17E-03	0.0184	2.49E-03	–7.02E-04
		–8.22E-04	4.73E-04	1.26E-05	5.08E-05		–7.02E-04	6.46E-04
		–1.03E-04	1.26E-05	4.05E-06	7.52E-06			
		–3.17E-03	5.08E-05	7.52E-06	3.89E-04			
10	0.022	2.98E-02	–8.49E-04	–1.07E-04	–3.50E-03	0.0177	2.89E-03	–7.77E-04
		–8.49E-04	4.96E-04	1.33E-05	5.25E-05		–7.77E-04	6.95E-04
		–1.07E-04	1.33E-05	4.29E-06	7.68E-06			
		–3.50E-03	5.25E-05	7.68E-06	4.29E-04			
4	0.024	3.54E-02	–9.50E-04	–1.21E-04	–4.17E-03	0.0191	3.57E-03	–9.49E-04
		–9.50E-04	5.66E-04	1.53E-05	5.84E-05		–9.49E-04	8.36E-04
		–1.21E-04	1.53E-05	4.93E-06	8.59E-06			
		–4.17E-03	5.84E-05	8.59E-06	5.12E-04			
2	0.026	4.08E-02	–1.06E-03	–1.37E-04	–4.80E-03	0.0212	4.17E-03	–1.12E-03
		–1.06E-03	6.41E-04	1.74E-05	6.49E-05		–1.12E-03	9.77E-04
		–1.37E-04	1.74E-05	5.58E-06	9.67E-06			
		–4.80E-03	6.49E-05	9.67E-06	5.90E-04			
1	0.029	4.68E-02	–1.20E-03	–1.55E-04	–5.52E-03	0.0246	4.90E-03	–1.33E-03
		–1.20E-03	7.31E-04	1.99E-05	7.26E-05		–1.33E-03	1.16E-03
		–1.55E-04	1.99E-05	6.36E-06	1.09E-05			
		–5.52E-03	7.26E-05	1.09E-05	6.78E-04			
0.5	0.033	5.32E-02	–1.34E-03	–1.74E-04	–6.28E-03	0.0281	5.65E-03	–1.56E-03
		–1.34E-03	8.27E-04	2.26E-05	8.08E-05		–1.56E-03	1.35E-03
		–1.74E-04	2.26E-05	7.19E-06	1.23E-05			
		–6.28E-03	8.08E-05	1.23E-05	7.71E-04			
0.2	0.039	6.31E-02	–1.58E-03	–2.06E-04	–7.45E-03	0.0349	6.86E-03	–1.94E-03
		–1.58E-03	9.85E-04	2.70E-05	9.44E-05		–1.94E-03	1.67E-03
		–2.06E-04	2.70E-05	8.53E-06	1.46E-05			
		–7.45E-03	9.44E-05	1.46E-05	9.14E-04			

†From Gotvald and Knaak, 2011.

Table 11. Range of explanatory variables used to develop regression equations for urban and small, rural streams.

[Values in parentheses are for the urban streamgages only; --, not applicable; mi^2, square miles]

Basin characteristics	Hydrologic Region (shown in fig. 2)							
	1		3		4		†5	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Drainage area (mi^2)	0.10 (0.10)	436 (378)	0.14 (0.22)	459 (5.67)	0.10 (0.10)	53.5 (43.9)	0.2	10.0
Percent of impervious area	0.0 (12.5)	47.9 (47.9)	--	--	0.02 (10.8)	34.8 (34.8)	0.0	36.0
Percent of developed land	--	--	2.8 (67.0)	98.5 (98.5)	--	--	--	--
24-hour, 50-year maximum precipitation	--	--	--	--	6.51 (6.51)	10.9 (10.9)	--	

†From Gotvald and Knaak, 2009.

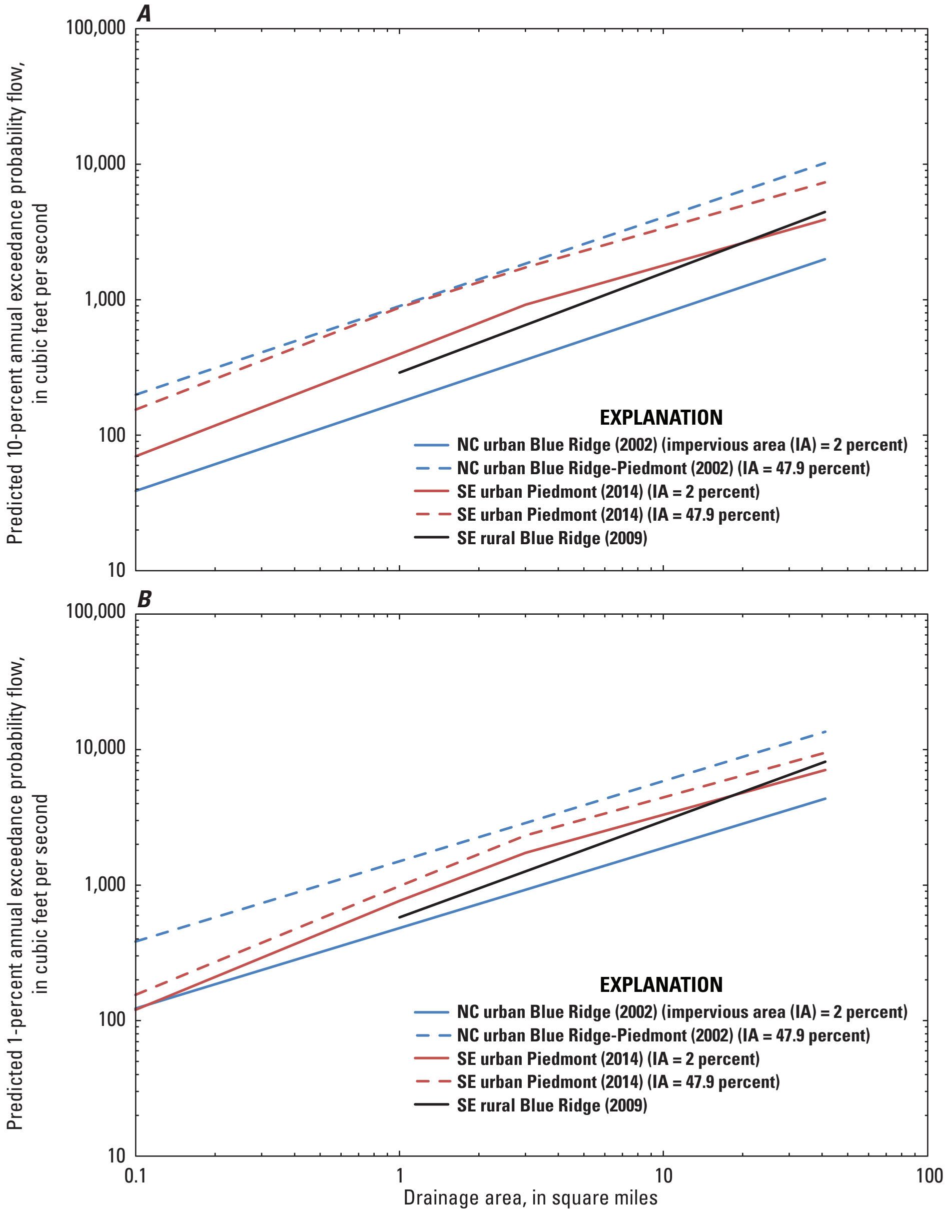


Figure 13. North Carolina urban flood-frequency curve for the Blue Ridge-Piedmont region (Mason and others, 2002), Southeast urban flood-frequency curve for the Piedmont region from this investigation, and Southeast rural flood-frequency curve for the Blue Ridge region (Feaster and others, 2009; Gotvald and others, 2009; Weaver and others, 2009) for the (*A*) 10- and (*B*) 1-percent annual exceedance probability flows in cubic feet per second.

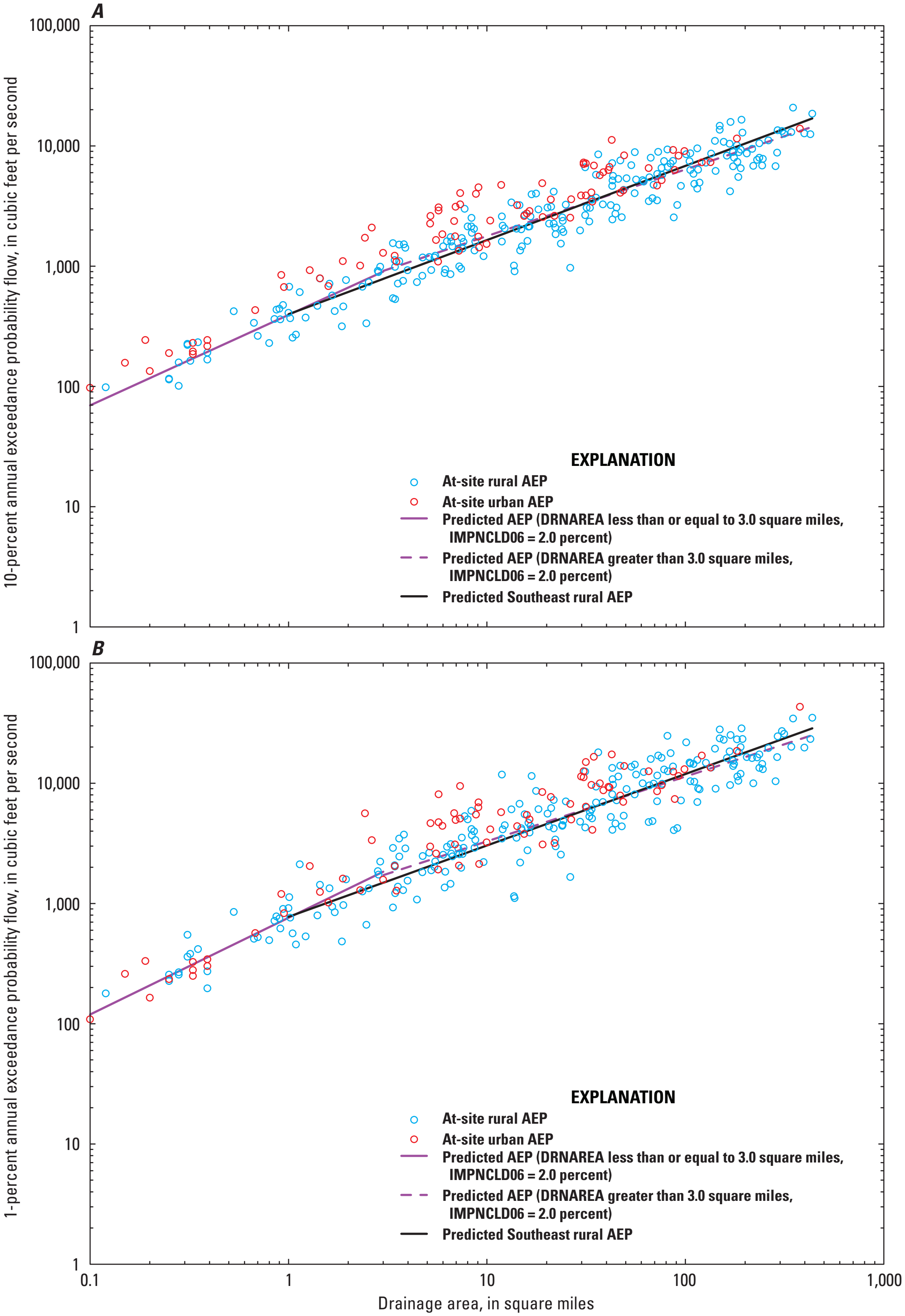


Figure 14. Southeast rural flood-frequency equations (Feaster and others, 2009; Gotvald and others, 2009; Weaver and others, 2009) with the urban and small, rural flood-frequency equations in hydrologic region 1 for the (*A*) 10-percent annual exceedance probability (AEP) flow, and (*B*) 1-percent AEP, in cubic feet per second.

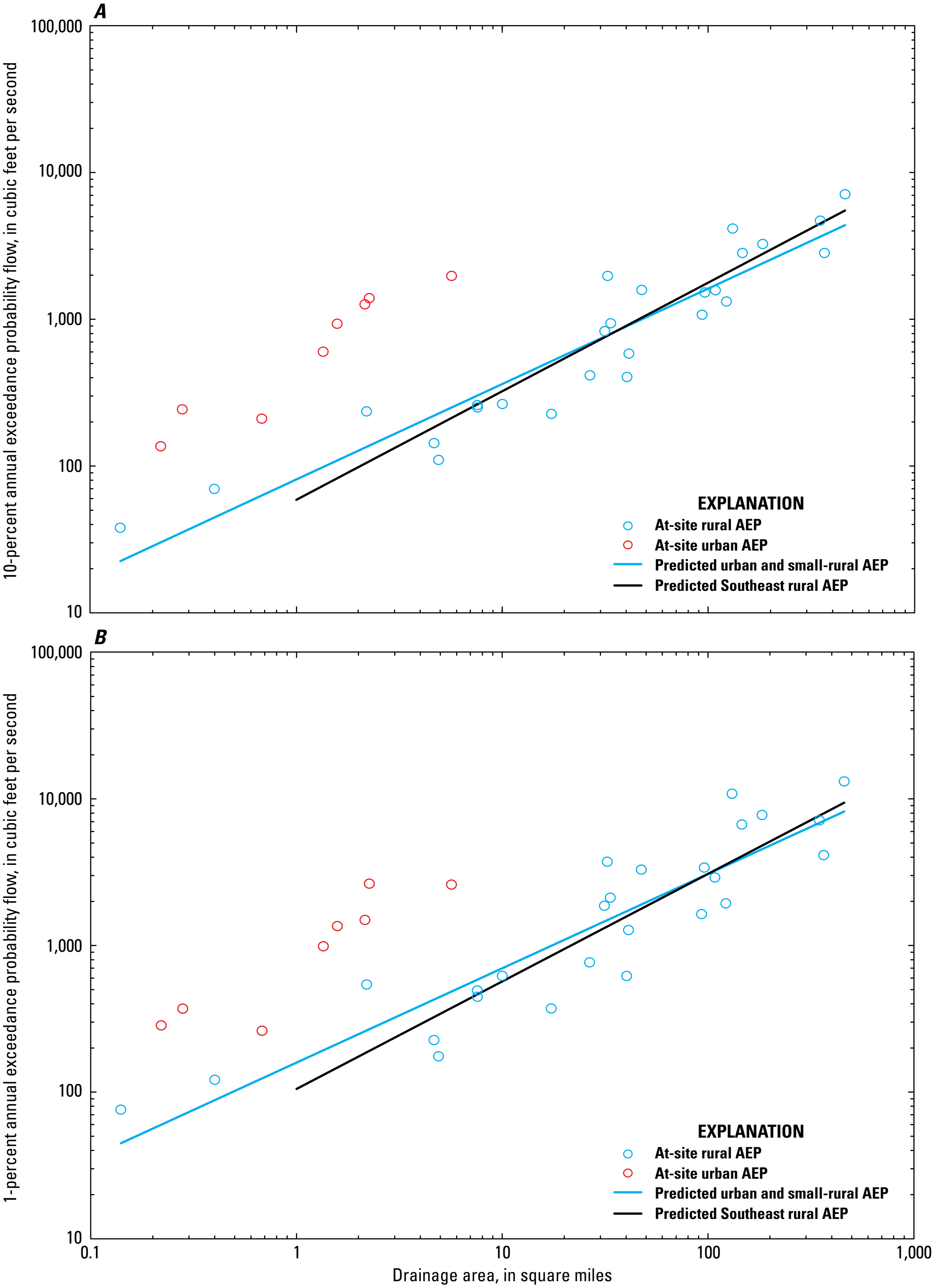


Figure 15. Southeast rural flood-frequency equations (Feaster and others, 2009; Gotvald and others, 2009; Weaver and others, 2009) with the urban and small, rural flood-frequency equations in hydrologic region 3 for the (*A*) 10-percent annual exceedance probability (AEP) flow, and (*B*) 1-percent AEP, in cubic feet per second.

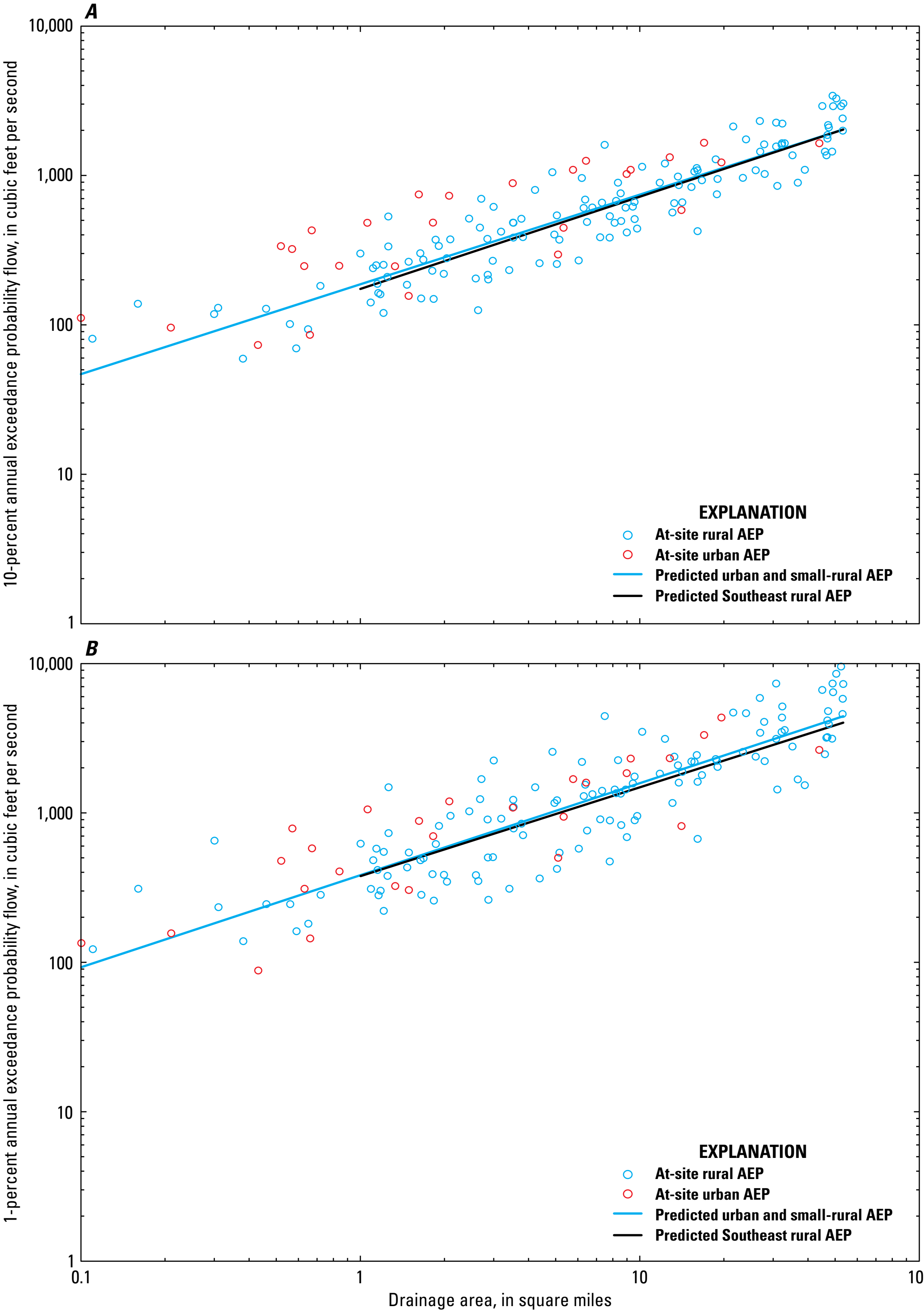


Figure 16. Southeast rural flood-frequency equations (Feaster and others, 2009; Gotvald and others, 2009; Weaver and others, 2009) with the urban and small, rural flood-frequency equations in hydrologic region 4 for the (*A*) 10-percent annual exceedance probability (AEP) flow, and (*B*) 1-percent AEP, in cubic feet per second.

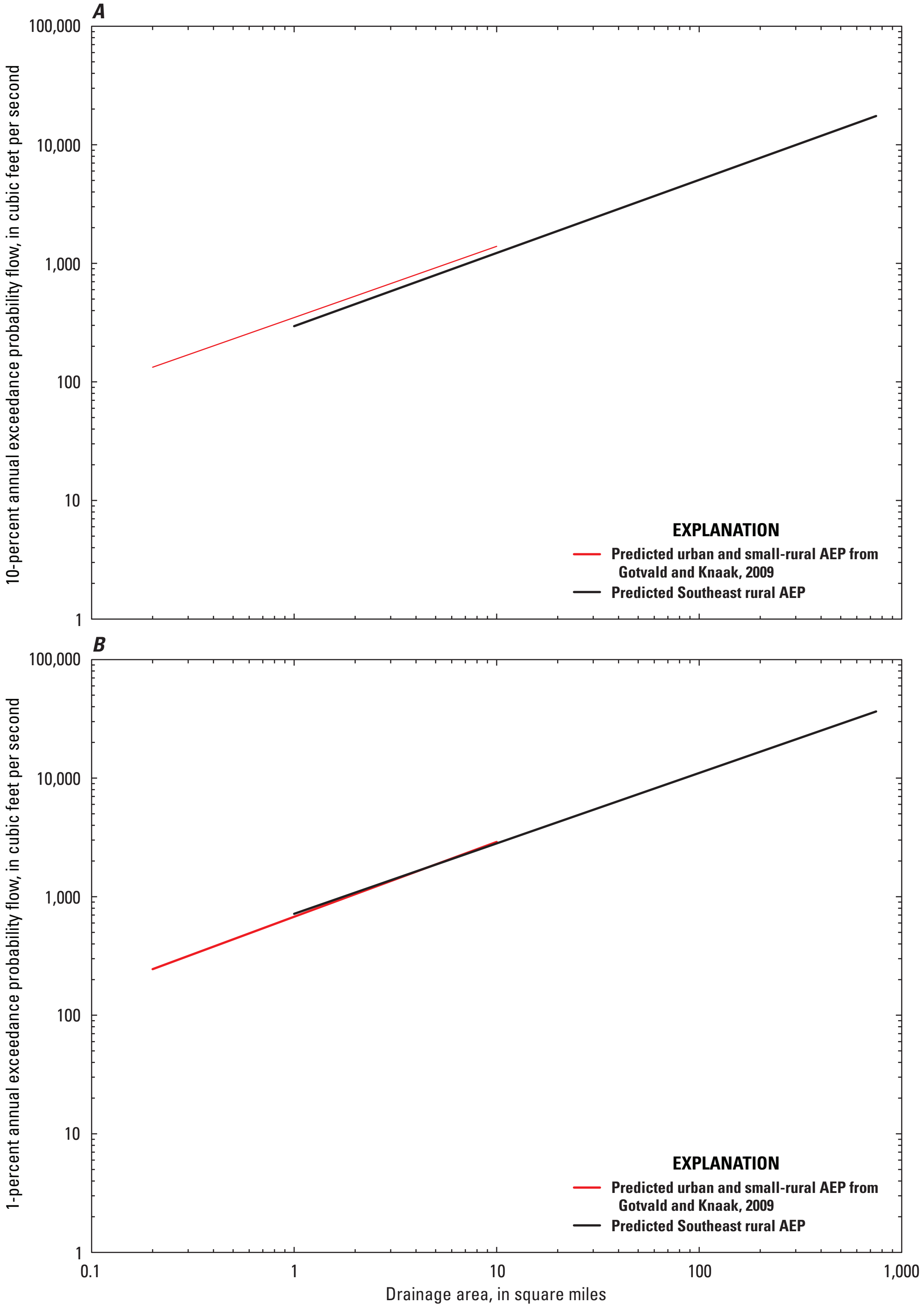


Figure 17. Southeast rural flood-frequency equations (Feaster and others, 2009; Gotvald and others, 2009; Weaver and others, 2009) with the urban and small, rural flood-frequency equations in hydrologic region 5 (Gotvald and Knaak, 2011) for the (*A*) 10-percent annual exceedance probability (AEP) flow, and (*B*) 1-percent AEP, in cubic feet per second.

for the larger DRNAREA basins. Nonetheless, the difference in the 10-percent AEP flows between the two curves is well within the uncertainty of the accuracy statistics for the two regressions.

Application of Methods

The best estimates of flood frequencies for a site typically are obtained from weighted estimates produced by combining estimates from more than one method. Tasker (1975) demonstrated that if two independent estimates of a streamflow statistic are available, a properly weighted average of the independent estimates will provide an estimate that is more accurate than either of the independent estimates. Historically, USGS urban flood-frequency reports have not included this weighting procedure because the peak-flow estimates were based on rainfall-runoff models and (or) the urban regional regression equations were based on a small number of clustered streamgages. Because this study does not include peak flows from rainfall-runoff models, covers a large geographical area that includes both rural and urban streamgages, and includes a variety of record lengths at those streamgages, weighting of the P-percent AEP streamflow estimates was considered appropriate. Improved flood-frequency estimates can be determined for the urban and small, rural streamgages by weighting estimates determined from the Bulletin 17B analysis with estimates obtained from the regression equations provided in this report. Improved estimates also can be determined for ungaged sites on the same stream by weighting the estimates obtained from the regression equations with estimates that were determined on the basis of the flow of an upstream or downstream gaged station. The following sections describe the weighting process for gaged and ungaged sites in more detail and provide example calculations. The results are rounded to three significant figures.

Estimation for a Gaged Station

The Interagency Advisory Committee on Water Data (1982) recommends combining (weighting) the streamgaging flow estimate determined from the log-Pearson Type III analysis of the annual peak flows with the flow estimate obtained for the station from regression equations to obtain a better estimate of flood-frequency statistics for a gaged station. Optimal weighted flow estimates can be obtained if the variance of prediction for each of the two estimates is known or can be estimated accurately. The variance of prediction can be thought of as a measure of the uncertainty in either the streamgage flow estimate or the regional regression results. If the two estimates are assumed to be independent and are weighted in inverse proportion to the associated variances, the variance of the weighted estimate will be less than the variance of either of the independent estimates.

The variance of prediction corresponding to the streamgage flow estimate from the log-Pearson Type III analysis is computed by using the asymptotic formula given in Cohn and others (2001) with the addition of the mean-squared error of generalized skew (Griffis and others, 2004). The variance of prediction varies as a function of the length of record, the fitted log-Pearson Type III distribution parameters (mean, standard deviation, and weighted skew), and the accuracy of the method used to determine the generalized-skew component of the weighted skew. The variance of prediction for the streamgage estimate generally decreases with length of record and the quality of the log-Pearson Type III distribution fit. Subsequent to the publications by Cohn and others (2001) and Griffis and others (2004), additional enhancements to these uncertainty statistics have been incorporated into the USGS computer program PeakFQ version 7.0.29368 (Tim Cohn, U.S. Geological Survey, written commun., October 29, 2013).

The variance of prediction values for the streamflow estimates for the urban and small, rural streamgages included in this study are listed in table 12, p. 94. The variance of prediction from the regional regression equations is a function of the regression equations and the values of the explanatory variables used to develop the flow estimate from the regression equations. This variance generally increases as the values of the explanatory variables move further from the mean values of the explanatory variables. The average variance of prediction values for the regional regression equations used in the current study also are given in table 12.

Once the variances have been computed, the two independent flow estimates can be weighted using the following equation:

$$\log Q_{P(g)w} = \frac{V_{p,P(g)r} \log Q_{P(g)s} + V_{p,P(g)s} \log Q_{P(g)r}}{V_{p,P(g)s} + V_{p,P(g)r}} \quad (12)$$

where

$Q_{P(g)w}$ is the weighted estimate of peak flow for any P-percent chance exceedance for a gaged station, in cubic feet per second;

$V_{p,P\,(g)r}$ is the variance of prediction at the gaged station derived from the applicable regional regression equations for the selected P-percent chance exceedance (from table 9), in log units;

$Q_{P(g)s}$ is the estimate of peak flow at the gaged station from the log-Pearson Type III analysis for the selected P-percent chance exceedance, in cubic feet per second;

$V_{p,P(g)s}$ is the variance of prediction at the gaged station from the log-Pearson Type III analysis for the selected P-percent chance exceedance (from table 11), in log units; and

$Q_{P(g)r}$ is the peak-flow estimate for the P-percent chance exceedance at the gaged station derived from the applicable regional regression equations (table 7), in cubic feet per second.

The weighted (best) flow estimates were computed using equation 12 along with the variance of prediction values from table 12 for the urban and small, rural streamgages in Georgia, South Carolina, and North Carolina. The weighted flow estimates for the urban and small, rural streamgages included in this study are given in table 5.

When the variance of prediction corresponding to one of the estimates is high, the uncertainty is also high, and so the weight for that estimate is relatively small. Conversely, when the variance of prediction is low, the uncertainty is also low, and so the weight is correspondingly large. The variance of prediction associated with the weighted estimate, $V_{p,\,P\,(g)w}$, is computed using the following equation:

$$V_{p,P(g)w} = \frac{V_{p,P(g)s} V_{p,P(g)r}}{V_{p,P(g)s} + V_{p,P(g)r}} \qquad (13)$$

The variance of prediction values associated with the weighted estimates are given in table 12.

Estimation for an Ungaged Site near a Gaged Station

Sauer (1974) presented a method to improve flood-frequency estimates for an ungaged site near a streamgage, on the same stream, that has 10 or more years of peak-flow record. To obtain a weighted peak-flow estimate ($Q_{P(u)w}$) for P-percent AEP at the ungaged site, the weighted flow estimate for an upstream or downstream gaged station ($Q_{P(u)w}$) must first be determined by using the equation provided in the previous section. The weighted estimate for the ungaged site ($Q_{P(u)w}$) is then computed using the following equation:

$$Q_{P(u)w} = \left[\left(\frac{2\Delta A}{A_{(g)}} \right) + \left(1 - \frac{2\Delta A}{A_{(g)}} \right) \left(\frac{Q_{P(g)w}}{Q_{P(g)r}} \right) \right] Q_{P(u)r} \qquad (14)$$

where

$Q_{P(u)w}$ is the weighted estimate of peak flow for the selected P-percent AEP at the ungaged site, in cubic feet per second;

ΔA is the absolute value of the difference between the drainage areas of the gaged station and the ungaged site, in square miles;

$A_{(g)}$ is the drainage area for the streamgage, in square miles;

$Q_{P\,(u)r}$ is the peak-flow estimate derived from the applicable regional equations for the selected P-percent AEP at the ungaged site, in cubic feet per second;

$Q_{P\,(g)w}$ and $Q_{P\,(g)r}$ are previously defined in equation 12.

Use of equation 14 above gives full weight to the regression estimates when the drainage area for the ungaged site is equal to 0.5 or 1.5 times the drainage area for the streamgage and increasing weight to the weighted streamgage estimate ($Q_{P(u)w}$) as the drainage-area ratio approaches 1. The weighting procedure should not be applied when the drainage area ratio for the ungaged site and gaged station is less than 0.5 or greater than 1.5.

An example of the application of the procedure described above is the computation of the weighted 1-percent chance exceedance flow, and its associated equivalent years of record, for a hypothetical ungaged site on the Reedy River located upstream from the USGS station 02164000, Reedy River near Greenville, South Carolina:

1. Calculate the value of $Q_{1\%(g)w}$ using equation 12 (value can also be found in table 5); $Q_{1\%\ (g)w}$ = 7,490 ft^3/s;
2. Obtain the drainage areas for both the gaged and ungaged sites; A_g = 48.6 mi^2, and A_u = 30.0 mi^2;
3. Obtain the percentage of impervious area for both the gaged and ungaged site (for this example, the ungaged IMPNLCD06 is assumed to be 18 percent); gaged IMPNLCD06 = 18.8 percent;
4. Compute $Q_{1\%(u)r}$ for the ungaged site using appropriate equation from table 7; $Q_{1\%\ (u)r}$ = $941*(30)^{0.5386}$ $10(^{0.0028*18})$ = 6,600 ft^3/s;
5. Compute $Q_{1\%\ (g)r}$ for the gaged station using appropriate equation from table 7 (value can also be found in table 5); $Q_{1\%\ (g)r}$ = 7,010 ft^3/s;
6. Compute ΔA, where ΔA = 48.6–30.0 = 18.6 mi^2;
7. Compute the weighted estimate for the ungaged site, $Q_{P(u)w}$ using equation 14; $Q_{1\%\ (u)w}$ = [((2*18.6)/48.6)+((1– ((2*18.6)/48.6))*(7,940/7,010))] *6,600 = 6,810 ft^3/s.

For an ungaged site that is located between two streamgages on the same stream, two flow estimates can be made using the methods and criteria outlined above. In addition to evaluating any differences in the hydrologic regions of the two streamgages in comparison to the ungaged site, additional hydrologic judgment may be necessary to determine which of the two estimates (or some interpolation thereof) is most appropriate. Other factors that might be considered when evaluating the two estimates include differences in the length of record at the two streamgages and the hydrologic conditions that existed during the data-collection period at each gaged station (that is, does the time series represent a climatic period that was predominately wet or dry).

Estimation for an Ungaged Site Draining More Than One Hydrologic Region

For an ungaged site on a stream for which the drainage basin is contained in more than one hydrologic region, the P-percent AEP can be estimated by applying the appropriate equation from table 7 for each hydrologic region as though the drainage area were located entirely in the respective hydrologic region. The individual estimates can then be weighted by the proportion of the drainage area within each hydrologic region and added to produce the final estimate for the ungaged site. For example, if an ungaged site drained 40 percent from HR3 and 60 percent from HR4, the P-percent AEP estimate assuming the ungaged site was 100 percent in HR3 would be multiplied by 0.40 and the P-percent AEP estimate assuming the ungaged site was 100 percent in HR4 would be multiplied by 0.60 and the two estimates would be added together to obtain the final weighted estimate. The variance of prediction for such a weighted estimate also can be approximated using the same weighting procedure based on the proportional drainage areas.

Summary and Conclusions

This report presents methods for determining the magnitude and frequency of floods at urban and small, rural streams in the Southeast United States, which for this investigation includes Georgia, South Carolina, and North Carolina. The regional regression analysis for the investigation includes at-site flood-frequency estimates for 488 streamgages: 340 rural; 32 small, rural; and 116 urban. The at-site flood-frequency analyses for 336 of the 340 rural streamgages were previously published as part of a U.S. Geological Survey (USGS) Southeast rural flood-frequency investigation, which included annual peak-flow data through water year 2006. The at-site flood-frequency analyses for the remaining 152 urban, rural, and small, rural streamgages were completed using annual peak-flow data through water year 2011 and was done using a modified version of the Bulletin 17B procedures by including the expected moments algorithm and a generalized Grubbs-Becks test that allows for the detection of multiple potentially influential low outliers.

In order to expand the range of the drainage area sizes for which the Coastal Plain regression equations would be applicable, 16 urban and 2 rural streamgages were included from the inner Coastal Plain of New Jersey. Analyses comparing rural flood-frequency estimates for streamgages in Virginia, Maryland, Delaware, and New Jersey with streamgages included in the Southeast rural flood-frequency investigation indicated that the 1-percent chance annual exceedance probability (AEP) flows from Virginia, Maryland, and the inner Coastal Plain of New Jersey respond similarly to the 1-percent AEP flows from the Southeast. Consequently, it seemed reasonable to assume that the 1-percent AEP flows from the urban basins in these States also would have characteristics similar to urban basins in the Southeast. However, only the inner Coastal Plain of New Jersey had streamgages with sufficient measured annual peak-flow data to be included in the regression analysis. Including the New Jersey urban streamgages allowed the upper range of the applicable drainage area size for the urban streamgage regression equations to be increased from 2.1 to 53.5 square miles.

The regional regression analysis was completed using generalized least squares regression. The regional-regression analysis resulted in predictive equations that can be used to estimate the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent AEP flows at urban and small, rural ungaged locations in three hydrologic regions (HR) of South Carolina, North Carolina, and Georgia: HR1, Piedmont–Ridge and Valley; HR3, Sand Hills; and HR4, Coastal Plain. In addition, similar predictive equations for urban and small, rural ungaged locations in HR5, Southwest Georgia, which were published in 2011 in a USGS flood-frequency investigation of urban and small, rural basins in Georgia, were included in this report. There was not a sufficient number of urban streamgages from the Blue Ridge region to allow for generation of urban and small, rural predictive equations. Average standard error of prediction for the predictive equations, which is a measure of the average accuracy of the regression equations when predicting flood estimates for ungaged sites, range from 25.0 percent for the 10-percent AEP regression equation for the Piedmont–Ridge and Valley region to 73.3 percent for the 0.2-percent AEP regression equation for the Sand Hills region.

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Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.

[USGS, U.S. Geological Survey; mi², square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
1	01400795	Bear Brook at Route 571 near Grovers Mill, NJ	NJ	40 17 41	74 35 33	9.28	4	U	1986–2000	15	
2	01401160	Duck Pond Run near Princeton Junction, NJ	NJ	40 17 47	74 38 46	1.81	4	R	1980–2000	21	
3	01405300	Matchaponix Brook at Spotswood, NJ	NJ	40 22 52	74 22 50	43.9	4	U	1957–1967	11	
4	01407290	Big Brook near Marlboro, NJ	NJ	40 19 11	74 12 51	6.42	4	U	1980–2011	32	
5	01464524	Crosswicks Creek tributary 3 at US Route 206 near Bordentown, NJ	NJ	40 10 15	74 41 58	0.66	4	U	1995–2010	16	
6	01464525	Thorton Creek at Bordentown, NJ	NJ	40 08 50	74 41 45	0.84	4	U	1995–2010	16	
7	01465880	Southwest Branch Rancocas Creek at Medford, NJ	NJ	39 53 43	74 49 25	47.2	4	R	1983–2010	19	
8	01467057	Pompeston Creek at Cinnaminson, NJ	NJ	40 00 11	74 58 59	5.77	4	U	1975–1988	14	
9	01467069	North Branch Pennsauken Creek near Moorestown, NJ	NJ	39 57 07	74 58 09	12.8	4	U	1975–1988	14	
10	01467081	South Branch Pennsauken Creek at Cherry Hill, NJ	NJ	39 56 30	75 00 04	8.98	4	U	1968–2010	42	
11	01467130[h]	Cooper River at Kirkwood, NJ	NJ	39 50 10	75 00 05	5.10	4	U	1964–2004	18	65
12	01467150[h]	Cooper River at Haddonfield, NJ	NJ	39 54 11	75 01 17	17.0	4	U	1964–2011	48	72
13	01467160[h]	North Branch Cooper River near Marlton, NJ	NJ	39 53 20	74 58 07	5.34	4	U	1964–2004	26	65
14	01467305	Newton Creek at Collingswood, NJ	NJ	39 54 30	75 03 12	1.33	4	U	1964–2009	45	
15	01467317	South Branch Newton Creek at Haddon Heights, NJ	NJ	39 52 45	75 04 25	0.63	4	U	1989–2010[a]	22	
16	01467330	South Branch Big Timber Creek at Blackwood, NJ	NJ	39 48 17	75 04 32	19.6	4	U	1964–1984	21	
17	01475017	Bees Branch at Hurffville, NJ	NJ	39 46 17	75 06 20	0.43	4	U	1997–2010	13	
18	01475019	Mantua Creek at Salina, NJ	NJ	39 46 13	75 07 58	14.1	4	U	1975–1988	14	
19	02053110	Wildcat Swamp near Jackson, NC	NC	36 25 49	77 22 23	1.09	4	R	1953–1971	19	
20	02053170	Cutawhiskie Creek at NC 35 near Woodland, NC	NC	36 18 07	77 11 44	11.8	4	R	1953–1971	19	
21	02053510	Ahoskie Creek tributary at Poortown, NC	NC	36 16 30	77 00 37	2.04	4	R	1964–1973	10	
22	02053550	Chinkapin Creek near Colerain, NC	NC	36 11 53	76 47 13	8.90	4	R	1953–1971	19	
23	02068610	Hog Rock Creek near Moores Springs, NC	NC	36 23 53	80 19 45	0.31	1	SR	1955–1971	15	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

[USGS, U.S. Geological Survey; mi^2, square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
24	02068660	Little Snow Creek near Lawsonville, NC	NC	36 27 54	80 10 27	5.44	1	R	1954–1971	18	
25	02069030	Belews Creek near Kernersville, NC	NC	36 12 20	80 04 24	14.9	1	R	1954–1971	17	
26	02070810	Jacobs Creek near Wentworth, NC	NC	36 20 54	79 53 13	16.2	1	R	1954–1973	18	
27	02071410	Matrimony Creek near Leaksville, NC	NC	36 31 39	79 50 07	12.0	1	R	1958–1973	15	
28	02075160	Moon Creek near Yanceyville, NC	NC	36 28 14	79 23 04	32.8	1	R	1954–1989	22	
29	02075230	South Country Line Creek near Hightowers, NC	NC	36 19 29	79 18 19	6.57	1	R	1954–1976	23	
30	02077200	Hyco Creek near Leasburg, NC	NC	36 23 52	79 11 48	45.9	1	R	1965–2006	39	
31	02077210[h]	Kilgore Creek tributary near Leasburg, NC	NC	36 22 39	79 09 56	0.25	1	SR	1954–1971	13	18
32	02077240[h]	Double Creek near Roseville, NC	NC	36 21 45	79 05 47	7.47	1	R	1965–1982	16	18
33	02077250[r]	South Hyco Creek near Roseville, NC	NC	36 23 10	79 06 25	56.5	1	R	1967–1976	14	
34	02077310	Storys Creek near Roxboro, NC	NC	36 23 49	79 01 13	1.86	1	R	1954–1971	18	
35	02081060	Smithwick Creek tributary near Williamston, NC	NC	35 43 52	77 04 41	2.86	4	R	1953–1971	19	
36	02081110	White Oak Swamp near Windsor, NC	NC	36 04 47	76 58 35	18.7	4	R	1953–1971	16	
37	02081210	Shelton Creek near Oxford, NC	NC	36 18 48	78 43 15	22.2	1	R	1954–1971	18	
38	02081500	Tar River near Tar River, NC	NC	36 11 39	78 34 59	167	1	R	1940–2006	67	
39	02081710	Long Creek at Kittrell, NC	NC	36 13 31	78 27 14	7.25	1	R	1954–1976	20	
40	02081747	Tar River at US 401 at Louisburg, NC	NC	36 05 35	78 17 46	427	1	R	1964–2006	43	
41	02081800	Cedar Creek near Louisburg, NC	NC	36 03 15	78 20 23	47.8	1	R	1954–1975	22	
42	02082540	Wildcat Branch near Mapleville, NC	NC	36 03 30	78 08 38	0.32	1	SR	1953–1963	11	
43	02082630	Harts Mill Run near Tarboro, NC	NC	35 55 41	77 37 09	8.58	4	R	1953–1971	18	
44	02082835	Fishing Creek near Warrenton, NC	NC	36 23 01	78 10 53	45.0	1	R	1954–1976	22	
45	02083090	Beaverdam Swamp near Heathsville, NC	NC	36 16 50	77 41 47	9.44	4	R	1953–1971	19	
46	02083410	Deep Creek near Scotland Neck, NC	NC	36 09 27	77 28 23	12.3	4	R	1953–1973	21	
47	02084240	Collie Swamp near Everetts, NC	NC	35 49 35	77 12 02	30.8	4	R	1953–1976	24	
48	02084500	Herring Run near Washington, NC	NC	35 34 04	77 01 08	9.59	4	R	1951–1980	30	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

[USGS, U.S. Geological Survey; mi^2, square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
49	02084520	Upper Goose Creek near Yeatsville, NC	NC	35 31 26	76 53 22	1.49	4	R	1953–1973	21	
50	02084540	Durham Creek at Edward, NC	NC	35 19 26	76 52 27	26.0	4	R	1966–2004	39	
51	02084557[d]	Van Swamp near Hoke, NC	NC	35 43 51	76 44 46	23.0	4	R	1978–2006	29	
52	02084570	Acre Swamp near Pinetown, NC	NC	35 35 03	76 50 22	32.2	4	R	1953–1969	17	
53	02084909	Sevenmile Creek near Efland, NC	NC	36 03 56	79 08 39	14.1	1	R	1988–2004	17	
54	02085000	Eno River at Hillsborough, NC	NC	36 04 16	79 05 44	66.0	1	R	1928–2006	64	
55	02085020	Stony Creek tributary near Hillsboro, NC	NC	36 03 02	79 02 13	0.80	1	SR	1953–1971	19	
56	02085070	Eno River near Durham, NC	NC	36 04 20	78 54 28	141	1	R	1964–2006	43	
57	02085190	North Fork Little River tributary near Rougemont, NC	NC	36 11 42	79 00 51	1.02	1	R	1954–1976	23	
58	0208521324[c]	Little River at SR1461 near Orange Factory, NC	NC	36 08 30	78 55 09	78.2	1	R	1962–2006	45	
59	0208524090	Mountain Creek at SR1617 near Bahama, NC	NC	36 08 59	78 53 48	8.00	1	R	1995–2006	11	
60	02085500	Flat River at Bahama, NC	NC	36 10 58	78 52 44	149	1	R	1926–2006	81	
61	02086000	Dial Creek near Bahama, NC	NC	36 10 37	78 51 23	4.73	1	R	1926–1991	47	
62	0208650112	Flat River tributary near Willardville, NC	NC	36 07 55	78 50 00	1.14	1	R	1989–2006	14	
63	02086624	Knap Of Reeds Creek near Butner, NC	NC	36 07 41	78 47 54	43.0	1	R	1983–2006	14	
64	02086849	Ellerbe Creek near Gorman, NC	NC	36 03 33	78 49 58	21.9	1	U	1983–2011	14	
65	02087030	Lick Creek near Durham, NC	NC	35 58 51	78 44 18	13.8	1	R	1954–1971	18	
66	02087140	Lower Barton Creek tributary near Raleigh, NC	NC	35 54 45	78 40 54	0.70	1	SR	1954–1971	18	
67	02087240[h]	Stirrup Iron Creek tributary near Nelson, NC	NC	35 53 07	78 49 36	0.25	1	SR	1954–1973	21	22
68	0208726005[h]	Crabtree Creek at Ebenezer Church Road near Raleigh, NC	NC	35 50 43	78 43 28	76.0	1	U	1989–2011	18	39
69	02087275[n]	Crabtree Creek at Highway 70 at Raleigh, NC	NC	35 50 17	78 40 27	97.6	1	U	1973–2011	15	39
70	02087324[h]	Crabtree Creek at US 1 at Raleigh, NC	NC	35 48 40	78 36 39	124	1	U	1973–2011	21	39
71	0208732885	Marsh Creek near New Hope, NC	NC	34 49 01	78 35 35	6.81	1	U	1984–2011	28	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

[USGS, U.S. Geological Survey; mi^2, square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
72	0208735012[d]	Rocky Branch below Pullen Drive at Raleigh, NC	NC	35 46 48	78 39 59	1.20	1	U	1997–2011	15	
73	02087359	Walnut Creek at Sunnybrook Drive near Raleigh, NC	NC	35 45 30	78 34 59	29.7[b]	1	U	1996–2011	16	
74	02087580	Swift Creek near Apex, NC	NC	35 43 08	78 45 08	21.0	1	U	2002–2011	10	
75	02087910	Middle Creek near Holly Springs, NC	NC	35 39 29	78 48 05	8.67	1	R	1954–1971	18	
76	02088140	Stone Creek near Newton Grove, NC	NC	35 20 25	78 21 53	27.9	4	R	1953–1971	19	
77	02088210	Hannah Creek near Benson, NC	NC	35 23 37	78 31 47	2.68	4	R	1953–1971	19	
78	02090560	Lee Swamp tributary near Lucama, NC	NC	35 38 22	78 01 36	3.82	4	R	1953–1971	19	
79	02090625	Turner Swamp near Eureka, NC	NC	35 34 15	77 52 46	2.10	4	R	1969–1987	19	
80	02090780	Whiteoak Swamp tributary near Wilson, NC	NC	35 42 25	77 47 10	2.85	4	R	1953–1971	19	
81	02090960	Nahunta Swamp near Pikeville, NC	NC	35 30 50	77 58 52	19.0	4	R	1953–2003	22	
82	02091430	Shepherd Run near Snow Hill, NC	NC	35 26 07	77 38 41	1.47	4	R	1953–1971	19	
83	02091810	Halfmoon Creek near Fort Barnwell, NC	NC	35 17 59	77 21 13	4.87	4	R	1953–1965	12	
84	02091970	Creeping Swamp near Vanceboro, NC	NC	35 23 31	77 13 45	27.0	4	R	1972–1985	14	
85	02092020	Palmetto Swamp near Vanceboro, NC	NC	35 20 19	77 10 15	24.0	4	R	1953–1976	24	
86	02092120	Bachelor Creek near New Bern, NC	NC	35 10 25	77 06 13	32.4	4	R	1953–1971	19	
87	02092290	Rattlesnake Branch near Comfort, NC	NC	35 00 32	77 35 49	5.05	4	R	1953–1971	19	
88	02092520	Vine Swamp near Kinston, NC	NC	35 09 30	77 33 15	6.30	4	R	1953–1971	19	
89	02092620	Upper Broad Creek tributary near Grantsboro, NC	NC	35 08 07	76 56 30	3.00	4	R	1953–1973	21	
90	02092720	White Oak River at Belgrade, NC	NC	34 53 31	77 14 01	53.3	4	R	1953–1973	21	
91	02092780	Bell Swamp near Hubert, NC	NC	34 42 05	77 14 00	4.95	4	R	1953–1970	18	
92	02093040	Southwest Creek tributary near Jacksonville, NC	NC	34 47 19	77 33 07	1.00	4	R	1954–1973	19	
93	02093070	Southwest Creek near Jacksonville, NC	NC	34 43 57	77 32 01	26.9	4	R	1953–1973	20	
94	02093229	Hewletts Creek at SR1102 near Wilmington, NC	NC	34 11 28	77 53 32	2.08[b]	4	U	1977–1990	14	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

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Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
95	02093290	Haw River near Summerfield, NC	NC	36 14 32	79 52 19	26.3	1	R	1954–1971	18	
96	02093500[h]	Haw River near Benaja, NC	NC	36 15 00	79 33 59	168	1	R	1929–1971	43	56
97	02093800[h]	Reedy Fork near Oak Ridge, NC	NC	36 10 21	79 57 10	20.6	1	R	1956–2006	51	91
98	0209399200	Horsepen Creek at US 220 near Greensboro, NC	NC	36 08 16	79 51 36	15.9	1	U	1999–2011	11	
99	02094659	South Buffalo Creek near Pomona, NC	NC	36 02 58	79 51 19	7.33	1	U	1999–2011	13	
100	02094770	South Buffalo Creek at US 220 at Greensboro, NC	NC	36 02 17	79 47 59	15.4	1	U	1999–2011	13	
101	02095000	South Buffalo Creek near Greensboro, NC	NC	36 03 36	79 43 33	34.0	1	U	1999–2011	13	
102	02095181[n]	North Buffalo Creek at Westover Terrace at Greensboro, NC	NC	36 04 45	79 48 46	9.55	1	U	1999–2011	13	
103	02095271	North Buffalo Creek at Church St. at Greensboro, NC	NC	36 05 52	79 46 57	14.2	1	U	1998–2011	14	
104	02095500	North Buffalo Creek near Greensboro, NC	NC	36 07 14	79 42 29	37.1	1	U	1999–2011	34	
105	0209553650	Buffalo Creek at SR2819 near McLeansville, NC	NC	36 07 41	79 39 42	88.5	1	U	1999–2011	13	
106	02096660	Rock Creek near Whitsett, NC	NC	36 03 55	79 35 56	14.6	1	R	1954–1971	17	
107	02096700	Big Alamance Creek near Elon College, NC	NC	36 02 21	79 31 28	116	1	R	1958–1980	23	
108	02096846	Cane Creek near Orange Grove, NC	NC	35 59 14	79 12 22	7.54	1	R	1989–2006	18	
109	02096850	Cane Creek near Teer, NC	NC	35 56 35	79 14 45	33.7	1	R	1960–1973	14	
110	02097010	Robeson Creek near Pittsboro, NC	NC	35 43 30	79 12 32	1.71	1	R	1954–1976	23	
111	02097314	New Hope Creek near Blands, NC	NC	35 53 06	78 57 55	75.9	1	R	1983–2006	20	
112	0209741955	Northeast Creek at SR1100 near Genlee, NC	NC	35 52 20	78 54 47	21.1	1	U	1983–2011	20	
113	02097464	Morgan Creek near White Cross, NC	NC	35 55 25	79 06 54	8.35	1	R	1989–2006	17	
114	0209782609[s]	White Oak Creek at mouth near Green Level, NC	NC	35 45 37	78 55 13	11.9	1	R	2000–2011	12	
115	02097910	White Oak Creek near Wilsonville, NC	NC	35 44 48	79 00 43	23.6	1	R	1954–1971	18	
116	02098000	New Hope River near Pittsboro, NC	NC	35 44 13	79 01 35	285	1	R	1950–1973	24	
117	02100500[h]	Deep River at Ramseur, NC	NC	35 43 35	79 39 20	349	1	R	1901–2006	85	106
118	02101030	Falls Creek near Bennett, NC	NC	35 33 21	79 29 55	3.43	1	R	1954–1973	20	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

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Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydro-logic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
119	02101480	Sugar Creek near Tramway, NC	NC	35 25 29	79 14 49	0.85	1	SR	1954–1973	20	
120	0210166029	Rocky River at SR1300 near Crutchfield Crossroads, NC	NC	35 48 25	79 31 39	7.42	1	R	1989–2006	18	
121	02101800	Tick Creek near Mount Vernon Springs, NC	NC	35 39 35	79 24 06	15.5	1	R	1959–2006	36	
122	02101890	Bear Creek near Goldston, NC	NC	35 37 34	79 17 53	43.2	1	R	1952–1971	19	
123	02102908	Flat Creek near Inverness, NC	NC	35 10 58	79 10 39	7.58	3	R	1969–2006	38	
124	02102910	Dunhams Creek tributary near Carthage, NC	NC	35 18 42	79 22 52	2.19	3	R	1954–1971	18	
125	02102930	Crane Creek near Vass, NC	NC	35 17 54	79 16 18	32.4	3	R	1954–1971	18	
126	02103000	Little River at Manchester, NC	NC	35 11 36	78 59 08	348	3	R	1939–2006	15	
127	02103390	South Prong Anderson Creek near Lillington, NC	NC	35 15 32	78 55 26	7.56	3	R	1953–1971	19	
128	02103500	Little River at Linden, NC	NC	35 15 47	78 46 34	459	3	R	1928–1971	44	
129	02104080	Reese Creek near Fayetteville, NC	NC	35 04 50	78 47 44	9.79	4	R	1953–1971	17	
130	02104220	Rockfish Creek at Raeford, NC	NC	34 59 59	79 12 53	93.1	3	R	1989–2006	18	
131	02105570	Browns Creek near Elizabethtown, NC	NC	34 36 33	78 36 56	13.3	4	R	1953–1973	18	
132	02105900	Hood Creek near Leland, NC	NC	34 16 43	78 07 31	21.6	4	R	1953–2006	34	
133	02106240	Turkey Creek near Turkey, NC	NC	35 00 12	78 11 05	15.7	4	R	1955–1973	18	
134	02106410	Stewarts Creek tributary near Warsaw, NC	NC	34 57 26	78 04 41	0.46	4	SR	1955–1971	16	
135	02106910[h]	Big Swamp near Roseboro, NC	NC	34 58 39	78 34 06	32.3	4	R	1953–1973	20	21
136	02107590	Northeast Cape Fear River tributary near Mount Olive, NC	NC	35 11 07	77 57 33	0.56	4	SR	1954–1971	18	
137	02107600	Northeast Cape Fear River near Seven Springs, NC	NC	35 10 21	77 55 55	47.5	4	R	1959–1975	17	
138	02107620	Mathews Creek near Pink Hill, NC	NC	35 05 50	77 49 09	8.13	4	R	1953–1969	16	
139	02107980	Limestone Creek near Beulaville, NC	NC	34 45 49	77 48 14	53.5	4	R	1953–1971	19	
140	02108548	Little Rockfish Creek at Wallace, NC	NC	34 44 03	77 58 02	7.80	4	R	1977–1992	16	
141	02108610	Pike Creek near Burgaw, NC	NC	34 30 01	77 53 57	1.26	4	R	1953–1971	18	
142	02108630	Turkey Creek near Castle Hayne, NC	NC	34 23 48	77 54 47	10.2	4	R	1953–1971	19	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

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Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
143	02108960	Buckhead Branch near Bolton, NC	NC	34 20 53	78 26 18	16.7	4	R	1953–1971	19	
144	02109640	Wet Ash Swamp near Ash, NC	NC	34 02 18	78 30 13	16.0	4	R	1953–1971	18	
145	02110020	Mill Branch near Tabor City, NC	NC	34 11 00	78 48 07	3.52	4	R	1953–1971	18	
146	02110740[h]	Midway Swash at Myrtle Beach, SC	SC	33 39 44	78 55 25	0.67[b]	4	U	1987–2001	15	61
147	02114450	Little Yadkin River at Dalton, NC	NC	36 17 57	80 24 53	42.8	1	R	1961–2006	46	
148	02115500	Forbush Creek near Yadkinville, NC	NC	36 08 00	80 32 59	22.1	1	R	1941–1971	31	
149	02115520	Logan Creek near Smithtown, NC	NC	36 12 50	80 33 31	0.90	1	SR	1954–1971	18	
150	02115540	South Deep Creek near Yadkinville, NC	NC	36 08 00	80 45 59	17.7	1	R	1954–1966	13	
151	02115845	Peters Creek at Winston–Salem, NC	NC	36 05 03	80 15 30	5.18	1	U	1965–1977	13	
152	02115900	South Fork Muddy Creek near Clemmons, NC	NC	36 00 22	80 18 06	42.9	1	R	1965–1991	19	
153	02117030	Humpy Creek near Fork, NC	NC	35 51 17	80 26 23	1.05	1	R	1969–1983	15	
154	02117410	Mcclelland Creek near Statesville, NC	NC	35 57 04	80 56 45	1.22	1	R	1954–1976	22	
155	02120500[r]	Third Creek at Cleveland, NC	NC	35 45 01	80 40 59	87.4	1	R	1941–1954	14	
156	02120780	Second Creek near Barber, NC	NC	35 43 04	80 35 45	118	1	R	1980–2006	27	
157	02120820	Deal Branch near Salisbury, NC	NC	35 44 44	80 30 24	3.88	1	R	1954–1971	15	
158	02121180	North Potts Creek at Linwood, NC	NC	35 45 28	80 19 23	9.62	1	R	1980–1990	11	
159	02121500	Abbotts Creek at Lexington, NC	NC	35 48 25	80 14 05	174	1	R	1941–2006	33	
160	02121940	Flat Swamp Creek near Lexington, NC	NC	35 43 59	80 06 36	6.56	1	R	1954–1971	18	
161	02122560	Cabin Creek near Jackson Hill, NC	NC	35 34 57	80 09 11	13.7	1	R	1954–1971	17	
162	02122720	Beaverdam Creek tributary near Denton, NC	NC	35 31 58	80 05 03	2.90	1	R	1954–1971	18	
163	02123500[h]	Uwharrie River near Eldorado, NC	NC	35 26 57	80 01 02	342	1	R	1939–1971	32	44
164	02123567	Dutchmans Creek near Uwharrie, NC	NC	35 22 45	80 01 49	3.44	1	R	1982–2004	20	
165	02124060	N Prong Clarke Creek near Huntersville, NC	NC	35 25 14	80 47 53	3.61	1	R	1954–1973	20	
166	0212414900	Mallard Creek below Stony Creek near Harrisburg, NC	NC	35 19 58	80 42 57	34.2	1	U	1995–2011	16	

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Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydro-logic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
167	02125000	Big Bear Creek near Richfield, NC	NC	35 20 05	80 20 08	55.6	1	R	1955–2006	52	
168	02125410	Chinkapin Creek near Monroe, NC	NC	35 02 49	80 29 32	7.73	1	R	1953–1971	18	
169	02127000[h]	Brown Creek near Polkton, NC	NC	35 02 01	80 08 59	110	1	R	1936–1971	36	64
170	02127390	Palmetto Branch at Ansonville, NC	NC	35 06 04	80 07 10	0.91	1	SR	1953–1971	17	
171	02128000	Little River near Star, NC	NC	35 23 14	79 49 53	106	1	R	1955–2006	51	
172	02129530	Little Creek tributary near Pee Dee, NC	NC	34 55 08	79 54 37	0.14	3	SR	1955–1971	11	
173	02130900	Black Creek near McBee, SC	SC	34 30 51	80 10 59	108	3	R	1960–2006	46	
174	02131110	Jeffries Creek above Florence, SC	SC	34 10 41	79 48 33	46.6	4	R	1968–2006	38	
175	02131130	Gully Branch at Florence, SC	SC	34 53 00	79 46 12	1.62	4	U	1985–2011	26	
176	02131309	Fork Creek at Jefferson, SC	SC	34 38 20	80 23 19	24.3	1	R	1977–1997	21	
177	02131320	Little Fork Creek at Jefferson, SC	SC	34 38 14	80 24 22	15.0	1	R	1991–2000	10	
178	02131472	Hanging Rock Creek near Kershaw, SC	SC	34 30 59	80 34 58	23.9	1	R	1981–2005	24	
179	02132100	Two Mile Br near Lake City, SC	SC	33 53 39	79 45 37	18.9	4	R	1976–2003	28	
180	02132230	Bridge Creek tributary at Johns, NC	NC	34 42 13	79 26 33	6.05	4	R	1953–1973	18	
181	02133500	Drowning Creek near Hoffman, NC	NC	35 03 40	79 29 38	183	3	R	1940–2006	67	
182	02133590	Beaverdam Creek near Aberdeen, NC	NC	35 00 43	79 26 49	4.66	3	R	1953–1971	18	
183	02133624	Lumber River near Maxton, NC	NC	34 46 22	79 19 55	365	3	R	1988–2006	18	
184	02134380	Tenmile Swamp near Lumberton, NC	NC	34 43 35	78 59 30	16.1	4	R	1953–1973	18	
185	02135300	Scape Ore Swamp near Bishopville, SC	SC	34 09 03	80 18 17	96.0	3	R	1969–2006	38	
186	02135518	Turkey Creek at Sumter, SC	SC	33 55 13	80 19 43	1.82	4	U	1987–2011	23	
187	02142480	Hagan Creek near Catawba, NC	NC	35 40 20	81 08 11	8.40	1	R	1954–1971	15	
188	0214253830	Norwood Creek near Troutman, NC	NC	35 40 50	80 56 43	7.18	1	R	1984–2006	22	
189	0214266000	McDowell Creek near Charlotte, NC	NC	35 23 23	80 55 16	26.3	1	U	1998–2011	14	
190	02142900	Long Creek near Paw Creek, NC	NC	35 19 43	80 54 35	16.4	1	U	1975–2011	37	
191	0214291555	Long Creek near Rhyne, NC	NC	35 18 02	80 58 22	31.5	1	U	1999–2011	13	

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Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
192	0214295600	Paw Creek at Wilkinson Blvd. near Charlotte, NC	NC	35 14 25	80 58 28	10.4[b]	1	U	1995–2011	17	
193	02143500[h]	Indian Creek near Laboratory, NC	NC	35 25 14	81 15 55	69.2	1	R	1952–2006	55	91
194	02144000	Long Creek near Bessemer City, NC	NC	35 18 23	81 14 05	31.8	1	R	1954–2006	53	
195	02145940	Little Dutchman Creek tributary at Rock Hill, SC	SC	34 58 34	81 01 02	3.47	1	U	1986–1997	12	
196	02146211	Irwin Creek at Statesville Ave. at Charlotte, NC	NC	35 15 43	80 50 13	6.07	1	U	1982–2011	25	
197	0214627970	Stewart Creek at State St. at Charlotte, NC	NC	35 14 25	80 52 06	9.27[b]	1	U	2000–2011	12	
198	02146300	Irwin Creek near Charlotte, NC	NC	35 11 52	80 54 16	29.4	1	U	1975–2011[a]	37	
199	02146315	Taggart Creek at West Boulevard near Charlotte, NC	NC	35 12 24	80 55 19	5.71	1	U	1999–2011	13	
200	02146348	Coffey Creek near Charlotte, NC	NC	35 08 45	80 55 37	9.14	1	U	1999–2011	13	
201	02146381	Sugar Creek at NC 51 near Pineville, NC	NC	35 05 27	80 53 58	65.0	1	U	1995–2011	17	
202	02146409	Little Sugar Creek at Medical Center Dr. at Charlotte, NC	NC	35 12 13	80 50 13	11.7	1	U	1995–2011	17	
203	0214642825	Briar Creek near Charlotte, NC	NC	35 14 10	80 46 16	5.20	1	U	1998–2011	14	
204	0214645022	Briar Creek above Colony Rd. at Charlotte, NC	NC	35 10 31	80 49 51	18.9	1	U	1997–2011	16	
205	02146470	Little Hope Creek at Seneca Place at Charlotte, NC	NC	35 09 52	80 51 11	2.75	1	U	1983–2011[a]	24	
206	02146500	Little Sugar Creek near Charlotte, NC (Site 55)	NC	35 09 13	80 51 18	41.0	1	U	1924–1977	53	
207	02146507	Little Sugar Creek at Archdale Dr. at Charlotte, NC	NC	35 08 53	80 51 28	41.8	1	U	1978–2011	34	
208	02146530	Little Sugar Creek at Pineville, NC	NC	35 05 07	80 52 56	49.5	1	U	1997–2011[a]	15	
209	0214655255	McAlpine Creek at SR3150 near Idlewild, NC	NC	35 10 33	80 43 09	7.52[b]	1	U	1999–2011	11	
210	02146562	Campbell Creek near Charlotte, NC	NC	35 11 12	80 44 12	5.60[b]	1	U	1999–2011	13	
211	0214657975[s]	Irvins Creek at Secondary Road 3168 near Charlotte, NC	NC	35 09 31	80 42 48	8.37	1	R	1999–2011	13	

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Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
212	02146600	McAlpine Creek at Sardis Road near Charlotte, NC	NC	35 08 16	80 46 03	38.4[b]	1	U	1975–2011[a]	37	
213	02146700	McMullen Creek at Sharon View Road near Charlotte, NC	NC	35 08 27	80 49 12	7.05	1	U	1975–2011[a]	37	
214	02146750	McAlpine Creek below McMullen Creek near Pineville, NC	NC	35 03 59	80 52 11	91.8	1	U	1975–2011	37	
215	0214678175	Steele Creek at SR1441 near Pineville, NC	NC	35 06 18	80 57 13	6.91[b]	1	U	1998–2011	14	
216	02146900[m]	Twelve Mile Creek near Waxhaw, NC	NC	34 57 07	80 45 21	76.5	1	R	1954–2004	51	
217	02147500	Rocky Creek at Great Falls, SC	SC	34 33 56	80 55 11	194	1	R	1952–2006	50	
218	02148090	Swift Creek near Camden, SC	SC	34 11 50	80 28 57	4.90	3	R	1991–2004	12	
219	02148300	Colonels Creek near Leesburg, SC	SC	34 00 26	80 43 57	40.2	3	R	1968–2006	15	
220	02152420	Big Knob Creek near Fallston, NC	NC	35 29 34	81 32 24	16.4	1	R	1953–1971	18	
221	02152610	Sugar Branch near Boiling Springs, NC	NC	35 15 00	81 37 14	1.44	1	R	1954–1987	34	
222	02153780	Clarks Fork Creek near Smyrna, SC	SC	35 04 45	81 23 16	24.1	1	R	1981–2006	24	
223	02153800	Bullock Creek near Sharon, SC	SC	34 57 13	81 22 57	84.3	1	R	1991–2006	16	
224	02153840	Bells Creek near Sharon, SC	SC	34 53 09	81 25 50	6.12	1	R	1991–2005	12	
225	02154790	South Pacolet River near Campobello, SC	SC	35 06 23	82 07 46	55.5	1	R	1989–2006	18	
226	021563931	Turkey Creek near Lowrys, SC	SC	34 48 47	81 22 09	81.5	1	R	1991–2006	16	
227	02157000	North Tyger River near Fairmont, SC	SC	34 55 45	82 02 39	44.4	1	R	1951–1988	38	
228	02157500	Middle Tyger River at Lyman, SC	SC	34 56 35	82 07 59	68.3	1	R	1939–2005	51	
229	02158000[m]	North Tyger River near Moore, SC	SC	34 48 10	81 57 56	162	1	R	1935–1978	41	
230	02159000[m]	South Tyger River near Woodruff, SC	SC	34 45 21	81 56 18	174	1	R	1935–1978	44	
231	02159785	Fairforest Creek tributary at Spartanburg, SC	SC	34 57 10	81 57 57	0.39	1	U	1987–2011	23	
232	02160000	Fairforest Creek near Union, SC	SC	34 40 45	81 41 24	183	1	R	1940–2006	65	
233	02160325	Brushy Creek near Greenville, SC	SC	34 53 00	82 18 05	9.13	1	U	1986–2011	24	
234	02160500	Enoree River near Enoree, SC	SC	34 36 38	81 54 34	307	1	R	1930–2006	77	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

[USGS, U.S. Geological Survey; mi^2, square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
235	02162010	Cedar Creek near Blythewood, SC	SC	34 11 45	81 06 12	48.9	1	R	1967–1996	29	
236	02162093	Smith Branch at Columbia, SC	SC	34 01 38	81 02 31	5.41	3	U	1977–2011	35	
237	02164000	Reedy River near Greenville, SC	SC	34 48 00	82 21 55	48.3	1	U	1987–2011[a]	25	
238	02164011	Brushy Creek (Reedy River tributary) at Greenville, SC	SC	34 49 25	82 24 26	3.00	1	U	1985–2011	27	
239	02165000	Reedy River near Ware Shoals, SC	SC	34 25 02	82 09 05	236	1	R	1940–2002	63	
240	02165200	South Rabon Creek near Gray Court, SC	SC	34 31 12	82 09 25	29.5	1	R	1968–2006	30	
241	02166975[d]	Sample Branch at Greenwood, SC	SC	34 12 56	82 09 02	1.14	1	U	1986–2011	25	
242	02167020	Crane Creek tributary at Columbia, SC	SC	34 03 02	81 02 05	0.28	3	U	1986–2011	26	
243	02167450	Little River near Silverstreet, SC	SC	34 12 34	81 45 47	230	1	R	1991–2006	16	
244	02167582	Bush River near Prosperity, SC	SC	34 10 08	81 36 37	115	1	R	1991–2006	16	
245	02168845	Saluda River tributary at Columbia, SC	SC	34 02 26	81 08 29	0.39	1	U	1986–2011	16	
246	02169505	Rocky Branch at Pickens St. at Columbia, SC	SC	33 59 41	81 01 26	2.15	3	U	1985–2004	19	
247	02169550	Congaree Creek at Cayce, SC	SC	33 56 16	81 04 39	122	3	R	1960–1980	21	
248	02169568	Pen Branch at Columbia, SC	SC	34 00 46	80 58 56	2.15	3	U	1986–2011	26	
249	02169570[d]	Gills Creek at Columbia, SC	SC	33 59 22	80 58 28	59.3	3	U	1965–2011	47	
250	02169630	Big Beaver Creek near St. Matthews, SC	SC	33 44 13	80 57 29	10.0	3	R	1967–1993	27	
251	02169960	Lake Marion tributary near Vance, SC	SC	33 27 27	80 26 31	1.21	4	R	1976–2004	26	
252	02173491	Hess Branch at Orangeburg, SC	SC	33 30 12	80 52 41	0.52	4	U	1987–2011	25	
253	02173495[d]	Sunnyside Canal at Orangeburg, SC	SC	33 29 31	80 52 33	1.18	4	U	1986–2011	26	
254	02174250	Cow Castle Creek near Bowman, SC	SC	33 22 44	80 41 59	23.4	4	R	1971–2006	22	
255	02176380	Coosawhatchie River tributary at Allendale, SC	SC	32 59 53	81 19 01	1.49	4	U	1986–2006	19	
256	02186000	Twelvemile Creek near Liberty, SC	SC	34 48 05	82 44 55	106	1	R	1955–2006	27	
257	02186645	Coneross Creek near Seneca, SC	SC	34 38 57	82 59 30	65.4	1	R	1989–2003	15	
258	02187910	Rocky River near Starr, SC	SC	34 22 59	82 34 38	111	1	R	1989–2006	17	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

[USGS, U.S. Geological Survey; mi^2, square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
259	02188500[h]	Beaverdam Creek at Dewy Rose, GA	GA	34 10 52	82 56 38	38.4	1	R	1943–1977	35	126
260	02188600	Beaverdam Creek above Elberton, GA	GA	34 10 07	82 53 48	72.0	1	R	1987–2006	12	
261	02189020[h]	Indian Creek near Carnesville, GA	GA	34 21 19	83 17 16	7.63	1	R	1964–1976	13	16
262	02189030	Stephens Creek tributary at Carnesville, GA	GA	34 21 51	83 13 16	0.39	1	SR	1964–1976	13	
263	02189600	Bear Creek near Mize, GA	GA	34 29 07	83 18 38	3.62	1	R	1957–1969	13	
264	02190100	Toms Creek near Eastanollee, GA	GA	34 29 01	83 14 02	4.75	1	R	1957–1969	13	
265	02190200	Toms Creek tributary near Avalon, GA	GA	34 29 35	83 13 23	1.01	1	R	1955–1969	14	
266	02190800	Double Branch at Bowersville, GA	GA	34 22 51	83 05 28	0.53	1	SR	1960–1975	16	
267	02191200	Hudson River at Homer, GA	GA	34 20 15	83 29 17	60.9	1	R	1951–1979	29	
268	02191270	Scull Shoal Creek near Danielsville, GA	GA	34 09 30	83 09 51	8.75	1	R	1964–1975	12	
269	02191280	Mill Shoal Creek near Royston, GA	GA	34 16 13	83 06 08	0.39	1	SR	1964–1987	24	
270	02191600	Double Branch near Danielsville, GA	GA	34 06 06	83 14 11	5.12	1	R	1964–1976	13	
271	02191750	Fork Creek at Carlton, GA	GA	34 02 55	83 01 16	16.0	1	R	1964–1975	12	
272	02191890	Brooks Creek near Lexington, GA	GA	33 50 30	83 05 22	12.3	1	R	1964–1975	12	
273	02191910	Trouble Creek at Lexington, GA	GA	33 52 24	83 05 60	2.47	1	R	1959–1978	18	
274	02191930	Buffalo Creek near Lexington, GA	GA	33 46 40	83 03 01	5.24	1	R	1964–2006	43	
275	02191960[h]	Macks Creek near Lexington, GA	GA	33 55 24	82 58 30	3.45	1	R	1959–1975	17	30
276	02191970[h]	Little Macks Creek near Lexington, GA	GA	33 56 09	82 57 41	1.89	1	R	1959–1985	27	38
277	02192400	Anderson Mill Creek near Danburg, GA	GA	33 48 35	82 41 35	5.49	1	R	1964–1975	12	
278	02192420	Anderson Mill Creek tributary near Danburg, GA	GA	33 49 42	82 41 12	1.00	1	R	1964–1975	12	
279	02192500	Little River near Mt. Carmel, SC	GA	34 04 17	82 30 02	217	1	R	1940–2006	64	
280	02193300	Stephens Creek near Crawfordville, GA	GA	33 36 05	82 55 28	6.30	1	R	1961–1975	13	
281	02193340	Kettle Creek near Washington, GA	GA	33 40 57	82 51 29	33.9	1	R	1987–2006	20	
282	02193400	Harden Creek near Sharon, GA	GA	33 33 10	82 50 15	3.98	1	R	1964–1975	12	
283	02193500	Little River near Washington, GA	GA	33 36 46	82 44 33	292	1	R	1950–2006	39	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

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Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
284	02196689	Little Horse Creek near Graniteville, SC	SC	33 33 49	81 52 26	26.6	3	R	1990–2006	13	
285	02196725	Oates Creek at White Road, at Augusta, GA	GA	33 27 19	82 00 22	0.68	3	U	1979–1989	11	
286	02196760	Rocky Creek Tributary at US Highway 78/278 at Augusta, GA	GA	33 27 07	82 02 56	1.35	3	U	1979–1996	18	
287	02197410	Miller Creek tributary near Baldoc, SC	SC	33 04 09	82 35 35	7.82	4	R	1977–1998	20	
288	02197600	Brushy Creek near Wrens, GA	GA	33 10 38	82 18 20	28.0	4	R	1959–2005	47	
289	02197810[h]	Walnut Branch near Waynesboro, GA	GA	33 08 12	82 02 09	13.1	4	R	1965–1974	11	27
290	02198100	Beaverdam Creek near Sardis, GA	GA	32 56 16	81 48 55	30.8	4	R	1987–2006	20	
291	02199700	South Fork Ogeechee River near Crawfordville, GA	GA	33 31 00	82 54 22	31.3	1	R	1951–1969	19	
292	02200930	Spring Creek near Louisville, GA	GA	32 55 21	82 18 48	14.2	4	R	1965–2006	42	
293	02201110[h]	Nails Creek near Bartow, GA	GA	32 52 26	82 26 33	8.36	4	R	1965–1974	11	27
294	02201160	Boggy Gut Creek near Wadley, GA	GA	32 53 43	82 24 01	7.49	4	R	1965–1974	10	
295	02201250[h]	Seals Creek tributary near Midville, GA	GA	32 51 05	82 13 57	0.65	4	SR	1964–1974	12	27
296	02201350[h]	Buckhead Creek near Waynesboro, GA	GA	32 58 22	82 07 14	50.5	4	R	1963–1983	23	62
297	02201800	Richardson Creek near Millen, GA	GA	32 43 24	81 58 34	35.2	4	R	1963–1983	22	
298	02201830	Sculls Creek near Millen, GA	GA	32 39 35	81 59 28	4.38	4	R	1965–1975	12	
299	02202300	Mill Creek near Statesboro, GA	GA	32 28 29	81 45 16	39.0	4	R	1963–1974	12	
300	02202605	Mill Creek near Pembroke, GA	GA	32 09 40	81 36 14	3.53	4	R	1979–1996	18	
301	02202800[h]	Canoochee Creek near Swainsboro, GA	GA	32 36 20	82 15 20	46.0	4	R	1951–1976	29	63
302	02202810[h]	Hughes Prong near Swainsboro, GA	GA	32 37 30	82 19 03	5.05	4	R	1930–1991	14	63
303	02202820[h]	Reedy Creek near Twin City, GA	GA	32 35 41	82 12 22	8.99	4	R	1930–1993	12	65
304	02202850[h]	Reedy Branch near Metter, GA	GA	32 28 44	82 07 44	3.41	4	R	1965–1991	12	27
305	02202910[h]	Tenmile Creek tributary at Pulaski, GA	GA	32 23 19	81 58 16	1.14	4	R	1965–1993	25	46
306	02202950[h]	Cypress Flat Creek near Collins, GA	GA	32 13 10	82 07 13	1.25	4	R	1965–1974	11	17

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

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Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
307	02203543	Wilshire Canal at Tibet Avenue at Savannah, GA	GA	31 59 28	81 08 14	1.06	4	U	1979–1996	18	
308	02203544	Wilshire Canal Tributary at Windsor Road at Savannah, GA	GA	31 58 26	81 08 19	0.10	4	U	1979–1996	18	
309	02203559	Peacock Creek at Mcintosh, GA	GA	31 48 50	81 31 12	36.8	4	R	1967–1977	11	
310	02203800	South River at Bouldercrest Road at Atlanta, GA	GA	33 40 46	84 18 30	41.5	1	U	1961–1990[a]	27	
311	02203835	Shoal Creek at Line Street at Atlanta, GA	GA	33 44 48	84 16 50	3.43	1	U	1973–1996	24	
312	02203845	Shoal Creek Tributary at Glendale Drive near Atlanta, GA	GA	33 43 05	84 15 45	0.95	1	U	1963–1996	26	
313	02203884	Conley Creek at Rock Cut Road near Forest Park, GA	GA	33 38 08	84 20 37	1.88	1	U	1974–1996	21	
314	02203900	South River at Flakes Mill Road near Atlanta, GA	GA	33 39 58	84 13 29	99.0	1	U	1961–1991[a]	31	
315	02204070	South River at Klondike Road, near Lithonia, GA	GA	33 37 47	84 07 43	182	1	U	1984–2011	28	
316	02204135	Camp Creek tributary near Stockbridge, GA	GA	33 34 35	84 08 51	0.28	1	SR	1977–2006	30	
317	02205000	Wildcat Creek near Lawrenceville, GA	GA	34 00 07	84 00 18	1.28	1	U	1975–2010[a]	24	
318	02205230	Wolf Creek at Dean Road, near Suwanee, GA	GA	34 00 04	84 02 57	0.33	1	U	1987–2011	25	
319	02205500[h]	Pew Creek near Lawrenceville, GA	GA	33 56 05	84 00 60	2.43	1	U	1995–2011[a]	17	93
320	02205596	Yellow River Tributary at Plantation Road, near Lawrenceville, GA	GA	33 54 45	84 02 45	7.23	1	U	1997–2011	15	
321	02206105	Jackson Creek at Angels Lane, near Lilburn, GA	GA	33 53 12	84 12 42	0.15	1	U	1987–2011	23	
322	02206136	Jackson Creek Tributary 1 at Williams Road, near Lilburn,GA	GA	33 53 19	84 10 59	0.33	1	U	1987–2011	17	
323	02206165	Jackson Creek Tributary 2 at Worchester Place, near Lilburn, GA	GA	33 54 09	84 10 01	0.10	1	U	1987–2008	21	
324	02206465	Watson Creek Tributary 2 at Tanglewood Drive, at Snellville, GA	GA	33 51 46	84 02 07	0.20	1	U	1987–2011	25	
325	02206500	Yellow River near Snellville, GA	GA	33 51 11	84 04 45	134	1	U	1943–2002	60	
326	02207000	Garner Creek near Snellville, GA	GA	33 51 45	84 05 50	5.54	1	U	1995–2011[a]	13	
327	02207500	Yellow River near Covington, GA	GA	33 36 52	83 54 54	378	1	U	1976–1999[a]	24	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

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Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
328	02208050	Alcovy River near Lawrenceville, GA	GA	33 58 40	83 56 23	9.97	1	U	1995–2011[a]	15	
329	02208200	Beaverdam Creek tributary at Bold Springs, GA	GA	33 53 59	83 47 36	1.09	1	R	1965–1975	11	
330	02208450	Alcovy River above Covington, GA	GA	33 38 24	83 46 45	185	1	R	1973–2006	34	
331	02209000[h]	Alcovy River below Covington, GA	GA	33 30 21	83 49 30	244	1	R	1929–1965	25	79
332	02211300[h]	Towaliga River near Jackson, GA	GA	33 15 50	84 04 17	105	1	R	1961–1983	23	33
333	02211459	Big Towaliga Creek near Barnesville, GA	GA	33 04 20	84 11 04	2.36	1	R	1969–1981	13	
334	02211500[h]	Towaliga River near Forsyth, GA	GA	33 07 17	83 56 36	315	1	R	1929–1966	25	76
335	02212600	Falling Creek near Juliette, GA	GA	33 05 59	83 43 25	72.2	1	R	1965–2006	42	
336	02213050[h]	Walnut Creek near Gray, GA	GA	32 58 20	83 37 08	31.3	1	R	1962–1994	33	47
337	02213350[h]	Tobesofkee Creek below Forsyth, GA	GA	32 59 37	83 56 41	53.4	1	R	1963–1987	24	32
338	02213400[h]	Little Tobesofkee Creek near Forsyth, GA	GA	32 57 10	84 02 33	16.8	1	R	1951–1961	11	44
339	02213470[h]	Tobesofkee Creek above Macon, GA	GA	32 52 02	83 50 24	156	1	R	1967–1978	12	28
340	02214280	Savage Creek near Bullard, GA	GA	32 35 34	83 28 11	33.0	4	R	1979–2006	28	
341	02215220	Ocmulgee River tributary near Abbeville, GA	GA	32 06 54	83 24 12	1.83	4	R	1965–1975	11	
342	02215230[h]	Cedar Creek near Pineview, GA	GA	32 05 35	83 30 12	7.33	4	R	1965–1975	12	27
343	02215245	Folsom Creek tributary near Rochelle, GA	GA	32 00 20	83 26 07	1.26	4	R	1964–2006	43	
344	02215280	Ball Creek tributary near Rochelle, GA	GA	31 49 58	83 22 05	2.45	4	R	1960–1977	19	
345	02216180	Turnpike Creek near Mcrae, GA	GA	31 59 29	82 55 19	49.2	4	R	1983–2006	24	
346	02216610	Tillman Mill Creek near Lumber City, GA	GA	31 58 54	82 38 31	2.71	4	R	1966–1985	20	
347	02217000	Allen Creek at Talmo, GA	GA	34 11 34	83 43 11	18.2	1	R	1952–1974	24	
348	02217200	Middle Oconee River near Jefferson, GA	GA	34 05 46	83 36 23	135	1	R	1951–1965	15	
349	02217250	Buffalo Creek tributary near Jefferson, GA	GA	34 05 00	83 38 01	0.35	1	SR	1964–1976	13	
350	02217380	Mulberry River near Winder, GA	GA	34 03 08	83 39 49	142	1	R	1983–2006	24	
351	02217400	Mulberry River tributary near Winder, GA	GA	34 03 53	83 39 45	2.54	1	R	1965–2006	42	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

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Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydro-logic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
352	02217450[h]	Mulberry River tributary near Jefferson, GA	GA	34 04 38	83 38 53	0.67	1	SR	1965–1974	10	12
353	02217500[h]	Middle Oconee River near Athens, GA	GA	33 56 48	83 25 22	398	1	R	1929–2006	69	105
354	02217505	Brooklyn Creek at Dudley Drive, at Athens, GA	GA	33 56 32	83 24 07	1.44	1	U	1979–1994	16	
355	02217660	Little Curry Creek near Jefferson, GA	GA	34 08 25	83 32 09	0.87	1	SR	1964–1976	13	
356	02217900	North Oconee River at Athens, GA	GA	33 56 55	83 22 04	290	1	R	1929–1972	31	
357	02218100	Porters Creek at Watkinsville, GA	GA	33 50 56	83 23 42	1.95	1	R	1964–1975	12	
358	02218450[h]	Town Creek near Greensboro, GA	GA	33 38 29	83 13 36	11.9	1	R	1964–1987	24	40
359	02218565	Apalachee River at Fence Road, near Dacula, GA	GA	34 00 37	83 53 39	5.68	1	U	1994–2011	18	
360	02219000[h]	Apalachee River near Bostwick, GA	GA	33 47 17	83 28 27	176	1	R	1945–2006	34	93
361	02219500	Apalachee River near Buckhead, GA	GA	33 36 31	83 20 58	436	1	R	1901–1978	49	
362	02220550	Whitten Creek near Sparta, GA	GA	33 23 12	83 01 34	16.6	1	R	1961–1986	26	
363	02220900[h]	Little River near Eatonton, GA	GA	33 18 50	83 26 14	262	1	R	1971–2006	36	59
364	02221000[h]	Murder Creek near Monticello, GA	GA	33 24 56	83 39 43	24.0	1	R	1952–1976	25	39
365	02221525[h]	Murder Creek below Eatonton, GA	GA	33 15 08	83 28 53	190	1	R	1978–2006	29	46
366	02223300[h]	Big Sandy Creek near Jeffersonville, GA	GA	32 48 16	83 25 04	33.5	3	R	1959–1971	13	23
367	02223700	Indian Branch tributary near Scott, GA	GA	32 33 23	82 44 32	1.99	4	R	1965–1975	11	
368	02224200	Mercer Creek near Soperton, GA	GA	32 26 39	82 41 29	16.1	4	R	1965–1975	11	
369	02224400	Cypress Creek near Tarrytown, GA	GA	32 16 50	82 35 44	6.77	4	R	1965–1975	11	
370	02224650	Peterson Creek at Glenwood, GA	GA	32 10 09	82 40 00	5.16	4	R	1965–1974	10	
371	02224800	Oconee River tributary near Glenwood, GA	GA	32 03 17	82 39 08	1.18	4	R	1965–1974	10	
372	02225180	Mulepen Creek near Adrian, GA	GA	32 32 59	82 31 25	13.8	4	R	1965–1974	10	
373	02225210[h]	Hurricane Branch near Wrightsville, GA	GA	32 47 01	82 34 41	3.53	4	R	1965–1974	12	26
374	02225240	Crooked Creek near Kite, GA	GA	32 40 23	82 26 42	7.22	4	R	1965–1974	12	
375	02225330	Beaver Creek near Cobbtown, GA	GA	32 16 53	82 11 26	9.58	4	R	1965–2006	41	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

[USGS, U.S. Geological Survey; mi^2, square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydro-logic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
376	02225350	Reedy Creek tributary near Soperton, GA	GA	32 25 36	82 29 51	1.68	4	R	1965–1988	26	
377	02226030[h]	Doctors Creek near Ludowici, GA	GA	31 44 08	81 42 07	31.1	4	R	1966–1987	23	26
378	02226190[h]	Little Creek near Willacoochee, GA	GA	31 27 25	83 03 02	6.38	4	R	1965–1987	24	28
379	02226465	Dryden Creek near Dixie Union, GA	GA	31 20 24	82 28 42	13.7	4	R	1978–1988	11	
380	02226580[h]	Big Creek near Hoboken, GA	GA	31 10 29	82 11 16	53.2	4	R	1966–1987	23	26
381	02227100[h]	Little Hurricane Creek near Alma, GA	GA	31 29 45	82 31 40	52.6	4	R	1948–1962	15	61
382	02227422	Crooked Creek tributary near Bristol, GA	GA	31 26 26	82 15 02	0.38	4	SR	1976–2006	31	
383	02227990	Satilla River tributary at Atkinson, GA	GA	31 13 33	81 51 09	0.59	4	SR	1977–2006	29	
384	02228055	Satilla River tributary near Winokur, GA	GA	30 59 60	81 57 29	1.91	4	R	1980–1989	10	
385	02246497	McCoy Creek at Jacksonville, FL	FL	30 19 35	81 41 56	1.64	4	U	1976–1988	13	
386	02246522	Red Bay Branch Tributary at Jacksonville, FL	FL	30 20 40	81 35 22	0.43	4	U	1975–1986	12	
387	02315650	Alapaha River tributary near Pitts, GA	GA	32 00 21	83 33 27	0.11	4	SR	1965–1975	11	
388	02315670	Alapaha River tributary near Rochelle, GA	GA	31 56 41	83 30 52	2.87	4	R	1965–1975	11	
389	02315980	Jacks Creek near Ocilla, GA	GA	31 33 39	83 21 28	1.21	4	R	1960–1975	18	
390	02316220	Little Brushy Creek near Ocilla, GA	GA	31 36 31	83 13 56	1.65	4	R	1966–1975	11	
391	02316260	Alapaha River tributary near Willacoochee, GA	GA	31 16 51	83 03 45	3.19	4	R	1965–1975	11	
392	02317730[h]	New River tributary near Nashville, GA	GA	31 17 19	83 20 36	1.16	4	R	1960–1975	18	27
393	02317760	Little River near Ashburn, GA	GA	31 41 33	83 42 08	8.54	4	R	1965–1975	12	
394	02317765	Newell Branch near Worth, GA	GA	31 44 21	83 43 30	1.15	4	R	1965–1975	11	
395	02317770[h]	Newell Branch near Ashburn, GA	GA	31 41 47	83 41 51	6.48	4	R	1965–1975	13	29
396	02317775[h]	Daniels Creek near Ashburn, GA	GA	31 40 41	83 45 06	1.11	4	R	1965–1993	25	29
397	02317780[h]	Lime Sink Creek near Sycamore, GA	GA	31 36 21	83 40 31	2.59	4	R	1965–1993	22	30
398	02317795[h]	Mill Creek near Tifton, GA	GA	31 29 37	83 34 04	6.21	4	R	1965–1975	14	
399	02317810	Arnold Creek tributary near Tifton, GA	GA	31 25 31	83 34 23	0.16	4	SR	1965–2002	37	
400	02317840	Warrior Creek near Sylvester, GA	GA	31 33 11	83 48 53	8.23	4	R	1965–1975	13	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

[USGS, U.S. Geological Survey; mi^2, square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
401	02317845	Warrior Creek tributary near Sylvester, GA	GA	31 32 55	83 49 11	1.64	4	R	1965–1975	11	
402	02317890	Little Creek near Sylvester, GA	GA	31 36 49	83 45 29	0.31	4	SR	1965–1975	11	
403	02317900[h]	Ty Ty Creek at Ty Ty, GA	GA	31 28 23	83 39 47	47.0	4	R	1948–1991	32	64
404	02317905[h]	Little Creek near Omega, GA	GA	31 23 36	83 37 60	4.22	4	R	1965–1991	14	27
405	02317910[h]	Ty Ty Creek tributary at Crosland, GA	GA	31 19 18	83 37 24	1.86	4	R	1960–1986	17	27
406	02334885	Suwanee Creek at Suwanee, GA	GA	34 01 56	84 05 22	47.0	1	U	1985–2011	27	
407	02335347	Crooked Creek Tributary 2, near Norcross, GA	GA	33 57 24	84 14 43	0.19	1	U	1987–2008	22	
408	02335700	Big Creek near Alpharetta, GA	GA	34 03 02	84 16 10	72.0	1	U	1961–2011	51	
409	02335870	Sope Creek near Marietta, GA	GA	33 57 14	84 26 36	30.7	1	U	1985–2011[a]	27	
410	02336080	North Fork Peachtree Creek at Shallowford Road, near Chamblee, GA	GA	33 51 43	84 17 13	19.1	1	U	1961–1990	22	
411	02336102	North Fork Peachtree Creek Tributary at Drew Valley Road, near Atlanta, GA	GA	33 51 20	84 19 19	2.30	1	U	1973–1996	23	
412	02336238	South Fork Peachtree Creek Tributary at East Rock Springs Road, near Atlanta,GA	GA	33 47 11	84 20 29	0.92	1	U	1974–1996	23	
413	02336300	Peachtree Creek at Atlanta, GA	GA	33 49 10	84 24 28	86.8	1	U	1970–2011[a]	42	
414	02336360	Nancy Creek at Rickenbacker Drive, at Atlanta, GA	GA	33 52 09	84 22 44	26.6	1	U	1961–2011	18	
415	02336635[h]	Nickajack Creek at US Highway 78/278, near Mableton, GA	GA	33 48 12	84 31 17	31.5	1	U	1990–2011[a]	16	93
416	02336700	South Utoy Creek Tributary at Headland Drive at East Point, GA	GA	33 41 25	84 28 05	0.68	1	U	1964–1996	32	
417	02336705	South Utoy Creek at Adams Drive, at Atlanta, GA	GA	33 42 57	84 29 11	8.80	1	U	1961–1983	11	
418	02337000[h]	Sweetwater Creek near Austell, GA	GA	33 46 22	84 36 53	246	1	R	1904–2006	70	103
419	02337400[h]	Dog River near Douglasville, GA	GA	33 39 36	84 51 41	47.0	1	R	1951–1977	27	40
420	02337448	Hurricane Creek tributary near Fairplay, GA	GA	33 35 03	84 50 54	0.31	1	SR	1977–2006	30	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

[USGS, U.S. Geological Survey; mi², square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi²)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
421	02337500	Snake Creek near Whitesburg, GA	GA	33 31 46	84 55 42	35.5	1	R	1955–2001	47	
422	02338660	New River near Corinth, GA	GA	33 14 07	84 59 16	127	1	R	1979–2006	28	
423	02338840	Yellowjacket Creek below Hogansville, GA	GA	33 08 22	84 58 31	91.0	1	R	1979–2006	13	
424	02339000	Yellowjacket Creek near La Grange, GA	GA	33 05 27	85 03 40	182	1	R	1951–1971	21	
425	02340250	Flat Shoal Creek near West Point, GA	GA	32 52 53	85 04 41	204	1	R	1948–2006	29	
426	02340500	Mountain Oak Creek near Hamilton, GA	GA	32 44 28	85 04 08	61.7	1	R	1944–1973	30	
427	02341220	Mulberry Creek near Mulberry Grove, GA	GA	32 42 11	84 57 29	190	1	R	1984–2006	22	
428	02341544	Mill Branch at Chalbena Road, at Columbus, GA	GA	32 28 20	84 53 58	1.58	3	U	1977–1996	20	
429	02341546	Bull Creek Tributary at Woodland Drive, at Columbus, GA	GA	32 28 39	84 55 36	0.22	3	U	1977–1996	19	
430	02341548	Lindsey Creek Tributary at Canberra Avenue, at Columbus, GA	GA	32 31 34	84 56 21	1.59	1	U	1978–1996	19	
431	02341600	Juniper Creek near Geneva, GA	GA	32 31 42	84 34 14	47.4	3	R	1963–2006	44	
432	02341723	Pine Knot Creek near Juniper, GA	GA	32 26 15	84 39 25	31.4	3	R	1979–2006	27	
433	02343219	Bluff Springs Branch near Lumpkin, GA	GA	32 01 53	84 53 18	2.98	4	R	1977–2006	30	
434	02343244[h]	Cemochechobee Creek near Coleman, GA	GA	31 39 12	84 53 02	15.3	4	R	1984–2006	22	59
435	02343267[h]	Temple Creek near Blakely, GA	GA	31 26 35	84 58 60	2.64	4	R	1978–2006	28	59
436	02344700	Line Creek near Senoia, GA	GA	33 19 09	84 31 20	101	1	R	1965–2006	42	
437	02346193[h]	Scott Creek near Talbotton, GA	GA	32 39 48	84 36 06	3.36	1	R	1969–1987	19	26
438	02346195[h]	Lazer Creek near Talbotton, GA	GA	32 44 33	84 33 20	81.3	1	R	1981–2006	24	36
439	02346210[h]	Kimbrough Creek near Talbotton, GA	GA	32 41 19	84 30 48	6.62	1	R	1969–1987	19	43
440	02346217	Coleoatchee Creek near Manchester, GA	GA	32 49 20	84 36 16	2.82	1	R	1969–2006	37	
441	02346500[h]	Potato Creek near Thomaston, GA	GA	32 54 15	84 21 45	186	1	R	1938–1973	36	57
442	02348300[h]	Patsiliga Creek near Reynolds, GA	GA	32 34 21	84 05 27	131	3	R	1963–1984	22	32
443	02348485[h]	Whitewater Creek near Butler, GA	GA	32 30 15	84 20 03	17.3	3	R	1979–2002	22	59

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

[USGS, U.S. Geological Survey; mi^2, square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydrologic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
444	02349030	Cedar Creek near Rupert, GA	GA	32 23 22	84 17 49	41.1	3	R	1979–2005	27	
445	02349330	Buck Creek tributary near Tazewell, GA	GA	32 20 50	84 22 26	0.40	3	SR	1977–2006	30	
446	02349350	Buck Creek tributary near Ellaville, GA	GA	32 18 36	84 17 36	146	3	R	1979–2006	28	
447	02349695	Horsehead Creek near Montezuma, GA	GA	32 21 28	83 56 12	0.72	4	SR	1977–2006	30	
448	02349900	Turkey Creek at Byromville, GA	GA	32 11 44	83 54 08	45.0	4	R	1951–2006	56	
449	02350520[h]	Abrams Creek tributary near Doles, GA	GA	31 40 47	83 48 04	3.77	4	R	1965–1975	13	30
450	02350685	Choctahatchee Creek tributary near Plains, GA	GA	32 02 03	84 26 01	0.30	4	SR	1977–2006	29	
451	02351800[h]	Muckaloochee Creek at Smithville, GA	GA	31 54 20	84 14 44	47.0	4	R	1948–1978	29	79
452	02352605	Emily Avenue Canal at Albany, GA	GA	31 32 53	84 09 28	0.21	4	U	1987–1996	10	
453	02353200	Little Ichawaynochaway Creek near Shellman, GA	GA	31 46 46	84 36 13	48.8	4	R	1951–1962	12	
454	02356100	Spring Creek near Arlington, GA	GA	31 24 48	84 46 33	49.0	4	R	1951–1980	26	
455	02383000[h]	Rock Creek near Fairmount, GA	GA	34 21 32	84 46 46	6.17	1	R	1952–1974	23	39
456	02383200[h]	Redbud Creek near Ranger, GA	GA	34 31 57	84 43 39	1.61	1	R	1964–1974	11	40
457	02384600	Pinhook Creek near Eton, GA	GA	34 49 34	84 48 54	3.78	1	R	1964–2006	43	
458	02385000[h]	Coahulla Creek near Varnell, GA	GA	34 53 43	84 55 15	86.7	1	R	1940–1962	16	43
459	02387100[h]	Polecat Creek near Spring Place, GA	GA	34 39 08	84 50 33	1.40	1	R	1964–1974	11	27
460	02387200	Beamer Creek near Spring Place, GA	GA	34 38 03	84 51 52	1.66	1	R	1964–1974	11	
461	02387300	Dead Mans Branch near Resaca, GA	GA	34 35 44	84 52 11	0.28	1	SR	1965–1987	23	
462	02387560[h]	Oothkalooga Creek tributary at Adairsville, GA	GA	34 21 34	84 55 20	3.56	1	R	1965–1974	10	26
463	02387570[h]	Oothkalooga Creek at Adairsville, GA	GA	34 22 40	84 56 34	21.7	1	R	1964–1974	11	27
464	02387700	Rocky Creek at Curryville, GA	GA	34 26 44	85 05 12	8.61	1	R	1965–1974	10	
465	02387800[h]	Bailey Creek near Villanow, GA	GA	34 40 10	85 05 40	3.82	1	R	1965–1974	10	26
466	02388000[h]	West Armuchee Creek near Subligna, GA	GA	34 34 04	85 09 37	36.4	1	R	1961–1981	21	40
467	02388200[h]	Storey Mill Creek near Summerville, GA	GA	34 25 14	85 16 35	6.02	1	R	1966–1987	22	40

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

[USGS, U.S. Geological Survey; mi^2, square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydro-logic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
468	02388300	Heath Creek near Rome, GA	GA	34 21 57	85 16 17	14.7	1	R	1969–1990	22	
469	02388400[h]	Dozier Creek near Shannon, GA	GA	34 18 53	85 05 47	2.84	1	R	1965–1974	10	26
470	02389300[h]	Shoal Creek near Dawsonville, GA	GA	34 25 13	84 08 47	21.7	1	R	1959–1974	16	24
471	02392950[n]	Noonday Creek at Hawkins Store Road, near Woodstock,GA	GA	34 03 23	84 32 08	25.5	1	U	1999–2011	13	
472	02392975	Noonday Creek at Shallowford Road, near Woodstock,GA	GA	34 04 06	84 32 08	33.6	1	U	1999–2011	13	
473	02394400[h]	Pumpkinvine Creek below Dallas, GA	GA	33 54 59	84 52 41	42.8	1	R	1951–1977	27	40
474	02394820[h]	Euharlee Creek at Rockmart, GA	GA	33 59 55	85 03 09	42.1	1	R	1984–2006	23	93
475	02394950[h]	Hills Creek near Taylorsville, GA	GA	34 04 32	84 57 02	25.0	1	R	1960–1974	15	31
476	02395120	Two Run Creek near Kingston, GA	GA	34 14 34	84 53 23	33.1	1	R	1981–2006	26	
477	02395990	Etowah River Tributary at Atteiram Drive at Rome, GA	GA	34 16 02	85 08 18	0.33	1	U	1979–1997	19	
478	02396550	Silver Creek Tributary 3 at US Highway 27 at Rome, GA	GA	34 13 26	85 09 14	0.25	1	U	1979–1997	19	
479	02397410[h]	Cedar Creek at Cedartown, GA	GA	33 59 45	85 15 53	66.9	1	R	1949–1997	27	112
480	02397500[h]	Cedar Creek near Cedartown, GA	GA	34 03 41	85 18 47	115	1	R	1943–2006	36	121
481	02397750[h]	Duck Creek above Lafayette, GA	GA	34 42 16	85 19 51	6.70	1	R	1965–1974	10	26
482	02397830	Harrisburg Creek near Hawkins, GA	GA	34 36 02	85 23 21	13.3	1	R	1980–2006	27	
483	02398000	Chattooga River at Summerville, GA	GA	34 27 59	85 20 10	192	1	R	1938–2006	69	
484	02411735	Mcclendon Creek tributary near Dallas, GA	GA	33 50 58	84 57 20	0.94	1	SR	1977–2006	29	
485	02411800[h]	Little River near Buchanan, GA	GA	33 47 51	85 07 03	20.2	1	R	1960–1985	26	31
486	02411900[h]	Tallapoosa River at Tallapoosa, GA	GA	33 46 27	85 17 60	236	1	R	1951–1977	27	72
487	02411902	Mann Creek tributary near Tallapoosa, GA	GA	33 51 16	85 17 28	0.12	1	SR	1977–2006	29	
488	02413000	Little Tallapoosa River at Carrollton, GA	GA	33 35 50	85 04 49	95.1	1	R	1936–1965	29	

Table 1. Summary of U.S. Geological Survey streamflow-gaging stations that were considered for use in the regional regression analysis, 2011.—Continued

[USGS, U.S. Geological Survey; mi^2, square mile; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	Station name	State	Latitude (degree minute second)	Longitude (degree minute second)	Drainage area (mi^2)	Hydro-logic region (fig. 2)	Type	Period of record	Number of annual peaks	Historic period of record (years)
489	02413200[h]	Little Tallapoosa River near Bowden, GA	GA	33 30 46	85 14 03	220	1	R	1949–1977	29	55
490	03566660[h]	Sugar Creek near Ringgold, GA	GA	34 58 14	85 01 29	4.44	1	R	1965–1974	10	124
491	03566685[h]	Little Chickamauga Creek near Ringgold, GA	GA	34 50 32	85 08 28	35.5	1	R	1964–1975	12	109
492	03566687[h]	Little Chickamauga Creek tributary near Ringgold, GA	GA	34 51 36	85 08 40	3.36	1	R	1965–1974	10	124
493	03566700[h]	South Chickamauga Creek at Ringgold, GA	GA	34 55 07	85 07 32	169	1	R	1949–1965	17	124
494	03567200[h]	West Chickamauga Creek near Kensington, GA	GA	34 48 10	85 20 52	73.0	1	R	1950–1976	27	43
495	03568500	Chattanooga Creek near Flintstone, GA	GA	34 58 20	85 19 40	50.6	1	R	1951–1974	24	
496	03568933	Lookout Creek near New England, GA	GA	34 53 51	85 27 47	149	1	R	1980–2006	27	

[h] Peak-flow record adjusted for historical period.

[a] Homogenous portion of peak-flow record used in the flood-frequency analysis.

[r] Peak-flow record available for station includes regulated period that was not used in the regression analysis.

[d] Removed from regression analysis based on diagnostic statistics.

[c] Peaks at indicated station were combined with peaks at an adjacent nearby station on the same stream.

[n] Not included in regression due to nesting.

[b] Drainage area revised as a result of this study.

[m] Extended record using MOVE.1 analysis.

[s] Not included in Southeast rural flood-frequency study by Feaster and others, 2009.

Table 5. Magnitude and frequency of P-percent annual exceedance probability floods determined from at-site analysis, regional regression equations, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regresssion analysis.

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B/Expected Moments Algorithm (EMA) analysis of the streamgaging station; R, estimated from the regression equation; W, weighted using equation 12; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Flow, in cubic feet per second											
		50-percent AEP			20-percent AEP			10-percent AEP			4-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
23	02068610	129	73.5	121	186	123	171	226	161	205	278	212	255
31	02077210	46.5	60.8	50	83.9	103	91.9	116	134	125	164	177	172
42	02082540	57.7	74	63.6	114	125	120	163	163	163	239	216	223
55	02085020	89.1	144	100	166	247	195	229	328	272	324	442	382
64	02086849	1,980	1,870	1,980	2,390	2,860	2,410	2,620	3,540	2,670	2,870	4,410	2,970
66	02087140	111	171	122	196	272	222	263	346	297	359	444	399
67	02087240	50.1	64.3	52.4	85.7	107	91.4	114	138	122	155	181	166
68	0208726005	2,270	3,510	2,480	3,930	5,400	4,200	5,180	6,710	5,500	6,890	8,380	7,260
69	02087275	3,960	---	---	6,120	---	---	7,780	---	---	10,100	---	---
70	02087324	3,440	4,560	3,570	5,450	6,980	5,720	7,290	8,670	7,620	10,400	10,800	10,500
71	0208732885	918	1,190	955	1,690	1,740	1,700	2,370	2,110	2,290	3,460	2,570	3,050
72	0208735012	1,260	---	---	1,910	---	---	2,360	---	---	2,970	---	---
73	02087359	1,440	2,280	1,610	2,650	3,450	2,930	3,870	4,270	4,060	6,100	5,260	5,550
74	02087580	1,840	1,630	1,800	2,760	2,560	2,700	3,590	3,230	3,430	4,920	4,080	4,440
94	02093229	323	312	320	568	514	557	729	661	715	927	853	906
98	0209399200	1,110	1,640	1,260	2,030	2,480	2,190	2,740	3,060	2,880	3,750	3,780	3,770
99	02094659	1,860	1,630	1,830	2,700	2,210	2,610	3,260	2,580	3,090	3,990	3,020	3,670
100	02094770	1,670	2,390	1,720	2,240	3,250	2,330	2,610	3,800	2,760	3,090	4,450	3,330
101	02095000	2,810	3,430	2,820	3,200	4,730	3,230	3,440	5,580	3,510	3,720	6,580	3,850
102	02095181	1,770	---	---	2,180	---	---	2,350	---	---	2,500	---	---
103	02095271	2,050	1,950	2,040	2,770	2,770	2,770	3,210	3,310	3,230	3,720	3,960	3,760
104	02095500	2,850	3,080	2,870	4,490	4,440	4,480	5,700	5,330	5,640	7,350	6,430	7,130
105	0209553650	5,060	4,860	5,050	5,870	7,000	5,900	6,310	8,430	6,380	6,790	10,100	6,940
114	0209782609*	665	982	791	1,530	1,640	1,600	2,590	2,120	2,250	4,880	2,760	3,080
119	02101480	148	156	150	268	266	267	363	352	358	495	471	484
134	02106410	57.8	49.3	56.5	97.3	92.3	96.2	128	127	128	171	176	173
136	02107590	32.1	52.4	36.2	68.5	99.3	77.1	101	137	113	151	192	168
146	02110740	292	147	284	375	230	367	428	288	419	491	361	483
149	02115520	226	157	214	352	271	329	442	361	414	562	486	533
151	02115845	1,620	811	1,570	2,010	1,270	1,950	2,260	1,590	2,190	2,550	2,000	2,470

Table 5. Magnitude and frequency of P-percent annual exceedance probability floods determined from at-site analysis, regional regression equations, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B/Expected Moments Algorithm (EMA) analysis of the streamgaging station; R, estimated from the regression equation; W, weighted using equation 12; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Flow, in cubic feet per second											
		2-percent AEP			1-percent AEP			0.5-percent AEP			0.2-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
23	02068610	319	253	295	361	296	337	404	340	379	465	402	438
31	02077210	207	211	210	256	247	250	311	284	294	395	337	355
42	02082540	306	258	272	382	303	324	468	349	379	598	412	453
55	02085020	406	535	475	495	634	572	596	740	678	745	871	822
64	02086849	3,040	5,040	3,200	3,190	5,660	3,410	3,330	6,300	3,630	3,510	7,140	3,930
66	02087140	439	519	480	525	597	563	619	676	651	753	782	770
67	02087240	190	214	201	227	249	237	269	286	277	330	337	334
68	0208726005	8,240	9,590	8,650	9,640	10,800	10,100	11,100	12,100	11,500	13,100	13,700	13,400
69	02087275	12,100	---	---	14,200	---	---	16,400	---	---	19,800	---	---
70	02087324	13,300	12,300	12,800	17,000	13,900	15,200	21,400	15,400	17,400	28,900	17,500	20,300
71	0208732885	4,460	2,900	3,580	5,640	3,210	4,120	7,030	3,530	4,600	9,250	3,940	5,220
72	0208735012	3,430	---	---	3,910	---	---	4,400	---	---	5,070	---	---
73	02087359	8,390	6,000	6,590	11,400	6,730	7,580	15,300	7,460	8,510	22,400	8,430	9,710
74	02087580	6,170	4,720	5,210	7,690	5,360	5,990	9,510	6,010	6,760	12,500	6,900	7,800
94	02093229	1,070	1,000	1,050	1,200	1,160	1,180	1,320	1,310	1,320	1,470	1,530	1,500
98	0209399200	4,570	4,320	4,420	5,450	4,840	5,050	6,370	5,360	5,660	7,670	6,070	6,470
99	02094659	4,540	3,320	4,060	5,090	3,610	4,440	5,650	3,870	4,780	6,410	4,220	5,230
100	02094770	3,440	4,900	3,760	3,790	5,310	4,190	4,150	5,710	4,620	4,630	6,220	5,170
101	02095000	3,910	7,280	4,080	4,100	7,930	4,330	4,280	8,570	4,590	4,510	9,380	4,910
102	02095181	2,580	---	---	2,640	---	---	2,680	---	---	2,720	---	---
103	02095271	4,070	4,420	4,140	4,400	4,860	4,500	4,720	5,300	4,870	5,110	5,860	5,330
104	02095500	8,650	7,210	8,220	10,000	7,960	9,270	11,500	8,690	10,300	13,500	9,660	11,700
105	0209553650	7,100	11,400	7,330	7,400	12,600	7,730	7,660	13,700	8,110	7,960	15,200	8,580
114	0209782609*	7,640	3,250	3,670	11,800	3,760	4,270	17,900	4,280	4,850	30,600	5,000	5,650
119	02101480	604	568	586	719	670	694	841	780	809	1,010	914	955
134	02106410	207	216	210	246	260	251	288	305	295	348	372	359
136	02107590	196	237	215	246	286	266	302	337	321	386	413	401
146	02110740	537	417	528	582	472	573	627	526	617	684	601	675
149	02115520	656	589	628	752	697	728	851	815	835	989	959	975
151	02115845	2,770	2,300	2,680	2,980	2,600	2,900	3,190	2,900	3,120	3,470	3,320	3,430

Table 5. Magnitude and frequency of P-percent annual exceedance probability floods determined from at-site analysis, regional regression equations, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B/Expected Moments Algorithm (EMA) analysis of the streamgaging station; R, estimated from the regression equation; W, weighted using equation 12; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Flow, in cubic feet per second											
		50-percent AEP			20-percent AEP			10-percent AEP			4-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
166	0212414900	3,000	2,360	2,870	5,000	3,610	4,540	6,850	4,490	5,780	9,950	5,580	7,280
170	02127390	180	164	177	285	279	283	361	370	364	462	497	475
172	02129530	17.0	9.89	15.7	28.6	16.8	26.2	37.9	22.3	34.3	51.5	30.3	45.8
175	02131130	611	355	609	693	452	691	745	514	742	804	583	798
186	02135518	301	222	298	411	334	406	482	412	476	571	512	565
189	0214266000	979	1,820	1,150	1,770	2,880	2,130	2,530	3,630	3,020	3,840	4,590	4,300
190	02142900	1,540	1,610	1,550	2,300	2,460	2,310	2,870	3,050	2,890	3,670	3,780	3,690
191	0214291555	1,990	2,150	2,020	3,100	3,330	3,150	3,870	4,160	3,950	4,880	5,210	4,990
192	0214295600	1,170	1,220	1,180	1,880	1,880	1,880	2,390	2,350	2,380	3,070	2,930	3,020
195	02145940	873	738	869	1,010	1,120	1,010	1,090	1,380	1,100	1,170	1,710	1,200
196	02146211	893	1,010	905	1,380	1,520	1,410	1,840	1,870	1,850	2,630	2,300	2,470
197	0214627970	2,490	1,480	2,280	3,720	2,130	3,340	4,520	2,560	3,970	5,510	3,080	4,610
198	02146300	4,110	3,130	4,060	5,900	4,380	5,770	7,280	5,180	7,010	9,230	6,140	8,540
199	02146315	1,710	1,270	1,600	2,530	1,780	2,390	3,080	2,110	2,840	3,760	2,510	3,320
200	02146348	791	1,240	856	1,180	1,870	1,280	1,430	2,300	1,580	1,730	2,840	1,980
201	02146381	3,510	4,630	3,610	5,160	6,470	5,380	6,530	7,670	6,800	8,610	9,100	8,790
202	02146409	3,320	2,490	3,260	4,260	3,230	4,190	4,730	3,690	4,670	5,210	4,210	5,140
203	0214642825	1,480	906	1,410	2,110	1,370	1,960	2,610	1,690	2,340	3,340	2,100	2,820
204	0214645022	2,660	1,920	2,560	3,940	2,860	3,730	4,900	3,500	4,540	6,220	4,290	5,550
205	02146470	1,130	879	1,100	1,700	1,200	1,610	2,090	1,400	1,920	2,590	1,630	2,300
206	02146500	3,890	2,790	3,850	5,350	4,180	5,300	6,310	5,130	6,240	7,530	6,310	7,420
207	02146507	6,810	3,600	6,630	9,420	5,060	9,060	11,200	6,030	10,600	13,600	7,180	12,500
208	02146530	4,850	3,910	4,750	6,850	5,480	6,630	8,360	6,520	7,930	10,400	7,760	9,530
209	0214655255	1,190	951	1,060	2,720	1,490	1,990	4,050	1,880	2,590	6,040	2,370	3,250
210	02146562	906	998	939	1,920	1,490	1,700	2,900	1,830	2,230	4,560	2,250	2,850
211	0214657975*	1,200	815	1,070	1,990	1,360	1,790	2,520	1,760	2,250	3,190	2,290	2,830
212	02146600	3,720	2,580	3,670	5,130	3,920	5,060	6,030	4,840	5,940	7,140	6,000	7,020
213	02146700	1,700	991	1,640	2,550	1,530	2,450	3,120	1,900	2,970	3,850	2,380	3,580

Table 5. Magnitude and frequency of P-percent annual exceedance probability floods determined from at-site analysis, regional regression equations, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B/Expected Moments Algorithm (EMA) analysis of the streamgaging station; R, estimated from the regression equation; W, weighted using equation 12; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Flow, in cubic feet per second											
		2-percent AEP			1-percent AEP			0.5-percent AEP			0.2-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
166	0212414900	13,000	6,380	8,290	16,600	7,190	9,260	21,200	8,000	10,200	28,900	9,080	11,500
170	02127390	540	598	563	621	708	656	705	824	754	820	968	887
172	02129530	63.0	37.0	55.2	75.9	44.4	65.7	89.9	52.5	77.0	111	64.6	93.7
175	02131130	845	631	838	887	675	878	929	714	917	982	766	968
186	02135518	635	585	628	701	658	694	766	731	759	851	828	846
189	0214266000	5,120	5,310	5,250	6,730	6,030	6,200	8,750	6,760	7,120	12,200	7,760	8,380
190	02142900	4,310	4,330	4,310	5,010	4,880	4,970	5,750	5,410	5,630	6,840	6,140	6,540
191	0214291555	5,640	5,980	5,780	6,400	6,760	6,560	7,180	7,550	7,360	8,220	8,590	8,430
192	0214295600	3,590	3,370	3,500	4,140	3,790	3,980	4,700	4,230	4,460	5,470	4,810	5,090
195	02145940	1,230	1,950	1,270	1,280	2,180	1,330	1,320	2,420	1,400	1,380	2,740	1,490
196	02146211	3,430	2,610	2,940	4,430	2,920	3,370	5,690	3,230	3,780	7,910	3,640	4,330
197	0214627970	6,220	3,440	5,050	6,930	3,800	5,440	7,600	4,160	5,790	8,490	4,610	6,240
198	02146300	10,800	6,810	9,650	12,600	7,450	10,800	14,600	8,050	11,800	17,400	8,850	13,100
199	02146315	4,260	2,790	3,630	4,740	3,060	3,940	5,240	3,320	4,230	5,860	3,660	4,640
200	02146348	1,930	3,240	2,300	2,130	3,630	2,620	2,310	4,020	2,950	2,540	4,540	3,370
201	02146381	10,500	10,100	10,300	12,600	11,000	11,700	15,000	12,000	13,100	18,800	13,200	14,800
202	02146409	5,500	4,550	5,410	5,740	4,860	5,650	5,960	5,160	5,860	6,170	5,520	6,070
203	0214642825	3,960	2,390	3,140	4,660	2,690	3,460	5,450	2,980	3,790	6,640	3,370	4,230
204	0214645022	7,290	4,850	6,270	8,450	5,410	6,980	9,680	5,970	7,680	11,500	6,700	8,600
205	02146470	2,970	1,800	2,570	3,360	1,960	2,820	3,750	2,110	3,070	4,270	2,300	3,290
206	02146500	8,430	7,180	8,280	9,330	8,040	9,130	10,300	8,870	10,000	11,500	10,000	11,200
207	02146507	15,500	7,980	13,700	17,400	8,750	15,000	19,500	9,510	16,200	22,200	10,500	17,700
208	02146530	12,100	8,630	10,700	13,900	9,460	11,800	15,900	10,300	12,900	18,700	11,300	14,400
209	0214655255	7,690	2,730	3,650	9,480	3,100	4,050	11,400	3,470	4,430	14,100	3,970	4,950
210	02146562	6,170	2,560	3,260	8,110	2,860	3,650	10,500	3,160	4,020	14,400	3,560	4,540
211	0214657975*	3,680	2,700	3,230	4,160	3,120	3,630	4,630	3,560	4,050	5,240	4,160	4,600
212	02146600	7,940	6,840	7,790	8,750	7,670	8,570	9,530	8,530	9,330	10,600	9,640	10,400
213	02146700	4,400	2,720	4,010	4,950	3,080	4,440	5,500	3,420	4,840	6,240	3,900	5,390

Table 5. Magnitude and frequency of P-percent annual exceedance probability floods determined from at-site analysis, regional regression equations, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B/Expected Moments Algorithm (EMA) analysis of the streamgaging station; R, estimated from the regression equation; W, weighted using equation 12; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Flow, in cubic feet per second											
		50-percent AEP			20-percent AEP			10-percent AEP			4-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
214	02146750	5,120	4,190	5,070	7,110	6,320	7,070	8,300	7,780	8,270	9,680	9,590	9,680
215	0214678175	953	1,250	986	1,420	1,810	1,490	1,770	2,180	1,870	2,260	2,640	2,390
231	02159785	146	150	146	207	218	208	243	262	246	286	316	291
233	02160325	752	1,180	787	1,210	1,800	1,330	1,760	2,230	1,910	2,910	2,770	2,840
236	02162093	1,400	1,300	1,400	1,750	1,660	1,750	1,970	1,890	1,970	2,230	2,190	2,230
237	02164000	2,400	2,850	2,430	3,480	4,360	3,570	4,260	5,400	4,410	5,310	6,700	5,580
238	02164011	944	1,030	947	1,170	1,380	1,180	1,290	1,600	1,300	1,420	1,850	1,440
241	02166975	198	---	---	234	---	---	253	---	---	274	---	---
242	02167020	172	180	172	212	234	212	243	270	244	289	316	290
245	02168845	154	188	155	191	256	196	216	297	226	249	344	266
246	02169505	1,010	794	1,010	1,170	1,000	1,170	1,260	1,140	1,260	1,360	1,320	1,360
248	02169568	710	532	698	1,090	705	1,060	1,390	820	1,330	1,830	971	1,680
249	02169570	1,110	---	---	1,630	---	---	2,010	---	---	2,520	---	---
252	02173491	219	124	215	290	175	283	336	210	326	394	251	378
253	02173495	925	---	---	1,320	---	---	1,620	---	---	2,040	---	---
255	02176380	81.1	161	85.1	122	251	134	156	316	178	208	401	251
262	02189030	138	93.1	136	157	154	157	167	199	168	180	261	184
266	02190800	169	111	151	311	188	252	422	246	326	581	327	430
269	02191280	121	105	120	164	168	164	191	214	194	225	274	233
285	02196725	147	318	154	188	412	194	210	474	216	234	553	244
286	02196760	345	386	347	493	512	494	600	597	600	746	706	744
295	02201250	41.0	52.2	43.1	70.5	96.2	75.9	93.3	132	103	126	182	142
307	02203543	254	173	247	371	267	351	481	333	441	665	417	561
308	02203544	82.8	33.1	81.1	101	54.3	99.2	111	69.5	109	121	89.1	119
310	02203800	3,800	3,460	3,770	5,640	4,900	5,570	6,680	5,860	6,610	7,830	7,000	7,720
311	02203835	714	594	706	1,000	953	995	1,220	1,210	1,220	1,530	1,540	1,530
312	02203845	428	333	417	590	473	579	670	562	659	748	671	736
313	02203884	671	593	665	929	836	917	1,100	993	1,080	1,300	1,180	1,280
314	02203900	5,260	4,800	5,230	7,600	7,050	7,560	9,060	8,550	9,010	10,800	10,400	10,700

Table 5. Magnitude and frequency of P-percent annual exceedance probability floods determined from at-site analysis, regional regression equations, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B/Expected Moments Algorithm (EMA) analysis of the streamgaging station; R, estimated from the regression equation; W, weighted using equation 12; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Flow, in cubic feet per second											
		2-percent AEP			1-percent AEP			0.5-percent AEP			0.2-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
214	02146750	10,600	10,900	10,600	11,500	12,200	11,600	12,300	13,600	12,500	13,300	15,300	13,700
215	0214678175	2,660	2,960	2,780	3,100	3,270	3,180	3,560	3,580	3,570	4,240	3,990	4,090
231	02159785	316	355	325	344	393	356	370	430	386	403	484	428
233	02160325	4,280	3,170	3,530	6,310	3,560	4,170	9,310	3,960	4,760	15,600	4,500	5,490
236	02162093	2,410	2,420	2,410	2,590	2,640	2,590	2,760	2,880	2,770	2,990	3,180	3,000
237	02164000	6,140	7,660	6,520	7,010	8,610	7,490	7,940	9,570	8,510	9,250	10,900	9,900
238	02164011	1,510	2,030	1,540	1,580	2,200	1,630	1,650	2,370	1,710	1,720	2,560	1,820
241	02166975	287	---	---	299	---	---	310	---	---	323	---	---
242	02167020	328	351	330	370	385	372	417	421	417	488	469	484
245	02168845	275	378	297	302	408	331	330	437	363	369	484	411
246	02169505	1,430	1,450	1,430	1,490	1,570	1,490	1,560	1,710	1,560	1,630	1,880	1,640
248	02169568	2,210	1,090	1,970	2,630	1,200	2,240	3,110	1,320	2,530	3,830	1,480	2,910
249	02169570	2,930	---	---	3,350	---	---	3,800	---	---	4,430	---	---
252	02173491	437	280	415	479	308	450	521	335	485	577	371	530
253	02173495	2,400	---	---	2,780	---	---	3,200	---	---	3,820	---	---
255	02176380	253	466	314	306	530	386	366	596	464	460	684	570
262	02189030	189	310	197	197	361	209	205	413	220	214	484	235
266	02190800	711	391	511	851	458	601	1,000	530	692	1,210	622	807
269	02191280	249	321	262	273	368	291	296	417	319	327	484	359
285	02196725	249	614	263	262	673	282	274	735	300	288	817	323
286	02196760	863	789	857	984	873	973	1,120	959	1,100	1,300	1,080	1,270
295	02201250	153	222	175	182	266	210	213	313	249	258	379	304
307	02203543	843	480	650	1,060	542	733	1,340	604	820	1,800	689	934
308	02203544	128	104	126	135	119	134	140	134	139	147	155	148
310	02203800	8,570	7,800	8,430	9,230	8,570	9,070	9,790	9,330	9,660	10,500	10,300	10,400
311	02203835	1,780	1,790	1,780	2,050	2,040	2,050	2,340	2,300	2,320	2,770	2,650	2,710
312	02203845	794	750	785	830	826	829	859	902	870	891	1,000	925
313	02203884	1,460	1,320	1,420	1,610	1,460	1,570	1,760	1,580	1,710	1,970	1,750	1,890
314	02203900	12,000	11,700	12,000	13,100	13,000	13,100	14,100	14,400	14,200	15,500	16,000	15,600

Table 5. Magnitude and frequency of P-percent annual exceedance probability floods determined from at-site analysis, regional regression equations, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B/Expected Moments Algorithm (EMA) analysis of the streamgaging station; R, estimated from the regression equation; W, weighted using equation 12; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Flow, in cubic feet per second											
		50-percent AEP			20-percent AEP			10-percent AEP			4-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
315	02204070	6,580	6,280	6,560	9,420	9,350	9,410	11,500	11,400	11,500	14,200	14,000	14,200
316	02204135	30.4	70.1	37.9	67.5	116	81.7	101	151	121	154	198	176
317	02205000	300	384	324	640	560	607	925	678	801	1,340	822	1,030
318	02205230	141	119	139	196	177	194	230	216	229	271	264	270
319	02205500	542	698	587	1,120	995	1,050	1,720	1,190	1,360	2,850	1,430	1,730
320	02205596	735	1,030	772	1,100	1,580	1,170	1,340	1,960	1,460	1,640	2,440	1,840
321	02206105	84.5	90.6	85.1	127	122	126	157	141	153	197	161	185
322	02206136	129	153	130	164	213	168	186	250	194	212	292	224
323	02206165	73.8	61.8	72.5	90.6	84.7	90.3	97.5	98.2	97.5	103	113	104
324	02206465	76.9	155	87.2	116	192	122	134	211	142	150	229	165
325	02206500	3,630	5,510	3,700	5,710	8,130	5,850	7,330	9,910	7,550	9,590	12,100	9,940
326	02207000	851	740	828	1,330	1,190	1,300	1,650	1,520	1,620	2,050	1,950	2,020
327	02207500	5,510	7,980	5,840	9,550	12,400	10,300	13,900	15,400	14,500	22,100	19,300	20,400
328	02208050	697	1,250	775	1,150	1,910	1,320	1,530	2,360	1,790	2,110	2,920	2,460
349	02217250	117	82	109	183	137	167	233	179	209	302	236	268
352	02217450	209	130	196	285	221	269	337	291	323	405	389	399
354	02217505	506	512	506	670	708	675	793	832	801	962	977	966
355	02217660	201	163	191	335	276	311	434	363	401	568	484	526
359	02218565	495	787	545	845	1,260	918	1,090	1,590	1,180	1,420	2,020	1,540
382	02227422	19.0	39.6	21.2	40.6	74.6	45.7	59.3	103	67.4	87.5	144	101
383	02227990	23.1	60.1	26.4	48	114	56.2	69.5	157	83.5	102	218	127
387	02315650	48.4	19.4	44.7	67.8	35.4	62.3	80.7	48.1	73.9	97.5	65.6	89.5
399	02317810	45.9	23.6	42.1	95.9	43.7	84.1	138	59.7	116	201	82.2	160
402	02317890	62.2	36.1	56.3	101	66.5	91.2	130	90.6	116	170	125	151
406	02334885	1,780	2,730	1,890	3,070	4,200	3,260	4,080	5,220	4,340	5,500	6,520	5,820
407	02335347	147	133	146	207	171	202	243	191	235	283	211	270
408	02335700	2,040	3,230	2,120	3,550	5,050	3,680	4,670	6,320	4,860	6,180	7,940	6,490
409	02335870	3,740	2,270	3,570	5,730	3,450	5,420	7,060	4,280	6,580	8,750	5,300	7,940
410	02336080	2,180	2,330	2,180	2,400	3,290	2,400	2,560	3,930	2,580	2,770	4,680	2,830

Table 5. Magnitude and frequency of P-percent annual exceedance probability floods determined from at-site analysis, regional regression equations, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B/Expected Moments Algorithm (EMA) analysis of the streamgaging station; R, estimated from the regression equation; W, weighted using equation 12; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Flow, in cubic feet per second											
		2-percent AEP			1-percent AEP			0.5-percent AEP			0.2-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
315	02204070	16,400	15,900	16,300	18,600	17,700	18,300	21,100	19,500	20,500	24,400	22,000	23,400
316	02204135	202	235	219	256	274	266	318	313	315	411	370	385
317	02205000	1,680	931	1,190	2,050	1,040	1,340	2,430	1,140	1,480	2,980	1,280	1,640
318	02205230	300	301	300	327	336	328	354	371	356	389	423	394
319	02205500	4,050	1,610	1,970	5,640	1,780	2,210	7,730	1,950	2,460	11,600	2,160	2,680
320	02205596	1,860	2,800	2,150	2,070	3,160	2,450	2,280	3,510	2,760	2,560	3,990	3,180
321	02206105	228	175	208	260	188	229	293	199	249	339	222	276
322	02206136	231	323	247	250	352	270	268	378	291	292	423	324
323	02206165	106	124	108	109	133	112	110	142	114	112	160	118
324	02206465	159	241	180	165	251	192	169	259	199	174	281	216
325	02206500	11,500	13,700	11,900	13,500	15,200	13,900	15,700	16,700	16,000	18,900	18,700	18,800
326	02207000	2,330	2,270	2,310	2,610	2,600	2,610	2,880	2,930	2,900	3,230	3,400	3,320
327	02207500	31,000	22,100	24,600	43,200	24,900	28,400	59,800	27,900	32,100	91,600	31,700	36,800
328	02208050	2,620	3,340	3,000	3,220	3,760	3,540	3,900	4,180	4,080	4,950	4,730	4,790
349	02217250	358	281	316	418	327	367	482	377	423	574	444	496
352	02217450	456	468	460	509	552	525	564	640	593	638	753	685
354	02217505	1,100	1,080	1,090	1,250	1,180	1,220	1,410	1,280	1,350	1,650	1,410	1,520
355	02217660	673	582	625	782	685	730	895	796	841	1,050	933	983
359	02218565	1,670	2,340	1,820	1,920	2,670	2,100	2,170	3,000	2,400	2,500	3,460	2,810
382	02227422	112	177	130	139	213	163	168	251	197	211	306	248
383	02227990	131	270	165	162	324	209	198	383	257	250	467	327
387	02315650	110	79.8	102	123	94.6	115	135	110	127	153	132	147
399	02317810	254	100	193	312	120	228	375	140	264	467	170	314
402	02317890	202	152	179	235	182	209	270	213	241	320	258	287
406	02334885	6,650	7,460	6,980	7,910	8,410	8,140	9,250	9,350	9,300	11,200	10,600	10,900
407	02335347	309	224	293	333	236	312	355	246	329	382	269	351
408	02335700	7,360	9,140	7,750	8,590	10,400	9,060	9,840	11,600	10,400	11,600	13,200	12,200
409	02335870	9,980	6,050	8,820	11,200	6,790	9,670	12,400	7,550	10,500	14,000	8,550	11,500
410	02336080	2,930	5,210	3,040	3,100	5,730	3,280	3,280	6,220	3,550	3,530	6,870	3,950

Table 5. Magnitude and frequency of P-percent annual exceedance probability floods determined from at-site analysis, regional regression equations, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B/Expected Moments Algorithm (EMA) analysis of the streamgaging station; R, estimated from the regression equation; W, weighted using equation 12; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Flow, in cubic feet per second											
		50-percent AEP			20-percent AEP			10-percent AEP			4-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
411	02336102	723	574	717	904	853	901	1,010	1,040	1,010	1,130	1,290	1,140
412	02336238	586	290	571	738	425	705	843	514	797	984	625	912
413	02336300	6,460	5,280	6,430	8,170	7,410	8,150	9,250	8,810	9,230	10,600	10,500	10,600
414	02336360	2,440	2,490	2,440	3,140	3,620	3,160	3,600	4,390	3,640	4,160	5,310	4,250
415	02336635	3,040	2,280	2,860	5,310	3,480	4,710	7,180	4,310	5,940	9,930	5,350	7,410
416	02336700	300	209	296	382	313	378	431	384	427	489	473	487
417	02336705	2,690	1,090	2,550	3,490	1,690	3,280	3,990	2,120	3,710	4,610	2,650	4,220
420	02337448	68.5	72.1	69.3	149	122	139	221	159	192	334	211	268
428	02341544	582	368	570	794	495	779	931	582	911	1,100	695	1,070
429	02341546	69.0	72.6	69.3	105	103	105	136	123	134	185	151	178
430	02341548	411	429	413	574	637	583	681	778	701	817	957	852
445	02349330	33.9	19.8	32.9	54.7	33.4	53.4	69.7	44.1	67.8	89.7	59.7	87.2
447	02349695	103	55.2	98.1	150	103	147	182	142	178	222	197	219
450	02350685	14.6	34.1	19.6	57.5	63.4	60.2	118	86.9	100	255	120	159
452	02352605	44.5	99.5	54.4	75.2	131	86	95.7	150	108	121	172	136
461	02387300	79.3	72.3	78.4	125	119	124	158	154	157	201	200	201
471	02392950	1,620	---	---	2,660	---	---	3,660	---	---	5,440	---	---
472	02392975	1,840	2,620	1,980	3,020	3,880	3,250	4,100	4,740	4,290	5,890	5,790	5,860
477	02395990	110	111	110	163	169	164	195	207	198	232	258	238
478	02396550	140	131	140	171	179	171	189	207	190	209	240	212
484	02411735	211	161	204	360	279	341	475	371	445	635	501	589
487	02411902	47.0	38.5	46.1	76.4	62.5	73.7	98.4	79.8	93.8	129	103	121

Table 5. Magnitude and frequency of P-percent annual exceedance probability floods determined from at-site analysis, regional regression equations, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B/Expected Moments Algorithm (EMA) analysis of the streamgaging station; R, estimated from the regression equation; W, weighted using equation 12; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Flow, in cubic feet per second											
		2-percent AEP			1-percent AEP			0.5-percent AEP			0.2-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
411	02336102	1,210	1,480	1,240	1,290	1,660	1,330	1,370	1,850	1,430	1,460	2,060	1,550
412	02336238	1090	708	996	1200	789	1080	1320	869	1180	1480	975	1290
413	02336300	11,600	11,600	11,600	12,500	12,800	12,500	13,500	13,800	13,500	14,800	15,200	14,800
414	02336360	4,580	5,970	4,720	5,000	6,610	5,210	5,420	7,240	5,710	5,970	8,070	6,370
415	02336635	12,300	6,110	8,400	15,000	6,870	9,390	18,000	7,640	10,300	22,600	8,650	11,600
416	02336700	530	541	531	569	607	574	605	673	615	655	762	672
417	02336705	5,050	3,050	4,550	5,500	3,450	4,910	5,920	3,850	5,250	6,490	4,400	5,720
420	02337448	435	252	331	550	294	396	681	340	465	879	402	555
428	02341544	1,230	782	1,190	1,350	869	1,290	1,470	959	1,400	1,640	1,080	1,550
429	02341546	231	173	215	285	195	253	349	218	293	453	251	349
430	02341548	918	1,090	970	1,020	1,220	1,090	1,120	1,360	1,210	1,260	1,520	1,370
445	02349330	105	72.8	102	121	87.1	117	137	103	133	160	126	155
447	02349695	253	242	251	284	291	285	315	343	320	356	418	369
450	02350685	419	147	208	655	176	259	986	207	314	1,620	251	395
452	02352605	139	187	157	157	200	175	173	213	192	194	228	212
461	02387300	234	237	235	268	275	270	303	315	307	350	370	357
471	02392950	7,240	---	---	9,550	---	---	12,500	---	---	17,800	---	---
472	02392975	7,600	6,560	7,180	9,680	7,310	8,540	12,200	8,070	9,850	16,500	9,060	11,500
477	02395990	257	294	266	280	332	294	302	369	320	328	423	356
478	02396550	222	262	226	235	283	240	246	303	253	261	337	272
484	02411735	764	608	706	902	721	831	1050	843	965	1,260	993	1,140
487	02411902	153	120	142	179	138	165	206	157	187	245	185	220

*Stations 0209782609 and 0214657975 are “rural” stations that were not included in the Southeast rural flood-frequency study due to having insuffient lengths of record at the time of that investigation but are being included in this investigation because they now have sufficient record lengths and because they have impervious areas of 7.7 and 8.2 percent, respectively, which provides data in the “transitional” area between rural and urban stations.

Table 8. Explanatory variables that were used in the regional regression equations.

[USGS, U.S. Geological Survey; square mile, mi^2; in, inch; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	State	Type	Hydrologic region	Drainage area (mi^2)	Percentage of impervious area	Percentage of developed land	24-hour, 50-year maximum precipitation (in)
1	01400795	NJ	U	4	9.28	10.8	46.1	6.88
2	01401160	NJ	R	4	1.81	7.6	56.3	6.81
3	01405300	NJ	U	4	43.9	11.8	46.3	7.00
4	01407290	NJ	U	4	6.42	11.7	46.4	6.97
5	01464524	NJ	U	4	0.66	20.1	66.4	6.76
6	01464525	NJ	U	4	0.84	11.3	47.4	6.77
7	01465880	NJ	R	4	47.2	8.0	38.0	6.61
8	01467057	NJ	U	4	5.77	17.0	77.7	6.51
9	01467069	NJ	U	4	12.8	22.2	68.6	6.55
10	01467081	NJ	U	4	8.98	33.5	83.9	6.54
11	01467130	NJ	U	4	5.10	16.9	55.4	6.57
12	01467150	NJ	U	4	17.0	21.4	70.9	6.55
13	01467160	NJ	U	4	5.34	18.8	68.3	6.56
14	01467305	NJ	U	4	1.33	21.0	88.2	6.52
15	01467317	NJ	U	4	0.63	25.9	93.2	6.52
16	01467330	NJ	U	4	19.6	17.0	60.1	6.57
17	01475017	NJ	U	4	0.43	16.0	62.1	6.55
18	01475019	NJ	U	4	14.1	16.8	61.9	6.56
19	02053110	NC	R	4	1.09	0.1	1.8	7.66
20	02053170	NC	R	4	11.8	0.2	2.1	7.82
21	02053510	NC	R	4	2.04	0.7	7.5	7.94
22	02053550	NC	R	4	8.90	0.3	3.3	8.22
23	02068610	NC	SR	1	0.31	1.2	14.9	7.71
24	02068660	NC	R	1	5.44	0.3	5.0	7.72
25	02069030	NC	R	1	14.9	3.0	21.7	6.62
26	02070810	NC	R	1	16.2	0.8	5.4	6.87
27	02071410	NC	R	1	12.0	0.9	6.3	7.30
28	02075160	NC	R	1	32.8	0.4	3.9	6.74
29	02075230	NC	R	1	6.57	0.5	3.1	6.66
30	02077200	NC	R	1	45.9	0.6	3.7	6.60
31	02077210	NC	SR	1	0.25	0.0	0.0	6.56
32	02077240	NC	R	1	7.47	0.5	3.7	6.51
33	02077250	NC	R	1	56.5	0.5	3.7	6.53
34	02077310	NC	R	1	1.86	1.3	10.9	6.53
35	02081060	NC	R	4	2.86	0.5	4.4	8.48
36	02081110	NC	R	4	18.7	0.1	1.8	8.17
37	02081210	NC	R	1	22.2	0.2	2.9	6.54
38	02081500	NC	R	1	167	0.5	4.7	6.55
39	02081710	NC	R	1	7.25	2.0	11.0	6.62
40	02081747	NC	R	1	427	1.2	7.3	6.62
41	02081800	NC	R	1	47.8	1.2	8.3	6.75
42	02082540	NC	SR	1	0.32	0.7	6.6	7.15
43	02082630	NC	R	4	8.58	1.1	8.6	7.85
44	02082835	NC	R	1	45.0	1.0	7.6	6.80
45	02083090	NC	R	4	9.44	0.7	6.7	7.52

Table 8. Explanatory variables that were used in the regional regression equations.—Continued

[USGS, U.S. Geological Survey; square mile, mi²; in, inch; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	State	Type	Hydrologic region	Drainage area (mi²)	Percentage of impervious area	Percentage of developed land	24-hour, 50-year maximum precipitation (in)
46	02083410	NC	R	4	12.3	0.2	4.1	7.73
47	02084240	NC	R	4	30.8	0.8	5.6	8.25
48	02084500	NC	R	4	9.59	0.3	4.8	8.60
49	02084520	NC	R	4	1.49	0.3	4.4	8.68
50	02084540	NC	R	4	26.0	0.2	3.0	9.12
52	02084570	NC	R	4	32.2	0.3	4.3	8.67
53	02084909	NC	R	1	14.1	2.3	9.2	6.64
54	02085000	NC	R	1	66.0	2.0	11.7	6.61
55	02085020	NC	SR	1	0.80	1.1	12.1	6.69
56	02085070	NC	R	1	141	2.6	17.0	6.64
57	02085190	NC	R	1	1.02	0.4	6.4	6.54
58	0208521324	NC	R	1	78.2	0.6	6.0	6.57
59	0208524090	NC	R	1	8.00	1.3	9.1	6.56
60	02085500	NC	R	1	149	1.2	6.3	6.52
61	02086000	NC	R	1	4.73	0.5	4.4	6.57
62	0208650112	NC	R	1	1.14	0.1	1.4	6.64
63	02086624	NC	R	1	43.0	1.6	8.0	6.61
64	02086849	NC	U	1	21.9	20.3	74.2	6.71
65	02087030	NC	R	1	13.8	1.5	8.9	6.59
66	02087140	NC	SR	1	0.70	9.9	66.1	6.60
67	02087240	NC	SR	1	0.25	1.8	11.9	6.55
68	0208726005	NC	U	1	76.0	16.7	54.6	6.59
70	02087324	NC	U	1	121	16.5	63.8	6.63
71	0208732885	NC	U	1	6.84	29.5	94.8	6.76
73	02087359	NC	U	1	29.8	21.3	81.2	6.80
74	02087580	NC	U	1	21.0	15.3	75.4	6.74
75	02087910	NC	R	1	8.67	10.0	37.1	6.81
76	02088140	NC	R	4	27.9	1.4	6.1	7.77
77	02088210	NC	R	4	2.68	2.4	10.0	7.55
78	02090560	NC	R	4	3.82	0.4	5.3	7.87
79	02090625	NC	R	4	2.10	0.2	3.5	8.18
80	02090780	NC	R	4	2.85	0.3	3.0	7.99
81	02090960	NC	R	4	19.0	0.5	5.3	8.05
82	02091430	NC	R	4	1.47	1.6	12.8	8.58
83	02091810	NC	R	4	4.87	0.2	3.3	8.98
84	02091970	NC	R	4	27.0	0.3	3.2	8.76
85	02092020	NC	R	4	24.0	0.7	5.5	8.88
86	02092120	NC	R	4	32.4	0.7	6.1	9.29
87	02092290	NC	R	4	5.05	0.0	0.9	9.12
88	02092520	NC	R	4	6.30	0.2	3.3	8.94
89	02092620	NC	R	4	3.00	0.2	3.4	9.42
90	02092720	NC	R	4	53.3	0.3	3.1	9.61
91	02092780	NC	R	4	4.95	1.1	5.4	10.00
92	02093040	NC	R	4	1.00	0.3	1.8	9.50
93	02093070	NC	R	4	26.9	0.7	4.0	9.47

Table 8. Explanatory variables that were used in the regional regression equations.—Continued

[USGS, U.S. Geological Survey; square mile, mi^2; in, inch; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	State	Type	Hydrologic region	Drainage area (mi^2)	Percentage of impervious area	Percentage of developed land	24-hour, 50-year maximum precipitation (in)
94	02093229	NC	U	4	2.08	18.7	70.5	10.91
95	02093290	NC	R	1	26.3	1.8	9.1	6.59
96	02093500	NC	R	1	168	2.2	10.2	6.73
97	02093800	NC	R	1	20.6	4.1	16.1	6.44
98	0209399200	NC	U	1	15.9	22.5	78.7	6.37
99	02094659	NC	U	1	7.33	41.2	97.1	6.40
100	02094770	NC	U	1	15.4	39.5	96.6	6.43
101	02095000	NC	U	1	34.0	35.5	87.9	6.46
103	02095271	NC	U	1	14.2	32.7	98.8	6.43
104	02095500	NC	U	1	37.1	28.8	84.6	6.47
105	0209553650	NC	U	1	88.5	27.0	73.4	6.48
106	02096660	NC	R	1	14.6	1.9	11.5	6.58
107	02096700	NC	R	1	116	2.8	13.9	6.57
108	02096846	NC	R	1	7.54	0.3	4.5	6.70
109	02096850	NC	R	1	33.7	0.4	5.1	6.69
110	02097010	NC	R	1	1.71	1.3	11.2	6.89
111	02097314	NC	R	1	75.9	8.3	39.2	6.77
112	0209741955	NC	U	1	21.1	14.4	57.0	6.65
113	02097464	NC	R	1	8.35	0.4	5.2	6.80
114	0209782609	NC	R	1	11.9	7.7	32.7	6.68
115	02097910	NC	R	1	23.6	3.1	14.7	6.71
116	02098000	NC	R	1	285	5.7	27.3	6.77
117	02100500	NC	R	1	349	7.8	27.6	6.59
118	02101030	NC	R	1	3.43	0.2	1.8	7.00
119	02101480	NC	SR	1	0.85	2.5	13.1	7.26
120	0210166029	NC	R	1	7.42	4.2	16.7	6.78
121	02101800	NC	R	1	15.5	0.6	5.1	6.99
122	02101890	NC	R	1	43.2	0.7	4.9	7.00
123	02102908	NC	R	3	7.58	1.5	6.5	7.37
124	02102910	NC	R	3	2.19	2.7	8.9	7.33
125	02102930	NC	R	3	32.4	1.9	7.5	7.34
126	02103000	NC	R	3	348	2.4	10.2	7.34
127	02103390	NC	R	3	7.56	3.2	15.2	7.37
128	02103500	NC	R	3	459	2.9	11.4	7.36
129	02104080	NC	R	4	9.79	2.9	12.2	7.77
130	02104220	NC	R	3	93.1	1.4	9.2	7.36
131	02105570	NC	R	4	13.3	1.9	9.4	8.36
132	02105900	NC	R	4	21.6	0.7	2.8	10.24
133	02106240	NC	R	4	15.7	2.0	8.3	8.58
134	02106410	NC	SR	4	0.46	1.5	9.5	8.65
135	02106910	NC	R	4	32.3	0.7	4.4	8.02
136	02107590	NC	SR	4	0.56	0.4	5.2	8.56
137	02107600	NC	R	4	47.5	1.6	7.0	8.55
138	02107620	NC	R	4	8.13	0.4	3.3	8.81
139	02107980	NC	R	4	53.5	0.4	3.6	8.98

Table 8. Explanatory variables that were used in the regional regression equations.—Continued

[USGS, U.S. Geological Survey; square mile, mi²; in, inch; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	State	Type	Hydrologic region	Drainage area (mi²)	Percentage of impervious area	Percentage of developed land	24-hour, 50-year maximum precipitation (in)
140	02108548	NC	R	4	7.80	3.0	13.4	9.31
141	02108610	NC	R	4	1.26	0.1	0.6	10.02
142	02108630	NC	R	4	10.2	1.2	7.6	10.38
143	02108960	NC	R	4	16.7	0.6	3.5	8.90
144	02109640	NC	R	4	16.0	0.5	2.4	9.79
145	02110020	NC	R	4	3.52	1.2	5.8	8.86
146	02110740	SC	U	4	0.67	20.3	91.9	9.68
147	02114450	NC	R	1	42.8	0.9	9.1	7.53
148	02115500	NC	R	1	22.1	0.7	6.4	6.91
149	02115520	NC	SR	1	0.90	1.4	14.1	7.00
150	02115540	NC	R	1	17.7	1.6	9.9	7.09
151	02115845	NC	U	1	5.18	20.0	99.2	6.60
152	02115900	NC	R	1	42.9	6.7	35.8	6.53
153	02117030	NC	R	1	1.05	0.5	5.8	6.41
154	02117410	NC	R	1	1.22	0.7	4.9	7.16
155	02120500	NC	R	1	87.4	4.5	16.5	6.81
156	02120780	NC	R	1	118	1.7	7.3	6.51
157	02120820	NC	R	1	3.88	1.3	5.6	6.42
158	02121180	NC	R	1	9.62	3.2	12.8	6.38
159	02121500	NC	R	1	174	6.5	26.9	6.52
160	02121940	NC	R	1	6.56	1.1	6.1	6.56
161	02122560	NC	R	1	13.7	0.7	4.4	6.76
162	02122720	NC	R	1	2.90	0.3	2.6	6.84
163	02123500	NC	R	1	342	1.6	8.2	6.70
164	02123567	NC	R	1	3.44	0.1	1.4	7.01
165	02124060	NC	R	1	3.61	6.7	36.7	6.59
166	0212414900	NC	U	1	34.6	19.1	68.7	6.62
167	02125000	NC	R	1	55.6	0.6	5.2	6.90
168	02125410	NC	R	1	7.73	1.5	7.4	7.08
169	02127000	NC	R	1	110	1.0	5.3	7.29
170	02127390	NC	SR	1	0.91	2.4	17.7	7.12
171	02128000	NC	R	1	106	1.7	7.2	6.85
172	02129530	NC	SR	3	0.14	1.1	6.7	7.42
173	02130900	SC	R	3	108	1.7	6.2	7.58
174	02131110	SC	R	4	46.6	6.4	19.8	7.86
175	02131130	SC	U	4	1.62	34.8	96.9	7.81
176	02131309	SC	R	1	24.3	1.8	6.5	7.49
177	02131320	SC	R	1	15.0	2.0	8.4	7.46
178	02131472	SC	R	1	23.9	2.1	8.6	7.39
179	02132100	SC	R	4	18.9	1.1	6.2	8.08
180	02132230	NC	R	4	6.05	7.6	24.3	7.62
181	02133500	NC	R	3	183	1.2	7.4	7.25
182	02133590	NC	R	3	4.66	1.6	7.9	7.43
183	02133624	NC	R	3	365	1.9	10.5	7.32
184	02134380	NC	R	4	16.1	1.0	4.4	7.69

Table 8. Explanatory variables that were used in the regional regression equations.—Continued

[USGS, U.S. Geological Survey; square mile, mi^2; in, inch; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	State	Type	Hydrologic region	Drainage area (mi^2)	Percentage of impervious area	Percentage of developed land	24-hour, 50-year maximum precipitation (in)
185	02135300	SC	R	3	96.0	0.9	4.3	7.66
186	02135518	SC	U	4	1.82	20.7	66.6	8.05
187	02142480	NC	R	1	8.40	1.4	7.2	7.03
188	0214253830	NC	R	1	7.18	1.3	6.0	6.85
189	0214266000	NC	U	1	26.3	14.8	58.7	6.55
190	02142900	NC	U	1	16.4	21.0	64.2	6.52
191	0214291555	NC	U	1	31.5	17.4	62.9	6.49
192	0214295600	NC	U	1	10.4	20.4	79.5	6.46
193	02143500	NC	R	1	69.2	2.2	8.4	7.18
194	02144000	NC	R	1	31.8	3.1	13.3	7.01
195	02145940	SC	U	1	3.50	25.5	95.3	7.05
196	02146211	NC	U	1	5.97	26.0	74.5	6.55
197	0214627970	NC	U	1	9.07	32.0	84.3	6.49
198	02146300	NC	U	1	30.7	34.2	87.4	6.52
199	02146315	NC	U	1	5.71	36.8	95.2	6.48
200	02146348	NC	U	1	9.14	24.1	56.9	6.56
201	02146381	NC	U	1	65.3	32.4	82.1	6.56
202	02146409	NC	U	1	11.8	47.9	97.8	6.57
203	0214642825	NC	U	1	5.20	24.6	95.0	6.63
204	0214645022	NC	U	1	19.0	25.0	95.7	6.62
205	02146470	NC	U	1	2.63	32.8	100.0	6.58
206	02146500	NC	U	1	41.0	22.0	96.7	6.60
207	02146507	NC	U	1	42.6	32.0	96.5	6.60
208	02146530	NC	U	1	49.2	32.0	96.3	6.62
209	0214655255	NC	U	1	7.33	18.2	86.3	6.71
210	02146562	NC	U	1	5.71	26.4	94.2	6.67
211	0214657975	NC	R	1	8.37	8.3	60.2	6.76
212	02146600	NC	U	1	38.6	20.2	80.6	6.73
213	02146700	NC	U	1	6.95	21.3	96.8	6.66
214	02146750	NC	U	1	92.4	19.5	84.5	6.76
215	0214678175	NC	U	1	6.91	31.4	76.7	6.71
216	02146900	NC	R	1	76.5	2.3	10.3	7.02
217	02147500	SC	R	1	194	1.3	6.1	7.07
218	02148090	SC	R	3	4.90	1.7	6.5	7.57
219	02148300	SC	R	3	40.2	1.3	4.9	7.52
220	02152420	NC	R	1	16.4	1.0	6.7	7.44
221	02152610	NC	R	1	1.44	3.4	9.2	7.32
222	02153780	SC	R	1	24.1	0.4	2.7	7.09
223	02153800	SC	R	1	84.3	1.0	4.4	7.09
224	02153840	SC	R	1	6.12	0.8	5.7	7.16
225	02154790	SC	R	1	55.5	1.5	11.2	8.36
226	021563931	SC	R	1	81.5	1.2	6.9	7.12
227	02157000	SC	R	1	44.4	3.0	13.9	7.73
228	02157500	SC	R	1	68.3	1.7	9.7	8.15
229	02158000	SC	R	1	162	3.9	17.2	7.88

Table 8. Explanatory variables that were used in the regional regression equations.—Continued

[USGS, U.S. Geological Survey; square mile, mi²; in, inch; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	State	Type	Hydrologic region	Drainage area (mi^2)	Percentage of impervious area	Percentage of developed land	24-hour, 50-year maximum precipitation (in)
230	02159000	SC	R	1	174	4.1	16.1	7.94
231	02159785	SC	U	1	0.39	19.3	83.8	7.51
232	02160000	SC	R	1	183	4.8	17.9	7.56
233	02160325	SC	U	1	9.05	22.3	79.4	8.05
234	02160500	SC	R	1	307	7.2	25.2	7.89
235	02162010	SC	R	1	48.9	1.2	8.5	7.19
236	02162093	SC	U	3	5.67	41.1	93.2	7.31
237	02164000	SC	U	1	48.6	18.8	64.3	8.15
238	02164011	SC	U	1	3.00	34.9	97.8	8.12
239	02165000	SC	R	1	236	9.7	30.3	7.92
240	02165200	SC	R	1	29.5	3.6	10.8	7.80
242	02167020	SC	U	3	0.28	32.9	93.6	7.31
243	02167450	SC	R	1	230	1.4	8.3	7.53
244	02167582	SC	R	1	115	3.4	14.2	7.43
245	02168845	SC	U	1	0.39	26.6	91.7	7.28
246	02169505	SC	U	3	2.15	48.1	98.5	7.33
247	02169550	SC	R	3	122	6.3	22.4	7.35
248	02169568	SC	U	3	2.26	28.0	83.1	7.33
250	02169630	SC	R	3	10.0	0.7	4.2	7.63
251	02169960	SC	R	4	1.21	0.4	4.3	7.98
252	02173491	SC	U	4	0.52	25.2	90.6	7.87
254	02174250	SC	R	4	23.4	0.9	5.7	7.88
255	02176380	SC	U	4	1.49	16.4	53.1	7.76
256	02186000	SC	R	1	106	2.2	11.3	7.95
257	02186645	SC	R	1	65.4	3.9	13.1	7.76
258	02187910	SC	R	1	111	4.9	19.8	7.82
259	02188500	GA	R	1	38.4	2.1	9.0	7.44
260	02188600	GA	R	1	72.0	1.7	8.2	7.41
261	02189020	GA	R	1	7.63	2.5	11.4	7.65
262	02189030	GA	SR	1	0.39	3.6	15.4	7.59
263	02189600	GA	R	1	3.62	2.0	10.7	7.74
264	02190100	GA	R	1	4.75	2.1	9.7	7.75
265	02190200	GA	R	1	1.01	2.0	9.6	7.75
266	02190800	GA	SR	1	0.53	2.4	8.7	7.53
267	02191200	GA	R	1	60.9	1.4	7.9	7.81
268	02191270	GA	R	1	8.75	1.5	9.7	7.48
269	02191280	GA	SR	1	0.39	7.6	24.9	7.47
270	02191600	GA	R	1	5.12	1.3	7.7	7.51
271	02191750	GA	R	1	16.0	1.2	8.4	7.39
272	02191890	GA	R	1	12.3	1.2	8.0	7.34
273	02191910	GA	R	1	2.47	1.4	10.2	7.34
274	02191930	GA	R	1	5.24	0.4	5.1	7.28
275	02191960	GA	R	1	3.45	0.6	8.0	7.28
276	02191970	GA	R	1	1.89	0.8	8.2	7.27

Table 8. Explanatory variables that were used in the regional regression equations.—Continued

[USGS, U.S. Geological Survey; square mile, mi²; in, inch; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	State	Type	Hydrologic region	Drainage area (mi²)	Percentage of impervious area	Percentage of developed land	24-hour, 50-year maximum precipitation (in)
277	02192400	GA	R	1	5.49	0.3	3.6	7.12
278	02192420	GA	R	1	1.00	0.5	9.2	7.11
279	02192500	SC	R	1	217	1.0	6.3	7.67
280	02193300	GA	R	1	6.30	0.2	3.9	7.23
281	02193340	GA	R	1	33.9	0.2	3.2	7.19
282	02193400	GA	R	1	3.98	0.3	3.6	7.22
283	02193500	GA	R	1	292	0.3	4.0	7.21
284	02196689	SC	R	3	26.6	3.0	8.5	7.32
285	02196725	GA	U	3	0.68	35.9	93.0	7.32
286	02196760	GA	U	3	1.35	25.5	83.8	7.31
287	02197410	SC	R	4	7.82	0.4	3.1	7.63
288	02197600	GA	R	4	28.0	2.4	12.3	7.41
289	02197810	GA	R	4	13.1	0.9	6.4	7.50
290	02198100	GA	R	4	30.8	0.4	3.6	7.63
291	02199700	GA	R	1	31.3	0.6	5.2	7.26
292	02200930	GA	R	4	14.2	0.7	4.9	7.55
293	02201110	GA	R	4	8.36	0.7	6.1	7.55
294	02201160	GA	R	4	7.49	0.8	7.0	7.55
295	02201250	GA	SR	4	0.65	1.0	4.4	7.60
296	02201350	GA	R	4	50.5	1.0	6.3	7.51
297	02201800	GA	R	4	35.2	0.8	5.7	7.69
298	02201830	GA	R	4	4.38	2.9	3.1	7.72
299	02202300	GA	R	4	39.0	2.2	11.2	7.85
300	02202605	GA	R	4	3.53	1.0	9.0	8.22
301	02202800	GA	R	4	46.0	0.6	5.2	7.69
302	02202810	GA	R	4	5.05	2.5	14.8	7.70
303	02202820	GA	R	4	8.99	0.9	5.6	7.72
304	02202850	GA	R	4	3.41	0.8	4.4	7.79
305	02202910	GA	R	4	1.14	0.8	4.4	7.86
306	02202950	GA	R	4	1.25	1.6	9.4	7.93
307	02203543	GA	U	4	1.06	20.0	82.9	8.88
308	02203544	GA	U	4	0.10	13.4	80.9	8.90
309	02203559	GA	R	4	36.8	5.1	19.2	8.62
310	02203800	GA	U	1	41.5	30.9	76.5	8.00
311	02203835	GA	U	1	3.43	16.8	77.2	8.00
312	02203845	GA	U	1	0.95	24.7	86.4	8.00
313	02203884	GA	U	1	1.88	27.7	77.3	8.00
314	02203900	GA	U	1	99.0	23.6	70.3	8.00
315	02204070	GA	U	1	182	20.2	66.6	7.99
316	02204135	GA	SR	1	0.28	2.0	11.5	7.93
317	02205000	GA	U	1	1.28	22.4	85.4	7.97
318	02205230	GA	U	1	0.33	15.4	71.3	8.00
319	02205500	GA	U	1	2.43	27.1	80.5	7.95
320	02205596	GA	U	1	7.23	22.0	76.6	7.95

Table 8. Explanatory variables that were used in the regional regression equations.—Continued

[USGS, U.S. Geological Survey; square mile, mi²; in, inch; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	State	Type	Hydrologic region	Drainage area (mi^2)	Percentage of impervious area	Percentage of developed land	24-hour, 50-year maximum precipitation (in)
321	02206105	GA	U	1	0.15	24.9	80.4	8.00
322	02206136	GA	U	1	0.33	23.8	77.0	8.00
323	02206165	GA	U	1	0.10	21.8	96.8	8.00
324	02206465	GA	U	1	0.20	35.7	78.4	7.94
325	02206500	GA	U	1	134	22.1	68.0	7.99
326	02207000	GA	U	1	5.54	14.3	65.9	8.00
327	02207500	GA	U	1	378	12.5	43.3	7.92
328	02208050	GA	U	1	9.97	22.4	66.5	7.94
329	02208200	GA	R	1	1.09	2.0	12.6	7.80
330	02208450	GA	R	1	185	4.4	18.5	7.80
331	02209000	GA	R	1	244	3.7	16.2	7.78
332	02211300	GA	R	1	105	2.3	10.0	7.87
333	02211459	GA	R	1	2.36	5.7	23.9	7.77
334	02211500	GA	R	1	315	1.7	8.7	7.79
335	02212600	GA	R	1	72.2	0.1	3.7	7.52
336	02213050	GA	R	1	31.3	0.7	6.2	7.53
337	02213350	GA	R	1	53.4	1.2	7.8	7.66
338	02213400	GA	R	1	16.8	0.4	5.7	7.67
339	02213470	GA	R	1	156	0.6	5.2	7.64
340	02214280	GA	R	4	33.0	0.3	2.6	7.60
341	02215220	GA	R	4	1.83	0.2	3.0	7.88
342	02215230	GA	R	4	7.33	0.5	4.0	7.88
343	02215245	GA	R	4	1.26	0.1	2.6	7.93
344	02215280	GA	R	4	2.45	0.4	4.9	8.00
345	02216180	GA	R	4	49.2	0.4	4.5	7.96
346	02216610	GA	R	4	2.71	0.2	4.3	8.00
347	02217000	GA	R	1	18.2	4.5	14.9	7.90
348	02217200	GA	R	1	135	3.2	13.4	7.85
349	02217250	GA	SR	1	0.35	2.0	12.4	7.77
350	02217380	GA	R	1	142	4.1	18.3	7.88
351	02217400	GA	R	1	2.54	1.7	7.6	7.78
352	02217450	GA	SR	1	0.67	1.9	8.7	7.77
353	02217500	GA	R	1	398	3.6	16.0	7.81
354	02217505	GA	U	1	1.44	29.1	96.1	7.56
355	02217660	GA	SR	1	0.87	3.3	11.0	7.71
356	02217900	GA	R	1	290	2.8	12.7	7.71
357	02218100	GA	R	1	1.95	2.7	12.6	7.52
358	02218450	GA	R	1	11.9	0.2	3.8	7.29
359	02218565	GA	U	1	5.68	16.4	63.5	7.93
360	02219000	GA	R	1	176	2.7	12.3	7.73
361	02219500	GA	R	1	436	1.7	8.9	7.63
362	02220550	GA	R	1	16.6	0.1	2.8	7.29
363	02220900	GA	R	1	262	0.6	5.8	7.50
364	02221000	GA	R	1	24.0	0.2	3.9	7.58

Table 8. Explanatory variables that were used in the regional regression equations.—Continued

[USGS, U.S. Geological Survey; square mile, mi^2; in, inch; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	State	Type	Hydrologic region	Drainage area (mi^2)	Percentage of impervious area	Percentage of developed land	24-hour, 50-year maximum precipitation (in)
365	02221525	GA	R	1	190	0.4	5.2	7.51
366	02223300	GA	R	3	33.5	0.5	4.0	7.55
367	02223700	GA	R	4	1.99	0.1	2.9	7.70
368	02224200	GA	R	4	16.1	0.5	4.8	7.75
369	02224400	GA	R	4	6.77	0.5	4.5	7.86
370	02224650	GA	R	4	5.16	1.4	10.8	7.91
371	02224800	GA	R	4	1.18	0.5	5.4	7.97
372	02225180	GA	R	4	13.8	0.3	3.9	7.70
373	02225210	GA	R	4	3.53	0.3	4.2	7.60
374	02225240	GA	R	4	7.22	0.6	5.8	7.66
375	02225330	GA	R	4	9.58	0.9	5.8	7.88
376	02225350	GA	R	4	1.68	2.2	14.8	7.79
377	02226030	GA	R	4	31.1	0.4	5.4	8.53
378	02226190	GA	R	4	6.38	0.5	5.0	7.76
379	02226465	GA	R	4	13.7	0.8	5.3	8.00
380	02226580	GA	R	4	53.2	0.8	6.7	8.63
381	02227100	GA	R	4	52.6	0.8	5.0	8.00
382	02227422	GA	SR	4	0.38	0.0	4.6	8.27
383	02227990	GA	SR	4	0.59	1.7	7.9	9.03
384	02228055	GA	R	4	1.91	0.2	5.2	9.08
385	02246497	FL	U	4	3.51	28.6	99.9	9.76
386	02246522	FL	U	4	0.57	27.6	100.0	9.96
387	02315650	GA	SR	4	0.11	1.5	14.2	7.92
388	02315670	GA	R	4	2.87	0.9	7.3	7.95
389	02315980	GA	R	4	1.21	0.5	5.0	8.00
390	02316220	GA	R	4	1.65	5.2	20.9	8.00
391	02316260	GA	R	4	3.19	0.2	3.3	8.00
392	02317730	GA	R	4	1.16	0.7	4.3	8.00
393	02317760	GA	R	4	8.54	0.3	3.7	8.00
394	02317765	GA	R	4	1.15	0.3	3.2	8.00
395	02317770	GA	R	4	6.48	0.4	3.5	8.00
396	02317775	GA	R	4	1.11	0.4	3.9	8.00
397	02317780	GA	R	4	2.59	0.8	4.4	8.00
398	02317795	GA	R	4	6.21	1.2	7.0	8.00
399	02317810	GA	SR	4	0.16	0.6	5.8	8.00
400	02317840	GA	R	4	8.23	1.0	5.3	8.00
401	02317845	GA	R	4	1.64	2.8	13.2	8.00
402	02317890	GA	SR	4	0.31	1.5	5.7	8.00
403	02317900	GA	R	4	47.0	0.9	5.6	8.00
404	02317905	GA	R	4	4.22	0.6	4.5	8.00
405	02317910	GA	R	4	1.86	1.0	5.5	8.01
406	02334885	GA	U	1	47.0	17.8	56.8	7.99
407	02335347	GA	U	1	0.19	32.1	98.3	8.00
408	02335700	GA	U	1	72.0	14.5	50.3	8.00

Table 8. Explanatory variables that were used in the regional regression equations.—Continued

[USGS, U.S. Geological Survey; square mile, mi²; in, inch; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	State	Type	Hydrologic region	Drainage area (mi²)	Percentage of impervious area	Percentage of developed land	24-hour, 50-year maximum precipitation (in)
409	02335870	GA	U	1	30.7	20.3	76.7	8.00
410	02336080	GA	U	1	19.1	33.1	81.7	8.00
411	02336102	GA	U	1	2.30	22.0	82.3	8.00
412	02336238	GA	U	1	0.92	20.9	88.4	8.00
413	02336300	GA	U	1	86.8	31.0	82.8	8.00
414	02336360	GA	U	1	26.6	27.9	80.5	8.00
415	02336635	GA	U	1	31.5	19.9	73.0	8.00
416	02336700	GA	U	1	0.68	17.2	85.2	8.00
417	02336705	GA	U	1	8.80	19.6	73.3	8.00
418	02337000	GA	R	1	246	7.9	33.5	7.94
419	02337400	GA	R	1	47.0	2.2	13.1	8.00
420	02337448	GA	SR	1	0.31	0.6	5.0	8.00
421	02337500	GA	R	1	35.5	1.3	7.4	7.89
422	02338660	GA	R	1	127	1.5	7.6	8.00
423	02338840	GA	R	1	91.0	1.1	6.8	8.00
424	02339000	GA	R	1	182	1.1	6.7	8.00
425	02340250	GA	R	1	204	0.7	4.8	8.00
426	02340500	GA	R	1	61.7	0.6	6.6	8.00
427	02341220	GA	R	1	190	0.7	6.0	8.00
428	02341544	GA	U	3	1.58	18.3	78.4	8.00
429	02341546	GA	U	3	0.22	18.7	67.0	8.00
430	02341548	GA	U	1	1.59	21.0	71.8	8.00
431	02341600	GA	R	3	47.4	0.6	3.5	7.86
432	02341723	GA	R	3	31.4	0.3	2.8	7.90
433	02343219	GA	R	4	2.98	0.1	1.7	8.25
434	02343244	GA	R	4	15.3	0.2	2.0	8.57
435	02343267	GA	R	4	2.64	0.4	3.3	8.87
436	02344700	GA	R	1	101	7.0	27.6	8.00
437	02346193	GA	R	1	3.36	0.3	3.3	7.93
438	02346195	GA	R	1	81.3	0.4	4.1	7.96
439	02346210	GA	R	1	6.62	0.7	6.5	7.86
440	02346217	GA	R	1	2.82	0.8	4.3	7.98
441	02346500	GA	R	1	186	2.3	10.4	7.84
442	02348300	GA	R	3	131	0.5	3.5	7.78
443	02348485	GA	R	3	17.3	0.3	2.9	7.84
444	02349030	GA	R	3	41.1	0.5	3.4	7.86
445	02349330	GA	SR	3	0.40	0.7	6.7	7.89
446	02349350	GA	R	3	146	0.3	3.0	7.89
447	02349695	GA	SR	4	0.72	0.3	3.0	7.79
448	02349900	GA	R	4	45.0	0.6	4.3	7.81
449	02350520	GA	R	4	3.77	0.3	5.1	8.00
450	02350685	GA	SR	4	0.30	0.6	10.6	7.99
451	02351800	GA	R	4	47.0	0.5	3.9	7.98
452	02352605	GA	U	4	0.21	32.0	99.1	8.22

Table 8. Explanatory variables that were used in the regional regression equations.—Continued

[USGS, U.S. Geological Survey; square mile, mi^2; in, inch; U, urban; R, rural; SR, small rural]

Map index number (fig. 2)	USGS station number	State	Type	Hydrologic region	Drainage area (mi^2)	Percentage of impervious area	Percentage of developed land	24-hour, 50-year maximum precipitation (in)
453	02353200	GA	R	4	48.8	0.2	2.0	8.31
454	02356100	GA	R	4	49.0	0.3	3.0	8.70
455	02383000	GA	R	1	6.17	0.4	5.2	7.56
456	02383200	GA	R	1	1.61	0.5	8.1	7.51
457	02384600	GA	R	1	3.78	1.8	16.4	6.96
458	02385000	GA	R	1	86.7	1.2	8.6	6.84
459	02387100	GA	R	1	1.40	0.8	7.1	7.31
460	02387200	GA	R	1	1.66	0.9	7.1	7.29
461	02387300	GA	SR	1	0.28	3.0	18.1	7.32
462	02387560	GA	R	1	3.56	3.4	20.1	7.41
463	02387570	GA	R	1	21.7	2.3	15.0	7.39
464	02387700	GA	R	1	8.61	0.1	1.6	7.12
465	02387800	GA	R	1	3.82	0.7	6.0	6.96
466	02388000	GA	R	1	36.4	0.2	3.2	6.96
467	02388200	GA	R	1	6.02	0.1	2.7	7.05
468	02388300	GA	R	1	14.7	0.2	2.3	7.10
469	02388400	GA	R	1	2.84	2.6	16.5	7.24
470	02389300	GA	R	1	21.7	1.0	9.5	8.00
472	02392975	GA	U	1	33.6	24.2	73.2	8.00
473	02394400	GA	R	1	42.8	0.6	4.8	7.95
474	02394820	GA	R	1	42.1	3.5	6.8	7.48
475	02394950	GA	R	1	25.0	0.5	3.1	7.57
476	02395120	GA	R	1	33.1	1.6	10.6	7.52
477	02395990	GA	U	1	0.33	13.2	76.5	7.21
478	02396550	GA	U	1	0.25	25.1	62.1	7.21
479	02397410	GA	R	1	66.9	0.9	7.6	7.32
480	02397500	GA	R	1	115	2.3	12.8	7.30
481	02397750	GA	R	1	6.70	0.3	4.3	6.90
482	02397830	GA	R	1	13.3	0.2	2.8	6.94
483	02398000	GA	R	1	192	1.6	10.0	6.95
484	02411735	GA	SR	1	0.94	1.2	7.9	7.73
485	02411800	GA	R	1	20.2	1.7	9.1	7.59
486	02411900	GA	R	1	236	1.1	6.5	7.51
487	02411902	GA	SR	1	0.12	2.0	16.3	7.36
488	02413000	GA	R	1	95.1	3.6	15.1	7.75
489	02413200	GA	R	1	220	3.8	15.0	7.72
490	03566660	GA	R	1	4.44	0.6	6.6	6.83
491	03566685	GA	R	1	35.5	0.9	8.1	6.89
492	03566687	GA	R	1	3.36	1.9	14.4	6.84
493	03566700	GA	R	1	169	1.7	10.2	6.87
494	03567200	GA	R	1	73.0	0.5	4.5	6.89
495	03568500	GA	R	1	50.6	1.2	9.9	6.81
496	03568933	GA	R	1	149	1.2	8.3	6.86

Table 12. Variance from at-site analysis, regional regression analysis, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regional regresssion analysis.

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B (expected moments algorithm) analysis of the streamgaging station; R, from the regression analysis; W, weighted using equation 13; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Variance of prediction, in log units											
		50-percent AEP			20-percent AEP			10-percent AEP			4-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
23	02068610	0.0024	0.018	0.0020	0.0032	0.012	0.0030	0.0043	0.011	0.0030	0.0063	0.013	0.0040
31	02077210	0.0072	0.019	0.0050	0.0100	0.012	0.0050	0.0136	0.012	0.0060	0.0199	0.014	0.0080
42	02082540	0.0117	0.018	0.0070	0.0154	0.012	0.0070	0.0204	0.011	0.0070	0.0292	0.013	0.0090
55	02085020	0.0057	0.018	0.0040	0.0075	0.011	0.0040	0.0101	0.011	0.0050	0.0149	0.013	0.0070
64	02086849	0.0009	0.021	0.0010	0.0009	0.018	0.0010	0.0011	0.017	0.0010	0.0015	0.018	0.0010
66	02087140	0.0051	0.018	0.0040	0.0066	0.011	0.0040	0.0089	0.011	0.0050	0.0132	0.013	0.0070
67	02087240	0.0039	0.018	0.0030	0.0050	0.012	0.0040	0.0068	0.012	0.0040	0.0100	0.013	0.0060
68	0208726005	0.0053	0.021	0.0040	0.0048	0.018	0.0040	0.0051	0.017	0.0040	0.0067	0.018	0.0050
69	02087275	0.0034	---	---	0.0034	---	---	0.0039	---	---	0.0056	---	---
70	02087324	0.0032	0.021	0.0030	0.0044	0.018	0.0040	0.0058	0.017	0.0040	0.0104	0.018	0.0070
71	0208732885	0.0037	0.021	0.0030	0.0052	0.018	0.0040	0.0076	0.017	0.0050	0.0132	0.018	0.0080
72	0208735012	0.0035	---	---	0.0040	---	---	0.0053	---	---	0.0081	---	---
73	02087359	0.0067	0.021	0.0050	0.0110	0.018	0.0070	0.0168	0.017	0.0080	0.0312	0.018	0.0110
74	02087580	0.0048	0.021	0.0040	0.0083	0.018	0.0060	0.0121	0.017	0.0070	0.0211	0.017	0.0090
94	02093229	0.0091	0.033	0.0070	0.0067	0.028	0.0050	0.0074	0.028	0.0060	0.0116	0.030	0.0080
98	0209399200	0.0104	0.021	0.0070	0.0110	0.018	0.0070	0.0138	0.017	0.0080	0.0205	0.018	0.0100
99	02094659	0.0032	0.022	0.0030	0.0039	0.019	0.0030	0.0052	0.018	0.0040	0.0081	0.019	0.0060
100	02094770	0.0019	0.022	0.0020	0.0024	0.019	0.0020	0.0031	0.018	0.0030	0.0049	0.019	0.0040
101	02095000	0.0004	0.022	0.0000	0.0005	0.018	0.0000	0.0007	0.018	0.0010	0.0011	0.018	0.0010
102	02095181	0.0022	---	---	0.0008	---	---	0.0008	---	---	0.0013	---	---
103	02095271	0.0021	0.022	0.0020	0.0021	0.018	0.0020	0.0026	0.018	0.0020	0.0037	0.018	0.0030
104	02095500	0.0018	0.021	0.0020	0.0023	0.018	0.0020	0.0031	0.017	0.0030	0.0052	0.018	0.0040
105	0209553650	0.0006	0.021	0.0010	0.0005	0.018	0.0000	0.0007	0.017	0.0010	0.0010	0.018	0.0010
114	0209782609	0.0168	0.021	0.0090	0.0283	0.018	0.0110	0.0417	0.017	0.0120	0.0746	0.018	0.0150
119	02101480	0.0053	0.018	0.0040	0.0060	0.011	0.0040	0.0078	0.011	0.0050	0.0111	0.013	0.0060
134	02106410	0.0047	0.029	0.0040	0.0061	0.024	0.0050	0.0083	0.024	0.0060	0.0121	0.026	0.0080
136	02107590	0.0094	0.029	0.0070	0.0111	0.024	0.0080	0.0147	0.024	0.0090	0.0212	0.026	0.0120
146	02110740	0.0013	0.030	0.0010	0.0012	0.025	0.0010	0.0013	0.025	0.0010	0.0016	0.027	0.0020
149	02115520	0.0032	0.018	0.0030	0.0038	0.011	0.0030	0.0052	0.011	0.0040	0.0077	0.013	0.0050
151	02115845	0.0010	0.021	0.0010	0.0013	0.018	0.0010	0.0017	0.017	0.0020	0.0027	0.018	0.0020

Table 12. Variance from at-site analysis, regional regression analysis, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regional regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B (expected moments algorithm) analysis of the streamgaging station; R, from the regression analysis; W, weighted using equation 13; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Variance of prediction, in log units											
		2-percent AEP			1-percent AEP			0.5-percent AEP			0.2-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
23	02068610	0.0082	0.016	0.0050	0.0104	0.019	0.0070	0.0129	0.022	0.0080	0.0168	0.025	0.0100
31	02077210	0.0259	0.016	0.0100	0.0328	0.019	0.0120	0.0407	0.022	0.0140	0.0527	0.025	0.0170
42	02082540	0.0373	0.016	0.0110	0.0467	0.019	0.0140	0.0573	0.022	0.0160	0.0734	0.025	0.0190
55	02085020	0.0195	0.015	0.0080	0.0251	0.018	0.0100	0.0316	0.021	0.0130	0.0416	0.024	0.0150
64	02086849	0.0021	0.019	0.0020	0.0028	0.021	0.0020	0.0036	0.023	0.0030	0.0049	0.026	0.0040
66	02087140	0.0173	0.015	0.0080	0.0221	0.018	0.0100	0.0278	0.021	0.0120	0.0364	0.024	0.0140
67	02087240	0.0132	0.016	0.0070	0.0170	0.019	0.0090	0.0215	0.022	0.0110	0.0285	0.025	0.0130
68	0208726005	0.0089	0.019	0.0060	0.0122	0.021	0.0080	0.0164	0.023	0.0100	0.0235	0.026	0.0120
69	02087275	0.0079	---	---	0.0112	---	---	0.0155	---	---	0.0230	---	---
70	02087324	0.0171	0.019	0.0090	0.0269	0.021	0.0120	0.0403	0.023	0.0150	0.0638	0.026	0.0180
71	0208732885	0.0196	0.019	0.0100	0.0279	0.022	0.0120	0.0383	0.024	0.0150	0.0553	0.027	0.0180
72	0208735012	0.0113	---	---	0.0153	---	---	0.0203	---	---	0.0283	---	---
73	02087359	0.0486	0.019	0.0140	0.0724	0.021	0.0160	0.1029	0.023	0.0190	0.1545	0.026	0.0220
74	02087580	0.0320	0.019	0.0120	0.0472	0.021	0.0150	0.0669	0.023	0.0170	0.1005	0.026	0.0210
94	02093229	0.0172	0.033	0.0110	0.0246	0.037	0.0150	0.0337	0.042	0.0190	0.0480	0.050	0.0240
98	0209399200	0.0281	0.019	0.0110	0.0377	0.021	0.0130	0.0495	0.023	0.0160	0.0683	0.026	0.0190
99	02094659	0.0112	0.020	0.0070	0.0151	0.023	0.0090	0.0199	0.025	0.0110	0.0277	0.029	0.0140
100	02094770	0.0067	0.020	0.0050	0.0091	0.022	0.0060	0.0120	0.024	0.0080	0.0167	0.028	0.0100
101	02095000	0.0015	0.020	0.0010	0.0020	0.022	0.0020	0.0027	0.024	0.0020	0.0037	0.028	0.0030
102	02095181	0.0018	---	---	0.0024	---	---	0.0030	---	---	0.0039	---	---
103	02095271	0.0050	0.020	0.0040	0.0067	0.022	0.0050	0.0087	0.024	0.0060	0.0120	0.027	0.0080
104	02095500	0.0075	0.019	0.0050	0.0105	0.021	0.0070	0.0143	0.023	0.0090	0.0204	0.027	0.0120
105	0209553650	0.0014	0.019	0.0010	0.0019	0.021	0.0020	0.0025	0.023	0.0020	0.0035	0.027	0.0030
114	0209782609	0.1143	0.019	0.0160	0.1687	0.021	0.0190	0.2391	0.023	0.0210	0.3583	0.026	0.0240
119	02101480	0.0145	0.015	0.0070	0.0185	0.018	0.0090	0.0231	0.021	0.0110	0.0303	0.024	0.0130
134	02106410	0.0157	0.028	0.0100	0.0200	0.032	0.0120	0.0250	0.036	0.0150	0.0327	0.042	0.0180
136	02107590	0.0275	0.028	0.0140	0.0348	0.032	0.0170	0.0431	0.035	0.0190	0.0559	0.042	0.0240
146	02110740	0.0021	0.030	0.0020	0.0027	0.034	0.0030	0.0035	0.038	0.0030	0.0050	0.045	0.0050
149	02115520	0.0100	0.015	0.0060	0.0127	0.018	0.0070	0.0157	0.021	0.0090	0.0203	0.024	0.0110
151	02115845	0.0038	0.019	0.0030	0.0051	0.021	0.0040	0.0067	0.023	0.0050	0.0093	0.027	0.0070

Table 12. Variance from at-site analysis, regional regression analysis, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regional regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B (expected moments algorithm) analysis of the streamgaging station; R, from the regression analysis; W, weighted using equation 13; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Variance of prediction, in log units											
		50-percent AEP			20-percent AEP			10-percent AEP			4-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
166	0212414900	0.0047	0.021	0.0040	0.0076	0.018	0.0050	0.0115	0.017	0.0070	0.0212	0.018	0.0100
170	02127390	0.0036	0.018	0.0030	0.0043	0.011	0.0030	0.0055	0.011	0.0040	0.0079	0.013	0.0050
172	02129530	0.0065	0.038	0.0060	0.0090	0.046	0.0080	0.0122	0.053	0.0100	0.0177	0.063	0.0140
175	02131130	0.0002	0.031	0.0000	0.0002	0.026	0.0000	0.0003	0.026	0.0000	0.0006	0.028	0.0010
186	02135518	0.0012	0.029	0.0010	0.0014	0.024	0.0010	0.0019	0.024	0.0020	0.0030	0.025	0.0030
189	0214266000	0.0071	0.021	0.0050	0.0111	0.018	0.0070	0.0164	0.017	0.0080	0.0287	0.017	0.0110
190	02142900	0.0013	0.021	0.0010	0.0017	0.018	0.0020	0.0025	0.017	0.0020	0.0043	0.018	0.0030
191	0214291555	0.0048	0.021	0.0040	0.0051	0.018	0.0040	0.0064	0.017	0.0050	0.0096	0.018	0.0060
192	0214295600	0.0042	0.021	0.0040	0.0045	0.018	0.0040	0.0058	0.017	0.0040	0.0089	0.018	0.0060
195	02145940	0.0006	0.021	0.0010	0.0006	0.018	0.0010	0.0007	0.017	0.0010	0.0011	0.018	0.0010
196	02146211	0.0024	0.021	0.0020	0.0044	0.018	0.0040	0.0071	0.017	0.0050	0.0150	0.018	0.0080
197	0214627970	0.0045	0.022	0.0040	0.0043	0.018	0.0030	0.0053	0.018	0.0040	0.0079	0.018	0.0050
198	02146300	0.0010	0.022	0.0010	0.0015	0.018	0.0010	0.0022	0.018	0.0020	0.0042	0.018	0.0030
199	02146315	0.0061	0.022	0.0050	0.0035	0.019	0.0030	0.0049	0.018	0.0040	0.0085	0.019	0.0060
200	02146348	0.0045	0.021	0.0040	0.0039	0.018	0.0030	0.0045	0.017	0.0040	0.0068	0.018	0.0050
201	02146381	0.0025	0.022	0.0020	0.0040	0.018	0.0030	0.0060	0.018	0.0050	0.0111	0.018	0.0070
202	02146409	0.0016	0.023	0.0010	0.0011	0.019	0.0010	0.0011	0.019	0.0010	0.0014	0.020	0.0010
203	0214642825	0.0023	0.021	0.0020	0.0038	0.018	0.0030	0.0057	0.017	0.0040	0.0105	0.018	0.0070
204	0214645022	0.0028	0.021	0.0020	0.0036	0.018	0.0030	0.0049	0.017	0.0040	0.0079	0.018	0.0050
205	02146470	0.0022	0.020	0.0020	0.0024	0.013	0.0020	0.0031	0.012	0.0020	0.0049	0.014	0.0040
206	02146500	0.0006	0.021	0.0010	0.0007	0.018	0.0010	0.0010	0.017	0.0010	0.0017	0.018	0.0020
207	02146507	0.0009	0.021	0.0010	0.0012	0.018	0.0010	0.0017	0.017	0.0020	0.0029	0.018	0.0020
208	02146530	0.0022	0.021	0.0020	0.0032	0.018	0.0030	0.0046	0.017	0.0040	0.0077	0.018	0.0050
209	0214655255	0.0216	0.021	0.0110	0.0198	0.018	0.0090	0.0235	0.017	0.0100	0.0349	0.018	0.0120
210	02146562	0.0123	0.021	0.0080	0.0164	0.018	0.0090	0.0225	0.017	0.0100	0.0358	0.018	0.0120
211	0214657975	0.0085	0.021	0.0060	0.0069	0.018	0.0050	0.0076	0.017	0.0050	0.0104	0.018	0.0070
212	02146600	0.0009	0.021	0.0010	0.0010	0.018	0.0010	0.0012	0.017	0.0010	0.0020	0.018	0.0020
213	02146700	0.0014	0.021	0.0010	0.0015	0.018	0.0010	0.0019	0.017	0.0020	0.0031	0.018	0.0030
214	02146750	0.0011	0.021	0.0010	0.0009	0.018	0.0010	0.0011	0.017	0.0010	0.0017	0.018	0.0020
215	0214678175	0.0032	0.022	0.0030	0.0044	0.018	0.0040	0.0061	0.018	0.0050	0.0099	0.018	0.0060

Table 12. Variance from at-site analysis, regional regression analysis, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regional regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B (expected moments algorithm) analysis of the streamgaging station; R, from the regression analysis; W, weighted using equation 13; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Variance of prediction, in log units											
		2-percent AEP			1-percent AEP			0.5-percent AEP			0.2-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
166	0212414900	0.0328	0.019	0.0120	0.0484	0.021	0.0150	0.0686	0.023	0.0170	0.1024	0.026	0.0210
170	02127390	0.0103	0.015	0.0060	0.0130	0.018	0.0080	0.0162	0.021	0.0090	0.0211	0.024	0.0110
172	02129530	0.0228	0.070	0.0170	0.0287	0.078	0.0210	0.0353	0.087	0.0250	0.0454	0.100	0.0310
175	02131130	0.0009	0.031	0.0010	0.0013	0.034	0.0010	0.0019	0.038	0.0020	0.0028	0.046	0.0030
186	02135518	0.0043	0.028	0.0040	0.0059	0.031	0.0050	0.0080	0.035	0.0070	0.0113	0.041	0.0090
189	0214266000	0.0431	0.019	0.0130	0.0623	0.021	0.0160	0.0866	0.022	0.0180	0.1271	0.026	0.0220
190	02142900	0.0063	0.019	0.0050	0.0090	0.021	0.0060	0.0124	0.023	0.0080	0.0178	0.026	0.0110
191	0214291555	0.0132	0.019	0.0080	0.0180	0.021	0.0100	0.0237	0.023	0.0120	0.0330	0.026	0.0150
192	0214295600	0.0125	0.019	0.0080	0.0171	0.021	0.0090	0.0228	0.023	0.0110	0.0320	0.026	0.0140
195	02145940	0.0014	0.019	0.0010	0.0019	0.022	0.0020	0.0025	0.024	0.0020	0.0033	0.027	0.0030
196	02146211	0.0253	0.019	0.0110	0.0401	0.021	0.0140	0.0597	0.023	0.0170	0.0938	0.027	0.0210
197	0214627970	0.0109	0.020	0.0070	0.0149	0.022	0.0090	0.0198	0.024	0.0110	0.0276	0.027	0.0140
198	02146300	0.0064	0.020	0.0050	0.0094	0.022	0.0070	0.0131	0.024	0.0080	0.0193	0.027	0.0110
199	02146315	0.0121	0.020	0.0080	0.0163	0.022	0.0090	0.0209	0.024	0.0110	0.0277	0.028	0.0140
200	02146348	0.0097	0.019	0.0060	0.0135	0.021	0.0080	0.0182	0.023	0.0100	0.0258	0.027	0.0130
201	02146381	0.0171	0.020	0.0090	0.0253	0.022	0.0120	0.0357	0.024	0.0140	0.0532	0.027	0.0180
202	02146409	0.0020	0.021	0.0020	0.0027	0.024	0.0020	0.0035	0.026	0.0030	0.0049	0.030	0.0040
203	0214642825	0.0163	0.019	0.0090	0.0244	0.021	0.0110	0.0349	0.023	0.0140	0.0530	0.027	0.0180
204	0214645022	0.0112	0.019	0.0070	0.0157	0.021	0.0090	0.0212	0.023	0.0110	0.0303	0.026	0.0140
205	02146470	0.0069	0.017	0.0050	0.0096	0.020	0.0060	0.0129	0.024	0.0080	0.0183	0.025	0.0110
206	02146500	0.0025	0.019	0.0020	0.0036	0.021	0.0030	0.0050	0.023	0.0040	0.0073	0.026	0.0060
207	02146507	0.0042	0.019	0.0030	0.0060	0.022	0.0050	0.0082	0.024	0.0060	0.0117	0.027	0.0080
208	02146530	0.0111	0.019	0.0070	0.0156	0.022	0.0090	0.0211	0.024	0.0110	0.0302	0.027	0.0140
209	0214655255	0.0487	0.019	0.0140	0.0667	0.021	0.0160	0.0888	0.023	0.0180	0.1241	0.026	0.0210
210	02146562	0.0502	0.019	0.0140	0.0686	0.021	0.0160	0.0913	0.023	0.0180	0.1279	0.027	0.0220
211	0214657975	0.0140	0.019	0.0080	0.0186	0.021	0.0100	0.0242	0.023	0.0120	0.0330	0.026	0.0150
212	02146600	0.0029	0.019	0.0030	0.0040	0.021	0.0030	0.0055	0.023	0.0040	0.0078	0.026	0.0060
213	02146700	0.0045	0.019	0.0040	0.0063	0.021	0.0050	0.0085	0.023	0.0060	0.0122	0.027	0.0080
214	02146750	0.0026	0.019	0.0020	0.0037	0.021	0.0030	0.0051	0.023	0.0040	0.0075	0.026	0.0060
215	0214678175	0.0140	0.020	0.0080	0.0193	0.022	0.0100	0.0258	0.024	0.0120	0.0364	0.027	0.0160

Table 12. Variance from at-site analysis, regional regression analysis, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regional regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B (expected moments algorithm) analysis of the streamgaging station; R, from the regression analysis; W, weighted using equation 13; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Variance of prediction, in log units											
		50-percent AEP			20-percent AEP			10-percent AEP			4-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
231	02159785	0.0018	0.018	0.0020	0.0016	0.011	0.0010	0.0019	0.011	0.0020	0.0030	0.013	0.0020
233	02160325	0.0024	0.021	0.0020	0.0056	0.018	0.0040	0.0091	0.017	0.0060	0.0193	0.018	0.0090
236	02162093	0.0004	0.034	0.0000	0.0005	0.041	0.0000	0.0007	0.047	0.0010	0.0012	0.055	0.0010
237	02164000	0.0016	0.021	0.0010	0.0021	0.018	0.0020	0.0029	0.017	0.0020	0.0049	0.018	0.0040
238	02164011	0.0007	0.020	0.0010	0.0005	0.013	0.0000	0.0006	0.013	0.0010	0.0010	0.015	0.0010
241	02166975	0.0006	---	---	0.0005	---	---	0.0006	---	---	0.0009	---	---
242	02167020	0.0005	0.033	0.0000	0.0009	0.041	0.0010	0.0015	0.047	0.0010	0.0032	0.055	0.0030
245	02168845	0.0007	0.018	0.0010	0.0012	0.012	0.0010	0.0018	0.011	0.0020	0.0033	0.013	0.0030
246	02169505	0.0004	0.034	0.0000	0.0004	0.041	0.0000	0.0005	0.047	0.0000	0.0008	0.055	0.0010
248	02169568	0.0020	0.032	0.0020	0.0028	0.039	0.0030	0.0043	0.045	0.0040	0.0077	0.052	0.0070
249	02169570	0.0010	---	---	0.0012	---	---	0.0017	---	---	0.0029	---	---
252	02173491	0.0010	0.030	0.0010	0.0012	0.024	0.0010	0.0016	0.024	0.0020	0.0026	0.026	0.0020
253	02173495	0.0014	---	---	0.0021	---	---	0.0031	---	---	0.0056	---	---
255	02176380	0.0022	0.029	0.0020	0.0035	0.024	0.0030	0.0054	0.023	0.0040	0.0100	0.025	0.0070
262	02189030	0.0007	0.018	0.0010	0.0004	0.012	0.0000	0.0005	0.011	0.0000	0.0009	0.013	0.0010
266	02190800	0.0067	0.018	0.0050	0.0078	0.011	0.0050	0.0100	0.011	0.0050	0.0143	0.013	0.0070
269	02191280	0.0013	0.018	0.0010	0.0013	0.011	0.0010	0.0018	0.011	0.0020	0.0028	0.013	0.0020
285	02196725	0.0021	0.033	0.0020	0.0016	0.040	0.0020	0.0018	0.046	0.0020	0.0027	0.054	0.0030
286	02196760	0.0020	0.032	0.0020	0.0023	0.039	0.0020	0.0026	0.045	0.0020	0.0036	0.053	0.0030
295	02201250	0.0073	0.029	0.0060	0.0075	0.024	0.0060	0.0091	0.024	0.0070	0.0123	0.026	0.0080
307	02203543	0.0025	0.029	0.0020	0.0047	0.024	0.0040	0.0074	0.024	0.0060	0.0149	0.026	0.0090
308	02203544	0.0007	0.030	0.0010	0.0007	0.025	0.0010	0.0008	0.025	0.0010	0.0012	0.026	0.0010
310	02203800	0.0024	0.021	0.0020	0.0016	0.018	0.0010	0.0016	0.017	0.0010	0.0027	0.018	0.0020
311	02203835	0.0014	0.021	0.0010	0.0020	0.018	0.0020	0.0030	0.017	0.0030	0.0053	0.018	0.0040
312	02203845	0.0020	0.018	0.0020	0.0011	0.012	0.0010	0.0011	0.011	0.0010	0.0023	0.013	0.0020
313	02203884	0.0015	0.019	0.0010	0.0017	0.012	0.0010	0.0023	0.012	0.0020	0.0036	0.014	0.0030
314	02203900	0.0016	0.021	0.0010	0.0014	0.018	0.0010	0.0017	0.017	0.0020	0.0026	0.018	0.0020
315	02204070	0.0013	0.021	0.0010	0.0017	0.018	0.0020	0.0025	0.017	0.0020	0.0042	0.018	0.0030
316	02204135	0.0064	0.018	0.0050	0.0065	0.012	0.0040	0.0093	0.011	0.0050	0.0144	0.013	0.0070
317	02205000	0.0082	0.018	0.0060	0.0079	0.012	0.0050	0.0095	0.011	0.0050	0.0147	0.013	0.0070

Table 12. Variance from at-site analysis, regional regression analysis, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regional regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B (expected moments algorithm) analysis of the streamgaging station; R, from the regression analysis; W, weighted using equation 13; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Variance of prediction, in log units											
		2-percent AEP			1-percent AEP			0.5-percent AEP			0.2-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
231	02159785	0.0044	0.015	0.0030	0.0062	0.018	0.0050	0.0085	0.021	0.0060	0.0122	0.025	0.0080
233	02160325	0.0336	0.019	0.0120	0.0549	0.021	0.0150	0.0842	0.023	0.0180	0.1363	0.026	0.0220
236	02162093	0.0018	0.062	0.0020	0.0025	0.069	0.0020	0.0034	0.076	0.0030	0.0049	0.088	0.0050
237	02164000	0.0071	0.019	0.0050	0.0099	0.021	0.0070	0.0135	0.023	0.0090	0.0192	0.026	0.0110
238	02164011	0.0014	0.017	0.0010	0.0021	0.021	0.0020	0.0029	0.024	0.0030	0.0042	0.026	0.0040
241	02166975	0.0013	---	---	0.0018	---	---	0.0025	---	---	0.0035	---	---
242	02167020	0.0054	0.062	0.0050	0.0086	0.069	0.0080	0.0128	0.076	0.0110	0.0201	0.087	0.0160
245	02168845	0.0052	0.016	0.0040	0.0077	0.018	0.0050	0.0110	0.022	0.0070	0.0165	0.025	0.0100
246	02169505	0.0012	0.062	0.0010	0.0016	0.069	0.0020	0.0022	0.076	0.0020	0.0032	0.088	0.0030
248	02169568	0.0115	0.059	0.0100	0.0167	0.065	0.0130	0.0231	0.072	0.0170	0.0337	0.083	0.0240
249	02169570	0.0043	---	---	0.0060	---	---	0.0083	---	---	0.0119	---	---
252	02173491	0.0038	0.029	0.0030	0.0052	0.032	0.0040	0.0071	0.036	0.0060	0.0101	0.043	0.0080
253	02173495	0.0085	---	---	0.0123	---	---	0.0170	---	---	0.0248	---	---
255	02176380	0.0154	0.028	0.0100	0.0228	0.031	0.0130	0.0322	0.034	0.0170	0.0478	0.041	0.0220
262	02189030	0.0014	0.015	0.0010	0.0019	0.018	0.0020	0.0024	0.021	0.0020	0.0033	0.025	0.0030
266	02190800	0.0184	0.015	0.0080	0.0232	0.018	0.0100	0.0289	0.021	0.0120	0.0374	0.024	0.0150
269	02191280	0.0038	0.015	0.0030	0.0048	0.018	0.0040	0.0060	0.021	0.0050	0.0078	0.025	0.0060
285	02196725	0.0040	0.061	0.0040	0.0056	0.067	0.0050	0.0076	0.075	0.0070	0.0107	0.086	0.0100
286	02196760	0.0049	0.059	0.0050	0.0066	0.065	0.0060	0.0088	0.072	0.0080	0.0127	0.083	0.0110
295	02201250	0.0156	0.028	0.0100	0.0194	0.032	0.0120	0.0239	0.035	0.0140	0.0309	0.042	0.0180
307	02203543	0.0248	0.029	0.0130	0.0389	0.032	0.0180	0.0577	0.036	0.0220	0.0903	0.042	0.0290
308	02203544	0.0018	0.029	0.0020	0.0025	0.033	0.0020	0.0033	0.036	0.0030	0.0047	0.043	0.0040
310	02203800	0.0042	0.019	0.0030	0.0063	0.021	0.0050	0.0089	0.023	0.0060	0.0129	0.027	0.0090
311	02203835	0.0080	0.019	0.0060	0.0115	0.021	0.0070	0.0159	0.023	0.0090	0.0232	0.027	0.0120
312	02203845	0.0037	0.015	0.0030	0.0056	0.018	0.0040	0.0078	0.021	0.0060	0.0110	0.024	0.0080
313	02203884	0.0050	0.016	0.0040	0.0069	0.019	0.0050	0.0093	0.022	0.0070	0.0131	0.025	0.0090
314	02203900	0.0038	0.019	0.0030	0.0055	0.021	0.0040	0.0076	0.023	0.0060	0.0109	0.026	0.0080
315	02204070	0.0061	0.019	0.0050	0.0087	0.021	0.0060	0.0118	0.023	0.0080	0.0169	0.026	0.0100
316	02204135	0.0191	0.016	0.0090	0.0246	0.019	0.0110	0.0308	0.022	0.0130	0.0403	0.025	0.0150
317	02205000	0.0211	0.015	0.0090	0.0296	0.018	0.0110	0.0403	0.021	0.0140	0.0576	0.024	0.0170

Table 12. Variance from at-site analysis, regional regression analysis, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regional regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B (expected moments algorithm) analysis of the streamgaging station; R, from the regression analysis; W, weighted using equation 13; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Variance of prediction, in log units											
		50-percent AEP			20-percent AEP			10-percent AEP			4-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
318	02205230	0.0015	0.018	0.0010	0.0013	0.011	0.0010	0.0013	0.011	0.0010	0.0015	0.013	0.0010
319	02205500	0.0087	0.019	0.0060	0.0136	0.012	0.0060	0.0206	0.012	0.0080	0.0372	0.014	0.0100
320	02205596	0.0036	0.021	0.0030	0.0037	0.018	0.0030	0.0047	0.017	0.0040	0.0072	0.018	0.0050
321	02206105	0.0022	0.019	0.0020	0.0027	0.012	0.0020	0.0037	0.012	0.0030	0.0060	0.014	0.0040
322	02206136	0.0010	0.018	0.0010	0.0013	0.012	0.0010	0.0017	0.011	0.0010	0.0027	0.013	0.0020
323	02206165	0.0021	0.019	0.0020	0.0005	0.013	0.0000	0.0006	0.012	0.0010	0.0012	0.014	0.0010
324	02206465	0.0044	0.020	0.0040	0.0016	0.013	0.0010	0.0019	0.013	0.0020	0.0045	0.015	0.0030
325	02206500	0.0010	0.021	0.0010	0.0013	0.018	0.0010	0.0019	0.017	0.0020	0.0033	0.018	0.0030
326	02207000	0.0050	0.021	0.0040	0.0046	0.018	0.0040	0.0054	0.017	0.0040	0.0081	0.018	0.0060
327	02207500	0.0039	0.021	0.0030	0.0073	0.018	0.0050	0.0118	0.017	0.0070	0.0250	0.018	0.0100
328	02208050	0.0047	0.021	0.0040	0.0067	0.018	0.0050	0.0097	0.017	0.0060	0.0163	0.018	0.0090
349	02217250	0.0046	0.018	0.0040	0.0055	0.012	0.0040	0.0078	0.011	0.0050	0.0121	0.013	0.0060
352	02217450	0.0027	0.018	0.0020	0.0032	0.011	0.0020	0.0044	0.011	0.0030	0.0067	0.013	0.0040
354	02217505	0.0014	0.019	0.0010	0.0021	0.012	0.0020	0.0032	0.012	0.0030	0.0057	0.013	0.0040
355	02217660	0.0059	0.018	0.0040	0.0068	0.011	0.0040	0.0087	0.011	0.0050	0.0122	0.013	0.0060
359	02218565	0.0054	0.021	0.0040	0.0047	0.018	0.0040	0.0046	0.017	0.0040	0.0052	0.018	0.0040
382	02227422	0.0051	0.029	0.0040	0.0057	0.024	0.0050	0.0073	0.024	0.0060	0.0107	0.026	0.0080
383	02227990	0.0047	0.029	0.0040	0.0054	0.024	0.0040	0.0070	0.024	0.0050	0.0104	0.026	0.0070
387	02315650	0.0029	0.030	0.0030	0.0037	0.025	0.0030	0.0051	0.025	0.0040	0.0074	0.027	0.0060
399	02317810	0.0045	0.030	0.0040	0.0050	0.025	0.0040	0.0064	0.025	0.0050	0.0093	0.027	0.0070
402	02317890	0.0065	0.029	0.0050	0.0077	0.024	0.0060	0.0108	0.024	0.0070	0.0164	0.026	0.0100
406	02334885	0.0034	0.021	0.0030	0.0042	0.018	0.0030	0.0057	0.017	0.0040	0.0093	0.018	0.0060
407	02335347	0.0020	0.019	0.0020	0.0017	0.013	0.0020	0.0019	0.012	0.0020	0.0026	0.014	0.0020
408	02335700	0.0020	0.021	0.0020	0.0020	0.018	0.0020	0.0026	0.017	0.0020	0.0041	0.017	0.0030
409	02335870	0.0022	0.021	0.0020	0.0022	0.018	0.0020	0.0028	0.017	0.0020	0.0043	0.018	0.0030
410	02336080	0.0000	0.022	0.0000	0.0001	0.018	0.0000	0.0003	0.018	0.0000	0.0008	0.018	0.0010
411	02336102	0.0007	0.018	0.0010	0.0007	0.012	0.0010	0.0009	0.011	0.0010	0.0014	0.013	0.0010
412	02336238	0.0007	0.018	0.0010	0.0010	0.011	0.0010	0.0014	0.011	0.0010	0.0026	0.013	0.0020
413	02336300	0.0004	0.021	0.0000	0.0004	0.018	0.0000	0.0006	0.017	0.0010	0.0009	0.018	0.0010
414	02336360	0.0008	0.021	0.0010	0.0008	0.018	0.0010	0.0010	0.017	0.0010	0.0017	0.018	0.0020

Table 12. Variance from at-site analysis, regional regression analysis, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regional regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B (expected moments algorithm) analysis of the streamgaging station; R, from the regression analysis; W, weighted using equation 13; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Variance of prediction, in log units											
		2-percent AEP			1-percent AEP			0.5-percent AEP			0.2-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
318	02205230	0.0018	0.015	0.0020	0.0023	0.018	0.0020	0.0030	0.021	0.0030	0.0042	0.025	0.0040
319	02205500	0.0565	0.016	0.0120	0.0822	0.019	0.0150	0.1149	0.023	0.0190	0.1692	0.025	0.0220
320	02205596	0.0101	0.019	0.0070	0.0138	0.021	0.0080	0.0184	0.023	0.0100	0.0258	0.027	0.0130
321	02206105	0.0088	0.016	0.0060	0.0124	0.019	0.0080	0.0170	0.023	0.0100	0.0246	0.026	0.0130
322	02206136	0.0038	0.015	0.0030	0.0052	0.018	0.0040	0.0070	0.022	0.0050	0.0098	0.025	0.0070
323	02206165	0.0019	0.017	0.0020	0.0027	0.020	0.0020	0.0035	0.024	0.0030	0.0045	0.027	0.0040
324	02206465	0.0075	0.017	0.0050	0.0112	0.020	0.0070	0.0152	0.024	0.0090	0.0210	0.026	0.0120
325	02206500	0.0049	0.019	0.0040	0.0070	0.021	0.0050	0.0097	0.023	0.0070	0.0140	0.026	0.0090
326	02207000	0.0115	0.019	0.0070	0.0158	0.021	0.0090	0.0212	0.023	0.0110	0.0299	0.026	0.0140
327	02207500	0.0424	0.019	0.0130	0.0673	0.021	0.0160	0.1006	0.023	0.0190	0.1584	0.026	0.0220
328	02208050	0.0236	0.019	0.0110	0.0332	0.021	0.0130	0.0452	0.023	0.0150	0.0648	0.026	0.0190
349	02217250	0.0159	0.015	0.0080	0.0203	0.018	0.0100	0.0252	0.022	0.0120	0.0325	0.025	0.0140
352	02217450	0.0088	0.015	0.0060	0.0113	0.018	0.0070	0.0139	0.021	0.0080	0.0179	0.024	0.0100
354	02217505	0.0086	0.016	0.0060	0.0125	0.019	0.0080	0.0175	0.022	0.0100	0.0257	0.025	0.0130
355	02217660	0.0155	0.015	0.0080	0.0195	0.018	0.0090	0.0240	0.021	0.0110	0.0308	0.024	0.0130
359	02218565	0.0063	0.019	0.0050	0.0080	0.021	0.0060	0.0104	0.023	0.0070	0.0145	0.026	0.0090
382	02227422	0.0142	0.029	0.0100	0.0186	0.032	0.0120	0.0238	0.036	0.0140	0.0321	0.042	0.0180
383	02227990	0.0139	0.029	0.0090	0.0182	0.032	0.0120	0.0233	0.036	0.0140	0.0314	0.042	0.0180
387	02315650	0.0095	0.029	0.0070	0.0120	0.033	0.0090	0.0147	0.037	0.0110	0.0188	0.044	0.0130
399	02317810	0.0123	0.029	0.0090	0.0160	0.033	0.0110	0.0206	0.037	0.0130	0.0277	0.043	0.0170
402	02317890	0.0215	0.029	0.0120	0.0272	0.032	0.0150	0.0336	0.036	0.0170	0.0430	0.042	0.0210
406	02334885	0.0134	0.019	0.0080	0.0188	0.021	0.0100	0.0254	0.023	0.0120	0.0361	0.026	0.0150
407	02335347	0.0035	0.017	0.0030	0.0047	0.020	0.0040	0.0061	0.024	0.0050	0.0084	0.026	0.0060
408	02335700	0.0059	0.019	0.0050	0.0084	0.021	0.0060	0.0116	0.022	0.0080	0.0167	0.026	0.0100
409	02335870	0.0062	0.019	0.0050	0.0087	0.021	0.0060	0.0118	0.023	0.0080	0.0168	0.026	0.0100
410	02336080	0.0014	0.020	0.0010	0.0022	0.022	0.0020	0.0034	0.024	0.0030	0.0054	0.027	0.0050
411	02336102	0.0020	0.016	0.0020	0.0027	0.019	0.0020	0.0037	0.022	0.0030	0.0052	0.025	0.0040
412	02336238	0.0039	0.015	0.0030	0.0057	0.018	0.0040	0.0079	0.021	0.0060	0.0115	0.024	0.0080
413	02336300	0.0012	0.019	0.0010	0.0017	0.022	0.0020	0.0023	0.024	0.0020	0.0033	0.027	0.0030
414	02336360	0.0025	0.019	0.0020	0.0036	0.021	0.0030	0.0050	0.023	0.0040	0.0073	0.027	0.0060

Table 12. Variance from at-site analysis, regional regression analysis, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regional regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B (expected moments algorithm) analysis of the streamgaging station; R, from the regression analysis; W, weighted using equation 13; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Variance of prediction, in log units											
		50-percent AEP			20-percent AEP			10-percent AEP			4-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
415	02336635	0.0055	0.021	0.0040	0.0072	0.018	0.0050	0.0100	0.017	0.0060	0.0161	0.018	0.0080
416	02336700	0.0006	0.018	0.0010	0.0006	0.011	0.0010	0.0008	0.011	0.0010	0.0013	0.013	0.0010
417	02336705	0.0013	0.021	0.0010	0.0017	0.018	0.0020	0.0022	0.017	0.0020	0.0035	0.018	0.0030
420	02337448	0.0051	0.018	0.0040	0.0061	0.012	0.0040	0.0082	0.011	0.0050	0.0121	0.013	0.0060
428	02341544	0.0015	0.031	0.0010	0.0017	0.039	0.0020	0.0022	0.044	0.0020	0.0035	0.052	0.0030
429	02341546	0.0026	0.032	0.0020	0.0044	0.040	0.0040	0.0068	0.046	0.0060	0.0129	0.054	0.0100
430	02341548	0.0018	0.018	0.0020	0.0022	0.012	0.0020	0.0030	0.011	0.0020	0.0048	0.013	0.0040
445	02349330	0.0020	0.035	0.0020	0.0023	0.043	0.0020	0.0030	0.049	0.0030	0.0044	0.058	0.0040
447	02349695	0.0025	0.029	0.0020	0.0013	0.024	0.0010	0.0020	0.024	0.0020	0.0037	0.026	0.0030
450	02350685	0.0158	0.030	0.0100	0.0206	0.024	0.0110	0.0282	0.024	0.0130	0.0431	0.026	0.0160
452	02352605	0.0103	0.031	0.0080	0.0083	0.026	0.0060	0.0093	0.025	0.0070	0.0140	0.028	0.0090
461	02387300	0.0025	0.018	0.0020	0.0028	0.012	0.0020	0.0036	0.011	0.0030	0.0052	0.013	0.0040
471	02392950	0.0061	---	---	0.0090	---	---	0.0092	---	---	0.0109	---	---
472	02392975	0.0057	0.021	0.0040	0.0073	0.018	0.0050	0.0075	0.017	0.0050	0.0091	0.018	0.0060
477	02395990	0.0032	0.018	0.0030	0.0025	0.011	0.0020	0.0030	0.011	0.0020	0.0042	0.013	0.0030
478	02396550	0.0007	0.019	0.0010	0.0007	0.012	0.0010	0.0009	0.012	0.0010	0.0013	0.013	0.0010
484	02411735	0.0025	0.018	0.0020	0.0030	0.011	0.0020	0.0040	0.011	0.0030	0.0060	0.013	0.0040
487	02411902	0.0020	0.019	0.0020	0.0026	0.012	0.0020	0.0036	0.012	0.0030	0.0055	0.014	0.0040

Table 12. Variance from at-site analysis, regional regression analysis, and weighted estimates for urban and small, rural U.S. Geological Survey streamflow-gaging stations in Georgia, South Carolina, and North Carolina that were considered for use in the regional regresssion analysis.—Continued

[AEP, annual exceedance probability; G, estimated from the Bulletin 17B (expected moments algorithm) analysis of the streamgaging station; R, from the regression analysis; W, weighted using equation 13; ---, not included in regression analysis]

Map index number (fig. 2)	USGS station number	Variance of prediction, in log units											
		2-percent AEP			1-percent AEP			0.5-percent AEP			0.2-percent AEP		
		G	R	W	G	R	W	G	R	W	G	R	W
415	02336635	0.0228	0.019	0.0100	0.0314	0.021	0.0130	0.0420	0.023	0.0150	0.0591	0.026	0.0180
416	02336700	0.0018	0.015	0.0020	0.0026	0.018	0.0020	0.0036	0.021	0.0030	0.0051	0.024	0.0040
417	02336705	0.0049	0.019	0.0040	0.0067	0.021	0.0050	0.0089	0.023	0.0060	0.0124	0.026	0.0080
420	02337448	0.0160	0.016	0.0080	0.0209	0.019	0.0100	0.0266	0.022	0.0120	0.0355	0.025	0.0150
428	02341544	0.0049	0.058	0.0050	0.0067	0.064	0.0060	0.0090	0.071	0.0080	0.0127	0.082	0.0110
429	02341546	0.0204	0.060	0.0150	0.0307	0.067	0.0210	0.0439	0.074	0.0280	0.0663	0.085	0.0370
430	02341548	0.0069	0.015	0.0050	0.0098	0.018	0.0060	0.0133	0.021	0.0080	0.0192	0.025	0.0110
445	02349330	0.0058	0.065	0.0050	0.0076	0.072	0.0070	0.0097	0.080	0.0090	0.0130	0.092	0.0110
447	02349695	0.0053	0.028	0.0040	0.0072	0.032	0.0060	0.0093	0.035	0.0070	0.0123	0.042	0.0100
450	02350685	0.0583	0.029	0.0190	0.0770	0.032	0.0230	0.0993	0.036	0.0260	0.1344	0.043	0.0330
452	02352605	0.0200	0.030	0.0120	0.0278	0.034	0.0150	0.0375	0.038	0.0190	0.0528	0.045	0.0240
461	02387300	0.0069	0.016	0.0050	0.0089	0.018	0.0060	0.0113	0.022	0.0070	0.0151	0.025	0.0090
471	02392950	0.0149	---	---	0.0223	---	---	0.0337	---	---	0.0557	---	---
472	02392975	0.0120	0.019	0.0070	0.0171	0.021	0.0090	0.0246	0.023	0.0120	0.0388	0.026	0.0160
477	02395990	0.0054	0.015	0.0040	0.0070	0.018	0.0050	0.0088	0.021	0.0060	0.0116	0.025	0.0080
478	02396550	0.0018	0.016	0.0020	0.0025	0.019	0.0020	0.0033	0.022	0.0030	0.0046	0.025	0.0040
484	02411735	0.0080	0.015	0.0050	0.0104	0.018	0.0070	0.0132	0.021	0.0080	0.0178	0.024	0.0100
487	02411902	0.0074	0.017	0.0050	0.0098	0.020	0.0070	0.0126	0.023	0.0080	0.0170	0.027	0.0100

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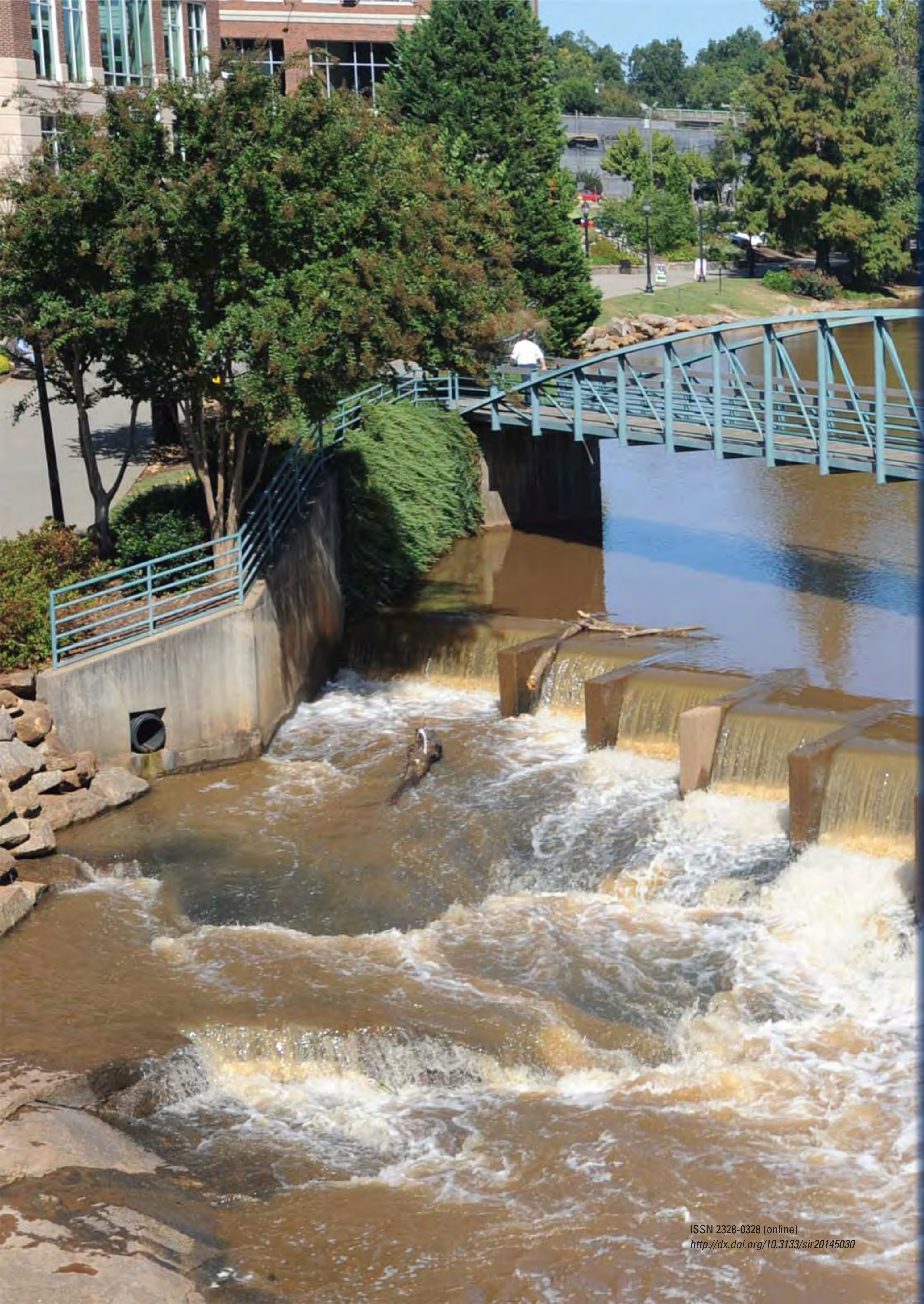

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