Prepared in cooperation with the
Virginia Department of Conservation and Recreation

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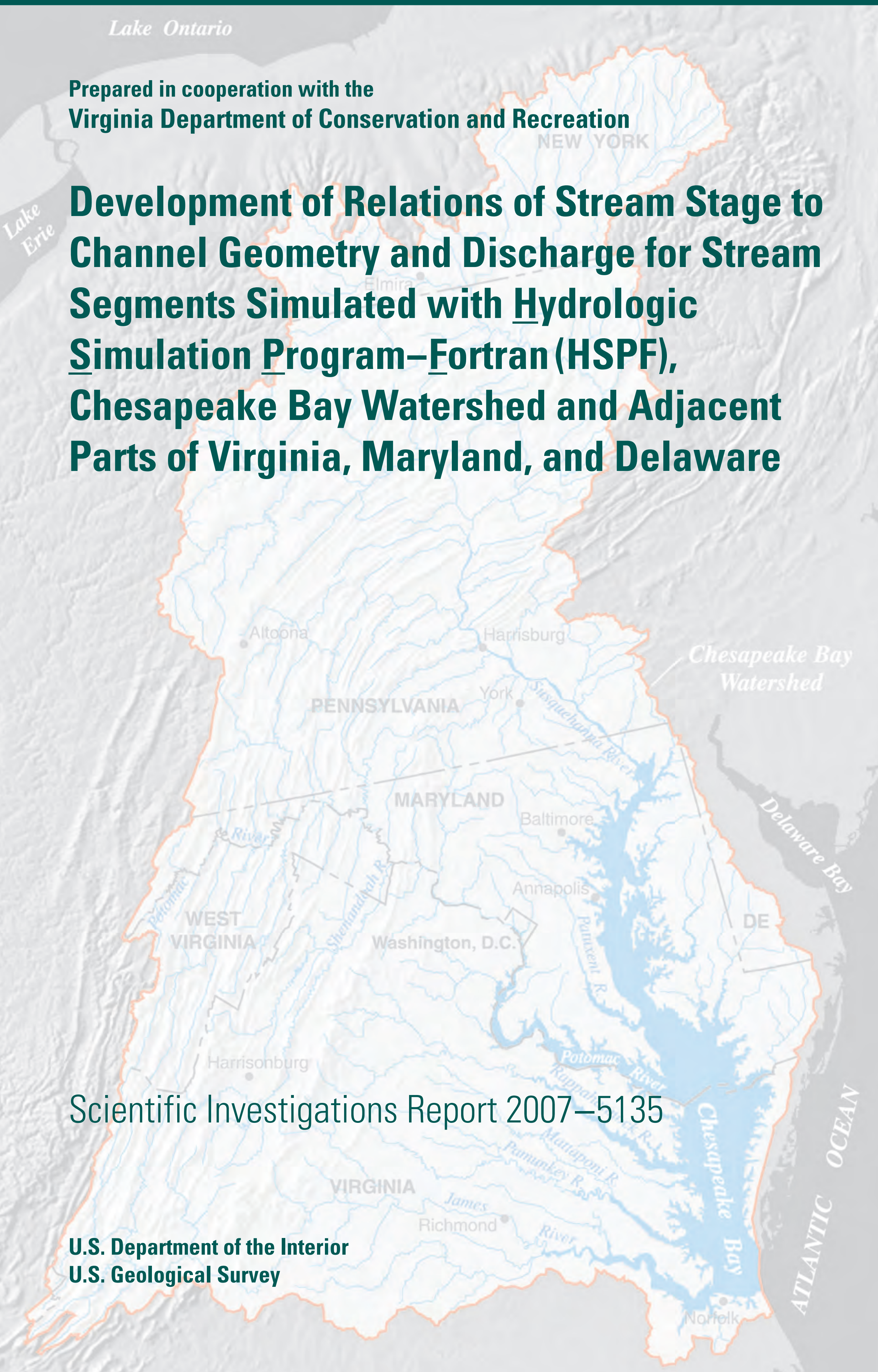

Scientific Investigations Report 2007–5135

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

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	929.0	square centimeter (cm^2)
square foot (ft^2)	0.09290	square meter (m^2)
square inch (in^2)	6.452	square centimeter (cm^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	28.32	cubic decimeter (dm^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic yard (yd^3)	0.7646	cubic meter (m^3)
cubic mile (mi^3)	4.168	cubic kilometer (km^3)
	Flow rate	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

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

Development of Relations of Stream Stage to Channel Geometry and Discharge for Stream Segments Simulated with Hydrologic Simulation Program–Fortran (HSPF), Chesapeake Bay Watershed and Adjacent Parts of Virginia, Maryland, and Delaware

By Douglas L. Moyer and Mark R. Bennett

Abstract

The U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (USEPA), Chesapeake Bay Program (CBP), Interstate Commission for the Potomac River Basin (ICPRB), Maryland Department of the Environment (MDE), Virginia Department of Conservation and Recreation (VADCR), and University of Maryland (UMD) are collaborating to improve the resolution of the Chesapeake Bay Regional Watershed Model (CBRWM). This watershed model uses the Hydrologic Simulation Program–Fortran (HSPF) to simulate the fate and transport of nutrients and sediment throughout the Chesapeake Bay watershed and extended areas of Virginia, Maryland, and Delaware. Information from the CBRWM is used by the CBP and other watershed managers to assess the effectiveness of water-quality improvement efforts as well as guide future management activities.

A critical step in the improvement of the CBRWM framework was the development of an HSPF function table (FTABLE) for each represented stream channel. The FTABLE is used to relate stage (water depth) in a particular stream channel to associated channel surface area, channel volume, and discharge (streamflow). The primary tool used to generate an FTABLE for each stream channel is the XSECT program, a computer program that requires nine input variables used to represent channel morphology. These input variables are reach length, upstream and downstream elevation, channel bottom width, channel bankfull width, channel bankfull stage, slope of the floodplain, and Manning's roughness coefficient for the channel and floodplain. For the purpose of this study, the nine input variables were grouped into three categories: channel geometry, Manning's roughness coefficient, and channel and floodplain slope. Values of channel geometry for every stream segment represented in CBRWM were obtained by first developing regional regression models that relate basin drainage area to observed values of bankfull width, bankfull depth, and bottom width at each of the 290 USGS streamflow-gaging stations included in the areal extent of the model. These regression models were developed on the basis of data from stations in four physiographic provinces (Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain) and were used to predict channel geometry for all 738 stream segments in the modeled area from associated basin drainage area. Manning's roughness coefficient for the channel and floodplain was represented in the XSECT program in two forms. First, all available field-estimated values of roughness were compiled for gaging stations in each physiographic province. The median of field-estimated values of channel and floodplain roughness for each physiographic province was applied to all respective stream segments. The second representation of Manning's roughness coefficient was to allow roughness to vary with channel depth. Roughness was estimated at each gaging station for each 1-foot depth interval. Median values of roughness were calculated for each 1-foot depth interval for all stations in each physiographic province. Channel and floodplain slope were determined for every stream segment in CBRWM using the USGS National Elevation Dataset.

Function tables were generated by the XSECT program using values of channel geometry, channel and floodplain roughness, and channel and floodplain slope. The FTABLEs for each of the 290 USGS streamflow-gaging stations were evaluated by comparing observed discharge to the XSECT-derived discharge. Function table stream discharge derived using depth-varying roughness was found to be more representative of and statistically indistinguishable from values of observed stream discharge. Additionally, results of regression analysis showed that XSECT-derived discharge accounted for approximately 90 percent of the variability associated with observed discharge in each of the four physiographic provinces. The results of this study indicate that the methodology

developed to generate FTABLEs for every simulated stream segment in the CBRWM is appropriate. Additionally, the methodology developed in this study can be applied to stream-channel representation in association with other modeling efforts such as Total Maximum Daily Load (TMDL) development and other watershed-scale water-quality assessments.

Introduction

Eutrophication of freshwater, estuarine, and coastal water bodies is a primary focus for watershed managers at the Federal, state, and local level. This process of nutrient (nitrogen and phosphorus) loading to these water bodies is in part natural but has been accelerated as a result of anthropogenic inputs of these nutrients through sewage disposal, agricultural runoff, urban runoff, and acid rain (Officer and others, 1984; Nixon, 1987; Schlesinger, 1997). Accelerated eutrophication has been linked to the loss of critical habitat for living resources within the Chesapeake Bay estuary (U.S. Environmental Protection Agency, 1983). Cooper and Brush (1991) found that accelerated algal production resulting from elevated nutrient loading has led to an increased occurrence of anoxic conditions in bottom waters and associated sediment throughout the Chesapeake Bay estuary (Cooper and Brush, 1991).

The Chesapeake Bay Program (CBP) was initiated in 1983 to direct the restoration and protection of the Chesapeake Bay. The CBP is composed of various Federal, state, academic, and local watershed organizations. In 1987, the CBP established the first nutrient reduction goal, which was to reduce nitrogen and phosphorus loading to the Chesapeake Bay by 40 percent by the year 2000. In 2000, the CBP further refined the nutrient reduction goals as well as established criteria for dissolved oxygen, chlorophyll, and water clarity (Chesapeake Bay Program, 2000). The CBP utilizes many tools to assess progress toward achieving these goals, one of which is the Chesapeake Bay Regional Watershed Model[1] (CBRWM).

The CBRWM has been used since the late 1980's to simulate the transport of nutrients and sediment in the Chesapeake Bay watershed. In response to the requirements of the Chesapeake Bay Program (2000), the U.S. Geological Survey (USGS) and U.S. Environmental Protection Agency (USEPA), along with the Virginia Department of Conservation and Recreation (VADCR), the Interstate Commission for the Potomac River Basin (ICPRB), and the Maryland Department of the Environment (MDE), began collaborating to improve the resolution and predictive ability of the CBRWM. Additionally, the areal extent of the CBRWM was increased to include the extended regions of Virginia, Maryland, and Delaware (Martucci and others, 2005).

[1] The Chesapeake Bay Regional Watershed Model is referred to by the CBP as the Phase 5 Watershed Model, in reference to its predecessor, the Phase 4.3 Chesapeake Bay Watershed Model.

The CBRWM utilizes the Hydrologic Simulation Program–FORTRAN (HSPF) version 11 to simulate the hydrology and associated water-quality constituent transport within the Chesapeake Bay watershed and extended areas of Virginia, Maryland, and Delaware (Bicknell and others, 1997). HSPF is a continuous simulation and lumped parameter watershed model that is used to simulate the transport and storage of water and associated water-quality constituents by linking surface, soil, and instream processes (Donigian and others, 1995). HSPF represents these mechanisms of transport and storage for three unique land segments or model elements: pervious land segments, impervious land segments, and stream channels. Natural variability in these hydrologic transport mechanisms occurs because of spatial changes in watershed characteristics such as topography, land use, and soil properties; HSPF accounts for this variability by simulating runoff from smaller, more homogeneous portions of the watershed.

One critical step in the improvement of the CBRWM framework was the development of an HSPF function table (FTABLE) for each stream channel. The FTABLE is used to relate stage (water depth) in a particular stream channel to associated channel surface area, channel volume, and discharge (streamflow) (Bicknell and others, 1997). An FTABLE is typically constructed on the basis of measurements of channel geomorphology such as width, depth, length, slope, and roughness (Manning's *n*). In the CBRWM, there are approximately 290 simulated stream channels for which observed channel geomorphology data are available. These data are typically associated with the presence of a USGS streamflow-gaging station. Additionally, there are 448 simulated stream channels with insufficient channel geomorphology data to generate FTABLEs.

In 2002, the USGS, in cooperation with the VADCR, began a study to develop FTABLEs for all stream channels represented in the CBRWM. The specific study objectives were to (1) develop an approach to predict channel geomorphology for stream channels with no geomorphological data, (2) generate FTABLEs for the 738 stream channels represented in the CBRWM, and (3) evaluate the effectiveness of the current approach for generating FTABLEs that are representative of the geomorphological characteristics of the associated stream channel.

This report describes the approach and methodology used to create function tables for the 738 simulated stream segments in the CBRWM. Observed data for stream channel geometry (bottom width, bankfull width, and bankfull stage), channel roughness, channel length and slope, and floodplain slope were collected at USGS streamflow-gaging stations. These gaging stations were grouped into four physiographic provinces: Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain. This report describes the approach that was developed to relate observed channel data to channels where observed data were not available. Finally, this report evaluates the representativeness of the FTABLEs that were generated from observed and predicted channel data.

Physical Setting

The study area represented in the CBRWM includes the 64,000-mi^2 Chesapeake Bay watershed as well as the entire states of Virginia, Maryland, and Delaware for a total simulated drainage area of 92,000 mi^2 (fig. 1). The CBRWM represents watersheds in New York, Pennsylvania, Maryland, Delaware, Washington, D.C., Virginia, West Virginia, and North Carolina. The major river basins represented within the Chesapeake Bay watershed are those of the Susquehanna, Potomac, Patuxent, Rappahannock, York, and James. The CBRWM also represents the major river basins outside the Chesapeake Bay watershed that drain Virginia (Big Sandy, Upper Tennessee, New, Roanoke, and Meherrin Rivers) and Maryland (Youghiogheny River). Additionally, the CBRWM represents basins in Delaware that drain to Delaware Bay as well as coastal basins in Delaware, Maryland, and Virginia that drain directly to the Atlantic Ocean. There are 1,063 watersheds represented in the CBRWM; of these, stream channels associated with 738 watersheds are simulated (Martucci and others, 2005).

Physiography

One organizing feature for all of the watersheds represented in the CBRWM is physiographic province. There are five major physiographic provinces in the CBRWM study area: Appalachian Plateaus, Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain (fig. 2). Each physiographic province is geologically unique, and geology governs the geomorphologic characteristics of the stream and river channel within each physiographic province.

Appalachian Plateaus Physiographic Province

The Appalachian Plateaus physiographic province is a narrow chain of westward-facing folded mountains that extend from southwestern Virginia to central New York (Fenneman, 1938). The Appalachian Plateaus consist of the Allegheny Plateau and the Cumberland Plateau. The Allegheny Plateau is further subdivided into unglaciated (Allegheny Mountains) and glaciated (Catskill Mountains) regions. In the CBRWM, the Allegheny Plateau is the dominant feature of the Appalachian Plateaus whereas the Cumberland Plateau occurs only in far southwestern Virginia. The underlying geology in the Appalachian Plateaus is dominated by shale, sandstone, and coal (Fenneman, 1938). Extensive erosion has resulted in steep slopes and narrow valleys throughout this province (Hayes, 1991).

Valley and Ridge Physiographic Province

The Valley and Ridge physiographic province is composed of lowlands surmounted by folded ridges. The valley is commonly underlain by limestone, shale, and dolomite, all of which are easily eroded. The ridges are formed from more resistant sandstone, quartzite, and conglomerates (Fenneman, 1938, Hayes, 1991, and Nelms and others, 1997). The Valley and Ridge physiographic province extends from southwestern Virginia, through the panhandles of West Virginia and Maryland, to central Pennsylvania. Streams and rivers are the primary geomorphic agents in the Valley and Ridge province (Fenneman, 1938). These streams and rivers are structurally controlled and typically follow the beds of soft rock (limestone, shale, and dolomite) but do eventually cut through beds of harder rock to create water gaps (Fenneman, 1938). Streams typically flow on or near bedrock (Keaton and others, 2005).

Blue Ridge Physiographic Province

The Blue Ridge physiographic province lies between the Valley and Ridge (to the west) and Piedmont (to the east) physiographic provinces and extends from the Roanoke to the Susquehanna River. Geologically, this province consists primarily of metamorphic and igneous rocks, and sedimentary rocks to a lesser extent. For the purpose of this study, the Blue Ridge physiographic province was included in the Valley and Ridge physiographic province.

Piedmont Physiographic Province

The Piedmont physiographic province lies between the Blue Ridge and Coastal Plain physiographic provinces and extends from North Carolina to southeastern Pennsylvania. The Piedmont province is formed of deformed igneous and metamorphic rocks that consist of granite, gneiss, schist, and slate (Fenneman, 1938). These geologic formations are typically covered by a deep saprolite (Hayes, 1991). Soils in this province are known for their fertility as well as for being highly susceptible to erosion.

Coastal Plain Physiographic Province

The Coastal Plain physiographic province is composed of unconsolidated layers of sand and gravel separated by layers of clay (Fenneman, 1938). The Coastal Plain extends north to south from Maryland to North Carolina. The Fall Line divides the Piedmont province from the Coastal Plain. At the Fall Line, the sharper hills and finer textured drainages of the Piedmont give way to the gentler slopes and more widely spaced streams of the Coastal Plain (Fenneman, 1938).

HSPF Function Table Development

HSPF is used to simulate the routing of water and associated water-quality constituents through a stream channel network that consists of a series of connected stream reaches. The CBRWM stream network consists of one stream reach for each modeled watershed. Water is supplied to a stream reach

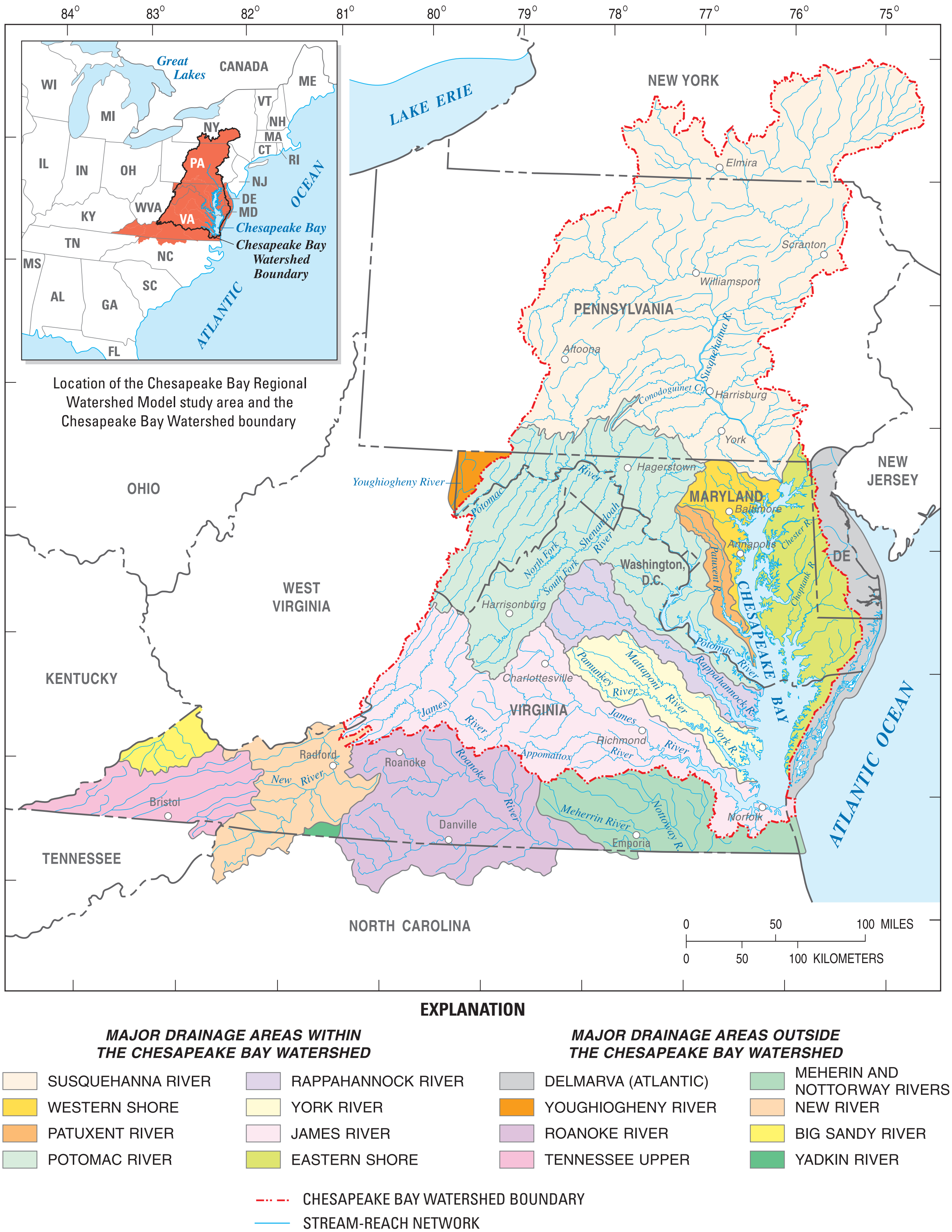

Figure 1. The region included in the Chesapeake Bay Regional Watershed Model, highlighting the major river basins and the associated stream-reach network.

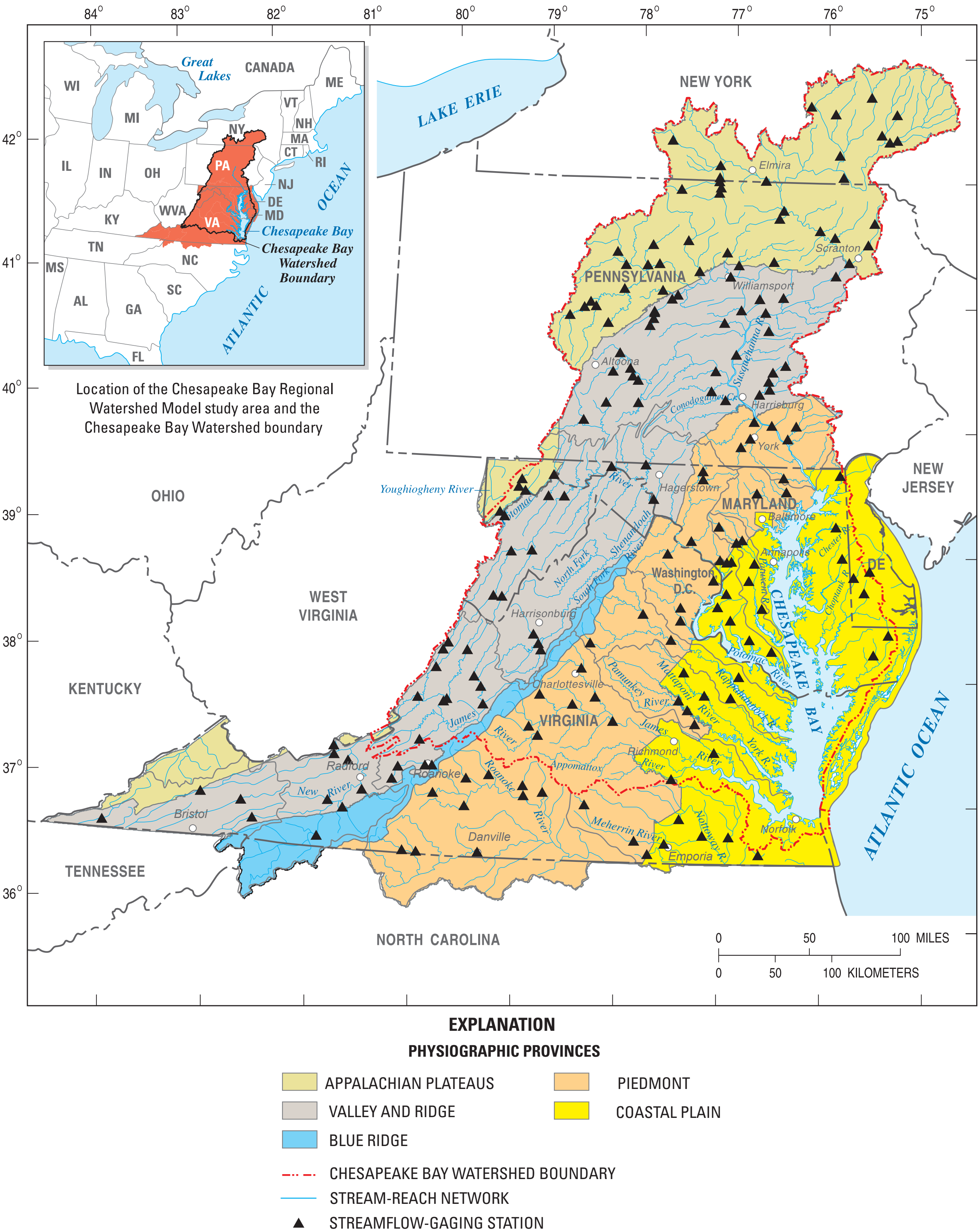

Figure 2. Physiographic provinces represented and streamflow-gaging stations used in HSPF function table development in the Chesapeake Bay Regional Watershed Model.

from pervious (overland flow, interflow, and base flow) and impervious (overland flow) land surfaces within the associated watershed. Additionally, water is supplied to a stream segment from associated point sources (for example, sewage-treatment plants) and upstream reaches. These inflows are assumed to enter the reach at a single upstream point and the water is transported downstream in a unidirectional manner. Water transported down a reach is assumed to follow the kinematic wave function (Martin and McCutcheon, 1999).

The function table in HSPF serves as the only mechanism to relate channel depth to channel area, channel volume, and discharge. The FTABLE is analogous to the stage-discharge rating curves that are developed for every USGS streamflow-gaging station. An example FTABLE is provided in table 1. The columns in the FTABLE represent, from left to right, channel depth (ft), channel surface area (ft^2), channel volume (ft^3), and discharge (ft^3/s). Each row in the FTABLE represents a different channel depth. Channel surface area represents the average channel width for a given channel length. Channel volume is calculated by multiplying the channel area by the depth of the channel. Channel discharge is a function of the channel area, channel slope, and channel roughness. An FTABLE is typically generated by first collecting channel geomorphology data. These data serve as input to computer programs used to generate FTABLEs. Two programs commonly used to generate FTABLEs are the Channel Geometry Analysis Program (CGAP) (Regan and Schaffranek, 1985) and XSECT (Aqua Terra Consultants, written commun., 1998). CGAP requires surveyed *x-y* coordinates for at least two representative channel transects while XSECT requires parameters that represent average channel geomorphology. The data requirements for XSECT closely match the data typically available at USGS streamflow-gaging stations and as a result were used exclusively to generate FTABLEs for the CBRWM.

Table 1. Example Hydrologic Simulation Program-Fortran function table.

[ft^3/s, cubic feet per second]

Channel depth (feet)	Channel surface area (acres)	Channel volume (acre-feet)	Stream discharge (ft^3/s)
0.000	0.000	0.00	0.00
.953	1,770.105	1,659.98	228.63
1.907	1,827.840	3,375.00	715.74
2.860	1,885.575	5,145.06	1,503.62
3.813	1,943.310	6,970.16	2,495.52
4.767	2,001.046	8,850.30	3,890.89
5.720	2,058.781	10,785.49	5,694.86
7.627	2,174.251	14,820.98	9,799.58
9.533	2,289.72	19,076.63	13,708.14
11.440	2,405.192	23,552.45	20,876.49
15.253	3,237.963	34,312.07	36,138.66
19.067	4,070.733	48,247.31	54,641.45
22.880	4,903.503	65,358.19	76,178.46
26.693	5,736.274	85,644.70	100,601.06
30.507	6,569.044	109,106.83	127,797.05
34.320	7,401.815	135,744.61	157,678.72
38.133	8,234.585	165,557.98	190,175.75
41.947	9,067.354	198,547.02	225,230.77
45.760	9,900.125	234,711.66	262,796.25

XSECT Program

XSECT is a FORTRAN program that produces FTABLEs based on nine input variables used to represent channel morphology. These nine input variables are reach length, upstream and downstream elevation, channel bottom width, channel bankfull width, channel bankfull stage, slope of the floodplain, and Manning's roughness coefficient for the channel and floodplain (table 2). The XSECT program assumes a trapezoidal channel form. The initial trapezoidal form is established for the channel based on the values of channel bottom width, bankfull width, and bankfull stage (fig. 3). The dimensions of the trapezoid are adjusted, based on floodplain slope, to represent the area above bankfull stage. For the purpose of this study, the nine input variables were grouped into three categories: channel geometry, Manning's roughness coefficient, and channel and floodplain slope. The following sections describe the methodology used to determine the values of the channel morphology variable for each of the stream segments represented in the CBRWM.

Estimation of Channel Geometry

Stream channel geometry, for the purpose of FTABLE development, is represented by bankfull stage, bankfull width, and bottom width. Values of these parameters can be obtained easily through field measurements or through simple derivations of available data associated with USGS gaging stations. The challenge for this current study, however, was representing channel geometry for the 448 stream segments within the CBRWM for which no observed channel geomorphology data are available. The approach that was selected for representing channel geometry for the stream segments in the CBRWM was to develop regional relations between each of the variables of channel geometry and associated watershed drainage area. Leopold and Maddock (1953) described the relation between stream discharge and channel geometry. They found that as discharge increases, the depth and width of the channel also increase. Dunne and Leopold (1978) added that in a given geographical area, natural streams with similar drainage areas exhibit similar channel dimensions. Leopold and Maddock (1953) and Dunne and Leopold (1978) demonstrated that the relation of both discharge and drainage area to measurements of channel geometry in a given region was best represented

Table 2. Required input parameters and associated format as required by the XSECT program.

[RCHNM, Reach number; LENGTH, Channel length, in miles; ELUP, Upstream elevation, in feet; ELDOWN, Downstream elevation, in feet; BW, Channel bottom width, in feet; BFW, Channel bankfull width, in feet; H, Channel height, in feet; SFP, Slope of floodplain; NCH, Manning's *n* for the channel; NFP, Manning's *n* for the floodplain]

Input format: (I5,9F8.0)

RCHNM	LENGTH	ELUP	ELDOWN	BW	BFW	H	SFP	NCH	NFP
110	16.0	290.0	230.6	2,100.0	5,800.0	14.4	0.028	0.034	0.081

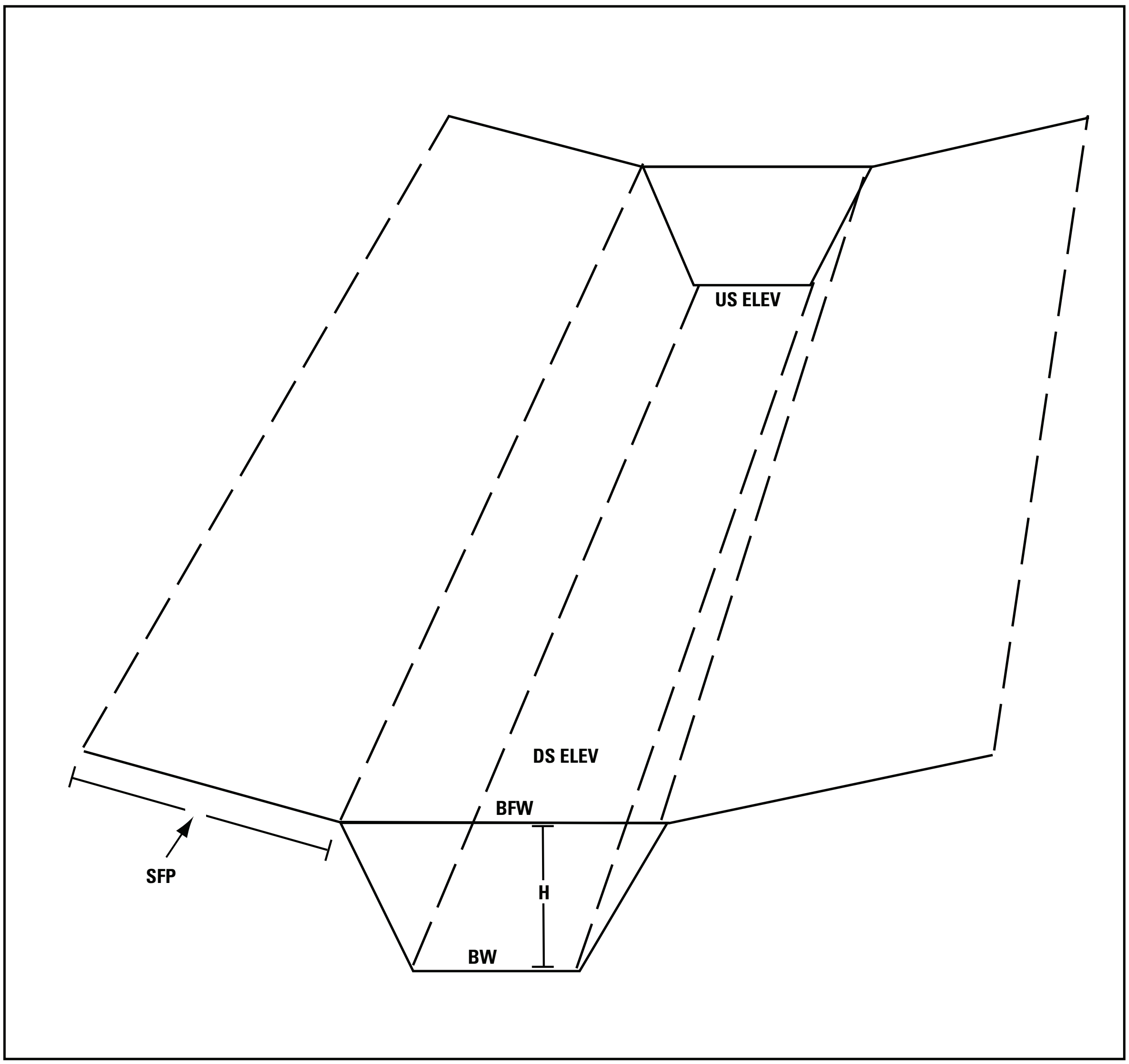

Figure 3. Theoretical stream channel as represented in the XSECT program by bankfull stage (H), bankfull width (BFW), bottom width (BW), upstream elevation (US ELEV), downstream elevation (DS ELEV), and slope of the floodplain (SFP).

by a power function. Many studies have applied the concepts described in both Leopold and Maddock (1953) and Dunne and Leopold (1978) toward the development of regional curves that relate drainage area to bankfull channel geometry within a region, typically physiographic province (Keaton and others, 2005; Chaplin, 2005; McCandless, 2003; Messinger and Wiley, 2003; Cinotto, 2003; White, 2001). These regional curves are based on intensive field measurements and observations of bankfull channel geometry and are used to represent natural channel form in channel restoration efforts. This current study applies similar concepts to the development of regional relations between drainage area and channel geometry; however, these regional relations are based on available data for USGS streamflow-gaging stations and not on intensive field surveys. Therefore, the regional relations described in this document are not appropriate for representing natural channel form in the context of channel restoration efforts.

Each regional regression model developed in this current study utilizes a power function to relate basin drainage area to channel geometry. The power function has the form

$$y = ax^b \quad , \tag{1}$$

where

- y is the dependent variable (measures of channel geometry),
- x is the independent variable (basin drainage area), and
- a and b are constants.

The purpose for relating observations of y and x is to develop a model that is then used to predict y from associated observations of x where no observations are available. A prediction interval is associated with each regional regression model developed in this study. The prediction interval provides the upper and lower bounds between which the true value of y will reside, within a specified certainty, for a given x (Helsel and Hirsch, 1992). The extent, or certainty, of the prediction interval is defined by the level of significance (α). A 95-percent prediction interval ($\alpha = 0.05$) was used for the purpose of this study.

The USGS continuously monitors stream stage at gaging stations across the United States. This continuous stream stage is used as a surrogate for predicting stream discharge using the stage-discharge rating curve developed for each station. The rating curve is developed by first manually collecting stream discharge measurements during various hydrologic conditions and then relating the measured values of stream discharge to the corresponding values of stage. As a result of developing the stage-discharge rating curve, many other data parameters related to channel geometry and stream discharge are available. These observed parameters measured under various hydrologic conditions include channel width, depth, cross-sectional area, average stream velocity, and discharge. The USGS employs indirect-discharge measurement techniques once stream conditions reach levels that do not permit direct measurements of stream discharge (Benson and Dalrymple, 1967). Data commonly available as a result of indirect-discharge measurements include surveyed channel geometry, channel slope, and estimated channel and floodplain roughness. Data collected at the USGS gaging stations were incorporated into the methodology for representing channel geometry and roughness associated with each of the CBRWM stream segments.

Station Selection

A total of 240 USGS streamflow-gaging stations were chosen for the development of regional relations between drainage area and channel geometry. The USGS gaging stations were grouped into four physiographic provinces: Appalachian Plateaus, Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain (fig. 2). Of the 240 stations, 43 were located in the Appalachian Plateaus, 84 were located in the Valley and Ridge, 70 were located in the Piedmont, and 43 were located in the Coastal Plain (table 3 in back of report). The basin drainage area associated with the selected stations ranged from 24 to 8,720 mi^2 in the Appalachian Plateaus, 2 to 11,220 mi^2 in the Valley and Ridge, 1.5 to 25,990 mi^2 in the Piedmont, and 2.3 to 1,421 mi^2 in the Coastal Plain. Sites were excluded from the study if they were affected by (1) regulated flow, (2) major flow withdrawals, and(or) (3) intensive urbanization.

Identification of Bankfull Stage

Bankfull stage occurs when the stream channel is completely filled or when the water surface in the active channel is level with the floodplain (Dunne and Leopold, 1978). Bankfull stage for each of the 240 streamflow-gaging stations was identified either (1) as the published bankfull stage value (Prugh and others, 1991; McCandless and Everett, 2002; North Carolina Stream Restoration Institute, 2006a; North Carolina Stream Restoration Institute, 2006b) or (2) through the application of a flood-flow frequency analysis. Of the 240 streamflow-gaging stations, 60 were determined to have published values of bankfull stage (Prugh and others, 1991). For the remaining 180 stations, bankfull stage was determined by applying a flood-flow frequency analysis. Dunne and Leopold (1978) state that the best approximation of bankfull stage when observed channel cross-section data are not available is through the construction of a flood-frequency curve for stream discharge. Bankfull stage generally has a recurrence interval of 1.5 years for a large variety of streams and rivers (Dunne and Leopold, 1978). The 1.5-year recurrence interval was used in the CBRWM; however, this recurrence interval may not be universally applicable. The USGS program PeakFQ (Flynn and others, 2006) was used to generate a flood-frequency curve for each of the 180 stations. PeakFQ performs the frequency analysis by fitting a Pearson Type III frequency distribution to the logarithms of the annual peak discharges in the station record. This procedure produces recurrence intervals for a variety of discharges following the methodology described in Bulletin 17B of the Interagency Advisory Committee on Water Data (1982). Additionally, stream-discharge values corresponding to a recurrence of 1.5 years were converted to bankfull stage using the stage-discharge rating curve for each gaging station.

A regression analysis was performed on data collected from gaging stations within each of the four physiographic provinces to relate bankfull stage for the 240 gaging stations to watershed drainage area. This analysis was performed to predict bankfull stage for CBRWM stream segments lacking gaging-station data. The relation between bankfull stage and drainage area within each of the four provinces is shown in figure 4. The regression models developed for each of the four physiographic provinces indicate that drainage area is a statistically significant predictor of channel bankfull stage (table 4). Drainage area accounted for 63, 72, 74, and 61 percent of the variability associated with channel bankfull stage within the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces, respectively. Residual plots display the measured difference between predicted and observed values for the dependent variable in the regression model; no difference will generate a residual equal to zero. Examination of the residual plots indicates no apparent changes in variance as drainage area increases. Additionally, the residuals associated with each physiographic province are homoscedastically distributed around zero, indicating no bias in the regression model (fig. 5). Therefore, the regression model was used to estimate bankfull stage from associated watershed drainage area for stream channels represented in the CBRWM.

Identification of Bankfull Width and Bottom Width

Bankfull width and bottom width of the stream channel were established once the values for bankfull stage were determined at each of the 240 gaging stations. The function of the bankfull width and bottom width in the FTABLE generation process is to set the upper and lower dimensions of the trapezoidal representation of the stream channel. Bankfull width is defined as the top width of the wetted stream channel at bankfull stage. Bankfull width for each of the 240 streamflow-gaging stations was identified either (1) as the published bankfull width value (McCandless and Everett, 2002; North Carolina Stream Restoration Institute, 2006a; North Carolina Stream Restoration Institute, 2006b) or (2) by the retrieval of USGS stream-gaging data. The USGS measures channel width, channel depth, and stream velocity in order to calculate stream discharge at each streamflow-gaging station. These measurements are collected at various stages and are stored in the USGS Automated Data Processing System (ADAPS) database. ADAPS was queried to identify the corresponding channel width associated with each station's estimated bankfull stage. A regression analysis was performed to relate bankfull width to the associated basin drainage area for each of the four physiographic provinces. The results of the regression analysis for each physiographic province (fig. 6) indicate that drainage area is a statistically significant predictor of associated bankfull width (table 4). Drainage area accounted for 88, 86, 85, and 87 percent of the variability associated with channel bankfull width within the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces, respectively. Visual inspection of the regression residuals for bankfull width indicates no apparent changes in variance as drainage area increases (fig. 7). Therefore, the regression model was used to estimate bankfull width from associated watershed drainage area for all stream channels represented in the CBRWM.

Bottom width is defined as the wetted width of the stream channel at the lowest observed stage. Values of bottom width were identified as the width associated with the lowest observed stage for each station, as listed in ADAPS. The values of bottom width were related to the associated basin drainage area through regression analysis (fig. 8). Drainage area was found to be a statistically significant predictor of associated channel bottom width (table 4). Drainage area accounted for 78, 87, 83, and 83 percent of the variability associated with channel bottom width within the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces, respectively. The variability in the regression residuals for bottom width is homoscedastically distributed around zero and exhibits no apparent changes as drainage area increases (fig. 9). Therefore, the regression model was used to estimate bottom width from associated watershed drainage area for all stream channels represented in the CBRWM.

Estimation of Manning's *n*

Manning's roughness coefficient (*n*) is a quantitative representation of the flow-impeding characteristics of the stream channel (Coon, 1998). Many natural factors work to impede the downstream movement of water. The primary factor that impedes flow is the roughness of the stream channel, which is determined by grain size and shape and the distribution of the material that lines the channel bottom (Arcement and Schneider, 1989; Coon, 1998). Additional major factors that influence the overall channel roughness are channel-surface irregularity, variation in channel shape, obstructions, type and density of vegetation, and channel meandering (Barnes, 1967; Arcement and Schneider, 1989; Coon, 1998). Estimates of channel and floodplain roughness are commonly made through visual interpretation and quantification of roughness factors present at a particular site (Barnes, 1967). The USGS makes estimates of channel and floodplain roughness as part of the calculation of indirect discharge measurements (Benson and Dalrymple, 1967). These channel and floodplain roughness estimates for each gaging station are available at respective USGS State Water Science Centers.

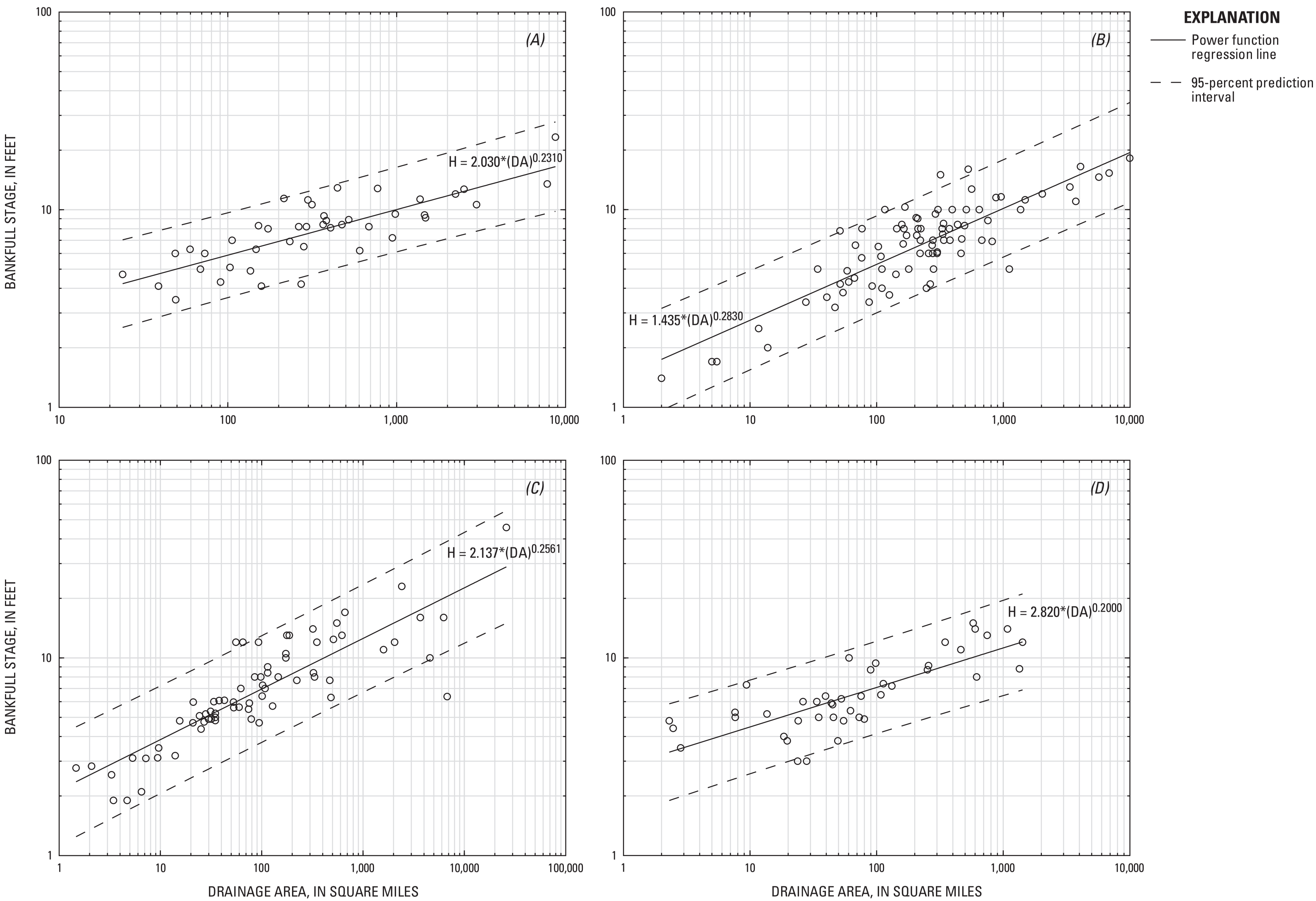

Figure 4. Relation of bankfull stage to basin drainage area for streamflow-gaging stations in the (*A*) Appalachian Plateaus, (*B*) Valley and Ridge, (*C*) Piedmont, and (*D*) Coastal Plain physiographic provinces.

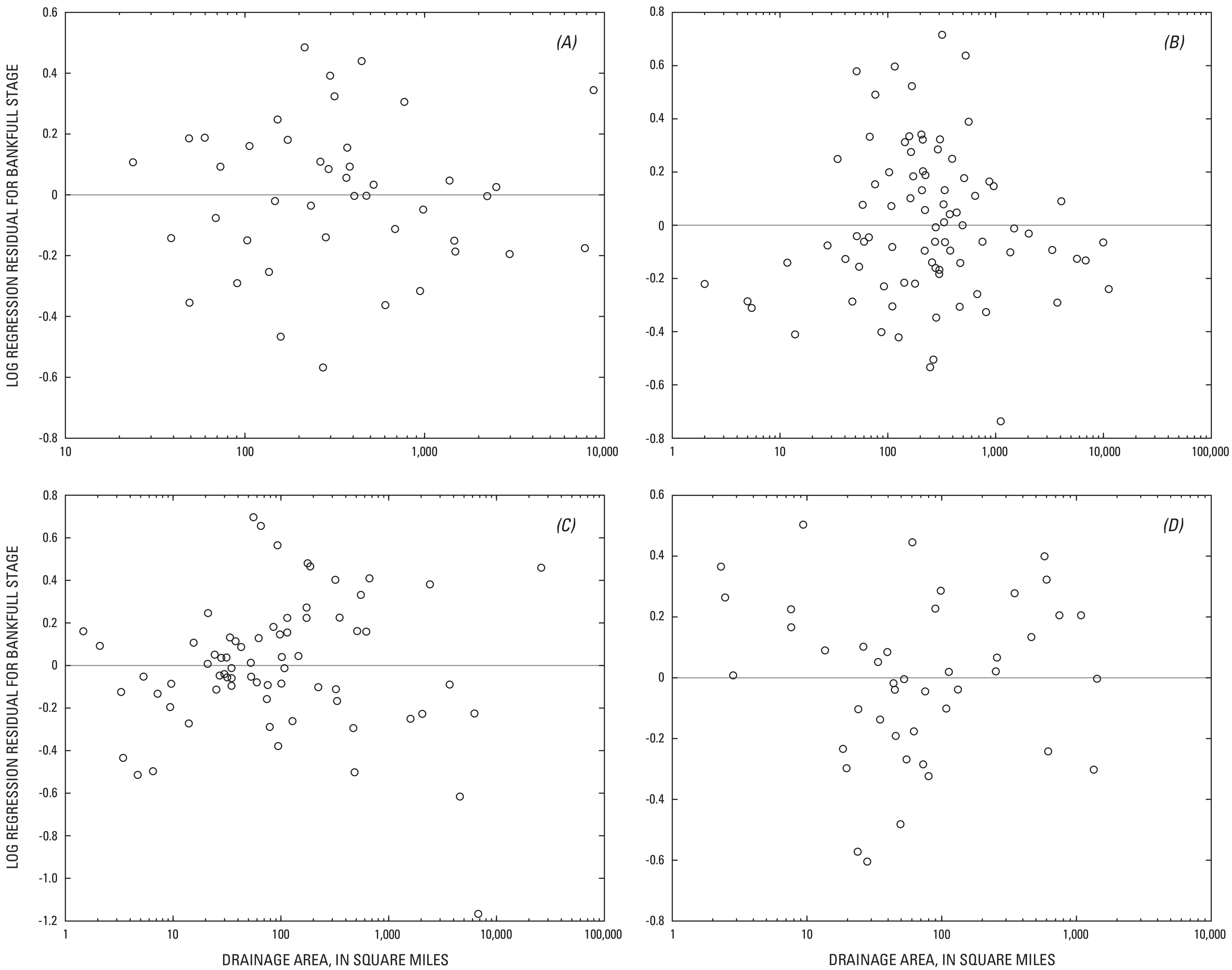

Figure 5. Regression residuals for predicted minus observed bankfull stage relative to basin drainage area in the (*A*) Appalachian Plateaus, (*B*) Valley and Ridge, (*C*) Piedmont, and (*D*) Coastal Plain physiographic provinces.

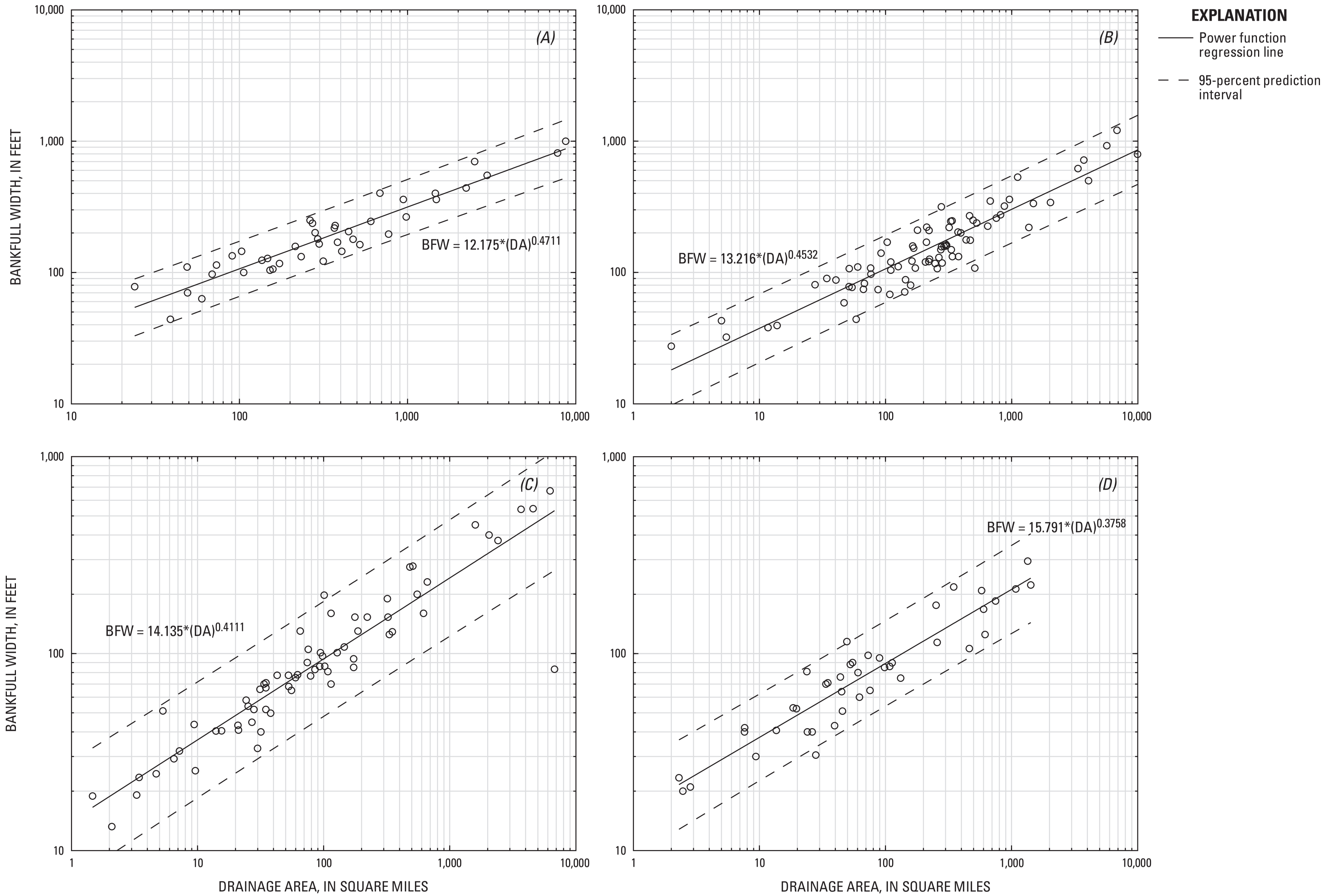

Figure 6. Relation of bankfull width to basin drainage area for streamflow-gaging stations in the (*A*) Appalachian Plateaus, (*B*) Valley and Ridge, (*C*) Piedmont, and (*D*) Coastal Plain physiographic provinces.

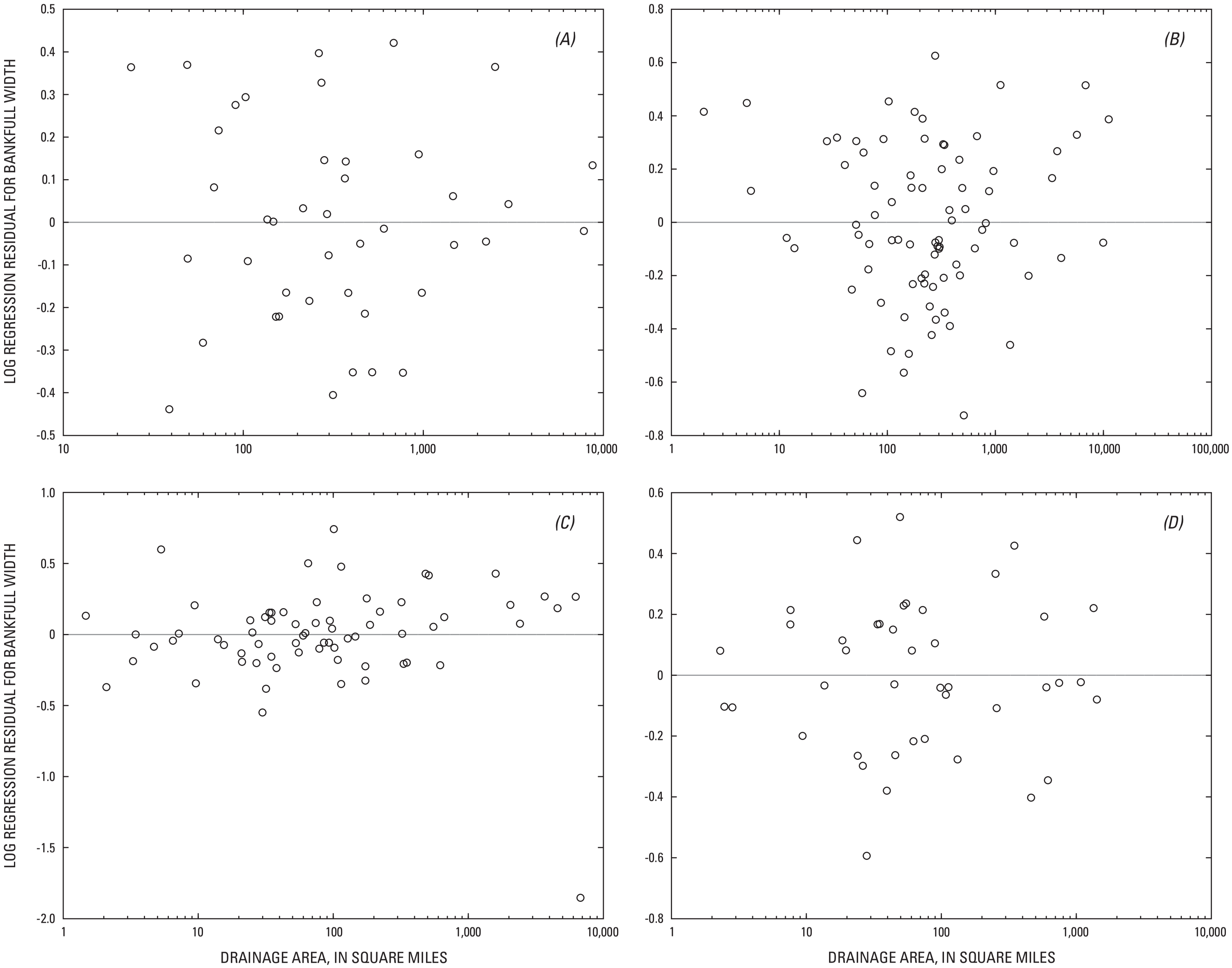

Figure 7. Regression residuals for predicted minus observed bankfull width relative to basin drainage area in the (*A*) Appalachian Plateaus, (*B*) Valley and Ridge, (*C*) Piedmont, and (*D*) Coastal Plain physiographic provinces.

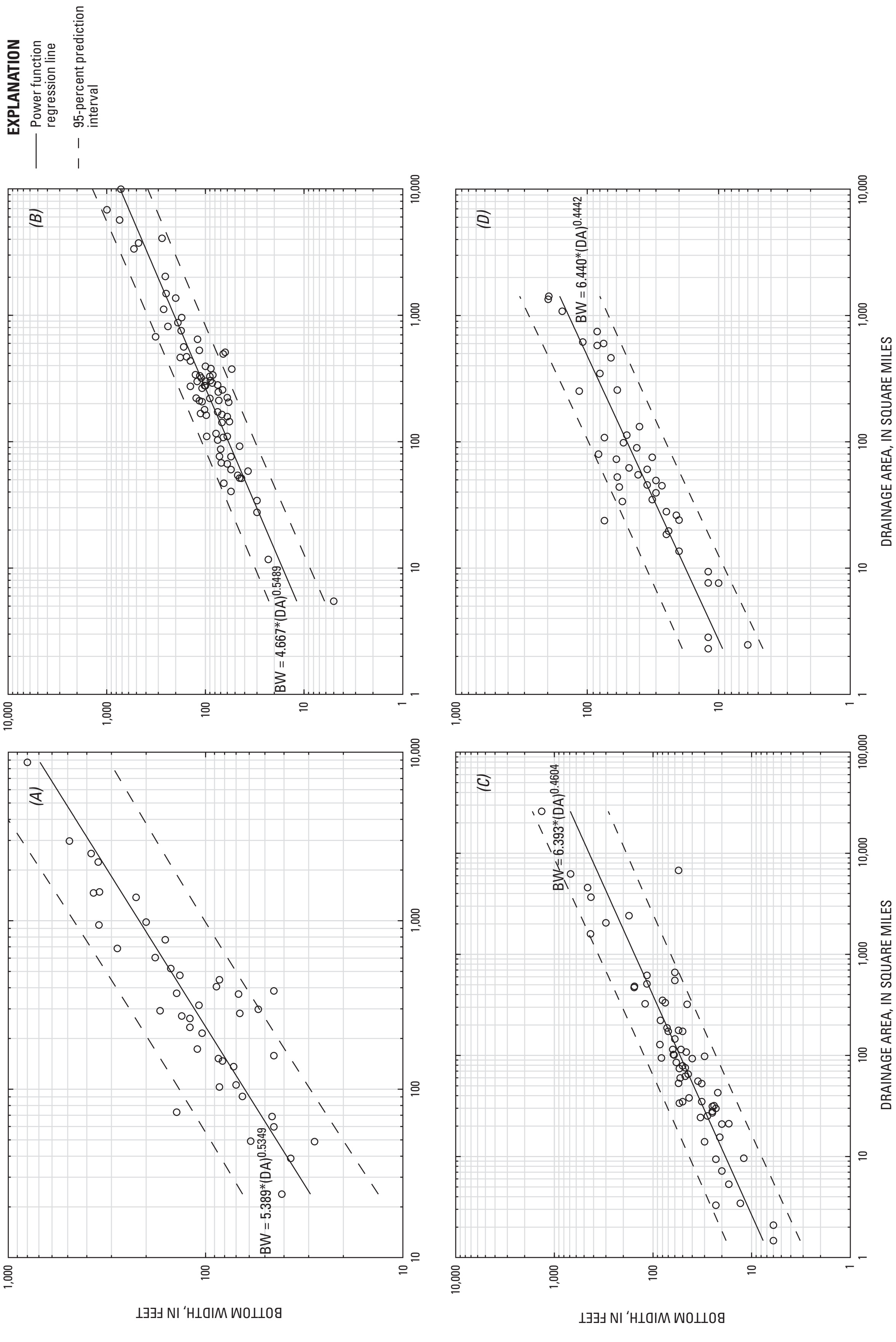

Figure 8. Relation of bottom width to basin drainage area for streamflow-gaging stations in the (*A*) Appalachian Plateaus, (*B*) Valley and Ridge, (*C*) Piedmont, and (*D*) Coastal Plain physiographic provinces.

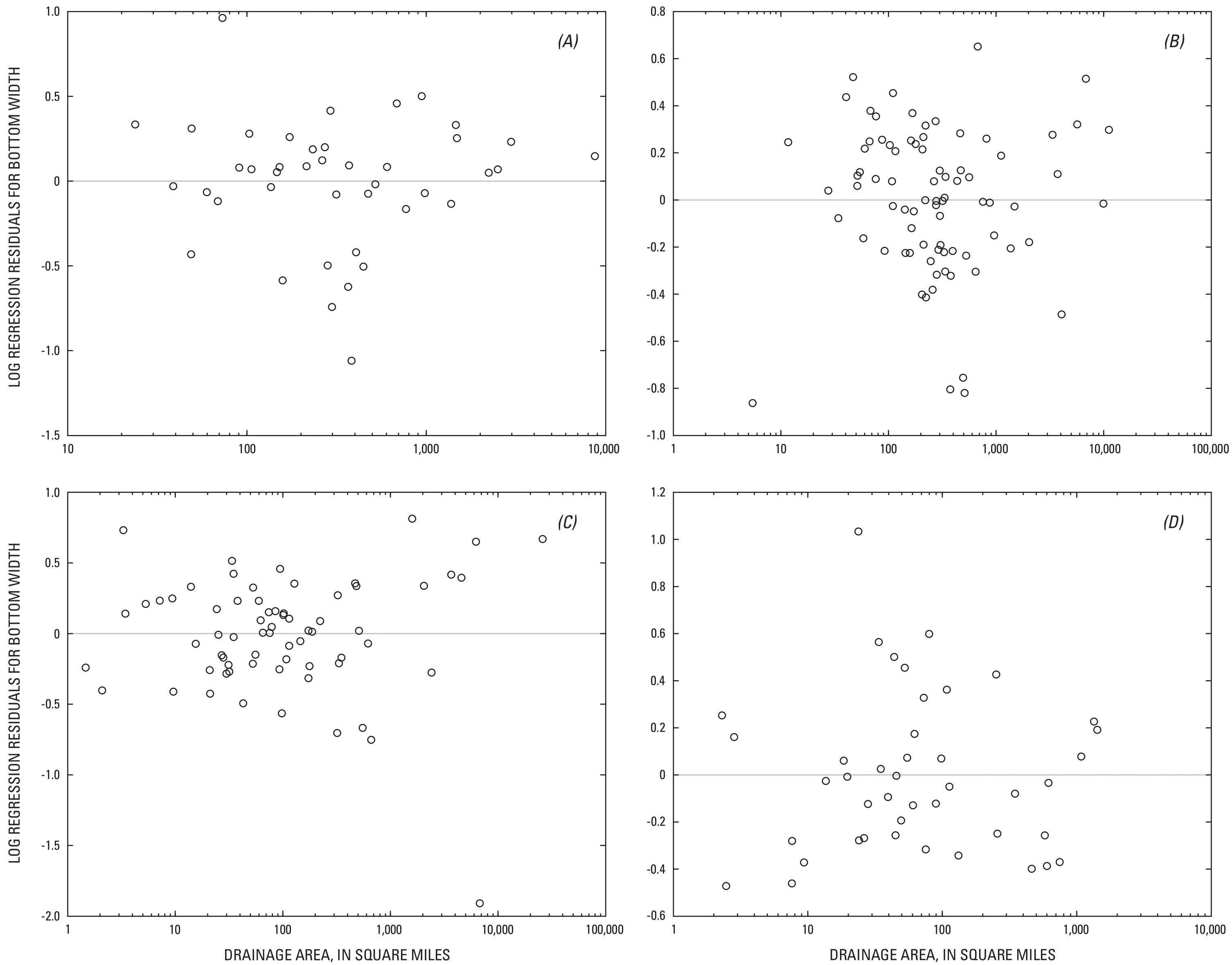

Figure 9. Regression residuals for predicted minus observed bottom width relative to basin drainage area in the (*A*) Appalachian Plateaus, (*B*) Valley and Ridge, (*C*) Piedmont, and (*D*) Coastal Plain physiographic provinces.

Table 4. Regional regression equations, relating channel geometry to basin drainage area and associated diagnostic statistics, for streamflow-gaging stations in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.

[R^2, correlation coefficient; %, percent; H, bankfull stage; BFW, bankfull width; BW, bottom width; DA, basin drainage area]

Province	Equation	*p*-value	R^2	Residual standard error (natural log)	Residual standard error (%) [1]	F-statistic
			Bankfull stage			
Appalachian Plateaus	$H = 2.030*(DA)^{0.2310}$	0.00	0.633	0.243	24.3	70.77
Valley and Ridge	$H = 1.435*(DA)^{0.2830}$	.00	.718	.282	28.6	208.48
Piedmont	$H = 2.137*(DA)^{0.2561}$	.00	.735	.310	31.8	188.24
Coastal Plain	$H = 2.820*(DA)^{0.2000}$	.00	.609	.267	26.4	63.96
			Bankfull width			
Appalachian Plateaus	$BFW = 12.175*(DA)^{0.4711}$	.00	.882	.238	24.3	299.92
Valley and Ridge	$BFW = 13.216*(DA)^{0.4532}$	.00	.861	.293	29.6	490.84
Piedmont	$BFW = 14.135*(DA)^{0.4111}$	.00	.846	.335	35.0	361.23
Coastal Plain	$BFW = 15.791*(DA)^{0.3758}$	.00	.868	.248	25.4	262.41
			Bottom width			
Appalachian Plateaus	$BW = 5.389*(DA)^{0.5349}$	.00	.776	.376	39.4	138.21
Valley and Ridge	$BW = 4.667*(DA)^{0.5489}$	.00	.865	.310	31.8	498.71
Piedmont	$BW = 6.393*(DA)^{0.4604}$	.00	.827	.418	43.9	315.35
Coastal Plain	$BW = 6.440*(DA)^{0.4442}$	.00	.830	.336	35.0	200.51

[1] Tasker, 1978.

For this study, Manning's *n* was estimated in two ways—on the basis of field observations, and from derivations using Manning's equation. The purpose for estimating Manning's *n* by two different methods was to evaluate which method allows for the more representative determination of stream discharge. The concern is that the Manning's *n* derived from field observations is specific to a single stage and may result in inaccurate stream discharge values for some depth intervals. In contrast, calculating Manning's *n* for various depth intervals at a given station should result in predicted stream-discharge values that more closely represent observed stream discharge at a given stream depth. The following paragraphs describe the two methods that were used to represent channel roughness.

First, estimates of channel and floodplain roughness for each station, made as part of the determination of indirect discharge measurements, were obtained from the various USGS State Water Science Centers. Table 5 lists the range of channel and floodplain roughness obtained for stations in each of the physiographic provinces. The number of stations with available estimates of channel and floodplain roughness ranged from 5 in the Coastal Plain to 46 in the Valley and Ridge. The median channel roughness ranged from 0.033 in the Coastal Plain to 0.040 in the Piedmont; the median floodplain roughness ranged from 0.048 in the Valley and Ridge to 0.063 in the Piedmont. The median values for channel and floodplain roughness for each physiographic province were used to represent site-specific values in XSECT.

The second method used to represent channel and floodplain roughness (Manning's *n*) was to calculate channel roughness as a function of channel depth. Channel depth has been identified as another factor that impedes the downstream movement of water (Coon, 1998). Typically, channel roughness is inversely related to channel depth for depths up to bankfull stage. Variation in channel depth is not typically accounted for when roughness values are selected as part of an indirect–discharge measurement. Roughness values designated in the indirect-discharge measurement are representative of the channel depth for which the discharge is being calculated. Typically, these depths are associated with extreme stormflow events. However, because this current study predicts discharge values over the full range of channel depth, the importance of representing channel and floodplain roughness as a function of depth was evaluated. Values of channel and floodplain roughness for associated channel depths at each gaging station were obtained using the Manning equation:

$$V = \frac{1.49 R^{2/3} S^{1/2}}{n} , \qquad (2)$$

where

V is the average velocity (ft/s),
R is the hydraulic radius (ft),
S is the slope (%) of the water surface, and
n is Manning's roughness coefficient.

Table 5. Descriptive statistics for field-estimated values of Manning's roughness coefficient associated with the channel and floodplain for streamflow-gaging stations in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.

	Manning's Roughness Coefficient: Channel				Manning's Roughness Coefficient: Floodplain			
	Appalachian Plateaus	Valley and Ridge	Piedmont	Coastal Plain	Appalachian Plateaus	Valley and Ridge	Piedmont	Coastal Plain
Minimum	0.029	0.03	0.02	0.03	0.028	0.035	0.033	0.04
Mean	.038	.04	.041	.034	.053	.054	.078	.056
Median	.036	.038	.04	.033	.055	.048	.063	.06
Maximum	.07	.06	.095	.04	.08	.116	.243	.07
Number of observations	27	46	29	5	24	44	26	5

Discharge for a given depth (Q_d) is equal to the velocity at that depth (V_d) multiplied by the channel cross-sectional area at that depth (A_d). Therefore, multiplying equation 2 by cross-sectional area yields:

$$Q_d = V_d \times A_d = \frac{1.49 R_d^{2/3} S_d^{1/2} A_d}{n_d} , \qquad (3)$$

where the subscript d denotes each associated variable at a specified channel depth. Channel roughness for a given depth (n_d) is calculated using the equation:

$$n_d = \frac{1}{Q_d}\left(1.49 R_d^{2/3} S_d^{1/2} A_d\right) . \qquad (4)$$

For each station, values for the parameters on the right side of equation 4 were obtained from the XSECT program (R_d, S_d, and A_d) and the stage-discharge rating curve (Q_d).

Values of depth-varying roughness were calculated for each station and grouped according to physiographic province (fig. 10). The general pattern observed is that channel roughness is greatest at the lowest stages. This pattern is most pronounced for stations in the Coastal Plain and Piedmont physiographic provinces. Channel roughness decreases as stage increases toward bankfull levels. Once channel depth exceeds bankfull, roughness begins to increase as a result of obstructions associated with the floodplain. As a reference, the median values of field-estimated channel and floodplain roughness from table 5 are represented by the solid and dotted lines, respectively, in figure 10. The XSECT program was modified for each physiographic province to use the median roughness value for each 1-ft interval in stage. The final XSECT input data values are provided in appendix 1 and the modified XSECT programs for the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces are provided in appendixes 2–5, respectively. The columns for channel roughness and floodplain roughness in appendix 1 are populated with a value of 1, which serves as a multiplier to obtain the depth-varying values of roughness in each respective XSECT program.

Determination of Channel Slope, Floodplain Slope, and Watershed Drainage Area

Channel slope and floodplain slope, as represented in XSECT, serve two distinct functions. Channel slope is used as an input variable for the determination of stream discharge. Floodplain slope (across the channel valley) is used to establish the shape of the trapezoidal representation of the stream channel above bankfull depth. Channel and floodplain slope for every stream channel represented in the CBRWM was obtained from the USGS National Elevation Dataset (NED) (U.S. Geological Survey, 1999; Martucci and others, 2005). Channel slope was calculated by subtracting the elevation at the downstream end of the stream channel from the elevation at the upstream end of the stream channel and dividing the difference by the length of the stream channel. Slope of the floodplain was determined by first identifying the extent of the floodplain perpendicular to the stream channel. The extent of the floodplain was identified by utilizing USGS digital topographical quadrangles and identifying the point at which where the rate of elevation change increases (for example, the point of transition from the shallow floodplain to the steeper uplands). The total change in elevation was divided by the width of the floodplain.

The USGS National Elevation Dataset was used to delineate watershed boundaries for all stream channels represented in the CBRWM. The methods used to delineate watershed boundaries for the CBRWM are described in detail in Martucci and others (2005).

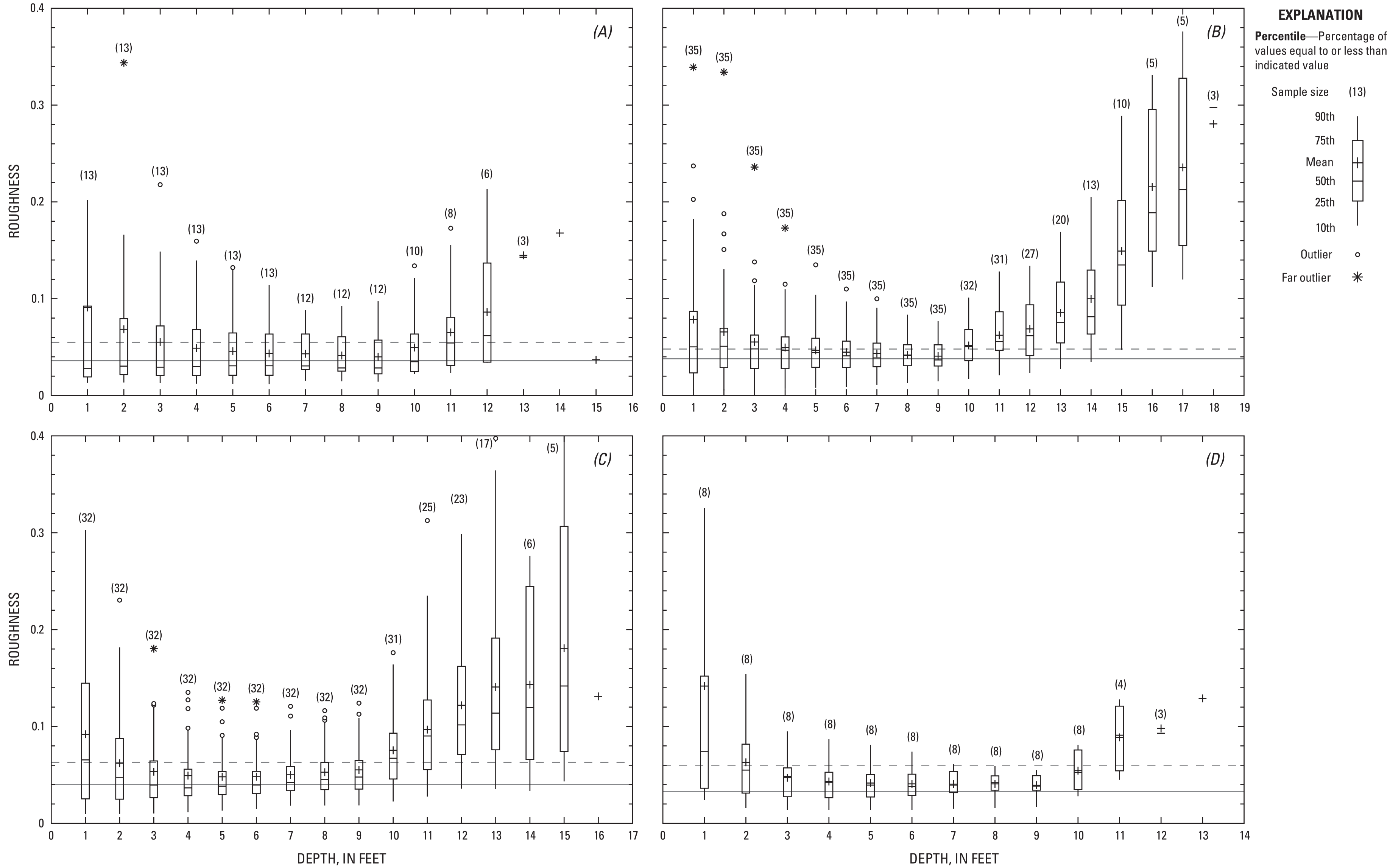

Figure 10. Model observed depth-varying channel roughness for streamflow-gaged streams in the (*A*) Appalachian Plateaus, (*B*) Valley and Ridge, (*C*) Piedmont, and (*D*) Coastal Plain physiographic provinces. (Solid and dashed reference lines represent the median of field-observed channel and floodplain roughness, respectively, as listed in table 5.)

Evaluation of HSPF Function Tables

HSPF function tables were initially generated for each of the gaging stations for two different scenarios. The same values of upstream and downstream elevation, channel bottom width, channel bankfull width, channel bankfull stage, and slope of the floodplain were used in both scenarios. In the first scenario (scenario 1), however, the median field-estimated roughness values were used for the stream channel and floodplain for each physiographic province (table 5, fig. 10). In the second scenario (scenario 2), channel and floodplain roughness were represented as the median value for each 1-ft depth interval for each physiographic province (fig. 10). Function tables generated under both scenarios by XSECT were evaluated by comparing simulated (XSECT-derived) discharge to observed (stage-discharge rating curve) discharge for gaging stations within each physiographic province. The Kolmogorov-Smirnov (KS) test was used to compare the distribution of simulated and observed discharge. The KS test statistically tests the null hypothesis that the distribution of simulated discharges is equal to the distribution of observed discharges for stations in each physiographic province. Distributions of simulated and observed discharge are considered significantly unrelated with *p*-values less than 0.05. For *p*-values greater than 0.05, simulated and observed discharge are statistically indistinguishable.

Evaluation of simulated and observed discharge for stations in the Coastal Plain revealed that in scenario 1, simulated discharge values were greater than and significantly different ($p = 0.012$) from observed discharge over the entire range of observations (fig. 11A); whereas the distribution of simulated discharge generated under scenario 2 closely resembles and is statistically ($p = 0.985$) indistinguishable from the distribution of observed discharge (fig. 11B). The depth-varying values of roughness used under scenario 2 are all greater than the median field-observed values used under scenario 1 (fig. 10). The function of the depth-varying values of roughness in the Coastal Plain is to decrease the amount of stream discharge associated with each 1-ft interval in channel depth. Using depth-varying roughness (scenario 2) in XSECT considerably improved the representativeness of simulated discharge over the entire extent of flow conditions in the Coastal Plain physiographic province (fig. 11B).

The use of depth-varying values of roughness (scenario 2) similarly improved simulated discharge values in the Piedmont province. Simulated discharge generated under scenario 1 was greater than observed discharge ($p = 0.043$) over the entire distribution range of observed discharge (fig. 12A). The distribution of simulated discharge under scenario 2 was statistically similar ($p = 0.778$) to the distribution of observed discharge (fig. 12B). The most noticeable improvement in the match between simulated and observed stream discharge under scenario 2 is in higher flows greater than 3,000 ft^3/s (fig. 12B). This improvement resulted from the use of higher median roughness values for depths of 9 to 15 ft (fig. 10B) under scenario 2.

Comparison of the distributions of simulated and observed discharge for stations in the Valley and Ridge province revealed that simulated and observed discharge had similar distributions in both scenario 1 and scenario 2, with respective *p*-values of 0.327 and 0.783 (figs. 13A and 13B). However, utilizing depth-varying roughness (scenario 2) generated discharge values that better represented observed discharge. The most noticeable improvement in the match between simulated and observed discharge under scenario 2 occurred for discharge values less than 300 ft^3/s and greater than 10,000 ft^3/s (fig. 13B). The improvements in simulated discharge in the Valley and Ridge, like those in the Piedmont, are related to the use of higher median roughness values for depths of 1 to 6 ft and 10 to 17 ft.

Finally, comparison of simulated and observed discharge for stations in the Appalachian Plateaus indicated that the discharge generated in scenario 1 (fig. 14A) resembled the distribution of the observed discharge more closely than did the discharge generated in scenario 2 (fig. 14B). However, the distribution of simulated discharge generated in both scenarios is not significantly different from the distribution of observed discharge, with respective *p*-values of 0.996 and 0.800. The effect of applying depth-varying values of roughness (scenario 2) is an overprediction of discharge for stations in the Appalachian Plateaus (fig. 14B). Under scenario 2, the median values of roughness for depths of 1 to 9 ft are less than the median channel roughness used in scenario 1 (fig. 10D); therefore, simulated discharge is greater under scenario 2.

On the basis of results of the comparison of discharge values generated under scenario 1 (median of observed roughness values) and scenario 2 (median roughness value for each 1-ft depth interval), the HSPF function tables were generated using all parameter values under scenario 2. Using a single value of channel roughness and floodplain roughness (scenario 1) generally resulted in an overestimation of observed discharge. The observed discharge for stations in the Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces is more closely approximated, using XSECT, when channel roughness varies with channel depth. The relation between simulated (as estimated using scenario 2) and observed discharge for each of the four physiographic provinces is shown in figure 15. XSECT-generated discharge accounted for 94, 92, 90, and 89 percent of the variability associated with observed discharge (stage-discharge rating curve) from gaging stations within the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces, respectively (table 6). The residuals for the regression models relating simulated and observed discharge in the four physiographic provinces are generally evenly distributed around zero (fig. 16). The regression residuals for the Valley and Ridge province show the greatest variability in estimating discharge values between 10 and 100 ft^3/s.

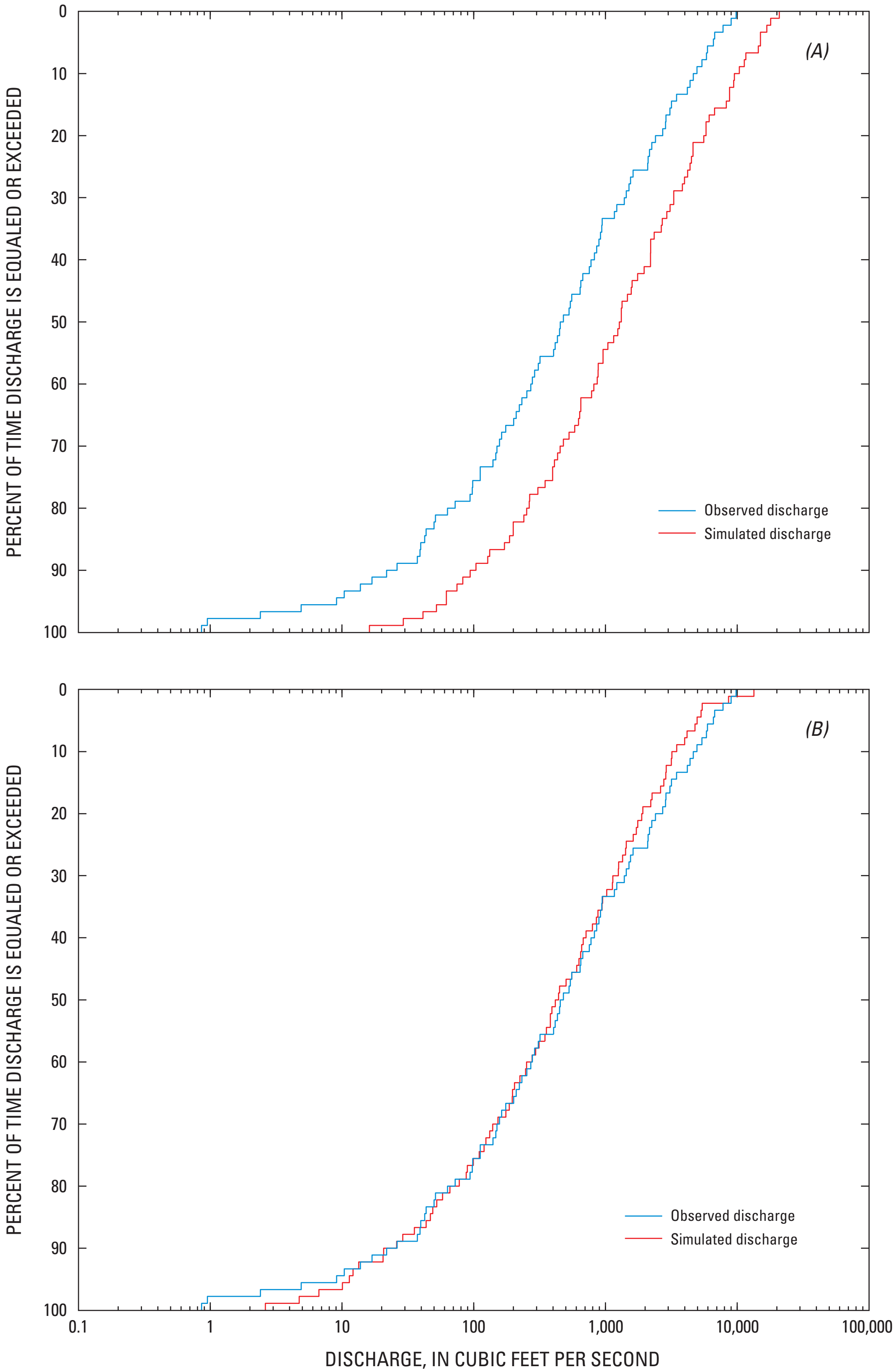

Figure 11. Cumulative distribution plots for observed and simulated discharge for streamflow-gaging stations in the Coastal Plain physiographic province. Simulated discharge derived from the XSECT program based on (*A*) single roughness values for the channel and floodplain and from (*B*) depth-varying roughness values.

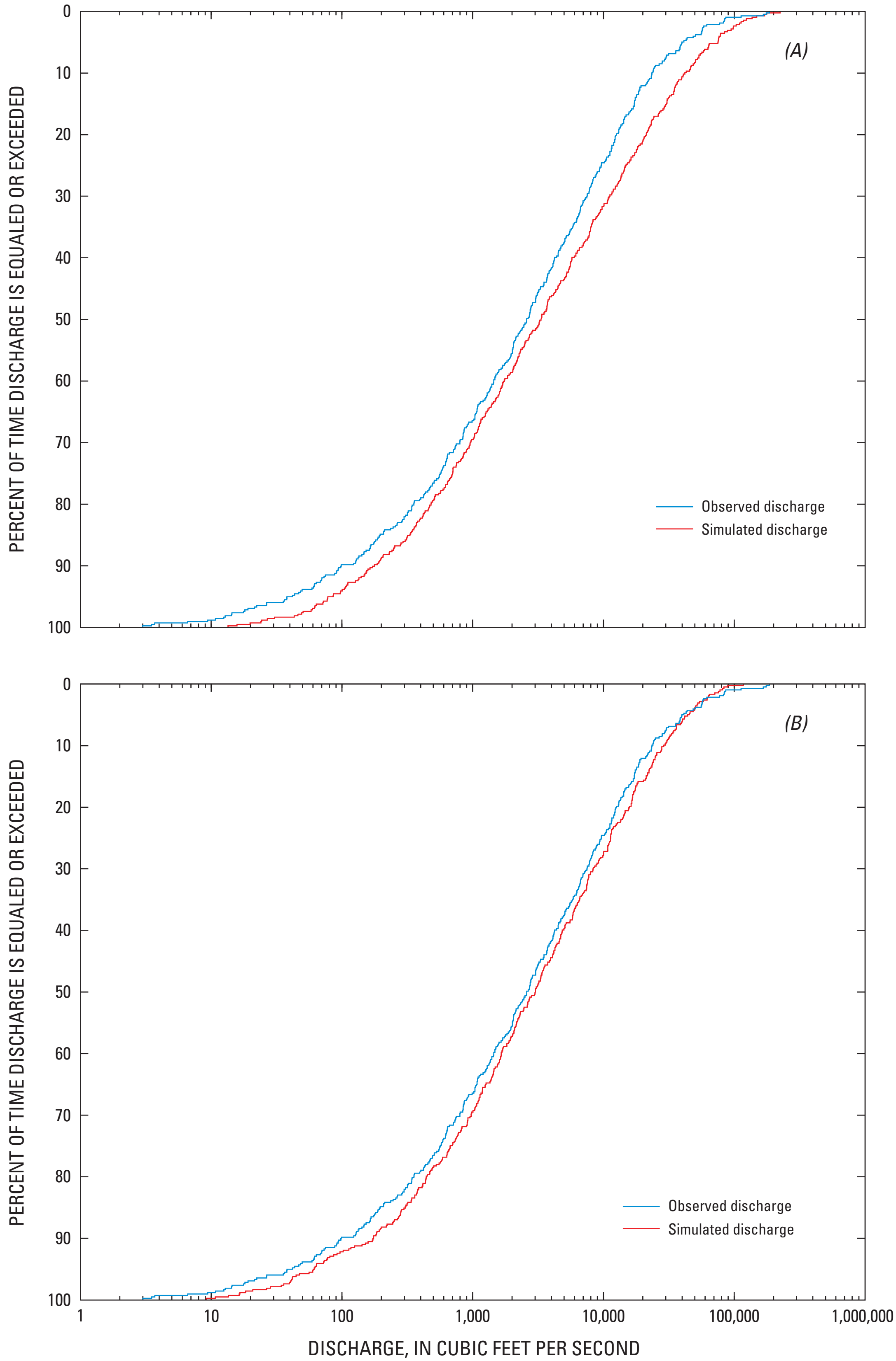

Figure 12. Cumulative distribution plots for observed and simulated discharge for streamflow-gaging stations in the Piedmont physiographic province. Simulated discharge derived from the XSECT program based on (*A*) single roughness values for the channel and floodplain and from (*B*) depth-varying roughness values.

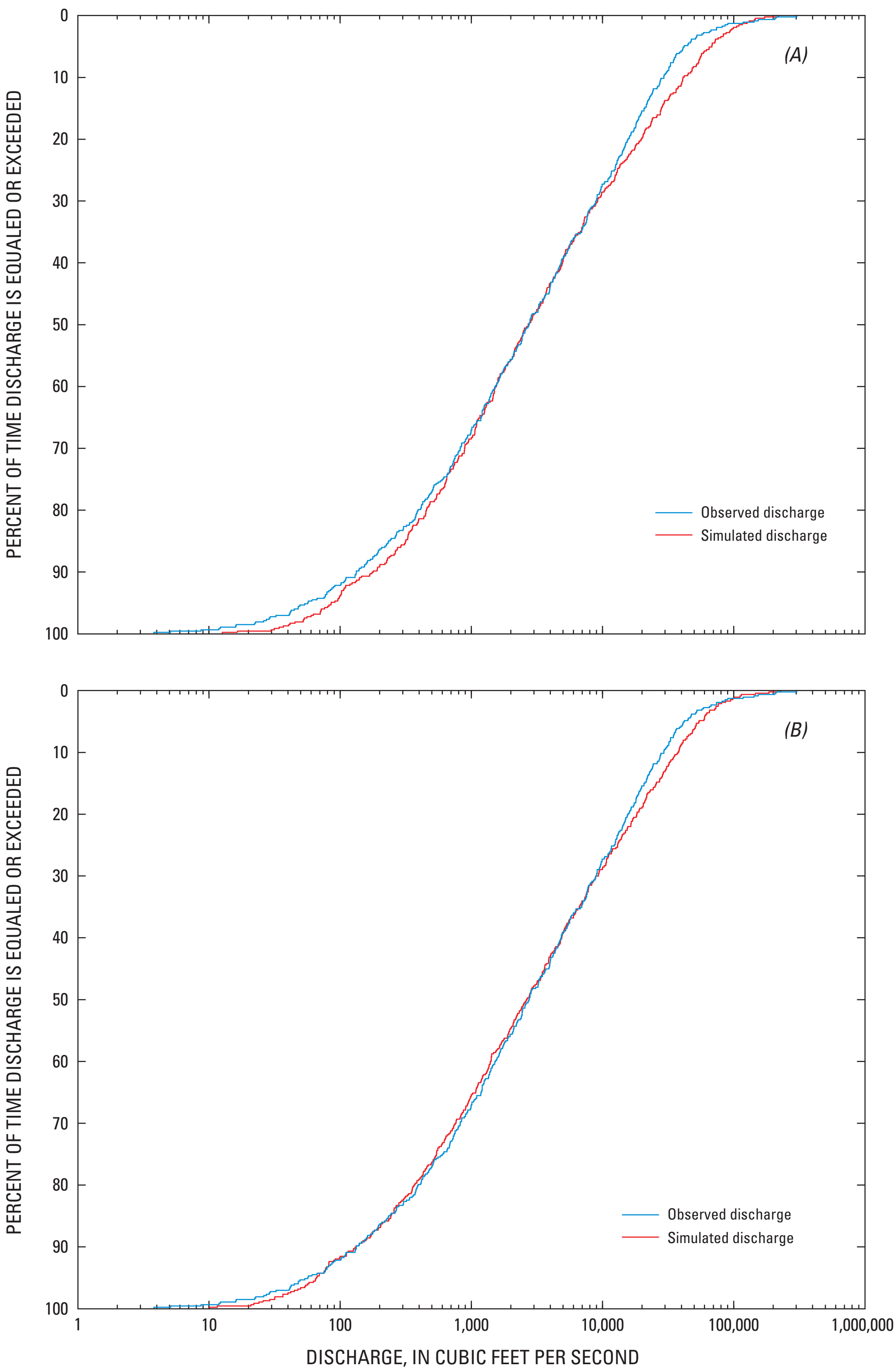

Figure 13. Cumulative distribution plots for observed and simulated discharge for streamflow-gaging stations in the Valley and Ridge physiographic province. Simulated discharge derived from the XSECT program based on (*A*) single roughness values for the channel and floodplain and from (*B*) depth-varying roughness values.

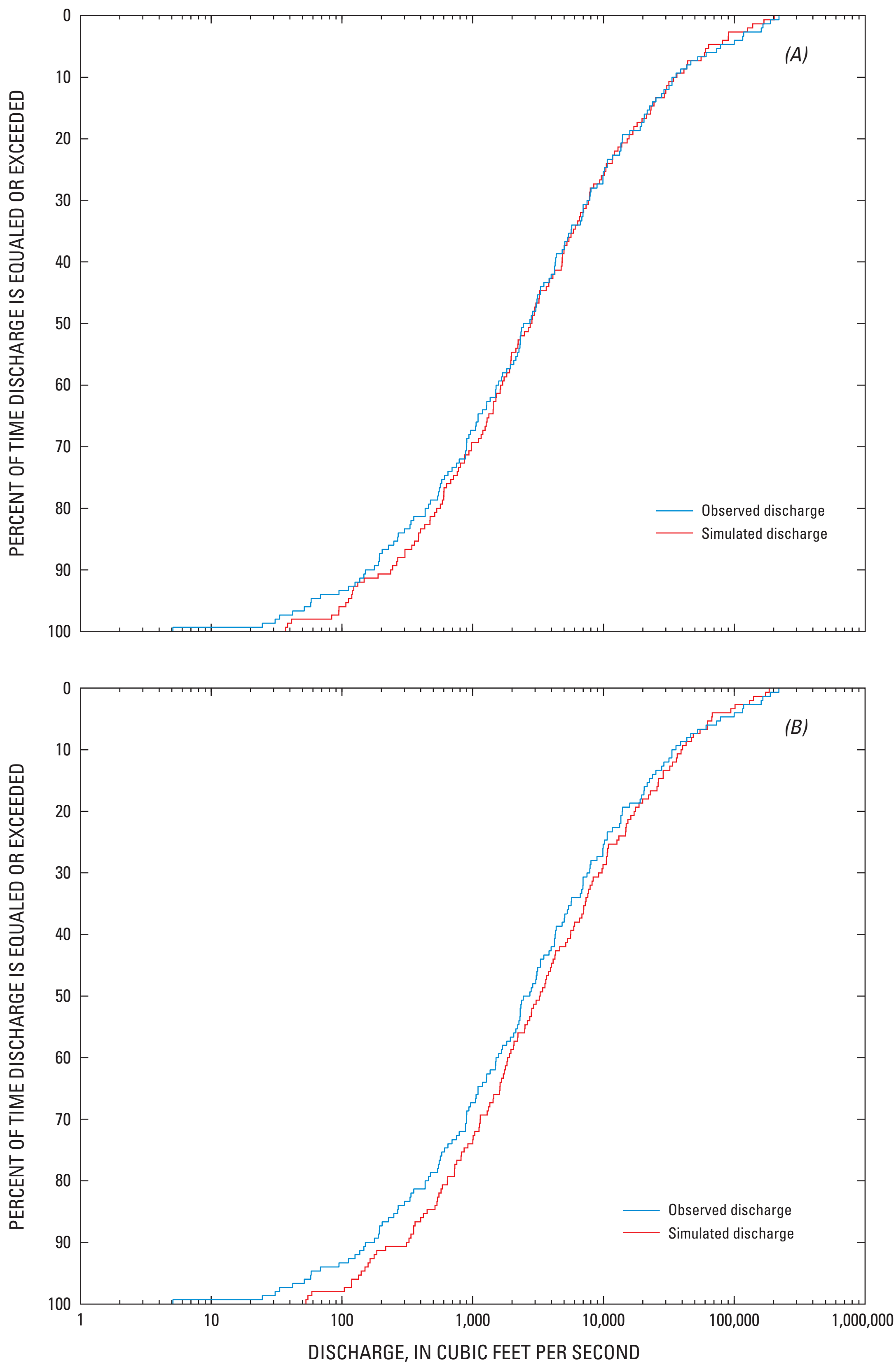

Figure 14. Cumulative distribution plots for observed and simulated discharge for streamflow-gaging stations in the Appalachian Plateaus physiographic province. Simulated discharge derived from the XSECT program based on (*A*) single roughness values for the channel and floodplain and from (*B*) depth-varying roughness values.

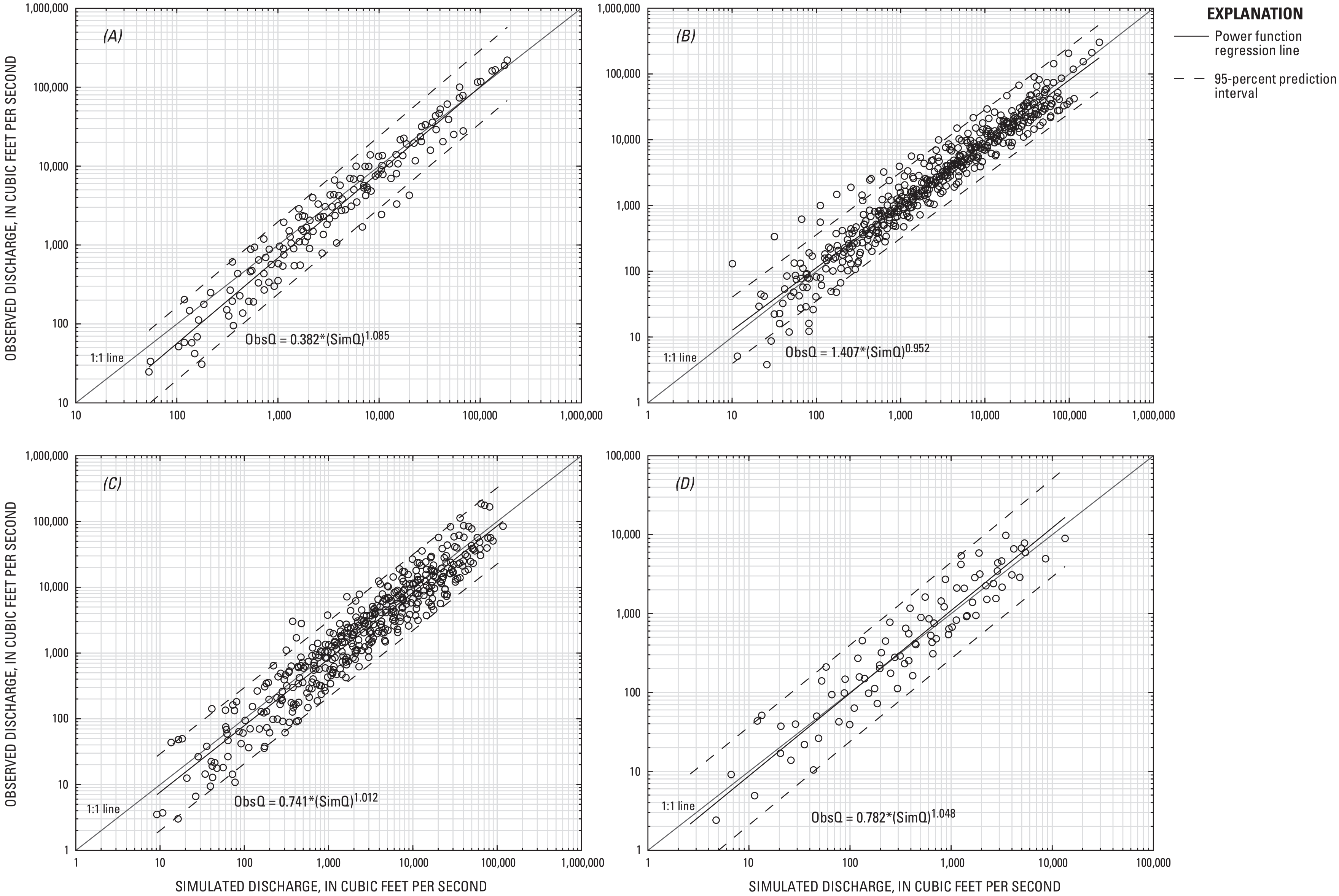

Figure 15. Relation of XSECT-simulated discharge to observed discharge for streamflow-gaging stations in the (*A*) Appalachian Plateaus, (*B*) Valley and Ridge, (*C*) Piedmont, and (*D*) Coastal Plain physiographic provinces.

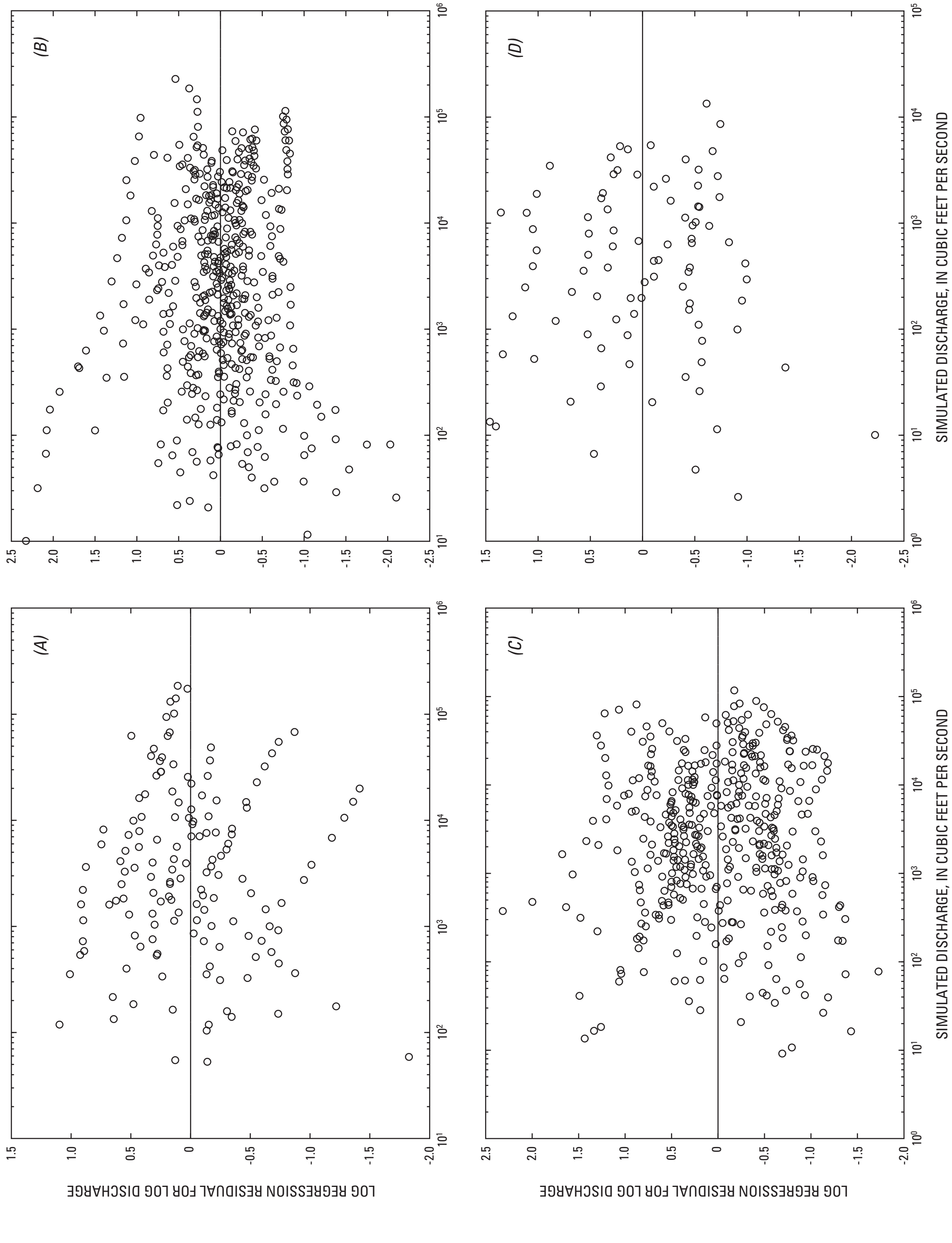

Figure 16. Regression residuals for simulated minus observed discharge relative to simulated discharge in the (*A*) Appalachian Plateaus, (*B*) Valley and Ridge, (*C*) Piedmont, and (*D*) Coastal Plain physiographic provinces.

Table 6. Equations and diagnostic statistics regression analysis relating simulated and observed stream discharge for streamflow-gaging stations in the Appalachian Plateaus, Valley and Ridge, Piedmont, Coastal Plain, and physiographic provinces.

[R^2, correlation coefficient; %, percent; ObsQ, observed discharge; SimQ, simulated discharge]

Province	Equation	*p*-value	R^2	Residual standard error (natural log)	Residual standard error (%) [1]	F-statistic
Appalachian Plateaus	ObsQ = 0.382*(SimQ)$^{1.085}$	0.00	0.937	0.528	57.0	2,186.52
Valley and Ridge	ObsQ = 1.407*(SimQ)$^{0.952}$	.00	.921	.580	63.2	5,513.31
Piedmont	ObsQ = 0.741*(SimQ)$^{1.012}$	.00	.900	.667	73.9	3,801.53
Coastal Plain	ObsQ = 0.782*(SimQ)$^{1.048}$	.00	.888	.702	79.6	698.82

[1] Tasker, 1978.

Direction of Future Research

The results of this study demonstrate the utility of using depth-varying values of channel and floodplain roughness for the estimation of stream discharge over a range of stream depths. Additionally, these depth-varying values of roughness differ with physiographic province. One potential key area of future research would be to perform field-based quantification of depth-varying channel roughness to test the statistical approach described here. Also, estimating channel roughness for additional regions would test the reproducibility of this method. The benefits of having a method for accurately estimating depth-varying channel roughness for a region are numerous. The primary benefit is reducing the subjectivity associated with the selection of a roughness value for a given channel. This information also would serve to improve calculations of indirect discharge measurements as well as models for predicting and designing bridge crossings and culverts, natural-channel hydraulic design, and stream restoration.

In this study, regression models were used to predict channel geometry from basin drainage area. These regression models were developed specifically for each of the four physiographic provinces represented in this study: the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain. The regression models for each physiographic province were developed and used to predict channel geometry solely for stream channels in each respective physiographic province. However, when the observed basin drainage area and stream channel-geomorphology data from each physiographic province are compared, the regression equations are statistically indistinguishable with respect to the slope and intercept of each model. The relation between basin drainage area and channel bankfull height, bankfull width, and bottom width for stream-flow gaging stations in all four physiographic provinces combined is presented in figure 17. Basin drainage area, for all physiographic provinces, accounted for 64, 87, and 85 percent of the variability in bankfull height, bankfull width, and bottom width, respectively (table 7). The regression residuals for each physiographic province in the combined model are presented in figure 18. In general, the combined models more closely represent the channel geometry features for stream channels within the Piedmont and Valley and Ridge than for stream channels in the Appalachian Plateaus and Coastal Plain. Given these results, additional research is needed to determine the spatial extent for which these channel geometry equations remain valid.

Table 7. Regression equations, relating channel geometry to basin drainage area and associated diagnostic statistics for streamflow-gaging stations in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.

[R^2, correlation coefficient; %, percent; H, bankfull stage; BFW, bankfull width; BW, bottom width; DA, basin drainage area]

Dependent variable	Equation	*p*-value	R^2	Residual standard error (natural log)	Residual standard error (%)	F-statistic
Bankfull stage	H = 2.177*(DA)$^{0.2293}$	0.00	0.645	0.306	30.7	431.62
Bankfull width	BFW = 13.128*(DA)$^{0.4432}$	.00	.872	.302	30.7	1,577.23
Bottom width	BW = 5.471*(DA)$^{0.5103}$	.00	.847	.375	39.4	1,283.44

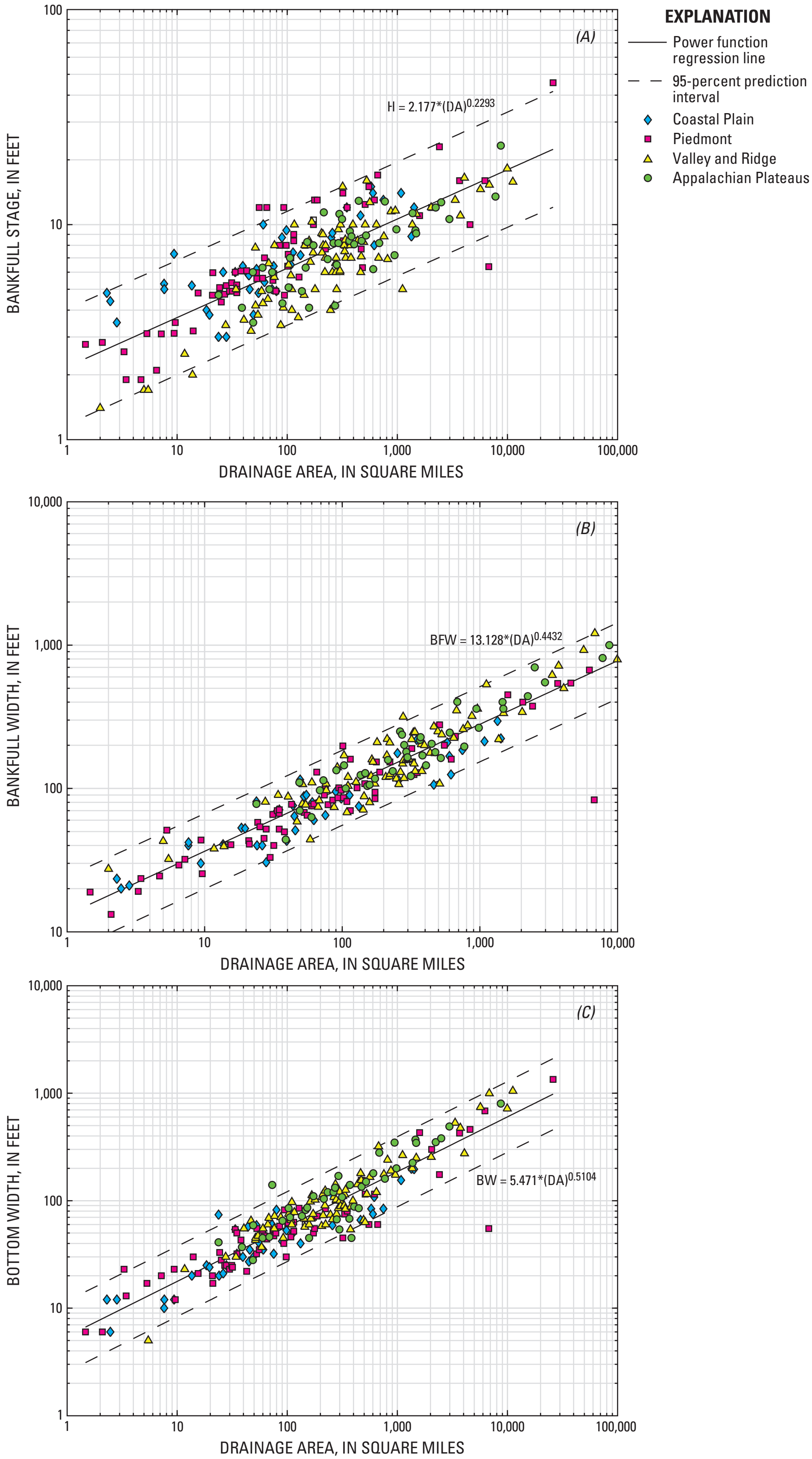

Figure 17. Relation of (*A*) bankfull stage, (*B*) bankfull width, and (*C*) bottom width to basin drainage area for streamflow-gaging stations in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.

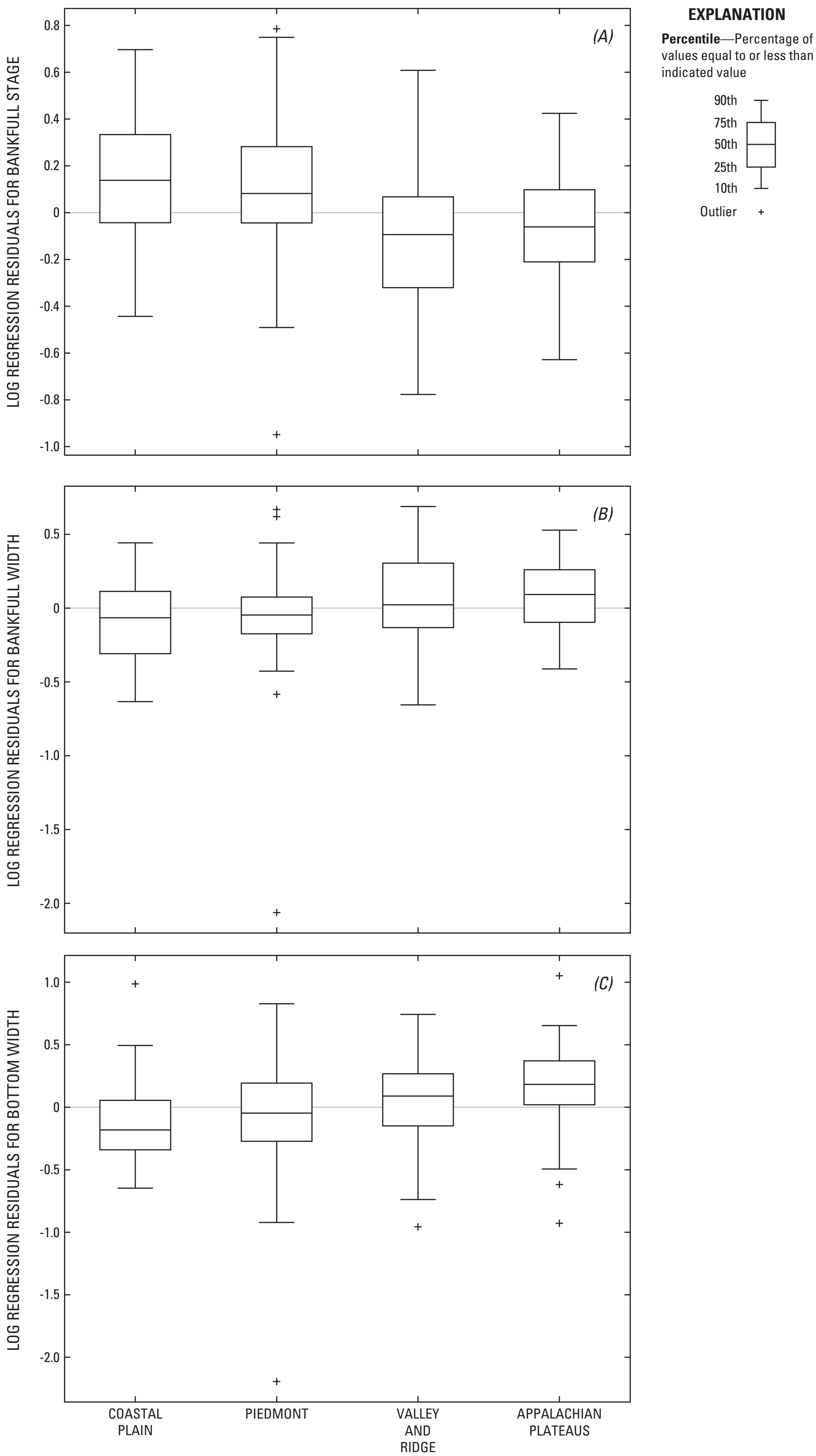

Figure 18. Distribution of regression residuals for predicted minus observed (*A*) bankfull stage, (*B*) bankfull width, and (*C*) bottom width for streamflow-gaging stations in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.

Summary and Application

The Chesapeake Bay Regional Watershed Model (CBRWM) is a mathematical model that is used to simulate the fate and transport of nutrients and sediment from the headwaters of the Chesapeake Bay to the estuaries. This model, in various forms, has been used by the Chesapeake Bay Program (CBP), which consists of various Federal, state, academic, and local watershed organizations, to evaluate the current status of nutrients and sediment in streams and rivers across the watershed. Additionally, the CBRWM is used to simulate potential changes in water-quality conditions as a result of nutrient-reduction goals established by the CBP and associated watershed-management activities. In 2000, the CBP established water-quality improvement goals through continued nutrient- and sediment-reduction strategies as well as criteria for dissolved oxygen, chlorophyll, and water clarity. In response to the CBP water-quality goals, the U.S. Geological Survey (USGS) and U.S. Environmental Protection Agency (USEPA), along with the Virginia Department of Conservation and Recreation (VADCR), the Interstate Commission for the Potomac River Basin (ICPRB), and the Maryland Department of the Environment (MDE), began collaborating to improve the resolution and predictive ability of the CBRWM. Additionally, the areal extent of the model was increased to include the extended regions of Virginia, Maryland, and Delaware.

The CBRWM utilizes the Hydrologic Simulation Program–Fortran (HSPF) version 11 to simulate the hydrology of and associated water-quality constituent transport in the Chesapeake Bay watershed and extended areas of Virginia, Maryland, and Delaware. HSPF is a continuous simulation and lumped parameter watershed model that is used to simulate the transport and storage of water and associated water-quality constituents by linking surface, soil, and instream processes. One critical element in the improvement of the CBRWM framework was the development of an HSPF function table (FTABLE) for each stream channel. The FTABLE is used to relate stage (water depth) in a particular stream channel to associated channel surface area, channel volume, and discharge. An FTABLE is typically constructed based on measurements of channel geomorphology such as width, depth, length, slope, and roughness (Manning's *n*). In the CBRWM, there are approximately 290 simulated stream channels for which observed channel geomorphology data are available. These data are typically associated with the presence of a USGS streamflow-gaging station. However, there are 448 simulated stream channels for which channel geomorphology data are insufficient to generate FTABLEs.

In 2002, the USGS, in cooperation with the VADCR, began a study to develop FTABLEs for all stream channels represented in the CBRWM. The specific study objectives were to (1) develop an approach to predict channel geomorphology for stream channels with no geomorphology data, (2) generate FTABLEs for the 738 stream channels represented in the CBRWM, and (3) evaluate the effectiveness of the current approach for generating FTABLEs that are representative of the geomorphologic characteristics of the associated stream channel.

XSECT is a FORTRAN program that calculates FTABLEs based on nine input variables used to represent channel morphology. These nine input variables are reach length, upstream and downstream elevation, channel bottom width, channel bankfull width, channel bankfull stage, slope of the floodplain, and Manning's roughness coefficient for the channel and floodplain. For the purpose of this study, the nine input variables were grouped into three categories: channel geometry, Manning's roughness coefficient, and channel and floodplain slope. Values of channel geometry for every stream segment represented in the CBRWM were obtained by first developing regional regression models that relate basin drainage area to observed values of bankfull width, bankfull depth, and bottom width at each of the 290 USGS gaging stations. These regression models were developed for stations in four physiographic provinces (Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain) and were used to predict channel geometry for all 738 stream segments from associated basin drainage area. Manning's roughness coefficient for the channel and floodplain was represented in the XSECT program in two forms. First, all available field-estimated values of roughness were compiled for gaging stations in each physiographic province. The median of the field-estimated values of channel and floodplain roughness for each physiographic province was applied to all respective stream segments. The second representation of Manning's roughness coefficient was to allow roughness to vary with channel depth. Roughness was calculated at each gaging station for each 1-ft depth interval. Median values of roughness were calculated for each 1-ft depth interval for all stations in each physiographic province. Channel and floodplain slope were determined for every stream segment in the CBRWM using the USGS National Elevation Dataset.

Function tables were generated with the XSECT program using values of channel geometry, channel and floodplain roughness, and channel and floodplain slope. These FTABLEs were evaluated for each of the 290 USGS gaging stations by comparing observed discharge to the XSECT-derived discharge. The first comparison evaluated the representativeness of FTABLE discharge derived from (1) a single value of roughness for the channel and floodplain and (2) depth-varying roughness. The results of this comparison showed that FTABLE discharge derived from depth-varying roughness was statistically indistinguishable from observed discharge. Results of regression analysis showed that XSECT-derived discharge accounted for approximately 90 percent of the variability associated with observed discharge within each of the four physiographic provinces. The results of this study indicate that the methodology developed to generate FTABLEs for every simulated stream segment in the CBRWM is appropriate. Additionally, the methodology developed in this study can be applied to stream-channel representation in association with other modeling efforts such as total maximum daily load (TMDL) development and other watershed-scale water-quality assessments.

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Table 3

Table 3. Streamflow-gaging stations and associated basin and channel characteristics used for the development of regional models to predict channel geometry.

[mi^2, square mile; ft, foot; USGS, U.S. Geological Survey; SRIa, North Carolina Stream Restoration Institute, 2006a; USFWS, U.S. Fish and Wildlife Service; SRIb, North Carolina Stream Restoration Institute, 2006b; AP, Appalachian Plateaus; VR, Valley and Ridge; PD, Piedmont; CP, Coastal Plain; –, no data; ns, no station number]

Station number	Station name	Drainage area (mi^2)	Bankfull height (ft)	Bankfull width (ft)	Bottom width (ft)	Data source
	Appalachian Plateaus Physiographic Province					
1500000	Ouleout Creek at East Sidney, N.Y.	103.0	5.1	145.0	85.0	USGS
1500500	Susquehanna River at Unadilla, N.Y.	982.0	9.5	265.0	200.0	USGS
1502000	Butternut Creek at Morris, N.Y.	59.7	6.3	63.0	45.0	USGS
1502500	Unadilla River at Rockdale, N.Y.	520.0	8.9	163.0	150.0	USGS
1503000	Susquehanna River at Conklin, N.Y.	2,232.0	12.0	440.0	350.0	USGS
1505000	Chenango River at Sherburne, N.Y.	263.0	8.2	250.0	120.0	USGS
1509000	Tioughnioga River at Cortland, N.Y.	292.0	8.2	180.0	170.0	USGS
1510000	Otselic River at Cincinnatus, N.Y.	147.0	6.3	128.0	82.0	USGS
1512500	Chenango River near Chenango Forks, N.Y.	1,483.0	9.1	360.0	345.0	USGS
1518000	Tioga River at Tioga, Pa.	282.0	6.5	201.0	67.0	USGS
1518700	Tioga River at Tioga Junction, Pa.	446.0	12.9	205.0	85.0	USGS
1518862	Cowanesque River at Westfield, Pa.	90.6	4.3	134.0	65.0	USGS
1520000	Cowanesque River near Lawrenceville, Pa.	298.0	11.2	165.0	54.0	USGS
1520500	Tioga River near Lindley, N.Y.	771.0	12.8	196.0	160.0	USGS
1524500	Canisteo River Below Canacadea Creeek at Hornell, N.Y.	158.0	4.1	106.0	45.0	USGS
1526500	Tioga River near Erwins, N.Y.	1,377.0	11.3	–	225.0	USGS
1531000	Chemung River at Chemung, N.Y.	2,506.0	12.7	700.0	380.0	USGS
1531500	Susquehanna River at Towanda, Pa.	7,797.0	13.5	813.0	–	USGS
1532000	Towanda Creek near Monroeton, Pa.	215.0	11.4	158.0	104.0	USGS
1533400	Susquehanna River at Meshoppen, Pa.	8,720.0	23.3	1,000.0	800.0	USGS
1534000	Tunkhannock Creek near Tunkhannock, Pa.	383.0	8.8	170.0	45.0	USGS
1534300	Lackawanna River near Forest City, Pa.	38.8	4.1	44.0	37.0	USGS
1541000	West Branch Susquehanna River at Bower, Pa.	315.0	10.6	122.0	108.0	USGS
1541200	Wb Susquehanna River near Curwensville, Pa.	367.0	8.4	218.0	68.0	USGS
1541303	West Branch Susquehanna River at Hyde, Pa.	474.0	8.4	179.0	135.0	USGS
1541500	Clearfield Creek at Dimeling, Pa.	371.0	9.3	228.0	140.0	USGS
1542000	Moshannon Creek at Osceola Mills, Pa.	68.8	5.0	97.0	46.0	USGS
1542500	Wb Susquehanna River at Karthaus, Pa.	1,462.0	9.4	401.0	370.0	USGS
1543000	Driftwood Br Sinnemahoning Cr at Sterling Run, Pa.	272.0	4.2	237.0	132.0	USGS
1543500	Sinnemahoning Creek at Sinnemahoning, Pa.	685.0	8.2	402.0	280.0	USGS
1544500	Kettle Creek at Cross Fork, Pa.	136.0	4.9	124.0	72.0	USGS
1545000	Kettle Creek near Westport, Pa.	233.0	6.9	132.0	120.0	USGS
1545500	West Branch Susquehanna River at Renovo, Pa.	2,975.0	10.6	550.0	490.0	USGS
1547950	Beech Creek at Monument, Pa.	152.0	8.3	104.0	86.0	USGS
1548500	Pine Creek at Cedar Run, Pa.	604.0	6.2	245.0	180.0	USGS
1549700	Pine Creek Bl L Pine Creek near Waterville, Pa.	944.0	7.2	360.0	347.0	USGS
1550000	Lycoming Creek near Trout Run, Pa.	173.0	8.0	117.0	110.0	USGS

Table 3. Streamflow-gaging stations and associated basin and channel characteristics used for the development of regional models to predict channel geometry.—Continued

[mi^2, square mile; ft, feet; USGS, U.S. Geological Survey; SRIa, North Carolina Stream Restoration Institute, 2006a; USFWS, U.S. Fish and Wildlife Service; SRIb, North Carolina Stream Restoration Institute, 2006b; AP, Appalachian Plateaus; VR, Valley and Ridge; PD, Piedmont; CP, Coastal Plain; –, no data; ns, no station number]

Station number	Station name	Drainage area (mi^2)	Bankfull height (ft)	Bankfull width (ft)	Bottom width (ft)	Data source
	Appalachian Plateaus Physiographic Province—Continued					
1552500	Muncy Creek near Sonestown, Pa.	23.8	4.7	78.0	41.0	USGS
1595000	North Branch Potomac River at Steyer, Md.	73.0	6.0	114.0	140.0	USGS
1595200	Stony River near Mount Storm, W.Va.	48.8	6.0	110.0	28.0	USGS
1596500	Savage River near Barton, Md.	49.1	3.5	70.0	59.0	USGS
1597500	Savage Riv Bl Savage Riv Dam near Bloomington, Md.	106.0	7.0	100.0	70.0	USGS
1598500	North Branch Potomac River at Luke, Md.	406.0	8.1	145.0	88.0	USGS
	Valley and Ridge Physiographic Province					
1534500	Lackawanna River at Archbald, Pa.	108.0	5.8	68.0	66.0	USGS
1536000	Lackawanna River at Old Forge, Pa.	332.0	7.5	149.0	114.0	USGS
1536500	Susquehanna River at Wilkes-Barre, Pa.	9,960.0	18.2	794.0	719.0	USGS
1539000	Fishing Creek near Bloomsburg, Pa.	274.0	6.6	149.0	142.0	USGS
1540500	Susquehanna River at Danville, Pa.	11,220.0	15.8	1,332.0	1,050.0	USGS
1546400	Spring Creek at Houserville, Pa.	58.5	4.9	44.0	37.0	USGS
1546500	Spring Creek near Axemann, Pa.	87.2	3.4	74.0	70.0	USGS
1547100	Spring Creek at Milesburg, Pa.	142.0	4.7	71.0	68.0	USGS
1547200	Bald Eagle Creek Bl Spring Creek at Milesburg, Pa.	265.0	4.2	130.0	108.0	USGS
1547500	Bald Eagle Creek at Blanchard, Pa.	339.0	7.0	132.0	126.0	USGS
1548005	Bald Eagle Creek near Beech Creek Station, Pa.	562.0	12.7	–	166.0	USGS
1551500	Wb Susquehanna River at Williamsport, Pa.	5,682.0	14.6	923.0	740.0	USGS
1552000	Loyalsock Creek at Loyalsockville, Pa.	435.0	8.4	177.0	142.0	USGS
1553500	West Branch Susquehanna River at Lewisburg, Pa.	6,847.0	15.3	1,210.0	995.0	USGS
1553700	Chillisquaque Creek at Washingtonville, Pa.	51.3	7.8	78.0	43.0	USGS
1554500	Shamokin Creek at Shamokin, Pa.	54.2	3.8	77.0	47.0	USGS
1555000	Penns Creek at Penns Creek, Pa.	301.0	6.1	159.0	100.0	USGS
1555500	East Manhantango Creek near Dalmatia, Pa.	162.0	6.7	122.0	98.0	USGS
1556000	Frankstown Br Juniata River at Williamsburg, Pa.	291.0	9.5	158.0	85.0	USGS
1558000	Little Juniata River at Spruce Creek, Pa.	220.0	6.0	121.0	90.0	USGS
1559000	Juniata River at Huntington, Pa.	816.0	6.9	275.0	240.0	USGS
1560000	Dunning Creek at Beldon, Pa.	172.0	7.4	108.0	75.0	USGS
1562000	Raytown Branch Juniata River at Saxton, Pa.	756.0	8.8	259.0	176.0	USGS
1563200	Rays Br Juniata R Blw Rays Dam near Huntingdon, Pa.	960.0	11.6	360.0	174.0	USGS
1563500	Juniata River at Mapleton Depot, Pa.	2,030.0	12.0	341.0	255.0	USGS
1564500	Aughwick Creek near Three Springs, Pa.	205.0	9.1	–	58.0	USGS
1567000	Juniata River at Newport, Pa.	3,354.0	13.0	618.0	530.0	USGS
1568000	Sherman Creek at Shermans Dale, Pa.	207.0	7.4	120.0	108.0	USGS
1570000	Condoguinet Creek near Hogestown, Pa.	470.0	7.1	176.0	155.0	USGS
1572025	Swatara Creek near Pine Grove, Pa.	116.0	10.0	–	78.0	USGS
1572190	Swatara Creek near Inwood, Pa.	167.0	10.3	153.0	112.0	USGS

Table 3. Streamflow-gaging stations and associated basin and channel characteristics used for the development of regional models to predict channel geometry.—Continued

[mi^2, square mile; ft, feet; USGS, U.S. Geological Survey; SRIa, North Carolina Stream Restoration Institute, 2006a; USFWS, U.S. Fish and Wildlife Service; SRIb, North Carolina Stream Restoration Institute, 2006b; AP, Appalachian Plateaus; VR, Valley and Ridge; PD, Piedmont; CP, Coastal Plain; –, no data; ns, no station number]

Station number	Station name	Drainage area (mi^2)	Bankfull height (ft)	Bankfull width (ft)	Bottom width (ft)	Data source
	Valley and Ridge Physiographic Province—Continued					
1573000	Swatara Creek at Harper Tavern, Pa.	337.0	8.5	247.0	84.0	USGS
1603000	North Branch Potomac River near Cumberland, Md.	875.0	11.5	320.0	190.0	USGS
1604500	Patterson Creek near Headsville, W.Va.	211.0	9.0	170.0	115.0	USGS
1605500	South Branch Potomac River at Franklin, W.Va.	179.0	5.0	210.0	102.0	USGS
1606500	So. Branch Potomac River near Petersburg, W.Va.	676.0	7.0	350.0	320.0	USGS
1607500	So Fk So Br Potomac River at Brandywine, W.Va.	103.0	6.5	170.0	75.0	USGS
1608000	So Fk South Branch Potomac River near Moorefield, W.Va.	277.0	6.0	316.0	100.0	USGS
1608500	South Branch Potomac River near Springfield, W.Va.	1,486.0	11.2	335.0	250.0	USGS
1613000	Potomac River at Hancock, Md.	4,073.0	16.5	500.0	275.0	USGS
1614500	Conococheague Creek at Fairview, Md.	494.0	8.3	250.0	66.0	USGS
1619500	Antietam Creek near Sharpsburg, Md.	281.0	5.0	118.0	75.0	USGS
1622000	North River near Burketown, Va.	379.0	7.0	132.0	88.0	USGS
1625000	Middle River near Grottoes, Va.	375.0	8.0	203.0	54.0	USGS
1627500	South River at Harriston, Va.	212.0	8.0	221.0	73.0	USGS
2011400	Jackson River near Bacova, Va.	158.0	8.4	80.0	60.0	USGS
2011460	Back Creek near Sunrise, Va.	60.2	4.3	110.0	55.0	USGS
2011470	Back Creek at Sunrise, Va.	76.1	5.7	108.0	55.0	USGS
2013000	Dunlap Creek near Covington, Va.	164.0	8.0	159.0	68.0	USGS
2015700	Bullpasture River at Williamsville, Va.	110.1	4.0	104.0	97.0	USGS
2016000	Cowpasture River near Clifton Forge, Va.	463.8	6.0	270.0	180.0	USGS
2016500	James River at Lick Run, Va.	1,368.5	10.0	220.0	200.0	USGS
2018500	Catawba Creek near Catawba, Pa.	34.2	5.0	90.0	30.0	USGS
2020500	Calfpasture River Above Mill Creek at Goshen, Va.	144.0	8.0	88.0	57.0	USGS
2021500	Maury River at Rockbridge Baths, Va.	328.9	8.0	245.0	90.0	USGS
2024000	Maury River near Buena Vista, Va.	646.2	10.0	225.0	120.0	USGS
2053800	Sf Roanoke River near Shawsville, Va.	110.0	5.0	120.0	60.0	USGS
2054500	Roanoke River at Lafayette, Va.	257.0	6.0	107.0	67.0	USGS
2055000	Roanoke River at Roanoke, Va.	395.0	10.0	200.0	100.0	USGS
2056000	Roanoke River at Niagara, Va.	510.4	10.0	108.0	63.0	USGS
3164000	New River near Galax, Va.	1,114.7	5.0	532.0	265.0	USGS
3167000	Reed Creek at Grahams Forge, Va.	247.0	4.0	117.0	74.0	USGS
3167500	Big Reed Island Creek near Allisonia, Va.	278.0	7.0	157.0	102.0	USGS
3170000	Little River at Graysontown, Va.	300.0	6.0	164.0	121.0	USGS
3173000	Walker Creek at Bane, Va.	305.0	10.0	161.0	89.0	USGS
3175500	Wolf Creek near Narrows, Va.	223.0	8.0	126.0	60.0	USGS
3176500	New River at Glen Lyn, Va.	3,737.7	11.0	718.0	476.0	USGS
3439000	French Broad River at Rosman, N.C.	67.9	6.6	82.4	69.0	SRIa
3440000	Catheys Creek near Brevard, N.C.	11.7	2.5	38.0	23.0	SRIa

Table 3. Streamflow-gaging stations and associated basin and channel characteristics used for the development of regional models to predict channel geometry.—Continued

[mi², square mile; ft, feet; USGS, U.S. Geological Survey; SRIa, North Carolina Stream Restoration Institute, 2006a; USFWS, U.S. Fish and Wildlife Service; SRIb, North Carolina Stream Restoration Institute, 2006b; AP, Appalachian Plateaus; VR, Valley and Ridge; PD, Piedmont; CP, Coastal Plain; –, no data; ns, no station number]

Station number	Station name	Drainage area (mi²)	Bankfull height (ft)	Bankfull width (ft)	Bottom width (ft)	Data source
	Valley and Ridge Physiographic Province—Continued					
3441000	Davidson River near Brevard, N.C.	40.4	3.6	87.6	55.0	SRIa
3446000	Mills River near Mills River, N.C.	66.7	4.5	74.3	60.0	SRIa
3450000	BeeTree Creek near Swannanoa, N.C.	5.5	1.7	32.1	5.0	SRIa
3454000	Big Laurel Creek near Stackhouse, N.C.	126.0	3.7	110.8	–	SRIa
3455500	W F Pigeon R Above Lake Logan near Hazelwood, N.C.	27.6	3.4	80.6	30.0	SRIa
3456500	East Fork Pigeon River near Canton, N.C.	51.5	4.2	107.0	45.0	SRIa
3460000	Cataloochee Creek near Cataloochee, Nc.	46.9	3.2	58.7	65.0	SRIa
3471500	Sf Holston River at Riverside near Chilhowie, Va.	76.6	8.0	97.0	72.0	USGS
3479000	Watauga River near Sugar Grove, N.C.	92.1	4.1	140.3	45.0	SRIa
3488000	Nf Holston River near Saltville, Va.	221.3	7.0	209.0	124.0	USGS
3524000	Clinch River at Cleveland, Va.	528.0	16.0	238.0	115.0	USGS
3531500	Powell River near Jonesville, Va.	319.0	15.0	220.0	110.0	USGS
ns	East Fork Hickey Fork Creek, N.C.	2.0	1.4	27.4	–	SRIa
ns	Cold Spring Creek, N.C.	5.0	1.7	42.9	–	SRIa
ns	Caldwell Fork, N.C.	13.8	2.0	39.4	–	SRIa
	Piedmont Physiographic Province					
1495000	Big Elk Creek at Elk Mills, Md.	52.6	6.0	77.5	32.0	USFWS
1496000	Northeast Creek at Leslie, Md.	24.3	5.1	58.0	33.0	USFWS
1573160	Quittapahilla Creek near Bellgrove, Pa.	74.2	5.5	90.0	54.0	USGS
1573560	Swatara Creek near Hershey, Pa.	483.0	6.3	275.0	154.0	USGS
1574000	West Conewago Creek near Manchester, Pa.	510.0	12.4	278.0	115.0	USGS
1574500	Codorus Creek at Spring Grove, Pa.	75.5	5.9	105.0	47.0	USGS
1575500	Codorus Creek near York, Pa.	222.0	7.7	153.0	84.0	USGS
1576000	Susquehanna River at Marietta, Pa.	25,990.0	45.7	–	1,345.0	USGS
1576500	Conestoga River at Lancaster, Pa.	324.0	8.4	153.0	120.0	USGS
1576754	Conestoga River at Conestoga, Pa.	470.0	7.7	–	155.0	USGS
1579000	Basin Run at Liberty Grove, Md.	5.3	3.1	51.1	17.0	USFWS
1580000	Deer Creek at Rocks, Md.	94.4	4.7	101.0	82.0	USFWS
1581700	Winters Run near Benson, Md.	34.8	5.2	67.0	50.0	USFWS
1582000	Little Falls at Blue Mount, Md.	52.9	5.6	68.0	55.0	USFWS
1583000	Slade Run near Glyndon, Md.	2.1	2.8	13.2	6.0	USFWS
1583500	Western Run at Western Run, Md.	59.8	5.6	75.4	53.0	USFWS
1583580	Baisman Run at Broadmoor, Md.	1.5	2.8	18.9	6.0	USFWS
1583600	Beaverdam Run at Cockeysville, Md.	20.9	4.7	43.2	20.0	USFWS
1584050	Long Green Creek at Glen Arm, Md.	9.4	3.1	43.6	23.0	USFWS
1585500	Cranberry Branch near Westminster, Md.	3.3	2.6	19.1	23.0	USFWS
1586210	Beaver Run near Finksburg, Md.	14.0	3.2	40.4	30.0	USFWS
1586610	Morgan Run at Louisville, Md.	28.0	5.2	52.0	25.0	USFWS

Table 3. Streamflow-gaging stations and associated basin and channel characteristics used for the development of regional models to predict channel geometry.—Continued

[mi², square mile; ft, feet; USGS, U.S. Geological Survey; SRIa, North Carolina Stream Restoration Institute, 2006a; USFWS, U.S. Fish and Wildlife Service; SRIb, North Carolina Stream Restoration Institute, 2006b; AP, Appalachian Plateaus; VR, Valley and Ridge; PD, Piedmont; CP, Coastal Plain; –, no data; ns, no station number]

Station number	Station name	Drainage area (mi^2)	Bankfull height (ft)	Bankfull width (ft)	Bottom width (ft)	Data source
	Piedmont Physiographic Province—Continued					
1589440	Jones Falls at Sorrento, Md.	25.2	4.4	54.0	28.0	USFWS
1591000	Patuxent River near Unity, Md.	34.8	4.8	52.0	50.0	USFWS
1591700	Hawlings River near Sandy Spring, Md.	27.0	4.7	44.8	25.0	USFWS
1593500	Little Patuxent River at Guilford, Md.	38.0	6.1	49.8	43.0	USFWS
1639000	Monocacy River at Bridgeport, Md.	173.0	10.5	85.0	70.0	USGS
1639140	Piney Creek at Taneytown, Md.	31.3	5.4	65.8	25.0	USFWS
1639500	Big Pipe Creek at Bruceville, Md.	102.0	7.3	86.2	62.0	USFWS
1643500	Bennett Creek at Park Mills, Md.	6,780.0	6.4	83.2	55.0	USFWS
1644000	Goose Creek near Leesburg, Va.	332.0	8.0	125.0	75.0	USGS
1645000	Seneca Creek at Dawsonville, Md.	101.0	6.4	198.0	61.0	USFWS
1648000	Rock Creek at Sherrill Drive, Md.	62.2	7.0	78.0	47.0	USGS
1650500	Nw Branch Anacostia River near Colesville, Md.	21.1	6.0	40.9	17.0	USFWS
1653000	Cameron Run at Alexandria, Va.	33.7	6.0	70.0	54.0	USGS
1660400	Aquia Creek near Garrisonville, Va.	34.9	5.0	71.0	32.0	USGS
1664000	Rappahannock River at Remington, Va.	620.0	13.0	160.0	115.0	USGS
1665500	Rapidan River near Ruckersville, Va.	114.6	9.0	160.0	52.0	USGS
1668000	Rappahannock River near Fredricksburg, Va.	1,596.0	11.0	450.0	430.0	USGS
2026000	James River at Bent Creek, Va.	3,680.9	16.0	540.0	425.0	USGS
2027800	Buffalo River near Tye River, Va.	145.7	8.0	108.0	60.0	USGS
2028500	Rockfish River near Greenfield, Va.	93.0	12.0	86.0	40.0	USGS
2029000	James River at Scottsville, Va.	4,581.8	10.0	544.0	460.0	USGS
2032680	Nf Rivanna River near Proffit, Va.	176.9	13.0	153.0	55.0	USGS
2034000	Rivanna River at Palmyra, Va.	664.0	17.0	231.0	60.0	USGS
2035000	James River at Cartersville, Va.	6,253.1	16.0	670.0	685.0	USGS
2051000	North Meherrin River near Lunenburg, Va.	55.6	12.0	65.0	35.0	USGS
2051500	Meherrin River near Lawrenceville, Va.	552.0	15.0	200.0	60.0	USGS
2052500	Fountains Creek near Brink, Va.	65.2	12.0	130.0	44.0	USGS
2056900	Blackwater River near Rocky Mount, Va.	114.5	8.4	70.0	63.0	USGS
2058400	Pigg River near Sandy Level, Va.	350.8	12.0	129.0	80.0	USGS
2059500	Goose Creek near Huddleston, Va.	187.3	13.0	130.0	72.0	USGS
2061500	Big Otter River near Evington, Va.	320.0	14.0	190.0	45.0	USGS
2062500	Roanoke (Staunton) River at Brookneal, Va.	2,415.0	23.0	375.0	175.0	USGS
2064000	Falling River near Naruna, Va.	173.0	10.0	94.0	50.0	USGS
2065500	Cub Creek at Phenix, Va.	98.0	8.0	97.0	30.0	USGS
2069700	South Mayo River near Nettleridge, Va.	85.3	8.0	83.0	58.0	USGS
2070000	North Mayo River near Spencer, Va.	108.0	7.0	81.0	46.0	USGS
2075000	Dan River at Danville, Va.	2,050.0	12.0	400.0	300.0	USGS
2075160	Moon Creek near Yanceyville, N.C.	29.9	4.9	33.0	23.0	SRIb

Table 3. Streamflow-gaging stations and associated basin and channel characteristics used for the development of regional models to predict channel geometry.—Continued

[mi^2, square mile; ft, feet; USGS, U.S. Geological Survey; SRIa, North Carolina Stream Restoration Institute, 2006a; USFWS, U.S. Fish and Wildlife Service; SRIb, North Carolina Stream Restoration Institute, 2006b; AP, Appalachian Plateaus; VR, Valley and Ridge; PD, Piedmont; CP, Coastal Plain; –, no data; ns, no station number]

Station number	Station name	Drainage area (mi^2)	Bankfull height (ft)	Bankfull width (ft)	Bottom width (ft)	Data source
	Piedmont Physiographic Province—Continued					
2101800	Tick Creek near Mount Vernon Springs, N.C.	15.5	4.8	40.5	21.0	SRIb
2112360	Mitchell River near State Road, N.C.	78.8	4.9	77.0	50.0	SRIb
2113000	Fisher River near Copeland, N.C.	128.0	5.7	101.0	85.0	USGS
2114450	Little Yadkin River at Dalton, N.C.	42.8	6.1	77.5	22.0	SRIb
2121180	North Pott's Creek at Linwood, N.C.	9.6	3.5	25.4	12.0	SRIb
2123567	Dutchmans Creek near Uwharrie, N.C.	3.4	1.9	23.5	13.0	SRIb
2144000	Long Creek near Bessemer, N.C.	31.8	4.9	40.0	24.0	SRIb
214253830	Norwood Creek near Troutman, N.C.	7.2	3.1	32.0	20.0	SRIb
ns	Mill Creek, N.C.	4.7	1.9	24.5	–	SRIb
ns	Upper Mitchell River, N.C.	6.5	2.1	29.2	–	SRIb
	Coastal Plain Physiographic Province					
1484000	Murderkill River near Felton, De.	13.6	5.2	40.7	20.0	USGS
1484100	Beaverdam Branch at Houston, De.	2.8	3.5	21.0	12.0	USGS
1485000	Pocomoke River near Willards, Md.	60.5	10.0	80.0	35.0	USGS
1485500	Nassawango Creek near Snow Hill, Md.	44.9	5.8	64.0	27.0	USGS
1487000	Nanticoke River near Bridgeville, De.	75.4	6.4	65.0	32.0	USGS
1488500	Marshyhope Creek near Adamsville, De.	43.9	5.9	76.0	57.0	USGS
1491000	Choptank River near Greensboro, Md.	113.0	7.4	89.7	50.0	USGS
1493000	Unicorn Branch near Millington, Md.	19.7	3.8	52.5	24.0	USGS
1495000	Big Elk Creek at Elk Mills, Md.	52.6	6.2	88.0	59.0	USGS
1585100	Whitemarsh Run at White Marsh, Md.	7.6	5.3	40.0	10.0	USGS
1589100	East Branch Herbert Run, Md.	2.5	4.4	20.0	6.0	USGS
1592500	Patuxent River near Laurel, Md.	132.0	7.2	75.0	40.0	USGS
1594000	Little Patuxent River at Savage, Md.	98.4	9.4	85.0	53.0	USGS
1594440	Patuxent River near Bowie, Md.	348.0	12.0	218.0	80.0	USGS
1594526	Western Branch at Upper Marlboro, Md.	89.7	8.7	95.0	42.0	USGS
1594670	Hunting Creek near Huntingtown, Md.	9.4	7.3	30.0	12.0	USGS
1648000	Rock Creek at Sherrill Drive Washington, D.C.	62.2	5.4	60.0	48.0	USGS
1649500	North East Branch Anacostia River at Riverdale, Md.	72.8	5.0	98.0	60.0	USGS
1651000	NW Branch Anacostia River near Hyattsville, Md.	49.4	3.8	115.0	30.0	USGS
1653000	Cameron Run at Alexandria, Va.	33.7	6.0	70.0	54.0	USGS
1653600	Piscataway Creek at Piscataway, Md.	39.5	6.4	43.0	30.0	USGS
1658000	Mattawoman Creek near Pomonkey, Md.	54.8	4.8	90.0	41.0	USGS
1658500	S F Quantico Creek near Independent Hill, Va.	7.6	5.0	42.0	12.0	USGS
1660400	Aquia Creek near Garrisonville, Va.	34.9	5.0	71.0	32.0	USGS
1660900	Wolf Den Branch near Cedarville, Md.	2.3	4.8	23.4	12.0	USGS
1660920	Zekiah Swamp Run near Newtown, Md.	79.9	4.9	–	82.0	USGS
1661050	St Clement Creek near Clements, Md.	18.5	4.0	53.0	25.0	USGS

Table 3. Streamflow-gaging stations and associated basin and channel characteristics used for the development of regional models to predict channel geometry.—Continued

[mi², square mile; ft, feet; USGS, U.S. Geological Survey; SRIa, North Carolina Stream Restoration Institute, 2006a; USFWS, U.S. Fish and Wildlife Service; SRIb, North Carolina Stream Restoration Institute, 2006b; AP, Appalachian Plateaus; VR, Valley and Ridge; PD, Piedmont; CP, Coastal Plain; –, no data; ns, no station number]

Station number	Station name	Drainage area (mi²)	Bankfull height (ft)	Bankfull width (ft)	Bottom width (ft)	Data source
	Coastal Plain Physiographic Province—Continued					
1661500	St Marys River at Great Mills, Md.	24.0	4.8	40.0	20.0	USGS
1668500	Cat Point Creek near Montross, Va.	45.6	5.0	51.0	35.0	USGS
1669000	Piscataway Creek near Tappahannock, Va.	28.0	3.0	30.5	25.0	USGS
1669520	Dragon Swamp at Mascot, Va.	108.0	6.5	86.0	74.0	USGS
1671020	North Anna River at Hart Corner near Doswell, Va.	463.0	11.0	106.0	66.0	USGS
1673000	Pamunkey River near Hanover, Va.	1,081.0	14.0	213.0	155.0	USGS
1673550	Totopotomoy Creek near Studley, Va.	26.2	6.0	40.0	21.0	USGS
1674000	Mattaponi River near Bowling Green, Va.	257.0	9.1	114.0	59.0	USGS
1674500	Mattaponi River near Beulahville, Va.	601.0	14.0	168.0	75.0	USGS
2041650	Appomattox River at Matoaca, Va.	1,344.0	8.8	295.0	198.0	USGS
2042500	Chickahominy River near Providence Forge, Va.	252.0	8.7	176.0	115.0	USGS
2043500	Cypress Swamp at Cypress Chapel, Va.	23.8	3.0	81.0	74.0	USGS
2045500	Nottoway River near Stony Creek, Va.	579.0	15.0	209.0	84.0	USGS
2047000	Nottoway River near Sebrell, Va.	1,421.0	12.0	223.0	196.0	USGS
2049500	Blackwater River near Franklin, Va.	617.0	8.0	125.0	108.0	USGS
2052000	Meherrin River at Emporia, Va.	747.0	13.0	185.0	84.0	USGS

Appendix 1. XSECT Input Parameters for Chesapeake Bay Regional Watershed Model Reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain Physiographic Provinces

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Appalachian Plateaus Physiographic Province									
10	39.46	1476.00	1066.00	93.05	149.64	6.95	0.067	1.00	1.00
20	29.60	1498.96	1167.68	64.17	107.88	5.92	0.021	1.00	1.00
40	26.10	1495.68	1141.44	60.41	102.29	5.76	0.035	1.00	1.00
50	23.43	1269.36	1059.44	49.43	85.71	5.29	0.032	1.00	1.00
60	28.61	1410.40	1066.00	60.98	103.13	5.79	0.046	1.00	1.00
70	19.81	1285.76	1059.44	69.60	115.87	6.13	0.027	1.00	1.00
80	22.46	1676.08	1092.24	48.11	83.69	5.22	0.041	1.00	1.00
90	4.66	1059.44	1036.48	106.26	168.21	7.36	0.039	1.00	1.00
100	30.43	1833.52	1092.24	69.65	115.94	6.13	0.055	1.00	1.00
110	31.97	1456.32	1023.36	77.81	127.82	6.43	0.075	1.00	1.00
120	33.30	1558.00	1082.40	89.97	145.28	6.85	0.026	1.00	1.00
130	16.35	1177.52	1039.76	66.38	111.13	6.00	0.055	1.00	1.00
140	7.35	1167.68	1141.44	98.62	157.50	7.12	0.058	1.00	1.00
150	31.10	1833.52	1082.40	85.69	139.16	6.70	0.052	1.00	1.00
160	17.60	1554.72	1082.40	65.03	109.14	5.95	0.024	1.00	1.00
170	16.39	1036.48	980.72	121.07	188.70	7.78	0.025	1.00	1.00
180	11.78	1141.44	1092.24	124.79	193.80	7.88	0.052	1.00	1.00
190	21.75	1066.00	1003.68	128.55	198.93	7.99	0.021	1.00	1.00
200	7.73	1177.52	980.72	48.91	84.93	5.26	0.166	1.00	1.00
210	15.89	1092.24	1003.68	72.96	120.78	6.25	0.025	1.00	1.00
220	7.19	1082.40	1039.76	176.96	263.61	9.17	0.025	1.00	1.00
230	3.34	1092.24	1082.40	147.13	224.05	8.47	0.035	1.00	1.00
250	15.66	1039.76	1000.40	201.51	295.57	9.70	0.039	1.00	1.00
260	25.33	1082.40	941.36	142.97	218.46	8.36	0.04	1.00	1.00
270	32.03	980.72	885.60	165.95	249.11	8.92	0.021	1.00	1.00
280	26.51	1561.28	885.60	65.01	109.11	5.95	0.077	1.00	1.00
290	18.94	1948.91	1151.63	63.18	106.40	5.88	0.048	1.00	1.00
300	9.81	1003.68	970.88	159.46	240.51	8.77	0.021	1.00	1.00
310	6.97	970.88	961.04	281.71	397.03	11.21	0.03	1.00	1.00
320	4.70	1092.24	1000.40	66.57	111.42	6.01	0.114	1.00	1.00
330	31.40	1512.08	865.92	63.64	107.08	5.90	0.018	1.00	1.00
340	8.55	1000.40	970.88	220.35	319.78	10.08	0.024	1.00	1.00
350	12.35	941.36	879.04	187.76	277.74	9.41	0.104	1.00	1.00
360	4.01	1079.12	951.20	39.75	70.74	4.81	0.066	1.00	1.00
370	28.92	1259.52	1010.24	144.57	220.60	8.40	0.029	1.00	1.00
380	10.61	1453.04	961.04	38.75	69.17	4.76	0.073	1.00	1.00
390	21.47	1262.80	865.92	55.24	94.52	5.55	0.03	1.00	1.00
400	4.32	961.04	951.20	286.44	402.91	11.29	0.089	1.00	1.00
410	10.05	1338.24	941.36	30.31	55.71	4.28	0.059	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Appalachian Plateaus Physiographic Province—Continued									
420	15.70	879.04	820.00	279.97	394.88	11.18	0.017	1.00	1.00
430	6.51	885.60	879.04	182.98	271.49	9.30	0.037	1.00	1.00
440	18.21	1249.68	803.60	67.91	113.39	6.06	0.018	1.00	1.00
450	35.91	1348.08	744.56	76.64	126.14	6.39	0.021	1.00	1.00
460	7.37	951.20	941.36	293.02	411.05	11.40	0.023	1.00	1.00
470	20.54	970.88	816.72	78.82	129.29	6.47	0.015	1.00	1.00
480	43.10	941.36	839.68	333.59	460.78	12.06	0.029	1.00	1.00
490	12.51	1010.24	931.52	165.78	248.88	8.91	0.028	1.00	1.00
500	12.20	820.00	803.60	456.13	606.99	13.80	0.011	1.00	1.00
510	12.81	1193.92	1128.32	80.97	132.40	6.54	0.003	1.00	1.00
520	10.98	839.68	820.00	337.92	466.05	12.12	0.013	1.00	1.00
530	27.54	931.52	810.16	334.37	461.73	12.07	0.029	1.00	1.00
540	20.21	780.64	744.56	501.21	659.54	14.37	0.022	1.00	1.00
550	14.95	803.60	780.64	469.49	622.63	13.97	0.038	1.00	1.00
560	4.68	865.92	816.72	88.50	143.19	6.80	0.03	1.00	1.00
570	7.08	1128.32	1108.64	88.58	143.30	6.80	0.012	1.00	1.00
580	30.77	1108.64	974.16	132.38	204.14	8.09	0.049	1.00	1.00
590	2.67	816.72	780.64	122.21	190.26	7.81	0.048	1.00	1.00
600	13.65	780.64	728.16	361.19	494.21	12.48	0.013	1.00	1.00
610	10.74	810.16	780.64	354.55	486.19	12.38	0.019	1.00	1.00
620	19.69	1994.24	1108.64	61.82	104.39	5.82	0.03	1.00	1.00
630	4.95	974.16	938.08	157.90	238.43	8.73	0.223	1.00	1.00
640	25.75	1797.44	974.16	72.35	119.89	6.23	0.057	1.00	1.00
650	5.22	938.08	931.52	258.10	367.58	10.79	0.1	1.00	1.00
660	22.91	1380.88	767.52	66.03	110.62	5.99	0.094	1.00	1.00
670	12.97	1918.80	1564.56	37.71	67.54	4.70	0.124	1.00	1.00
680	20.12	1472.72	810.16	77.30	127.10	6.41	0.044	1.00	1.00
690	9.98	977.44	938.08	194.36	286.31	9.55	0.031	1.00	1.00
700	34.03	1433.36	646.16	96.54	154.58	7.06	0.214	1.00	1.00
710	14.75	767.52	646.16	131.32	202.70	8.06	0.166	1.00	1.00
720	5.78	744.56	728.16	510.08	669.81	14.48	0.03	1.00	1.00
730	20.42	695.36	646.16	670.72	852.49	16.30	0.127	1.00	1.00
740	22.59	1341.93	1026.95	110.20	173.69	7.47	0.078	1.00	1.00
750	12.76	728.16	701.92	641.43	819.61	15.99	0.03	1.00	1.00
760	27.32	1279.20	610.08	68.25	113.89	6.08	0.282	1.00	1.00
770	4.38	993.84	977.44	142.83	218.27	8.36	0.028	1.00	1.00
780	17.78	1676.08	767.52	52.18	89.91	5.41	0.114	1.00	1.00
790	3.81	1020.08	993.84	140.14	214.65	8.29	0.02	1.00	1.00
800	34.44	1377.60	701.92	89.25	144.24	6.82	0.046	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Appalachian Plateaus Physiographic Province—Continued									
810	17.52	1564.56	905.28	66.24	110.93	6.00	0.121	1.00	1.00
820	13.94	1918.80	1341.52	59.80	101.37	5.74	0.058	1.00	1.00
830	5.17	1131.95	1082.73	90.66	146.26	6.87	0.016	1.00	1.00
840	17.02	1633.94	1089.29	65.80	110.28	5.98	0.026	1.00	1.00
850	4.59	701.92	695.36	650.20	829.48	16.08	0.03	1.00	1.00
860	20.44	646.16	610.08	686.32	869.93	16.46	0.19	1.00	1.00
870	6.34	770.80	695.36	109.29	172.42	7.45	0.037	1.00	1.00
880	16.75	2004.08	1308.72	61.12	103.35	5.79	0.084	1.00	1.00
890	29.75	1551.44	810.16	72.00	119.38	6.22	0.045	1.00	1.00
900	1.45	810.16	770.80	95.54	153.17	7.03	0.053	1.00	1.00
910	3.87	646.16	580.56	135.09	207.81	8.16	0.215	1.00	1.00
920	27.64	2099.20	1131.60	79.20	129.84	6.48	0.019	1.00	1.00
930	34.77	1308.72	842.96	134.24	206.66	8.14	0.335	1.00	1.00
940	24.06	1994.24	810.16	57.24	97.55	5.63	0.123	1.00	1.00
950	12.91	603.52	580.56	698.00	882.96	16.58	0.206	1.00	1.00
960	3.73	610.08	603.52	691.82	876.07	16.52	0.082	1.00	1.00
990	26.34	2151.68	603.52	70.74	117.54	6.17	0.076	1.00	1.00
1000	20.36	1777.76	842.96	72.86	120.63	6.25	0.078	1.00	1.00
1010	2.61	580.56	564.16	715.16	902.06	16.76	0.159	1.00	1.00
1020	30.26	1908.96	564.16	69.75	116.10	6.13	0.228	1.00	1.00
1030	18.98	1689.20	990.56	56.84	96.94	5.61	0.128	1.00	1.00
1040	21.28	1233.28	698.64	85.11	138.33	6.68	0.044	1.00	1.00
1050	17.19	2086.08	1308.72	52.98	91.12	5.45	0.11	1.00	1.00
1060	30.33	990.56	610.08	132.13	203.79	8.08	0.299	1.00	1.00
1070	27.47	2053.28	990.56	73.51	121.59	6.27	0.244	1.00	1.00
1080	32.59	1744.96	600.24	86.81	140.77	6.74	0.165	1.00	1.00
1090	27.04	1850.48	954.77	95.74	153.45	7.03	0.085	1.00	1.00
1100	22.20	1925.36	1046.32	75.35	124.27	6.34	0.101	1.00	1.00
1110	5.94	842.96	783.92	165.31	248.26	8.90	0.294	1.00	1.00
1150	22.99	783.92	600.24	186.95	276.68	9.39	0.214	1.00	1.00
1160	12.87	1318.56	610.08	37.04	66.47	4.67	0.149	1.00	1.00
1170	16.83	1722.00	1006.96	53.57	92.01	5.47	0.071	1.00	1.00
1180	9.75	1951.60	1026.64	29.16	53.85	4.21	0.315	1.00	1.00
1190	27.88	1026.64	469.04	92.63	149.05	6.93	0.043	1.00	1.00
1200	28.35	1348.08	626.48	67.92	113.41	6.06	0.027	1.00	1.00
1210	29.87	1961.44	626.48	68.18	113.79	6.07	0.114	1.00	1.00
1220	19.53	698.64	501.84	108.28	171.03	7.42	0.02	1.00	1.00
1230	32.76	636.32	536.28	413.92	557.24	13.23	0.118	1.00	1.00
1240	23.59	1685.92	1006.96	78.58	128.95	6.46	0.063	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Appalachian Plateaus Physiographic Province—Continued									
1250	22.65	1459.60	514.96	59.37	100.74	5.72	0.037	1.00	1.00
1260	11.16	610.08	488.72	148.98	226.52	8.51	0.009	1.00	1.00
1270	10.50	1006.96	882.32	113.25	177.91	7.56	0.045	1.00	1.00
1330	6.91	659.28	636.32	388.45	526.92	12.88	0.152	1.00	1.00
1350	13.68	600.24	521.52	214.68	312.52	9.97	0.017	1.00	1.00
1360	46.21	1492.40	803.60	126.72	196.43	7.94	0.217	1.00	1.00
1370	10.33	882.32	803.60	117.54	183.85	7.68	0.211	1.00	1.00
1380	8.23	898.72	760.96	107.15	169.45	7.38	0.15	1.00	1.00
1390	4.02	754.40	659.28	102.54	163.02	7.24	0.273	1.00	1.00
1400	7.04	678.96	659.28	367.15	501.38	12.57	0.208	1.00	1.00
1430	4.17	803.60	760.96	178.50	265.63	9.20	0.182	1.00	1.00
1490	13.42	760.96	678.96	220.78	320.33	10.09	0.232	1.00	1.00
1520	19.60	1233.28	747.84	79.37	130.09	6.49	0.201	1.00	1.00
1540	28.02	852.80	678.96	278.57	393.14	11.15	0.193	1.00	1.00
1650	38.29	1085.68	852.80	229.62	331.60	10.26	0.272	1.00	1.00
1720	13.42	1193.92	1085.68	149.78	227.60	8.53	0.047	1.00	1.00
1750	40.10	1459.60	852.80	108.60	171.46	7.43	0.354	1.00	1.00
1800	7.68	1148.00	1085.68	131.59	203.07	8.07	0.104	1.00	1.00
1870	56.82	1813.84	1148.00	127.46	197.44	7.96	0.197	1.00	1.00
1920	13.88	1840.08	1459.60	51.90	89.47	5.40	0.078	1.00	1.00
1940	4.24	1259.52	1239.84	116.89	182.94	7.67	0.04	1.00	1.00
1950	30.65	1728.56	1259.52	83.99	136.73	6.65	0.097	1.00	1.00
2020	33.73	1813.84	1259.52	72.61	120.28	6.24	0.114	1.00	1.00
3140	35.93	2279.60	692.08	89.05	143.96	6.82	0.011	1.00	1.00
3680	4.64	692.08	613.36	104.09	165.17	7.29	0.051	1.00	1.00
3800	12.39	2509.20	2102.50	49.88	86.40	5.31	0.06	1.00	1.00
3850	15.60	2558.40	1574.40	42.96	75.76	4.98	0.118	1.00	1.00
3940	19.66	2010.64	898.72	54.10	92.82	5.50	0.113	1.00	1.00
3950	17.29	2532.16	1466.16	43.12	76.00	4.98	0.141	1.00	1.00
3951	15.78	2112.32	1466.16	112.70	177.16	7.55	0.134	1.00	1.00
3970	33.13	898.72	613.36	167.88	251.66	8.96	0.04	1.00	1.00
4300	5.14	1416.96	957.76	68.44	114.16	6.08	0.054	1.00	1.00
4440	2.03	957.76	898.72	134.12	206.50	8.13	0.07	1.00	1.00
4530	11.24	2525.60	2361.60	39.29	70.02	4.79	0.07	1.00	1.00
4531	20.08	2656.80	2361.60	60.10	101.82	5.75	0.054	1.00	1.00
4532	9.20	2361.60	2112.32	82.36	134.39	6.59	0.141	1.00	1.00
4720	15.90	2696.16	2276.32	53.54	91.96	5.47	0.119	1.00	1.00
4750	3.99	2276.32	2095.92	58.06	98.77	5.67	0.2	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Appalachian Plateaus Physiographic Province—Continued									
4760	6.89	2558.40	2099.20	47.69	83.05	5.20	0.132	1.00	1.00
8350	29.80	1908.96	888.88	111.61	175.64	7.51	0.324	1.00	1.00
8440	2.64	1249.68	1190.64	114.03	179.00	7.58	0.398	1.00	1.00
8580	28.73	2610.88	1262.80	65.49	109.82	5.97	0.391	1.00	1.00
8590	22.87	1718.72	1259.52	79.68	130.53	6.50	0.384	1.00	1.00
8730	17.50	2446.88	1459.60	49.49	85.81	5.29	0.295	1.00	1.00
Valley and Ridge Physiographic Province									
970	23.33	905.28	528.08	114.03	184.78	7.45	0.13	1.00	1.00
980	21.47	564.16	528.08	673.45	803.53	18.67	0.14	1.00	1.00
1120	9.45	528.08	518.24	690.38	820.21	18.91	0.01	1.00	1.00
1140	31.30	518.24	478.88	702.00	831.62	19.07	0.02	1.00	1.00
1280	11.57	554.32	449.36	120.44	193.33	7.67	0.04	1.00	1.00
1290	27.43	1157.84	626.48	56.81	103.80	5.20	0.24	1.00	1.00
1300	9.24	488.72	469.04	535.99	665.18	16.59	0.06	1.00	1.00
1310	5.15	626.48	554.32	100.00	165.75	6.96	0.01	1.00	1.00
1320	7.53	501.84	488.72	510.64	639.04	16.18	0.01	1.00	1.00
1340	12.66	514.96	501.84	495.76	623.58	15.93	0.01	1.00	1.00
1410	15.71	469.04	439.52	551.36	680.93	16.83	0.01	1.00	1.00
1420	16.62	478.88	449.36	710.89	840.33	19.20	0.10	1.00	1.00
1440	9.03	536.28	521.52	432.86	557.35	14.85	0.01	1.00	1.00
1450	7.85	731.44	501.84	40.91	79.10	4.39	0.03	1.00	1.00
1460	8.45	439.52	429.68	556.38	686.06	16.91	0.04	1.00	1.00
1470	5.33	521.52	514.96	487.87	615.36	15.80	0.02	1.00	1.00
1480	26.26	1590.80	626.48	45.26	86.00	4.62	0.35	1.00	1.00
1500	10.12	626.48	478.88	78.59	135.79	6.15	0.19	1.00	1.00
1510	17.95	501.84	426.40	62.14	111.80	5.44	0.05	1.00	1.00
1530	13.04	437.88	419.84	737.50	866.28	19.56	0.08	1.00	1.00
1550	41.10	1702.32	447.72	73.33	128.22	5.93	0.02	1.00	1.00
1560	28.04	1508.80	439.52	38.18	74.71	4.23	0.02	1.00	1.00
1570	28.03	1748.24	429.68	68.27	120.85	5.72	0.03	1.00	1.00
1580	10.05	596.96	536.28	174.98	263.38	9.30	0.04	1.00	1.00
1590	1.94	449.36	447.72	724.82	853.93	19.39	0.02	1.00	1.00
1600	10.73	747.84	596.96	78.03	134.99	6.12	0.04	1.00	1.00
1610	6.48	444.44	437.88	734.68	863.53	19.53	0.03	1.00	1.00
1620	3.91	447.72	444.44	730.41	859.38	19.47	0.20	1.00	1.00
1630	23.00	1164.40	444.44	54.57	100.40	5.09	0.11	1.00	1.00
1640	3.95	429.68	426.40	563.55	693.37	17.02	0.02	1.00	1.00
1660	2.27	610.08	596.96	120.53	193.46	7.67	0.01	1.00	1.00
1670	50.92	1203.76	405.08	74.46	129.86	5.98	0.05	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Valley and Ridge Physiographic Province—Continued									
1680	5.23	426.40	419.84	569.17	699.09	17.11	0.02	1.00	1.00
1700	19.45	603.52	416.56	69.15	122.15	5.75	0.02	1.00	1.00
1710	58.46	1672.80	511.68	106.41	174.50	7.19	0.02	1.00	1.00
1730	16.38	1239.84	603.52	42.20	81.17	4.46	0.07	1.00	1.00
1740	19.07	511.68	419.84	119.03	191.47	7.62	0.02	1.00	1.00
1760	4.00	419.84	416.56	954.44	1072.37	22.36	0.04	1.00	1.00
1770	28.54	1357.92	715.04	64.18	114.83	5.54	0.03	1.00	1.00
1780	8.46	416.56	405.08	958.95	1076.56	22.41	0.02	1.00	1.00
1790	33.94	724.88	419.84	78.79	136.08	6.16	0.03	1.00	1.00
1810	39.83	924.96	387.04	76.35	132.58	6.06	0.04	1.00	1.00
1830	5.62	823.28	715.04	71.59	125.69	5.86	0.15	1.00	1.00
1840	1.57	419.84	405.08	146.30	227.11	8.48	0.02	1.00	1.00
1850	12.24	649.44	498.56	63.27	113.48	5.50	0.04	1.00	1.00
1880	13.84	405.08	387.04	982.21	1098.12	22.69	0.01	1.00	1.00
1890	7.24	944.64	823.28	53.31	98.49	5.03	0.23	1.00	1.00
1900	28.16	1174.24	439.52	82.71	141.65	6.31	0.04	1.00	1.00
1910	9.73	1154.56	944.64	43.63	83.44	4.53	0.05	1.00	1.00
1930	15.81	439.52	410.00	351.81	469.47	13.34	0.04	1.00	1.00
1960	37.93	783.92	372.28	63.40	113.68	5.50	0.07	1.00	1.00
1970	20.71	410.00	370.64	379.52	499.88	13.88	0.02	1.00	1.00
1980	7.56	760.96	659.28	113.08	183.51	7.42	0.03	1.00	1.00
1990	10.66	498.56	446.08	77.04	133.57	6.08	0.03	1.00	1.00
2000	23.16	547.76	426.40	58.20	105.91	5.26	0.04	1.00	1.00
2010	3.55	596.96	583.84	199.86	294.01	9.96	0.06	1.00	1.00
2030	8.21	387.04	372.28	987.65	1103.16	22.75	0.01	1.00	1.00
2040	28.92	1374.32	760.96	89.29	150.91	6.57	0.06	1.00	1.00
2050	14.74	334.56	293.56	1093.02	1199.70	23.98	0.02	1.00	1.00
2070	6.74	446.08	426.40	82.93	141.96	6.32	0.02	1.00	1.00
2080	15.71	372.28	334.56	993.92	1108.95	22.83	0.03	1.00	1.00
2090	8.41	426.40	387.04	109.85	179.15	7.31	0.02	1.00	1.00
2100	5.49	387.04	350.96	113.24	183.72	7.43	0.01	1.00	1.00
2110	24.84	1236.56	465.76	38.43	75.12	4.25	0.03	1.00	1.00
2120	34.88	528.08	439.52	329.56	444.77	12.90	0.03	1.00	1.00
2130	16.13	370.64	334.56	389.23	510.43	14.06	0.07	1.00	1.00
2140	6.50	350.96	334.56	135.93	213.70	8.16	0.03	1.00	1.00
2150	27.70	888.88	370.64	49.60	92.77	4.85	0.04	1.00	1.00
2160	43.45	885.60	465.76	87.73	148.74	6.51	0.02	1.00	1.00
2170	1.46	465.76	410.00	99.56	165.16	6.95	0.02	1.00	1.00
2210	7.28	583.84	551.04	292.28	402.70	12.12	0.06	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Valley and Ridge Physiographic Province—Continued									
2220	3.83	367.36	350.96	50.96	94.87	4.91	0.07	1.00	1.00
2230	18.47	839.68	665.84	122.17	195.63	7.72	0.04	1.00	1.00
2250	35.30	1341.52	839.68	103.30	170.27	7.08	0.05	1.00	1.00
2260	13.61	429.68	334.56	94.39	158.02	6.76	0.02	1.00	1.00
2280	27.19	1193.92	596.96	49.21	92.16	4.83	0.08	1.00	1.00
2290	43.44	931.52	429.68	86.26	146.67	6.45	0.02	1.00	1.00
2320	7.18	551.04	528.08	296.14	407.09	12.21	0.10	1.00	1.00
2330	15.32	354.24	293.56	139.07	217.78	8.26	0.12	1.00	1.00
2340	5.08	596.96	583.84	196.74	290.20	9.88	0.17	1.00	1.00
2370	49.79	537.92	354.24	130.80	207.00	8.00	0.05	1.00	1.00
2400	49.57	1026.64	308.32	88.12	149.28	6.52	0.12	1.00	1.00
2450	11.60	596.96	528.08	109.60	178.82	7.30	0.03	1.00	1.00
2500	6.00	619.92	596.96	88.46	149.75	6.53	0.06	1.00	1.00
2510	42.83	793.76	436.24	84.44	144.10	6.38	0.09	1.00	1.00
2530	30.62	1833.52	1131.60	78.06	135.02	6.13	0.01	1.00	1.00
2540	31.82	1223.44	537.92	60.74	109.71	5.38	0.04	1.00	1.00
2570	16.12	1338.24	859.36	57.19	104.38	5.22	0.03	1.00	1.00
2580	37.53	1302.16	619.92	85.62	145.77	6.43	0.07	1.00	1.00
2660	9.51	859.36	800.32	172.12	259.80	9.22	0.05	1.00	1.00
2670	13.32	1249.68	537.92	38.45	75.14	4.25	0.04	1.00	1.00
2740	30.69	1085.68	859.36	156.34	239.93	8.77	0.03	1.00	1.00
2790	51.21	1315.28	436.24	101.50	167.81	7.02	0.04	1.00	1.00
2820	4.24	1131.60	1085.68	83.92	143.37	6.36	0.02	1.00	1.00
2840	45.60	1033.20	439.52	74.87	130.44	5.99	0.03	1.00	1.00
2900	33.06	1866.32	1085.68	75.48	131.32	6.02	0.02	1.00	1.00
3000	15.03	1334.96	557.60	56.34	103.09	5.18	0.08	1.00	1.00
3030	25.78	774.08	383.76	62.67	112.59	5.47	0.13	1.00	1.00
3080	9.42	439.52	370.64	87.62	148.58	6.50	0.06	1.00	1.00
3090	34.32	557.60	328.00	101.51	167.83	7.02	0.04	1.00	1.00
3100	28.27	1075.84	419.84	59.79	108.29	5.34	0.13	1.00	1.00
3170	17.57	1295.60	780.64	42.31	81.33	4.46	0.03	1.00	1.00
3180	17.10	1200.48	800.32	46.93	88.63	4.71	0.18	1.00	1.00
3290	9.57	436.24	396.88	138.82	217.45	8.25	0.10	1.00	1.00
3370	27.59	800.32	501.84	74.43	129.81	5.98	0.04	1.00	1.00
3390	15.79	396.88	329.64	148.30	229.66	8.54	0.02	1.00	1.00
3440	5.66	383.76	375.56	434.81	559.43	14.89	0.05	1.00	1.00
3530	1.59	387.04	383.76	427.47	551.60	14.76	0.07	1.00	1.00
3580	10.79	780.64	593.68	56.69	103.63	5.19	0.03	1.00	1.00
3590	2.62	375.56	370.64	442.92	568.05	15.03	0.05	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Valley and Ridge Physiographic Province—Continued									
3600	17.17	362.44	329.64	473.25	600.06	15.55	0.05	1.00	1.00
3610	10.76	410.00	387.04	426.52	550.59	14.74	0.09	1.00	1.00
3630	39.11	980.72	375.56	71.28	125.25	5.84	0.04	1.00	1.00
3640	5.58	370.64	362.44	455.56	581.44	15.25	0.03	1.00	1.00
3690	3.85	419.84	410.00	383.86	504.60	13.96	0.07	1.00	1.00
3730	9.14	329.64	318.16	502.77	630.88	16.05	0.04	1.00	1.00
3750	20.25	318.16	282.08	522.75	651.56	16.38	0.05	1.00	1.00
3770	54.96	1095.52	362.44	100.34	166.22	6.97	0.07	1.00	1.00
3780	10.49	593.68	554.32	200.62	294.93	9.98	0.01	1.00	1.00
3860	37.95	665.84	410.00	163.44	248.91	8.98	0.10	1.00	1.00
3870	25.08	478.88	419.84	376.04	496.08	13.81	0.10	1.00	1.00
3890	2.28	613.36	603.52	186.99	278.25	9.62	0.05	1.00	1.00
3900	10.05	390.32	318.16	113.30	183.80	7.43	0.05	1.00	1.00
3930	10.10	554.32	518.24	235.19	336.41	10.84	0.03	1.00	1.00
3990	2.04	603.52	593.68	187.30	278.63	9.63	0.03	1.00	1.00
4000	15.46	393.60	213.20	64.57	115.40	5.55	0.12	1.00	1.00
4020	6.08	501.84	478.88	369.18	488.57	13.68	0.09	1.00	1.00
4050	4.99	328.00	272.24	103.60	170.67	7.09	0.22	1.00	1.00
4080	3.69	282.08	272.24	523.21	652.03	16.38	0.04	1.00	1.00
4150	10.54	244.36	213.20	668.86	798.99	18.60	0.25	1.00	1.00
4160	13.32	665.84	554.32	101.84	168.28	7.03	0.24	1.00	1.00
4170	3.66	518.24	501.84	350.63	468.16	13.32	0.03	1.00	1.00
4180	10.10	272.24	244.36	539.01	668.29	16.64	0.05	1.00	1.00
4210	13.98	583.84	518.24	247.94	351.43	11.13	0.07	1.00	1.00
4220	27.30	501.84	390.32	100.99	167.11	7.00	0.07	1.00	1.00
4280	75.02	2066.40	665.84	125.25	199.70	7.82	0.12	1.00	1.00
4310	49.89	800.32	583.84	246.19	349.38	11.09	0.03	1.00	1.00
4340	52.35	1866.32	665.84	86.08	146.42	6.44	0.09	1.00	1.00
4360	35.85	1148.00	665.84	88.80	150.23	6.55	0.01	1.00	1.00
4370	5.29	282.08	244.36	365.67	484.73	13.61	0.16	1.00	1.00
4380	56.87	446.08	282.08	364.24	483.16	13.59	0.10	1.00	1.00
4730	17.30	728.16	501.84	43.79	83.68	4.54	0.06	1.00	1.00
4790	25.44	1659.68	718.32	59.08	107.22	5.30	0.09	1.00	1.00
4830	11.54	718.32	495.28	74.49	129.90	5.98	0.04	1.00	1.00
4860	21.19	810.16	393.60	64.76	115.69	5.56	0.09	1.00	1.00
5050	18.54	1023.36	800.32	189.85	281.77	9.70	0.01	1.00	1.00
5080	8.98	495.28	446.08	204.46	299.59	10.08	0.07	1.00	1.00
5100	62.51	849.52	495.28	174.86	263.22	9.30	0.13	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Valley and Ridge Physiographic Province—Continued									
5190	46.13	1567.84	800.32	103.18	170.11	7.08	0.06	1.00	1.00
5200	3.98	459.20	446.08	264.57	370.83	11.52	0.09	1.00	1.00
5210	21.19	1535.04	1023.36	108.55	177.40	7.26	0.13	1.00	1.00
5240	54.05	744.56	459.20	261.37	367.12	11.44	0.06	1.00	1.00
5380	21.63	1430.08	1023.36	111.30	181.10	7.36	0.09	1.00	1.00
5520	20.94	3709.68	1535.04	47.49	89.49	4.74	0.26	1.00	1.00
5550	23.48	2128.72	1059.44	86.87	147.53	6.47	0.03	1.00	1.00
5560	23.79	1059.44	849.52	139.69	218.57	8.28	0.02	1.00	1.00
5620	16.26	1718.72	1430.08	99.04	164.43	6.93	0.07	1.00	1.00
5700	35.13	3073.36	1535.04	78.01	134.95	6.12	0.03	1.00	1.00
5820	11.94	2571.52	1430.08	24.55	51.83	3.37	0.12	1.00	1.00
5840	46.87	1016.80	744.56	238.01	339.74	10.90	0.07	1.00	1.00
5990	33.77	2870.00	1128.32	109.51	178.70	7.30	0.16	1.00	1.00
6050	13.39	1902.40	1567.84	62.19	111.88	5.45	0.04	1.00	1.00
6080	18.33	2574.80	1718.72	79.98	137.77	6.20	0.03	1.00	1.00
6150	4.10	1334.96	1243.12	18.06	40.21	2.87	0.04	1.00	1.00
6160	8.26	1243.12	1128.32	37.65	73.84	4.20	0.01	1.00	1.00
6161	2.23	1128.32	1115.20	118.82	191.18	7.61	0.14	1.00	1.00
6230	4.98	1056.16	1036.48	180.48	270.21	9.45	0.05	1.00	1.00
6280	8.83	1115.20	1056.16	126.10	200.83	7.85	0.06	1.00	1.00
6290	20.74	3161.92	2154.96	44.52	84.84	4.58	0.23	1.00	1.00
6300	25.26	2581.36	1610.48	61.53	110.89	5.42	0.27	1.00	1.00
6340	19.86	2243.52	1610.48	50.40	94.01	4.89	0.01	1.00	1.00
6360	4.29	1036.48	1016.80	208.86	304.92	10.19	0.003	1.00	1.00
6380	41.14	2732.24	1643.28	74.70	130.20	5.99	0.16	1.00	1.00
6410	39.83	2889.68	1426.80	70.33	123.87	5.80	0.09	1.00	1.00
6420	8.08	1138.16	1036.48	92.32	155.15	6.68	0.03	1.00	1.00
6460	66.55	1840.08	1056.16	118.52	190.78	7.60	0.08	1.00	1.00
6490	12.84	1259.52	1138.16	87.43	148.32	6.50	0.02	1.00	1.00
6590	5.64	2154.96	1938.48	50.91	94.79	4.91	0.09	1.00	1.00
6600	12.18	1938.48	1705.60	68.36	120.99	5.72	0.15	1.00	1.00
6640	10.33	1426.80	1108.64	110.66	180.25	7.34	0.11	1.00	1.00
6650	59.08	1610.48	1026.64	133.04	209.93	8.07	0.09	1.00	1.00
6660	5.17	1298.88	1259.52	72.19	126.57	5.88	0.02	1.00	1.00
6730	24.55	1679.36	1298.88	66.44	118.16	5.64	0.03	1.00	1.00
6790	22.78	1108.64	875.76	142.55	222.28	8.36	0.13	1.00	1.00
6810	5.13	1705.60	1630.16	70.30	123.81	5.80	0.29	1.00	1.00
6880	27.63	2315.68	875.76	64.05	114.64	5.53	0.23	1.00	1.00
6940	23.25	2551.84	606.80	56.23	102.93	5.17	0.05	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Valley and Ridge Physiographic Province—Continued									
6950	17.56	1416.96	1252.96	129.83	205.73	7.97	0.11	1.00	1.00
7000	17.85	1190.64	1026.64	190.35	282.38	9.71	0.03	1.00	1.00
7080	16.59	2604.32	652.72	39.16	76.30	4.29	0.05	1.00	1.00
7140	33.04	2253.36	1252.96	77.24	133.86	6.09	0.07	1.00	1.00
7180	23.27	1902.40	738.00	68.28	120.87	5.72	0.31	1.00	1.00
7190	5.98	652.72	639.60	48.59	91.21	4.79	0.09	1.00	1.00
7200	4.19	606.80	554.32	60.34	109.11	5.36	0.07	1.00	1.00
7260	12.37	875.76	738.00	164.66	250.44	9.01	0.19	1.00	1.00
7300	16.34	1026.64	947.92	245.53	348.60	11.08	0.25	1.00	1.00
7330	4.91	1252.96	1190.64	155.68	239.09	8.75	0.14	1.00	1.00
7360	6.45	1292.32	1190.64	79.01	136.39	6.16	0.17	1.00	1.00
7380	5.07	738.00	678.96	182.65	272.89	9.51	0.03	1.00	1.00
7400	12.64	993.84	947.92	118.20	190.35	7.59	0.19	1.00	1.00
7420	24.56	813.44	678.96	307.58	420.07	12.45	0.13	1.00	1.00
7450	42.12	2417.36	1292.32	73.97	129.15	5.96	0.14	1.00	1.00
7490	34.80	1243.12	993.84	110.64	180.22	7.34	0.26	1.00	1.00
7500	18.66	879.04	813.44	296.96	408.02	12.22	0.20	1.00	1.00
7510	5.52	947.92	879.04	279.08	387.58	11.84	0.24	1.00	1.00
7560	23.85	1302.16	879.04	63.10	113.23	5.49	0.06	1.00	1.00
7630	32.47	2476.40	1243.12	59.90	108.45	5.34	0.11	1.00	1.00
7690	31.17	2036.88	1243.12	62.08	111.71	5.44	0.14	1.00	1.00
7740	6.88	918.40	849.52	140.05	219.04	8.29	0.27	1.00	1.00
7750	17.85	1836.80	1302.16	32.87	66.00	3.92	0.06	1.00	1.00
7820	42.34	1735.12	1577.68	367.40	486.62	13.65	0.16	1.00	1.00
7880	18.02	2919.20	1558.00	38.99	76.02	4.28	0.28	1.00	1.00
7900	14.48	1066.00	918.40	119.27	191.78	7.63	0.04	1.00	1.00
7960	5.35	1577.68	1558.00	387.35	508.39	14.02	0.33	1.00	1.00
8020	10.82	1377.60	1193.92	96.38	160.77	6.83	0.05	1.00	1.00
8030	3.18	1574.40	1495.68	41.74	80.44	4.43	0.16	1.00	1.00
8050	8.41	1558.00	1518.64	391.76	513.18	14.11	0.09	1.00	1.00
8051	6.50	1518.64	1495.68	409.81	532.67	14.44	0.08	1.00	1.00
8130	7.79	1193.92	1066.00	101.71	168.09	7.02	0.14	1.00	1.00
8170	8.16	1587.52	1577.68	107.63	176.15	7.23	0.30	1.00	1.00
8180	4.31	1597.36	1518.64	93.23	156.41	6.71	0.10	1.00	1.00
8210	48.16	2338.64	1597.36	89.87	151.73	6.59	0.07	1.00	1.00
8280	17.89	2624.00	1377.60	60.34	109.11	5.36	0.06	1.00	1.00
8290	54.54	2414.08	1682.64	101.16	167.34	7.00	0.18	1.00	1.00
8420	64.97	2679.76	1876.16	107.64	176.16	7.23	0.25	1.00	1.00
8430	6.85	1876.16	1735.12	114.69	185.66	7.47	0.05	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Valley and Ridge Physiographic Province—Continued									
8480	40.56	2479.68	1876.16	90.27	152.29	6.60	0.26	1.00	1.00
8570	40.85	2397.68	1876.16	65.66	117.02	5.60	0.05	1.00	1.00
8600	39.87	2463.28	1945.04	97.02	161.65	6.85	0.28	1.00	1.00
8640	7.03	1869.60	1859.76	279.52	388.09	11.85	0.30	1.00	1.00
8650	42.87	2489.52	1712.16	89.48	151.18	6.57	0.14	1.00	1.00
8680	22.40	1876.16	1531.76	143.19	223.10	8.38	0.08	1.00	1.00
8690	47.95	2781.44	1859.76	100.79	166.83	6.99	0.16	1.00	1.00
8700	7.07	1945.04	1869.60	99.90	165.62	6.96	0.27	1.00	1.00
8740	29.64	2833.92	1859.76	52.96	97.94	5.01	0.14	1.00	1.00
8760	13.38	1928.64	1869.60	254.33	358.91	11.28	0.08	1.00	1.00
8790	42.83	2479.68	1820.40	86.19	146.56	6.45	0.08	1.00	1.00
8800	70.64	1712.16	1200.48	149.31	230.96	8.57	0.14	1.00	1.00
8810	24.74	1531.76	1374.32	162.31	247.49	8.94	0.28	1.00	1.00
8820	33.32	2968.40	1928.64	69.67	122.91	5.78	0.27	1.00	1.00
8860	29.87	2266.48	1374.32	58.55	106.43	5.28	0.38	1.00	1.00
8870	30.32	2214.00	1928.64	236.48	337.94	10.87	0.20	1.00	1.00
8880	44.25	2358.32	1357.92	84.63	144.37	6.39	0.09	1.00	1.00
8950	14.83	2492.80	2109.04	50.66	94.41	4.90	0.05	1.00	1.00
8960	23.22	2860.16	2214.00	53.24	98.37	5.03	0.28	1.00	1.00
8970	42.35	1941.76	1230.00	68.15	120.69	5.71	0.18	1.00	1.00
9000	33.35	1374.32	1230.00	199.68	293.79	9.96	0.35	1.00	1.00
9010	42.62	2276.32	1200.48	56.73	103.69	5.19	0.13	1.00	1.00
9030	18.65	3522.72	2476.40	50.59	94.31	4.90	0.05	1.00	1.00
9040	18.67	2109.04	1813.84	70.28	123.79	5.80	0.09	1.00	1.00
9050	10.96	2266.48	2214.00	204.13	299.19	10.07	0.09	1.00	1.00
9060	14.79	2020.48	1357.92	54.92	100.94	5.11	0.08	1.00	1.00
9070	11.23	1820.40	1735.12	93.83	157.24	6.74	0.15	1.00	1.00
9080	26.16	2476.40	2266.48	187.43	278.79	9.64	0.11	1.00	1.00
9100	20.57	2407.52	1918.80	57.93	105.49	5.25	0.32	1.00	1.00
9130	8.91	2535.44	2476.40	162.86	248.18	8.96	0.165	1.00	1.00
9150	28.35	2945.44	2266.48	65.09	116.18	5.58	0.314	1.00	1.00
9170	18.45	2630.56	2535.44	102.97	169.82	7.07	0.182	1.00	1.00
9180	5.27	1813.84	1735.12	109.24	178.33	7.29	0.217	1.00	1.00
9190	13.09	3421.04	2630.56	42.55	81.72	4.48	0.187	1.00	1.00
9200	2.92	1918.80	1813.84	75.58	131.46	6.02	0.165	1.00	1.00
9220	20.23	2066.40	1922.08	42.75	82.03	4.49	0.251	1.00	1.00
9230	12.28	1357.92	1354.64	108.51	177.34	7.26	0.162	1.00	1.00
9240	25.16	2669.92	2535.44	110.44	179.94	7.33	0.176	1.00	1.00
9250	25.05	3427.60	2630.56	71.18	125.11	5.84	0.284	1.00	1.00
9310	44.35	3043.84	2669.92	84.62	144.36	6.39	0.262	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Piedmont Physiographic Province									
2180	11.12	469.04	367.36	47.45	85.16	6.49	0.114	1.00	1.00
2190	24.03	560.88	331.28	65.47	115.38	7.76	0.061	1.00	1.00
2200	27.88	711.76	331.28	65.52	115.45	7.77	0.061	1.00	1.00
2240	17.16	334.56	277.16	131.33	222.46	11.45	0.03	1.00	1.00
2270	5.38	293.56	287.00	834.72	1272.82	32.12	0.032	1.00	1.00
2300	25.94	665.84	226.32	62.14	109.83	7.54	0.046	1.00	1.00
2310	5.11	277.16	255.84	849.97	1294.75	32.45	0.058	1.00	1.00
2350	8.20	331.28	262.40	98.50	169.59	9.75	0.093	1.00	1.00
2380	11.13	287.00	277.16	838.89	1278.82	32.21	0.023	1.00	1.00
2390	23.89	577.28	239.44	41.75	75.48	6.04	0.125	1.00	1.00
2410	33.96	492.00	170.56	68.79	120.89	7.98	0.087	1.00	1.00
2420	13.46	239.44	170.56	119.71	203.84	10.87	0.105	1.00	1.00
2430	7.11	255.84	241.08	859.21	1308.01	32.64	0.027	1.00	1.00
2440	3.48	308.32	287.00	81.92	142.53	8.80	0.036	1.00	1.00
2460	75.46	934.80	255.84	124.68	211.82	11.12	0.059	1.00	1.00
2470	6.97	262.40	239.44	100.17	172.31	9.84	0.066	1.00	1.00
2480	42.81	570.72	9.84	80.03	139.43	8.68	0.081	1.00	1.00
2490	6.64	241.08	226.32	864.13	1315.07	32.75	0.145	1.00	1.00
2550	14.51	370.64	241.08	91.81	158.72	9.38	0.102	1.00	1.00
2650	22.73	482.16	75.44	40.58	73.48	5.95	0.045	1.00	1.00
2730	2.30	387.04	370.64	82.04	142.73	8.81	0.024	1.00	1.00
2750	25.84	662.56	98.40	65.07	114.71	7.74	0.059	1.00	1.00
2760	8.92	439.65	387.16	53.95	96.12	6.97	0.08	1.00	1.00
2770	15.21	669.12	387.04	59.85	106.00	7.38	0.039	1.00	1.00
2810	12.42	357.52	0.00	41.56	75.16	6.03	0.047	1.00	1.00
2830	6.83	514.96	439.52	47.68	85.56	6.51	0.031	1.00	1.00
2860	31.83	1049.60	373.92	72.59	127.17	8.22	0.034	1.00	1.00
2910	23.26	797.04	278.80	53.85	95.96	6.96	0.065	1.00	1.00
3020	12.52	514.96	298.48	69.80	122.55	8.05	0.042	1.00	1.00
3040	9.58	373.92	364.08	98.33	169.31	9.74	0.012	1.00	1.00
3060	22.05	278.80	29.52	72.25	126.60	8.20	0.021	1.00	1.00
3120	27.57	728.16	367.36	57.51	102.09	7.22	0.026	1.00	1.00
3240	13.30	616.64	226.32	32.98	60.42	5.30	0.051	1.00	1.00
3320	4.76	298.48	255.84	75.60	132.13	8.41	0.042	1.00	1.00
3330	10.97	226.32	0.00	50.07	89.59	6.69	0.036	1.00	1.00
3340	22.77	364.08	239.44	147.74	248.57	12.23	0.052	1.00	1.00
3350	14.98	639.60	328.00	43.02	77.63	6.14	0.027	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Piedmont Physiographic Province—Continued									
3400	1.60	367.36	364.08	76.67	133.90	8.48	0.053	1.00	1.00
3450	18.91	587.12	367.36	50.64	90.55	6.73	0.019	1.00	1.00
3481	13.34	170.56	0.00	111.09	189.97	10.43	0.074	1.00	1.00
3490	4.08	328.00	262.40	51.32	91.70	6.78	0.032	1.00	1.00
3510	19.79	1249.68	393.60	45.55	81.93	6.34	0.214	1.00	1.00
3650	5.36	259.12	16.40	42.43	76.63	6.10	0.047	1.00	1.00
3660	9.91	518.24	357.52	31.82	58.42	5.19	0.03	1.00	1.00
3710	20.16	649.44	239.44	52.33	93.39	6.85	0.093	1.00	1.00
3880	9.49	318.16	265.68	93.00	160.65	9.44	0.031	1.00	1.00
3910	12.22	357.52	3.28	44.85	80.75	6.29	0.054	1.00	1.00
4040	18.22	239.44	195.16	170.36	284.33	13.24	0.078	1.00	1.00
4060	18.71	265.68	0.00	105.53	180.99	10.13	0.109	1.00	1.00
4090	17.13	446.08	173.84	54.71	97.41	7.02	0.045	1.00	1.00
4130	6.99	488.72	380.48	32.83	60.16	5.28	0.033	1.00	1.00
4200	7.82	208.28	195.16	531.78	831.94	24.98	0.021	1.00	1.00
4250	18.76	501.84	216.48	55.91	99.42	7.11	0.065	1.00	1.00
4290	2.73	213.20	208.28	528.15	826.57	24.88	0.038	1.00	1.00
4410	12.68	195.16	185.32	559.49	872.76	25.70	0.042	1.00	1.00
4430	28.32	675.68	208.28	53.33	95.08	6.92	0.145	1.00	1.00
4460	22.32	446.08	154.16	43.89	79.13	6.21	0.03	1.00	1.00
4500	5.73	216.48	180.40	62.92	111.13	7.59	0.023	1.00	1.00
4580	19.79	180.40	42.64	579.54	902.22	26.21	0.139	1.00	1.00
4620	9.33	185.32	180.40	572.60	892.03	26.03	0.004	1.00	1.00
4640	9.27	295.20	42.64	28.29	52.29	4.86	0.174	1.00	1.00
4660	11.95	252.56	185.32	108.08	185.11	10.27	0.116	1.00	1.00
4670	17.72	393.60	252.56	100.27	172.46	9.85	0.089	1.00	1.00
4780	9.17	154.16	6.56	48.75	87.36	6.59	0.148	1.00	1.00
4820	3.40	42.64	9.84	580.46	903.58	26.23	0.138	1.00	1.00
4970	31.55	357.52	121.36	77.01	134.46	8.50	0.029	1.00	1.00
5000	8.73	282.08	36.08	32.88	60.26	5.29	0.046	1.00	1.00
5010	8.00	308.32	193.52	27.33	50.61	4.77	0.045	1.00	1.00
5130	13.81	193.52	6.56	39.50	71.63	5.86	0.02	1.00	1.00
5140	15.99	232.88	147.60	65.01	114.61	7.73	0.015	1.00	1.00
5220	42.33	980.72	268.96	88.24	152.88	9.17	0.06	1.00	1.00
5360	12.90	147.60	121.36	104.80	179.81	10.09	0.063	1.00	1.00
5370	20.76	606.80	209.92	53.52	95.39	6.94	0.018	1.00	1.00
5470	16.84	209.92	147.60	77.29	134.92	8.52	0.022	1.00	1.00
5500	29.95	2030.32	321.44	69.20	121.56	8.01	0.113	1.00	1.00
5610	13.63	321.44	268.96	103.01	176.91	10.00	0.064	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Piedmont Physiographic Province—Continued									
5640	25.57	268.96	108.24	160.89	269.40	12.82	0.182	1.00	1.00
5690	2.69	170.56	68.88	41.51	75.07	6.02	0.136	1.00	1.00
5730	10.29	295.20	170.56	32.76	60.04	5.28	0.043	1.00	1.00
5810	31.47	1636.72	321.44	61.88	109.40	7.52	0.114	1.00	1.00
5940	32.15	2578.08	285.36	74.00	129.50	8.31	0.062	1.00	1.00
6030	11.68	108.24	52.48	217.99	358.76	15.19	0.131	1.00	1.00
6040	30.87	259.12	108.24	144.39	243.27	12.07	0.139	1.00	1.00
6090	23.15	2519.04	436.24	59.27	105.04	7.34	0.038	1.00	1.00
6120	41.38	380.48	88.56	88.42	153.18	9.18	0.004	1.00	1.00
6170	9.37	285.36	259.12	118.74	202.29	10.82	0.037	1.00	1.00
6200	1.73	285.36	283.72	76.96	134.37	8.50	0.01	1.00	1.00
6220	23.65	436.24	285.36	86.43	149.92	9.07	0.102	1.00	1.00
6240	24.92	908.56	321.44	73.48	128.64	8.28	0.052	1.00	1.00
6330	28.64	216.48	75.44	118.25	201.50	10.80	0.068	1.00	1.00
6440	7.66	426.53	393.72	80.94	140.92	8.74	0.138	1.00	1.00
6470	76.12	488.72	108.24	109.24	186.98	10.33	0.117	1.00	1.00
6520	26.83	321.44	268.96	144.92	244.10	12.09	0.071	1.00	1.00
6560	17.01	675.68	426.40	54.07	96.32	6.98	0.222	1.00	1.00
6570	28.89	324.72	98.40	57.22	101.61	7.20	0.051	1.00	1.00
6680	8.49	98.40	62.32	60.21	106.61	7.41	0.023	1.00	1.00
6690	11.31	108.24	62.32	118.62	202.08	10.82	0.116	1.00	1.00
6710	14.00	268.96	173.84	151.83	255.07	12.41	0.061	1.00	1.00
6740	8.47	173.84	160.72	418.55	663.76	21.86	0.138	1.00	1.00
6760	25.37	921.68	354.24	59.51	105.44	7.36	0.052	1.00	1.00
6770	12.77	1062.72	580.56	53.47	95.31	6.93	0.064	1.00	1.00
6800	36.43	147.60	101.68	444.76	702.90	22.61	0.013	1.00	1.00
6850	24.09	580.56	295.20	86.76	150.47	9.08	0.052	1.00	1.00
6890	13.13	295.20	265.68	367.17	586.63	20.32	0.089	1.00	1.00
6910	8.86	354.24	229.60	64.91	114.44	7.73	0.062	1.00	1.00
6960	5.20	229.60	196.80	374.60	597.82	20.54	0.123	1.00	1.00
6970	13.54	196.80	173.84	386.19	615.26	20.90	0.027	1.00	1.00
6990	7.75	265.68	229.60	368.05	587.96	20.34	0.054	1.00	1.00
7020	51.11	574.00	160.72	91.93	158.90	9.38	0.032	1.00	1.00
7030	8.21	157.44	147.60	430.23	681.22	22.19	0.042	1.00	1.00
7070	8.85	101.68	9.84	445.93	704.65	22.64	0.022	1.00	1.00
7090	7.89	416.56	331.28	112.39	192.07	10.50	0.318	1.00	1.00
7100	2.00	160.72	157.44	428.19	678.18	22.13	0.051	1.00	1.00
7110	37.54	659.28	305.04	83.00	144.31	8.86	0.037	1.00	1.00
7120	3.25	305.04	196.80	86.36	149.81	9.06	0.044	1.00	1.00
7150	20.17	331.28	295.20	353.37	565.81	19.89	0.031	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Piedmont Physiographic Province—Continued									
7160	17.48	678.96	577.28	310.16	500.32	18.49	0.099	1.00	1.00
7170	18.82	331.28	147.60	49.87	89.26	6.67	0.079	1.00	1.00
7240	32.83	2738.80	436.24	66.75	117.50	7.85	0.112	1.00	1.00
7250	7.74	554.32	416.56	77.80	135.76	8.55	0.107	1.00	1.00
7280	44.29	301.76	206.64	147.56	248.30	12.22	0.02	1.00	1.00
7290	30.87	190.24	0.00	74.70	130.66	8.36	0.129	1.00	1.00
7320	10.78	380.48	331.28	332.57	534.35	19.22	0.045	1.00	1.00
7340	3.52	206.64	200.08	149.59	251.51	12.31	0.037	1.00	1.00
7350	2.30	436.24	416.56	68.47	120.35	7.96	0.102	1.00	1.00
7410	32.51	426.40	200.08	65.71	115.77	7.78	0.028	1.00	1.00
7430	7.05	400.16	380.48	329.50	529.70	19.12	0.034	1.00	1.00
7440	39.15	577.28	400.16	324.56	522.20	18.96	0.262	1.00	1.00
7470	11.44	200.08	167.28	168.02	280.64	13.13	0.009	1.00	1.00
7530	16.87	705.20	400.16	42.56	76.86	6.11	0.062	1.00	1.00
7550	39.66	642.88	301.76	97.28	167.62	9.68	0.035	1.00	1.00
7570	5.07	180.40	170.56	79.15	137.98	8.63	0.02	1.00	1.00
7600	18.31	331.28	180.40	69.44	121.95	8.02	0.019	1.00	1.00
7610	37.55	1259.52	580.56	97.71	168.32	9.71	0.053	1.00	1.00
7620	34.14	282.08	52.48	61.70	109.10	7.51	0.012	1.00	1.00
7640	19.67	465.76	301.76	68.85	120.98	7.99	0.031	1.00	1.00
7650	32.61	993.84	616.64	75.58	132.11	8.41	0.28	1.00	1.00
7670	23.28	731.44	459.20	70.31	123.39	8.08	0.148	1.00	1.00
7700	23.16	629.76	429.68	54.76	97.48	7.03	0.036	1.00	1.00
7720	22.13	360.80	131.20	58.52	103.78	7.29	0.096	1.00	1.00
7770	43.21	505.12	196.80	99.52	171.25	9.81	0.058	1.00	1.00
7780	12.04	580.56	531.36	108.31	185.48	10.28	0.047	1.00	1.00
7830	23.10	131.20	68.88	86.39	149.85	9.06	0.027	1.00	1.00
7840	8.73	459.20	377.20	84.75	147.18	8.97	0.13	1.00	1.00
7890	35.19	531.36	377.20	267.13	434.58	17.01	0.106	1.00	1.00
7910	27.35	469.04	344.40	81.70	142.17	8.79	0.055	1.00	1.00
7970	19.58	377.20	360.80	286.71	464.57	17.70	0.028	1.00	1.00
7980	10.74	429.68	360.80	67.53	118.79	7.90	0.019	1.00	1.00
7990	10.79	554.32	383.76	41.04	74.26	5.98	0.05	1.00	1.00
8070	11.64	616.64	567.44	88.46	153.24	9.18	0.059	1.00	1.00
8100	17.46	383.76	301.76	68.51	120.41	7.96	0.052	1.00	1.00
8120	16.16	567.44	531.36	231.56	379.79	15.71	0.052	1.00	1.00
8190	39.86	301.76	186.96	127.75	216.73	11.27	0.042	1.00	1.00
8200	10.04	360.80	350.96	296.14	478.97	18.02	0.069	1.00	1.00
8250	17.92	432.96	301.76	56.66	100.68	7.16	0.044	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Piedmont Physiographic Province—Continued									
8260	23.02	186.96	75.44	149.53	251.42	12.31	0.051	1.00	1.00
8320	35.15	1508.80	892.16	59.25	105.01	7.34	0.205	1.00	1.00
8340	67.00	816.72	373.92	128.34	217.68	11.30	0.07	1.00	1.00
8370	2.63	350.96	344.40	297.22	480.61	18.06	0.008	1.00	1.00
8390	8.13	652.72	603.52	108.91	186.45	10.31	0.018	1.00	1.00
8400	20.85	75.44	22.96	155.71	261.21	12.59	0.001	1.00	1.00
8410	19.09	344.40	321.44	314.19	506.45	18.62	0.081	1.00	1.00
8450	20.11	387.04	206.64	57.45	102.00	7.22	0.027	1.00	1.00
8460	59.17	1262.80	652.72	103.07	177.01	10.00	0.109	1.00	1.00
8510	36.14	167.28	22.96	85.46	148.33	9.01	0.003	1.00	1.00
8520	11.59	373.92	324.72	134.05	226.80	11.58	0.027	1.00	1.00
8530	12.42	229.60	167.28	46.01	82.72	6.38	0.066	1.00	1.00
8621	4.84	324.72	321.44	316.74	510.32	18.71	0.011	1.00	1.00
8630	20.82	839.68	692.08	107.08	183.49	10.22	0.068	1.00	1.00
8660	22.66	347.68	324.72	287.13	465.20	17.71	0.004	1.00	1.00
8670	22.49	892.16	488.72	58.52	103.79	7.29	0.098	1.00	1.00
8710	15.14	380.48	321.44	113.76	194.27	10.57	0.042	1.00	1.00
8720	27.02	688.80	524.80	128.98	218.70	11.33	0.134	1.00	1.00
8770	17.48	410.00	396.88	263.24	428.61	16.87	0.051	1.00	1.00
8780	15.54	396.88	347.68	276.46	448.88	17.34	0.046	1.00	1.00
8830	11.09	393.60	380.48	93.57	161.57	9.48	0.017	1.00	1.00
8840	37.84	2837.20	918.40	60.05	106.34	7.40	0.189	1.00	1.00
8850	27.91	1377.60	780.64	58.04	102.98	7.26	0.065	1.00	1.00
8890	6.41	488.72	410.00	60.82	107.62	7.45	0.059	1.00	1.00
8900	32.40	524.80	410.00	237.79	389.42	15.94	0.037	1.00	1.00
8910	21.46	1804.00	924.96	51.23	91.54	6.77	0.064	1.00	1.00
8930	13.58	924.96	780.64	66.24	116.65	7.81	0.092	1.00	1.00
8931	17.37	780.64	560.88	97.58	168.11	9.70	0.15	1.00	1.00
8940	33.80	590.40	396.88	64.80	114.26	7.72	0.025	1.00	1.00
8990	11.51	551.04	524.80	184.65	306.77	13.85	0.057	1.00	1.00
9020	30.76	918.40	603.52	103.59	177.84	10.03	0.094	1.00	1.00
9110	13.46	603.52	560.88	138.84	234.43	11.81	0.066	1.00	1.00
9140	9.02	560.88	551.04	176.67	294.25	13.51	0.043	1.00	1.00
9270	22.10	947.92	603.52	63.65	112.34	7.64	0.012	1.00	1.00
Coastal Plain Physiographic Province									
3520	12.17	55.76	3.28	49.26	90.88	6.89	0.014	1.00	1.00
3670	6.40	196.80	6.56	23.01	46.53	4.45	0.024	1.00	1.00
3740	9.89	295.20	19.68	30.02	58.80	5.18	0.029	1.00	1.00
3791	12.30	72.16	13.12	30.82	60.17	5.26	0.012	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Coastal Plain Physiographic Province—Continued									
3830	8.94	59.04	3.28	25.35	50.67	4.70	0.025	1.00	1.00
3980	16.81	59.04	13.12	52.87	96.71	7.17	0.013	1.00	1.00
4100	16.54	62.32	6.56	49.39	91.10	6.90	0.023	1.00	1.00
4141	7.82	52.48	6.56	25.68	51.26	4.74	0.018	1.00	1.00
4231	2.58	55.76	39.36	13.29	28.71	3.24	0.007	1.00	1.00
4270	17.07	173.84	22.96	61.20	110.00	7.80	0.008	1.00	1.00
4400	12.30	65.60	32.80	36.03	69.03	5.75	0.01	1.00	1.00
4480	18.03	154.16	22.96	64.20	114.73	8.02	0.01	1.00	1.00
4510	19.54	373.92	16.40	37.93	72.23	5.93	0.014	1.00	1.00
4540	15.87	373.92	9.84	44.25	82.71	6.48	0.011	1.00	1.00
4560	9.50	49.20	19.68	43.21	81.00	6.39	0.015	1.00	1.00
4590	12.31	32.80	6.56	56.39	102.35	7.44	0.011	1.00	1.00
4650	3.61	22.96	16.40	85.10	146.98	9.43	0.014	1.00	1.00
4690	18.77	114.80	0.00	48.47	89.60	6.82	0.016	1.00	1.00
5070	14.51	236.16	19.68	33.54	64.82	5.52	0.016	1.00	1.00
5110	7.76	39.36	22.96	39.16	74.28	6.04	0.003	1.00	1.00
5150	7.27	39.36	3.28	23.20	46.88	4.47	0.01	1.00	1.00
5230	18.11	200.08	42.64	38.96	73.94	6.02	0.01	1.00	1.00
5270	19.17	22.96	6.56	64.75	115.58	8.06	0.004	1.00	1.00
5300	15.79	180.40	32.80	45.52	84.79	6.58	0.013	1.00	1.00
5320	2.42	39.36	16.40	18.27	37.99	3.89	0.024	1.00	1.00
5400	7.10	42.64	6.56	33.35	64.49	5.50	0.029	1.00	1.00
5430	11.25	42.64	16.40	35.78	68.60	5.73	0.002	1.00	1.00
5490	9.23	242.72	6.56	28.74	56.58	5.05	0.114	1.00	1.00
5510	10.40	104.96	6.56	35.09	67.44	5.67	0.007	1.00	1.00
5530	5.88	134.48	52.48	19.81	40.80	4.08	0.033	1.00	1.00
5540	2.96	288.64	242.72	16.58	34.88	3.68	0.048	1.00	1.00
5570	15.04	42.64	16.40	40.82	77.05	6.18	0.003	1.00	1.00
5630	3.76	32.80	13.12	47.30	87.70	6.73	0.004	1.00	1.00
5710	2.15	52.48	13.12	22.37	45.40	4.38	0.005	1.00	1.00
5720	5.99	95.12	22.96	22.45	45.54	4.38	0.017	1.00	1.00
5750	6.80	88.56	9.84	24.49	49.17	4.61	0.018	1.00	1.00
5830	6.18	62.32	9.84	29.73	58.30	5.15	0.031	1.00	1.00
5910	5.48	91.84	9.84	27.57	54.56	4.93	0.034	1.00	1.00
6000	9.07	26.24	3.28	24.52	49.22	4.61	0.001	1.00	1.00
6180	9.14	91.84	39.36	35.50	68.14	5.71	0.022	1.00	1.00
6370	20.67	173.84	62.32	57.13	103.54	7.50	0.025	1.00	1.00
6430	23.15	88.56	62.32	95.35	162.44	10.07	0.003	1.00	1.00
6540	7.52	72.16	32.80	28.98	57.00	5.08	0.027	1.00	1.00

Table 1-1. XSECT input parameters for Chesapeake Bay Regional Watershed Model reaches in the Appalachian Plateaus, Valley and Ridge, Piedmont, and Coastal Plain physiographic provinces.—Continued

[CBRWM, Chesapeake Bay Regional Watershed Model; mi, mile; ft, foot]

CBRWM reach number	Reach length (mi)	Upstream elevation (ft)	Downstream elevation (ft)	Channel bottom width (ft)	Channel bankfull width (ft)	Channel bankfull height (ft)	Flood-plain slope	Channel roughness multiplier	Floodplain roughness multiplier
Coastal Plain Physiographic Province—Continued									
6580	29.03	108.24	3.28	57.68	104.41	7.54	0.012	1.00	1.00
6620	8.21	62.32	52.48	114.26	190.45	11.17	0.01	1.00	1.00
6670	1.29	62.32	60.68	106.32	178.76	10.72	0.008	1.00	1.00
6700	2.11	75.44	62.32	95.98	163.38	10.11	0.015	1.00	1.00
6720	8.14	62.32	39.36	137.95	224.77	12.45	0.006	1.00	1.00
6750	15.41	39.36	9.84	141.61	230.01	12.64	0.004	1.00	1.00
6820	36.82	173.84	13.12	73.08	128.56	8.64	0.006	1.00	1.00
6840	4.21	45.92	9.84	30.12	58.97	5.19	0.025	1.00	1.00
6860	11.87	150.88	45.92	27.94	55.20	4.97	0.044	1.00	1.00
7540	47.11	141.04	32.80	78.38	136.72	9.00	0.021	1.00	1.00
7590	20.69	78.72	16.40	47.02	87.24	6.71	0.02	1.00	1.00
7680	12.91	32.80	16.40	82.25	142.64	9.25	0.009	1.00	1.00
7710	30.32	52.48	19.68	144.20	233.70	12.77	0.02	1.00	1.00
7730	28.56	104.96	16.40	51.70	94.84	7.08	0.009	1.00	1.00
7810	21.92	72.16	9.84	50.63	93.11	7.00	0.009	1.00	1.00
7860	9.45	16.40	9.84	96.37	163.97	10.13	0.017	1.00	1.00
7930	36.38	196.80	118.08	104.59	176.20	10.62	0.015	1.00	1.00
7950	2.99	68.88	52.48	123.14	203.41	11.66	0.005	1.00	1.00
8010	4.94	118.08	68.88	105.54	177.62	10.67	0.015	1.00	1.00
8080	4.86	9.84	6.56	107.65	180.73	10.80	0.024	1.00	1.00
8161	6.87	19.68	6.56	155.72	250.04	13.35	0.006	1.00	1.00
8230	48.71	239.44	19.68	69.55	123.08	8.40	0.012	1.00	1.00
8300	6.20	55.76	32.80	26.67	52.99	4.84	0.008	1.00	1.00

Appendix 2. XSECT Program for the Appalachian Plateaus Physiographic Province

```
C    XSECT program - Modified with Depth Varying Values of Channel and
C    Floodplain Roughness for Stream Channels in the Appalachian Plateaus.
C
C
C    PROGRAM XSECT
C
      IMPLICIT NONE
C
C    XSECT - PROGRAM TO CONVERT CROSS SECTIONS FROM HSP-II FORMAT
C           TO HSPF FTABLE FORMAT, ENGLISH UNITS
C    VERSION 3 ADDED THE ABILITY TO ADJUST THE CHANNEL HEIGHT FOR
C            INITIAL DEPTH GREATER THAN ZERO.  ALSO, TOTAL AREA FOR
C            FLOOD PLAIN AND INCISED CHANNEL WERE COMBINED FOR OUTPUT
C
C    *** FORTRAN FILE NUMBERS ***
C       INPUT  - UNIT 8, INPUT FILE
C       OUTPUT - UNIT 7, OUTPUT FILE
C
C    + + + LOCAL VARIABLES + + +
      INTEGER I1,I2,I3,RCHNUM,ROWS,INPUT,OUTPUT
      REAL    LENGTH,ELUP,ELDOWN,W1,W2,H,SFP,NCH,SLOPE,THETA1,WP1,
     1       THETA2,WP2,INC,DEPTH,TW,AREA,VOLUME,WETP,HYDRAD,DISCH,
     2       SFAREA,AREAIN,WETPIN,NFP,FLOTIM,NCH2,NCH3,NFP2,AREAC,
     3       AREAOB,AREAT,HYDRADC,HYDRADOB,HYDRADT,BKFH,IDEPTH
      CHARACTER*80 FILNAM
C
C    + + + DATA INITIALIZATIONS + + +
      DATA INPUT,OUTPUT/8,7/
C
C    + + + READ FORMATS + + +
1000  FORMAT(I5,9F8.0)
C
C    + + + WRITE FORMATS + + +
2000  FORMAT('  FTABLE    ',I4)
2010  FORMAT(I5,'    4')
2020  FORMAT(F10.3,F10.3,F10.2,F10.2,F10.1)
2030  FORMAT(' ROWS COLS ***')
2040  FORMAT('  END FTABLE',I4,/)
2050  FORMAT('     DEPTH      AREA    VOLUME     DISCH  FLO-THRU ***')
2060  FORMAT('      (FT)   (ACRES)   (AC-FT)     (CFS)     (MIN) ***')
2070  FORMAT('      .000      .000     .0000      .000       0.0')
2080  FORMAT(1X,'  RCH  LENGTH    ELUP    ELDN      W1      W2    BKFH',
     1         '     SFP     NCH     NFP',/)
2090  FORMAT(1X,I5,F8.3,2F8.1,2F8.1,F8.2,3F8.3)
C
 3    CONTINUE
       WRITE (*,*) ' ENTER INPUT FILENAME: '
       READ (*,*) FILNAM
       OPEN (UNIT=INPUT,FILE=FILNAM,STATUS='OLD',ERR=3)
 5    CONTINUE
       WRITE (*,*) ' ENTER OUTPUT FILENAME: '
       READ (*,*) FILNAM
       OPEN (UNIT=OUTPUT,FILE=FILNAM,STATUS='UNKNOWN', ERR=5)
C
C    SEE BELOW FOR DEFINITIONS AND UNITS
      READ(INPUT,1000,END=60,ERR=60) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
     1                      BKFH,SFP,NCH,NFP
```

```
C
      IF (RCHNUM .LE. 0) GOTO 60
      WRITE(*,2080)
      WRITE(*,2090) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,BKFH,
     1              SFP,NCH,NFP
C
C     LENGTH -   REACH LENGTH (MILES)
C     ELUP   -   UPSTREAM ELEVATION (FT)
C     ELDOWN -   DOWNSTREAM ELEVATION (FT)
C     W1     -   CHANNEL BOTTOM WIDTH (FT)
C     W2     -   CHANNEL BANKFULL WIDTH (FT)
C     BKFH   -   CHANNEL HEIGHT (FT)
C     SFP    -   SLOPE OF FLOOD PLAIN (-)
C     NCH    -   MANNINGS N FOR THE CHANNEL
C     NFP    -   MANNINGS N FOR THE FLOOD PLAIN
C
C     DOUNTIL END OF FILE
10    CONTINUE
      IDEPTH= 0.0
      DEPTH = IDEPTH
      H     = BKFH - DEPTH
      INC   = H/12.0
      WRITE (OUTPUT,2000) RCHNUM
      WRITE (OUTPUT,2030)
      SLOPE  = ABS(ELUP-ELDOWN)/(LENGTH*5280.)
C      WRITE (TTYOUT,*) SLOPE,ELUP,ELDOWN,LENGTH
      THETA1 = ATAN((W2-W1)/(2.*H))
      WP1    = COS(THETA1)
      THETA2 = ATAN(SFP)
      WP2    = SIN(THETA2)
C
      ROWS= 19
      WRITE (OUTPUT,2010) ROWS
      WRITE (OUTPUT,2050)
      WRITE (OUTPUT,2060)
      WRITE (OUTPUT,2070)
C
C      MAIN CHANNEL COMPUTATIONS
C
      DO 40 I1 = 1,6
        DEPTH  = DEPTH + INC
        TW     = W1 + ((W2-W1)/H)*DEPTH
        SFAREA = TW*LENGTH*5280./43560.
        AREA   = ((TW+W1)/2)*DEPTH
        VOLUME = AREA*LENGTH*5280./43560.
        WETP   = W1 + 2*(DEPTH/WP1)
        HYDRAD = AREA/WETP
          IF(I1 .EQ. 1) THEN
            NCH2 = NCH*0.028
          ENDIF
          IF(I1 .EQ. 2) THEN
            NCH2 = NCH*0.030
          ENDIF
          IF(I1 .EQ. 3) THEN
            NCH2 = NCH*0.029
          ENDIF
          IF(I1 .EQ. 4) THEN
```

```
            NCH2 = NCH*0.030
          ENDIF
          IF(I1 .EQ. 5) THEN
            NCH2 = NCH*0.031
          ENDIF
          IF(I1 .EQ. 6) THEN
            NCH2 = NCH*0.031
          ENDIF
        DISCH  = 1.49*AREA*(HYDRAD**0.667)*(SLOPE**0.5)/NCH2
        FLOTIM = (VOLUME*43560.)/(DISCH*60.)
c 3000    FORMAT (I3,5F8.3)
c         WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRAD'
c         WRITE (*,3000) I1,DEPTH,TW,AREA,WETP,HYDRAD
        WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
40      CONTINUE
C
      INC  = 2.0*INC
      DO 42 I2 = 7,9
        DEPTH  = DEPTH+ INC
        TW     = W1+ ((W2-W1)/H)*DEPTH
        SFAREA = TW*LENGTH*5280./43560.
        AREA   = ((TW+W1)/2)*DEPTH
        VOLUME = AREA*LENGTH*5280./43560.
        WETP   = W1+ 2*(DEPTH/WP1)
        HYDRAD = AREA/WETP
          IF(I2 .EQ. 7) THEN
            NCH3 = NCH*0.031
          ENDIF
          IF(I2 .EQ. 8) THEN
            NCH3 = NCH*0.028
          ENDIF
          IF(I2 .EQ. 9) THEN
            NCH3 = NCH*0.028
          ENDIF
        DISCH  = 1.49*AREA*(HYDRAD**0.667)*(SLOPE**0.5)/NCH3
        FLOTIM = (VOLUME*43560.)/(DISCH*60.)
c         WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRAD'
c         WRITE (*,3000) I2,DEPTH,TW,AREA,WETP,HYDRAD
        WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
42      CONTINUE
C
C       OVERBANK COMPUTATIONS
C
      AREAIN = ((W1+W2)/2)*H
      WETPIN = W1+ 2*(H/WP1)
      INC    = 2.0*INC
      DO 50 I3 = 10,18
        DEPTH  = DEPTH+ INC
        TW     = W2+ 2*(DEPTH-H)/SFP
        SFAREA = TW*LENGTH*5280./43560.
C
C         INCISED CHANNEL
        AREAC  = AREAIN+ W2*(DEPTH-H)
        VOLUME = AREAC*LENGTH*5280./43560.
        HYDRADC= AREAC/WETPIN
c         WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRADC'
c         WRITE (*,3000) I3,DEPTH,TW,AREAC,WETPIN,HYDRADC
```

```
      DISCH  = 1.49*AREAC*(HYDRADC**0.667)*(SLOPE**0.5)/NCH3
C
C       OVERBANK
      AREAOB  = (DEPTH-H)*(DEPTH-H)/SFP
      VOLUME  = VOLUME+ AREAOB*LENGTH*5280./43560.
      WETP    = 2*(DEPTH-H)/WP2
      HYDRADOB= AREAOB/WETP
        IF(I2 .EQ. 10) THEN
          NFP2 = NFP*0.035
        ENDIF
        IF(I2 .EQ. 11) THEN
          NFP2 = NFP*0.054
        ENDIF
        IF(I2 .EQ. 12) THEN
          NFP2 = NFP*0.062
        ENDIF
        IF(I2 .EQ. 13) THEN
          NFP2 = NFP*0.062
        ENDIF
        IF(I2 .EQ. 14) THEN
          NFP2 = NFP*0.062
        ENDIF
        IF(I2 .EQ. 15) THEN
          NFP2 = NFP*0.062
        ENDIF
        IF(I2 .EQ. 16) THEN
          NFP2 = NFP*0.062
        ENDIF
        IF(I2 .EQ. 17) THEN
          NFP2 = NFP*0.062
        ENDIF
        IF(I2 .EQ. 18) THEN
          NFP2 = NFP*0.062
        ENDIF
c       WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRADOB'
c       WRITE (*,3000) I3,DEPTH,TW,AREAOB,WETP,HYDRADOB
      DISCH  = DISCH+ 1.49*AREAOB*(HYDRADOB**0.667)*(SLOPE**0.5)/NFP2
C
      FLOTIM = (VOLUME*43560.)/(DISCH*60.)
      AREAT  = AREAC + AREAOB
      HYDRADT= HYDRADC + HYDRADOB
      WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
50    CONTINUE
C
     WRITE (OUTPUT,2040) RCHNUM
     READ (INPUT,1000,END=60) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
   1                    BKFH,SFP,NCH,NFP
     WRITE (*,2090) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
   1                BKFH,SFP,NCH,NFP
C
    GO TO 10
C    ENDDO
C
60   CONTINUE
C
c
    END
```

Appendix 3. XSECT Program for the Valley and Ridge Physiographic Province

```
C    XSECT program - Modified with Depth Varying Values of Channel and
C    Floodplain Roughness for Stream Channels in the Valley and Ridge.
C
C
C    PROGRAM XSECT
C
      IMPLICIT NONE
C
C    XSECT - PROGRAM TO CONVERT CROSS SECTIONS FROM HSP-II FORMAT
C            TO HSPF FTABLE FORMAT, ENGLISH UNITS
C    VERSION 3 ADDED THE ABILITY TO ADJUST THE CHANNEL HEIGHT FOR
C              INITIAL DEPTH GREATER THAN ZERO.  ALSO, TOTAL AREA FOR
C              FLOOD PLAIN AND INCISED CHANNEL WERE COMBINED FOR OUTPUT
C
C    *** FORTRAN FILE NUMBERS ***
C       INPUT  - UNIT 8, INPUT FILE
C       OUTPUT - UNIT 7, OUTPUT FILE
C
C    + + + LOCAL VARIABLES + + +
      INTEGER I1,I2,I3,RCHNUM,ROWS,INPUT,OUTPUT
      REAL    LENGTH,ELUP,ELDOWN,W1,W2,H,SFP,NCH,SLOPE,THETA1,WP1,
     1        THETA2,WP2,INC,DEPTH,TW,AREA,VOLUME,WETP,HYDRAD,DISCH,
     2        SFAREA,AREAIN,WETPIN,NFP,FLOTIM,NCH2,NCH3,NFP2,AREAC,
     3        AREAOB,AREAT,HYDRADC,HYDRADOB,HYDRADT,BKFH,IDEPTH
      CHARACTER*80 FILNAM
C
C    + + + DATA INITIALIZATIONS + + +
      DATA INPUT,OUTPUT/8,7/
C
C    + + + READ FORMATS + + +
1000  FORMAT(I5,9F8.0)
C
C    + + + WRITE FORMATS + + +
2000  FORMAT('  FTABLE    ',I4)
2010  FORMAT(I5,'    4')
2020  FORMAT(F10.3,F10.3,F10.2,F10.2,F10.1)
2030  FORMAT(' ROWS COLS ***')
2040  FORMAT('  END FTABLE',I4,/)
2050  FORMAT('     DEPTH      AREA    VOLUME     DISCH  FLO-THRU ***')
2060  FORMAT('      (FT)   (ACRES)   (AC-FT)     (CFS)     (MIN) ***')
2070  FORMAT('      .000      .000     .0000      .000       0.0')
2080  FORMAT(1X,'  RCH  LENGTH    ELUP    ELDN      W1      W2    BKFH',
     1        '     SFP     NCH     NFP',/)
2090  FORMAT(1X,I5,F8.3,2F8.1,2F8.1,F8.2,3F8.3)
C
 3    CONTINUE
       WRITE (*,*) ' ENTER INPUT FILENAME: '
       READ (*,*) FILNAM
       OPEN (UNIT=INPUT,FILE=FILNAM,STATUS='OLD',ERR=3)
 5    CONTINUE
       WRITE (*,*) ' ENTER OUTPUT FILENAME: '
       READ (*,*) FILNAM
       OPEN (UNIT=OUTPUT,FILE=FILNAM,STATUS='UNKNOWN', ERR=5)
C
C    SEE BELOW FOR DEFINITIONS AND UNITS
      READ(INPUT,1000,END=60,ERR=60) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
     1                  BKFH,SFP,NCH,NFP
```

```
C
     IF (RCHNUM .LE. 0) GOTO 60
     WRITE(*,2080)
     WRITE(*,2090) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,BKFH,
    1             SFP,NCH,NFP
C
C    LENGTH -   REACH LENGTH (MILES)
C    ELUP   -   UPSTREAM ELEVATION (FT)
C    ELDOWN -   DOWNSTREAM ELEVATION (FT)
C    W1     -   CHANNEL BOTTOM WIDTH (FT)
C    W2     -   CHANNEL BANKFULL WIDTH (FT)
C    BKFH   -   CHANNEL HEIGHT (FT)
C    SFP    -   SLOPE OF FLOOD PLAIN (-)
C    NCH    -   MANNINGS N FOR THE CHANNEL
C    NFP    -   MANNINGS N FOR THE FLOOD PLAIN
C
C    DOUNTIL END OF FILE
10   CONTINUE
     IDEPTH= 0.0
     DEPTH = IDEPTH
     H     = BKFH - DEPTH
     INC   = H/12.0
     WRITE (OUTPUT,2000) RCHNUM
     WRITE (OUTPUT,2030)
     SLOPE  = ABS(ELUP-ELDOWN)/(LENGTH*5280.)
C     WRITE (TTYOUT,*) SLOPE,ELUP,ELDOWN,LENGTH
     THETA1 = ATAN((W2-W1)/(2.*H))
     WP1    = COS(THETA1)
     THETA2 = ATAN(SFP)
     WP2    = SIN(THETA2)
C
     ROWS= 19
     WRITE (OUTPUT,2010) ROWS
     WRITE (OUTPUT,2050)
     WRITE (OUTPUT,2060)
     WRITE (OUTPUT,2070)
C
C     MAIN CHANNEL COMPUTATIONS
C
     DO 40 I1 = 1,6
      DEPTH  = DEPTH + INC
      TW     = W1 + ((W2-W1)/H)*DEPTH
      SFAREA = TW*LENGTH*5280./43560.
      AREA   = ((TW+W1)/2)*DEPTH
      VOLUME = AREA*LENGTH*5280./43560.
      WETP   = W1 + 2*(DEPTH/WP1)
      HYDRAD = AREA/WETP
        IF(I1 .EQ. 1) THEN
          NCH2 = NCH*0.050
        ENDIF
        IF(I1 .EQ. 2) THEN
          NCH2 = NCH*0.051
        ENDIF
        IF(I1 .EQ. 3) THEN
          NCH2 = NCH*0.048
        ENDIF
        IF(I1 .EQ. 4) THEN
```

```
            NCH2 = NCH*0.047
          ENDIF
          IF(I1 .EQ. 5) THEN
            NCH2 = NCH*0.044
          ENDIF
          IF(I1 .EQ. 6) THEN
            NCH2 = NCH*0.041
          ENDIF
        DISCH  = 1.49*AREA*(HYDRAD**0.667)*(SLOPE**0.5)/NCH2
        FLOTIM = (VOLUME*43560.)/(DISCH*60.)
c 3000    FORMAT (I3,5F8.3)
c         WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRAD'
c         WRITE (*,3000) I1,DEPTH,TW,AREA,WETP,HYDRAD
        WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
40      CONTINUE
C
      INC  = 2.0*INC
      DO 42 I2 = 7,9
        DEPTH  = DEPTH+ INC
        TW     = W1+ ((W2-W1)/H)*DEPTH
        SFAREA = TW*LENGTH*5280./43560.
        AREA   = ((TW+W1)/2)*DEPTH
        VOLUME = AREA*LENGTH*5280./43560.
        WETP   = W1+ 2*(DEPTH/WP1)
        HYDRAD = AREA/WETP
          IF(I2 .EQ. 7) THEN
            NCH3 = NCH*0.039
          ENDIF
          IF(I2 .EQ. 8) THEN
            NCH3 = NCH*0.041
          ENDIF
          IF(I2 .EQ. 9) THEN
            NCH3 = NCH*0.037
          ENDIF
        DISCH  = 1.49*AREA*(HYDRAD**0.667)*(SLOPE**0.5)/NCH3
        FLOTIM = (VOLUME*43560.)/(DISCH*60.)
c         WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRAD'
c         WRITE (*,3000) I2,DEPTH,TW,AREA,WETP,HYDRAD
        WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
42      CONTINUE
C
C       OVERBANK COMPUTATIONS
C
      AREAIN = ((W1+W2)/2)*H
      WETPIN = W1+ 2*(H/WP1)
      INC    = 2.0*INC
      DO 50 I3 = 10,18
        DEPTH  = DEPTH+ INC
        TW     = W2+ 2*(DEPTH-H)/SFP
        SFAREA = TW*LENGTH*5280./43560.
C
C         INCISED CHANNEL
        AREAC  = AREAIN+ W2*(DEPTH-H)
        VOLUME = AREAC*LENGTH*5280./43560.
        HYDRADC= AREAC/WETPIN
c         WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRADC'
c         WRITE (*,3000) I3,DEPTH,TW,AREAC,WETPIN,HYDRADC
```

```
      DISCH  = 1.49*AREAC*(HYDRADC**0.667)*(SLOPE**0.5)/NCH3
C
C       OVERBANK
      AREAOB  = (DEPTH-H)*(DEPTH-H)/SFP
      VOLUME  = VOLUME+ AREAOB*LENGTH*5280./43560.
      WETP    = 2*(DEPTH-H)/WP2
      HYDRADOB= AREAOB/WETP
        IF(I2 .EQ. 10) THEN
           NFP2 = NFP*0.051
        ENDIF
        IF(I2 .EQ. 11) THEN
           NFP2 = NFP*0.056
        ENDIF
        IF(I2 .EQ. 12) THEN
           NFP2 = NFP*0.062
        ENDIF
        IF(I2 .EQ. 13) THEN
           NFP2 = NFP*0.075
        ENDIF
        IF(I2 .EQ. 14) THEN
           NFP2 = NFP*0.075
        ENDIF
        IF(I2 .EQ. 15) THEN
           NFP2 = NFP*0.075
        ENDIF
        IF(I2 .EQ. 16) THEN
           NFP2 = NFP*0.075
        ENDIF
        IF(I2 .EQ. 17) THEN
           NFP2 = NFP*0.075
        ENDIF
        IF(I2 .EQ. 18) THEN
           NFP2 = NFP*0.075
        ENDIF
c       WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRADOB'
c       WRITE (*,3000) I3,DEPTH,TW,AREAOB,WETP,HYDRADOB
      DISCH  = DISCH+ 1.49*AREAOB*(HYDRADOB**0.667)*(SLOPE**0.5)/NFP2
C
      FLOTIM = (VOLUME*43560.)/(DISCH*60.)
      AREAT  = AREAC + AREAOB
      HYDRADT= HYDRADC + HYDRADOB
      WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
50    CONTINUE
C
     WRITE (OUTPUT,2040) RCHNUM
     READ (INPUT,1000,END=60) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
    1                    BKFH,SFP,NCH,NFP
     WRITE (*,2090) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
    1                 BKFH,SFP,NCH,NFP
C
    GO TO 10
C    ENDDO
C
60   CONTINUE
C
c
    END
```

Appendix 4. XSECT Program for the Piedmont Physiographic Province

```
C    XSECT program - Modified with Depth Varying Values of Channel and
C    Floodplain Roughness for Stream Channels in the Piedmont.
C
C
C    PROGRAM XSECT
C
      IMPLICIT NONE
C
C    XSECT - PROGRAM TO CONVERT CROSS SECTIONS FROM HSP-II FORMAT
C            TO HSPF FTABLE FORMAT, ENGLISH UNITS
C    VERSION 3 ADDED THE ABILITY TO ADJUST THE CHANNEL HEIGHT FOR
C             INITIAL DEPTH GREATER THAN ZERO.  ALSO, TOTAL AREA FOR
C             FLOOD PLAIN AND INCISED CHANNEL WERE COMBINED FOR OUTPUT
C
C    *** FORTRAN FILE NUMBERS ***
C       INPUT  - UNIT 8, INPUT FILE
C       OUTPUT - UNIT 7, OUTPUT FILE
C
C    + + + LOCAL VARIABLES + + +
      INTEGER I1,I2,I3,RCHNUM,ROWS,INPUT,OUTPUT
      REAL    LENGTH,ELUP,ELDOWN,W1,W2,H,SFP,NCH,SLOPE,THETA1,WP1,
     1        THETA2,WP2,INC,DEPTH,TW,AREA,VOLUME,WETP,HYDRAD,DISCH,
     2        SFAREA,AREAIN,WETPIN,NFP,FLOTIM,NCH2,NCH3,NFP2,AREAC,
     3        AREAOB,AREAT,HYDRADC,HYDRADOB,HYDRADT,BKFH,IDEPTH
      CHARACTER*80 FILNAM
C
C    + + + DATA INITIALIZATIONS + + +
      DATA INPUT,OUTPUT/8,7/
C
C    + + + READ FORMATS + + +
1000  FORMAT(I5,9F8.0)
C
C    + + + WRITE FORMATS + + +
2000  FORMAT('  FTABLE    ',I4)
2010  FORMAT(I5,'    4')
2020  FORMAT(F10.3,F10.3,F10.2,F10.2,F10.1)
2030  FORMAT(' ROWS COLS ***')
2040  FORMAT('  END FTABLE',I4,/)
2050  FORMAT('     DEPTH      AREA    VOLUME     DISCH  FLO-THRU ***')
2060  FORMAT('      (FT)   (ACRES)   (AC-FT)     (CFS)     (MIN) ***')
2070  FORMAT('      .000      .000     .0000      .000       0.0')
2080  FORMAT(1X,'  RCH  LENGTH    ELUP    ELDN      W1      W2    BKFH',
     1        '     SFP     NCH     NFP',/)
2090  FORMAT(1X,I5,F8.3,2F8.1,2F8.1,F8.2,3F8.3)
C
 3    CONTINUE
       WRITE (*,*) ' ENTER INPUT FILENAME: '
       READ (*,*) FILNAM
       OPEN (UNIT=INPUT,FILE=FILNAM,STATUS='OLD',ERR=3)
 5    CONTINUE
       WRITE (*,*) ' ENTER OUTPUT FILENAME: '
       READ (*,*) FILNAM
       OPEN (UNIT=OUTPUT,FILE=FILNAM,STATUS='UNKNOWN', ERR=5)
C
C    SEE BELOW FOR DEFINITIONS AND UNITS
      READ(INPUT,1000,END=60,ERR=60) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
     1                   BKFH,SFP,NCH,NFP
```

```
C
      IF (RCHNUM .LE. 0) GOTO 60
      WRITE(*,2080)
      WRITE(*,2090) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,BKFH,
     1            SFP,NCH,NFP
C
C    LENGTH -   REACH LENGTH (MILES)
C    ELUP   -   UPSTREAM ELEVATION (FT)
C    ELDOWN -   DOWNSTREAM ELEVATION (FT)
C    W1     -   CHANNEL BOTTOM WIDTH (FT)
C    W2     -   CHANNEL BANKFULL WIDTH (FT)
C    BKFH   -   CHANNEL HEIGHT (FT)
C    SFP    -   SLOPE OF FLOOD PLAIN (-)
C    NCH    -   MANNINGS N FOR THE CHANNEL
C    NFP    -   MANNINGS N FOR THE FLOOD PLAIN
C
C    DOUNTIL END OF FILE
10    CONTINUE
      IDEPTH= 0.0
      DEPTH = IDEPTH
      H     = BKFH - DEPTH
      INC   = H/12.0
      WRITE (OUTPUT,2000) RCHNUM
      WRITE (OUTPUT,2030)
      SLOPE  = ABS(ELUP-ELDOWN)/(LENGTH*5280.)
C      WRITE (TTYOUT,*) SLOPE,ELUP,ELDOWN,LENGTH
      THETA1 = ATAN((W2-W1)/(2.*H))
      WP1    = COS(THETA1)
      THETA2 = ATAN(SFP)
      WP2    = SIN(THETA2)
C
      ROWS= 19
      WRITE (OUTPUT,2010) ROWS
      WRITE (OUTPUT,2050)
      WRITE (OUTPUT,2060)
      WRITE (OUTPUT,2070)
C
C      MAIN CHANNEL COMPUTATIONS
C
      DO 40 I1 = 1,6
        DEPTH  = DEPTH + INC
        TW     = W1 + ((W2-W1)/H)*DEPTH
        SFAREA = TW*LENGTH*5280./43560.
        AREA   = ((TW+W1)/2)*DEPTH
        VOLUME = AREA*LENGTH*5280./43560.
        WETP   = W1 + 2*(DEPTH/WP1)
        HYDRAD = AREA/WETP
          IF(I1 .EQ. 1) THEN
            NCH2 = NCH*0.066
          ENDIF
          IF(I1 .EQ. 2) THEN
            NCH2 = NCH*0.048
          ENDIF
          IF(I1 .EQ. 3) THEN
            NCH2 = NCH*0.040
          ENDIF
          IF(I1 .EQ. 4) THEN
```

```
            NCH2 = NCH*0.037
          ENDIF
          IF(I1 .EQ. 5) THEN
            NCH2 = NCH*0.038
          ENDIF
          IF(I1 .EQ. 6) THEN
            NCH2 = NCH*0.040
          ENDIF
        DISCH  = 1.49*AREA*(HYDRAD**0.667)*(SLOPE**0.5)/NCH2
        FLOTIM = (VOLUME*43560.)/(DISCH*60.)
c 3000     FORMAT (I3,5F8.3)
c          WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRAD'
c          WRITE (*,3000) I1,DEPTH,TW,AREA,WETP,HYDRAD
        WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
40      CONTINUE
C
       INC  = 2.0*INC
       DO 42 I2 = 7,9
        DEPTH  = DEPTH+ INC
        TW     = W1+ ((W2-W1)/H)*DEPTH
        SFAREA = TW*LENGTH*5280./43560.
        AREA   = ((TW+W1)/2)*DEPTH
        VOLUME = AREA*LENGTH*5280./43560.
        WETP   = W1+ 2*(DEPTH/WP1)
        HYDRAD = AREA/WETP
          IF(I2 .EQ. 7) THEN
            NCH3 = NCH*0.042
          ENDIF
          IF(I2 .EQ. 8) THEN
            NCH3 = NCH*0.045
          ENDIF
          IF(I2 .EQ. 9) THEN
            NCH3 = NCH*0.048
          ENDIF
        DISCH  = 1.49*AREA*(HYDRAD**0.667)*(SLOPE**0.5)/NCH3
        FLOTIM = (VOLUME*43560.)/(DISCH*60.)
c          WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRAD'
c          WRITE (*,3000) I2,DEPTH,TW,AREA,WETP,HYDRAD
        WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
42      CONTINUE
C
C       OVERBANK COMPUTATIONS
C
       AREAIN = ((W1+W2)/2)*H
       WETPIN = W1+ 2*(H/WP1)
       INC    = 2.0*INC
       DO 50 I3 = 10,18
        DEPTH  = DEPTH+ INC
        TW     = W2+ 2*(DEPTH-H)/SFP
        SFAREA = TW*LENGTH*5280./43560.
C
C         INCISED CHANNEL
        AREAC  = AREAIN+ W2*(DEPTH-H)
        VOLUME = AREAC*LENGTH*5280./43560.
        HYDRADC= AREAC/WETPIN
c          WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRADC'
c          WRITE (*,3000) I3,DEPTH,TW,AREAC,WETPIN,HYDRADC
```

```
      DISCH  = 1.49*AREAC*(HYDRADC**0.667)*(SLOPE**0.5)/NCH3
C
C       OVERBANK
      AREAOB  = (DEPTH-H)*(DEPTH-H)/SFP
      VOLUME  = VOLUME+ AREAOB*LENGTH*5280./43560.
      WETP    = 2*(DEPTH-H)/WP2
      HYDRADOB= AREAOB/WETP
        IF(I2 .EQ. 10) THEN
          NFP2 = NFP*0.067
        ENDIF
        IF(I2 .EQ. 11) THEN
          NFP2 = NFP*0.090
        ENDIF
        IF(I2 .EQ. 12) THEN
          NFP2 = NFP*0.102
        ENDIF
        IF(I2 .EQ. 13) THEN
          NFP2 = NFP*0.102
        ENDIF
        IF(I2 .EQ. 14) THEN
          NFP2 = NFP*0.102
        ENDIF
        IF(I2 .EQ. 15) THEN
          NFP2 = NFP*0.102
        ENDIF
        IF(I2 .EQ. 16) THEN
          NFP2 = NFP*0.102
        ENDIF
        IF(I2 .EQ. 17) THEN
          NFP2 = NFP*0.102
        ENDIF
        IF(I2 .EQ. 18) THEN
          NFP2 = NFP*0.102
        ENDIF
c       WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRADOB'
c       WRITE (*,3000) I3,DEPTH,TW,AREAOB,WETP,HYDRADOB
      DISCH  = DISCH+ 1.49*AREAOB*(HYDRADOB**0.667)*(SLOPE**0.5)/NFP2
C
      FLOTIM = (VOLUME*43560.)/(DISCH*60.)
      AREAT  = AREAC + AREAOB
      HYDRADT= HYDRADC + HYDRADOB
      WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
50    CONTINUE
C
     WRITE (OUTPUT,2040) RCHNUM
     READ (INPUT,1000,END=60) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
   1                    BKFH,SFP,NCH,NFP
     WRITE (*,2090) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
   1                BKFH,SFP,NCH,NFP
C
    GO TO 10
C   ENDDO
C
60   CONTINUE
C
c
    END
```

Appendix 5. XSECT Program for the Coastal Plain Physiographic Province

```
C    XSECT program - Modified with Depth Varying Values of Channel and
C    Floodplain Roughness for Stream Channels in the Coastal Plain.
C
C
C    PROGRAM XSECT
C
     IMPLICIT NONE
C
C    XSECT - PROGRAM TO CONVERT CROSS SECTIONS FROM HSP-II FORMAT
C            TO HSPF FTABLE FORMAT, ENGLISH UNITS
C    VERSION 3 ADDED THE ABILITY TO ADJUST THE CHANNEL HEIGHT FOR
C              INITIAL DEPTH GREATER THAN ZERO.  ALSO, TOTAL AREA FOR
C              FLOOD PLAIN AND INCISED CHANNEL WERE COMBINED FOR OUTPUT
C
C    *** FORTRAN FILE NUMBERS ***
C       INPUT  - UNIT 8, INPUT FILE
C       OUTPUT - UNIT 7, OUTPUT FILE
C
C    + + + LOCAL VARIABLES + + +
     INTEGER I1,I2,I3,RCHNUM,ROWS,INPUT,OUTPUT
     REAL    LENGTH,ELUP,ELDOWN,W1,W2,H,SFP,NCH,SLOPE,THETA1,WP1,
    1        THETA2,WP2,INC,DEPTH,TW,AREA,VOLUME,WETP,HYDRAD,DISCH,
    2        SFAREA,AREAIN,WETPIN,NFP,FLOTIM,NCH2,NCH3,NFP2,AREAC,
    3        AREAOB,AREAT,HYDRADC,HYDRADOB,HYDRADT,BKFH,IDEPTH
     CHARACTER*80 FILNAM
C
C    + + + DATA INITIALIZATIONS + + +
     DATA INPUT,OUTPUT/8,7/
C
C    + + + READ FORMATS + + +
1000  FORMAT(I5,9F8.0)
C
C    + + + WRITE FORMATS + + +
2000  FORMAT('  FTABLE    ',I4)
2010  FORMAT(I5,'    4')
2020  FORMAT(F10.3,F10.3,F10.2,F10.2,F10.1)
2030  FORMAT(' ROWS COLS ***')
2040  FORMAT('  END FTABLE',I4,/)
2050  FORMAT('     DEPTH      AREA    VOLUME     DISCH  FLO-THRU ***')
2060  FORMAT('      (FT)   (ACRES)   (AC-FT)     (CFS)     (MIN) ***')
2070  FORMAT('      .000      .000     .0000      .000       0.0')
2080  FORMAT(1X,'  RCH  LENGTH    ELUP    ELDN      W1      W2    BKFH',
    1         '     SFP     NCH     NFP',/)
2090  FORMAT(1X,I5,F8.3,2F8.1,2F8.1,F8.2,3F8.3)
C
 3    CONTINUE
      WRITE (*,*) ' ENTER INPUT FILENAME: '
      READ (*,*) FILNAM
      OPEN (UNIT=INPUT,FILE=FILNAM,STATUS='OLD',ERR=3)
 5    CONTINUE
      WRITE (*,*) ' ENTER OUTPUT FILENAME: '
      READ (*,*) FILNAM
      OPEN (UNIT=OUTPUT,FILE=FILNAM,STATUS='UNKNOWN', ERR=5)
C
C    SEE BELOW FOR DEFINITIONS AND UNITS
     READ(INPUT,1000,END=60,ERR=60) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
    1                    BKFH,SFP,NCH,NFP
```

```
C
      IF (RCHNUM .LE. 0) GOTO 60
      WRITE(*,2080)
      WRITE(*,2090) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,BKFH,
     1             SFP,NCH,NFP
C
C     LENGTH -    REACH LENGTH (MILES)
C     ELUP   -    UPSTREAM ELEVATION (FT)
C     ELDOWN -    DOWNSTREAM ELEVATION (FT)
C     W1     -    CHANNEL BOTTOM WIDTH (FT)
C     W2     -    CHANNEL BANKFULL WIDTH (FT)
C     BKFH   -    CHANNEL HEIGHT (FT)
C     SFP    -    SLOPE OF FLOOD PLAIN (-)
C     NCH    -    MANNINGS N FOR THE CHANNEL
C     NFP    -    MANNINGS N FOR THE FLOOD PLAIN
C
C     DOUNTIL END OF FILE
10    CONTINUE
      IDEPTH= 0.0
      DEPTH = IDEPTH
      H     = BKFH - DEPTH
      INC   = H/12.0
      WRITE (OUTPUT,2000) RCHNUM
      WRITE (OUTPUT,2030)
      SLOPE  = ABS(ELUP-ELDOWN)/(LENGTH*5280.)
C       WRITE (TTYOUT,*) SLOPE,ELUP,ELDOWN,LENGTH
      THETA1 = ATAN((W2-W1)/(2.*H))
      WP1    = COS(THETA1)
      THETA2 = ATAN(SFP)
      WP2    = SIN(THETA2)
C
      ROWS= 19
      WRITE (OUTPUT,2010) ROWS
      WRITE (OUTPUT,2050)
      WRITE (OUTPUT,2060)
      WRITE (OUTPUT,2070)
C
C       MAIN CHANNEL COMPUTATIONS
C
      DO 40 I1 = 1,6
        DEPTH  = DEPTH + INC
        TW     = W1 + ((W2-W1)/H)*DEPTH
        SFAREA = TW*LENGTH*5280./43560.
        AREA   = ((TW+W1)/2)*DEPTH
        VOLUME = AREA*LENGTH*5280./43560.
        WETP   = W1 + 2*(DEPTH/WP1)
        HYDRAD = AREA/WETP
          IF(I1 .EQ. 1) THEN
             NCH2 = NCH*0.074
          ENDIF
          IF(I1 .EQ. 2) THEN
             NCH2 = NCH*0.055
          ENDIF
          IF(I1 .EQ. 3) THEN
             NCH2 = NCH*0.048
          ENDIF
          IF(I1 .EQ. 4) THEN
```

```
            NCH2 = NCH*0.042
          ENDIF
          IF(I1 .EQ. 5) THEN
            NCH2 = NCH*0.039
          ENDIF
          IF(I1 .EQ. 6) THEN
            NCH2 = NCH*0.038
          ENDIF
        DISCH  = 1.49*AREA*(HYDRAD**0.667)*(SLOPE**0.5)/NCH2
        FLOTIM = (VOLUME*43560.)/(DISCH*60.)
c 3000     FORMAT (I3,5F8.3)
c          WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRAD'
c          WRITE (*,3000) I1,DEPTH,TW,AREA,WETP,HYDRAD
        WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
40      CONTINUE
C
       INC  = 2.0*INC
       DO 42 I2 = 7,9
        DEPTH  = DEPTH+ INC
        TW     = W1+ ((W2-W1)/H)*DEPTH
        SFAREA = TW*LENGTH*5280./43560.
        AREA   = ((TW+W1)/2)*DEPTH
        VOLUME = AREA*LENGTH*5280./43560.
        WETP   = W1+ 2*(DEPTH/WP1)
        HYDRAD = AREA/WETP
          IF(I2 .EQ. 7) THEN
            NCH3 = NCH*0.040
          ENDIF
          IF(I2 .EQ. 8) THEN
            NCH3 = NCH*0.042
          ENDIF
          IF(I2 .EQ. 9) THEN
            NCH3 = NCH*0.039
          ENDIF
        DISCH  = 1.49*AREA*(HYDRAD**0.667)*(SLOPE**0.5)/NCH3
        FLOTIM = (VOLUME*43560.)/(DISCH*60.)
c          WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRAD'
c          WRITE (*,3000) I2,DEPTH,TW,AREA,WETP,HYDRAD
        WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
42      CONTINUE
C
C       OVERBANK COMPUTATIONS
C
       AREAIN = ((W1+W2)/2)*H
       WETPIN = W1+ 2*(H/WP1)
       INC    = 2.0*INC
       DO 50 I3 = 10,18
        DEPTH  = DEPTH+ INC
        TW     = W2+ 2*(DEPTH-H)/SFP
        SFAREA = TW*LENGTH*5280./43560.
C
C         INCISED CHANNEL
        AREAC  = AREAIN+ W2*(DEPTH-H)
        VOLUME = AREAC*LENGTH*5280./43560.
        HYDRADC= AREAC/WETPIN
c          WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRADC'
c          WRITE (*,3000) I3,DEPTH,TW,AREAC,WETPIN,HYDRADC
```

```
      DISCH  = 1.49*AREAC*(HYDRADC**0.667)*(SLOPE**0.5)/NCH3
C
C       OVERBANK
      AREAOB  = (DEPTH-H)*(DEPTH-H)/SFP
      VOLUME  = VOLUME+ AREAOB*LENGTH*5280./43560.
      WETP    = 2*(DEPTH-H)/WP2
      HYDRADOB= AREAOB/WETP
        IF(I2 .EQ. 10) THEN
          NFP2 = NFP*0.053
        ENDIF
        IF(I2 .EQ. 11) THEN
          NFP2 = NFP*0.053
        ENDIF
        IF(I2 .EQ. 12) THEN
          NFP2 = NFP*0.053
        ENDIF
        IF(I2 .EQ. 13) THEN
          NFP2 = NFP*0.053
        ENDIF
        IF(I2 .EQ. 14) THEN
          NFP2 = NFP*0.053
        ENDIF
        IF(I2 .EQ. 15) THEN
          NFP2 = NFP*0.053
        ENDIF
        IF(I2 .EQ. 16) THEN
          NFP2 = NFP*0.053
        ENDIF
        IF(I2 .EQ. 17) THEN
          NFP2 = NFP*0.053
        ENDIF
        IF(I2 .EQ. 18) THEN
          NFP2 = NFP*0.053
        ENDIF
c       WRITE (*,*) ' LVL DEPTH  TOPWID XSAREA WETP HYDRADOB'
c       WRITE (*,3000) I3,DEPTH,TW,AREAOB,WETP,HYDRADOB
      DISCH  = DISCH+ 1.49*AREAOB*(HYDRADOB**0.667)*(SLOPE**0.5)/NFP2
C
      FLOTIM = (VOLUME*43560.)/(DISCH*60.)
      AREAT  = AREAC + AREAOB
      HYDRADT= HYDRADC + HYDRADOB
      WRITE (OUTPUT,2020) DEPTH,SFAREA,VOLUME,DISCH,FLOTIM
50    CONTINUE
C
     WRITE (OUTPUT,2040) RCHNUM
     READ (INPUT,1000,END=60) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
   1                  BKFH,SFP,NCH,NFP
     WRITE (*,2090) RCHNUM,LENGTH,ELUP,ELDOWN,W1,W2,
   1              BKFH,SFP,NCH,NFP
C
    GO TO 10
C    ENDDO
C
60   CONTINUE
C
c
    END
```

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