FLOOD-HYDROLOGY DATA FOR THE POTOMAC RIVER AND SELECTED TRIBUTARIES IN THE VICINITY OF THE CHESAPEAKE AND OHIO CANAL NATIONAL HISTORICAL PARK, MARYLAND, WEST VIRGINIA, AND THE DISTRICT OF COLUMBIA

U.S. GEOLOGICAL SURVEY

Open-File Report 97-200

Prepared in cooperation with the

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
foot(ft)	0.3048	meter
square foot (ft^2)	0.0929	square meter
foot per second (ft/s)	0.3048	meter per second
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
square mile (mi^2)	2.590	square kilometer

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

Cover. Chesapeake and Ohio Canal National Historical Park at Hancock, Maryland.

(Photograph by James Gerhart, U.S. Geological Survey)

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by Edward J. Doheny

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Baltimore, Maryland

1997

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Mark Schaefer, Acting Director

For additional information write to:

District Chief
U.S. Geological Survey, WRD
8987 Yellow Brick Road
Baltimore, MD 21237

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By Edward J. Doheny

ABSTRACT

This report presents flood-hydrology data for the Potomac River and selected tributaries in the vicinity of the Chesapeake and Ohio Canal National Historical Park (C & O Canal NHP). Data were compiled for the floods of (1) March 17-19, 1936; (2) June 22-24, 1972; (3) November 4-7, 1985; (4) January 19-21, 1996; (5) September 6-8, 1996; and (6) the peak of record for 6 U.S. Geological Survey (USGS) streamflow-gaging stations on the Potomac River and 10 streamflow-gaging stations on selected tributaries to the Potomac River. Peak discharge, peak gage height, the date and time of the peak, and approximate recurrence interval are presented for each flood event at these streamflow-gaging stations.

Data compiled from selected high-flow discharge measurements at the six Potomac River streamflow-gaging stations are presented. The gage height, top width, cross-sectional area, mean velocity, maximum velocity, and discharge are presented for each selected discharge measurement. Any corresponding discharge on the C & O Canal that was measured or estimated during these discharge measurements is presented. Ranges of Manning's roughness coefficient were computed for the range of selected discharge measurements based on estimates of water-surface slope or the channel-bed slope.

An inventory of selected flood studies and reports, and additional USGS data collected along the Potomac River and the C & O Canal NHP also are presented. Included are (1) a listing of selected flood studies and reports, and (2) a listing of USGS indirect flood-discharge measurements that have been made at the six Potomac River streamflow-gaging stations in the vicinity of the C & O Canal NHP. Information on historical streamflow-gaging station records and discharge measurements on the C & O Canal also is presented.

INTRODUCTION

The Chesapeake and Ohio Canal National Historical Park (C & O Canal NHP) is operated by the U.S. Department of the Interior, National Park Service (NPS). The park extends from Cumberland, Md., to Georgetown in the District of Columbia. The C & O Canal and its towpath are located well within the flood plain of the Potomac River. The towpath is a historic structure that serves as an important corridor for visitor recreation, including horse, bicycle, and pedestrian uses.

The C & O Canal NHP is often impacted by flooding on the Potomac River. Since being established in January 1971, the park has experienced four major flood events--in June 1972, November 1985, January 1996, and September 1996--causing significant damage to the C & O Canal, towpath, and other park infrastructure. The costs associated with park repairs has risen into the tens of millions of dollars. Flooding and subsequent damage to the C & O Canal NHP has emphasized a need for the NPS to begin (1) correlating park-related flood damage with specific flood events in the Potomac River Basin, (2) predicting expected inundation and subsequent damage based on the magnitude and frequency of flood events, and (3) prioritizing park structures for protection from future flood damage. In order to assist NPS in meeting these objectives, the U.S. Geological Survey (USGS), in cooperation with NPS, initiated a study in November 1996 to (1) compile hydrologic data from specific flood events on the Potomac River and selected tributaries in the vicinity of the C & O Canal NHP, and (2) inventory selected resources and flood-study information along the Potomac River and the C & O Canal NHP.

Purpose and Scope

This report presents hydrologic data on flooding of the Potomac River and selected tributaries to the Potomac River in the vicinity of the C & O Canal NHP. An inventory of selected reports, flood studies, and additional USGS data along the Potomac River and C & O Canal NHP is presented.

This report presents data that were compiled for the floods of (1) March 17-19, 1936; (2) June 22-24, 1972; (3) November 4-7, 1985; (4) January 19-21, 1996; (5) September 6-8, 1996; and (6) the peak of record for 6 USGS streamflow-gaging stations on the Potomac River and 10 USGS streamflow-gaging stations on selected tributaries in the vicinity of the C & O Canal NHP (fig. 1). The peak discharge, peak gage height, the date and time of the peak, and approximate recurrence interval are presented for each flood event.

Data compiled from selected high-flow discharge measurements at the six Potomac River streamflow-gaging stations are presented. Gage height, top width, cross-sectional area, mean velocity, maximum velocity, mean depth, and discharge are presented for each selected discharge measurement. Any corresponding estimates or measurements of discharge on the C & O Canal are also presented for each selected discharge measurement. Ranges of Manning's roughness coefficient (Manning's n) were computed for the range of selected discharge measurements based on estimates of water-surface slope or the channel-bed slope. These data will be used for subsequent hydraulic studies by engineers for maintenance, protection, or restoration of the C & O Canal.

The report also provides an inventory of selected flood studies and reports related to the Potomac River Basin in the vicinity of the C & O Canal NHP. A listing of USGS indirect flood discharge measurements that have been made at the six Potomac River streamflow-gaging stations in the vicinity of the C & O Canal NHP is provided. Information on historical streamflow-gaging station records and discharge measurements on the C & O Canal also is presented.

Acknowledgments

The author would like to thank Patrick L. Toops of the National Park Service, C & O Canal NHP, for planning assistance. Special thanks are extended to the U.S. Geological Survey, West Virginia District, for providing additional data and technical information on streamflow-gaging stations near the Potomac River in West Virginia.

FLOOD-HYDROLOGY DATA FOR THE POTOMAC RIVER

Flood-hydology data were compiled for six USGS streamflow-gaging stations on the Potomac River in the vicinity of the C & O Canal NHP. The streamflow-gaging stations are (1) Station 01603000, North Branch Potomac River near Cumberland, Md.; (2) Station 01610000, Potomac River at Paw Paw, W. Va.; (3) Station 01613000, Potomac River at Hancock, Md.; (4) Station 01618000, Potomac River at Shepherdstown, W. Va.; (5) Station 01638500, Potomac River at Point of Rocks, Md.; and (6) Station 01646500, Potomac River at Little Falls near Washington, D.C. Data compiled for these streamflow-gaging stations include (1) basic data regarding the drainage basin and the station, (2) peak-flow data and recurrence intervals for selected flood events, and (3) flow characteristics that were defined in selected discharge measurements made at the stations.

Basic Data

Basic data compiled for each of the six Potomac River streamflow-gaging stations include the (1) latitude and longitude of the station, (2) period of gage record, (3) drainage area at the station, (4) percentage of the total basin drainage area, and (5) mean sea level datum of the station in relation to the National Geodetic Vertical Datum (NGVD) of 1929. This information is listed in table 1.

Peak Flows and Recurrence Intervals

Peak-flow data and approximate recurrence intervals were compiled for the six Potomac River streamflow-gaging stations for the floods of (1) March 17-19, 1936; (2) June 22-24, 1972; (3) November 4-7, 1985; (4) January 19-21, 1996; and (5) September 6-8, 1996. Data for the peak of record also were compiled if the peak occurred during a different flood event than those listed above. The peak-flow data that were compiled included the peak gage height, peak discharge, and the date and time of the peak. An approximate recurrence interval for each event was determined from the station data, and techniques described by the Interagency Advisory Committee on Water Data (1982) and Dillow (1996).

The recurrence interval of a specific flood is the average number of years between floods equal to or greater than that specific flood. It is emphasized that this is an average number of years and does not imply that it will be that many years before another event of that magnitude occurs. Similar or greater events can occur in the same year, as demonstrated by the 1996 floods on the Potomac River. The reciprocal of the recurrence interval is the probability of the event occurring in any one year. For instance, a 100-year flood has a 0.01 probability, or 1 percent chance, of occurring in any year (Lescinsky, 1987).

Peak-flow data and approximate recurrence intervals for the six Potomac River streamflow-gaging stations during the specified flood events are shown in table 2. A flood hydrograph for the streamflow-gaging station on the Potomac River at Point of Rocks, Md., during the flood of January 19-21, 1996, is shown as an example (fig. 2).

Selected Discharge Measurements

Data from selected historical discharge measurements were compiled for the six USGS streamflow-gaging stations on the Potomac River in the vicinity of the C & O Canal NHP. Twelve to thirteen measurements were selected for each streamflow-gaging station that represented a range of high-flow events. The date of the measurement, the sequential measurement number, gage height, top width, cross-sectional area, mean velocity, maximum velocity, mean depth, and discharge are presented for each selected discharge measurement. If any corresponding flow in the C & O Canal was estimated or measured during the measurement, this value also is presented. The maximum velocity is presented in two ways. The section maximum mean velocity is presented as the maximum mean velocity measured in any measurement subsection along the cross section. When discharge measurements are made, the mean velocity in each measurement subsection is determined as the average of point velocities measured at 0.2 and 0.8 of the depth of the subsection at that point, provided that the depth is 2.5 ft or greater at that point. If the depth of the measurement subsection is less than 2.5 ft, the mean velocity for the measurement subsection is

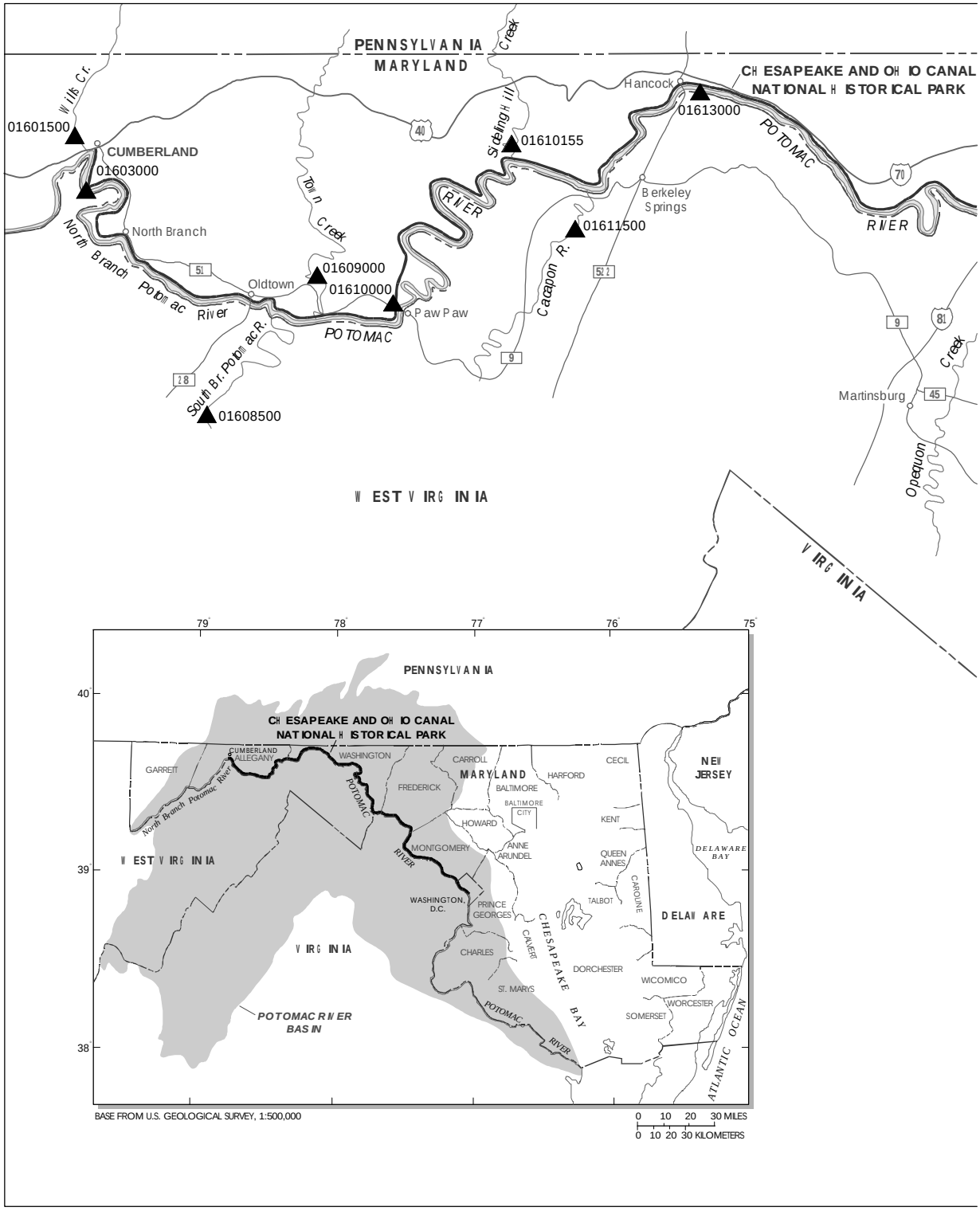

Figure 1. Locations of U.S. Geological Survey streamflow-gaging stations on the Potomac River and selected tributaries in the vicinity of the Chesapeake and Ohio Canal National Historical Park, Maryland, West Virginia, and the District of Columbia. [Modified from Taylor and others, 1984.]

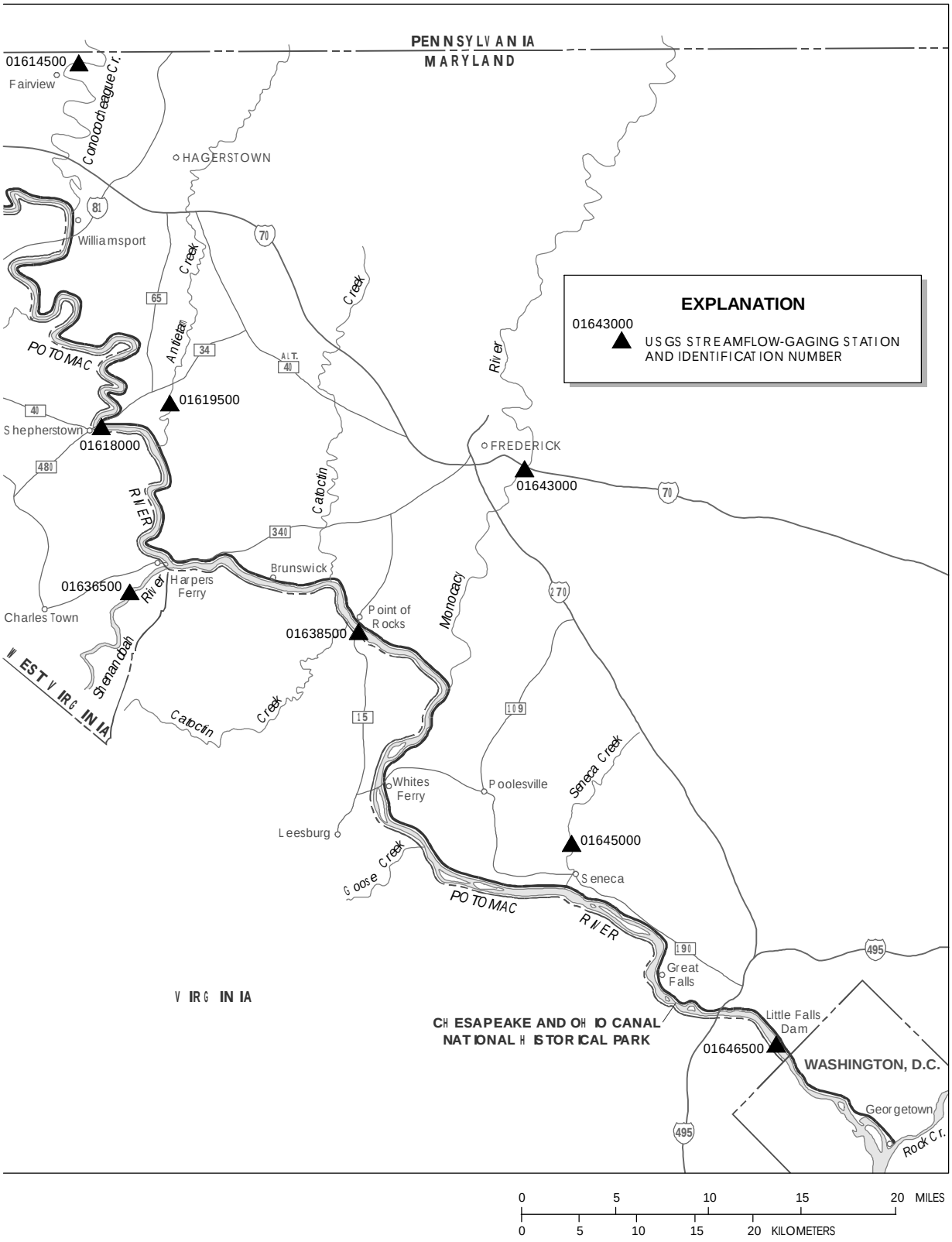
PENNSYLVANIA
MARYLAND
WEST VIRGINIA
VIRGINIA
01614500
Fairview
Conococheague Cr.
HAGERSTOWN
Williamsport
POTOMAC
Antietam Creek
Catoctin Creek
Monocacy River
01619500
Shepherstown
01618000
RIVER
Harpers Ferry
01636500
Charles Town
Brunswick
Point of Rocks
01638500
Shenandoah
Catoctin Creek
FREDERICK
01643000
Whites Ferry
Poolesville
Seneca Creek
Leesburg
01645000
Seneca
Goose Creek
POTOMAC RIVER
Great Falls
CHESAPEAKE AND OHIO CANAL
NATIONAL HISTORICAL PARK
Little Falls Dam
01646500
WASHINGTON, D.C.
Georgetown
Rock Cr.
EXPLANATION
01643000
USGS STREAMFLOW-GAGING STATION AND IDENTIFICATION NUMBER
0 5 10 15 20 MILES
0 5 10 15 20 KILOMETERS

Table 1. *Basic data for Potomac River streamflow-gaging stations in the vicinity of the Chesapeake and Ohio Canal National Historical Park*

[° = degrees, ‘ = minutes, “ = seconds; % = percentage]

Station no.	Station name and location	Latitude (° ‘ “)	Longitude (° ‘ “)	Period of record (years)	Drainage area at gage (square miles)	Percentage of total basin drainage area (%)	Station datum (feet above sea level)
01603000	North Branch Potomac River near Cumberland, Md.	39 37 18	78 46 24	1929 to present	875	6.0	585.22
01610000	Potomac River at Paw Paw, W. Va.	39 32 20	78 27 24	1938 to present	3,109	21.2	487.88
01613000	Potomac River at Hancock Md.	39 41 49	78 10 39	1932 to present	4,073	27.8	383.68
01618000	Potomac River at [1] Shepherdstown, W. Va.	39 26 04	77 48 07	1928-53 1964-93	5,936	40.5	281.00
01638500	Potomac River at Point of Rocks, Md.	39 16 25	77 32 35	1895 to present	9,651	65.8	200.63
01646500	Potomac River at Little Falls near Washington, D.C.	38 56 58	77 07 40	1930 to present	11,560	78.8	37.95

.[1] Annual maximum discharges were recorded from 1954 to 1964.

determined by measuring a point velocity at 0.6 of the depth of the subsection at that point. The section maximum point velocity is presented as the maximum point velocity measured at any point in any measurement subsection along the cross section. Tables 3 through 8 summarize selected discharge-measurement data for high flows at the six USGS streamflow-gaging stations on the Potomac River in the vicinity of the C & O Canal NHP.

The discharge in a uniform-flow channel can be determined by use of the following empirical formula:

$$Q = (1.49/n) \cdot (A) \cdot (RH)^{2/3} \cdot (S)^{1/2}$$

where

Q is the discharge, in cubic feet per second;

n is the dimensionless Manning roughness coefficient, or Manning’s n;

A is the cross-sectional area of the channel cross section, in square feet;

RH is the hydraulic radius of the channel cross section, in feet; and

S is the channel-bed slope or the water-surface slope.

Table 2. *Peak-flow data and approximate recurrence intervals for Potomac River streamflow-gaging stations in the vicinity of the Chesapeake and Ohio Canal National Historical Park*

[An asterisk (*) indicates the peak of record for the gaging stations; > = greater than]

Park

Date of peak	Time of peak (hours)	Peak gage height (feet)	Peak discharge (cubic feet per second)	Recurrence interval (years)
		01603000 North Branch Potomac River near Cumberland, Maryland		
06/01/1889*	Unknown	29.20	89,000	>100
03/17/1936	2330	29.10	88,200	>100
06/23/1972	1800	14.55	17,400	2
11/05/1985	0915	18.85	25,500	4
01/19/1996	1545	25.56	59,200	50
09/07/1996	0515	22.48	42,300	20
		01610000 Potomac River at Paw Paw, West Virginia		
03/18/1936*	0800-1000	54.00	240,000	>100
06/23/1972	2100	28.83	64,500	5
11/06/1985	2215	53.60	235,000	>100
01/20/1996	1030	40.86	122,000	35
09/07/1996	1830	43.45	140,000	60
		01613000 Potomac River at Hancock, Maryland		
03/18/1936 *	1800	47.60	340,000	>100
06/23/1972	0800	30.79	112,000	8
11/06/1985	0630	41.20	207,000	50
01/20/1996	1515	36.29	152,000	20
09/08/1996	0200	35.81	148,000	20
		01618000 Potomac River at Shepherdstown, West Virginia		
03/19/1936*	0600	42.10	335,000	>100
06/23/1972	2330	31.58	187,000	25
11/07/1985	0030	31.44	187,000	25
01/1996		Gaging station discontinued		
09/1996		Gaging station discontinued		

Table 2. *Peak-flow data and approximate recurrence intervals for Potomac River streamflow-gaging stations in the vicinity of the Chesapeake and Ohio Canal National Historical Park--Continued*

Date of peak	Time of peak (hours)	Peak gage height (feet)	Peak discharge (cubic feet per second)	Recurrence interval (years)
		01638500 Potomac River at Point of Rocks, Maryland		
03/19/1936 *	0930	41.03	480,000	>100
06/23/1972	2330	37.43	347,000	55
11/07/1985	0330	36.28	309,000	35
01/21/1996	0430	36.54	313,000	40
09/08/1996	1500	36.32	310,000	40
		01646500 Potomac River at Little Falls near Washington, D.C.		
03/19/1936*	1645	28.10	484,000	90
06/24/1972	0330	22.03	359,000	35
11/07/1985	1315	18.00	317,000	23
01/21/1996	1230	19.29	347,000	30
09/08/1996	2315	17.84	314,000	23

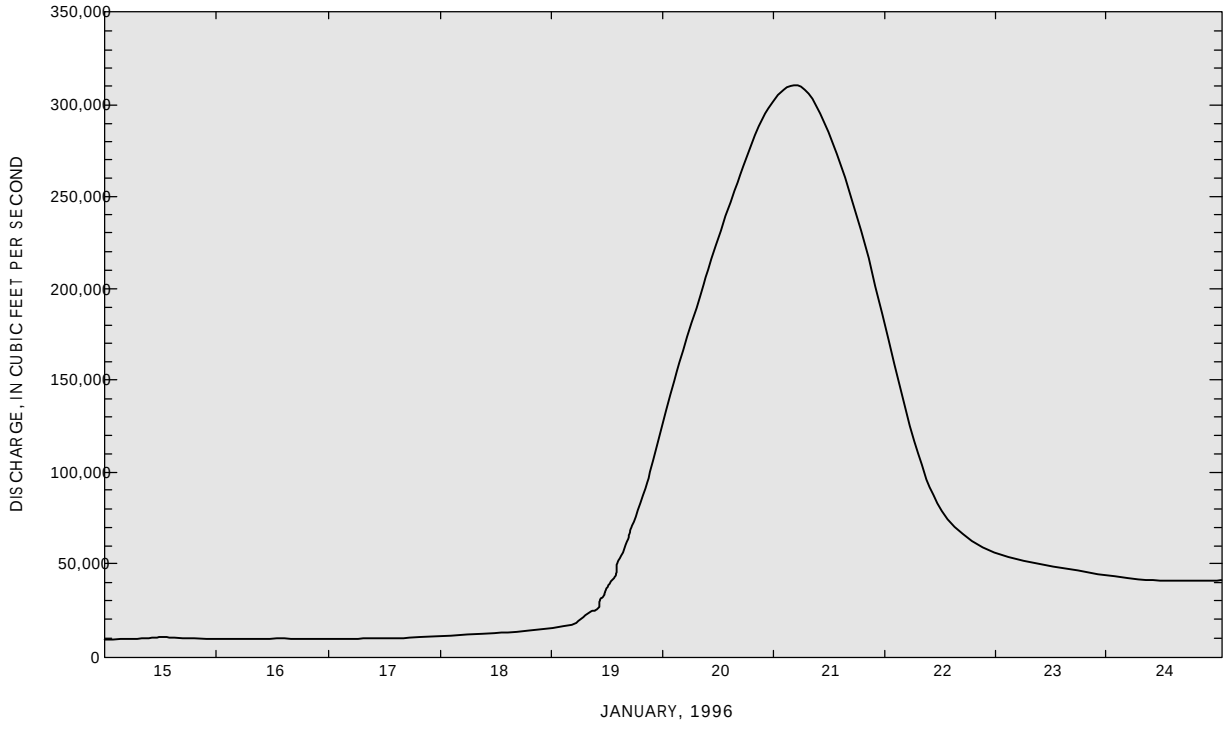

Figure 2. Flood hydrograph for U.S. Geological Survey streamflow-gaging station 01638500, Potomac Riv at Point of Rocks, Maryland during the flood of January 19-21, 1996.

When uniform flow is assumed in an open channel, the longitudinal lines of the channel bed and water surface are parallel to each other, and the slopes of these parallel lines are equal (Hwang and Hita, 1987). If estimates of water-surface slope or channel-bed slope can be made in the vicinity of a streamflow-gaging station, discharge-measurement data can be used to determine an approximate Manning's n value for the measured flow conditions.

Ranges of Manning's n were calculated for the ranges of discharge and flow conditions presented in tables 3 through 8, based on the assumption of uniform flow conditions. The calculations were made using estimates of water-surface slope that were based on previous flood studies (Somervell, 1930), and flood insurance studies (Federal Emergency Management Agency, 1981, 1985, 1989). Where information on water-surface slope was not available, channel-bed slopes were determined by use of USGS topographic maps. These channel-bed slopes were used as an estimate of water-surface slope. The calculated values of Manning's n apply to the entire crosssection that was used during the discharge measurement. Insufficient data exist to calculate Manning's n values for flows in the C & O Canal for these discharge measurements. However, approximations can be made using accepted hydraulic design practices. Table 9 summarizes the general ranges of Manning's n values for the selected discharges and flow conditions presented in tables 3 through 8.

Table 9 shows a large range of Manning's n values for the selected flow conditions at most gaging stations. Direct measurements of water-surface slope during discharge measurements could serve to (1) provide a means to directly calculate Manning's n for any discharge measurement, and (2) provide a means to calibrate the ranges of Manning's n values presented in table 9.

FLOOD-HYDROLOGY DATA FOR SELECTED TRIBUTARIES

Flood-hydology data were compiled for 10 USGS streamflow-gaging stations on selected tributaries to the Potomac River in the vicinity of the C & O Canal NHP. The streamflow-gaging stations are (1) Station 01601500, Wills Creek near Cumberland, Md.; (2) Station 01608500, South Branch Potomac River near Springfield, W. Va.; (3) Station 01609000, Town Creek near Oldtown, Md.; (4) Station 01610155, Sideling Hill Creek near Bellegrove, Md.; (5) Station 01611500, Cacapon River near Great Cacapon, W. Va.; (6) Station 01614500, Conococheague Creek at Fairview, Md.; (7) Station 01619500, Antietam Creek near Sharpsburg, Md.; (8) Station 01636500, Shenandoah River at Millville, W. Va.; (9) Station 01643000, Monocacy River at Jug Bridge near Frederick, Md.; and (10) Station 01645000, Seneca Creek at Dawsonville, Md. Data compiled for these streamflow-gaging stations include (1) basic data regarding the drainage basin and the station, and (2) peak-flow data and recurrence intervals for the five selected flood events and the peak of record.

Basic Data

Basic data compiled for each of the 10 Potomac River tributary streamflow-gaging stations include the (1) latitude and longitude of the station, (2) period of gage record, (3) drainage area at the station, (4) percentage of the total basin drainage area, and (5) mean sea level (NGVD) datum of the station. This information is listed in table 10.

Peak Flows and Recurrence Intervals

Peak-flow data and approximate recurrence intervals were compiled for the 10 Potomac River tributary streamflow-gaging stations for the five selected flood events and for the peak of record. For some stations, data were not available for some flood events because the station was not in operation at the time of the specified flood event. Peak-flow data and approximate recurrence intervals for the 10 Potomac River tributary streamflow-gaging stations during the specified flood events are shown in table 11. A flood hydrograph for the streamflow-gaging station at Conococheague Creek at Fairview, Md., during the flood of January 19-21, 1996, is shown as an example (fig. 3).

Table 3. *Selected discharge-measurement data for high flows at U.S. Geological Survey streamflow-gaging station 01603000, North Branch Potomac River near Cumberland, Maryland*

[ft = feet; ft^2= square feet; ft/s = feet per second; ft^3/s= cubic feet per second; --, no data available]

Date	Measure-ment no.	Gage height (ft)	Top width (ft)	Cross-sectional area (ft^2)	Mean velocity (ft/s)	Maximum mean velocity (ft/s)	Maximum point velocity (ft/s)	Mean depth (ft)	River discharge (ft^3/s)	C & O Canal discharge (ft^3/s)
02/14/1984	603	14.54	374	3,540	5.08	7.54	7.97	9.47	18,000	--
04/03/1970	464	13.12	247	2,720	5.26	8.00	8.90	11.01	14,300	--
03/07/1967	428	18.59	399	4,730	5.41	9.30	9.89	11.85	25,600	--
04/30/1964	376	13.37	249	2,770	5.52	8.16	9.07	11.12	15,300	--
05/09/1960	328	13.84	303	3,180	4.87	7.88	8.68	10.50	15,900[a]	--
05/06/1958	304	14.08	240	2,940	5.14	7.62	8.71	12.25	15,100	--
08/19/1955	275	22.24	302	4,840	5.99	9.78	10.16	16.03	32,200[a]	--
12/30/1954	266	13.70	303	3,000	4.83	7.02	7.57	9.90	14,500	--
06/14/1951	221	14.53	237	3,070	5.10	8.02	8.99	12.95	15,400	--
04/27/1937	58	17.14	382	4,230	4.92	8.62	8.95	11.07	20,800[a]	--
05/13/1932	25	15.40	382	3,700	4.98	7.32	8.04	9.69	18,400[a]	--
05/12/1932	24	14.26	382	3,320	4.92	8.57	8.57	8.69	16,300[a]	--

[a] Discharge adjusted for rapidly changing stage during measurement.

Table 4. *Selected discharge-measurement data for high flows at U.S. Geological Survey streamflow-gaging station 01610000, Potomac River at Paw Paw, West Virginia*

[ft = feet; ft^2 = square feet; ft/s = feet per second; ft^3/s = cubic feet per second; --, no data available]

Date	Measurement no.	Gage height (ft)	Top width (ft)	Cross-sectional area (ft^2)	Mean velocity (ft/s)	Maximum mean velocity (ft/s)	Maximum point velocity (ft/s)	Mean depth (ft)	River discharge (ft^3/s)	C & O Canal discharge (ft^3/s)
08/01/1996	364	18.85	330	4,820	6.58	8.72	9.46	14.64	31,700	--
02/23/1971	264	22.10	414	6,730	6.29	9.54	10.61	16.26	42,300	--
04/30/1964	210	23.21	540	7,270	6.12	9.21	10.36	13.46	44,500	--
02/26/1961	193	24.80	531	7,770	6.73	10.86	11.10	14.63	52,300	--
08/19/1955	161	34.40	557	12,600	6.68	11.22	13.00	22.62	84,200	--
03/23/1955	156	21.42	414	5,830	6.24	8.68	10.34	14.08	36,400	--
06/14/1951	120	25.17	345	6,884	7.33	9.96	11.34	19.95	50,400	--
12/08/1950	116	24.13	337	6,617	7.31	9.78	11.11	19.64	48,400	--
06/19/1949	97	32.13	549	11,470	6.65	11.20	12.46	20.89	76,300	--
05/17/1942	34	17.96	328	4,760	5.58	7.42	8.77	14.50	26,500	--
02/04/1939	13	28.72	351	9,436	6.96	13.61	13.61	26.90	65,700	--
01/31/1939	8	19.10	378	5,481	5.54	7.76	8.91	14.50	30,400[a]	--

[a] Discharge adjusted for rapidly changing stage during measurement.

Table 5. *Selected discharge-measurement data for high flows at U.S. Geological Survey streamflow-gaging station 01613000, Potomac River at Hancock, Maryland*

[ft = feet; ft^2 = square feet; ft/s = feet per second, ft^3/s= cubic feet per second; --, no data available]

Date	Measure-ment no.	Gage height (ft)	Top width (ft)	Cross-sectional area (ft^2)	Mean velocity (ft/s)	Maximum mean velocity (ft/s)	Maximum point velocity (ft/s)	Mean depth (ft)	River discharge (ft^3/s)	C & O Canal discharge (ft^3/s)
03/21/1996	402	15.34	623	8,210	4.20	5.78	7.26	13.18	34,500[a]	--
04/26/1983	360	18.13	600	8,850	4.78	7.88	8.54	14.75	42,300[a]	--
02/23/1971	305	19.41	490	9,100	5.25	8.40	8.78	18.57	47,800	--
03/08/1967	280	26.54	1,350	16,500	5.06	10.25	10.97	12.22	83,500	--
05/10/1960	231	17.76	635	9,040	3.99	7.30	7.95	14.24	38,300[a]	--
04/06/1960	230	19.87	631	10,050	4.43	7.96	8.87	15.93	44,500[a]	--
08/20/1955	202	24.71	830	11,100	5.33	8.58	13.60	13.37	67,800	--
10/17/1954	192	24.92	1,005	15,600	3.85	7.31	9.23	15.52	68,300	--
06/14/1951	160	23.59	685	11,100	5.99	9.72	10.27	16.20	66,500	--
10/16/1942	67	36.27	1,380	30,200	5.03	11.89	12.15	21.88	153,300	100
10/30/1937	37	17.39	675	9,110	4.40	6.73	7.55	13.50	40,100[a]	--
10/30/1937	36	21.66	736	11,100	5.34	8.53	8.78	15.08	59,300	0
10/29/1937	35	31.35	762	19,600	6.07	10.70	11.07	25.72	119,000	50[b]

[a] Discharge measured by use of horizontal angle coefficients.

[b] Estimated discharge.

Table 6. *Selected discharge-measurement data for high flows at U.S. Geological Survey streamflow-gaging station 01618000, Potomac River at Shepherdstown, West Virginia*

[ft = feet; ft^2 = square feet; ft/s = feet per second, ft^3/s= cubic feet per second; --, no data available]

Date	Measurement no.	Gage height (ft)	Top width (ft)	Cross-sectional area (ft^2)	Mean velocity (ft/s)	Maximum mean velocity (ft/s)	Maximum point velocity (ft/s)	Mean depth (ft)	River discharge (ft^3/s)	C & O Canal discharge (ft^3/s)
03/18/1982	316	14.70	640	10,600	4.76	5.87	6.54	16.56	50,400	--
03/15/1978	297	18.02	670	12,600	6.06	7.61	8.17	18.81	76,400	--
02/24/1971	273	16.88	680	12,400	5.49	7.10	7.26	18.24	68,100	--
03/07/1963	220	19.17	673	12,900	6.19	7.40	7.79	19.17	79,800	--
10/17/1954	219	21.97	673	14,800	6.73	8.32	8.82	21.99	99,700	80
06/14/1951	198	17.84	700	12,300	6.04	7.36	7.52	17.57	72,800[a]	--
12/31/1942	111	21.17	758	15,000	6.66	8.04	8.61	19.79	99,900	50
10/17/1942	108	27.52	850	20,700	7.15	9.37	10.17	24.35	148,000	--
10/16/1942	106	32.54	880	25,300	7.63	11.90	12.29	28.75	193,000	--
05/14/1932	31	23.81	566	15,000	7.27	10.20	11.81	26.50	108,000	50[b]
04/18/1929	8	18.14	563	11,800	5.95	10.16	10.21	20.96	70,200	--
04/18/1929	7	21.70	567	14,100	6.71	11.18	11.50	24.87	98,600	--

[a] Discharge adjusted for rapidly changing stage during measurement.

[b] Estimated discharge.

Table 7. *Selected discharge-measurement data for high flows at U.S. Geological Survey streamflow-gaging station 01638500, Potomac River at Point of Rocks, Maryland*

[ft = feet; ft^2 =square feet; ft/s = feet per second, ft^3/s= cubic feet per second; --, no data available]

Date	Measurement no.	Gage height (ft)	Top width (ft)	Cross-sectional area (ft^2)	Mean velocity (ft/s)	Maximum mean velocity (ft/s)	Maximum point velocity (ft/s)	Mean depth (ft)	River discharge (ft^3/s)	C & O Canal discharge (ft^3/s)
03/06/1993	355	23.99	1,464	30,300	4.92	7.80	8.17	20.73	149,000	--
02/16/1984	342	26.00	1,434	32,900	5.26	8.35	9.89	22.97	173,000	--
10/10/1976	324	25.10	1,451	32,642	4.99	8.82	9.46	22.50	163,000	--
09/27/1975	319	23.55	1,362	29,300	4.11	6.41	7.33	21.49	120,300	--
06/23/1972	311	36.49	1,564	48,200	5.98	10.26	11.53	30.80	288,000	--
08/20/1955	246	28.73	1,462	37,500	5.55	9.56	11.25	25.64	208,000	--
06/15/1951	219	17.47	1,255	20,400	5.00	7.68	8.53	16.26	102,000	--
10/18/1942	133	19.46	1,355	24,800	4.40	6.44	8.22	18.28	109,000	--
10/17/1942	132	35.24	1,565	47,700	6.12	11.28	11.66	30.50	292,000	--
04/28/1937	103	--	1,543	38,300	6.08	10.59	10.59	24.82	233,000[a]	315
05/14/1932	87	22.36	1,255	27,600	5.25	9.04	11.02	21.96	145,000	241
03/30/1924	65	19.90	1,260	25,300	5.24	10.08	10.08	20.06	132,500	--

[a] Measurement was made at Brunswick, Maryland. Gage height and discharge at Point of Rocks were 30.50 ft and 244,000 ft^3/s. Discharge for Point of Rocks was determined by correcting measured discharge for storage and inflow between Brunswick and Point of Rocks.

Table 8. *Selected discharge-measurement data for high flows at U.S. Geological Survey streamflow-gaging station 01646500, Potomac River at Little Falls near Washington, D.C.*

[ft = feet, ft^2 = square feet; ft/s = feet per second, ft^3/s= cubic feet per second; --, no data available; **Note**: All measurements were made at the 14th Street Bridge, Washington, D.C., except for measurement 326, which was made at the Key Bridge, Washington, D.C.]

Date	Measure-ment no.	Gage height (ft)	Top width (ft)	Cross-sectional area (ft^2)	Mean velocity (ft/s)	Maximum mean velocity (ft/s)	Maximum point velocity (ft/s)	Mean depth (ft)	River discharge (ft^3/s)	C & O Canal discharge (ft^3/s)
09/09/1996	330	15.75	2,195	45,200	6.12	8.09	9.07	20.60	271,000	--
09/09/1996	330	15.75	2,195	45,200	6.12	8.09	9.07	20.60	271,000	--
03/06/1993	326	12.10	940	26,700	6.85	8.98	9.46	28.40	183,000	--
11/07/1985	316	17.95	2,153	47,700	6.45	9.27	10.36	22.16	308,000	--
02/27/1979	307	12.94	2,022	46,000	4.51	7.36	8.17	22.75	204,900	--
09/27/1975	289	13.17	2,024	40,100	4.86	8.25	9.07	19.81	194,700	--
06/24/1972	285	21.58	2,260	48,440	7.18	11.56	11.93	21.43	348,000	--
06/22/1972	284	13.58	2,108	38,030	4.89	7.02	7.85	18.04	186,000	--
10/18/1942	56	17.25	1,976	44,100	4.78	7.33	--	22.32	210,800	--
10/17/1942	55	25.64	2,058	54,920	7.20	9.81	--	26.69	394,200	--
03/23/1936	26	10.07	2,047	36,600	2.50	3.44	4.08	17.88	87,200	--
03/21/1936	25	11.90	2,058	38,900	2.99	4.26	5.16	18.90	122,500	--
03/20/1936	24	22.10	2,149	50,000	6.52	10.52	10.74	23.27	314,000	--
03/19/1936	23	27.75	2,145	53,000	8.83	13.48	13.67	24.71	473,000	--

Table 9. *Calculated ranges of Manning's roughness coefficient values for selected discharges and flow conditions at Potomac River streamflow-gaging stations*

Station no.	Station name and location	Manning's roughness coefficient range
01603000	North Branch Potomac River near Cumberland, Md.	0.035-0.043
01610000	Potomac River at Paw Paw, W. Va.	0.033-0.045
01613000	Potomac River at Hancock, Md.	0.032-0.051
01618000	Potomac River at Shepherdstown, W.Va.	0.031-0.039
01638500	Potomac River at Point of Rocks, Md.	0.036-0.052
01646500	Potomac River at Little Falls near Washington, D.C.	0.021-0.047

Table 10. *Basic data for streamflow-gaging stations on tributaries to the Potomac River in the vicinity of the Chesapeake and Ohio Canal National Historical Park*

[°= degrees, ‘ = minutes, “ = seconds; % = percentage]

Station no.	Station name and location	Latitude (° ‘ “)	Longitude (° ‘ “)	Period of record (years)	Drainage area at gage (square miles)	Percentage of total basin drainage area (%)	Station datum (feet above sea level)
01601500	Wills Creek near Cumberland, Md.	39 40 07	78 47 18	1905 to 1906, 1929 to present	247	97.2	640.89
01608500	South Branch Potomac River near Springfield, W. Va.	39 26 49	78 39 16	1894 to 1896, 1899 to 1902, 1903 to 1906, 1928 to present	1,471	98.9	562.02
01609000	Town Creek near Oldtown, Md.	39 33 12	78 33 19	1928 to 1935, 1967 to 1981	148	94.9	547.97
01610155	Sideling Hill Creek near Bellegrove, Md.	39 38 58	78 20 40	1967 to 1977	102	98.5	440.41
01611500	Cacapon River near Great Cacapon, W. Va.	39 34 43	78 18 34	1922 to 1995	677	99.4	456.78
01614500	Conococheague Creek at Fairview, Md.	39 42 57	77 49 28	1928 to present	494	87.7	391.85
01619500	Antietam Creek near Sharpsburg, Md.	39 27 01	77 43 52	1897 to 1905, 1928 to present	281	96.2	311.05
01636500	Shenandoah River at Millville, W. Va.	39 16 55	77 47 22	1895 to 1909 1928 to present	3,040	99.5	293.00
01643000	Monocacy River at Jug Bridge near Frederick, Md.	39 24 13	77 21 58	1929 to present	817	84.2	231.92
01645000	Seneca Creek at Dawsonville, Md.	39 07 41	77 20 13	1930 to present	101	78.3	214.02

Table 11. *Peak-flow data and approximate recurrence intervals for selected streamflow-gaging stations on tributaries to the Potomac River in the vicinity of the Chesapeake and Ohio Canal National Historical Park*

[An asterisk (*) indicates the peak of record for the gaging stations; > = greater than]

Date of peak	Time of peak (hours)	Peak gage height (feet)	Peak discharge (cubic feet per second)	Recurrence interval (years)
		01601500 Wills Creek near Cumberland, Maryland		
03/17/1936	2300	20.20	38,100	>100
06/23/1972	1245	10.06	11,300	7
11/05/1985	0830	9.10	8,970	4
01/19/1996 *	1330	22.58	44,500	>100
09/07/1996	0000	11.54	14,900	13
		01608500 South Branch Potomac River near Springfield, West Virginia		
03/18/1936	0530	34.20	143,000	100
06/23/1972	1600	17.87	31,500	3
11/05/1985 *	Unknown	44.22	240,000	>100
01/20/1996	0430	28.36	93,500	50
09/07/1996	1000	34.99	147,000	>100
		01609000 Town Creek near Oldtown, Maryland		
03/17/1936 *	2400	19.08	27,000	>100
06/22/1972	1515	14.13	11,700	30
11/1985		Gaging station discontinued		
01/1996		Gaging station discontinued		
09/1996		Gaging station discontinued		
		01610155 Sideling Hill Creek near Bellegrove, Maryland		
03/1936		Gaging station not yet in operation		
06/22/1972 *	0915	12.44	14,200	100
11/1985		Gaging station discontinued		
01/1996		Gaging station discontinued		
09/1996		Gaging station discontinued		

Table 11. *Peak-flow data and approximate recurrence intervals for selected streamflow-gaging stations on tributaries to the Potomac River in the vicinity of the Chesapeake and Ohio Canal National Historical Park--Continued*

Date of peak	Time of peak (hours)	Peak gage height (feet)	Peak discharge (cubic feet per second)	Recurrence interval (years)
		01611500 Cacapon River near Great Cacapon, West Virginia		
03/18/1936 *	0800	30.10	87,600	>100
06/22/1972	2300	22.17	45,500	20
11/05/1985	2330	21.95	44,500	20
01/1996		Gaging station discontinued		
09/1996		Gaging station discontinued		
		01614500 Conococheague Creek at Fairview, Maryland		
03/18/1936	0500	13.27	13,700	10
06/23/1972 *	1700	24.50	32,400	>100
11/05/1985	1445	7.92	4,760	1
01/20/1996	0430	14.49	15,300	20
09/07/1996	0915	10.32	7,970	2
		01619500 Antietam Creek near Sharpsburg, Maryland		
03/18/1936	1400	8.88	3,930	4
07/20/1956 *	1700	16.73	12,600	80
06/23/1972	1400	14.30	9,880	40
11/05/1985	0445	4.93	1,210	1
01/19/1996	1500	13.71	8,960	25
09/06/1996	2145	7.03	2,600	2
		01636500 Shenandoah River at Millville, West Virginia		
03/18/1936	2030	26.36	151,000	50
10/16/1942 *	1500	32.40	230,000	>100
06/23/1972	1200	21.89	103,000	15
11/06/1985	1900	25.60	142,000	40
01/20/1996	2130	23.61	121,000	25
09/08/1996	0800	26.82	156,000	55

Table 11. *Peak-flow data and approximate recurrence intervals for selected streamflow-gaging stations on tributaries to the Potomac River in the vicinity of the Chesapeake and Ohio Canal National Historical Park--Continued*

Date of peak	Time of peak (hours)	Peak gage height (feet)	Peak discharge (cubic feet per second)	Recurrence interval (years)
		0164300 Monocacy River at Jug Bridge near Frederick, Maryland		
03/18/1936	1230	9.95	8,640	1
06/23/1972 *	0600	35.90	81,600	>100
11/05/1985	0830	8.02	5,610	1
01/20/1996	1230	23.67	37,400	15
09/07/1996	2030	17.74	21,600	3
		01645000 Seneca Creek at Dawsonville, Maryland		
03/18/1936	0230	3.99	820	1
06/22/1972 *	0200	16.40	26,100	100
11/05/1985	0445	4.27	862	1
01/19/1996	2200	10.41	9,290	11
09/07/1996	0415	9.48	6,370	6

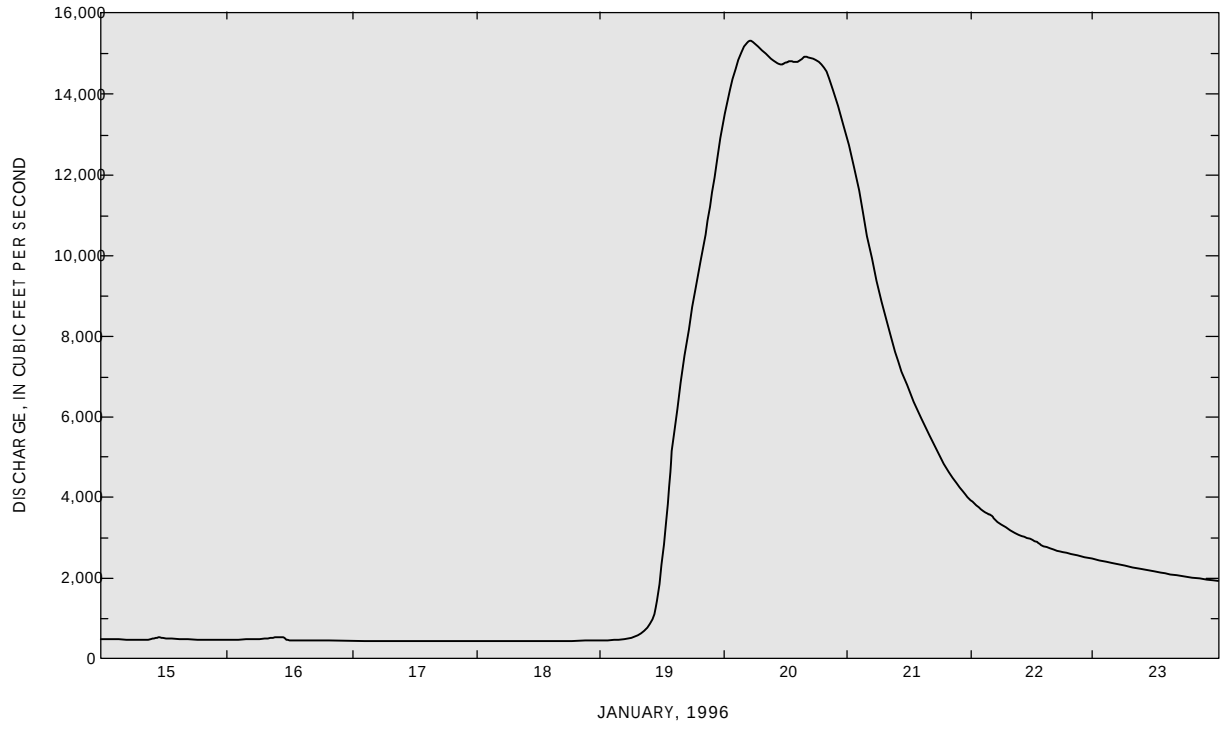

Figure 3. Flood hydrograph for U.S. Geological Survey streamflow-gaging station 01614500, Conococheague at Fairview, Maryland during the flood of January 19-21, 1996.

A list of additional USGS streamflow-gaging stations with surface-water data in the vicinity of the C & O Canal NHP also was prepared. This list is shown in the appendix.

ADDITIONAL INFORMATION AND RESOURCES

A search was conducted of (1) the libraries of the USGS Maryland-Delaware-D.C. District office and the Interstate Commission on the Potomac River Basin, and (2) original USGS data files, to compile information and resources related to flooding in the Potomac River Basin in the vicinity of the C & O Canal NHP. Records at these locations are among the most complete available. An inventory of significant flood studies and reports pertaining to the Potomac River Basin in the vicinity of the C & O Canal NHP is presented in the following section. USGS indirect flood-discharge measurements that have been made at the six USGS streamflow-gaging stations on the Potomac River in the vicinity of the C & O Canal NHP also are listed. Information on historical streamflow-gaging station records and discharge measurements on the C & O Canal is summarized.

Flood Studies and Reports

The following inventory of flood studies and reports on the Potomac River Basin in the vicinity of the C & O Canal NHP is sorted by category. Report categories include (1) USGS Annual Water-Resources Data Reports, (2) USGS Water-Supply Papers, (3) other flood studies and reports, and (4) flood-insurance studies.

USGS Annual Water-Resources Data Reports: The USGS releases an annual water-resources data report for each water year, which runs from October 1st of one year to September 30th of the next. For example, October 1, 1996 to September 1, 1997 is referred to as "Water Year 1997". These reports have been published for Maryland and West Virginia on a yearly basis since 1961. The reports summarize flow conditions at all active USGS streamflow-gaging stations for the given water year. This includes such information as mean daily discharges for each day of the water year, mean annual discharge, and the instantaneous peak gage height and discharge at each streamflow-gaging station for the given water year (U.S. Geological Survey, 1961-95).

USGS Water-Supply Papers: Prior to 1961, USGS streamflow-gaging station records were published as part of a report series entitled "Water-Supply Papers." Water-Supply Papers are publications that are intended to present significant interpretive results of hydrologic investigations that are broader than local interest. Specific Water-Supply Papers (WSP) that were used in the preparation of this report include:

a. WSP 800, The Floods of March, 1936, Part III, Potomac, James, and Upper Ohio Rivers (Grover, 1937).

b. WSP 971, Surface Water Supply of the United States, 1943, part 1B, North Atlantic Slope Basins, New York to York River (Parker and others, 1945).

c. WSP 1302, Compilation of Records of Surface Waters of the United States through September, 1950, part 1B, North Atlantic Slope Basins, New York to York River (Wells and others, 1960).

d. WSP 1432, Surface Water Supply of the United States, 1956, part 1B, North Atlantic Slope Basins, New York to York River (Wells and others, 1959).

e. WSP 1672, Magnitude and Frequency of Floods in the United States, part 1B, North Atlantic Slope Basins, New York to York River (Tice, 1968).

f. WSP 1722, Compilation of Records of Surface Waters of the United States, October 1950 to September 1960, part 1B, North Atlantic Slope Basins, New York to York River (Hendricks and others, 1964).

Other Flood Studies and Reports: Often studies are conducted and reports are prepared in the aftermath of major floods. These studies and reports usually document peak gage heights and peak discharges for streamflow-gaging stations during a specific flood event. Some studies and reports may present estimated flood profiles for specific flood events or for flood events of a certain

magnitude or frequency. Others may contain descriptive material about specific flood events. The subjects and authors of notable studies and reports related to flooding in the Potomac River Basin in the vicinity of the C & O Canal NHP are listed below in chronological order.

a. Development of Great Falls for Water Power and Increase of Water Supply for the District of Columbia (U.S. Army Corps of Engineers, 1921).

b. Report to the Chief of Engineers, U.S. Army on the Potomac River and its Tributaries, Including Occoquan Creek (Somervell, 1930).

c. Floods of 1936 and 1937 (Pennsylvania Railroad Company, 1937).

d. Flow Data and Draft Storage Curves for Major Streams, 1929-1937 (Maryland Water Resources Commission, State Planning Commission, 1940).

e. Storm and Flood of October 16, 17, 18, 1942 (U.S. Army Corps of Engineers, 1942).

f. Joint Reconnaissance Survey and Study of the Chesapeake and Ohio Canal, Between Great Falls, Maryland and Cumberland, Maryland (Bureau of Public Roads and National Park Service, 1950).

g. Storms and Floods of August, 1955 (U.S. Army Corps of Engineers, 1955).

h. The Water Resources of Carroll and Frederick Counties (Beall and Meyer, 1958).

i. Maryland Streamflow Characteristics; Flood Frequency, Low Flow Frequency, and Flow Duration (Darling, 1962).

j. Tropical Storm Agnes--June, 1972, Basins of the Susquehanna and Potomac Rivers and Maryland Portions of Chesapeake Bay and Atlantic Coast, Post Flood Report, Volume 1, Meteorology and Hydrology (Prepared by Gannett, Fleming, Corddry, and Carpenter Engineers for the U.S. Army Corps of Engineers, Baltimore District, 1974).

k. Flood Plain Information, Frederick County, Potomac River, Maryland (U.S. Army Corps of Engineers, 1975).

l. USGS Professional Paper 924, Hurricane Agnes Rainfall and Floods, June-July, 1972 (Bailey and others, 1975).

m. Historic Structure Report, Chesapeake and Ohio Canal Dam Number 2 and Associated Structures (Unrau, 1976a).

n. The Major Floods of the Potomac River and Their Effect on the Chesapeake and Ohio Canal: 1828-1936 (Unrau, 1976b).

o. Tropical Storm Eloise, September, 1975, Susquehanna and Potomac River Basins, Post Flood Report (U.S. Army Corps of Engineers, 1976).

p. Flood Plain Information, Washington County, Potomac River, Maryland, Part 1, (U.S. Army Corps of Engineers, 1977).

q. Floodplain Reconnaissance Study, November 1985 Flood, Potomac River Basin (Scatena, 1986).

r. USGS Open-File Report 86-486, Flood of November, 1985 in West Virginia, Pennsylvania, Maryland, and Virginia (Lescinsky, 1987).

s. USGS Water-Resources Investigations Report 88-4213, Floods in West Virginia, Virginia, Pennsylvania, and Maryland, November 1985 (Carpenter, 1988).

t. C & O Canal: The Making of a Park (MacKintosh, 1991).

Most of these studies and reports provide hydrologic data, peak-flow data or descriptive information for certain flood events. A few of the U.S. Army Corps of Engineers' publications provide flood profiles for certain flood events or cross sections of the Potomac River in various locations.

Flood-Insurance Studies: The Federal Emergency Management Agency (FEMA) publishes flood-insurance studies for Maryland counties and some specific towns and communities along the Potomac River. The reports for these studies contain various hydrologic and hydraulic

data for streams and rivers within the study area. Cross-sectional data are usually obtained from USGS topographic maps or from field surveys. Hydraulic data and flood profiles are usually determined by use of step-backwater hydraulic modeling. Most FEMA flood-insurance studies present drainage areas, peak-flow data, and recurrence-interval information, as of the most recent date that the information was updated. Channel widths, cross-sectional areas, and mean velocities are presented for different segments of each stream or river that is studied. Flood profiles are presented for each stream or river that is studied for the 10-year, 50-year, 100-year, and 500-year recurrence intervals.

FEMA flood-insurance studies for counties and towns in the vicinity of the C & O Canal NHP include the Town of Hancock, Md. (FEMA, 1981), the City of Cumberland, Md. (FEMA, 1983), the District of Columbia (FEMA, 1985), and Allegany County, Md. (FEMA, 1989). These reports contain data and flood profiles for the North Branch Potomac River and Potomac River. Reports are available for Frederick County, Md. (FEMA, 1991), Washington County, Md. (FEMA, 1992a), and Montgomery County, Md. (FEMA, 1992b), but data and flood profiles for the Potomac River are not included in these reports. A flood-insurance report was published for the Town of Williamsport, Md. (U.S. Department of Housing and Urban Development, Federal Insurance Administration, 1976), but was not available for review.

Indirect Flood-Discharge Measurements

The discharge of streams and rivers is usually measured directly using a current meter. During floods, however, it is sometimes impossible or impractical to measure the discharge by this method. Consequently, some peak discharges must be determined after the passage of the flood by indirect methods, such as slope-area, contracted-opening, flow-over-dam, and flow-through-culvert, rather than by direct current-meter measurement (Benson and Dalrymple, 1967).

Indirect methods of determining flood discharge are based on hydraulic equations which relate the discharge to the water-surface profile and geometry of the channel. A field survey is made after the flood to determine the location of high-water marks and the physical characteristics of the channel (Benson and Dalrymple, 1967). Hydraulic equations that are most appropriate for the study reach are then solved based on the field data to determine the peak discharge for the study reach.

Indirect flood-discharge measurements can provide information such as (1) records of high-water marks, (2) cross-section geometry and diagrams, (3) estimates of Manning's n, and (4) calculations of water-surface slopes. The data files of the USGS Maryland-Delaware-D.C. District were searched to inventory indirect flood-discharge measurements that have been made at the six USGS streamflow-gaging stations on the Potomac River in the vicinity of the C & O Canal NHP. The results of the search are listed below.

Station 01603000, North Branch Potomac River near Cumberland, Md.--An indirect measurement of peak discharge was made for the flood of March 17-19, 1936. The peak discharge was determined to be 88,200 ft ^{3}/s, including documentation of flow in the overbank areas.

Station 0161000, Potomac River at Paw Paw, W. Va.--An indirect measurement of peak discharge was made for the flood of March 17-19, 1936. The peak discharge was determined to be 240,000 ft ^{3}/s, including documentation of flow in the overbank areas and the C & O Canal. The results indicated that a peak discharge of approximately 3,000 ft ^{3}/s was carried in the C & O Canal for this event.

Station 01613000, Potomac River at Hancock, Md.--An indirect measurement of peak discharge was made for the flood of March 17-19, 1936. The peak discharge was determined to be 340,000 ft ^{3}/s, including documentation of flow in the overbank areas and the C & O Canal. The results indicated that a peak discharge of approximately 1,700 ft ^{3}/s was carried in the C & O Canal for this event.

An indirect measurement of peak discharge was also made for the flood of April 27, 1937. The peak discharge was determined to be 153,000 ft ^{3}/s, including documentation of flow in the overbank areas. The flow for this event did not overtop the C & O Canal as it did in March 1936. However, the water surface at the peak was nearly level with the top of the towpath.

Station 01618000, Potomac River at Shepherdstown, W. Va.--High watermarks were documented for the flood of April 27, 1937. An indirect measurement of peak discharge was made for the flood of October 16-18, 1942. The results indicated a peak discharge of 190,000 ft ^{3}/s, including documentation of flow in the overbank areas and the C & O Canal. Estimates of flow in the C & O Canal ranged from 1,280 ft ^{3}/s to 1,780 ft ^{3}/s depending on the location and hydraulic characteristics of the measured cross sections.

Station 01638500, Potomac River at Point of Rocks, Md.--An indirect measurement of peak discharge was made for the flood of March 17-19, 1936. The peak discharge was determined to be 480,000 ft ^{3}/s, including documentation of flow in the overbank areas and the C & O Canal. Estimates of flow in the C & O Canal ranged from 1,700 ft ^{3}/s to 3,630 ft ^{3}/s depending on the location and hydraulic characteristics of the measured cross sections.

Streamflow-Gaging Stations on the Chesapeake and Ohio Canal

The USGS previously operated two streamflow-gaging stations on the C & O Canal. Streamflow-gaging station 01602000, on the C & O Canal at Cumberland, Md., was in operation from October 1929 to September 1934. Streamflow-gaging station 01620000, on the C & O Canal at Point of Rocks, Md., was in operation from August 1931 to November 1935.

Data and related information that are available for these streamflow-gaging stations include (1) mean daily discharges, (2) summaries of discharge measurements, (3) rating curves and tables of gage height versus discharge that were valid during the period of record, and (4) descriptions of the stations and their locations. The maximum known discharge and gage height during the period of record for the streamflow-gaging station on the C & O Canal at Cumberland, Md., was 104 ft ^{3}/s at a gage height of 9.85 ft on May 16, 1930. This maximum discharge did not occur during a flood event on the North Branch Potomac River. The maximum known discharge and gage height during the period of record for the streamflow-gaging station on the C & O Canal at Point of Rocks, Md., was 146 ft ^{3}/s at a gage height of 2.64 ft (approximately 227.64 ft above sea level) on May 13, 1932. This maximum discharge occurred during a flood event on the Potomac River during May 13 and 14, 1932. The peak discharge and gage height at streamflow-gaging station 01638500 (Potomac River at Point of Rocks) were 158,000 ft ^{3}/s and 23.34 ft (223.97 ft above sea level), respectively. The recurrence interval for this flood event was approximately 5 years.

Other Discharge Measurements on the Chesapeake and Ohio Canal

Between 1923 and 1995, over 250 discharge measurements were made on the C & O Canal at several locations. Many of these discharge measurements were made in the vicinity of the Potomac River at Chain Bridge because the C & O Canal diverts flow from the Potomac River at this location. Since discharge measurements for station 01646500, Potomac River at Little Falls near Washington, D.C., are often made at Chain Bridge, the diversion of flow from the Potomac River requires an estimate or measurement of flow in the C & O Canal at this location to obtain the total discharge. Other locations where discharge measurements have been made on the C & O Canal include Cumberland, Md.; Hancock, Md.; Harpers Ferry, W. Va.; and Brunswick, Md. These discharge measurements document the same types of data variables that were presented for the Potomac River streamflow-gaging stations in tables 3 through 8, including the channel width, cross-sectional area, mean and maximum velocities, and discharge.

SUMMARY

This report presents flood-hydrology data for the Potomac River and selected tributaries in the vicinity of the Chesapeake and Ohio Canal National Historical Park. Data were compiled for selected flood events at 6 USGS streamflow-gaging stations on the Potomac River and 10 streamflow-gaging stations on selected tributaries to the Potomac River. Peak discharge, peak gage height, the date and time of the peak, and approximate recurrence interval are presented for each flood event at these streamflow-gaging stations.

Data compiled from selected high-flow discharge measurements on the six Potomac River streamflow-gaging stations are presented. The gage height, top width, cross-sectional area, mean velocity, maximum velocity, and discharge are presented for each selected discharge measurement. Any corresponding discharge on the C & O Canal that was measured or estimated for these discharge measurements is presented. Ranges of Manning's n were computed for the range of selected discharge measurements based on estimates of water-surface slope or the channel-bed slope.

An inventory of flood studies, reports, and additional USGS data collected along the Potomac River and the C & O Canal NHP is also presented. Included are (1) a listing of selected flood studies and reports, and (2) a listing of USGS indirect flood-discharge measurements that have been made at the six Potomac River streamflow-gaging stations in the vicinity of the C & O Canal NHP. Information on historical streamflow-gaging station records and discharge measurements on the C & O Canal is also presented.

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APPENDIX

Appendix: *U.S. Geological Survey streamflow-gaging stations with surface-water flow data in the vicinity of the Chesapeake and Ohio Canal National Historical Park*

[misc. meas. = miscellaneous measurement]

Station no.	Station name and location	Period of record	Data type
01601500	Wills Creek near Cumberland, Md.	1929-present	discharge, other
01602000	Chesapeake and Ohio Canal at Cumberland, Md.	1929-34	discharge
01603000	North Branch Potomac River near Cumberland, Md.	1929-present	discharge
01604000	Evitts Creek near Cumberland, Md.	1929-32	discharge, other
01604150	Collier Run at Spring Gap, Md.	1964-74	low flow
01605425	Mill Run at Oldtown, Md.	1975-77	low flow
01605475	Seven Springs Run at Oldtown, Md.	1975-81	low flow
01605600	Friends Run near Franklin, W. Va.	1969-77	discharge
01606000	North Fork South Branch Potomac River at Cabins, W. Va.	1940-61	discharge
01607000	Big Spring at Masonville, W. Va.	1946-59	discharge
01608050	Fort Run near Moorefield, W. Va.	1969-77	discharge
01608400	Buffalo Creek near Romney, W. Va.	1969-77	discharge
01608500	South Branch Potomac River near Springfield, W. Va. [1]	1928-present	discharge, other
01608975	Maple Run near Town Creek, Md.	1977-78, 80-81	low flow
01609000	Town Creek near Oldtown, Md.	1928-35, 67-81	discharge, other
01609500	Sawpit Run near Oldtown, Md.	1948-58	discharge, other
01609800	Little Cacapon River near Levels, W. Va.	1966-77	discharge
01610000	Potomac River at Paw Paw, W. Va.	1938-present	discharge
01610030	Potomac River at Magnolia, W. Va.	1958-67	high flow
01610065	Deep Run near Little Orleans, Md.	1975-77	low flow
01610075	Fifteen Mile Creek at Little Orleans, Md.	1975-79	low flow
01610155	Sideling Hill Creek near Bellegrove, Md.	1967-77	discharge, other
01610170	Potomac River tributary at Woodmont, Md.	1985-86	low flow
01610200	Lost River at McCauley near Baker, W. Va.	1972-80	discharge
01610300	Cacapon River above Wardensville, W. Va.	1972-73	discharge

Appendix: *U.S. Geological Survey streamflow-gaging stations with surface-water flow data in the vicinity of the Chesapeake and Ohio Canal National Historical Park--Continued*

Station no.	Station name and location	Period of record	Data type
01610500	Cacapon River at Yellow Spring, W. Va.	1940-52	discharge
01611200	North River at North River Mills, W. Va.	1960-64, 69-70	low flow
01611500	Cacapon River near Great Cacapon, W. Va.	1922-95	discharge
01612500	Little Tonoloway Creek near Hancock, Md.	1947-63	discharge, other
01613000	Potomac River at Hancock, Md.	1932-present	discharge, other
01613100	Tonoloway Creek at Hancock, Md.	1985-86	low flow
01613150	Ditch Run near Hancock, Md.	1965-86	high flow, low flow
01613160	Potomac River tributary near Hancock, Md.	1965-76	high flow
01613400	Sleepy Creek near Berkeley Springs, W. Va.	1960-64, 70	low flow
01613545	Licking Creek near Pectonville, Md.	1985-86	low flow
01614000	Back Creek near Jones Springs, W. Va.	1928-74	discharge
01614050	Little Conococheague Creek near Charlton, Md.	1985-86	low flow
01614500	Conococheague Creek at Fairview, Md.	1928-present	discharge
01614625	Meadow Brook at Conococheague, Md.	1976-79, 81-82, 85-86	low flow
01614705	Conococheague Creek at Williamsport, Md.	1985-86	low flow
01614850	Potomac River near Falling Waters, W. Va.	1958-67	high flow
01616500	Opequon Creek near Martinsburg, W. Va. [1]	1947-present	discharge
01617000	Tuscarora Creek above Martinsburg, W. Va.	1949-63, 68-77	discharge
01617600	Downey Branch near Downsville, Md.	1976-79, 81	low flow
01617780	St. James Run at Spielman, Md.	1977-79, 81-82, 85-86	low flow
01617800	Marsh Run at Grimes Md.	1963-present	discharge
01617850	Potomac River at Lock 40 near Mondell, Md.	1957-67	high flow
01618000	Potomac River at Shepherdstown, Md.	1928-93	discharge, high flow
01619500	Antietam Creek near Sharpsburg, Md. [1]	1928-present	discharge, other
01619525	Sharmans Branch near Antietam, Md.	1977-79, 81	low flow

Appendix: *U.S. Geological Survey streamflow-gaging stations with surface-water flow data in the vicinity of the Chesapeake and Ohio Canal National Historical Park--Continued*

Station no.	Station name and location	Period of record	Data type
01620000	Chesapeake and Ohio Canal at Point of Rocks, Md.	1931-36	discharge
01636500	Shenandoah River at Millville, W. Va. [1]	1928-present	discharge
01636650	Potomac River at Weverton, Md.	1958-70	high flow
01636690	Piney Run near Lovettsville, Va.	1968-69	low flow
01636730	Israel Creek at Weverton, Md.	1975-77	low flow
01636850	Little Catoctin Creek near Brunswick, Md.	1977-81	low flow
01638480	Catoctin Creek at Taylorstown, Va.	1971-present	discharge
01638500	Potomac River at Point of Rocks, Md.	1895-present	discharge
01638600	Tuscarora Creek at Tuscarora, Md.	1975-77	low flow
01643000	Monocacy River near Frederick, Md.	1929-present	discharge
01643495	Bennett Creek tributary at Park Mills, Md.	1992-93	discharge
01643500	Bennett Creek at Park Mills, Md. [1]	1966-present	discharge
01643550	Potomac River at Lock 27 near Dickerson, Md.	1957-68	high flow
01643580	Monocacy River near Dickerson, Md.	1975-77, 79-83	misc. meas.
01643585	Potomac River tributary near Lucketts, Va.	1979-80	low flow
01643590	Limestone Branch near Leesburg, Va.	1968-69	misc. meas.
01643600	Limestone Branch tributary near Leesburg, Va.	1979-80	low flow
01643615	Broad Run near Elmer, Md.	1975-82	low flow
01644000	Goose Creek near Leesburg, Va. [1]	1930-present	discharge
01644100	South Fork-Sycolin Creek near Leesburg, Va.	1966-77	high flow
01644115	Dry Mill Branch near Leesburg, Va.	1969	misc. meas.
01644277	Beaverdam Run near Ashburn, Va.	1979-81	misc. meas.
01644283	Potomac River tributary No. 2 near Sterling, Va.	1979-80	misc. meas.
01645000	Seneca Creek at Dawsonville, Md.	1930-present	discharge
01645050	Dry Seneca Creek near Seneca, Md.	1975-82	low flow
01645080	Seneca Creek near Seneca, Md.	unknown	misc. meas.
01645500	Potomac River at Great Falls, Md.	1886-1891	discharge
01645975	Rocky Run near Great Falls, Va..	1961-67	high flow
01646000	Difficult Run near Great Falls, Va.	1934-present	discharge

Appendix: *U.S. Geological Survey streamflow-gaging stations with surface-water flow data in the vicinity of the Chesapeake and Ohio Canal National Historical Park--Continued*

Station no.	Station name and location	Period of record	Data type
01646200	Scott Run near McLean, Va.	1961-73	high flow
01646220	Rock Run near Cabin John, Md.	1964, 66-67	low flow
01646500	Potomac River near Washington, D.C.	1930-present	discharge
01646550	Little Falls Branch near Bethesda, Md.	1944-59, 62-79	discharge
01646700	Pimmitt Run at Arlington, Va.	1961-68	high flow
01646750	Little Pimmitt Run tributaryat Arlington, Va.	1962-66	high flow
01646755	Little Pimmitt Run tributary at Arlington, Va.	1962-69	high flow
01646800	Little Pimmitt Run at Arlington, Va.	1961-66	high flow
01647600	Potomac River at Wisconsin Avenue at Washington, D.C.	1935-present	tide gage
01648000	Rock Creek at Washington, D.C.	1929-present	discharge
01649000	Rock Creek at Q Street at Washington, D.C.	1892-1895, 1930-1933	discharge
01652580	Oxen Run at Washington, D.C.	1980-82	low flow

[1] Station contains other shorter periods of record prior to current period of record.