In cooperation with the West Virginia Conservation Agency

Water Resources in the Wardensville Area, Hardy County, West Virginia, October 2003-May 2004

By Ronald D. Evaldi and Kurt J. McCoy

Open File Report 2004-1363

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

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Reston, Virginia

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CONVERSION FACTORS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
gallon per minute (gal/min)	0.002228	cubic foot per second
	0.06309	liter per second
gallon per day (gal/d)	0.000001547	cubic foot per second
cubic foot per second (ft3/s)	0.02832	cubic meter per second
	Transmissivity*	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows:

$°F = 1.8(°C) + 32$

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Horizontal coordinate information in tables of this report is referenced to the North American Datum of 1927 (NAD 27). Report figures are plotted in North American Datum of 1983 (NAD 83).

*Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness $[(ft^3/d)/ft^2]ft$. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

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Abstract

Communities within the Valley and Ridge Physiographic Province of West Virginia are concerned about the availability and sustainability of their water supplies. The water resources of the Wardensville area of West Virginia were investigated and data sources were reviewed that will be useful in similar resource assessments elsewhere in the region. Estimates of long-term average discharge of the Cacapon River, Waites Run, and Trout Run are 170, 21, and 78 cubic feet per second (ft^3/s), respectively. Average flow from Wardensville Spring during the study was determined to be 0.265 ft^3/s, and the apparent age of this water was about 20 years. Increases in springflow and drops in temperature of the water during significant winter runoff events suggest that Wardensville Spring may be under the influence of surface runoff at such times. About 80 total coliform colonies per 100 milliliters (mL) of water were found in the spring, but less than1 colony per 100 mL of water was fecal coliform, and their source is unknown. A well completed during the study in the Marcellus Shale near the contact with the Oriskany Sandstone is capable of yielding 60 gallons per minute, and water produced from the well has an apparent age of 50 years. Iron and manganese concentrations in the well (1,680 and 114 micrograms per liter, respectively) exceeded the U.S. Environmental Protection Agency secondary maximum contaminant levels. It is likely that a well drilled about 130 feet from Wardensville Spring is hydraulically connected to the spring because pumping at the time of well completion induced drawdown at the spring. About 20 total coliform colonies per 100 mL of water were found in that well, but fecal coliform counts were less than1 colony per 100 mL of water. Transmissivity values of the aquifer as determined at two wells completed in the Marcellus Shale near the contact with the Oriskany Sandstone on opposite sides of Anderson Ridge are 200 and 400 feet squared per day.

Introduction

Water-resources managers in communities of the Eastern Panhandle of West Virginia, including the town of Wardensville (fig. 1), are concerned about the availability and sustainability of their water supplies. Both ground and surface-water resources and the interaction of ground and surface water must be considered in an evaluation of a community's water supplies. The U.S. Geological Survey (USGS), in cooperation with the West Virginia Conservation Agency (WVCA), conducted a study to provide a better understanding of the ground- and surface-water resources in the Wardensville area and to demonstrate methods that can be used to evaluate water resources in similar areas.

Purpose and Scope

The purpose of this report is to characterize ground- and surface-water resources and their interaction in the Wardensville area of the Valley and Ridge Physiographic Province of the Eastern Panhandle of West Virginia (fig. 1). The study was conducted from October 2003 to June 2004. Three streams, one spring, and two wells near Wardensville, WV were evaluated. Flow statistics of streams were estimated by correlation with records from nearby, long-term streamflow-gaging stations and/or by application of regional computation procedures. Flow from

Wardensville Spring (fig. 1) was monitored to provide information on the range of its total flow during the study. The quality of water in the streams, spring, and wells was evaluated, and evidence of possible ground- and surface-water interaction was examined.

Hydrologic Setting

Wardensville is in Hardy County in the Eastern Panhandle of West Virginia (fig. 1). The study area is within the Valley and Ridge Province, which consists of a series of northeast-trending mountains and valleys. The mountain ridges are mainly resistant sandstone and limestone, and the valleys are composed primarily of less-resistant shale and siltstone (fig. 2). Rocks in this part of the Valley and Ridge range in age from late Ordovician to early Mississippian (Lessing, 1996). Average annual precipitation is 35.4 in/yr (City-data.com, 2004, accessed Aug. 10, 2004). Geologic nomenclature used in this report is consistent with the West Virginia Geologic map produced by the West Virginia Department of Environmental Protection, 2000.

Trapp and Horn (1997) have described the general hydrogeology of the study area. Surface drainage patterns reflect the alternating bands of more- and less resistant rocks in the folded strata of the study area (fig. 2). Major streams and their tributaries intersect at nearly right angles to form a rectangular stream network known as a trellis drainage pattern.

Ground water in the Valley and Ridge aquifers flows mostly along fractures and bedding planes in all rock types, and in solution conduits that were formed in the carbonate rocks after deposition. The local flow systems receive recharge mostly through the regolith on the tops or flanks of ridges. The water then either moves into the underlying bedrock or stays within the regolith and flows downgradient toward the intervening valleys and discharges to streams or springs. Surface water that is channeled into small streams in the valleys can leak downward through the streambed to recharge the aquifer if the water table of the aquifer is lower than the water level in the stream.

Generally in the Valley and Ridge, sandstone aquifers are prominent in rocks of middle and late Ordovician, middle Devonian, and younger age. In the study area, predominately Silurian and Devonian rocks (mostly shale, sandstone, and conglomerate) are exposed. Wells completed in these clastic rocks and thin interbedded limestone units commonly yield 10 to 20 gal/min (Kozar and Mathes, 2001).

Spring location is related to geologic structure and topography. Many springs are on or near anticlinal axes and near the noses of plunging anticlines, as is the case of Wardensville Spring (fig. 2). Open tension fractures tend to be concentrated in these places, and in the case of plunging anticlines, water-yielding beds may drain in the direction of plunge. Major springs often occur at the bases of sandstone ridges. Wardensville Spring is located in a valley flanked by a ridge composed of Oriskany Sandstone (fig. 2).

Sources of Data

The eight-month study period did not allow for monitoring the full range of hydrologic conditions that would be expected during an annual hydrologic cycle. Conditions in the study area were wetter than usual during the study period, and there is a lack of information about low-flow conditions in the summer because the study period did not include the low-flow months of June-September. In addition, estimates of flow statistics based on comparisons of time-series data of short duration are subject to serial correlation errors.

A streamflow-gaging station has been active on Waites Run since January 2002 as part of an ongoing study of the Potomac River Basin by the USGS National Water-Quality Assessment Program. This station, Waites Run near Wardensville (01610400) (fig. 1), monitors flow from a 12.6-mi^2 drainage area and is 4.3 mi upstream of the confluence of Waites Run with the Cacapon River. Daily mean discharge records and records from continuous monitors of stream temperature and specific conductance for January 2002 to September 2003, and monthly water-quality data for October 2001 to September 2003, are provided in appendix A.

A USGS streamflow-gaging station was in operation on the Cacapon River about 1.2 mi west of Wardensville and 0.8 mi upstream of the confluence with Trout Run (fig. 1) from October 1971 to September 1973. Streamflow data for Cacapon River above Wardensville, WV (01610300), which drains 181 mi^2, are provided in appendix B.

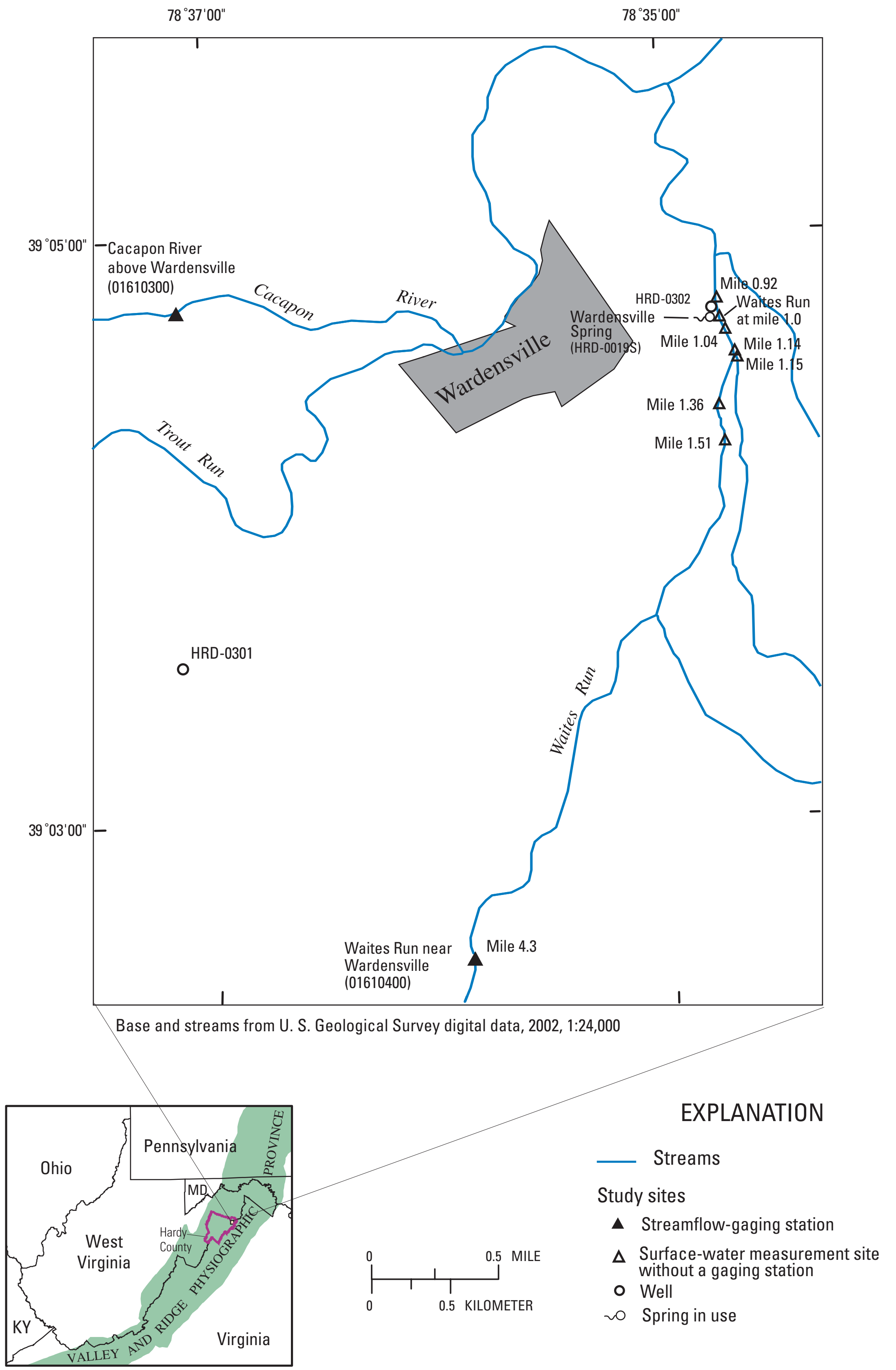
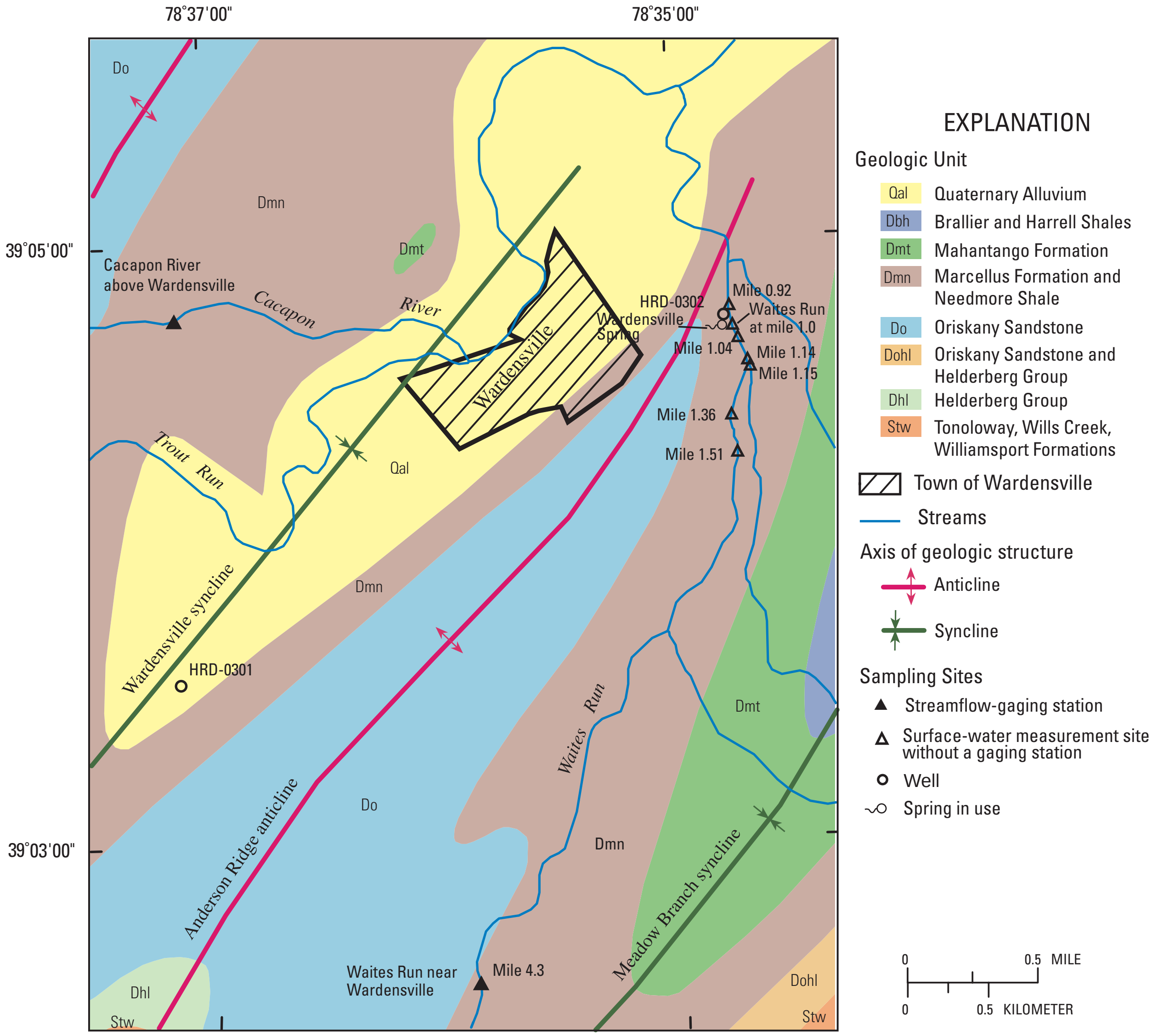


Figure 1. Location of study sites near Wardensville, WV.



Base map modified from Cardwell and others, 1968, 1:250,000; streams from U.S. Geological Survey digital data, 2002, 1:24,000

Figure 2. Geology, structural features, and sampling sites near Wardensville, WV

Daily mean discharge data for the USGS streamflow-gaging station Cacapon River at Great Cacapon, WV (01611500), are available for water years 1923-95 and 1997 to present. (A water year begins October 1 and ends September 30 of the following year). This station monitors flow from a 675-mi^2 drainage area that includes the study area (fig. 3). Flow statistics for this site are provided in several reports (Friel and others, 1989; Wiley, Atkins, and Tasker, 2000; Ward, Rosier, and Crosby, 2003). A long-term streamflow-gaging station in Virginia, Hogue Creek near Hayfield, VA (01613900), which is operated by the Virginia Department of Environmental Quality, was active during this study. This station drains a 15.0-mi^2 area, and daily mean discharge data are available for water years 1960-86 and 1993 to present (White and others, 2003, accessed Oct. 18, 2004). A value for mean base flow that was computed from hydrograph separation of daily streamflow records using methods by Rutledge (1992; 1993) is available for this station in Nelms, Harlow, and Hayes (1997). Peak discharge characteristics at this station are provided in Bisese (1995). Although the Hogue Creek station is outside of the study area (fig. 3), such long-term records are useful for comparison to records from stations within the study area.

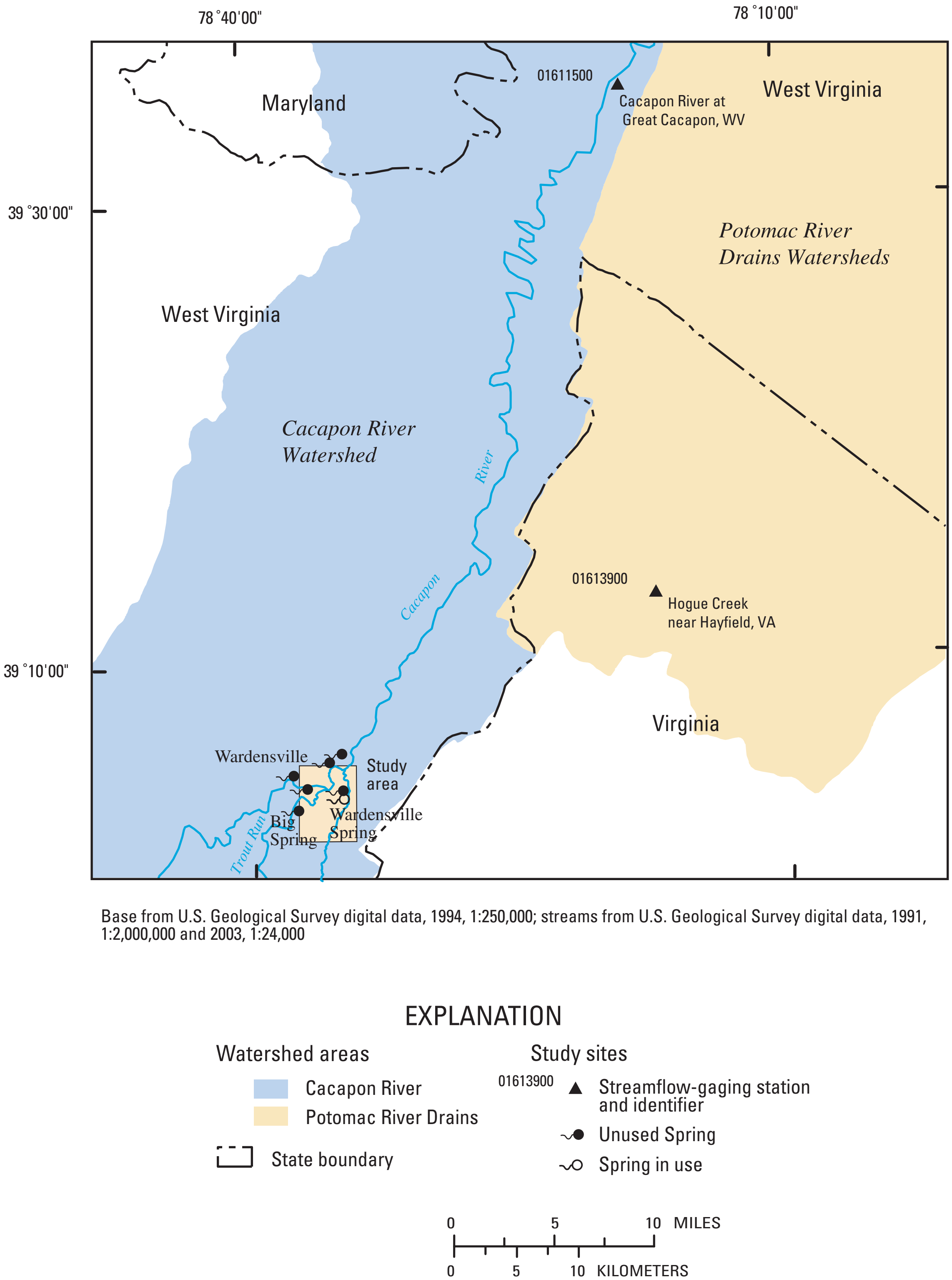


Figure 3. Streamflow-gaging stations and springs with data used for comparison to stream and spring data collected near Wardensville, WV

Pumpage records are available from Wardensville Spring (HRD-0019S), which is about 0.7 mi east of Wardensville and in a valley flanked by a ridge composed of Oriskany Sandstone; this spring is also known as

Hawkins Farm Spring (fig. 2). During the study period of October 2003 to May 2004, pumpage records were complete except for January 7-15, 2004. A recorder was installed for this study on October 22, 2003, in Wardensville Spring to monitor spring overflow, but the recorder malfunctioned from January 15 to March 16, 2004. The spring overflow and pumpage records were summed for computation of mean daily flow of Wardensville Spring. These mean daily flows for October 2003 to May 2004, excluding January 7 to March 16, are presented in appendix C. A water-temperature monitor was installed November 18, 2003, and operated through May 31, 2004.

Water-quality samples were obtained from a site on Waites Run at river mile 1.0, approximately 0.2 mi upstream of Wardensville Spring and approximately 3.2 mi downstream from the streamflow-gaging station at Waites Run near Wardensville, WV, (fig. 1). Samples were also obtained from Wardensville Spring, from a 12-in. diameter well near Wardensville Spring (HRD-0302), from regional monitoring well HRD-0301 on the opposite side of Anderson Ridge from the Waites Run streamflow-gaging station, Wardensville Spring, and well HRD-0302 (fig. 2).

Methods of Study

Flow-duration statistics commonly are used in the evaluation of streamflow data. For example, a flow-duration curve is a cumulative frequency curve that shows the percentage of time a specified discharge is equaled or exceeded during a given period of record (Searcy, 1959). These statistics are best defined from daily mean discharge computed at continuous-record streamflow-gaging stations for a period of at least 10 years. Estimates of flow-duration statistics can be made at continuous-record stations with shorter periods of record, or for discontinuous record stations, by correlation of data from the short-term record streamflow-gaging stations with concurrent data obtained at nearby, long-term, continuous-record streamflow-gaging stations, which commonly are referred to as index stations. An example of this method is shown in figure 4, where the short-term record streamflow-gaging station is Cacapon River above Wardensville, WV, and the index station is Cacapon River at Great Cacapon, WV. This method is based on the assumption that the flow at the short-term streamflow-gaging station is at the same flow statistic value as the concurrent flow at the index station. For example, the flow values at both stations are assumed to be at the median at the same time.

Annual average 7-consecutive-day minimum stream discharges having 2-year and 10-year recurrence intervals (7Q2 and 7Q10, respectively) were estimated based on regional equations by Friel and others (1989). High-flow statistics for stream sites were estimated based on methods described by Wiley, Atkins, and Tasker (2000). These reports contain the error terms associated with the estimation techniques.

Aquifer test data were analyzed using the straight-line method of Cooper and Jacob (1946). This analytic method defines transmissivity using the equation:

$$T = \frac{2.3Q}{4\pi(\Delta s)}$$

Where,

T	=	transmissivity
Q	=	discharge, and
s	=	drawdown.

This method requires that the following condition is met:

$r^2 S/4Tt \leq 0.01$

Where,

r	=	well radius,
S	=	aquifer storativity, and
t	=	time.

This condition was met by having a small radius (r) of the wells tested (r was 6 in. for both wells) and by ensuring sufficient time (t) of pumping. An additional test of the validity of the aquifer test methods used in this study was a check that the length of the test was sufficient for the case of confined conditions so that the effects of well-bore storage need not be considered given:

$$t \geq 25r^2 / T$$

Surface-water resources

The Cacapon River, Trout Run, and Waites Run flow through the Wardensville area (fig. 1). Correlation of short-term continuous streamflow-gaging records with nearby index station records and application of regional equations for low- and high-flow computations were used to estimate flow statistics of the Cacapon River and Waites Run. Trout Run was not monitored, and data were not available for correlation, but drainage-area comparisons to Waites Run allowed for rough estimates of some flow characteristics, and regional low- and high-flow equations were applicable.

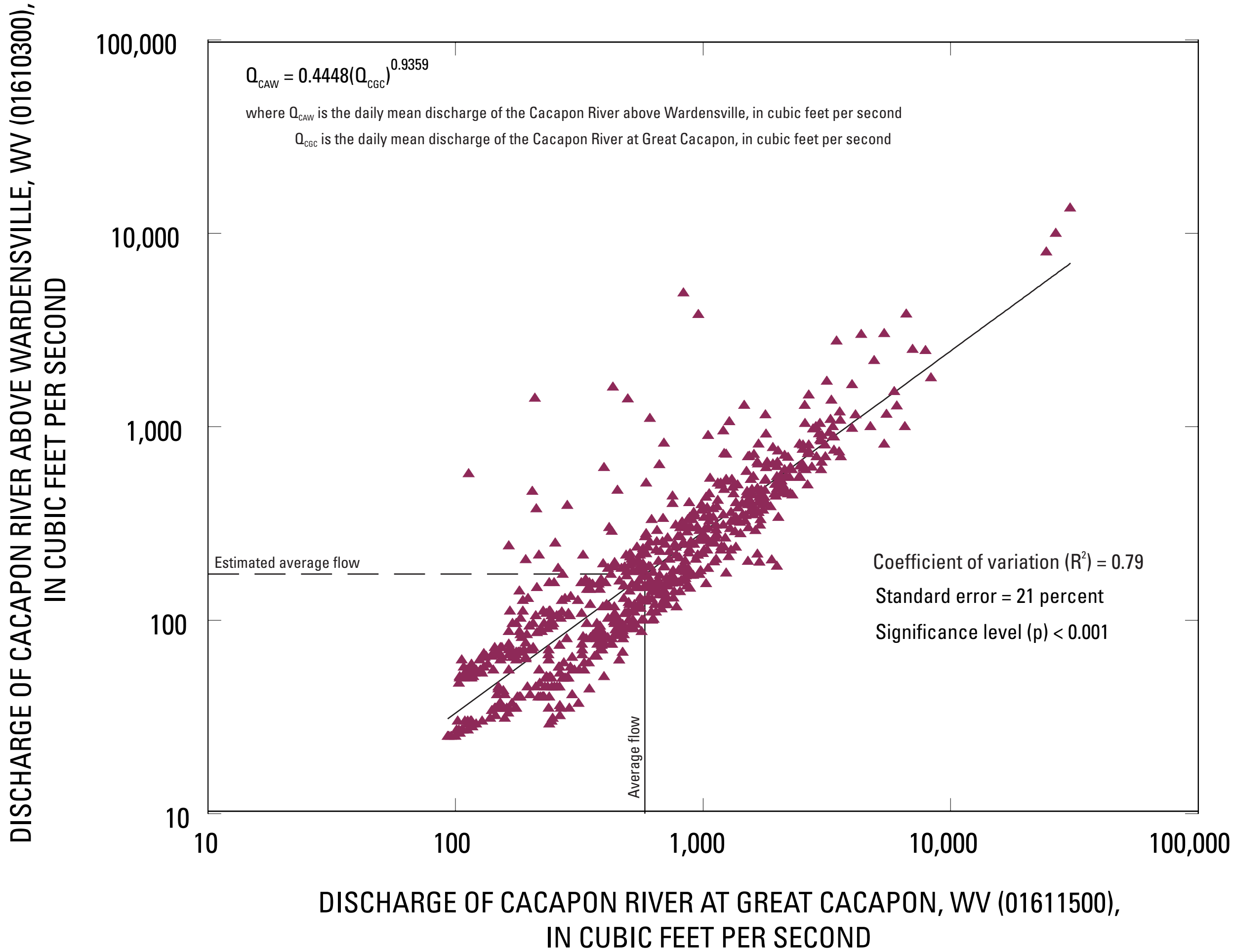


Figure 4. Relation of daily mean discharge of Cacapon River above Wardensville, WV, to daily mean discharge of Cacapon River at Great Cacapon, WV, October 1, 1971 to September 30, 1973.

Cacapon River

The Cacapon River flows north and west of the town of Wardensville and drains 181 mi^2 at a site about 0.8 mi upstream of the confluence with Trout Run (fig. 1). This site was operated from October 1971 to September 1973 as USGS daily-discharge station Cacapon River above Wardensville (01610300. This period of record was too brief to compute accurate flow statistics; therefore, the correlation procedures described above were used with concurrent records for USGS streamflow-gaging station Cacapon River at Great Cacapon, WV (01611500), and an average discharge of 170 ft^3/s was estimated for the Cacapon River above Wardensville (fig. 4, table 1). The equation for estimation of daily discharge of the Cacapon River above Wardensville from daily-discharge records of the Cacapon River at Great Cacapon has a coefficient of variation (r^2) of 0.79, a standard error of 21 percent, and is significant at the p=0.01 level:

$$Q_{CAW} = 0.4448\ (Q_{GC})^{0.9359}$$

where Q_{CAW} is the daily mean discharge of the Cacapon River above Wardensville, WV,

in ft^3/s; and

Q_{GC} is the daily mean discharge of the Cacapon River at Great Cacapon, WV.

Table 1. Estimates of flow statistics for streams in the Wardensville area, Hardy County, WV

[ft^3/s, cubic feet per second; ---, not estimated; mi^2, square mile]

Discharge estimates, in ft^3/s	Cacapon River above Wardensville, WV (river mile 76.5)	Waites Run near Wardensville, WV (river mile 4.3)	Trout Run at Wardensville, WV (at mouth)
7-day, 2-year low flow	[a] 22	[a] 1.1	[a] 4.9
7-day, 10-year low flow	[a] 9.2	[a] 0.4	[a] 1.9
Average	[b] 170	[c] 21	[d] 78
Mean base flow	---	[c] 14	[d] 53
Median	[b] 76	[c] 10	[d] 38
10-year peak	[e] 11,300	[e] 1,160	[e] 3,600
25-year peak	[e] 15,400	[e] 1,550	[e] 4,850
50-year peak	[e] 18,900	[e] 1,860	[e] 5,880
100-year peak	[e] 22,700	[e] 2,200	[e] 7,000

[a] Estimate based on regional equations by Friel and others, 1989.

[b] Estimate based on discharge record correlation to gaging station 01611500 Cacapon River at Great Cacapon, WV.

[c] Estimate based on discharge record correlation to gaging station 01613900 Hogue Creek near Hayfield, VA.

[d] Estimate based on drainage-area ratio comparison of Trout Run at Wardensville, WV (47.3 mi^2), to Waites Run near Wardensville, WV (12.6 mi^2).

Estimated median flow of the Cacapon River above Wardensville is 76 ft^3/s (table 1). An estimate of mean base flow was not possible using the relation between the Great Cacapon and Wardensville records because a value for this statistic was not available for the Great Cacapon station. At the Cacapon River above Wardensville, WV, station, the lowest average 7-consecutive day flow expected every 10 years is 9.2 ft^3/s (5,950,000 gal/d) based on regional regression analysis equations by Friel and others (1989). Peak flow of 22,700 ft^3/s has a 1-percent chance of occurrence each year (100-year flood) at this site based on regional regression analysis equations by Wiley, Atkins, and Tasker (2000).

Waites Run

The Waites Run near Wardensville, WV, streamflow-gaging station is located at a site about 4.3 mi upstream of the channel mouth (fig. 1) and drains 12.6 mi^2. This station was operated as USGS daily discharge record station Waites Run near Wardensville, WV (01610400), from January 2002 to September 2003. Because this period was too brief to compute accurate flow statistics, the correlation procedures described above were used with concurrent records for Hogue Creek near Hayfield, VA (01613900) to estimate an average discharge of 21 ft^3/s for Waites Run near Wardensville, WV (fig. 5, table 1). The equation for estimation of daily discharge of Waites Run near Wardensville, WV, from daily-discharge records of Hogue Creek near Hayfield, VA, has a coefficient of variation (r^2) of 0.78, a standard error of 22 percent, and is significant at the p=0.01 level:

$$Q_{WRW} = 3.33\,(Q_{HC})^{0.6725}$$

where Q_{WRW} is the daily mean discharge of Waites Run near Wardensville, WV, in ft^3/s; and

Q_{HC} is the daily mean discharge of Hogue Creek near Hayfield, VA.

The lowest average 7-consecutive-day flow expected every 10 years for Waites Run near Wardensville, WV, is 0.4 ft^3/s (259,000 gal/d) based on regional regression analysis equations by Friel and others (1989). Peak flow of 2,200 ft^3/s has a 1-percent chance of occurrence each year (100-year flood) at this site based on regional regression analysis equations by Wiley, Atkins, and Tasker (2000).

Trout Run

Trout Run lies west of Wardensville and drains to the Cacapon River at Wardensville (fig. 1). Total drainage area of Trout Run at its confluence with the Cacapon River is 47.3 mi^2. Trout Run was not gaged during this study, nor were historical records available. At its mouth, the lowest average 7-consecutive-day flow expected every 10 years is 1.9 ft^3/s (1,230,000 gal/d) based on regional regression analysis equations by Friel and others (1989). Peak flow of 7,000 ft^3/s has a 1-percent chance of occurrence each year (100-year flood) at this site based on regional regression analysis equations by Wiley, Atkins, and Tasker (2000). A drainage-area ratio was used to estimate average, median, and mean base flows of 78, 38, and 53 ft^3/s, respectively, based on estimates for the Waites Run near Wardensville, WV, station (table 1). The low-flow estimates for Trout Run may be too low because they are based on the assumption that the drainage divides of the surface-water and ground-water systems coincide. This might not be the case because Trout Run receives discharge from Big Spring, which is about 2.25 mi west-southwest of Wardensville. Big Spring is reported by McColloch (1986) to flow at a rate of about 11 ft^3/s (5,220 gal/min or 7,500,000 gal/d), and some of this flow might be from outside the topographic drainage divide.

Ground-Water Resources

Previous literature was reviewed, springflow was quantified, and aquifer transmissivity was evaluated to characterize the ground-water resources in Hardy County. Ground-water flow in the Wardensville area likely is controlled by fractures, bedding planes, and solution openings; these are common in aquifers of the Valley and Ridge Physiographic Province. The degree to which these features are interconnected determines the ability of the

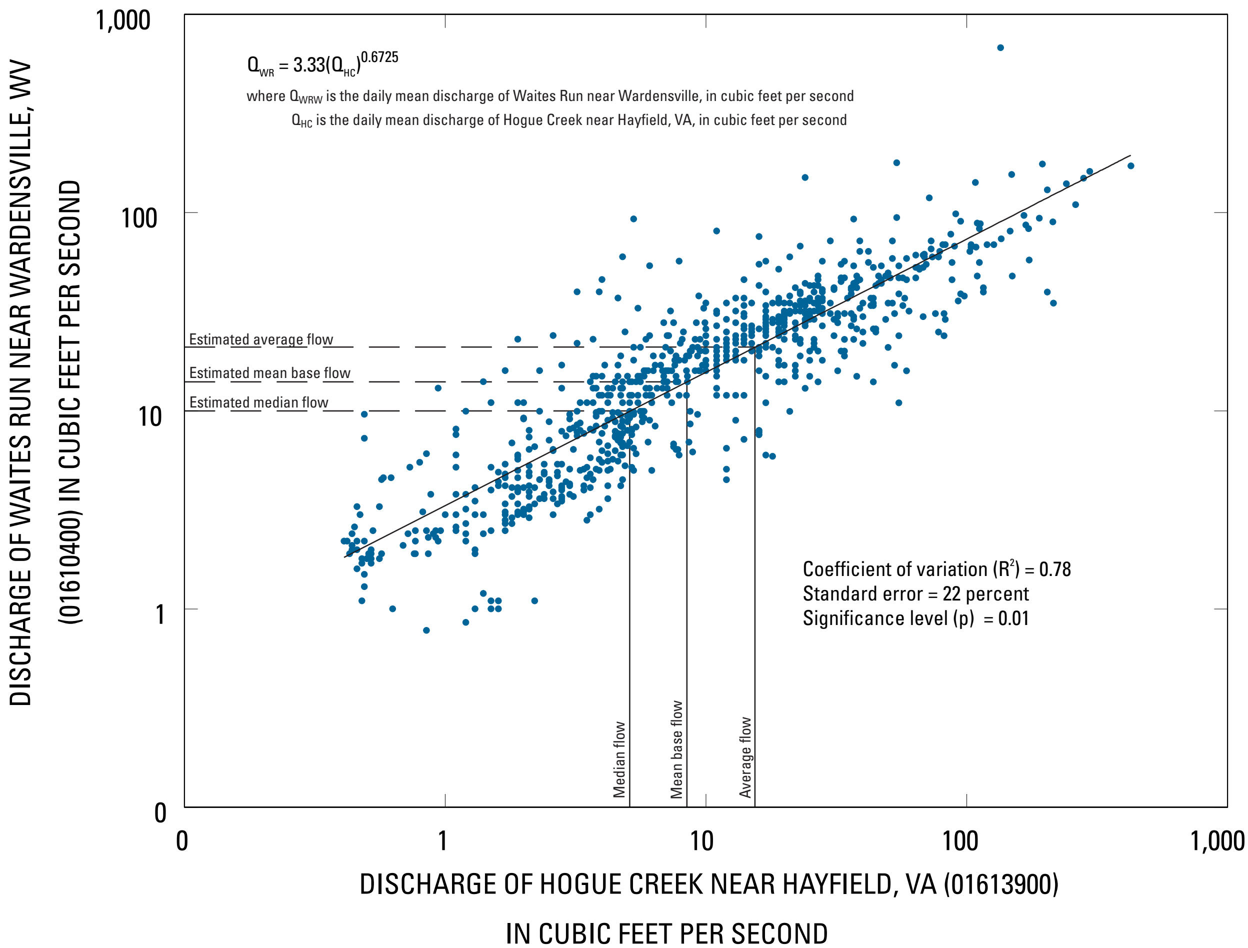


Figure 5. Relation of daily mean discharge of Waites Run near Wardensville, WV, to daily mean discharge of Hogue Creek near Hayfield, VA, January 26, 2002, to May 31, 2004.

rocks to transmit water. Ridges are considered recharge areas, and ground-water flow is driven by gravity to areas of lower elevation. Consequently, regional ground-water flow typically follows topography in mountainous regions.

Devonian rocks constitute the principal aquifers exposed in the immediate area surrounding Wardensville (fig. 2). Relatively thin alluvial deposits overlie bedrock in the Wardensville syncline and are not considered a viable aquifer for production purposes. Shales of the Marcellus Formation are exposed in the topographically low areas of the Wardensville and Meadow Branch synclines to the south and northeast of Wardensville (fig. 2). The Marcellus Formation consists chiefly of black, fissile shale with high carbon content that is interbedded with impure dark-gray limestones (Tilton and others, 1927). To the east of Wardensville, the plunging Anderson Ridge anticline is capped by the Oriskany Sandstone and extends NE-SW to form a high topographic boundary that separates two local tributaries to the Cacapon River, Trout Run to the west and Waites Run to the east.

Springs

Large springs in the Valley and Ridge Province of West Virginia are found along anticlinal axes, lineaments, faults, and fractures (McCulloch, 1986). Springs emanating in valleys are less susceptible to drought conditions than those on ridges (Hobba, 1985). The valleys typically have more fractures, greater fracture density, shallower ground-water levels, and streams connected to such springs. The quantity and quality of spring waters vary with lithology, structure, topography, and seasonal variations in precipitation.

Seven springs discharge within 2.5 miles of Wardensville (fig. 3). Discharges from these springs range from 40 to more than 5,000 gal/min and have near-neutral pH values and dissolved iron concentrations of 100 µg/L or less (Hobba, 1985; Friel, Hobba, and Chisholm, 1975; Erskine, 1948). Each of these springs, including Wardensville Spring, is in a valley flanked by ridges composed of coarse- to fine-grained calcareous Oriskany Sandstone.

Wardensville Spring discharge was quantified on a daily basis for this study. Total springflow was determined by summation of the spring overflow volume, which was gaged, and by the daily pumpage records from the spring (app. B). This method led to inaccurate discharge computations on some days, however, because pumpage volume records were not for a standard day but instead reflected times between pump inspections, which were usually at a time other than midnight. This was a problem only when pumpage rates changed significantly and the date of water withdrawal was uncertain. As calculated with this summation method, springflow during the period October 22, 2003, to January 14, 2004, and March 17 to May 31, 2004, ranged from 0.07 to 0.45 ft^3/s (45,200 to 291,000 gal/d). Calculations made over the entire record period were not affected by the above-mentioned problem that affected individual daily calculations. Based on periods when pumpage and overflow data were complete, the average pumpage rate was 0.150 ft^3/s (96,900 gal/d) and the average spring overflow was 0.115 ft^3/s (74,300 gal/d). The average total springflow based on these records was 0.265 ft^3/s (171,000 gal/d, or 119 gal/min), which is almost twice the 64 gal/min reported by McCulloch, 1986.

Wells

Generally, transmissivity is a measure of the aquifer's ability to yield water. As defined by Lohman and others (1972), transmissivity is the rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient. Kozar and Mathes (2001) analyzed specific capacity (gal/min per foot of drawdown) data from 15 wells completed in the Marcellus Formation in West Virginia. The median value of transmissivity calculated from the data was 170 ft^2/d with a range of 16 to 1,300 ft^2/d. Of the 15 wells, 4 were in Hardy County and those wells had a median transmissivity of 225 ft^2/d. Likewise, 8 wells completed in the Oriskany Sandstone of eastern West Virginia had a median transmissivity value of 82 ft^2/d, with a range of 19 to 1,500 ft^2/d. Of these 8 wells, the one in Hardy County had a transmissivity of 47 ft^2/d.

Wells HRD-0301 and HRD-0302 were used to evaluate aquifer transmissivity in the Wardensville area of Hardy County (fig. 1). Both wells are completed in the Marcellus Formation near the contact with the Oriskany Sandstone on opposite sides of the Anderson Ridge anticline. Well HRD-0301 was drilled during this study as a regional water-level monitoring station with real-time data available at http://waterdata.usgs.gov/wv/nwis. Water levels and other data from this well can provide information in future years to help describe current conditions as compared to long-term records. Well HRD-0302 is owned by the town of Wardensville and is midway between Waites Run and Wardensville Spring, approximately 130 ft from either one (fig. 1).

Well HRD-0301 is 160 ft deep, cased to 58 ft depth, and had a static water level of 15.85 ft below land surface on February 25, 2004. Well HRD-0302 is 195 ft deep, cased to 113 ft depth, and had a static water level of 5.26 ft below land surface on February 25, 2004. The driller's reported well yield for HRD-0301 is 60 gal/min. Yield of well HRD-0302 was not determined during this study.

Single-well aquifer tests were conducted on February 25, 2004; both tests lasted approximately 100 minutes. Both wells are assumed to fully penetrate the aquifer. Outflow was metered and periodically checked using the bucket and stopwatch method. The pumping rate for both wells was 13 gal/min, which was limited by the pump and not the permeability of the aquifer. Transmissivities for the wells were determined by the straight-line method of Cooper and Jacob (1946). Plots of drawdown and log time are shown in figures 6 and 7. Transmissivity values for HRD-0301 and HRD-0302 are 200 ft^2/d and 400 ft^2/d, respectively. These values are within the range of previous single-well aquifer test results of similar rocks from Kozar and Mathes (2001).

Well HRD-0302 and the upgradient Wardensville Spring could be hydraulically connected. Pumping at the time of well completion induced drawdown at the spring (Justin Kincaid, Wardensville Water Department, oral commun., 2003). However, no such drawdown was observed during the February 25, 2004, test and data are not available to evaluate long-term trends in water levels.

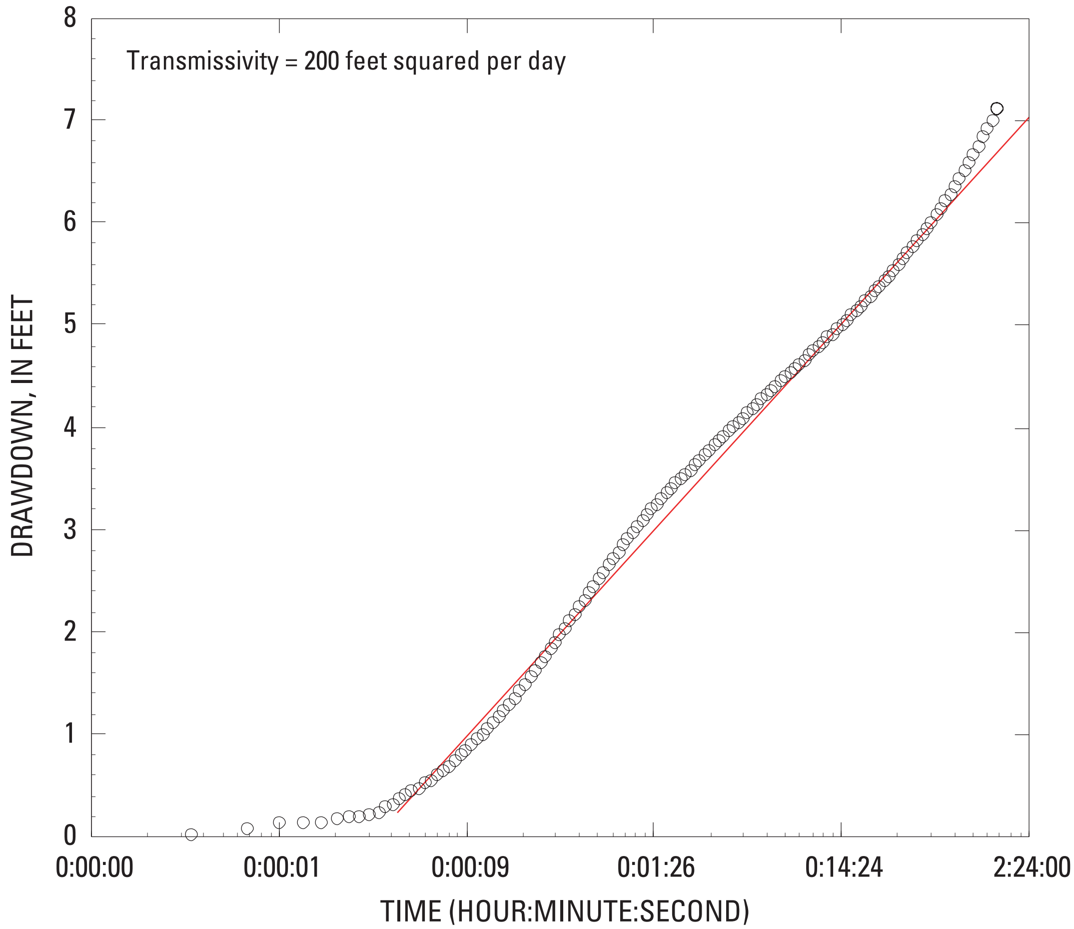


Figure 6. Elapsed time and drawdown during aquifer test of well HRD-0301, February 25, 2004, near Wardensville, WV.

Water quality

Waites Run near Wardensville, WV (river mile 4.3) (fig. 1), was sampled monthly from October 2001 to September 2003 as part of a USGS National Water-Quality Assessment Program study of the Potomac River Basin. Water temperature and specific conductance at that site were monitored continuously from January 2002 to September 2003. Maximum and minimum data from the analyses are shown in table 2. Sample analyses and daily monitoring records are provided in appendix A. All sample analyses summarized in table 2 meet the U.S. Environmental Protection Agency (EPA) primary and secondary maximum contaminant levels (MCLs) for drinking water except for minimum pH. Occasionally, pH values were less than 6.5 standard units, which is a secondary MCL for protection from a bitter metallic taste and corrosion. The Waites Run water was also analyzed to determine concentrations of several organic chemical constituents, but no concentrations were found greater than the method detection limit used for the analyses (appendix A).

A continuous temperature monitor was operated in Wardensville Spring from November 18, 2003, to May 31, 2004. Temperature ranged from 12.2 to 12.9°C during this period. Temperature dropped by 0.3°C on December 10, 2003, and by 0.4°C on February 6, 2004. These were the greatest temperature changes during the record period and corresponded with the timing of two large runoff events as recorded at the station at Waites Run near Wardensville. The overflow from Wardensville Spring increased by 0.14 ft^3/s (90,500 gal/d) from December 10 to 11 (overflow data were not available February 6). The increased spring overflow and temperature declines indicated that the spring responded rapidly to precipitation events and is probably influenced by surface runoff at such times.

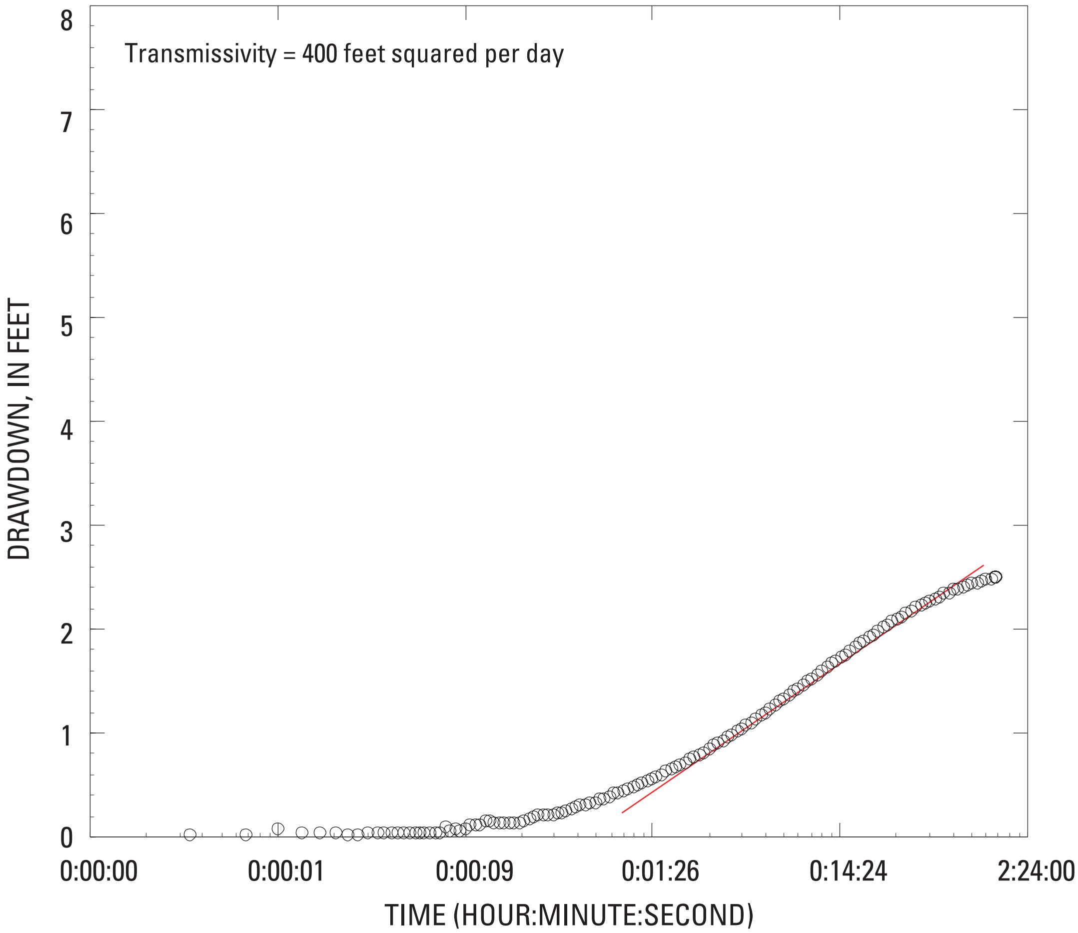


Figure 7. Elapsed time and drawdown during aquifer test of well HRD-0302, February 25, 2004, near Wardensville, WV.

Water-quality samples were obtained February 25, 2004, from Wardensville Spring, from Waites Run at mile 1.0 about 0.2 mi upstream of Wardensville Spring, and from wells HRD-0301 and HRD-0302. Results of the analyses show that, for most of the constituents determined, the quality of the water from the different sources is similar (table 3). As would be expected, the stream sample from Waites Run had lower specific conductance and smaller concentrations of dissolved minerals such as calcium, magnesium, and potassium than water from the spring or the wells. The greatest difference in the samples from the wells was that iron and manganese concentrations were much greater in the regional monitoring well (HRD-0301) than in the town of Wardensville well (HRD-0302). Iron and manganese concentrations in the regional monitoring well exceeded the EPA secondary MCLs of 300 and 50 µg/L, respectively, which are not health threatening but might cause taste or odor problems in water supplies.

About 80 total coliform colonies and 10 fecal coliform colonies per 100 mL of water were found in Waites Run. About 80 total coliform colonies per 100 mL of water were found in Wardensville Spring, but fecal coliform counts (less than 1 colony per 100 mL of water), including *E. coli* (1 colony per 100 mL of water), were low. About 20 total coliform bacteria per 100 mL of water were also found in the town of Wardensville well. *E . coli* should be a subset of fecal coliform colony counts, but exceeded the fecal coliform counts for this sample. Both *E. coli* and fecal coliform counts, however, were low in the well (7 and less than 1 colonies per 100 mL of water, respectively). There was no evidence at the time of this study to determine the source of the bacteria found in Wardensville Spring or the town of Wardensville well, but because fecal coliform counts were much lower than total coliform counts, the source does not appear to be primarily from warm-blooded animals, including humans.

Table 2. Summary of monthly water-quality analyses for Waites Run at mile 4.3 near Wardensville, WV, October 2001 to September 2003.

[µs/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; <, less than]

Constituent	Maximum	Minimum
pH, standard units	7.8	5.8
Specific conductance, µS/cm continuous	109	23
Water temperature, °C continuous	24.5	0
Dissolved oxygen, mg/L	17.8	7.8
Alkalinity, mg/L as $CaCO_3$ incremental titration	48	4
Bicarbonate, mg/L incremental titration	59	5
Carbonate, mg/L incremental titration	<1	<1
Chloride, mg/L filtered	1.34	0.34
Nitrogen, nitrite, mg/L as Nitrogen filtered	<.008	<.008
Nitrogen, ammonia, mg/L as Nitrogen filtered	<.04	<.04
Sulfate, mg/L filtered	5.6	3.8
Phosphorus, mg/L as Phosphorus unfiltered	0.017	[e] .002
Orthophosphate, mg/L as Phosphorus filtered	<.02	<.02
Organic carbon, mg/L as Carbon filtered	2.3	0.9
Suspended sediment, mg/L	8	0.6

[e] Estimated value.

A procedure developed by the National Research Program (NRP) of the USGS uses chlorofluorocarbons (CFC's) as tracers for determining the apparent (model) age of ground water (Nelms and Ahlin, 1993). CFCs are synthetic organic compounds that were developed in the 1930s and can be found in ground water that has been recharged since that time. This procedure was applied to water samples collected February 25, 2004, from the Wardensville regional monitoring well (HRD-0301) and from Wardensville Spring. The town of Wardensville well was not sampled for CFCs because of possible hydraulic connection to Wardensville Spring.

Atmospheric partial pressures of CFCs are determined by Henry's Law from the recharge temperature and measured concentrations of trichlorofluoromethane (CCl_3F, CFC-11), dichlorodifluoromethane (CCl_2F_2, CFC-12), and trichlorotrifluorethane (CCl_2FCClF_2, CFC-113) in the ground water. These calculated partial pressures are compared with the modeled increase in CFC concentrations in the atmosphere over time to determine the CFC-model recharge age. This age equates to the time at which the water was isolated from air in the unsaturated zone.

On the basis of CFC analyses, it was estimated that the water sampled from the regional motoring well (HRD-0301) was isolated about 50 years ago. The apparent age of water sampled from Wardensville Spring was estimated to be approximately 20 years. The fact that the apparent age of the water issuing from Wardensville Spring has a younger apparent age than the water of the monitoring well implies that either water presumably recharged along the Anderson Ridge anticline moves at a quicker rate to the spring discharge than to the deeper ground-water system, or that the spring at the time of sampling was a mixture of old (about 50 years) and young (less than 50 years) water sources.

Mixtures of old and young waters can be identified on the basis of the disparity between age estimates from concentrations of individual CFCs because historical rates of releases of each CFC into the atmosphere differ. The CFC-11 age estimate for Wardensville Spring water was 19.4 years, the CFC-12 age estimate was 22.6 years, and the CFC-113 age estimate was 19.4 years. The similarity in the individual age estimates indicates that there was little mixing of different-age waters at the time of the Wardensville Spring sampling, therefore, the age estimate of about 20 years is valid, and the spring contained little, if any, surface runoff at the time of sampling.

Table 3. Water-quality analyses of Wardensville Spring (HRD-0019S), Waites Run at mile 1.0, the Town of Wardensville well (HRD-0302), and the Wardensville regional monitor well (HRD-0301), Feb. 25, 2004.

[µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, mg/L, milligrams per liter; col, colonies; MF, membrane filtered; mL, milliliters; µg/L, micrograms per liter; <, les s than]

	Wardensville Spring HRD-0019S	Waites Run at mile 1.0	Town of Wardensville well HRD-0302	Regional monitoring well HRD-0301
pH, standard units	6.9	6.7	7.0	6.6
Specific conductance, µS/cm	243	59	207	187
Temperature, ºC water	12.2	3.2	13.4	11.6
Hardness, mg/L as $CaCO_3$ unfiltered	86	19	95	72
Calcium, mg/L filtered	30.0	5.17	33.5	19.3
Magnesium, mg/L filtered	2.56	1.51	2.69	5.62
Potassium, mg/L filtered	1.57	.74	1.28	.36
Sodium, mg/L filtered	1.45	.92	1.43	6.00
Alkalinity, mg/L as $CaCO_3$ incremental titration	75	12	77	77
Bicarbonate, mg/L incremental titration	91	15	94	94
Carbonate, mg/L incremental titration	<1	<1	<1	<1
Chloride, mg/L filtered	3.23	1.09	2.91	.93
Fluoride, mg/L filtered	<.2	<.2	<.2	<.2
Silica, mg/L filtered	7.3	5.8	7.2	24.6
Sulfate, mg/L filtered	8.6	7.0	8.1	8.5
Ammonia, mg/L as Nitrogen filtered	<.04	<.04	<.04	.15
Nitrite + nitrate, mg/L as Nitrogen filtered	.41	.38	.31	<.06
Orthophosphate, mg/L as Phosphorus filtered	.120	<.02	.03	<.02
E. coli, NA-MUG MF, col/100 mL	1	8	7	<1
Fecal coliform, M-FC .7µ MF, col/100 mL	<1	[e] 10	<1	<1
Total coliform, M-Endo, immediate, col/100 mL	80	83	[e] 20	<1
Arsenate, µg/L as Arsenic filtered	.3	<.3	.3	<.3
Arsenic, µg/L unfiltered	<2	<2	<2	<2
Arsenite, µg/L as Arsenic filtered	<.3	<.3	<.3	<.3
Dimethylarsinate, µg/L as Arsenic filtered	<.2	<.2	<.2	<.2
Monomethylarsonate, µg/L as Arsenic filtered	<.2	<.2	<.2	<.2
Iron, µg/L filtered	10	15	126	1,680
Manganese, µg/L filtered	<.8	2.5	14.9	114
Strontium, µg/L filtered	206	35.7	235	301

[e] Estimated from non-ideal colony count.

Surface- and ground-water interaction

Although CFC data did not indicate that Wardensville Spring contained surface runoff, the presence of surface runoff could not be disproved with data collected during this project. The overflow from Wardensville Spring increased by 0.14 ft^3/s (90,500 gal/d) December 10-11, 2003, and the temperature dropped by 0.3°C. This corresponded with a large runoff event at Waites Run near Wardensville and indicates that the spring responded rapidly to precipitation events and might be under the influence of surface runoff at times. Coliform bacteria found in Wardensville Spring may indicate that the spring is under the influence of surface water, although these bacteria are ubiquitous in soils. To check for a hydraulic connection between Waites Run and Wardensville Spring, seepage measurement studies were made on Waites Run on October 22, 2003, and on February 29 and June 2, 2004. These consisted of a series of discharge measurements along the Waites Run channel adjacent to Wardensville Spring and extended upstream of the spring (fig. 1, table 4).

Channel conditions are not ideal for conducting seepage studies on Waites Run because the rocky streambed creates poor measurement conditions. The accuracy of each individual discharge measurement was judged to be at least plus or minus 10 percent, and differences in adjacent measurements along the channel were generally within this margin of error. Another problem associated with the data is that the seepage study of February 29, 2004, was made when snowmelt along the channel may have been occurring. The measurements made October 22, 2003, and June 2, 2004, suggest that Waites Run may be losing flow along channel. However, to verify these possible channel losses and test for possible connection with Wardensville Spring, a dye injection study would be needed.

Summary and conclusions

Water resources of the Wardensville area of West Virginia were investigated from October 2003 to May 2004 by the U.S. Geological Survey in cooperation with the West Virginia Conservation Agency. Flow statistics were estimated for three streams in the Wardensville area: Cacapon River above Wardensville; Waites Run near Wardensville; and Trout Run at Wardensville. The average discharges of the Cacapon River, Waites Run, and Trout Run were 170, 21, and 78 ft^3/s, respectively. The lowest average 7-consecutive-day flows expected every 10 years for these sites are 9.2 ft^3/s for the Cacapon River, 0.4 ft^3/s for Waites Run, and at least 1.9 ft^3/s for Trout Run. About 80 total coliform and 10 fecal coliform colonies per 100 mL of water were found in Waites Run at mile 1.0 on February 25, 2004. Occasionally, pH values in monthly samples of Waites Run at mile 4.3 collected from January 2002 to September 2003 were less than the EPA secondary maximum contaminant level of 6.5 standard units.

The age of water sampled at Wardensville Spring on February 25, 2004 was estimated to be about 20 years on the basis of CFC analyses. Average flow from the spring during the study was 0.265 ft^3/s (119 gal/min). Increases in springflow and drops in water temperature during large winter runoff events suggest that Wardensville Spring could be under the influence of surface runoff at such times. About 80 total coliform colonies per 100 mL of water were found in the spring on February 25, 2004, but less than 1 colony per 100 mL of water was fecal coliform. CFC data collected the same day indicated that there was probably little mixing of old and young waters, which also

Table 4. Discharge measurements along Waites Run on October 22, 2003, February 29 and June 2, 2004.

[Discharge in cubic feet per second; ---, no data]

Waites Run river mile	Oct. 22, 2003	Feb. 29, 2004	June 2, 2004
4.3 (gage location)	12	17	12
1.51	13.3	19.8	11.8
1.36	---	20	10.8
1.15	tributary dry	tributary inflow 0.8	tributary dry
1.14	---	20.6	12.4
1.04	---	19.6	---
0.92 (below Wardensville Spring)	11.1	21.1	11.1

indicates little influence of surface runoff at the time of sampling. The source of the total coliform bacteria in Wardensville Spring is unknown. Although seepage measurements of Waites Run, which flows adjacent to Wardensville Spring, suggest that the stream may be losing flow along channel, no evidence was obtained during this study to show the stream was hydraulically connected with the spring.

Wells HRD-0301 and HRD-0302 are completed in the Marcellus Formation near the Oriskany Sandstone on each side of the Anderson Ridge anticline near Wardensville. Well HRD-0301 was drilled during this study as a regional monitoring well and is capable of yielding 60 gal/min. The apparent age of the water from well HRD-0301 is approximately 50 years based on CFC analyses. Concentrations of iron (1,680 µg/L) and manganese (114 µg/L) in well HRD-0301 exceeded the EPA secondary maximum contaminant levels. Well HRD-0302 is midway between Waites Run and Wardensville Spring, approximately 130 ft from either. Well HRD-0302 and Wardensville Spring could be hydraulically connected. Pumping at the time of well completion induced drawdown at the spring. About 20 total coliform colonies per 100 mL of water were found in well HRD-0302 on February 25, 2004, but fecal coliform counts were low (less than 1 fecal coliform, and 7 *E. coli* colonies per 100 mL of water). Transmissivity values of the aquifer determined at wells HRD-0301 and HRD-0302 are 200 and 400 ft^2/d, respectively.

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Appendix A:

Discharge and Water-Quality Records for Waites Run near Wardensville, WV (01610400)

Figures

Tables

Table A-1. Water-discharge records for Waites Run near Wardensville, WV (01610400), January 2002-September 2003.
[---, missing data; e, estimated]

LOCATION.--Lat 39°02'33.8", long 78°35'54.0", Hardy County, Hydrologic Unit 02070003, on left bank at downstream side of bridge on Waites Run Road, 2.6 mi south of Wardensville, 4.3 mi upstream from mouth, and 8.2 mi east of Baker.

DRAINAGE AREA.--12.6 mi^2.

PERIOD OF RECORD.--January 2002 to September 2003.

GAGE DATUM.--1240.00 ft above National Geodetic Vertical Datum of 1929.

DISCHARGE, CUBIC FEET PER SECOND
JANUARY 2002 TO SEPTEMBER 2002
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	6.7	2.5	33	39	9.6	2.7	5.2	2.5
2	---	---	---	---	5.6	2.9	26	46	8.4	2.5	4.5	2.5
3	---	---	---	---	5.1	7.5	23	35	7.5	2.3	7.3	2.3
4	---	---	---	---	5.1	4.2	e18	30	7.9	2.2	9.6	2.1
5	---	---	---	---	4.4	3.6	e16	28	8.1	1.9	4.6	1.9
6	---	---	---	---	4.5	3.6	e15	24	9.4	1.9	3.8	1.8
7	---	---	---	---	4.9	3.4	e14	25	9.4	1.9	3.3	1.7
8	---	---	---	---	4.8	3.3	e13	23	6.6	1.9	3.0	1.7
9	---	---	---	---	4.2	3.2	e15	30	5.7	1.9	2.6	1.6
10	---	---	---	---	3.9	3.2	e25	31	4.9	2.4	2.4	1.5
11	---	---	---	---	4.1	3.0	e17	26	4.2	2.4	2.2	e1.3
12	---	---	---	---	3.7	3.1	e13	26	4.1	2.2	2.2	e1.1
13	---	---	---	---	3.7	4.2	e15	35	16	2.4	2.1	e1.0
14	---	---	---	---	3.4	4.1	e40	32	22	15	2.0	e0.78
15	---	---	---	---	3.4	3.7	e60	28	12	5.0	3.3	e0.86
16	---	---	---	---	3.4	3.6	e33	24	9.4	3.0	4.6	e1.1
17	---	---	---	---	3.4	3.6	13	23	7.7	2.5	2.5	e1.2
18	---	---	---	---	3.1	5.8	13	64	7.1	3.8	2.2	e1.0
19	---	---	---	---	3.0	6.1	13	44	6.3	5.2	2.2	e1.1
20	---	---	---	---	3.1	72	16	37	5.3	3.0	2.0	e1.0
21	---	---	---	---	3.1	45	35	33	4.6	2.5	1.9	e1.0
22	---	---	---	---	3.0	30	95	28	4.0	5.5	1.8	e1.1
23	---	---	---	---	2.9	23	57	24	3.5	13	1.8	e5.4
24	---	---	---	---	2.7	19	43	21	3.2	9.2	1.9	e11
25	---	---	---	---	2.8	16	35	19	3.0	5.2	2.0	e6.9
26	---	---	---	4.5	2.8	19	28	17	10	37	1.9	e8.3
27	---	---	---	4.1	2.7	26	24	16	6.9	23	1.8	e19
28	---	---	---	4.0	2.5	20	69	15	4.5	16	2.4	e40
29	---	---	---	3.9	---	18	61	14	3.4	11	8.1	e23
30	---	---	---	3.8	---	17	47	12	3.0	7.6	3.1	e14
31	---	---	---	7.7	---	24	---	11	---	6.1	2.5	---
TOTAL	---	---	---	---	106.0	403.6	925	860	217.7	202.2	100.8	159.74
MEAN	---	---	---	---	3.79	13.0	30.8	27.7	7.26	6.52	3.25	5.32
MAX	---	---	---	---	6.7	72	95	64	22	37	9.6	40
MIN	---	---	---	---	2.5	2.5	13	11	3.0	1.9	1.8	0.78
CFSM	---	---	---	---	0.30	1.03	2.45	2.20	0.58	0.52	0.26	0.42
IN.	---	---	---	---	0.31	1.19	2.73	2.54	0.64	0.60	0.30	0.47

Table A-1. Water-discharge records for Waites Run near Wardensville, WV (01610400), January 2002-September 2003 --Continued.

DISCHARGE, CUBIC FEET PER SECOND
WATER YEAR OCTOBER 2002 TO SEPTEMBER 2003
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	e10	e20	14	E140	7.1	32	37	16	14	14	7.0	4.1
2	e6.0	e18	13	e90	7.5	e32	44	15	12	12	4.6	5.4
3	e3.8	e16	12	69	7.9	e31	39	13	12	17	5.7	e8.0
4	e2.6	e14	11	53	e7.6	e31	36	20	29	12	7.0	e15
5	e2.4	e54	11	43	e7.0	68	32	19	21	9.8	6.3	9.2
6	e2.2	e36	9.9	37	e6.5	94	27	19	18	9.0	4.8	6.4
7	e2.0	e22	12	32	e6.0	74	59	18	29	10	4.3	5.4
8	e2.0	e19	8.9	31	e5.7	67	47	21	26	12	4.2	4.9
9	e3.0	17	8.4	31	e5.5	83	69	26	29	12	6.4	4.7
10	e6.0	17	7.7	27	e5.3	69	67	87	22	12	24	4.5
11	e11	20	17	24	e5.1	55	156	88	20	9.6	46	4.1
12	e6.0	47	25	21	e5.0	47	99	59	55	8.1	22	4.1
13	e4.0	48	40	20	e5.0	52	72	45	179	7.4	17	8.0
14	e3.6	38	48	19	e5.1	62	57	36	119	6.7	13	8.1
15	e8.0	32	38	17	e5.2	53	48	31	93	6.3	11	6.1
16	e14	30	34	e16	e5.6	47	42	58	68	5.7	9.1	5.1
17	e10	69	27	e15	e6.5	43	36	48	72	5.2	9.2	4.5
18	e6.0	53	23	e14	e13	40	34	56	64	5.0	15	93
19	e5.0	42	23	e14	e11	35	37	53	55	5.0	8.8	679
20	e4.2	35	60	e13	e9.0	162	30	46	78	4.4	7.4	151
21	e3.6	35	57	12	e11	131	30	41	66	4.9	6.4	81
22	e3.2	37	46	e12	e40	83	40	35	54	4.7	5.9	57
23	e3.0	31	37	11	177	61	32	31	43	4.5	5.4	72
24	e2.8	28	31	e10	89	48	29	29	34	4.2	4.8	46
25	e11	24	28	e9.5	60	41	27	26	27	3.7	4.4	38
26	e10	21	24	e8.8	46	40	26	24	22	3.5	4.2	32
27	e8.0	20	20	8.3	39	34	22	21	19	3.4	5.0	28
28	e14	18	18	e8.0	34	29	20	20	16	8.4	4.6	26
29	e40	16	17	e7.7	---	28	18	18	14	6.6	4.1	21
30	e30	16	16	7.4	---	29	16	16	12	4.2	3.9	18
31	e24	---	18	6.9	---	28	---	16	---	3.8	4.0	---
TOTAL	261.4	893	754.9	827.6	632.6	1,729	1,328	1,051	1,322	235.1	285.5	1,449.6
MEAN	8.43	29.8	24.4	26.7	22.6	55.8	44.3	33.9	44.1	7.58	9.21	48.3
MAX	40	69	60	140	177	162	156	88	179	17	46	679
MIN	2.0	14	7.7	6.9	5.0	28	16	13	12	3.4	3.9	4.1
CFSM	0.67	2.36	1.93	2.12	1.79	4.43	3.51	2.69	3.50	0.60	0.73	3.83
IN.	0.77	2.64	2.23	2.44	1.87	5.10	3.92	3.10	3.90	0.69	0.84	4.28

e Estimated

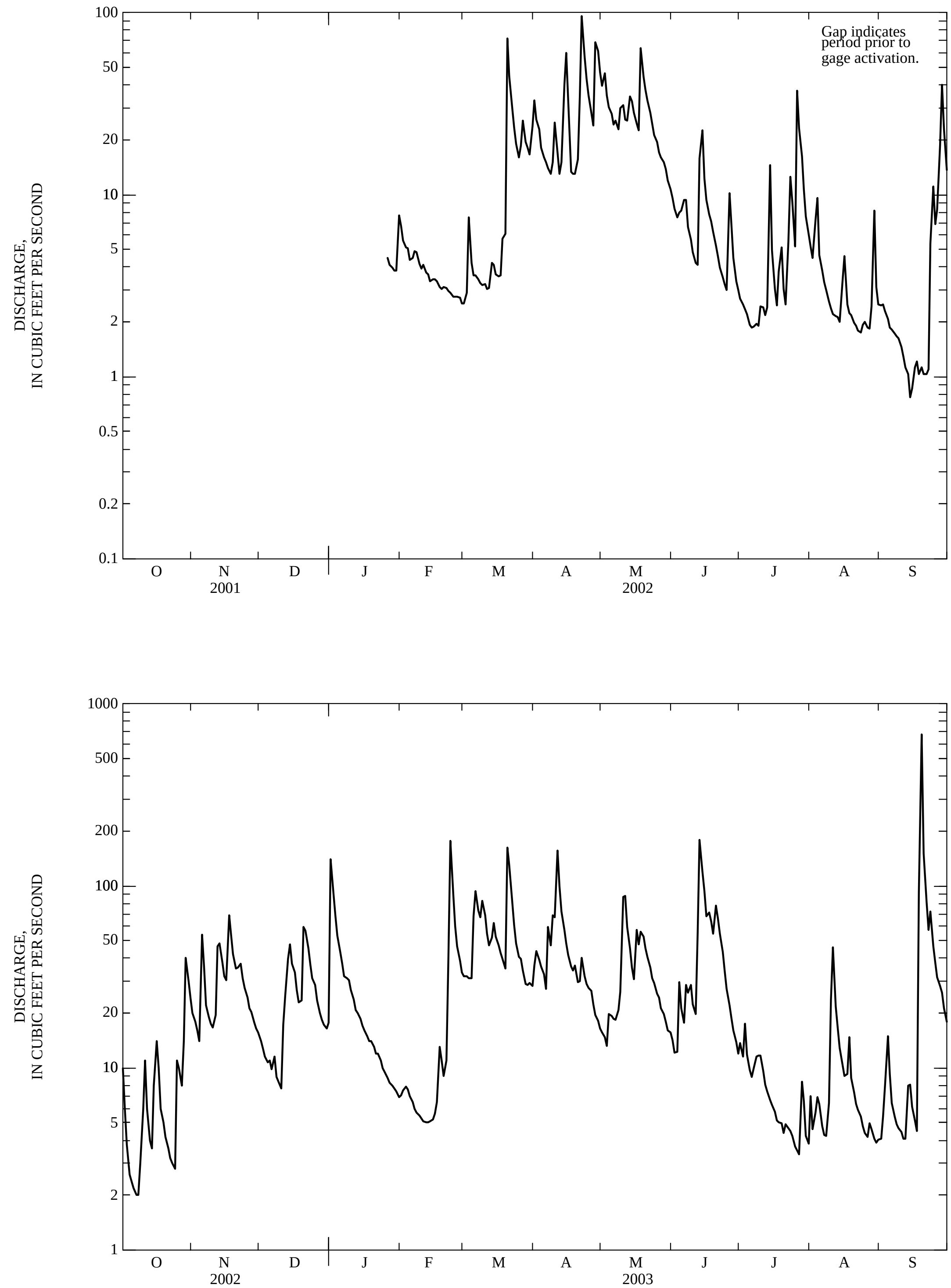


Figure A-1. Daily mean discharge for Waites Run near Wardensville, WV,

January 2002-September 2003.

Table A-2. Specific-conductance records for Waites Run near Wardensville, WV, January 2002-September 2003.

[---, missing data]

PERIOD OF DAILY RECORD: January 2002 to September 2003.

REMARKS.—Some missing record due to instrument malfunctions. Records good.

EXTREMES FOR PERIOD OF DAILY RECORD: Maximum, 109 microsiemens/cm, Sept. 10, 2002; minimum, 23 microsiemens/cm, Feb. 22, 2003.

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
JANUARY 2002

DAY										MAX	MIN	MEAN
											JANUARY	
1	---	---	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---	---	---
3	---	---	---	---	---	---	---	---	---	---	---	---
4	---	---	---	---	---	---	---	---	---	---	---	---
5	---	---	---	---	---	---	---	---	---	---	---	---
6	---	---	---	---	---	---	---	---	---	---	---	---
7	---	---	---	---	---	---	---	---	---	---	---	---
8	---	---	---	---	---	---	---	---	---	---	---	---
9	---	---	---	---	---	---	---	---	---	---	---	---
10	---	---	---	---	---	---	---	---	---	---	---	---
11	---	---	---	---	---	---	---	---	---	---	---	---
12	---	---	---	---	---	---	---	---	---	---	---	---
13	---	---	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---	---	---
15	---	---	---	---	---	---	---	---	---	---	---	---
16	---	---	---	---	---	---	---	---	---	---	---	---
17	---	---	---	---	---	---	---	---	---	---	---	---
18	---	---	---	---	---	---	---	---	---	---	---	---
19	---	---	---	---	---	---	---	---	---	72	69	70
20	---	---	---	---	---	---	---	---	---	70	65	67
21	---	---	---	---	---	---	---	---	---	71	68	69
22	---	---	---	---	---	---	---	---	---	70	63	66
23	---	---	---	---	---	---	---	---	---	69	64	66
24	---	---	---	---	---	---	---	---	---	64	57	61
25	---	---	---	---	---	---	---	---	---	57	54	56
26	---	---	---	---	---	---	---	---	---	60	57	58
27	---	---	---	---	---	---	---	---	---	61	58	59
28	---	---	---	---	---	---	---	---	---	62	58	60
29	---	---	---	---	---	---	---	---	---	63	58	60
30	---	---	---	---	---	---	---	---	---	63	60	62
31	---	---	---	---	---	---	---	---	---	62	50	55

Table A-2. Specific-conductance records for Waites Run near Wardensville, WV, January 2002-September 2003—Continued.

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
FEBRUARY TO MAY 2002

DAY	DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN
	FEBRUARY			MARCH			APRIL			MAY		
1	55	53	54	76	65	69	38	35	35	29	27	28
2	55	53	54	70	66	68	35	34	34	31	28	29
3	56	53	54	69	48	55	34	33	33	31	29	29
4	55	52	54	62	56	58	33	33	33	29	28	29
5	63	52	56	76	56	64	33	33	33	30	28	29
6	56	54	55	64	58	60	34	32	33	30	29	30
7	55	52	53	65	59	61	35	33	34	31	29	30
8	55	51	53	65	60	63	36	34	35	32	30	31
9	57	54	55	67	61	64	37	36	36	34	29	32
10	59	55	57	66	61	63	39	37	37	32	31	32
11	58	53	56	66	62	64	40	38	39	32	30	31
12	59	56	57	67	62	65	41	39	40	32	30	31
13	59	56	58	66	57	62	41	39	40	33	27	31
14	66	56	59	63	57	59	41	38	40	31	30	30
15	62	57	59	65	59	62	41	38	40	30	29	30
16	62	58	60	65	61	64	41	39	40	31	29	30
17	62	58	60	65	61	63	41	39	40	31	30	31
18	65	60	61	62	52	56	41	39	40	34	30	31
19	69	58	63	56	53	54	43	39	40	31	28	29
20	65	60	63	55	40	44	43	39	40	29	27	28
21	67	61	64	40	37	38	44	36	39	28	27	28
22	67	62	64	37	34	35	38	32	34	28	27	28
23	67	63	65	34	33	34	32	29	31	29	28	28
24	68	64	66	35	34	34	30	28	29	31	28	29
25	70	64	66	40	35	38	29	28	29	32	30	30
26	69	65	67	40	33	36	30	29	29	33	31	32
27	69	63	66	36	35	36	30	29	30	34	32	33
29	---	---	---	36	35	35	31	29	30	37	34	35
30	---	---	---	36	35	36	29	28	28	41	36	37
31	---	---	---	37	34	36	---	---	---	40	37	38
Month	70	51	60	76	33	52	44	28	35	41	27	31

Table A-2. Specific-conductance records for Waites Run near Wardensville, WV, January 2002-September 2003—Continued.

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
JUNE TO SEPTEMBER 2002

DAY	DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN
	JUNE			JULY			AUGUST			SEPTEMBER		
1	42	39	40	63	59	61	57	53	55	84	81	83
2	43	40	41	65	61	63	59	55	57	84	80	82
3	45	41	43	67	63	65	61	40	57	87	84	85
4	45	41	44	69	66	68	56	42	49	91	87	90
5	47	40	43	72	69	71	62	56	58	96	91	94
6	48	36	44	74	72	73	64	59	61	98	96	97
7	45	38	42	76	73	74	66	63	64	101	97	99
8	49	44	47	76	73	75	69	65	67	104	100	102
9	51	48	49	79	75	77	72	68	70	106	102	104
10	54	49	51	79	66	74	74	71	73	109	104	106
11	56	51	53	74	67	70	78	74	76	---	---	---
12	57	53	55	78	74	76	80	76	78	---	---	---
13	59	29	49	80	70	78	82	78	80	---	---	---
14	40	33	36	70	34	45	83	80	82	---	---	---
15	42	40	41	61	48	54	88	51	81	---	---	---
16	44	42	43	69	61	65	73	51	61	---	---	---
17	46	43	44	74	69	72	80	73	76	---	---	---
18	46	44	45	77	48	73	83	79	81	---	---	---
19	48	44	46	66	48	58	85	81	83	---	---	---
20	50	47	48	73	66	69	87	84	86	---	---	---
21	53	49	51	77	73	74	91	87	89	---	---	---
22	54	51	53	79	36	75	92	90	91	---	---	---
23	56	53	55	53	36	46	96	92	94	---	---	---
24	58	54	56	54	44	49	96	86	93	---	---	---
25	60	56	58	58	53	56	93	87	90	---	---	---
26	62	32	52	57	33	43	97	93	96	---	---	---
27	51	38	45	43	39	41	98	97	97	---	---	---
28	54	49	51	46	41	43	99	76	96	---	---	---
29	58	54	56	49	45	46	76	50	56	---	---	---
30	60	57	59	51	47	49	78	66	72	---	---	---
31	---	---	---	55	51	52	83	78	80	---	---	---
Month	62	29	48	80	33	62	99	40	76	---	---	---

Table A-2. Specific-conductance records for Waites Run near Wardensville, WV, January 2002-September 2003—Continued.

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
OCTOBER 2002 TO JANUARY 2003

DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
	OCTOBER			NOVEMBER			DECEMBER			JANUARY		
1	---	---	---	---	---	---	34	33	33	---	---	---
2	---	---	---	---	---	---	34	34	34	---	---	---
3	---	---	---	---	---	---	35	34	34	30	29	30
4	---	---	---	---	---	---	37	30	34	30	29	29
5	---	---	---	---	---	---	36	32	34	29	29	29
6	---	---	---	---	---	---	36	34	35	30	29	29
7	---	---	---	---	---	---	43	31	38	30	29	29
8	---	---	---	---	---	---	38	36	37	30	30	30
9	---	---	---	37	36	36	40	37	38	31	30	30
10	---	---	---	38	37	37	40	38	40	31	30	31
11	---	---	---	38	35	37	42	34	38	31	30	31
12	---	---	---	40	36	38	39	37	38	35	29	31
13	---	---	---	36	34	35	39	34	36	32	29	31
14	---	---	---	36	32	33	34	33	34	32	32	32
15	---	---	---	32	31	32	34	33	34	35	32	33
16	---	---	---	35	32	32	34	32	33	38	32	35
17	---	---	---	36	32	34	33	32	33	36	28	31
18	---	---	---	33	31	32	34	33	34	41	33	37
19	---	---	---	31	30	31	34	32	34	35	33	34
20	---	---	---	31	30	30	33	31	32	36	32	35
21	---	---	---	32	30	31	31	30	30	37	24	35
22	---	---	---	32	31	32	30	29	29	32	26	30
23	---	---	---	32	30	31	30	29	29	42	32	37
24	---	---	---	31	30	31	30	29	29	45	38	42
25	---	---	---	32	31	31	30	29	29	41	38	40
26	---	---	---	32	31	32	30	30	30	42	40	41
27	---	---	---	32	32	32	31	30	31	46	41	44
28	---	---	---	32	31	32	32	31	31	48	39	45
29	---	---	---	32	32	32	33	32	32	43	41	42
30	---	---	---	33	32	33	34	33	33	44	42	43
31	---	---	---	---	---	---	34	33	33	45	43	44
Month	---	---	---	---	---	---	43	29	34	48	24	35

Table A-2. Specific-conductance records for Waites Run near Wardensville, WV, January 2002-September 2003--Continued.

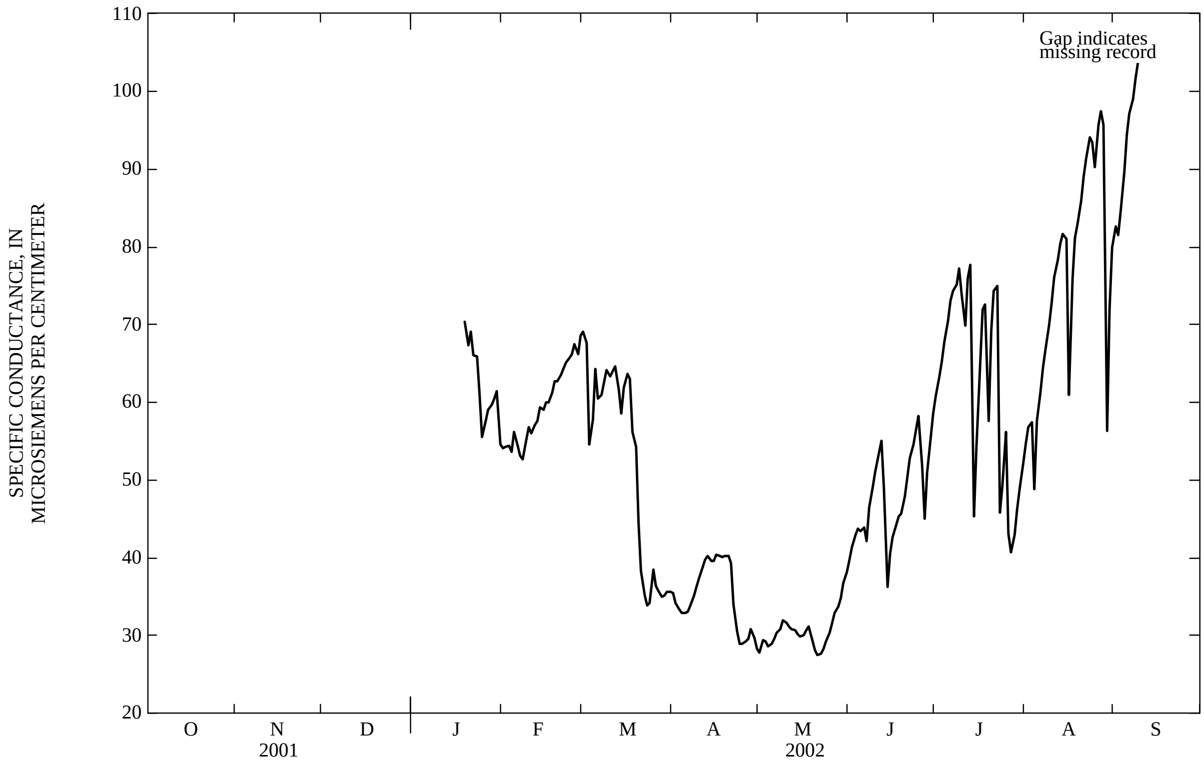
SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
FEBRUARY TO MAY 2003

DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
		FEBRUARY			MARCH			APRIL			MAY	
1	45	44	44	34	33	33	33	29	31	36	34	35
2	45	42	44	34	33	34	31	30	30	37	34	36
3	44	42	43	34	32	34	31	29	30	38	35	37
4	45	38	42	33	32	33	31	29	30	39	33	35
5	45	42	44	35	31	33	31	30	30	37	33	35
6	56	42	47	32	31	31	31	30	30	36	34	35
7	47	45	46	31	30	31	32	30	31	36	34	35
8	58	39	43	32	30	30	31	30	30	36	32	35
9	59	41	48	31	30	30	30	28	29	38	33	35
10	49	47	48	30	29	29	30	27	28	40	29	33
11	56	46	49	30	29	29	29	26	26	30	28	28
12	53	49	52	30	29	29	26	25	26	28	27	27
13	71	45	55	31	28	29	26	25	25	27	26	27
14	55	50	53	29	28	29	26	25	25	28	27	27
15	53	47	51	29	28	28	27	25	26	30	28	28
16	71	53	62	29	28	28	28	26	27	30	28	29
17	72	50	59	29	28	28	28	26	27	29	28	28
18	51	49	50	29	28	29	29	27	28	28	27	28
19	52	51	51	29	28	29	29	27	28	28	26	27
20	52	49	50	32	28	29	29	27	28	28	26	27
21	51	46	49	29	28	28	33	28	30	28	27	27
22	46	23	38	28	27	27	33	29	30	28	27	27
23	34	31	33	28	27	27	30	29	30	29	28	28
24	33	33	33	28	27	28	30	28	29	30	28	29
25	33	32	33	29	28	28	30	29	30	31	29	30
26	32	31	32	43	28	28	31	30	30	31	30	31
27	32	31	32	33	28	28	32	30	31	32	31	31
28	33	32	32	32	29	29	34	31	32	33	31	32
29	---	---	---	31	29	30	35	32	33	33	32	33
30	---	---	---	31	29	30	35	32	34	35	32	33
31	---	---	---	41	30	32	---	---	---	35	33	34
Month	72	23	45	43	27	30	35	25	29	40	26	31

Table A-2. Specific-conductance records of Waites Run near Wardensville, WV, January 2002-September 2003—Continued.

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
JUNE TO SEPTEMBER 2003

DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
		JUNE			JULY			AUGUST			SEPTEMBER	
1	38	32	35	39	32	36	74	52	62	71	68	70
2	37	35	36	39	38	39	72	65	68	71	54	67
	38	35	37	40	34	37	75	62	72	68	43	60
4	39	31	34	42	38	39	70	62	66	57	46	50
5	35	33	34	45	41	42	69	62	65	59	53	55
6	35	34	35	48	43	45	74	69	70	62	59	60
7	37	34	35	47	40	43	76	72	74	65	61	62
8	36	33	34	---	---	---	76	72	73	66	63	64
9	35	32	33	---	---	---	78	49	72	67	64	66
10	34	32	33	---	---	---	68	34	58	68	65	66
11	35	32	34	49	45	46	45	36	42	70	66	68
12	40	27	33	51	46	48	47	44	45	71	68	70
13	32	24	30	52	48	49	48	45	46	69	54	58
14	28	27	28	52	49	51	49	46	47	60	55	58
15	28	27	27	56	50	52	51	48	49	63	59	61
16	28	26	27	58	52	55	53	49	51	66	62	63
17	28	27	28	60	55	57	57	49	52	67	64	65
18	28	27	28	62	58	60	59	44	50	68	27	58
19	28	27	28	62	58	59	55	51	53	29	27	28
20	34	28	29	65	60	62	58	53	55	27	26	26
21	28	27	28	67	55	62	60	55	57	26	26	26
22	28	27	27	66	57	62	62	56	60	29	26	27
23	28	27	27	67	63	65	64	59	61	29	28	28
24	29	27	28	69	64	65	64	61	63	28	28	28
25	30	28	29	72	68	70	67	61	64	29	28	28
26	32	29	30	75	70	72	69	63	66	30	29	29
27	32	31	31	78	72	75	70	59	64	32	30	30
28	34	32	33	82	44	70	68	62	64	32	31	32
29	37	34	35	66	48	59	71	65	68	33	32	32
30	39	36	37	72	66	68	73	68	71	34	32	33
31	---	---	---	74	71	72	71	69	70	---	---	---
Month	40	24	31	82	32	56	78	34	61	71	26	49



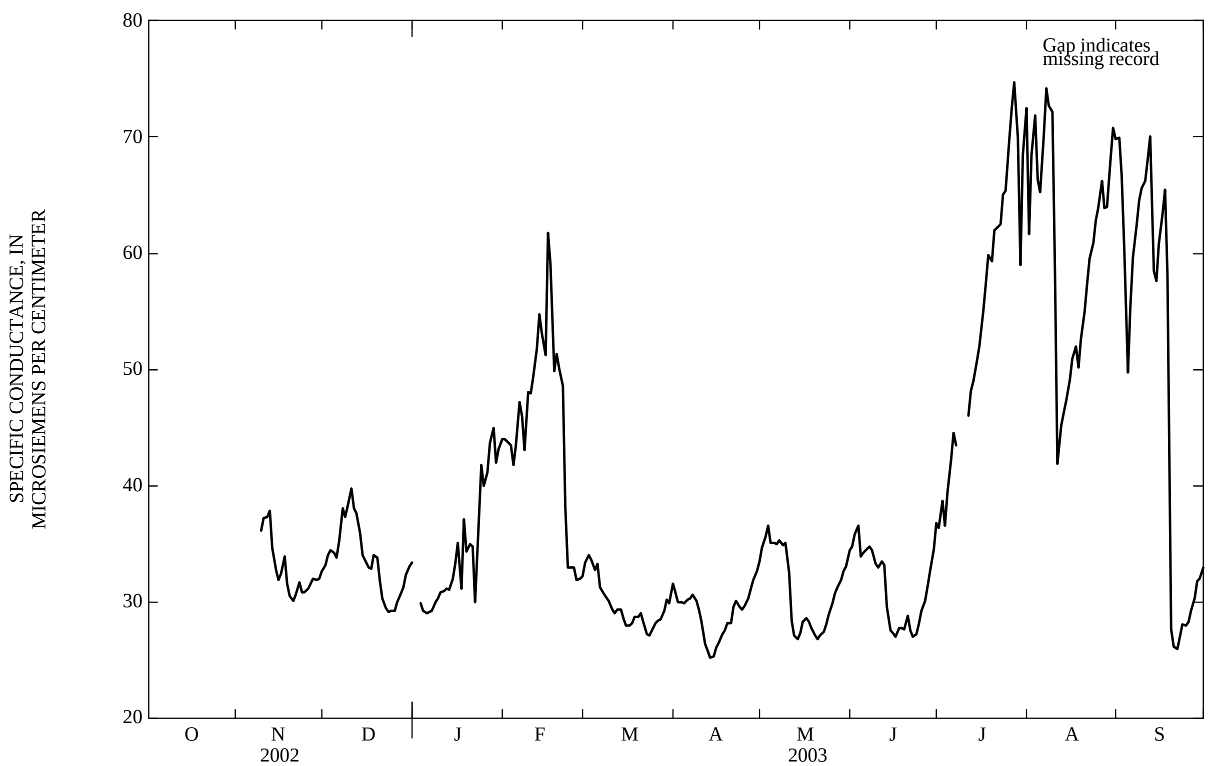


Figure A-2. Daily mean specific conductance for Waites Run near Wardensville, WV, January 2002-September 2003.

Table A-3. Water-temperature records for Waites Run near Wardensville, WV, January 2002-September 2003.

[---, missing data]

PERIOD OF DAILY RECORD: January 2002 to September 2003.

REMARKS.—Some missing record due to instrument malfunctions. Records good.

EXTREMES FOR PERIOD OF DAILY RECORD: Maximum, 24.5°C, July 3, 2002; minimum, 0.0°C, on many day during winter periods.

TEMPERATURE, WATER, DEGREES CELSIUS
JANUARY 2002

DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
											JANUARY	
1	---	---	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---	---	---
3	---	---	---	---	---	---	---	---	---	---	---	---
4	---	---	---	---	---	---	---	---	---	---	---	---
5	---	---	---	---	---	---	---	---	---	---	---	---
6	---	---	---	---	---	---	---	---	---	---	---	---
7	---	---	---	---	---	---	---	---	---	---	---	---
8	---	---	---	---	---	---	---	---	---	---	---	---
9	---	---	---	---	---	---	---	---	---	---	---	---
10	---	---	---	---	---	---	---	---	---	---	---	---
11	---	---	---	---	---	---	---	---	---	---	---	---
12	---	---	---	---	---	---	---	---	---	---	---	---
13	---	---	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---	---	---
15	---	---	---	---	---	---	---	---	---	---	---	---
16	---	---	---	---	---	---	---	---	---	---	---	---
17	---	---	---	---	---	---	---	---	---	---	---	---
18	---	---	---	---	---	---	---	---	---	---	---	---
19	---	---	---	---	---	---	---	---	---	1.3	0.4	1.0
20	---	---	---	---	---	---	---	---	---	2.9	0.5	1.7
21	---	---	---	---	---	---	---	---	---	4.0	1.5	2.7
22	---	---	---	---	---	---	---	---	---	4.4	1.5	2.8
23	---	---	---	---	---	---	---	---	---	6.5	3.1	4.8
24	---	---	---	---	---	---	---	---	---	7.1	4.9	6.0
25	---	---	---	---	---	---	---	---	---	6.5	2.9	4.7
26	---	---	---	---	---	---	---	---	---	4.9	1.7	3.1
27	---	---	---	---	---	---	---	---	---	5.7	2.1	3.7
28	---	---	---	---	---	---	---	---	---	6.4	2.5	4.4
29	---	---	---	---	---	---	---	---	---	8.4	4.8	6.6
30	---	---	---	---	---	---	---	---	---	8.7	7.8	8.1
31	---	---	---	---	---	---	---	---	---	8.6	7.6	8.1
Month	---	---	---	---	---	---	---	---	---	---	---	---

Table A-3. Water-temperature records for Waites Run near Wardensville, WV, January 2002-September 2003--Continued.

TEMPERATURE, WATER, DEGREES CELSIUS
FEBRUARY TO MAY 2002

DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
		FEBRUARY			MARCH			APRIL			MAY	
1	10.7	6.6	8.7	5.0	0.0	2.0	9.7	6.9	8.0	13.5	9.4	11.4
2	6.6	3.6	5.1	3.1	1.7	2.4	10.7	6.4	8.5	15.2	11.8	13.5
3	5.0	2.9	3.8	6.4	2.6	4.1	9.9	6.9	9.1	13.4	10.4	12.1
4	3.6	1.0	2.9	3.6	0.0	1.9	8.5	5.2	6.7	11.6	8.7	10.1
5	2.0	0.0	0.8	3.1	0.0	1.0	7.9	4.8	6.1	13.2	8.4	10.9
6	3.2	0.4	1.9	6.6	1.0	3.4	7.0	4.4	5.5	13.8	10.6	12.4
7	4.2	2.0	2.9	6.7	2.5	4.6	8.1	3.3	5.6	14.1	12.6	13.4
8	5.4	1.9	3.3	9.4	3.8	6.3	11.3	6.1	8.6	14.8	12.6	13.8
9	5.7	2.0	3.6	10.7	5.9	8.4	11.6	9.8	10.7	16.5	14.0	15.1
10	6.8	2.9	4.9	9.0	3.5	5.9	13.3	9.3	10.8	15.7	13.1	14.3
11	5.8	2.2	4.1	6.5	2.0	4.0	13.0	7.5	10	14.5	11.2	12.9
12	5.5	1.6	3.2	6.5	3.7	5.1	12.7	8.1	10.3	14.7	12.8	13.8
13	5.2	1.7	3.4	7.1	5.9	6.3	13.9	11.2	12.1	15.6	13.3	14.5
14	4.0	0.1	1.9	10.6	4.9	7.5	14.7	10.9	12.8	13.3	10.4	11.6
15	5.3	1.8	3.3	13.0	7.7	10.1	16.1	12.4	13.9	13.4	9.9	11.5
16	6.5	3.6	4.7	11.3	8.6	10.4	15.9	12.3	14.2	14.4	10.2	12.4
17	4.7	2.1	3.8	8.6	5.8	6.7	17.5	12.9	15.1	14.2	12.9	13.5
18	4.3	0.4	2.2	8.1	5.6	6.8	16.6	13.7	15.1	13.6	10.2	11.6
19	5.0	0.3	2.7	8.3	6.7	7.4	17.6	13.9	15.7	10.9	9.3	10.1
20	7.1	4.0	5.6	7.7	6.2	7.0	16.1	14.6	15.3	10.1	8.1	9.2
21	8.8	5.8	6.9	8.9	5.8	7.2	14.6	10.7	12.9	9.8	8.0	8.8
22	6.6	4.6	5.7	5.8	2.9	4.0	13.1	10.1	11.3	11.2	7.1	9.2
23	6.5	3.0	4.6	5.9	2.1	3.8	10.1	8.4	9.4	13.1	8.6	10.9
24	6.2	1.3	3.6	6.8	3.1	5.0	11.9	7.3	9.6	14.9	10.5	12.7
25	7.4	2.4	4.8	8.5	4.8	6.5	11.7	9.6	10.6	15.2	13.0	14.0
26	8.6	4.2	6.2	7.0	6.1	6.5	12.1	8.5	10.0	16.1	14.0	14.9
27	5.4	0.8	3.3	7.0	4.8	5.9	11.0	8.0	9.8	16.0	14.0	15.0
28	4.0	0.0	1.6	7.5	3.5	5.4	13.7	10.4	11.7	16.4	14.3	15.3
29	---	---	---	10.4	5.9	8.0	11.5	9.0	10.1	18.4	14.7	16.3
30	---	---	---	11.5	9.0	9.8	12.7	8.4	10.5	18.3	15.0	16.6
31	---	---	---	9.5	7.7	8.6	---	---	---	19.9	16.4	17.9
Month	10.7	0.0	3.9	13.0	0.0	5.9	17.6	3.3	10.7	19.9	7.1	12.9

Table A-3. Water-temperature records for Waites Run near Wardensville, WV, January 2002-September 2003--Continued.

TEMPERATURE, WATER, DEGREES CELSIUS
JUNE TO SEPTEMBER 2002

DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
		JUNE			JULY			AUGUST			SEPTEMBER	
1	20.3	16.9	18.3	22.7	18.5	20.4	23.6	20.0	21.5	17.7	17.0	17.3
2	19.9	16.5	17.8	23.6	19.3	21.2	24.1	20.0	21.8	19.1	16.8	17.6
3	18.5	14.6	16.4	24.5	20.1	22.0	24.2	20.3	21.7	20.9	16.9	18.8
4	19.7	15.7	17.6	24.4	20.2	22.1	22.8	19.3	20.9	21.9	18.2	19.8
5	21.2	17.6	19.1	24.3	20.0	22.0	23.3	19.9	21.4	20.4	16.4	18.2
6	19.2	17.3	18.3	22.2	17.9	19.8	22.2	18.4	20.6	20.2	16.4	18.0
7	18.6	15.7	17.0	21.0	17.0	19.1	19.8	16.4	18.0	19.7	15.3	17.4
8	19.1	14.3	16.4	22.4	17.1	19.6	20.2	15.9	17.7	19.9	15.5	17.6
9	19.5	15.0	17.2	23.2	19.4	21.0	20.4	15.6	17.7	19.9	15.5	17.5
10	20.5	16.3	18.4	21.8	20.0	20.6	21.0	15.9	18.2	20.3	15.6	17.7
11	21.5	17.7	19.4	21.0	17.2	19.0	21.9	17.2	19.4	---	---	---
12	21.4	17.8	19.4	20.9	15.4	17.9	22.1	18.5	20.2	---	---	---
13	19.9	18.2	18.9	18.8	17.2	18.0	22.2	18.9	20.4	---	---	---
14	19.1	17.5	18.1	18.1	17.5	17.8	23.5	19.3	21.1	---	---	---
15	17.7	15.7	16.9	21.1	17.5	19.0	22.4	19.2	20.6	---	---	---
16	17.9	15.5	16.5	22.4	18.0	19.9	21.7	19.9	20.6	---	---	---
17	18.2	14.8	16.3	23.1	18.4	20.6	22.3	19.9	21.0	---	---	---
18	18.0	14.5	16.2	22.3	19.9	20.6	23.1	19.8	21.3	---	---	---
19	18.6	15.2	16.7	21.8	19.5	20.4	23.3	19.9	21.5	---	---	---
20	19.9	15.6	17.5	23.0	19.4	20.8	22.6	19.5	20.9	---	---	---
21	20.3	15.8	17.8	22.9	18.9	20.8	22.2	18.1	20.0	---	---	---
22	20.6	15.7	17.8	24.2	20.0	21.7	23.5	19.7	21.3	---	---	---
23	21.2	15.9	18.3	23.1	20.2	21.3	23.2	20.3	21.6	---	---	---
24	22.1	17.4	19.4	20.8	19.5	20.1	23.0	20.6	21.6	---	---	---
25	22.6	18.0	20.0	19.6	19.2	19.4	22.0	19.2	20.5	---	---	---
26	21.5	18.7	19.7	19.2	18.6	18.8	20.9	18.4	19.5	---	---	---
27	21.1	18.4	19.5	20.3	18.4	19.3	20.5	17.9	19.2	---	---	---
28	21.4	18.5	19.6	21.6	19.0	20.2	19.2	17.1	18.3	---	---	---
29	21.9	17.9	19.5	22.7	19.8	21.1	17.4	16.6	17.0	---	---	---
30	21.3	17.5	19.3	22.9	20.5	21.4	18.1	16.5	17.3	---	---	---
31	---	---	---	23.2	20.2	21.4	18.2	15.8	17.1	---	---	---
Month	22.6	14.3	18.1	24.5	15.4	20.2	24.2	15.6	20.0	---	---	---

Table A-3. Water-temperature records for Waites Run near Wardensville, WV, January 2002-September 2003--Continued.

TEMPERATURE, WATER, DEGREES CELSIUS
OCTOBER 2002 TO JANUARY 2003

DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
		OCTOBER			NOVEMBER			DECEMBER			JANUARY	
1	---	---	---	---	---	---	4.0	1.9	2.7	---	---	---
2	---	---	---	---	---	---	3.6	1.8	2.7	---	---	---
3	---	---	---	---	---	---	3.2	0.2	1.9	5.9	4.8	5.2
4	---	---	---	---	---	---	0.9	0.0	0.4	4.8	3.4	4.1
5	---	---	---	---	---	---	0.7	0.0	0.1	3.7	3.2	3.4
6	---	---	---	---	---	---	1.6	0.0	0.8	4.5	3.0	3.9
7	---	---	---	---	---	---	0.6	0.0	0.2	3.0	1.5	2.3
8	---	---	---	---	---	---	2.8	0.5	1.8	4.8	3.0	3.9
9	---	---	---	9.6	7.2	8.5	1.8	0.1	0.8	5.8	4.5	5.0
10	---	---	---	12.4	9.6	11.1	1.9	0.2	0.9	4.8	3.1	4.3
11	---	---	---	13.1	11.3	12.5	2.3	1.2	1.6	3.1	0.9	1.7
12	---	---	---	11.3	10.2	10.7	3.4	2.3	2.9	0.9	0.0	0.4
13	---	---	---	10.2	8.2	9.4	3.8	2.9	3.4	2.0	0.0	0.9
14	---	---	---	9.8	8.1	8.9	4.6	3.8	4.3	1.7	0.7	1.2
15	---	---	---	9.4	7.8	8.7	4.7	3.7	4.3	0.9	0.0	0.4
16	---	---	---	9.2	9.0	9.1	4.8	3.2	4.3	0.0	0.0	0.0
17	---	---	---	9.0	7.9	8.7	3.2	2.0	2.7	0.3	0.0	0.0
18	---	---	---	7.9	7.0	7.4	4.0	3.0	3.5	0.0	0.0	0.0
19	---	---	---	8.0	6.5	7.3	6.9	3.7	5.0	0.0	0.0	0.0
20	---	---	---	8.0	6.4	7.2	7.4	5.4	6.8	0.8	0.0	0.3
21	---	---	---	8.8	7.1	8.1	5.6	4.9	5.2	0.9	0.0	0.4
22	---	---	---	8.8	6.8	8.2	6.1	4.5	5.3	0.0	0.0	0.0
23	---	---	---	6.8	5.3	5.9	5.5	4.3	4.7	0.0	0.0	0.0
24	---	---	---	7.4	5.6	6.4	4.3	3.2	3.8	0.0	0.0	0.0
25	---	---	---	8.0	5.7	6.9	3.6	2.4	3.2	0.0	0.0	0.0
26	---	---	---	7.8	5.8	6.6	3.2	2.1	2.7	0.0	0.0	0.0
27	---	---	---	5.8	4.1	5.3	2.6	1.1	1.9	0.0	0.0	0.0
28	---	---	---	4.1	3.1	3.5	2.9	1.3	2.2	0.0	0.0	0.0
29	---	---	---	4.5	2.9	3.8	4.1	2.9	3.3	0.3	0.0	0.1
30	---	---	---	5.7	4.0	4.9	3.6	2.2	3.0	0.8	0.3	0.6
31	---	---	---	---	---	---	5.2	3.5	4.4	0.9	0.5	0.7
Month	---	---	---	---	---	---	7.4	0.0	2.9	5.9	0.0	1.3

Table A-3. Water-temperature records for Waites Run near Wardensville, WV, January 2002-September 2003--Continued.

TEMPERATURE, WATER, DEGREES CELSIUS
FEBRUARY TO MAY 2003

DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
		FEBRUARY			MARCH			APRIL			MAY	
1	1.5	0.8	1.1	5.3	2.5	3.6	8.6	3.7	6.1	17.2	12.6	14.4
2	2.3	1.0	1.4	4.9	3.3	3.9	12.1	6.9	9.4	16.7	13.5	14.8
3	2.5	0.7	1.5	3.4	1.2	2.2	13.2	8.2	10.7	15.7	12.8	14.1
4	2.2	0.7	1.6	4.0	0.5	2.3	12.4	9.2	10.9	13.3	11.5	12.5
5	1.7	0.0	0.6	5.3	3.4	4.1	13.0	9.5	10.9	11.5	10.2	10.5
6	1.3	0.0	0.5	4.3	3.1	3.9	10.1	7.6	8.8	13.5	10.0	11.7
7	1.7	0.2	0.9	4.8	2.7	3.6	8.5	6.0	6.6	15.2	11.8	13.6
8	0.6	0.0	0.1	6.1	2.5	4.2	6.9	5.8	6.3	16.0	13.0	14.3
9	0.8	0.0	0.2	6.5	4.0	5.2	6.3	4.7	5.7	14.0	12.8	13.3
10	2.1	0.5	1.1	4.5	2.6	3.5	7.0	5.9	6.4	13.4	12.5	13.1
11	1.2	0.0	0.6	5.4	2.4	3.7	6.8	6.0	6.5	15.0	12.1	13.3
12	1.6	0.0	0.5	6.3	3.2	4.8	10.6	6.6	8.3	12.8	11.0	11.8
13	0.4	0.0	0.1	7.7	4.7	6.2	11.0	6.5	8.6	11.7	10.5	11.0
14	1.5	0.0	0.6	6.8	4.4	5.6	11.8	6.6	9.2	13.6	9.6	11.6
15	0.6	0.0	0.1	8.0	4.0	5.9	13.5	8.7	11.1	12.1	11.1	11.7
16	0.0	0.0	0.0	9.3	5.9	7.6	13.5	9.3	11.5	11.9	11.1	11.6
17	0.0	0.0	0.0	10.0	6.5	8.3	11.8	9.1	10.6	11.1	10.2	10.6
18	0.0	0.0	0.0	9.9	8.2	8.9	9.1	7.4	7.8	10.7	10.1	10.4
19	0.0	0.0	0.0	8.8	7.0	8.1	9.5	7.3	8.3	13.2	9.9	11.4
20	0.0	0.0	0.0	7.0	5.6	6.0	12.1	9.0	10.4	14.0	10.4	12.2
21	0.3	0.0	0.1	9.9	5.8	7.6	13.0	10.1	11.4	12.8	11.1	11.9
22	0.2	0.0	0.1	10.3	7.8	8.7	11.9	9.5	10.9	11.2	10.8	11.0
23	2.3	0.1	1.3	9.0	7.3	8.0	11.6	8.0	9.5	11.6	11.0	11.2
24	3.8	1.7	2.7	10.1	6.0	8.0	11.5	6.9	9.2	12.8	11.1	11.9
25	2.8	1.6	2.4	11.5	7.1	9.2	11.0	8.6	10.0	13.7	11.0	12.4
26	1.6	1.0	1.3	10.0	7.5	9.0	10.9	10.3	10.6	13.4	12.4	12.9
27	1.5	0.8	1.1	10.3	6.0	8.1	13.7	9.2	11.2	12.4	11.5	12.1
28	3.2	0.9	2.0	10.8	7.0	9.1	14.6	8.7	11.6	12.9	11.4	12.1
29	---	---	---	12.7	10.1	11.2	13.6	10.8	12.1	13.0	11.3	12.1
30	---	---	---	10.1	4.2	6.1	14.5	10.7	12.5	15.1	11.3	13.1
31	---	---	---	5.7	3.2	4.5	---	---	---	15.1	12.9	13.9
Month	3.8	0.0	0.8	12.7	0.5	6.2	14.6	3.7	9.4	17.2	9.6	12.3

Table A-3. Water-temperature records for Waites Run near Wardensville, WV, January 2002-September 2003--Continued.

TEMPERATURE, WATER, DEGREES CELSIUS
JUNE TO SEPTEMBER 2003

DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
		JUNE			JULY			AUGUST			SEPTEMBER	
1	14.5	12.1	13.1	18.7	16.7	17.7	20.1	18.8	19.3	20.4	18.4	19.3
2	14.2	10.5	12.4	17.6	16.7	17.1	21.8	18.2	19.9	19.9	19.3	19.6
3	13.2	12.1	12.7	17.7	16.3	16.9	21.6	19.3	20.1	20.9	18.9	19.7
4	13.3	12.8	13.1	20.0	16.4	18.1	20.9	18.8	19.6	19.8	18.5	19.3
5	14.8	12.2	13.4	21.0	18.0	19.4	20.7	18.6	19.4	18.5	16.9	17.6
6	15.8	12.2	14.0	21.6	18.6	20.0	21.2	17.7	19.2	18.5	15.8	16.9
7	14.3	13.4	13.7	21.6	18.9	20.1	19.4	18.2	18.9	18.6	15.2	16.8
8	14.6	13.1	13.9	---	---	---	20.6	18.2	19.2	17.5	15.9	16.8
9	15.1	13.1	14.1	---	---	---	20.4	18.6	19.3	17.1	16.1	16.5
10	16.3	12.9	14.6	---	---	---	20.7	18.1	19.3	17.7	15.0	16.0
11	16.8	14.6	15.7	21.0	18.3	19.3	19.2	17.6	18.3	17.6	13.9	15.6
12	18.0	15.1	16.1	19.7	17.2	18.2	19.9	17.6	18.6	15.9	14.9	15.3
13	16.6	14.4	15.2	19.7	16.2	17.7	19.9	17.9	18.9	15.9	15.1	15.5
14	15.9	13.9	14.8	20.1	16.6	18.1	20.8	18.2	19.4	17.7	15.9	16.7
15	14.5	13.7	14.2	21.1	17.1	18.9	21.1	18.7	19.8	18.4	16.5	17.3
16	14.1	13.1	13.7	22.3	19.1	20.3	21.6	19.2	20.3	17.7	14.8	16.0
17	13.8	13.3	13.6	21.4	17.6	19.2	20.9	19.3	20.0	17.3	14.0	15.5
18	15.4	13.2	14.2	18.8	17.3	18.2	20.5	18.7	19.4	16.4	14.5	15.0
19	15.8	13.9	14.7	20.6	17.5	18.6	19.8	17.6	18.7	16.4	15.1	15.8
20	14.5	13.3	14.1	20.8	16.2	18.3	21.3	18.2	19.6	15.8	14.6	15.2
21	13.3	12.8	13.0	21.8	17.6	19.5	21.8	18.7	20.1	16.0	14.8	15.3
22	15.3	12.9	13.9	22.0	19.3	20.3	22.4	19.4	20.6	16.1	15.0	15.6
23	16.4	12.9	14.6	21.2	18.4	19.5	21.5	18.5	20.0	16.1	14.1	15.6
24	17.1	13.5	15.2	20.7	17.6	18.9	19.9	16.6	18.0	15.1	12.8	14.0
25	17.8	14.2	16.0	20.8	16.5	18.4	20.8	16.8	18.6	15.8	13.7	14.8
26	18.6	15.2	16.9	20.9	17.1	18.9	21.8	18.5	19.9	16.3	14.9	15.6
27	17.2	15.7	16.5	22.4	18.2	20.0	21.3	19.0	19.8	17.5	15.4	16.4
28	17.5	14.5	16.1	20.3	19.2	19.8	21.5	18.0	19.6	16.5	14.2	15.4
29	19.0	15.7	17.3	20.3	18.5	19.2	22.2	19.1	20.5	14.2	11.8	12.9
30	19.0	16.5	17.8	20.4	17.5	18.8	21.3	19.8	20.5	12.3	10.6	11.5
31	---	---	---	20.0	17.6	18.9	20.1	18.5	19.0	---	---	---
Month	19.0	10.5	14.6	22.4	16.2	18.9	22.4	16.6	19.5	20.9	10.6	16.1

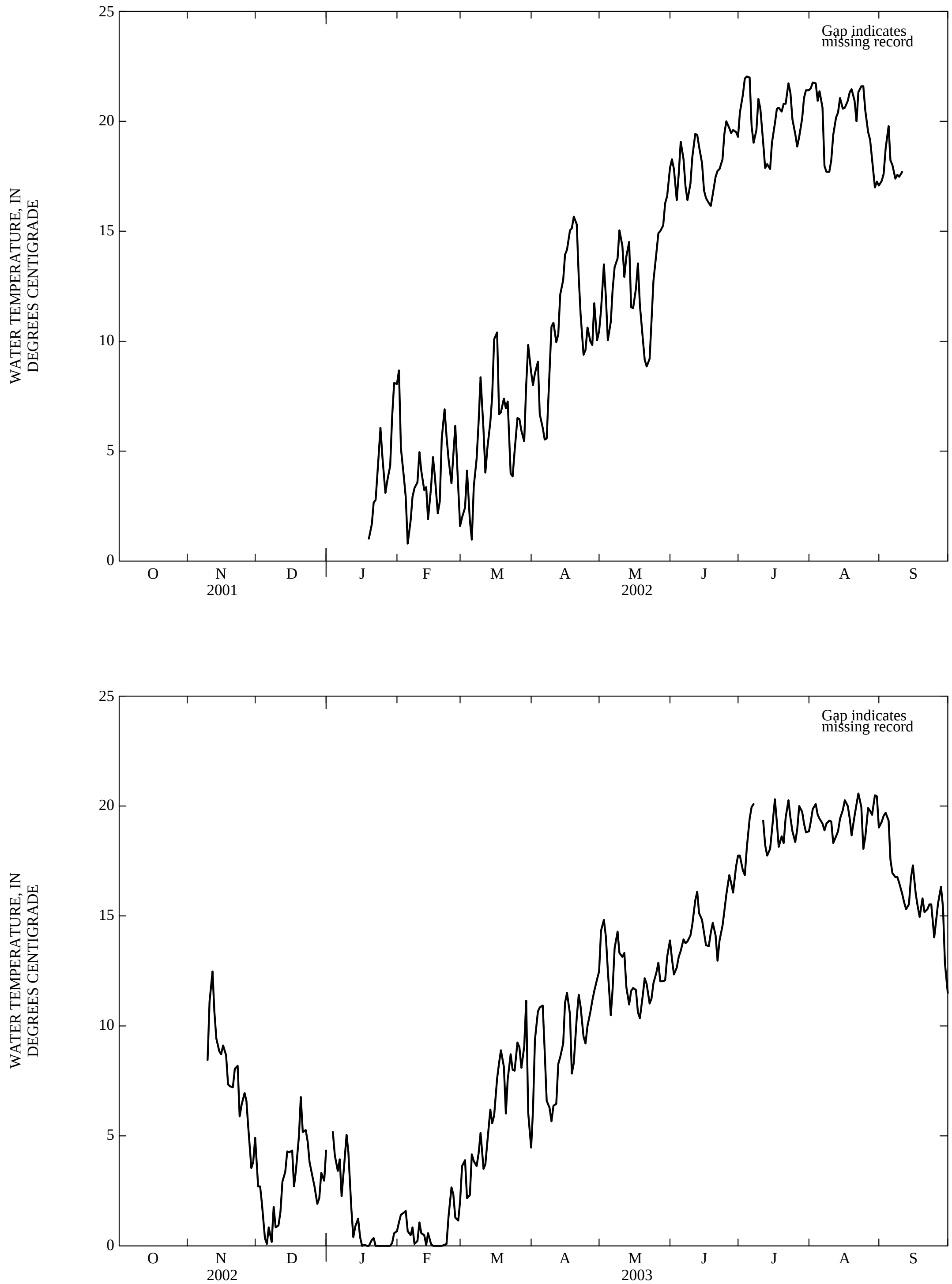


Figure A-3. Daily mean water temperature for Waites Run near Wardensville, WV, January 2002-September 2003.

Table A-4. Water-quality records for Waites Run near Wardensville, WV, October 2001-September 2003.

[--, missing data; <, less than; E, estimated; M, presence verified but not quantified]

WATER-QUALITY DATA, WATER YEAR OCTOBER 2001 TO SEPTEMBER 2002

Date	Time	Sample Type	DISCHARGE, INST. CUBIC FEET PER SECOND	SPECIFIC CONDUCTANCE (US/CM)	PH WATER WHOLE FIELD (STANDARD UNITS)	TEMPERATURE AIR (DEG C)	TEMPERATURE WATER (DEG C)	BAROMETRIC PRESSURE (MM OF HG)	OXYGEN, DISSOLVED (MG/L)	OXYGEN, DISSOLVED (PERCENT SATURATION)	ALKALINITY WAT DIS TOT IT FIELD MG/L AS CACO3	BICARBONATE WATER DIS IT FIELD MG/L AS HCO3
OCT												
24...	1145	ENVIRONMENTAL	2.2	94	7.3	24.0	15.8	725	8.6	91	43	52
NOV												
05...	1220	ENVIRONMENTAL	2.0	96	7.6	10.5	10.2	732	10.4	96	44	54
DEC												
13...	1615	ENVIRONMENTAL	3.1	74	7.4	14.5	9.9	727	10.4	96	31	37
JAN												
10...	1230	ENVIRONMENTAL	3.6	70	7.3	14.5	3.5	727	13.5	107	29	36
FEB												
13...	1330	ENVIRONMENTAL	3.7	58	7.2	2.5	4.5	732	12.2	98	24	29
MAR												
07...	1500	ENVIRONMENTAL	3.4	58	7.4	15.0	6.2	737	12.1	101	22	27
APR												
03...	1215	ENVIRONMENTAL	24	35	6.1	13.0	9.8	725	10.2	95	7	9
MAY												
08...	1230	ENVIRONMENTAL	21	34	6.6	23.0	14.4	734	10.7	109	9	11
08...	*1231*	*REPLICATE*	--	--	--	--	--	--	--	--	--	--
JUN												
03...	1245	ENVIRONMENTAL	6.5	45	7.0	24.5	17.5	730	9.2	100	15	19
JUL												
11...	*1300*	*BLANK*	--	--	--	--	--	--	--	--	--	--
11...	1500	ENVIRONMENTAL	2.3	72	7.8	24.0	20.9	734	8.6	100	--	--
31...	1230	ENVIRONMENTAL	6.0	--	--	--	--	--	--	--	--	--
31...	1400	ENVIRONMENTAL	6.3	--	--	--	--	--	--	--	--	--
31...	1630	ENVIRONMENTAL	6.0	--	--	--	--	--	--	--	--	--
AUG												
08...	1115	ENVIRONMENTAL	3.2	67	7.4	21.5	17.6	735	8.9	97	30	37
08...	*1116*	*REPLICATE*	--	--	--	--	--	--	--	--	--	--
SEP												
11...	1115	ENVIRONMENTAL	1.1	107	7.8	--	18.1	724	9.0	95	48	59

Date	CARBONATE WATER DIS IT FIELD MG/L AS CO3	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	NITROGEN, TOTAL (MG/L AS N)	NITROGEN, NITRITE DISSOLVED (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	PHOSPHORUS TOTAL (MG/L AS P)	ORTHOPHOSPHATE, DISSOLVED (MG/L AS P)	CARBON, ORGANIC DISSOLVED (MG/L AS C)	CARBON, ORGANIC PARTICULATE TOTAL (MG/L AS C)	2,6-DIETHYL ANILINE WAT FLT 0.7 U GF, REC (UG/L)
OCT													
24...	<1	4.7	.69	--	<.008	<.05	<.04	E.06	.008	<.02	1.5	<.1	--
NOV													
05...	<1	4.9	.69	--	<.008	<.05	<.04	<.10	.007	<.02	1.6	.2	<.002
DEC													
13...	<1	4.7	.81	--	<.008	E.04	<.04	E.09	.004	<.02	1.3	<.1	--
JAN													
10...	<1	5.4	.64	--	<.008	.11	E.02	E.06	.005	<.02	1.0	<.1	<.006
FEB													
13...	<1	5.5	.70	.28	<.008	.09	<.04	.19	E.002	<.02	.9	<.1	--
MAR													
07...	<1	5.6	.77	--	<.008	.12	<.04	E.07	E.002	<.02	1.0	<.1	<.006
APR													
03...	<1	5.4	.79	--	<.008	.33	<.04	E.09	.008	<.02	1.5	.3	<.006
MAY													
08...	<1	5.0	.35	--	<.008	.14	<.04	E.08	.005	<.02	1.8	.3	<.006
08...	--	5.0	.34	--	<.008	.14	<.04	E.09	.006	<.02	--	.2	<.006
JUN													
03...	<1	3.9	.72	.19	<.008	.09	E.03	.10	.006	<.02	1.2	.2	<.006
JUL													
11...	--	<.1	<.30	--	<.008	<.05	<.04	<.10	<.004	<.02	<.3	<.1	<.006
11...	--	3.8	.67	.19	<.008	.09	<.04	.10	.011	<.02	1.1	.2	<.006
31...	--	--	--	--	--	--	--	--	--	--	--	--	--
31...	--	--	--	--	--	--	--	--	--	--	--	--	--
31...	--	--	--	--	--	--	--	--	--	--	--	--	--
AUG													
08...	<1	4.0	.67	--	<.008	.10	<.04	E.07	.008	<.02	1.3	.1	--
08...	--	--	--	--	--	--	--	--	--	--	1.4	--	--
SEP													
11...	<1	4.7	.59	--	<.008	.11	<.04	E.08	.011	<.02	1.1	.2	<.006

Table A-3. Water-quality records for Waites Run near Wardensville, WV, October 2001-September 2003--Continued.

WATER-QUALITY DATA, WATER YEAR OCTOBER 2002 TO SEPTEMBER 2003

Date	Time	Sample type	Instantaneous discharge, cfs (00061)	Barometric pressure, mm Hg (00025)	Dissolved oxygen, mg/L (00300)	Dissolved oxygen, percent of saturation (00301)	pH, water, unfltrd field, std units (00400)	Specif. conductance, wat unf uS/cm 25 degC (00095)	Temperature, air, deg C (00020)	Temperature, water, deg C (00010)	Alkalinity, wat flt inc tit field, mg/L as CaCO3 (39086)	Bicarbonate, wat flt incrm. titr., field, mg/L (00453)
OCT 2002												
15...	1300	Environmental	3.8	729	10.5	100	7.4	64	13.5	11.3	23	28
NOV												
05...	1300	Environmental	15	728	13.2	116	6.8	38	7.0	7.7	13	15
DEC												
10...	1235	Environmental	8.6	733	17.8	132	6.7	40	4.0	1.4	15	19
JAN 2003												
09...	1320	Environmental	31	713	13.0	110	6.6	29	18.0	5.6	8	10
FEB												
11...	1145	Environmental	8.6	723	16.4	121	6.0	50	2.0	0.9	25	31
MAR												
06...	1200	Environmental	94	720	13.6	110	6.1	26	5.0	4.2	4	5
APR												
01...	1145	Environmental	27	724	15.7	134	6.5	32	14.0	6.5	7	9
MAY												
08...	*1000*	*Blank*	--	--	--	--	--	--	--	--	--	--
08...	1030	Environmental	20	727	9.6	98	5.8	35	21.0	14.0	10	13
JUN												
05...	1115	Environmental	22	729	10.0	100	6.2	36	19.0	13.3	11	13
05...	*1116*	*Replicate*	--	--	--	--	--	--	--	--	*10*	*12*
JUL												
10...	1030	Environmental	11	729	8.1	92	6.5	43	22.0	19.1	16	19
AUG												
04...	1115	Environmental	6.0	730	7.8	89	6.8	68	26.0	19.8	27	32
05...	1600	Environmental	--	--	--	--	--	--	--	--	--	--
SEP												
02...	1015	Environmental	4.2	734	8.6	97	7.3	69	23.0	19.7	26	32

Table A-3. Water-quality records for Waites Run near Wardensville, WV, October 2001-September 2003--Continued.

Date	Chlor-ide, water, fltrd, mg/L (00940)	Sulfate water, fltrd, mg/L (00945)	Ammonia + org-N, water, unfltrd mg/L as N (00625)	Ammonia water, fltrd, mg/L as N (00608)	Nitrate water, fltrd, mg/L as N (00618)	Nitrite + nitrate water fltrd, mg/L as N (00631)	Nitrite water, fltrd, mg/L as N (00613)	Ortho-phos-phate, water, fltrd, mg/L as P (00671)	Phos-phorus, water, unfltrd mg/L (00665)	Total nitro-gen, water, unfltrd mg/L (00600)	Organic carbon, suspnd sedimnt total, mg/L (00689)	Organic carbon, water, fltrd, mg/L (00681)	Peri-phyton biomass ash weight, g/m2 (00572)
OCT 2002													
15...	1.34	5.3	E.06	<0.04	--	0.07	<0.008	<0.02	0.007	--	<0.1	1.6	--
NOV													
05...	0.59	5.4	E.06	<0.04	--	0.20	<0.008	<0.02	E.004	--	<0.1	1.5	--
DEC													
10...	0.70	4.8	<0.10	<0.04	--	0.14	<0.008	<0.02	E.004	--	<0.1	1.1	--
JAN 2003													
09...	0.43	5.0	<0.10	<0.04	--	0.21	<0.008	<0.02	0.005	--	<0.1	1.5	--
FEB													
11...	0.44	5.2	E.09	<0.04	--	0.15	<0.008	<0.02	0.004	--	0.2	0.8	--
MAR													
06...	0.68	5.9	0.12	<0.04	--	0.32	<0.008	<0.02	0.007	0.44	0.2	2.0	--
APR													
01...	0.57	5.2	E.08	<0.04	--	0.15	<0.008	<0.02	0.017	--	0.6	1.6	--
MAY													
08...	*<0.20*	*<0.2*	*<0.10*	*<0.04*	--	*<0.06*	*<0.008*	*<0.02*	*<0.004*	--	*<0.1*	*<0.3*	--
08...	0.61	4.9	E.06	<0.04	--	0.09	<0.008	<0.02	0.008	--	0.3	1.5	--
JUN													
05...	0.57	4.9	0.31	<0.04	--	0.17	<0.008	--	0.014	0.48	0.4	1.6	--
05...	*0.57*	*4.9*	*0.14*	*<0.04*	--	*0.16*	*<0.008*	--	*0.009*	*0.30*	*0.4*	*1.5*	--
JUL													
10...	0.60	4.2	0.11	<0.04	0.10	0.11	0.008	<0.02	0.009	0.22	0.4	2.3	--
AUG													
04...	0.63	4.3	0.13	<0.04	--	0.09	<0.008	<0.02	0.015	0.22	0.2	2.1	--
05...	--	--	--	--	--	--	--	--	--	--	--	--	6.0
SEP													
02...	0.61	4.5	E.07	<0.04	--	0.07	<0.008	<0.02	0.008	--	0.2	1.4	--

Date	Peri-phyton biomass dry weight, g/m2 (00573)	Pheo-phytin a, peri-phyton, mg/m2 (62359)	Chloro-phyll a peri-phyton, chromo-fluoro, mg/m2 (70957)	Sus-pended sedi-ment concen-tration mg/L (80154)	Sus-pended sedi-ment load, tons/d (80155)
OCT 2002					
15...	--	--	--	2	0.03
NOV					
05...	--	--	--	1	0.05
DEC					
10...	--	--	--	M	0.01
JAN 2003					
09...	--	--	--	M	0.07
FEB					
11...	--	--	--	2	0.04
MAR					
06...	--	--	--	6	1.6
APR					
01...	--	--	--	2	0.12
MAY					
08...	--	--	--	*M*	--
08...	--	--	--	4	0.22
JUN					
05...	--	--	--	1	0.07
05...	--	--	--	*3*	--
JUL					
10...	--	--	--	5	0.14
AUG					
04...	--	--	--	8	0.12
05...	6.200	<0.1	0.2	--	--
SEP					
02...	--	--	--	2	0.02

Appendix B:

Discharge Records for Cacapon River above Wardensville, WV (01610300)

Table B-1. Discharge records for Cacapon River above Wardensville, WV (01610300), October 1971-September 1973.

LOCATION.—Lat 39°04'44", long 78°37'11", Hardy County, Hydrologic Unit 02070003, on right bank, 0.8 mi upstream from Trout Run, and 1.2 mi west of Wardensville.

DRAINAGE AREA.—181 mi^2.

PERIOD OF RECORD.—October 1971 to September 1973.

GAGE DATUM.—1,000 ft above National Geodetic Vertical Datum of 1929 (from topographic map).

DISCHARGE, CUBIC FEET PER SECOND
WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	50	160	500	45	84	1090	95	222	169	600	108	30
2	90	150	330	80	96	856	98	192	117	385	81	29
3	300	140	240	130	96	640	91	780	87	290	64	29
4	230	120	170	130	269	454	83	3030	68	213	57	28
5	180	100	130	120	210	363	81	1520	84	510	66	29
6	150	95	160	130	190	286	74	804	62	726	70	30
7	130	85	400	110	150	251	93	546	51	468	57	30
8	100	75	500	100	126	221	212	415	44	698	51	29
9	90	70	370	95	110	184	251	614	37	395	47	27
10	80	65	280	100	100	166	302	764	35	250	41	27
11	75	60	230	120	98	142	300	600	32	185	40	27
12	70	60	180	130	102	140	261	462	30	153	37	27
13	60	55	140	120	541	172	722	360	29	147	35	26
14	50	55	120	114	812	190	975	320	31	126	35	26
15	45	50	110	101	618	205	611	405	35	135	35	27
16	45	50	100	90	693	199	451	719	35	156	35	27
17	40	45	90	82	536	219	748	534	41	438	35	27
18	40	45	80	78	406	201	524	400	36	370	41	27
19	40	45	75	88	347	175	392	534	185	206	44	25
20	35	40	70	91	238	154	324	1290	93	153	43	25
21	35	40	65	83	254	146	269	1040	3800	120	41	25
22	35	40	65	80	376	164	950	712	10000	96	37	25
23	45	40	55	76	468	181	1190	656	13500	75	35	25
24	1400	40	55	89	446	155	844	480	8000	66	34	25
25	3000	40	50	104	1150	141	627	360	1000	57	32	25
26	1000	40	50	89	3830	135	476	258	700	53	35	25
27	700	55	50	82	1790	128	366	202	500	50	37	25
28	450	250	50	80	979	125	297	165	350	50	35	30
29	300	1100	45	85	931	115	251	141	230	51	33	30
30	200	900	45	85	---	110	217	120	700	62	31	30
31	170	---	40	85	---	100	---	150	---	156	31	---

Table B-1. Discharge records for Cacapon River above Wardensville, WV (01610300), October 1971-September 1973--Continued.

DISCHARGE, CUBIC FEET PER SECOND
WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	59	172	325	206	275	117	178	642	380	195	72	108
2	54	391	295	178	1060	117	703	534	305	156	72	96
3	50	335	275	162	1650	120	638	504	254	129	72	87
4	47	254	258	270	884	188	623	486	238	111	65	75
5	570	206	250	340	600	216	746	415	510	105	59	72
6	4900	172	246	310	468	290	553	370	405	93	55	66
7	2200	153	345	238	420	310	432	335	345	81	51	64
8	1000	1390	726	185	474	320	916	300	266	70	55	62
9	450	918	2510	160	504	330	1000	320	223	66	57	55
10	238	528	1160	150	432	305	1370	300	185	62	51	53
11	178	385	740	140	350	270	1080	270	162	195	67	51
12	144	285	546	130	310	246	812	246	144	126	65	51
13	126	226	450	120	258	226	656	230	162	87	57	51
14	110	820	370	120	246	201	656	220	144	68	55	57
15	97	1040	462	126	246	189	588	202	120	64	63	111
16	86	614	656	117	258	181	534	192	108	68	74	87
17	76	444	444	111	169	253	510	188	105	111	67	64
18	68	340	400	108	160	292	522	220	105	102	241	55
19	66	300	340	108	150	251	474	198	105	70	205	55
20	96	1460	310	123	170	232	450	178	102	64	287	53
21	84	884	266	90	160	217	395	169	96	66	613	53
22	72	600	1720	108	150	206	360	159	99	96	380	51
23	70	444	1280	216	147	188	340	156	111	129	270	50
24	70	350	756	169	141	176	340	153	96	156	238	50
25	68	290	552	150	129	168	432	198	90	111	1600	51
26	68	900	438	147	117	180	1290	195	375	96	552	51
27	64	804	395	330	117	188	2770	185	216	462	330	51
28	62	552	325	642	117	168	2480	635	195	216	234	50
29	141	420	266	558	---	153	1150	812	468	144	185	50
30	147	350	230	405	---	150	804	552	280	105	156	62
31	132	---	216	330	---	150	---	498	---	84	126	---

Appendix C:

Discharge Records of Wardensville Spring at Wardensville, WV (390443078345101)

Table C-1. Discharge records for Wardensville Spring at Wardensville, WV (390443078345101), October 2003-May 2004.

[---, missing data]

LOCATION.—Lat 39°04’41”, long 78°34’49”, Hardy County, Hydrologic Unit 02070003, in pumphouse with concrete reservoir, 0.7 mi east of Wardensville.

GEOLOGY.—Spring is in a valley flanked by coarse- to fine-grained Oriskany Sandstone.

DISCHARGE, CUBIC FEET PER SECOND
OCTOBER 2003 TO MAY 2004
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
1	---	0.15	0.29	0.27	---	---	0.30	0.19
2	---	.09	.27	.28	---	---	.39	.06
3	---	.28	.27	.27	---	---	.26	.10
4	---	.19	.27	.24	---	---	.26	.08
5	---	.24	.27	.27	---	---	.22	.07
6	---	.22	.24	.26	---	---	.25	.12
7	---	.23	.22	---	---	---	.24	.07
8	---	.22	.25	---	---	---	.24	.06
9	---	.29	.25	---	---	---	.24	.06
10	---	.09	.29	---	---	---	.28	.06
11	---	.22	.34	---	---	---	.30	.06
12	---	.25	.31	---	---	---	.27	.06
13	---	.27	.30	---	---	---	.37	.06
14	---	.24	.30	---	---	---	.34	.14
15	---	.23	.45	---	---	---	.30	.25
16	---	.23	.37	---	---	---	.27	.14
17	---	.32	.22	---	---	0.18	.27	.05
18	---	.18	.29	---	---	.26	.29	.05
19	---	.26	.31	---	---	.28	.29	.05
20	---	.32	.33	---	---	.28	.27	.05
21	---	.28	.27	---	---	.29	.27	.08
22	0.21	.33	.30	---	---	.34	.27	.05
23	.21	.26	.33	---	---	.30	.23	.05
24	.22	.28	.33	---	---	.28	.35	.05
25	.23	.30	.33	---	---	.25	.27	.05
26	.25	.38	.33	---	---	.24	.34	.12
27	.07	.37	.37	---	---	.24	.35	.19
28	.22	.27	.25	---	---	.24	.32	.12
29	.24	.40	.29	---	---	.24	.38	.05
30	.21	.24	.27	---	---	.24	.36	.04
31	.29	---	.27	---	---	.27	---	.05
TOTAL	---	7.63	9.18	---	---	---	8.79	2.63
MEAN	---	.25	.30	---	---	---	.29	.085
MAX	---	.40	.45	---	---	---	.39	.25
MIN	---	.09	.22	---	---	---	.22	.04