Water Resources Division
MD-DE-DC District Office
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Discrete and Continuous Water-Quality Monitoring, Mattawoman Creek Watershed, Charles County, Maryland

Scope of Work, Federal Fiscal Year 2003
(October 1, 2002, through September 30, 2003)

Project Period, Water Years 2003-2005
(October 1, 2002, through September 30, 2005)

Discrete and Continuous Water-Quality Monitoring, Mattawoman Creek Watershed, Charles County, Maryland

A Cooperative Project between the U.S. Geological Survey (USGS) and the Charles County Maryland Government (CCMG)

Problem

Mattawoman Creek Watershed is located within the Coastal Plain physiographic province in Prince Georges and Charles Counties, Maryland (Figure 1, Figure 2). Mattawoman Creek and its tidal and non-tidal wetlands were identified in a 1981 Maryland Department of State Planning report on areas of Critical State Concern. In 1998, the Maryland Clean Water Action Plan assessed watersheds in Maryland for water quality, aquatic living resources, landscape parameters, and clean water requirements. In the water quality category, Mattawoman Creek Watershed was in the top 25% of all watersheds in Maryland for having the highest modeled nitrogen and phosphorus loadings per acre. These two nutrients are known to cause algae blooms which block sunlight to submerged aquatic vegetation (SAV). Nitrogen and phosphorus also consume large amounts of dissolved oxygen from the water that fish and plants need to survive.

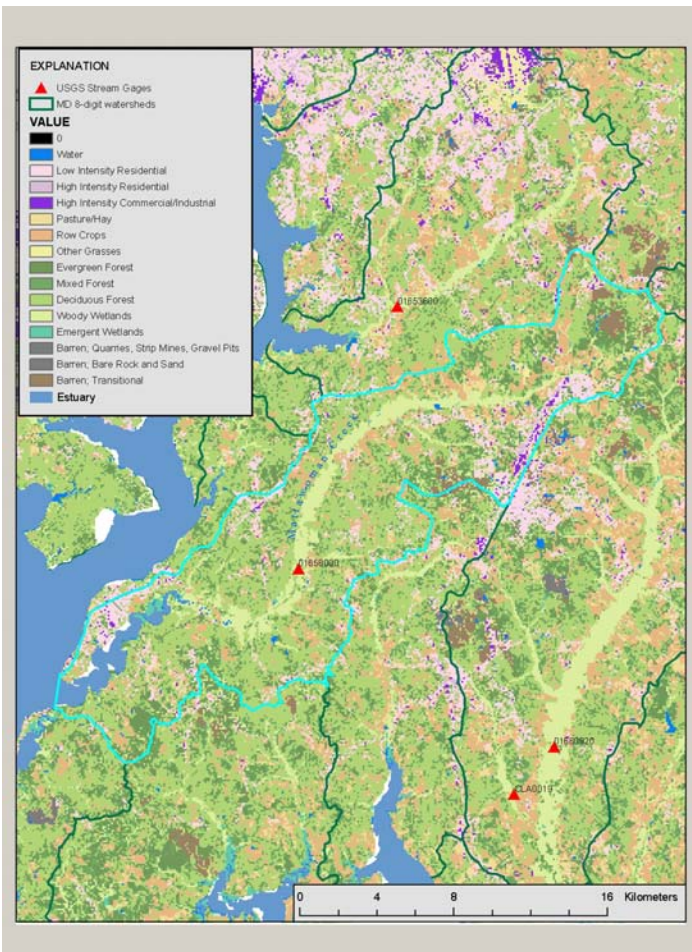

Figure 1. Land use in the Mattawoman Creek Watershed.

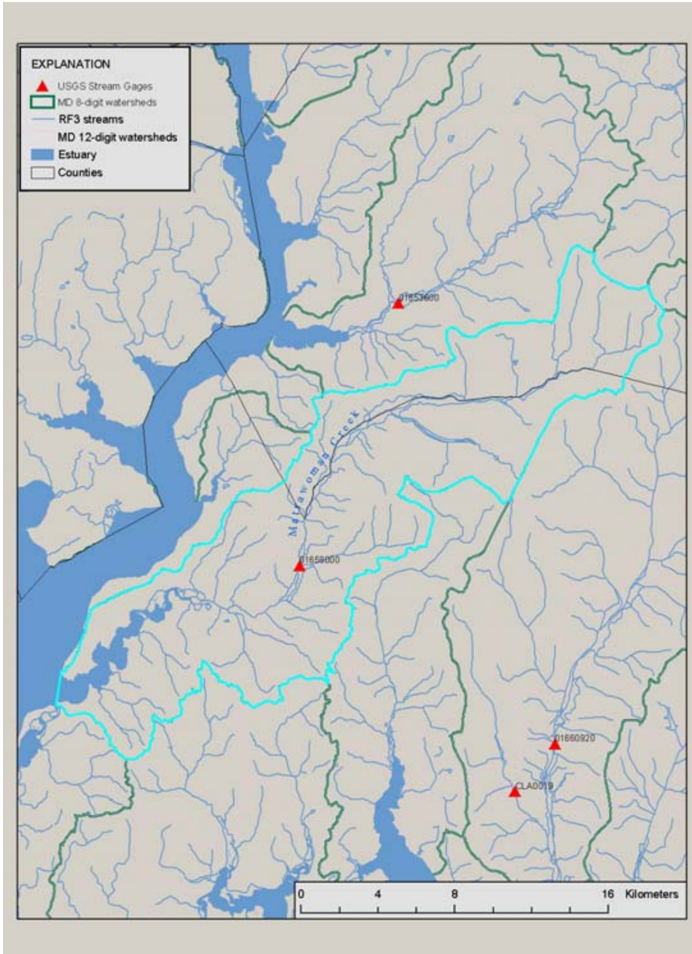

Figure 2. Hydrographic features of the Mattawoman Creek Watershed.

Mattawoman Creek exceeds two federal clean water quality requirements – nutrients and sediments – and is listed on the State's 303(d) list, that indicates water bodies that are impaired and require the development of a Total Maximum Daily Load (TMDL). Out of 138 watersheds in Maryland, the 1998 Maryland Clean Water Action Plan identified Mattawoman Creek Watershed as one of thirteen highest priority watersheds in need of restoration and protection.

USGS maintained a stream gage (station ID 01658000) and water-quality monitoring station on Mattawoman Creek nr Pomonkey, MD, in cooperation with Maryland Department of the Environment (MDE), from 2001 through September of 2002 (Figure 3). The broad goal of the project described below is to continue and expand water-quality data collection in support of Maryland's and Charles County's needs with regard to the Clean Water Action Plan, TMDLs, and the Charles County Comprehensive Plan.

Objectives

The USGS has responsibility for the following tasks:

Task 1. Continue collection of stage data at station ID 01658000 (Mattawoman Creek nr Pomonkey, MD) according to standard USGS protocols; refine the rating curve for continuous discharge determination; determine and report discharge data in the annual data report, as well as on-line through the real-time web page.

Task 2. Collect and analyze monthly and storm water samples at station ID 01658000 (Mattawoman Creek nr Pomonkey, MD), using methods described below, for nutrients (N and P) and suspended-sediment concentration.

Task 3. Expand data collection at station ID 01658000 (Mattawoman Creek nr Pomonkey, MD) to include real-time reporting of additional water-quality parameters (pH, dissolved oxygen, turbidity, specific conductance, temperature).

In subsequent project years, once adequate samples have been collected and analyzed, we will be able to develop regression relations to estimate continuous nitrate (NO_3), total nitrogen, total phosphorus, and suspended-sediment concentrations from continuously monitored parameters, enabling real-time estimation of these concentrations.

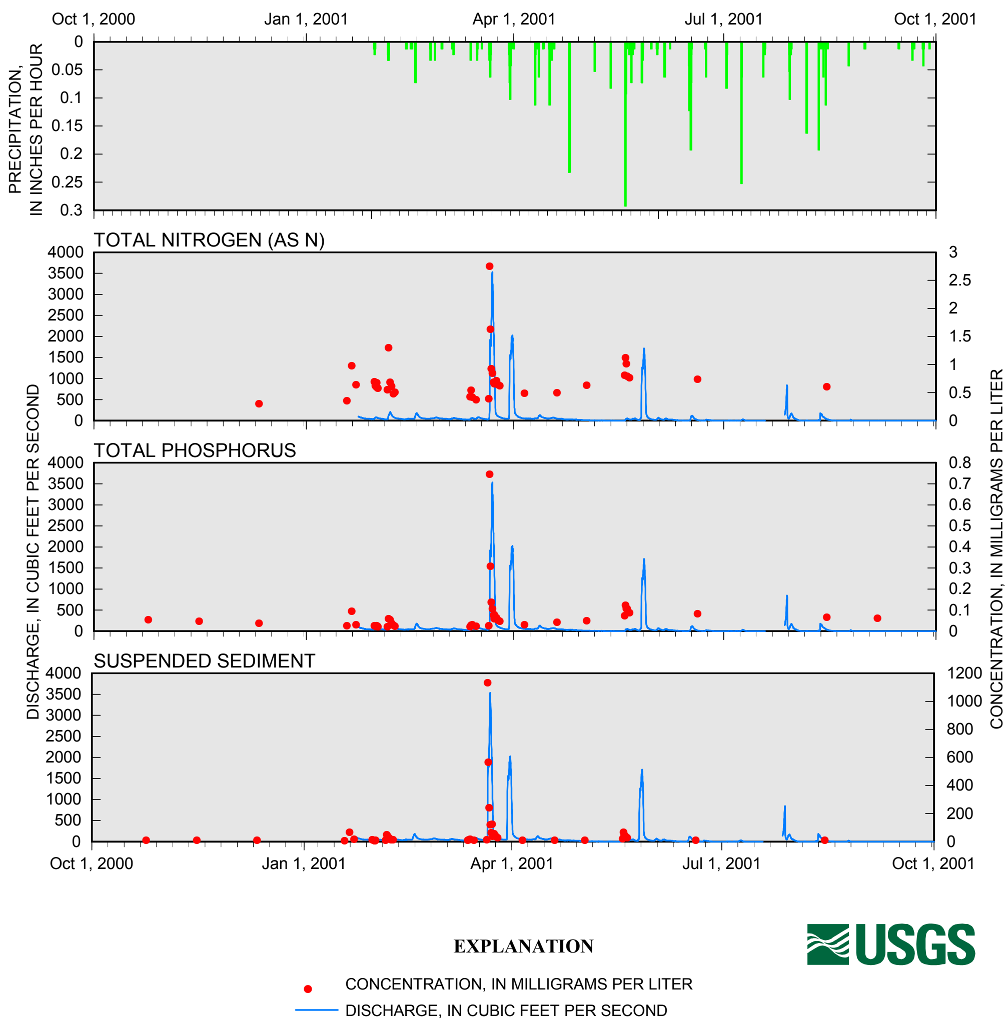

Figure 3. Hydrological and water-quality data collected at the Mattawoman Creek station for water year 2001. Note that collection of stream discharge and precipitation data began in late January 2001, while monthly sample collection began in October 2000.

Benefits and Relevance

Charles County needs tools and data to evaluate alternative approaches for correcting existing water-quality and water-quantity problems and for forecasting future conditions within the Mattawoman Creek Watershed. Data collected as described in this scope of work, combined with existing data from other USGS studies and historical and ongoing monitoring by other state and federal agencies, will provide valuable information for future management of the Watershed.

This study meets several goals of the Water Resources Division (WRD) of the USGS, by: 1) advancing knowledge of the regional hydrological system; 2) providing water-resources information that will be used by multiple parties for planning and operational purposes; and 3) contributing data to national databases that will be used to advance the understanding of regional and temporal variations in hydrological conditions.

Study Area and Background

In the Potomac River Basin, which includes the Mattawoman Creek Watershed, the quality of streams and ground water is affected by a number of natural and human processes. The National Water-Quality Assessment (NAWQA) Program, Potomac River Basin study unit (1992-95), indicated that elevated concentrations of nitrogen and phosphorus in surface and ground water in the Potomac basin often result from human activities such as manure and fertilizer application (Ator and others, 1998). Nutrients (as well as pesticides) are of particular interest to environmental managers within the basin. Although the nutrients nitrogen and phosphorus occur naturally and are essential for plant and animal growth, excessive nutrients in water can adversely affect human health and the environment.

Charles County is the eighth fastest growing county in Maryland, with a 19.5% population increase from 1990 to 1999. In the 1997 Charles County Comprehensive Plan, the majority of the Mattawoman Creek Watershed (area of 244 km^2) is designated as a Development District — a principal center of population, services, and employment in the County — and generally coincides with the Mattawoman Sewer Treatment planned sewer service area. The goal of the Comprehensive Plan is to encourage growth to emanate from the urban core and town centers, thus reserving the deferred development areas until the necessary public facilities are extended to serve these areas. The Plan calls for the County to develop protection strategies for the Mattawoman Creek Watershed.

The Smithsonian Environmental Research Center (SERC) was contracted in July 1997 by Charles County Government to conduct a research project to define nonpoint sources of nutrients and sediment. The project was designed to assess current conditions and to provide information for projections of future conditions under different development scenarios. Samples were collected and analyzed between March 1997 and May 2002. The results indicated that stream concentrations of total phosphate and various forms of nitrogen increase with increases in the percentage of developed land. Concentrations of nitrate and silicate increase and the concentration of total organic carbon decreases as the percentage of cropland increases.

The U. S. Army Corps of Engineers (USACE) conducted a Lower Potomac River Basin Reconnaissance Study in 1997 to determine priority watersheds for restoration and protection. The Mattawoman Watershed was one of the eight watersheds in the Basin found to be priority. This has led to a federal, state and county, interagency team, headed by USACE, to determine the most beneficial steps for the County to pursue in protecting the watershed. Computer modeling has been used as the tool for predicting and comparing Best Management Practices. An HSPF model of the Watershed is currently under development by the USACE.

USGS maintained a stream gage (station ID 01658000) and water-quality station on Mattawoman Creek nr Pomonkey, MD, in cooperation with Maryland Department of the Environment (MDE), from 2001 through September 2002. Data collected at the site during water year 2001 is shown in Figure 3 (http://md.water.usgs.gov/watershed/MD151/data.html). While baseflow concentrations of nitrogen (total, as N) and phosphorus (total, as P) are typically 0.5 to 1.5 and 0.05 to 0.15 mg/L, respectively, both may be elevated during storms; a concentration of greater than 2.5 mg/L (as N) total nitrogen was measured on a sample on the rising limb of a storm in March 2000; total phosphorus and suspended sediment were also higher than normal baseflow concentrations. Because loads are the integrated product of flow and concentration, the loads during this storm event were significant, indicating the importance of sampling these events.

Methods

Task 1: Streamflow

Stream stage will be recorded every 15 minutes and stored in an electronic data logger. Streamflow will be determined from stage data by use of a stage-discharge rating developed using methods described by Rantz and others (1982). A modem and telephone line will be used provide real-time remote access to stage and discharge data. Real-time data will be used to monitor storms and coordinate the field effort.

Task 2: Water-Quality Sampling and Analysis

Samples for water-quality analysis will be collected using both manual field-sampling methods (following NAWQA protocols; Shelton, 1994), and automatic samplers. Automatic water-sampling equipment will consist of a refrigerated, self-contained unit capable of collecting 12 discrete 2.5-L samples. The sampler will be equipped with a pressure transducer to measure fluid pressure (stage) and a data logger. Sample collection may be initiated by predetermined precipitation intensity or by a rise in stream stage above a specified value and will proceed at timed intervals. Sampling will proceed throughout the event, although not all samples may be analyzed for any given storm. Rather, samples will be selected for analysis on the basis of their timing relative to the rise, peak, and recession of the storm hydrograph.

Coordination of sampling events and sampling frequency

Storm samples - USGS will select storms targeted for sampling and appropriately program the automatic sampler. USGS will collect storm samples and maintain the samplers. After the storm event, USGS will review the hydrograph and select samples to be analyzed.

Baseflow and high-flow grab samples - USGS will select dates for baseflow and high-flow grab samples. Discharge will be recorded at the time of sample collection for the high-flow samples.

Sampling frequency - USGS will collect and analyze approximately 30–40 samples per water year from a site. In addition, 3–6 samples per year will be required for quality assurance and quality control.

Sampling and analytical methods for nutrients

Samples will be collected using USGS sampling techniques and composited in a churn splitter. Samples for whole-water analysis are collected directly from the churn and are fixed with concentrated sulfuric acid (1 mL/125 mL of sample). Samples for dissolved-phase constituents are collected with a peristaltic pump from the splitting device and filtered in line with a 0.45-µm polycarbonate capsule filter. Samples are shipped on ice overnight to the NWQL in Denver, Colorado, and are analyzed within 5 days of arrival. Nitrogen and phosphorus are analyzed by colorimetric methods using air-segmented continuous-flow analyzers (Alpkem Corp. Clackamas, Ore.), operated with pecked sampling and bubble-gated detectors (Patton and Wade, 1997). Kjeldahl nitrogen and phosphorus (Watstore codes 00666, 00625, 00625, and 00671) are predigested batch-wise using a Tecator Digestion System 40, model 1016 block digester (Patton and Truit, 1992). USGS analytical methods with approximately equivalent U.S. Environmental Protection Agency (USEPA) methods and method reporting limits are listed in Table 1 (Patton and Truitt, 1992; Fishman, 1993). All NWQL laboratory methods are documented and verified for bias, accuracy, and precision with standard reference materials and participation in the USGS Office of Water Quality sample-testing program (Maloney and others, 1994; Pritt and Raese, 1995). Field blanks, equipment blanks, and field duplicates and comparison samples are also collected to monitor bias and precision in all aspects of data collection.

Field methods

Field measurements will be made at the same time that samples are collected for nutrient analysis. Specific conductance, pH, dissolved oxygen, and water temperature will be determined with a calibrated multimeter. Methods for field analysis are documented in the USGS National Field Manual (Wilde and others, 1998).

Sample analysis, quality assurance, and quality control

All chemical analyses will be done at the National Water-Quality Laboratory in Denver, CO. Suspended-sediment analyses (including total suspended-sediment concentration, or SSC, and sand-fine fractionation) will be done at the USGS Kentucky District Sediment laboratory. Approximately one-third of the samples will be selected and analyzed for SSC and sand-fine fractions, while two-thirds will be analyzed only for SSC.

USGS will provide quality assurance and quality control oversight for water-quality samples. The primary quality-assurance objectives will be to control bias due to equipment contamination and poor sampler-intake efficiency, evaluate sample collection techniques and potential problems with laboratory performance, and estimate data precision. Due to a limited number of samples being collected, meaningful quality assurance through statistical process control is not possible. Quality-assurance procedures for sample collection will consist of using appropriate equipment cleaning and sample-collection techniques prescribed by Wood and Harr (1990) and Edwards and Glysson (1988) and submitting quality-control samples.

USGS Watstore Code	Constituent	USGS Method	USEPA Method	Method Reporting Limit
00010	Water Temperature (^{o}Celsius)	NA	NA	0.5
00300	Dissolved Oxygen (mg/L)	NA	NA	0.5
00095	Specific Conductance (µS/cm)	NA	NA	0.1
00400	pH	NA	NA	0.1
80156	Suspended Sediment (mg/L)	NA	NA	1
00666	Soluble Phosphorus (mg/L as P)	I-2610-91	365.4	0.0044
00625	Total Kjeldahl Nitrogen (mg/L as N)	I-4515-91	351.2	0.10
00665	Total Phosphorus (mg/L as P)	I-4610-91	365.4	0.0037
00623	Soluble Kjeldahl Nitrogen (mg/L as N)	I-2515-91	351.2	0.10
00671	Orthophosphate (mg/L as P)	I-2601-90	365.1	0.007
00613	Nitrite (mg/L as N)	I-2545-90	353.2	0.0023
00631	Nitrite + Nitrate (mg/L as N)	I-2545-90	353.2	0.013
00608	Ammonium (mg/L as N)	I-2522-90	350.1	0.015

Table 1. Methods for field parameters, suspended sediment, and NWQL schedule 1119 (for nutrients). (NA – not applicable.)

Quality-control samples will consist of equipment blanks, field blanks, field-split duplicates, and comparisons of the automatic sampler to the river cross-section. Field blanks and field replicates will be collected to monitor bias and precision in all aspects of data collection. Equipment blanks will provide data on sample contamination and will be collected using certified inorganic-free water; the ISCO automatic sampler blanks will be collected prior to field deployment as well as in situ. Field-split duplicates provide a measure of analytical precision on environmental samples and will be collected for base-flow and stormflow samples. Comparisons of the automatic sampler to the river cross section provide a measure of bias due to the automatic sampler, and will be collected over a range of flow conditions.

Task 3: Characterization of Surface-Water Quality through Continuous Data Collection

USGS has pioneered new methods of characterizing surface-water quality through use of multi-parameter probes combined with simultaneous sampling and analysis (Christensen and others, 2000; Christensen, 2001). Through application of multiple regression techniques, statistically significant relations may be developed between continuous variables measured by probe sensors and concentrations of various constituents measured in discrete samples. This allows for continuous estimation of constituent concentrations and real-time data presentation. With continuous flow data and concentration estimates, determinations of chemical loadings over a given time period (for example, during a storm) are made possible.

The site will be instrumented with a suite of sensors that will continuously measure and record water temperature, specific conductance, turbidity, pH, and dissolved-oxygen content at 15-minute intervals. This information will be relayed to the District office using telemetry and available as real-time data on the web. The accuracy of the continuous water-quality sensors will be checked on a monthly basis and corrected for any detected drift. Probe maintenance will also be performed monthly, including inspection and cleaning to remove organic films and sediment.

In subsequent project years, once adequate samples have been collected, the measured nutrient concentration values will be related to concurrent values of continuously measured parameters (water temperature, specific conductance, turbidity, pH, and dissolved-oxygen content) to estimate nitrate, total nitrogen, total phosphorus, and suspended-sediment concentrations in the stream water at 15-minute intervals. The load for each time interval will be calculated by multiplying the estimated concentration by the discharge for the interval computed from the stage-discharge relation established for the site. Total loads for any given period of time can be calculated by summing the loads computed for each measurement interval during the specified period.

Budget

Task 1: Streamflow data collection at Mattawoman Creek nr Pomonkey, MD site

For federal fiscal year 2003 (FY03), the gross cost to operate a USGS stream gage in the MD-DE-DC District will be $12,500. This includes real-time presentation of data on the web (http://waterdata.usgs.gov/nwis/uv?01658000).

Cost Category	FY03
Stream Gaging	$12,500
GROSS COST, TASK 1	**$12,500**

Task 2: Water-quality monitoring at Mattawoman Creek nr Pomonkey, MD site

Costs are in addition to the cost of gaging (Task 1).

Cost Category	FY03
Salaries and Benefits	$28,001
Vehicles	$1,056
Phone	$845
Postage	$1,056
Utilities	$845
Contracts/repairs/maintenance	$880
Supplies	$3,519
Laboratory	$9,615
GROSS COST, TASK 2	**$45,817**

Task 3: Expand water-quality monitoring at Mattawoman Creek nr Pomonkey, MD site, to include real-time continuous data collection

Costs are in addition to the cost of gaging (Task 1) and water-quality monitoring (Task 2). Estimated gross costs are also shown below for FY04, to indicate the fact that the cost for this task will decrease after the first year, because the first year cost includes equipment purchase, installation, and testing. The FY04 cost estimate below assumes that the stream gaging (Task 1) and water-quality monitoring (Task 2) continue through FY04.

Cost Category	FY03	FY04
Salaries and Benefits	$30,665	$15,349
Supplies	$1,870	$1,870
Equipment	$14,962	$0
GROSS COST, TASK 3	**$47,497**	**$17,219**

Total Project Cost and Cost-Sharing Arrangements

Gross project costs for FY03 are shown below. An estimate for FY04 is also shown, which reflects a decrease due to equipment purchases, which occur in the first project year, and a 3-5% annual increase for all other costs. The cost-sharing arrangement for FY03 for the project is shown below the budget.

Cost Category	FY03	FY04
Salaries and Benefits	$58,666	$44,750
Vehicles	$1,056	$1,109
Phone	$845	$887
Postage	$1,056	$1,109
Utilities	$845	$887
Contracts/repairs/maintenance	$880	$924
Supplies	$5,389	$5,658
Equipment	$14,962	$0
Laboratory	$9,615	$10,096
Stream Gaging	$12,500	$13,000
GROSS PROJECT COST, ALL TASKS	**$105,814**	**$78,420**

	FY03
GROSS PROJECT COST	$105,814
CCMG	$52,907
USGS	$52,907

Timeline and Products

The project will run from October 1, 2002, through September 30, 2005, although this scope of work is only for the period October 1, 2002, through September 30, 2003. Primary products from the project will be streamflow and water-quality data that will be published on a water-year basis in annual data reports by the District. Real-time data will also be available on the web.

References

Ator, S.W., Blomquist, J.D., Brakebill, J.W., Denis, J.M., Ferrari, M.J., Miller, C.V., and Zappia, H., 1998, Water quality in the Potomac River Basin, Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia, 1992–96: U.S. Geological Survey Circular 1166, 38 p.

Christensen, V.G., 2001, Characterization of surface-water quality based on real-time monitoring and regression analysis, Quivira National Wildlife Refuge, south-central Kansas, December 1998 through June 2001: U.S. Geological Survey Water-Resources Investigations Report 01-4248, 28 pp.

Christensen, V.G., Jian, X., and Ziegler, A.C., 2000, Regression analysis and real-time water-quality monitoring to estimate constituent concentrations, loads, and yields in the Little Arkansas River, south-central Kansas, 1995-99: U.S. Geological Survey Water-Resources Investigations Report 00-4126, 36 pp.

Edwards, T.K., and Glysson, G.D., 1988, Field methods for measurement of fluvial sediment: U.S. Geological Survey Open-File Report 86-531, 118 p.

Fishman, M.J., ed., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory–Determination of inorganic and organic constituents in water and fluvial sediments: U.S. Geological Survey Open-File Report 93-125. 217 p.

Maloney, T.J., Ludtke, A.S., and Krizman, T.L., 1994, Quality-assurance results for routine water analysis in U.S. Geological Survey Laboratories, Water Year 1991: U.S. Geological Survey Water-Resources Investigations Report 94-4046. 144 p.

Patton C.J., and Truitt, E.P., 1992, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory–Determination of total phosphorus by a Kjeldahl digestion method and an automated colorimetric finish that includes dialysis: U.S. Geological Survey Open-File Report 92-146. 39 p.

Patton, C.J., and Wade, A.P., 1997, Continuous flow analyzers, in Ewing, Galen, ed., Analytical Instrumentation Handbook (2nd. ed.): New York, Marcel Dekker, p. 125-220.

Pritt, J.W., and Raese, J.W., eds., 1995, Quality assurance/quality control manual, National Water Quality Laboratory: U.S. Geological Survey Open-File Report 95-443. 35 p.

Rantz, S.E., and others, 1982, Measurement and computation of streamflow: U.S. Geological Survey Water-Supply Paper 2175, Vols. 1 and 2, 631 p.

Shelton, L.R., 1994, Field guide for collecting and processing stream-water samples for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 94-455, 42 p.

Wilde, F.D., Radtke, J.G., and R.T. Iwatsubo, (eds.), 1998, National Field Manual for the Collection of Water-Quality Data, USGS Techniques of Water-Resources Investigations Book 9 9/98.

Wood, J.R., and Harr, C.A., eds, 1990, Methods for collection and processing of surface-water and bed-material samples for physical and chemical analyses: U.S. Geological Survey Open-File Report 90-140, 71 p.