WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY, MID-ATLANTIC PROGRAMS, 1987-91

Compiled by Judith A. McFarland, Linda S. Weiss, Amy J. Chen, Donna R. Lowry, Kimberle A. Bouder, Willie R. Caughron, and G. Jean Hyatt

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U.S. GEOLOGICAL SURVEY

Open-File Report 91-505

Towson, Maryland

1991

U.S. DEPARTMENT OF THE INTERIOR
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U.S. GEOLOGICAL SURVEY
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Message from the Area Assistant Regional Hydrologist

The U.S. Geological Survey (USGS) is known for its impartial fact-finding and research mission and, as such, gathers and interprets data that enable managers to make decisions based on objective information. This report is designed to inform managers and other interested persons of the current hydrologic-data programs and investigative water-resources activities of the USGS in the Mid-Atlantic Programs from 1987 to 1991. The States of Delaware, Maryland, Virginia, West Virginia, and the District of Columbia form the Mid-Atlantic Programs. Activities for the West Virginia District, which has just recently joined the Mid-Atlantic Programs, are for 1989-91 only.

The water-related studies of the Mid-Atlantic Programs are supported through joint-funding agreements with State and local agencies, by Federal funds from the USGS appropriation, and by reimbursable funding from other Federal agencies. Jointly funded programs are considered where hydrologic information is needed and when the study is mutually advantageous to the USGS and the State or local agency. In most cases, costs are shared equally. These cooperative, jointly funded programs are reviewed and renegotiated annually to ensure that they are responsive to the needs of the States and to the national priorities of the USGS.

If you would like more information about our water-resources activities in the Mid-Atlantic Programs, please contact me, or contact one of the several offices in the area. Points of contact are given in the Mid-Atlantic Programs Organization and District Addresses section of this publication. Sources of information on other activities of the USGS and sources of publications are given in the Sources of Information and Publications section of this report.

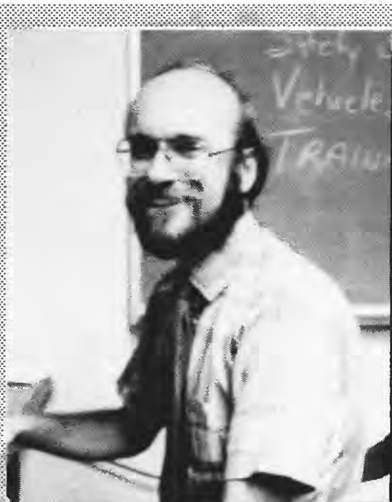
Herb Freiberger

Herbert J. Freiberger
Area Assistant Regional Hydrologist
Mid-Atlantic Programs

District Chiefs of the Mid-Atlantic Programs

David P. Brown
West Virginia

Gary S. Anderson
Virginia



David Grason
Maryland, Delaware, District of Columbia

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ILLUSTRATIONS

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.59	square kilometer
acre	4,947	square meter
foot per day (ft/d)	0.3048	meter per day
foot squared per day (ft^2/d)	0.09290	meter squared per day
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
gallon per minute (gal/min)	0.06309	liter per second
million gallons per day (Mgal/d)	0.04381	cubic meter per second

Water temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by using the following equation:

$$°F = 1.8\ (°C) + 32$$

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

Abbreviated water-quality units used in report: Chemical concentration and specific conductance are given in metric units. Chemical concentration is expressed in micrograms per liter (µg/L) and in milligrams per liter (mg/L). Specific conductance is expressed in microsiemens per centimeter at 25 degrees Celsius (µS/cm). Radon is expressed in picocuries per liter (pCi/L). Transmissivity is reported in feet squared per day (ft^2/d), a mathematical reduction of the unit cubic foot per day per square foot times foot of aquifer thickness ($[(ft^3/d)/ft^2]ft$).

WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY, MID-ATLANTIC PROGRAMS, 1987-91

Compiled by:

Judith A. McFarland, Linda S. Weiss, Amy J. Chen, Donna R. Lowry, Kimberle A. Bouder, Willie R. Caughron, and G. Jean Hyatt

ABSTRACT

The mission of the U.S. Geological Survey's Water Resources Division is to provide the hydrologic information and understanding needed for the optimum use and management of the Nation's water resources for the overall benefit of the people of the United States. This report summarizes the Water Resources Division's activities in the Mid-Atlantic Programs from 1987 to 1991.

The Mid-Atlantic Programs of the U.S. Geological Survey's Water Resources Division includes the States of Delaware, Maryland, Virginia, and West Virginia, and the District of Columbia. The water-resources activities of the Mid-Atlantic Programs are conducted from nine offices located in the four States. The activities consist of two elements: collection of long-term basic records concerning quantitative and qualitative data for streams, reservoirs, estuaries, and ground water; and short-term interpretive investigations of specific water-resources problems.

In addition to the introductory material describing the structure of the Mid-Atlantic Programs, information is presented on current projects, sites at which basic surface-water, water-quality, and ground-water data are collected, and reports on Mid-Atlantic Programs water resources published by the U.S. Geological Survey and cooperating agencies.

INTRODUCTION

The Water Resources Division of the U.S. Geological Survey (USGS) has the principal responsibility within the Federal Government for providing hydrologic information and appraising the Nation's water resources. Through its numerous cooperative efforts with Federal, State, and local agencies, it is uniquely structured to collect and evaluate water information. The USGS is unique among Government organizations because it has neither regulatory nor developmental authority--its sole product is information. The USGS's role is that of a scientific organization concerned with presenting impartial, accurate data and scientific analyses equally to all interested parties.

The Mid-Atlantic Programs of the USGS, Water Resources Division, includes the States of Delaware, Maryland, Virginia, and West Virginia, and the District of Columbia. The water-resources activities of the Mid-Atlantic Programs are conducted from nine offices located in four States (fig. 1). The activities consist of two elements: Collection of long-term basic records concerning quantitative and qualitative data for streams, reservoirs, estuaries, and ground water; and short-term interpretive investigations of specific water-resources problems.

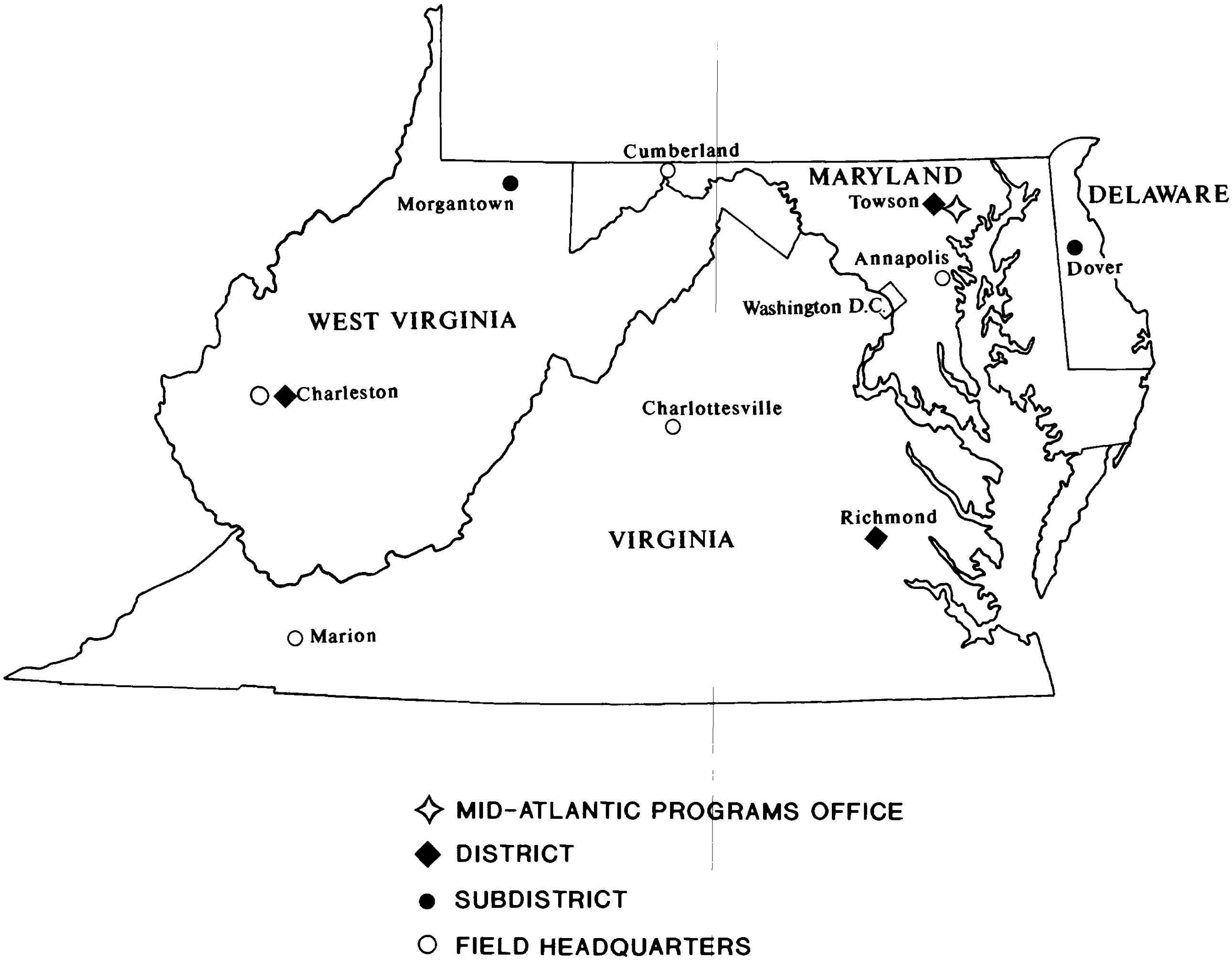


Figure 1.--Mid-Atlantic Programs office locations.

Purpose and Scope

This report describes the organization and activities of the Mid-Atlantic Programs. Following the organizational information are descriptions of projects that were active during 1987-91.

U.S. Geological Survey Programs

The USGS was established by an act of Congress on March 3, 1879, to provide a permanent Federal agency to conduct the systematic and scientific "classification of the public lands, and examination of the geological structure, mineral resources, and products of national domain." An integral part of that original mission includes publishing and disseminating the earth-science information needed to understand, to plan the use of, and to manage the Nation's energy, land, mineral, and water resources.

Since 1879, the research and fact-finding role of the USGS has grown and been modified to meet the changing needs of the Nation it serves. As part of that evolution, the USGS has become the Federal Government's largest earth-science research agency, the Nation's largest civilian mapmaking agency, and the primary source of data on the Nation's surface-water and ground-water resources. Today's programs serve a diversity of needs and users. Programs include–

(1) Conducting detailed assessments of the energy and mineral potential of the Nation's land and offshore areas.

(2) Investigating and issuing warnings of earthquakes, volcanic eruptions, landslides, and other geologic and hydrologic hazards.

(3) Conducting research on the geologic structure of the Nation.

(4) Studying the geologic features, structure, processes, and history of the other planets of our solar system.

(5) Conducting topographic surveys of the Nation and preparing topographic and thematic maps and related cartographic products.

(6) Developing and producing digital cartographic data bases and products.

(7) Collecting data on a routine basis to determine the quantity, quality, and use of surface water and ground water.

(8) Conducting water-resource appraisals in order to describe the consequences of alternative plans for developing land and water resources.

(9) Conducting research in hydraulics and hydrology, and coordinating all Federal water-data acquisition.

(10) Using remotely sensed data to develop new cartographic, geologic, and hydrologic research techniques for natural resources planning and management.

(11) Providing earth-science information through an extensive publications program and a network of public access points.

Along with its continuing commitment to meet the growing and changing earth-science needs of the Nation, the USGS remains dedicated to its original mission to collect, analyze, interpret, publish, and disseminate information about the natural resources of the Nation. To fulfill this diverse mission, the USGS is organized into three technical-program divisions--Geologic, National Mapping, and Water Resources.

Basic Mission and Program of the Water Resources Division

The mission of the Water Resources Division is to provide the hydrologic information and understanding needed for the optimum use and management of the Nation's water resources for the overall benefit of the people of the United States.

This is accomplished, in large part, through cooperation with other Federal and non-Federal agencies, by:

(1) Collecting, on a systematic basis, data needed for the continuing determination and evaluation of the quantity, quality, and use of the Nation's water resources.

(2) Conducting analytical and interpretive water-resource appraisals describing the occurrence, availability, and the physical, chemical, and biological characteristics of surface water and ground water.

(3) Conducting supportive basic and problem-oriented research in hydraulics, hydrology, and related fields of science to improve the scientific basis for investigations and measurement techniques and to understand hydrologic systems sufficiently well to quantitatively predict their response to stress, either natural or manmade.

(4) Disseminating the water data and the results of these investigations and research through reports, maps, computerized information services, and other forms of public releases.

(5) Coordinating the activities of Federal agencies in the acquisition of water data for streams, lakes, reservoirs, estuaries, and ground waters.

(6) Providing scientific and technical assistance in hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Power Commission, and to international agencies on behalf of the Department of State.

Sources of Information and Publications

The results of USGS investigations are published in its scientific reports and in its topographic, geologic, and hydrologic maps.

Copies of books, catalogs, pamphlets, Professional Papers, Water-Supply Papers, Water-Resources Investigations Reports, and Open-File Reports can be purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Denver Federal Center, Box 25425
Denver, CO 80225

Copies of maps can be purchased from:

U.S. Geological Survey
Map Distribution
Denver Federal Center
Box 25286
Denver, CO 80225

Information on topography, geology, and hydrogeology can be obtained from the USGS Earth Science Information Center. Sales of maps, digital data, aerial photographs, and books are available at these locations:

USGS Earth Science Information Center

Map Sales Office
12201 Sunrise Valley Drive
Reston, VA 22092
(703) 648-6892
[FTS 959-6892]

Department of the Interior
18th and E Streets, N.W., Room 2650
Washington, D.C. 20240
(202) 208-4047

Many publications resulting from the jointly funded, cooperative program of the Mid-Atlantic Programs are published by the cooperating agencies. These publications are available from:

Maryland Geological Survey
2300 St. Paul Street
Baltimore, MD 21218
(410) 554-5500

Delaware Geological Survey
University of Delaware
Newark, DE 19716
(302) 831-2834

Maryland Department of Natural Resources
580 Taylor Avenue
Tawes State Office Building
Annapolis, MD 21401
(410) 974-3782

West Virginia Geological and Economic Survey
P.O. Box 879
Morgantown, W.VA 26506
(304) 594-2331

Mid-Atlantic Programs Organization and District Addresses

Water-resources activities of the USGS Mid-Atlantic Programs are conducted from nine offices located in Delaware, Maryland, Virginia, and West Virginia (figs. 1 and 2). Activities in the District of Columbia are conducted from the Maryland office. The Mid-Atlantic Programs is divided into the three Districts of Virginia, Maryland-Delaware-District of Columbia, and West Virginia. The District headquarters offices in Towson, Md., Richmond, Va., and Charleston, W. Va., are the major centers for data-collection activities, hydrologic investigations, and for administrative and computer support. The Field Headquarters in Cumberland, Md., Charlottesville, Va., and Marion, Va., are primarily bases for data-collection activities. The Field Headquarters in Annapolis, Md., is a base for ground-water data collection and ground-water investigations. The Delaware Subdistrict in Dover, Del., and the Morgantown Subdistrict in Morgantown, Va., are bases for data collection and hydrologic investigations. The Mid-Atlantic Programs Office coordinates activities of the Districts and links Programs operations to the Regional and National Offices.

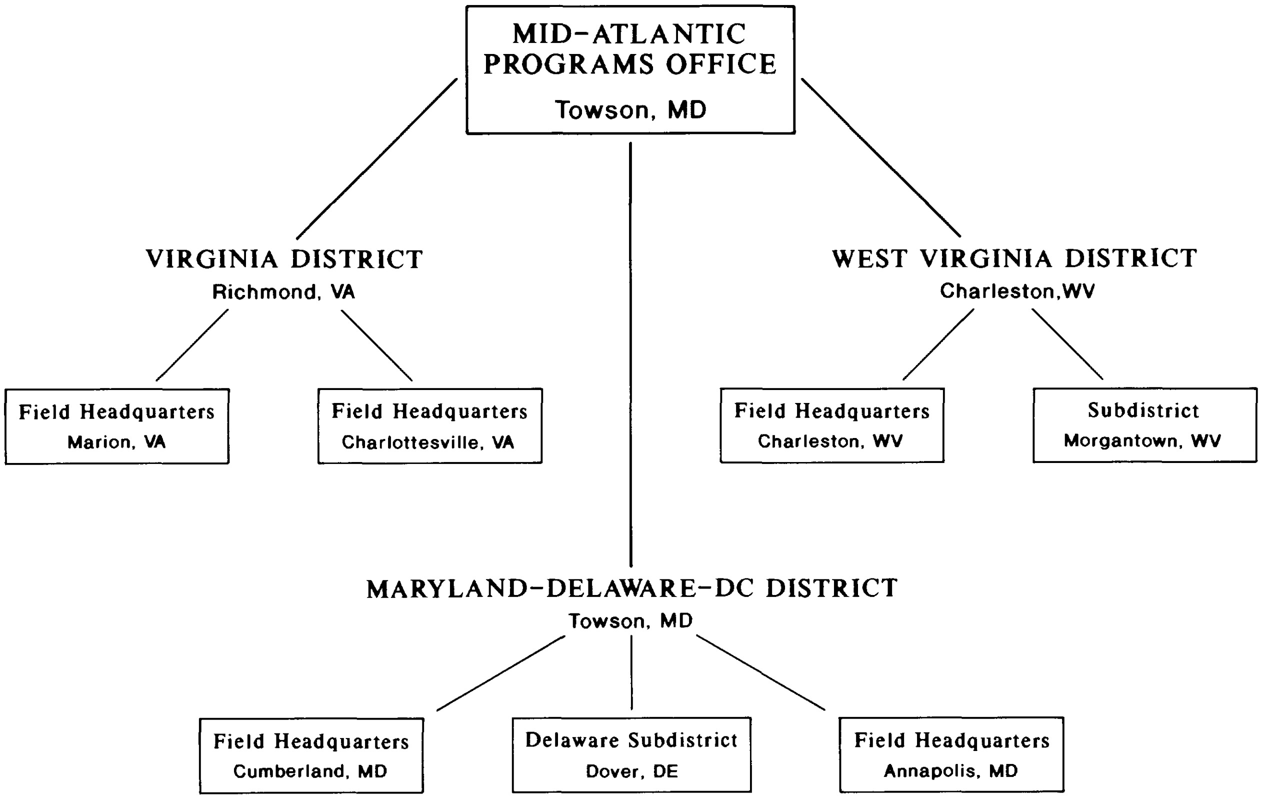


Figure 2.--Mid-Atlantic Programs organization.

Office	Phone	Address
Mid-Atlantic Programs Office Herbert J. Freiberger Area Assistant Regional Hydrologist	(410) 828-1535 [FTS 922-7872] FAX (410) 828-1538	U.S. Geological Survey 208 Carroll Building 8600 La Salle Road Towson, MD 21204
Maryland-Delaware-District of Columbia District David Grason District Chief	(410) 828-1535 [FTS 922-7872] FAX (410) 828-1538	U.S. Geological Survey 208 Carroll Building 8600 La Salle Road Towson, MD 21204
Virginia District Gary S. Anderson District Chief	(804) 771-2427 [FTS 925-2427] FAX (804) 358-0476	U.S. Geological Survey 3600 West Broad Street Room 606 Richmond, VA 23230
West Virginia District David P. Brown District Chief	(304) 347-5130 [FTS 930-5130] FAX (304) 347-5133	U.S. Geological Survey 603 Morris Street Charleston, WV 25301
Field Headquarters Frederick K. Mack Hydrologist	(410) 269-3660	U.S. Geological Survey Tawes State Office Bldg. 580 Taylor Avenue P.O. Box 1568 Annapolis, MD 21401
Field Headquarters Bernard F. Strain Technician-in-Charge	(301) 724-1840	U.S. Geological Survey P.O. Box 1206 Cumberland, MD 21502

Office	Phone	Address
Field Headquarters Floyd L. Snow Technician-in-Charge	(804) 295-6438	U.S. Geological Survey 1936 Arlington Boulevard, Room 118 Charlottesville, VA 22903
Field Headquarters Howard D. Williams Technician-in-Charge	(703) 783-6191	U.S. Geological Survey 1021 Terrace Drive Marion, VA 24354
Field Headquarters Stephen M. Ward Supervisory Hydrologist	(304) 347-5289	U.S. Geological Survey 1334 Smith Street, Room B5 Charleston, WV 25301
Delaware Subdistrict Robert Simmons, Hydrologist Judith Denver, Hydrologist	(302) 734-2506 [FTS 487-6241] FAX (302) 734-2964	U.S. Geological Survey Federal Bldg., Rm. 1201 300 South New Street Dover, DE 19901
Morgantown Subdistrict Mark D. Kozar Hydrologist	(304) 291-4251	U.S. Geological Survey P.O. Box 1647 Morgantown, WV 26505

Sources of Funding and Cooperating Agencies

Funds to support work performed in the Mid-Atlantic Programs are from three sources (fig. 3):

Federal Program--Funds for the Federal Program are appropriated by Congress and are specifically identified in the annual budget of the USGS. The Districts in the Mid-Atlantic Programs obtain funding from this source for specific projects that address high-priority topical programs identified in the Congressional appropriation. Such projects in the Mid-Atlantic Programs are related to the Acid Rain Program, the Global Climate Change Program, the Regional Aquifer-Systems Analysis (RASA), and the National Water-Quality Assessment (NAWQA).

Federal-State Cooperative Program--Federal funds are appropriated by Congress and are used to match funds furnished by State and other tax-supported local agencies. Federal funds cannot exceed 50 percent of the total project funding in the Federal-State cooperative program. These funds are used for a majority of the hydrologic data-collection activities and hydrologic investigations in the area. For many years, the jointly funded, cooperative arrangement has ensured responsiveness to water-information needs at all levels of government. It has enabled the Federal Government to be aware of State and local water problems and has contributed to valuable information exchange. Although studies conducted within the Federal-State cooperative program are usually linked to local problems, they are of substantial national interest because the information developed is applicable in other areas, or forms part of the informational base for larger areas.

Other Federal Agency (OFA) Program--In this program, other Federal agencies transfer funds to the USGS as reimbursement for data-collection activities or hydrologic investigations performed at their request.

Agencies supporting water-resources activities in the Mid-Atlantic Programs, during 1987-91, are listed on the following pages:

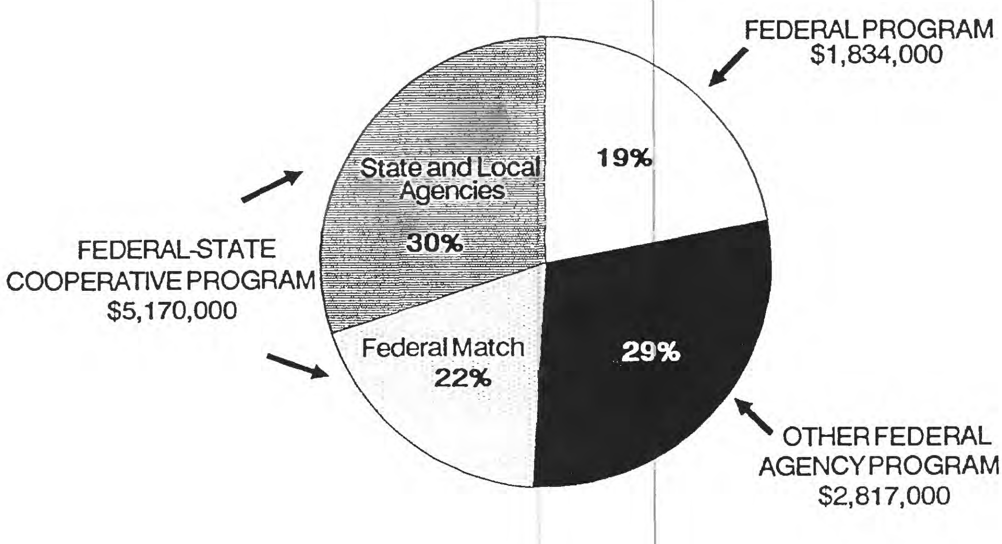


Figure 3.--Source of funds for 1990 fiscal year.

Delaware

Federal-State Cooperative Program

City of Wilmington

Delaware Department of Natural Resources and Environmental Control

Delaware Department of Transportation

Delaware Geological Survey

Delaware River Basin Commission

Water Resources Agency for New Castle County

Other Federal Agency Program

U.S. Army Corps of Engineers, Philadelphia, Pa., District

U.S. Environmental Protection Agency

Maryland/District of Columbia

Federal-State Cooperative Program

Anne Arundel County

Borough of Hyndman, Pennsylvania

Cecil County

Charles County

City of Baltimore

City of Salisbury

District of Columbia Department of Consumer and Regulatory Affairs

District of Columbia Department of Public Works

Harford County

Howard County

Interstate Commission on the Potomac River Basin

Maryland Bureau of Mines

Maryland Department of the Environment

Maryland Department of Natural Resources

Maryland Geological Survey

Maryland State Highway Administration

Maryland Water Resources Administration

Metropolitan Washington Council of Governments

Power Plant Research and Environmental Review, Division of the Maryland Tidewater Administration

Queen Annes County

Somerset County

Town of Indian Head

Town of Ocean City

Upper Potomac River Basin Commission

Washington Suburban Sanitary Commission

Other Federal Agency Program

Smithsonian Environmental Research Center

U.S. Air Force, Occupational and Environmental Health Laboratory

U.S. Army Aberdeen Proving Ground Support Activity Environmental Management Division

Maryland/District of Columbia --Continued

Other Federal Agency Program--Continued

U.S. Army Corps of Engineers,
Baltimore, Md., District
Philadelphia, Pa., District
Pittsburgh, Pa., District

U.S. Environmental Protection Agency

U.S. Navy, Indian Head Naval Ordnance Station

Virginia

Federal-State Cooperative Program

Accomack County

Accomack-Northampton Planning District Commission

City of Alexandria

City of Bedford

City of Newport News

City of Radford

City of Roanoke

City of Virginia Beach

City of Williamsburg

Clarke County

Council on the Environment

Department of Mines, Minerals and Energy,
Division of Mined Land Reclamation

Hampton Roads Planning District Commission

Henrico County

James City County

James City Service Authority

Lord Fairfax Planning District Commission

Mount Rodgers Planning District Commission

Northampton County

Northern Virginia Planning District Commission

Prince William Health District

Rappahannock-Rapidan Planning District Commission

Southeastern Public Service Authority of Virginia

University of Virginia

Virginia Commonwealth University

Virginia Department of Transportation

Virginia Polytechnic Institute and State University, Powell River Project

Virginia Water Control Board

York County

Virginia--Continued

Other Federal Agency Program

Department of Defense, Defense Logistics Agency, Defense General Supply Center

Department of Defense, U.S. Army Logistics Center and Fort Lee

Federal Emergency Management Agency

U.S. Army Corps of Engineers,
Baltimore, Md., District
Huntington, W.Va., District
Norfolk, Va., District
Wilmington, N.C., District

U.S. Environmental Protection Agency

Tennessee Valley Authority

West Virginia

Federal-State Cooperative Program

Jefferson County Commission

Region VII Planning and Development Council

Region IX Planning and Development Council

Marshall University Research Corporation

Morgantown Utility Board

Tucker County Planning Commission

West Virginia Department of Commerce, Division of Parks and Recreation

West Virginia Department of Health, Division of Environmental Engineering

West Virginia Department of Highways

West Virginia Department of Natural Resources,
Division of Water Resources
Division of Wildlife Resources

West Virginia Geological and Economic Survey

West Virginia Governor's Office of Community and Industrial Development

Washington Public Service District

Other Federal Agency Program

Federal Emergency Management Agency

Federal Power Commission

National Park Service

Office of Surface Mining

Soil Conservation Service

U.S. Army Corps of Engineers,
Baltimore, Md., District
Huntington, W.Va., District
Pittsburgh, Pa., District

PROJECT DESCRIPTIONS

Projects of the Mid-Atlantic Programs that were active during 1987-91 (1989-91 in West Virginia) are described on the following pages. Included are descriptions of projects in Delaware, Maryland, Virginia, and West Virginia. Interstate projects are described first, followed by projects in Delaware, Maryland, Virginia, and West Virginia. Projects involving the District of Columbia are not described separately. Surface-water stations for the District of Columbia are included in the description of Maryland project MD001. The order of presentation for each State is by physiographic province (fig. 4), moving generally from east to west. The project number follows the project title in parentheses.

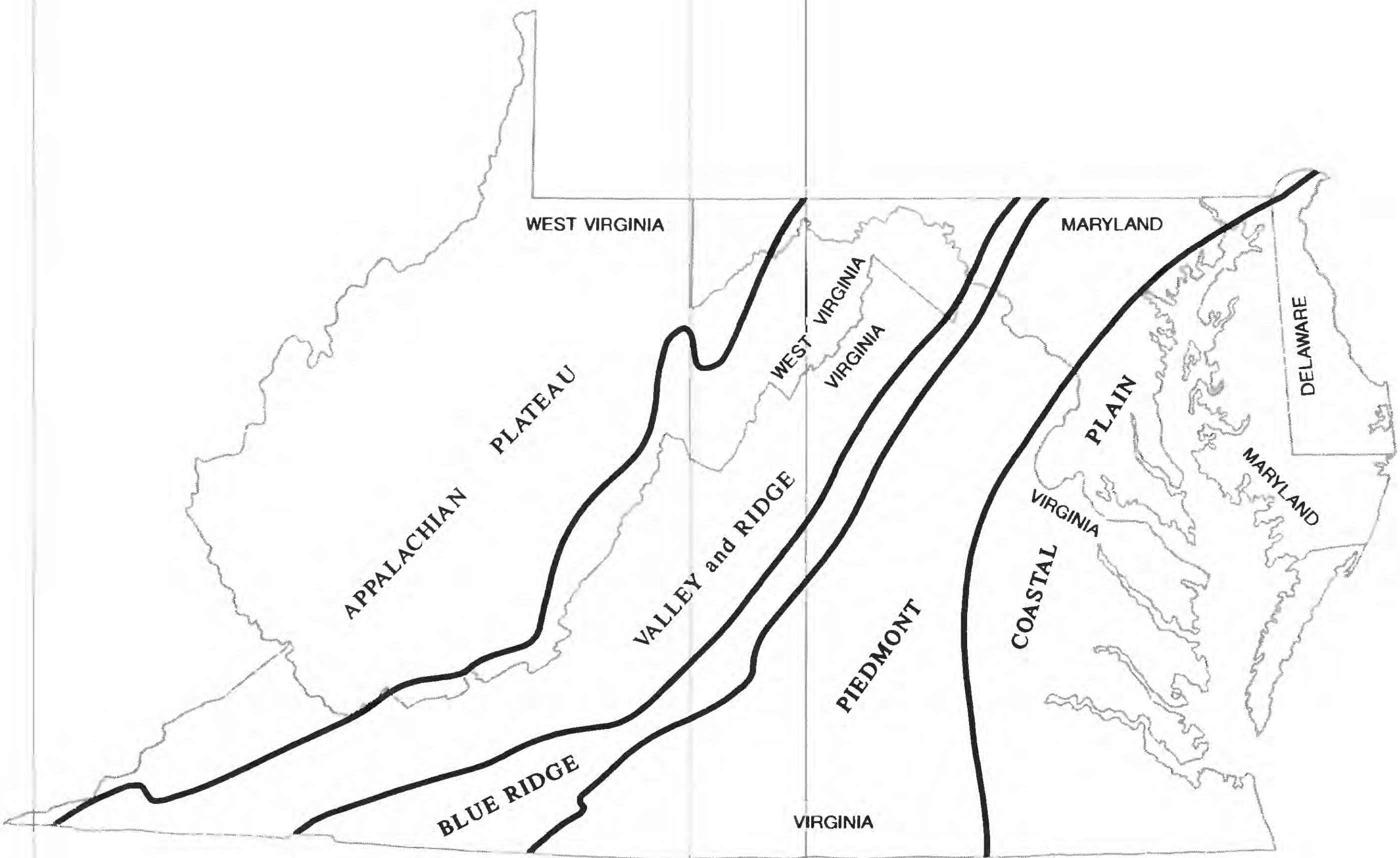
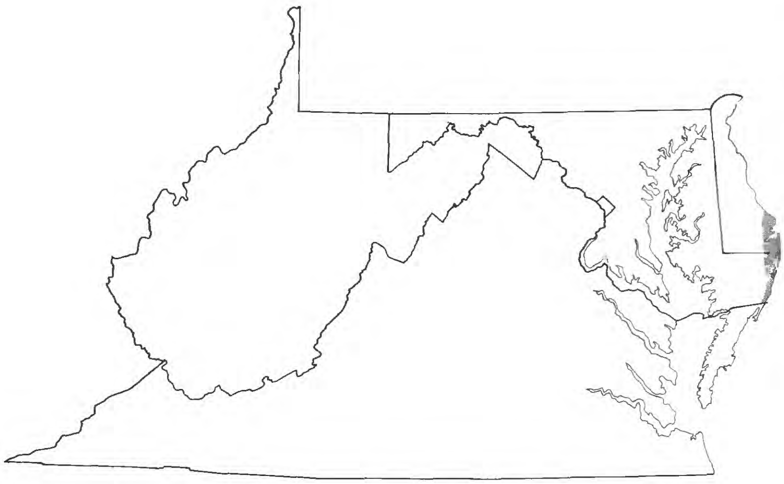


Figure 4.-- Physiographic provinces of the Mid-Atlantic Programs.



Water Levels and Salinity, Coastal Aquifers of Delaware and Maryland (DE020)

INTERSTATE

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Daniel J. Phelan

COOPERATORS:

Delaware Department of Natural Resources and Environmental Control

Delaware Geological Survey

Maryland Geological Survey

Maryland Water Resources Administration

Town of Ocean City, Maryland

PERIOD OF PROJECT: April 1985 through March 1987

PROBLEM: Ground water in the coastal areas of Delaware and Maryland is drawn from the same freshwater system comprised of the Manokin, Ocean City, Pocomoke, and water-table aquifers. These aquifers are susceptible to degradation of water quality from three potential saltwater sources (1) from above, by infiltration of water from the ocean and bays into and through the water-table aquifer; (2) from below, by infiltration of water from aquifers containing saltwater; and (3) from offshore, by lateral movement of the saltwater-freshwater interface.

OBJECTIVES: (1) Upgrade the present water-level measurement network to define annual drawdown and recovery cycles in areas affected by pumping. (2) Establish a well network to measure salinity of ground water so that variations can be recorded and trends identified. (3) Evaluate water-level and salinity data to describe the current situation and to compare the new data with historical data. (4) Prepare a proposal that will provide for continuation of water-level and salinity-measurement networks, and that will outline appropriate next steps in the continued assessment of the potential for excessive water-level declines and water-quality degradation.

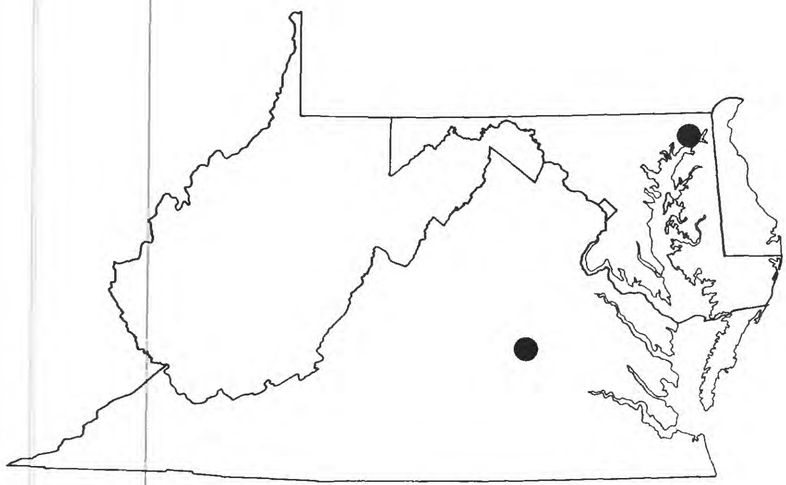
APPROACH: The Delaware water-level network consisted of 24 observation wells, of which 6 were equipped with water-level recorders. Water from 10 production wells was monitored weekly or bi-weekly for chloride content. The Maryland network consisted of 21 observation wells of which 11 were equipped with water-level recorders. Water from 15 production wells in Maryland was monitored for chloride content. Most wells were sampled every 6 to 8 weeks during the project for field measurement of chloride and conductivity. These wells were sampled for laboratory analysis of chloride and other major ions from 1985-87.

SUMMARY: Seasonal high water levels are affected more by annual rainfall than by pumpage. Seasonal low water levels have declined most years in areas of heavy pumpage along the coast. Several record low water levels in 1986 were caused by drought conditions rather than by pumpage. No substantial areal declines of water levels due to pumping were observed. Chloride concentrations in water from the Manokin aquifer range from 6 to 460 mg/L; concentrations in water from the Ocean City aquifer range from 6 to 260 mg/L; concentrations in water from the Pocomoke aquifer range from 5 to 46 mg/L; and concentrations in water from the unconfined aquifer range from 12 to 46 mg/L. Water from one production well in the Ocean City aquifer increased in chloride concentration from 50 mg/L in 1976 to 200 mg/L in 1986. With one exception (44th Street well), increased pumpage and lower water levels have not resulted in increased chloride concentrations in water from the confined aquifers.

Chesapeake Bay Fall Line Toxics Monitoring Program (MD00310)

INTERSTATE

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Linda D. Zynjuk and Donna Belval

COOPERATOR:

Maryland Department of the Environment

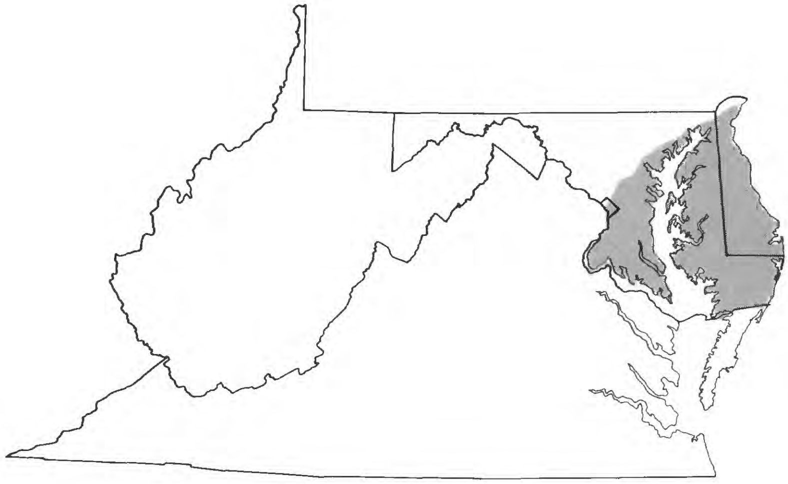
PERIOD: April 1990 through April 1992

PROBLEM: With the growing realization that the water quality of the Chesapeake Bay is potentially affected by toxic chemicals, there is a need to determine the types and quantities of these chemicals entering the Bay from all sources. Additionally, there are several difficulties encountered in the estimation of toxic-constituent loads, such as censored data (concentrations below limits of detection), and variable detection limits in the data base.

OBJECTIVES: (1) Document the occurrence of metals and pesticides in two major tributaries to the Chesapeake Bay. (2) Examine the relation of these constituents to flow, suspended sediment, and season. (3) Estimate monthly and annual loads at the Fall Line of each tributary.

APPROACH: The Chesapeake Bay Fall Line Toxics Monitoring Program was established as a pilot study in 1990 to define the magnitude, timing, and severity of nonpoint-source toxic input entering the Chesapeake Bay from two major tributaries, the Susquehanna and James Rivers. Base-flow and storm-flow water-quality samples are analyzed for trace metals, both total-recoverable and dissolved, and for the following total-recoverable pesticides: triazine herbicides, carbamate insecticides, organochlorine and organophosphorus insecticides, and the chlorophenoxy acid herbicides (2, 4-D). The estimation of toxic constituent loads using log-linear models will be evaluated. Constituent loads can be calculated with a known degree of accuracy given a data base of 0 to 90 percent censored data (values below analytical detection).

SUMMARY: Water-quality samples were collected during the period of April 1990 through April 1, 1991. Many trace-metal and pesticide constituents were found in concentrations above detection greater than 10 percent of the time at the two river stations. Monthly and annual loads will be estimated for these constituents using a seven-parameter log-linear model employing seasonality, flow, and time-trend variables. This model has been shown to work well in the estimation of nutrient and suspended-sediment loads at the two river stations. The monitoring program has received funding for an additional year of water-quality sampling.



Analysis by Use of Digital Models of the Coastal Plain Aquifers Underlying Maryland, Delaware, and the District of Columbia (MD037)

INTERSTATE

Coastal Plain

Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: William B. Fleck

PERIOD OF PROJECT: October 1979 through September 1989

PROBLEM: The Northern Atlantic Coastal Plain is densely populated and heavily industrialized. As the limit of available surface-water supplies is approached, an increasing demand for ground water, in turn, requires prudent ground-water management. The effects of additional stress on water levels need to be understood better. Good predictive capability is necessary to assist management agencies in the efficient development of the ground-water resources.

OBJECTIVES: (1) Update and centralize the ground-water data base, consistent with the needs of the District ground-water program, to meet the needs of the Regional Aquifer-Systems Analysis (RASA) program. (2) Describe the regional ground-water-flow system, to further develop the capability to predict long-term yields of the Coastal Plain aquifers, and to predict the effects of stresses on this system.

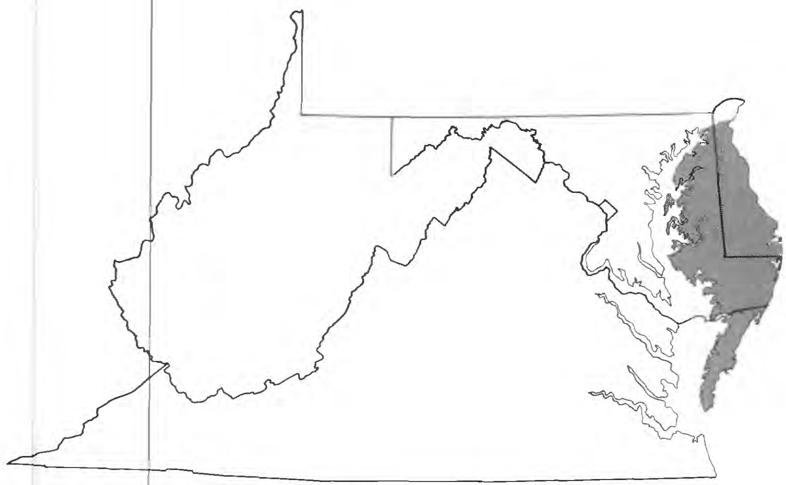
APPROACH: Collect and analyze data on aquifer characteristics, pumpage, head, and water quality. Construct interpretive maps from these data for use in developing the RASA model. Develop a coarse-grid model of the ground-water-flow system employing the USGS Trescott quasi three-dimensional, finite-difference, computer program to determine regional flow conditions and to aid in establishing boundary-flow conditions for finer-grid models.

SUMMARY: A 10-layer model was constructed to simulate the regional ground-water-flow system in the Coastal Plain sediments of Maryland, Delaware, and the District of Columbia. The 10 layers, in ascending order, are equivalent to the water-bearing parts (aquifers) of the Patuxent, Patapsco, Magothy, Matawan, Severn, Aquia, Piney Point, lower Chesapeake, upper Chesapeake, and the Plio-Pleistocene units. The model indicates that about 0.15 in. of recharge percolates into the deep confined system. The model-calculated ground-water budget for 1978-80 shows the principal source of water was areal recharge (7,400 Mgal/d) and the principal discharge was to surface water (7,200 Mgal/d). Total simulated ground-water pumpage for 1978-80 averaged about 131 Mgal/d, which was about 60 percent of total pumpage. This pumpage resulted in a corresponding reduction of ground-water discharge to surface water of about 119 Mgal/d, compared to prepumping conditions, and in 10 well-defined cones of depression. Pumping also caused major changes in the direction of ground-water flow. For example, ground-water flow in the Patuxent aquifer east of Baltimore originally was easterly, under Chesapeake Bay. Because of pumping, however, flow directions have been reversed and during 1978-80 the flow direction was predominately westerly. Average ground-water-flow velocities, as calculated for prepumping conditions, ranged from 0.01 ft/d for the Matawan and Severn aquifers to 0.19 ft/d for the Plio-Pleistocene aquifer.

National Water-Quality Assessment (NAWQA)--Ground-Water Quality in the Delmarva Peninsula, Delaware, Maryland, and Virginia (MD086)

INTERSTATE

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Robert J. Shedlock

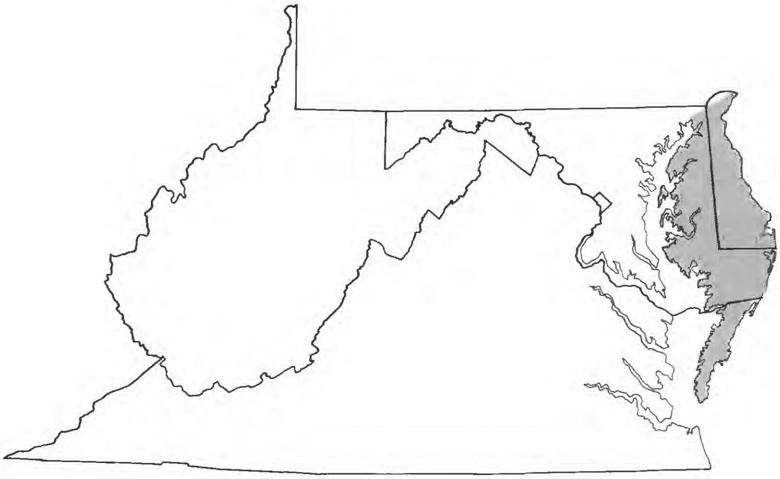
PERIOD OF PROJECT: March 1986 through September 1993

PROBLEM: The assessment of ground-water quality on a national or regional scale is a difficult task. Past studies have documented local water-quality problems in the Delmarva Peninsula, but ground-water quality has never been comprehensively addressed on a regional scale. In addition, data before 1986 are not available in a form suitable for evaluating water-quality trends. Additionally, there is no precedent for ground-water-quality monitoring on this scale.

OBJECTIVES: (1) Assess the ground-water quality of the Delmarva Peninsula based on the chemical and physical characteristics of the water. (2) Interpret the relation between geologic and geomorphic conditions, land use, and water quality. (3) Develop a comprehensive ground-water-quality data base for the Delmarva Peninsula. (4) Provide explanations for the processes and factors affecting ground-water quality. (5) Evaluate the methods and techniques needed for conducting a regional ground-water-quality assessment.

APPROACH: Sample ground water using separate networks, including the surficial aquifer at a regional scale, the surficial aquifer at a local scale, and the confined aquifer systems. Examine results based on geologic and geomorphic conditions and land use. Compile and evaluate existing ground-water data and place in a data base compatible with current data. Use statistical analysis, interpretation of ground-water-flow and chemical patterns, and applications of Geographical Information System to interpret the processes affecting ground-water-quality patterns. Review field procedures and interpretive methods to determine their transfer value to other regional assessments.

SUMMARY: Existing data have been compiled and evaluated, and a report has been written and published. Sampling networks have been established at a local and regional scale in the surficial aquifer, and samples have been collected. The study area has been divided into regions of similar hydrogeologic characteristics based on analysis of rock type and landforms. Protocols have been established to standardize field methods, quality-assurance procedures, and data handling. Preliminary results from the regional-scale networks in the surficial aquifer indicate that elevated nitrate concentrations are the most widespread water-quality problem. Trace amounts of triazine herbicides have been detected in samples from observation wells finished within 20 ft of the water table; however, pesticides were not generally found in wells used for water supply.



Evaluating Ground-water Vulnerability Factors and Developing Monitoring Strategies for Nonpoint Sources of Contaminants in the Delmarva Peninsula (MD103)

INTERSTATE

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Michael T. Koterba

COOPERATOR:

U.S. Environmental Protection Agency

PERIOD OF PROJECT: April 1991 through December 1992

PROBLEM: Agricultural practices and related chemical uses are contaminating ground water in some areas of the Delmarva Peninsula. There is a need to assess ground-water vulnerability to this type of contamination. DRASTIC is the most commonly used vulnerability assessment model. There is a need to assess the validity of the hydrologic features used in DRASTIC. With the increasing awareness that agriculture is a potential nonpoint source for ground-water contamination, there is also an increasing need to develop monitoring programs in agricultural areas. Effective monitoring strategies need to be developed using data on the variability in contaminants over time and under different hydrologic settings.

OBJECTIVE: To evaluate ground-water vulnerability factors and develop strategies for monitoring agriculturally related chemicals in ground water.

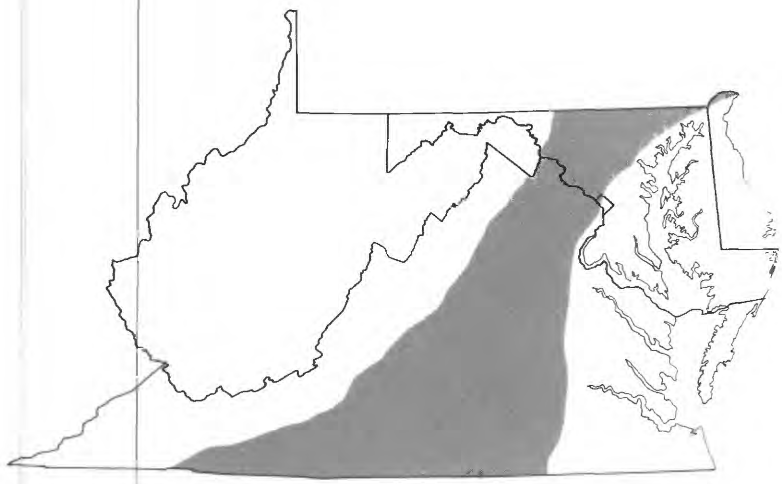
APPROACH: Evaluate ground-water vulnerability factors and DRASTIC. Existing studies that relate landscape and shallow subsurface features and processes will be expanded to include features used in DRASTIC to provide guidelines on developing monitoring networks. Existing sampling networks will be used to sample ground water for nitrate and pesticide variability over time and in different hydrologic settings. Based on these results, develop strategies on where to sample, timing and frequency of sampling, timing horizon of the program, and analytical methods needed.

SUMMARY: Project is just beginning.

Appalachian Valley and Ridge-Piedmont Regional Aquifer-System Analysis--APRASA (VA085)

INTERSTATE

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: David L. Nelms

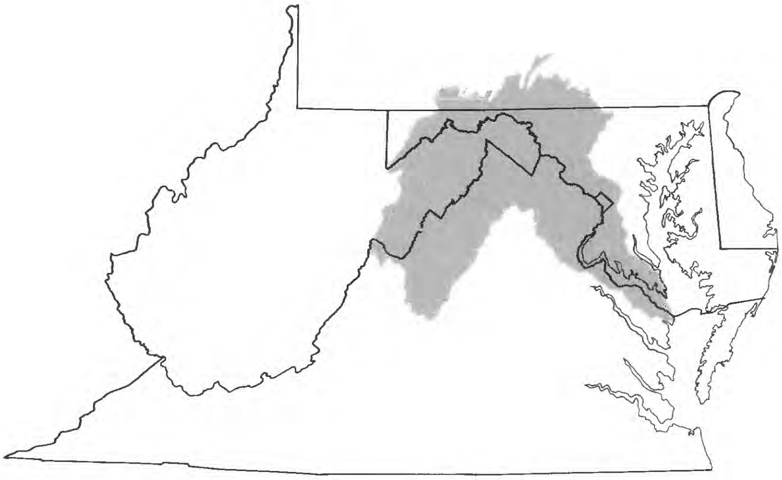
PERIOD OF PROJECT: April 1988 through September 1993

PROBLEM: The Appalachian Valley and Ridge, Blue Ridge, and Piedmont physiographic provinces cover 145,000 square miles of Eastern United States from New Jersey to Alabama. More than 10 percent of the United States population resides within this area. Because of the great diversity in geohydrology, little definitive knowledge exists of the geohydrologic-flow systems in this area, where secondary permeability of the rock systems serves as the principal transport and flow medium.

OBJECTIVE: Determine if base-flow characteristics of streams coupled with ARC/INFO data layers can statistically determine the ranking of water-yielding potentials of the hydrogeologic units in the northern Virginia Appalachian-Piedmont RASA area.

APPROACH: Digitize geologic maps of the Appalachian-Piedmont RASA study area of northern Virginia. Use a Geographic Information System and statistical analysis to delineate geohydrologic units that comprise this part of the APRASA area.

SUMMARY: The initial phase of the development of the geohydrologic framework has been to digitize geologic maps of the States covered by this part of the APRASA area. Formations have been subdivided using the lithological and textural-based geohydrologic classification system. A review of available literature has been initiated.



Potomac River Basin Study Unit, National Water-Quality Assessment (NAWQA) Program (MD102)

INTERSTATE

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: James M. Gerhart

PERIOD OF PROJECT: December 1990 through September 1996

PROBLEM: A comprehensive, consistent assessment of the quality of the Nation's surface water and ground water currently is not available. Such an assessment is needed to provide a sound, scientific basis for prioritizing national water-quality issues and for formulating effective national water policies. A detailed description of the physical, chemical, and biological characteristics of the Nation's streams and aquifers, and an understanding of the factors that affect the Nation's water quality, are two of the valuable products that would result from such an assessment. The Potomac River basin is one of 60 study units nationwide that together will provide the needed national assessment.

OBJECTIVES: (1) Determine the current water-quality conditions in the Potomac River basin. (2) Identify any trends in the observed water-quality conditions.
(3) Determine, to the extent possible, the causes of the observed water-quality conditions and trends.

APPROACH: Following 2 years of planning, analysis of existing data, and reconnaissance sampling, the study will enter a 3-year intensive data-collection and data-interpretation phase. Fixed-station, synoptic, and small-reach sampling of surface water will be conducted, as will be regional and targeted ground-water sampling. Results will be published in numerous reports and papers that will be completed during the sixth and final year of the study.

SUMMARY: In the first 8 months of the study, staffing and budget plans were developed, a briefing paper and a fact sheet were prepared and distributed, and a liaison committee was established and convened. The first draft of a detailed study plan was begun, including sections on environmental setting, plans for reconnaissance sampling, plans for analysis of existing data, study-management topics, and report plans. A preliminary reconnaissance sampling of the Monocacy River subbasin of the Potomac River basin was planned and conducted under low-flow conditions. The compilation of existing water-quality and ancillary data was begun and the data-management system for the study was planned.

Development of Highway Bridge-Scour Equations in Delaware, Maryland, and Virginia (VA092)

INTERSTATE

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Donald C. Hayes

COOPERATORS:

Delaware Department of Transportation

Maryland State Highway Administration

Virginia Department of Transportation

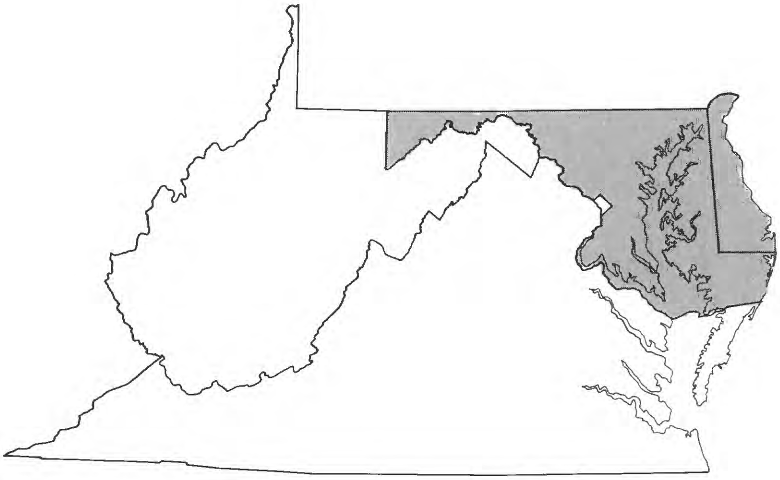
PERIOD OF PROJECT: April 1988 through March 1994

PROBLEM: Excessive scour at bridges can result in bridge failure. Numerous equations have been developed to predict scour depth, but the equations yield a wide range of depths for the same set of hydraulic conditions. In addition, most of the equations are based on laboratory-scale measurements and have not been validated because of the scarcity of onsite measurements. Collection and analysis of field-scour data are needed to develop equations and predict scour depths.

OBJECTIVES: (1) Develop scour-prediction equations that are more reliable than those currently used. (2) Develop and evaluate techniques for continuously monitoring scour at bridge piers.

APPROACH: Collect data on bridge scour from 15 to 20 sites. Instrument one pier to continuously monitor the scour process. Use multiple-regression analysis to develop equations to predict scour depths at existing or planned bridge crossings.

SUMMARY: Reconnoitered bridges in Delaware, Maryland, and Virginia that are more than 150 ft in length and are founded in alluvial channels. Bridges are in non-tidal and tidal areas. Seventeen bridge sites have been selected for event-based scour-data collection. Conducted equipment survey and acquired instrumentation for continuously monitoring the scour process. Selected a tidal site in Delaware for initial installation of monitoring equipment. Made scour measurements at other sites as appropriate.



Estimating Low-Flow Frequency Characteristics for Streams in Maryland and Delaware (MD090)

INTERSTATE

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: David H. Carpenter

COOPERATORS:

Delaware Department of Natural Resources and Environmental Control

Maryland Geological Survey

Maryland Water Resources Administration

PERIOD OF PROJECT: July 1987 through September 1990

PROBLEM: Hundreds of estimates of low-flow statistics (such as the 7-day, 10-year low-flow) are required each year for sites on streams in Maryland and Delaware. The most accurate estimates possible are needed. Techniques for estimating low-flow statistics are available in a report for Maryland streams (but not Delaware). Recent advances in techniques for estimation of low-flow statistics at partial-record sites and in techniques for regional low-flow analyses make it worthwhile to develop new prediction equations for estimating low-flow statistics in Maryland and Delaware.

OBJECTIVES: (1) Develop the best possible estimates of low-flow characteristics at gaged sites, based on the most current data and state-of-the-art techniques. (2) Develop improved low-flow estimating equations for ungaged sites. (3) Develop an improved technique for transferring estimates of low-flow characteristics upstream or downstream from gaged locations. (4) Provide a low-flow characteristics report directly applicable to Maryland streams.

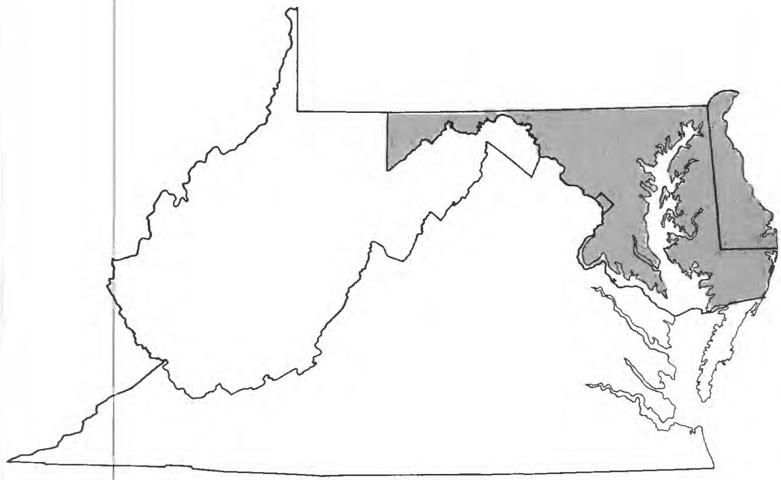
APPROACH: Determine estimates of low-flow characteristics at continuous-record stations by log-Pearson Type III curve-fitting procedures. Develop estimates of low-flow characteristics at partial-record sites from estimates of mean and variance of annual low flows derived from their relations with continuous-record (index) stations. Use multiple-regression analysis with a generalized least squares technique to develop regionalized low-flow estimating equations for ungaged sites, by relating low-flow characteristics to basin characteristics.

SUMMARY: A continuous-record station and low-flow partial-record station data base has been developed. Basin characteristics (such as percent forest cover) have been determined from topographic maps and other sources, for the network of 198 low-flow, partial-record stations. Low-flow characteristics have been determined from log-Pearson frequency curves for most of the regular (continuous-record) gaging stations. Correlations were made between the partial-record stations and associated long-term (index) gaging stations. Low-flow characteristics were determined for the partial-record stations by the recommended state-of-the-art statistical transfer technique. A report will be published summarizing the results of this analysis for Maryland.

Magnitude and Frequency of Floods in Maryland and Delaware (MD099)

INTERSTATE

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Frederick J. Kolberg

COOPERATORS:

Delaware Department of Transportation

Maryland State Highway Administration

PERIOD OF PROJECT: October 1990 through September 1994

PROBLEM: A convenient and reliable technique for estimating the magnitude and frequency of floods is required for the efficient design of bridges, culverts, embankments, and flood-protection structures in Maryland and Delaware, and for use in effective flood-plain management. A technique for estimating floods (using Maryland and Delaware data) by relating flood magnitude characteristics to basin characteristics such as drainage area and forest cover was developed by David H. Carpenter (U.S. Geological Survey Water-Resources Investigations Report 80-1016, "Technique for Estimating Magnitude and Frequency of Floods in Maryland") for Maryland using flood data through September 30, 1977. The Maryland State Highway Administration and Delaware Department of Transportation have requested that this report be updated to include data through September 30, 1989.

OBJECTIVES: (1) Develop estimates of flood-frequency (peak-flow) characteristics at gaged sites, using the most current data available. (2) Develop significantly improved peak-flow estimating equations for ungaged sites using state-of-the-art analysis techniques, updated estimates of peak-flow characteristics at gaged sites, and significant new basin characteristics. (3) Provide a technique for estimating the effects of land development on flood-peak discharges. (4) Provide a technique for estimating peak-flow characteristics in the limestone regions of Washington and Frederick Counties. (5) Provide an evaluation of the gaging-station networks to determine where additional station data or the relocation of stations would result in the most significant improvement in the accuracy of the estimating (multiple-regression) equations.

APPROACH: Determine estimates of flood-frequency (peak-flow) characteristics by log-Pearson Type III curve-fitting procedures for approximately 170 continuous-record stations and 40 partial-record stations in Maryland and Delaware using available data through 1990 and approximately 100 nearby stations in adjacent States. Use multiple-regression analysis to develop updated regionalized estimating equations to compute peak-flow characteristics for ungaged sites. Use multiple-regression analysis with the generalized least squares technique.

SUMMARY: Peak-flow data for 130 stream gages in Maryland and Delaware and 110 sites in adjoining States will be used in developing flood-frequency characteristics. A Geographic Information System will be used to measure basin characteristics and develop a new characteristic that will reduce the standard error of estimate.

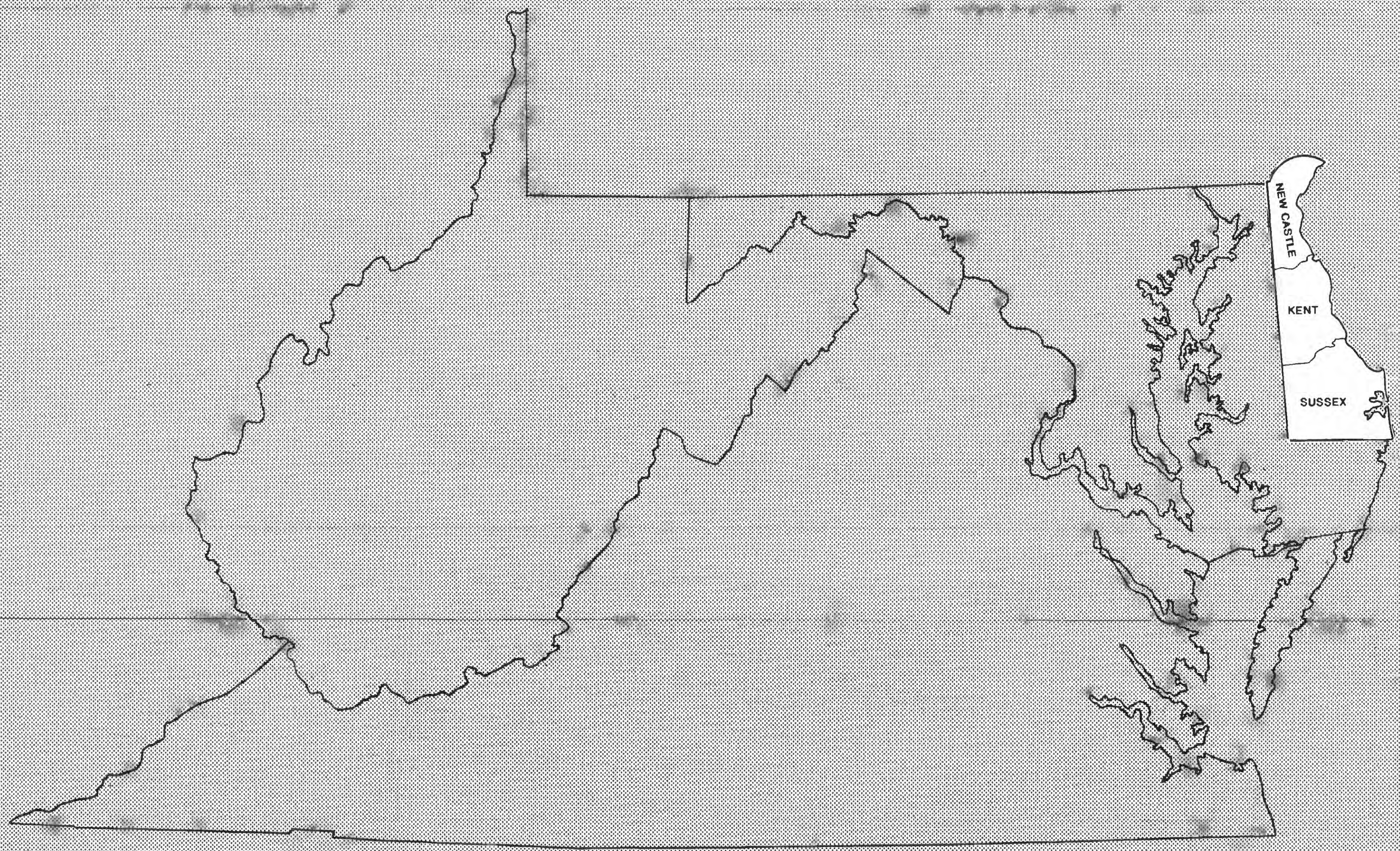


Figure 5.--Counties of Delaware.

Water Use in the St. Jones River Basin, Kent County, Delaware (DE007)

DELAWARE

Coastal Plain

Piedmont

LEADER: Daniel J. Phelan

COOPERATOR:

Delaware Department of Natural Resources and Environmental Control

PERIOD OF PROJECT: October 1984 through September 1988

PROBLEM: The Delaware Department of Natural Resources and Environmental Control is responsible for allocating water resources in the State. To make equitable decisions, water managers need accurate and reliable estimates of current water withdrawal, delivery, consumptive use, and return flow. Although most public and industrial water withdrawals are metered by the users, some usage, particularly that for irrigation, is estimated. Historically, total water-use figures for the State have been computed by integrating quantities reported by large users with estimates based on national averages for various categories of small users. As the margin between water availability and water use decreases, however, broad estimates based on national averages will become inadequate for making management decisions.

OBJECTIVE: To collect and analyze detailed information on total water use in a representative area in central Delaware, so that water managers can develop estimates of non-reported water use in similar areas elsewhere in the State.

APPROACH: Water-use data for 1985 were the basis for the analysis in this investigation. Water-delivery records were collected from public utilities that furnish metered water for domestic, industrial, commercial, and fossil-fuel power generation purposes. Analysis of these data provided a refined estimate of local water use. Return-flow data for Kent County wastewater facilities, corrected for line gains and losses, were compared to withdrawal and delivery data to estimate consumptive use in sewered areas. Time-totalizing meters were installed on irrigation-well pumps to determine running time, and non-intrusive flow meters were used to determine well discharge.

SUMMARY: In 1985, about 4,350 Mgal/d of water use existed in the St. Jones River basin. Fifty-four percent was public supplied, and the remaining 46 percent was self-supplied. Thirty-five percent of all water used was lost to consumptive use. Irrigation is the largest consumptive use of water in the basin. Thirty-nine percent of the consumptive use was by evapotranspiration. Power generation and public supply (domestic and commercial) consumed 25 and 22 percent of total water. The remaining 14 percent of total water was consumed by self-supplied commercial (6 percent), industrial (6 percent), and domestic self-supplied users (2 percent).

Geochemistry of Water in the Unconfined Aquifer in Eastern Sussex County, Delaware, with Emphasis on the Occurrence and Distribution of Nitrate Problems (DE019)

DELAWARE

Coastal Plain

Piedmont

LEADER: Judith M. Denver

COOPERATOR:

Delaware Geological Survey

PERIOD OF PROJECT: October 1984 through December 1987

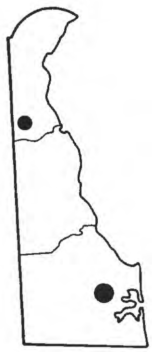
PROBLEM: The unconfined aquifer is a major source of water supply in eastern Sussex County, Delaware. It also is an important source of water for surface-water bodies and deeper, confined aquifers. The unconfined aquifer consists chiefly of sand and gravel, and is susceptible to contamination by nitrate and other chemical constituents associated with agricultural practices and effluent from septic systems. Commonly, nitrate concentrations are greater than 10 mg/L in water from the aquifer. An improved understanding of the occurrence and behavior of nitrate and other chemical constituents in the ground-water system is needed to give water managers a better comprehension of water quality, and to assist in locating future public water supplies of acceptable quality.

OBJECTIVE: (1) Describe the vertical and horizontal distribution and movement of nitrate and other chemical constituents around an irrigated field. (2) Compare the chemistry of water affected by agricultural practices with that of water affected by septic-system effluent to determine characteristics that could be used to uniquely identify sources of ground-water contamination.

APPROACH: A 220-acre field with a centrally located irrigation well was instrumented with 31 wells screened at different depths in the unconfined aquifer. Ground-water quality was evaluated in relation to irrigation-well pumping, unstressed ground-water flow, cropping and fertilization practices, soil characteristics, and recharge. Chemical analyses of water from wells identified as having elevated nitrate concentrations resulting from septic-system effluent were compared to analyses for water affected by agricultural practices and for water unaffected by human activities.

SUMMARY: Factors including upgradient land use, ground-water withdrawal, rates of fertilizer application, magnitude and timing of recharge, and aquifer properties affect the subsurface distribution of agricultural chemicals at the irrigated field site. Concentrations of nitrate (as nitrogen) range from less than 2 mg/L to greater than 40 mg/L and have a median concentration greater than 10 mg/L. Although agricultural practices have less influence on deep parts of the unconfined aquifer than on shallow parts, nitrate (as nitrogen) concentrations are as great as 29 mg/L near the base of the aquifer, 80 ft below land surface.

The major dissolved chemical constituents in septic-system effluent are organic and ammonia nitrogen, sodium, and chloride. Although these and other minor chemical constituents were present in ground water affected by septic-system effluent, their presence cannot be used to uniquely identify the source of water-quality problems because they also are present in manures, fertilizers, and pesticides.



The Occurrence of Pesticides in the Shallow Ground Water of Two Agricultural Areas in Delaware (DE022)

DELAWARE

Coastal Plain

Piedmont

LEADER: Judith M. Denver

COOPERATOR:

Delaware Geological Survey

PERIOD OF PROJECT: January 1988 through September 1990

PROBLEM: There is a need to identify the severity and extent of ground-water contamination by pesticides in Delaware, and to assess the potential for migration of pesticides into the unconfined aquifer. There is concern that after mobile pesticides migrate below the root zone to zones of reduced microbial activity in the aquifer, mechanisms for their removal from the ground-water system are limited. Because most domestic and many municipal water supplies are derived from the unconfined aquifer, pesticides, if present, have the potential to affect a large segment of the population.

OBJECTIVES: (1) Gather information on the severity and extent of pesticide contamination in the shallow ground water of two agricultural areas in Delaware with soil and aquifer characteristics typical of larger areas on the Delmarva Peninsula. (2) Identify the specific environmental factors influencing aquifer contamination by selected pesticides.

APPROACH: Select study areas. Research past pesticide usage and physical, chemical, and biological factors potentially affecting pesticide mobility in soil and ground water. Install wells for water-level and water-quality monitoring. Collect water samples from wells and local surface-water features for laboratory analysis of selected pesticides, major inorganic ions, and nutrients. Relate geochemical data to processes in the soil and aquifer that promote or impede pesticide mobility.

SUMMARY: Two areas with mixed agricultural and forested land uses were selected for study--one in southwestern New Castle County, and one in eastern Sussex County. Both sites were equipped with wells for water-level measurement and water-quality sampling. Water-quality sampling was conducted quarterly at selected sites. Laboratory analyses include inorganic constituents, nutrients, dissolved organic carbon, and selected pesticides. Field measurements of specific conductance, dissolved oxygen, pH, alkalinity, and temperature were made during sampling. Soil samples were collected and analyzed for selected physical and chemical characteristics. Water-quality data were related to past pesticide usage, information from previous and ongoing research projects, data on pesticide behavior in soils, physical and chemical characteristics of soils, and hydrogeologic data.

Water Quality and Geochemistry of Ground Water in the Coastal Plain Aquifers of Central New Castle County, Delaware (DE025)

DELAWARE

Coastal Plain
Piedmont

LEADER: Judith M. Denver

COOPERATOR:

Delaware Geological Survey

PERIOD OF PROJECT: January 1991 through September 1993

PROBLEM: Central New Castle County is a developing area that relies exclusively on ground water for water supply. Sediments of the Coastal Plain form a regional water-table aquifer underlain by four confined aquifers. Several naturally occurring substances in ground water cause localized and possibly extensive water-quality problems. These include radon, elevated concentrations of sodium (in glauconitic aquifers) and dissolved iron, and intrusion of brackish water. Nitrate from septic systems and agricultural chemicals could contribute to water-quality problems. Understanding the distribution of chemical constituents and geochemical controls on water chemistry is essential for future water-supply planning and development.

OBJECTIVES: (1) Develop a data base on ground-water quality and water levels for the principal aquifers. (2) Delineate the distribution and concentrations of selected inorganic chemical constituents in ground water for the principal aquifers. (3) Identify geochemical controls on ground-water chemistry.

APPROACH: Review available data to characterize chemistry of water in each aquifer. Inventory existing wells to develop a sampling network spatially distributed in each aquifer. Install shallow wells in areas where aquifers are undeveloped. Sample 50 to 60 wells for field parameters and laboratory determinations of major ions, nutrients, aluminum, and silica. Display data on maps and cross sections. Use mineralogic data, graphical techniques, and computer models (WATEQF, Balance, PHREEQE) to interpret geochemistry of ground water.

SUMMARY: Collected and reviewed pre-existing data on water quality and geology. Inventoried wells spatially distributed in each aquifer and obtained permission for sampling. Conducted initial water-quality sampling.

Reconnaissance of Ground-Water Resources of the Cockeysville Marble, New Castle County, Delaware (DE024)

DELAWARE

Coastal Plain

Piedmont

LEADER: William H. Werkheiser

COOPERATORS:

Delaware Department of Natural Resources and Environmental Control

Delaware Geological Survey

Water Resources Agency for New Castle County

PERIOD OF PROJECT: October 1989 through September 1991

PROBLEM: New Castle County, Delaware, is undergoing rapid urbanization as a result of recent residential, industrial, and commercial growth. A major source of ground water for northern New Castle County is the Cockeysville Marble, which in Delaware has an outcrop area of 1.3 square miles. Because the Cockeysville Marble receives direct recharge on a relatively small area, there is concern that large ground-water withdrawals for public supply could cause excessive water-level declines in the aquifer. There also is concern that concentrated residential development in the outcrop area could result in contamination of the aquifer. Information on the hydrogeologic characteristics of the Cockeysville Marble is needed so that resource managers can make informed decisions concerning ground-water supplies in this hydrologically complex and sensitive area.

OBJECTIVES: (1) Define the hydrogeologic framework of the Cockeysville Marble. (2) Acquire baseline hydrogeologic information. (3) Determine seasonal changes in ground-water levels and flow directions. (4) Evaluate the hydraulic connection between ground-water and surface-water systems. (5) Assess ground-water quality.

APPROACH: Conduct a comprehensive water-well inventory. Synoptically measure ground-water levels to define potentiometric surfaces. Install continuous recorders to determine temporal changes in ground-water levels. Establish a continuous streamflow-gaging station on Mill Creek, the principal stream draining the Cockeysville Marble. Conduct seepage investigations on streams draining the Cockeysville Marble to identify gaining and losing reaches. Collect about 25 ground-water samples for field and laboratory analysis.

SUMMARY: Ground-water withdrawals from the Cockeysville aquifer have caused significant changes in the hydrologic system. Water levels in the aquifer have declined by as much as 60 ft since the onset of pumping, and streams that drain the aquifer have become losing streams. In addition, ground-water-flow directions have changed from toward local streams to toward production wells. The project identified three primary sources of recharge for the aquifer: (1) stream leakage, (2) areal recharge, and (3) ground water from adjacent aquifers. The water budget for calendar year 1990 indicates that these sources of recharge were unable to meet water demand and ground water was released from storage to meet the deficit.

Surface-Water Stations (DE001)

DELAWARE

Coastal Plain
Piedmont

LEADER: Robert H. Simmons

COOPERATORS:

City of Wilmington, Delaware

Delaware Department of Natural Resources and Environmental Control

Delaware Geological Survey

U.S. Army Corps of Engineers

Water Resources Agency for New Castle County, Delaware

PERIOD OF PROJECT: Continuous since 1931

PROBLEM: Surface-water information is needed for purposes of surveillance, planning, design, hazard warning, operation, and management in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. To provide this information, an appropriate data base is necessary.

OBJECTIVES: (1) Collect surface-water data sufficient to satisfy the needs of current-purpose uses, such as assessment of water resources, operation of reservoirs and industries, forecasting, disposal of wastes and pollutants, acquisition of discharge data to accompany water-quality measurements, compact and legal requirements, and research or special studies. (2) Collect data required to define trends and statistical properties of the occurrence of water in streams, lakes, and estuaries.

APPROACH: Standard methods of data collection are used. Methods are described in the series "Techniques of Water-Resources Investigations of the United States Geological Survey." Partial-record gaging is used instead of complete-record gaging where it serves the required purpose.

SUMMARY: Surface-water data currently are collected at 22 sites in Delaware. Continuous records are collected at 21 stations and partial records are collected at 1 station. (See section "Annual Water-Data Reports" for locations of data-collection sites and information on publication of data.)

Ground-Water Stations (DE002)

DELAWARE

Coastal Plain
Piedmont

LEADER: Robert H. Simmons

PERIOD OF PROJECT: Continuous since 1944

PROBLEM: Long-term records of ground-water levels are needed to evaluate the effects of climatic variations on the ground-water system; provide a data base from which to assess the effects of development; assist in the development of future supplies; and provide information for management purposes.

OBJECTIVES: (1) Collect water-level data sufficient to provide a long-term data base so that the general response of hydrologic systems to natural climatic variations and induced stresses is known, and potential problems can be identified early enough to allow proper planning and management. (2) Provide a historical data base against which short-term records acquired in areal studies can be compared.

APPROACH: Monitoring regional ground-water levels allows broad, general evaluation of aquifer systems and their boundary conditions. With some knowledge of the hydrogeologic framework and stresses on the systems, decisions can be made on the most advantageous locations for observation of long-term system behavior. The water-level network is evaluated and refined as records become available, and as detailed areal studies of ground-water systems better define the aquifers, their properties, and the stresses to which they are subjected.

SUMMARY: Continuous ground-water-level data currently are collected at 4 sites, and periodic measurements are made at 18 other sites in Delaware. (See section "Annual Water-Data Reports" for locations of selected data- collection sites and information on publication of data.)

Delaware Water Use (DE007)

DELAWARE

Coastal Plain
Piedmont

LEADER: Daniel J. Phelan

COOPERATORS:

Delaware Department of Natural Resources and Environmental Control

Delaware River Basin Commission

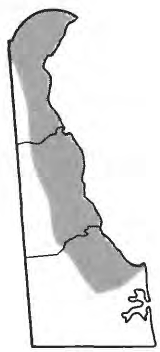
PERIOD OF PROJECT: Continuous since October 1988

PROBLEM: To make equitable resource-allocation decisions, water managers need accurate and reliable data on water use. Because water-use data for Delaware are collected and used by various agencies, coordination is needed to ensure that data quality is acceptable; information is readily transferable among agencies; and interagency communication on water-use matters is frequent and effective.

OBJECTIVES: (1) Develop and implement a quality-assurance plan for water-use data. (2) Develop a site-specific water-use data base on the U.S. Geological Survey computer that is accessible to other agencies. (3) Coordinate interagency water-use activities in Delaware.

APPROACH: Coordinate the organization of an interagency committee to develop a comprehensive water-use quality-assurance plan. Initiate an assessment of water-use data reliability through cooperatively developed questionnaires and interviews with large water users, especially public suppliers. Begin the automated transfer of ground-water-site data from State data bases to the U.S. Geological Survey's Ground Water Site Inventory (GWSI) data base. Update State Water Use Data System (SWUDS) annually.

SUMMARY: Organized an interagency committee to identify the principal water-use issues in Delaware. Began the development of water-use quality-assurance plan. Developed a computer program to transfer information from State data bases into GWSI, and began testing to determine accuracy of the computerized transfer process. Investigated availability of comprehensive water-use questionnaires.



Potential Effects of Climate Change on the Water Resources of the Delaware River Basin (DE023)

DELAWARE

Coastal Plain
Piedmont

LEADERS: William H. Werkheiser and Daniel J. Phelan

PERIOD OF PROJECT: April 1989 through September 1990

PROBLEM: Because of the current consensus that global warming will occur as a result of increasing concentrations of atmospheric gases, water-resources officials are concerned about the potential effects of climate change on water supplies. Such effects include infiltration of brackish water into coastal aquifers and changing water-use patterns. Water managers need specific information regarding the magnitude and extent of the hydrologic changes that may occur to develop plans to mitigate any anticipated adverse effects of climate change.

OBJECTIVES: The parent project is an interdisciplinary effort to improve understanding of the sensitivity of water resources in the Delaware River basin to potential effects of climate change. The principal objective of the parent project is to investigate the hydrologic response of the basin under existing water-management policy and infrastructure conditions to various climate-change scenarios. The objectives of the subprojects described herein are to (1) simulate estuary/aquifer interactions in the New Castle area, Delaware, and (2) assess basinwide water use.

APPROACH: Use a pre-existing three-dimensional ground-water-flow model of the Potomac aquifers in the New Castle area to determine the magnitude and extent of estuary/aquifer interaction under various hypothesized climatic conditions. Use analytical solutions as required to supplement the analysis.

Develop estimates of water use and consumptive water use for the period 1986-2040 for each of the five major subbasins in the Delaware River basin. Estimates will be based on per capita water-use information and population projections furnished by State and regional data centers.

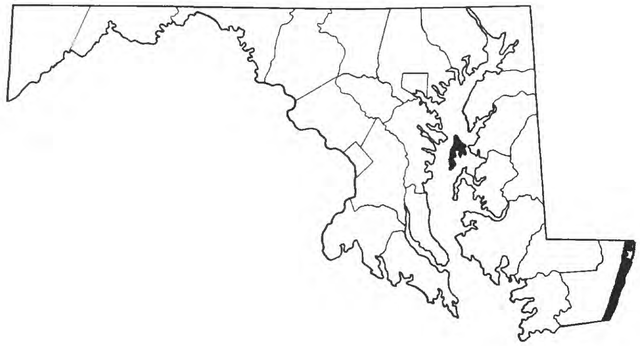
SUMMARY: The previously developed ground-water-flow model was reactivated and used with a particle-tracking routine to analyze river-water infiltration into the Potomac aquifers under present and increased sea-level boundary conditions.

Acquired data on basinwide-water withdrawals in 1986. Compiled population data and forecasts for the period 1986-2010 for each major subbasin. Estimated future withdrawals in subbasins.

(PAGE 37 FOLLOWS)

Figure 6.--Counties of Maryland.

Saltwater Intrusion Monitoring Network (MD002)



MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Michael J. Smigaj

COOPERATORS:

Maryland Geological Survey

Maryland Water Resources Administration

Queen Annes County, Maryland

Town of Ocean City, Maryland

PERIOD OF PROJECT: Continuous since 1983 (Kent Island) and 1987 (Ocean City)

PROBLEM: Coastal aquifers are susceptible to degradation of water quality from saltwater sources by (1) infiltration from above, from the ocean and bays, into and through the water-table aquifer; (2) infiltration from below, from aquifers containing saltwater; and (3) lateral movement of the saltwater-freshwater interface from offshore. Saltwater intrusion can be accelerated when the aquifers are stressed by declining water levels caused by increasing ground-water pumpage. Increased pumpage from the aquifers supplying the Kent Island (Aquia aquifer) and Ocean City (Manokin, Ocean City, and Pocomoke aquifers) areas has caused saltwater intrusion to occur in parts of the aquifers.

OBJECTIVES: (1) Continue monitoring water levels and chloride concentrations in the Kent Island and Ocean City areas to closely follow the effects of increased pumpage on the movement of saltwater. (2) Evaluate the water-level and salinity data to describe the current situation and to compare the new data with historic data.

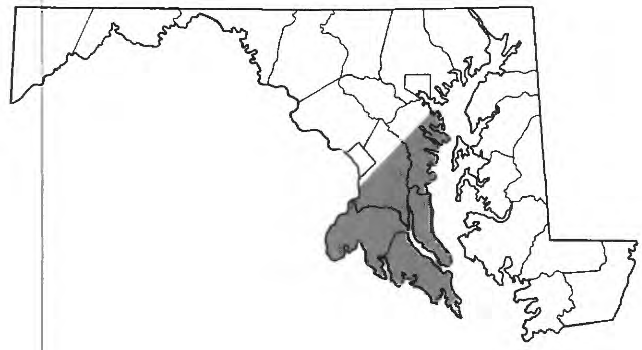
APPROACH: The Kent Island network includes 15 water-level observation wells measured at 4-week intervals. One well is equipped with an analog to digital recorder. Also, 9 wells are sampled quarterly for laboratory chloride and bromide concentration, field pH, specific conductance, temperature, and field chloride concentration analyses.

The Ocean City network includes 21 water-level observation wells measured at monthly intervals; 8 wells are equipped with analog to digital recorders. Of the 21 observation wells, 10 are sampled twice a year for chloride concentration analysis and 8 wells are sampled for major-ion concentration analysis once a year. The Worcester County Sanitary Commission analyzes water from 18 production wells for chloride concentrations.

SUMMARY: Chloride concentrations in the Aquia aquifer on Kent Island do not appear to be significantly increasing . Instead, the chloride concentrations seem to have stabilized with only slight changes. The chloride concentrations in the last 5 years ranged from 190 to 7,700 mg/L. The larger concentrations were found in the northern wells that are finished near the base of the Aquia aquifer.

Chloride concentrations in the aquifers in Ocean City area have not significantly increased in response to increased ground-water withdrawals, except at the 44th Street pumpage station in Ocean City, Maryland, where concentrations have increased in one well from 75 mg/L in 1974 to more than 460 mg/L in 1990.

Hydrologic Effects of Power Plants on Aquifers of Southern Maryland (MD040)



MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Stephen E. Curtin

COOPERATORS:

Maryland Geological Survey

Maryland Tidewater Administration, Power Plant Research and Environmental Review Division

PERIOD OF PROJECT: Continuous since 1979

PROBLEM: In southern Maryland, the Calvert Cliffs Power Plant withdraws water from the Aquia aquifer, the Morgantown Power Plant withdraws water from the Patapsco aquifer, and the Chalk Point Power Plant withdraws water from the Patapsco and Magothy aquifers. Definitive information on the response of these aquifers to the pumping is needed so State agencies can effectively manage area water supplies and minimize interference with other users.

OBJECTIVES: (1) Provide hydrologic data needed by the Power Plant Research and Environmental Review Division to evaluate the effects of ground-water pumping at the three power plants on water levels and on the availability of water in surrounding areas. (2) Evaluate and document hydrogeologic data collected during construction and testing of new wells. (3) Determine changes in ground-water levels and relate them to pumping by power plants and other users.

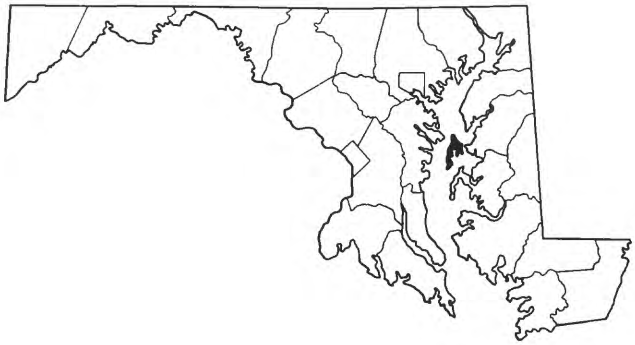
APPROACH: Obtain continuous or periodic water-level measurements in wells at the three power plants and in other wells in various aquifers in southern Maryland (about 375 wells). Prepare hydrographs for selected wells and potentiometric maps for various aquifers. Obtain pumpage data for wells at each power plant. Develop relations between pumpage and head changes. Document hydrogeologic data for new wells drilled at sites of present or proposed power plants.

SUMMARY: Water-level fluctuations in the Patapsco, Magothy, and Aquia aquifers in southern Maryland have been related to changes in pumpage.

The Morgantown Power Plant in southern Charles County withdraws water from the Patapsco aquifer. Withdrawals began in 1970 and by 1990 were nearly 0.73 Mgal/d. The water level in a nearby observation well was 13 ft above sea level in 1967 and declined to more than 100 ft below sea level by 1990.

An extensive cone of depression in the Magothy aquifer developed around the Chalk Point Power Plant in southeastern Prince Georges County. Withdrawals commenced in 1963 and were nearly 0.85 Mgal/d by 1980. Water levels in a nearby observation well declined as much as 66 ft by 1985. From 1985 to 1989, withdrawals decreased and water levels in the well recovered 11 ft. Pumpage from the Patapsco aquifer increased to 0.46 Mgal/d by 1990. The water level in a nearby observation well was 9 ft above sea level before pumping began in 1975 and declined to 21 ft below sea level by 1990.

The Calvert Cliffs Power Plant in southern Calvert County began withdrawing water from the Aquia aquifer in 1971. The water level in a nearby observation well was at sea level prior to pumping and by 1990 declined to 60 ft below sea level as pumpage increased to 0.32 Mgal/d.



Saltwater Intrusion in the Aquia Aquifer, Kent Island, Queen Annes County, Maryland (MD070)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: David D. Drummond

COOPERATORS:

Maryland Geological Survey

Maryland Water Resources Administration

Queen Annes County, Maryland

PERIOD OF PROJECT: July 1983 through August 1988

PROBLEM: Saltwater in the Aquia aquifer has become a serious problem on Kent Island in Queen Annes County, Maryland. Chloride concentrations more than three times greater than the U.S. Environmental Protection Agency recommended limit for drinking water have been measured in water from domestic wells. A study is needed to assess the present extent of saltwater in the Aquia aquifer, evaluate future consequences of higher pumping rates, and examine possible water-supply development alternatives.

OBJECTIVES: Determine (1) areal extent of elevated chloride concentrations; (2) vertical zonation of chloride concentrations in the Aquia aquifer and its confining units; (3) movement of chloride plume; and (4) changes in chloride concentration with time.

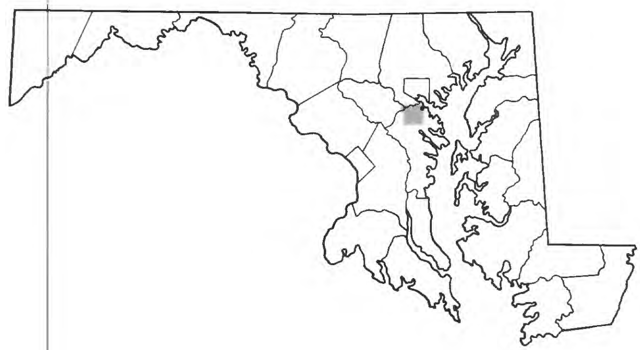
APPROACH: Collect field data including ground-water levels, chloride concentrations, and pumpage. Drill test wells where needed and collect water samples for complete chemical analysis. Develop flow and solute-transport models and use for scenario evaluation.

SUMMARY: Brackish water is present in the confined Aquia aquifer in the area adjacent to Chesapeake Bay on Kent Island, Maryland. A solute-transport model was used to estimate the flow of brackish water in response to projected pumpage, and to evaluate the importance of hydrogeologic controls on the distribution and flow of brackish water. Model results indicate the freshwater/brackish-water interface could move about 440 ft inland during the 21-year period, 1984-2005, using the best estimate of future pumpage and an average interface velocity of about 21 ft per year. Simulations designed to evaluate the importance of hydrogeologic controls on brackish-water flow indicate that density-dependent flow, water pressures in the Aquia aquifer, and the permeability of the overlying confining bed are most important. Calcite-cemented layers and paleochannel sediments provide minor controls on brackish-water flow in the Kent Island area.

Hydrologic Characteristics of the Lower Patapsco Aquifer in Anne Arundel County, Maryland (MD074)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Grufron Achmad

COOPERATORS:

Anne Arundel County

Maryland Geological Survey

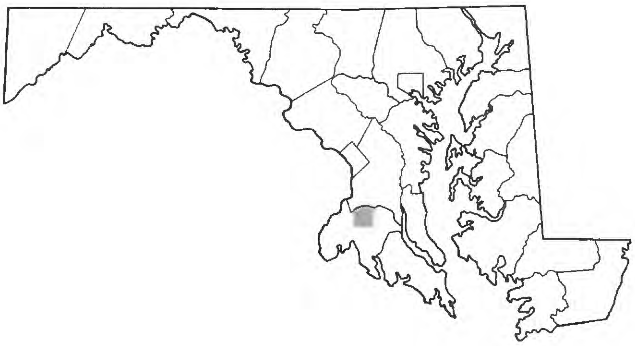
PERIOD OF PROJECT: July 1983 through September 1989

PROBLEM: Excessive drawdown of the potentiometric surface of the lower Patapsco aquifer might cause saltwater intrusion and decrease the flow of Sawmill Creek and Marley Creek in the Glen Burnie area. A study of the aquifer is needed to determine how lowering of the potentiometric surface is related to these potential effects.

OBJECTIVES: (1) Evaluate the water-supply potential of the lower Patapsco aquifer as a source of water for northern Anne Arundel County. (2) Determine the role of areal recharge areas in supplying water to the aquifer.

APPROACH: Drill 12 observation wells and conduct field tests to assess hydrologic properties of the aquifers. Establish stream gages and make synoptic base-flow measurements. Construct fine-grid model of ground-water flow and calibrate by comparing field-measured and simulated ground-water levels and streamflows. Simulate water levels and streamflows using increased pumpage scenarios for existing well fields.

SUMMARY: Simulating effects of the 1985 pumpage of 11.57 Mgal/d to the year 2005 showed that average annual base flow of Sawmill Creek at Glen Burnie would decrease to and stabilize at about 1 ft^3/s. Simulated water levels of the Patapsco aquifer system in the year 2000 were above sea level and fluxes into areas of tidal surface water of the Chesapeake Bay tributaries were outflow or discharging conditions. When pumpage was increased above the 1985 amount by 1.95 Mgal/d, simulated water levels remained above sea level, simulated base flow of Sawmill Creek at Glen Burnie decreased to 0.40 ft^3/s, and simulated water levels in hypothetical pumping wells remained above the top of the aquifer, except for one well in the Dorsey Road well field where the water level declined below the top of the aquifer. The model results suggest that increasing pumpage at existing well fields by 4.55 Mgal/d above the 1985 amount would lower the water table such that base flow in Sawmill Creek would cease, and the aquifer near the Glendale well field would become vulnerable to saltwater intrusion. A simulation of hypothetical 2-year drought conditions, assuming 60 percent of long-term average recharge, showed that Sawmill Creek at Glen Burnie would dewater even when pumpage was maintained at the 1985 level.



Availability of Water from the Patapsco Aquifers in the Waldorf Area of Charles County, Maryland (MD079)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: William B. Fleck and John M. Wilson

COOPERATORS:

Charles County

Maryland Geological Survey

PERIOD OF PROJECT: July 1984 through May 1989

PROBLEM: The Magothy aquifer, which is the principal source of water in the Waldorf area, possibly is reaching the limits of its productive capability. The underlying Patapsco aquifers are a possible source of additional water. Additional hydrologic data are required to quantitatively evaluate the water-producing capabilities of the Patapsco aquifers near Waldorf.

OBJECTIVES: (1) Define the areal distribution and thickness of the Patapsco aquifers. (2) Determine the hydrologic relations between the Magothy aquifer and the Patapsco aquifers. (3) Evaluate the hydrologic properties and estimate the productive capabilities of the Patapsco aquifers. (4) Assess the quality of water in the Patapsco aquifers and investigate the causes of major water-quality characteristics.

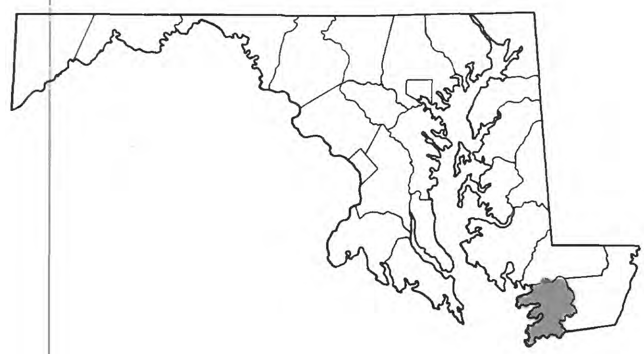
APPROACH: Compile historical data from various sources. Establish a well network for synoptic water-level measurements. Drill test holes into the upper Patapsco Formation. Obtain cores, drill cuttings, water samples, geophysical data, and aquifer-test data. Develop a variable-grid simulation model of the ground-water-flow system using the U.S. Geological Survey's modular computer model to determine flow conditions, to aid in understanding interactions between aquifers, and to assess head changes in response to pumping stresses.

SUMMARY: The principal water-bearing units, in descending order, are the surficial aquifer, Aquia aquifer, Waldorf aquifer system, White Plains aquifer, La Plata aquifer system, and Patuxent aquifer system. Measured transmissivities range from 2,000 to 8,500 ft^2/d in the Waldorf aquifer system; 20 to 2,000 ft^2/d in the White Plains aquifer; and 500 to 3,300 ft^2/d in the La Plata aquifer system. A 7-layer model was constructed to simulate selected development scenarios and to estimate pumpage limits with respect to available drawdown. Model results indicate that these limits will be reached at rates of about 6.6, 6.1, and 15.0 Mgal/d for the Waldorf aquifer system, White Plains aquifer, and La Plata aquifer system, respectively. A northeast-trending reverse fault of the Brandywine fault system, in the western part of the Waldorf area, was mapped. The fault has as much as 250 ft of throw at the pre-Cretaceous basement.

Ground-Water Supply Potential in Somerset County, Maryland (MD081)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: William H. Werkheiser

COOPERATORS:

Maryland Geological Survey

Somerset County

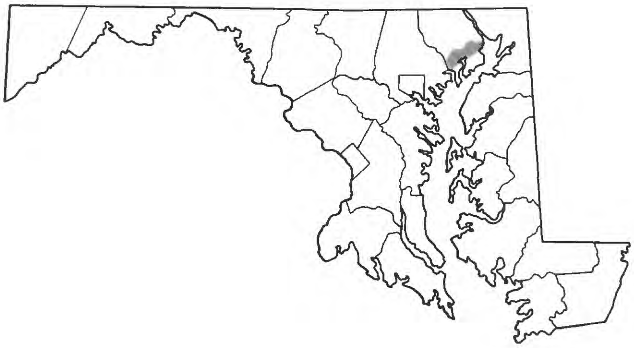
PERIOD OF PROJECT: April 1985 through March 1988

PROBLEM: Construction of a large State facility, proposed commercial/industrial expansion, and expected population growth has the potential to significantly increase ground-water demand in Somerset County, Maryland. These circumstances have heightened concerns over the ability of local ground-water resources to meet increased demand for supply, for potential water-quality degradation from changing land-use patterns, and for saltwater intrusion in areas of increased pumpage. Future water-management decisions will require additional information on the ground-water-flow system, water quality, and the interrelations of the various aquifer units.

OBJECTIVES: (1) Refine understanding of the hydrogeologic framework. (2) Describe the quality of ground water. (3) Evaluate effects on the ground-water-flow system of projected withdrawals at Princess Anne and Crisfield.

APPROACH: Review available data on ground-water levels, water quality, and pumpage, and lithologic and geophysical logs. Inventory water wells to obtain areally distributed hydrologic data representative of the principal aquifer units. Measure ground-water levels synoptically to obtain potentiometric data for the principal aquifers. Collect ground-water samples to assess current water-quality conditions. Use numerical and analytical ground-water-flow models to evaluate effects of increased stress on the flow system.

SUMMARY: The principal aquifer units in Somerset County are, in descending order, the surficial aquifer system, the Pocomoke aquifer, the Manokin aquifer, the Paleocene aquifer system, and the Potomac aquifer system. Of these, the Manokin aquifer is the most widely used as a source of drinking water. Although ground-water supplies suitable for drinking are available throughout the county, water in parts of the aquifers contains concentrations of chloride and iron above Secondary Maximum Contaminant Levels established by the U.S. Environmental Protection Agency. Water containing elevated concentrations of chloride possibly is migrating slowly toward major ground-water-pumping centers at Princess Anne and Crisfield. Simulations indicate that projected increased pumpage at Princess Anne will result in considerably lower water levels in the Manokin aquifer and cause brackish water to migrate toward Princess Anne.



Potential for Ground-Water Supply in the Coastal Plain of Harford County, Maryland (MD087)

MARYLAND

Coastal Plain

Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: David D. Drummond

COOPERATORS:

Harford County

Maryland Geological Survey

PERIOD OF PROJECT: July 1986 through June 1990

PROBLEM: The Coastal Plain part of Harford County is largely dependent on ground water for water supply. In 1980, about 6.2 Mgal/d of water was pumped from the Coastal Plain aquifers in the county. The potential of these aquifers to meet rapidly increasing demands needs to be evaluated in terms of productive capacity and water quality.

OBJECTIVES: (1) Evaluate the potential for Coastal Plain aquifers in Harford County to meet future water needs. (2) Assess the effect of increased pumpage on ground-water levels and base flow in nearby streams. (3) Document historical and current quality of water in each aquifer. (4) Determine the potential for pumping-induced water-quality changes, such as saline-water encroachment and contaminant migration.

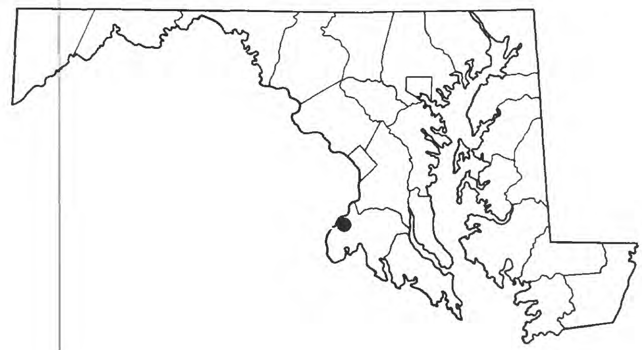
APPROACH: Compile and evaluate available hydrologic data. Drill test wells, conduct aquifer tests, run geophysical logs, and measure ground-water levels. Define the hydrogeologic framework. Construct and calibrate a digital ground-water-flow model, and evaluate scenarios of projected pumpage. Sample streams and wells for field constituents, major ions, selected organic substances, and selected metals. Identify chemical reactions controlling ground-water chemistry by using geochemical models. Use analytical or numercial models to evaluate the potential for encroachment of saline water and movement of contaminated ground water.

SUMMARY: Data were collected on about 100 wells. Sixteen test wells were drilled at eight sites, and data were collected and analyzed for lithology, aquifer properties, chemical water quality, and ground-water levels. Two stream gages were installed and 5 seepage runs were made on 7 streams at 17 sites. Synoptic water-level measurements were made and chemical water-quality samples were collected at about 50 well sites. Aquifers and confining units form a complex assemblage and, in general, are not laterally extensive. Ground-water quality is generally good, although some contamination by chloride and nitrate was identified. A ground-water- flow model was constructed to evaluate flow directions and rates, and to estimate the effects of increased pumpage.

Brackish-Water Intrusion at Indian Head, Maryland (MD092)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Steven N. Hiortdahl

COOPERATORS:

Town of Indian Head, Maryland

U.S. Navy, Indian Head Naval Ordnance Station

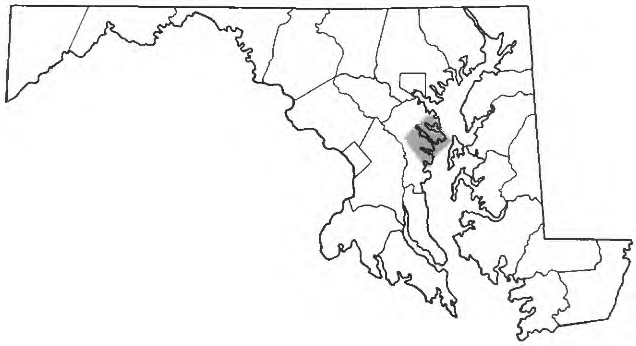
PERIOD OF PROJECT: October 1987 through September 1990

PROBLEM: Ground-water withdrawals from confined aquifers in the Indian Head area averaged about 1.8 Mgal/d during 1988. As a result of this pumpage, ground-water-flow directions have been reversed and the aquifers now receive some recharge from the tidal Potomac River. The water in the Potomac River is seasonally brackish and data for several wells indicate that natural ground-water quality already has been degraded.

OBJECTIVES: (1) Establish and operate a monitoring-well network, designed to document water-level and water-quality conditions of local confined-aquifer systems. (2) Compile and evaluate water-resources data available for the Indian Head area, and determine technical approaches for enhancing understanding of the dynamics of the natural ground-water-flow system.

APPROACH: Equip four observation wells with continuous water-level recorders, and periodically measure water levels in nine other wells in the area. Collect water-quality samples from 25 wells and analyze for major inorganic constituents.

SUMMARY: Pumping in the Indian Head area, which began around 1900, has resulted in a regional decline of the potentiometric surface of the confined Potomac Group aquifers. During 1988, pumpage in the area averaged about 1.8 Mgal/d, and water-level altitudes ranged from 55 to 90 ft below sea level. The pumping has caused a reversal of the natural ground-water-flow direction. Near Indian Head, the confined Potomac Group aquifers are partially recharged by leakage from the Potomac River. By the early 1970's, increasing concentrations of chloride and total dissolved solids were noted in water from several production and test wells in the area. The maximum chloride concentration measured in 1988 was 210 mg/L in water from a well located less than 1,000 ft from the Potomac River.



Bay-Water Intrusion into the Aquifers of Anne Arundel County, Maryland (MD094)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: William B. Fleck

COOPERATORS:

Anne Arundel County

Maryland Geological Survey

PERIOD OF PROJECT: October 1987 through June 1992

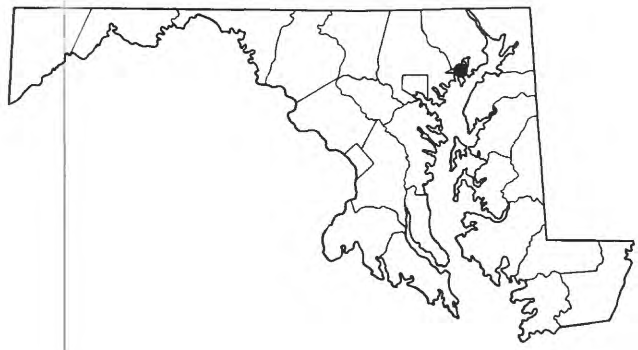
PROBLEM: Reduction of ground-water levels in the shoreline areas of Anne Arundel County could possibly result in the landward intrusion of brackish water in three heavily used aquifers--the Aquia, Magothy, and Upper Patapsco. Water levels in the Aquia have been lowered to near sea level and water levels in the Magothy and Upper Patapsco have been lowered to about 15 ft below sea level. As a result, chloride concentrations of about 1,000 mg/L in ground water have been recently reported.

OBJECTIVES: (1) Improve the definition of the hydrogeologic characteristics of the Aquia, Magothy, and Upper Patapsco aquifers. (2) Determine the present extent of brackish water in the aquifers. (3) Establish well networks to monitor future changes in water levels and chloride concentrations. (4) Evaluate the effect of future ground-water development schemes on the distribution and intrusion rate of brackish water.

APPROACH: Compile data from historical sources. Establish a well network for synoptic measurements of water levels and chloride concentrations. Inventory and sample pre-existing wells. Drill about 25 test wells at about 12 sites. Obtain geophysical logs and conduct aquifer tests using test wells. Analyze water-quality data. Construct geologic and hydrologic sections and maps. Construct and calibrate ground-water-flow and solute-transport models. Use models to evaluate the effects of pumping stress on the distribution and intrusion rate of brackish water.

SUMMARY: A network of about 65 wells in the Aquia aquifer has been established for synoptic water-level and water-quality measurements. Measurements were made in Autumn 1988 and Spring 1989. Water levels ranged from about 1 to 21 ft above sea level and chloride concentrations ranged from about 1 to 1,860 mg/L. Eighteen test wells were installed at nine sites. The wells range in depth from 38 to 199 ft. At four sites the brackish-water wedge was penetrated and chloride concentrations were as great as 7,400 mg/L. A ground-water-flow model and a solute-transport model have been constructed. The flow model uses the MODULAR program and the transport model uses SUTRA.

Ground-Water Investigation at O-Field, Aberdeen Proving Ground, Maryland (MD077)



MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Don A. Vroblesky

COOPERATORS:

U.S. Army Aberdeen Proving Ground Support Activity
Environmental Management Division

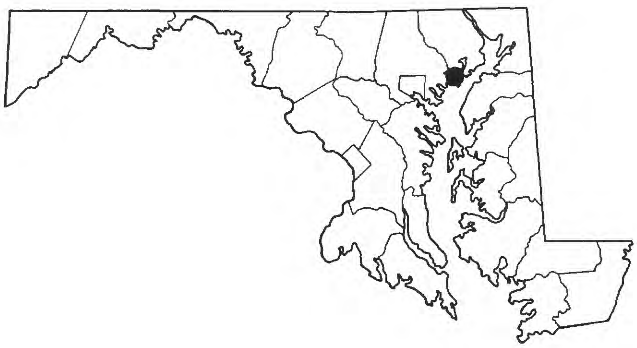
PERIOD OF PROJECT: August 1984 through October 1988

PROBLEM: O-Field, in the Edgewood area of Aberdeen Proving Ground, Maryland, has periodically been used for disposal of munitions and chemical-warfare agents during and since World War II. Analyses of ground-water, surface-water, and soil samples indicate that the contaminants are being transported from the site by ground water and are discharging into Watson Creek.

OBJECTIVES: (1) Define the hydrogeologic-flow system at O-Field. (2) Study the behavior of O-Field contaminants in the ground water and surface water at the site. (3) Investigate the potential hydrochemical effects of relevant remedial actions.

APPROACH: Conduct electromagnetic survey and botanical survey. Install wells. Collect and analyze samples from wells and surface water. Construct a ground-water-flow model of the O-Field area.

SUMMARY: Additional sampling of ground-water-monitoring wells was performed. A ground-water-flow model was calibrated to test selected remedial-action scenarios.



Investigation of Ground-Water and Surface-Water Contamination in the Canal Creek Area, Aberdeen Proving Ground, Maryland (MD084)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Michelle M. Lorah

COOPERATORS:

U.S. Army Aberdeen Proving Ground Support Activity
Environmental Management Division

PERIOD OF PROJECT: August 1985 through December 1991

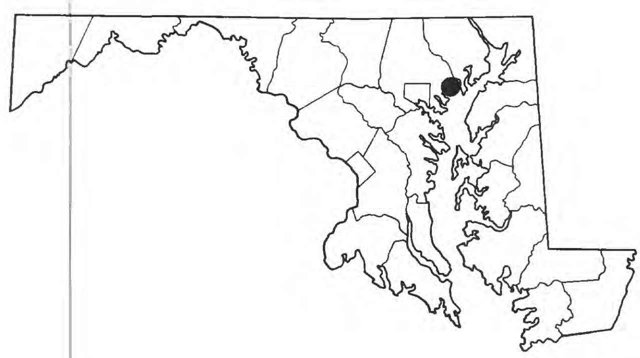
PROBLEM: The Canal Creek area of Aberdeen Proving Ground, Maryland, has been used to develop and manufacture military-related chemicals since 1917. The chemicals produced include chlorine, phosgene, mustard, white phosphorous, pyrotechnics, tear gas, and clothing-impregnating material. Other activities included filling of chemical munitions, land disposal of domestic and productive wastes, and the use of degreasing solvents. Evidence that activities in the Canal Creek area have affected the environment became apparent in 1977 when white phosphorus was found in the sediments of Canal Creek. In 1984, volatile-organic compounds were discovered in six wells. The Canal Creek area needs to be systematically studied to determine the type and extent of contamination in the ground water and surface water.

OBJECTIVES: (1) Define the hydrogeology in the Canal Creek area. (2) Determine the nature, extent, behavior, and as nearly as feasible, the sources of contamination in the ground water. (3) Evaluate the hydrologic and hydrochemical effects of relevant remedial activities. (4) Determine the extent of surface-water contamination.

APPROACH: Use borehole geophysics, lithologic logs, and water-level data to define the hydrogeology. Install and sample monitoring wells for inorganic and organic constituents to determine the types and extent of ground-water contamination. Use historical information, ground-water-flow directions, and water-quality data to locate possible contaminant sources. Develop a ground-water-flow model to assess possible remedial actions. Determine the extent of surface-water contamination by collecting and analyzing surface-water samples.

SUMMARY: A total of 152 monitoring wells were installed in two phases. The three aquifers and two confining units that have been delineated in the study area consist of a sequence of unconsolidated clay, silt, sand, and gravel deposits typical of the Coastal Plain of Maryland. Hydrographs and hydraulic-head-contour maps, constructed with data from continuous water-level recorders and synoptic water-level measurements, were used to define the ground-water-flow system. Water-quality data have been collected from each well at least once, and selected wells are being sampled on a seasonal basis. Volatile-organic compounds are the major contaminants that have been identified in the ground water. Surface-water samples have been collected twice from streams at each of 30 sites and analyzed for inorganic and organic constituents. Volatile-organic compounds have been detected in the surface water. Development of a multilayer ground-water-flow model has begun.

Hydrogeology and Chemical Quality of the Carroll Island and Graces Quarters Areas, Aberdeen Proving Ground, Maryland (MD089)



MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADERS: Frederick J. Tenbus and Scott W. Phillips

COOPERATORS:

U.S. Army Aberdeen Proving Ground Support Activity
Environmental Management Division

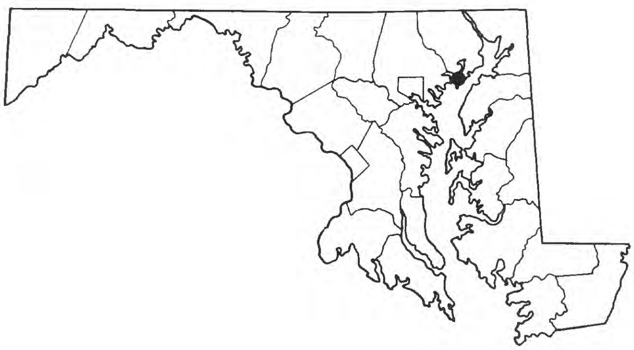
PERIOD OF PROJECT: October 1986 through March 1992

PROBLEM: The Carroll Island and Graces Quarters areas of Aberdeen Proving Ground, Maryland, were used for testing chemical-warfare agents from the late 1940's through 1971. Burn pits and small dump areas were used for disposal of test materials. Ground water underlying both study areas discharges into adjacent surface-water bodies that are tributaries of the Chesapeake Bay. If there are significant discharges of contaminated ground water to these surface-water bodies, the potential exists for adverse effects on wildlife and aquatic populations in the area. Additionally, approximately 250 domestic and industrial water-supply wells are reported to be within a 3-mi radius of the study areas and could potentially be effected by contamination. Therefore, it is important that the ground-water-flow system and extent of contamination be defined so the environmental impact of past practices in the area can be determined. The U.S. Environmental Protection Agency issued a Resource Conservation and Recovery Act permit in 1986 that required these studies be performed.

OBJECTIVES: The study is being conducted in two phases. The objectives of phase I are to (1) identify the location and dimensions of solid waste management units (SWMU's) and chemical-agent test sites, (2) define the hydrogeologic system, and (3) verify whether contaminant releases from SWMU's and chemical-agent test sites have occurred in the study areas. Contingent upon the results of objective (3), phase II will be implemented. The objectives of phase II are to (1) further characterize the extent of contamination, (2) model the hydrogeologic system, and (3) evaluate the hydrogeologic effects of various remedial action scenarios.

APPROACH: Compile and evaluate all existing data. Collect and interpret drilling data from installation of 90 monitoring wells. Collect and interpret at least 1 year of monthly water-level measurements and data from 27 continuous recorders. Determine water quality by conducting 2 sampling runs of all wells and 30 surface-water sites. Collect soil samples from 40 sites to determine shallow contamination. Analyze water and soil samples for priority pollutants. Compare chemical data to health and regulatory standards to determine if phase II is needed.

SUMMARY: Compilation of existing data is completed. All wells were installed from August 1987 to March 1988. All wells and surface-water sites were sampled in the summer of 1988 and the spring of 1989. Data compilation and interpretation is in progress.



Ground-Water Investigation at J-Field, Aberdeen Proving Ground, Maryland (MD091)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: W. Brian Hughes and Wayne H. Sonntag

COOPERATOR:

U.S. Army Aberdeen Proving Ground Support Activity
Environmental Management Division

PERIOD OF PROJECT: July 1987 through December 1992

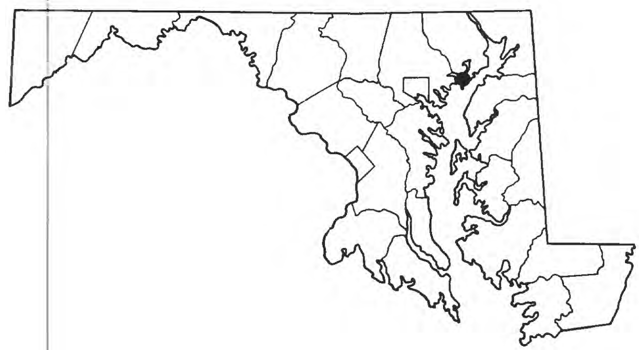
PROBLEM: J-Field, in the Edgewood area of Aberdeen Proving Ground, Maryland, has been used since the late 1940's for the disposal by open-pit burning of solvents, chemical-warfare agents, and related wastes. Samples from existing wells show that the ground water contains elevated concentrations of lead and organic solvents. Aliphatic hydrocarbons also are present, probably resulting from the use of fuel oil and diesel fuel during burning operations. To assess the environmental effect of past practices on the area, an understanding of the ground-water-flow system and the extent of contamination at J-Field is necessary.

OBJECTIVES: (1) Define the hydrogeologic framework and ground-water hydrology of the area. (2) Determine the extent, nature, source, and movement of contaminants in ground water, soil, and the unsaturated zone. (3) Determine the behavior of the contaminants on the hydrologic system. (4) Evaluate the hydrologic effects of various remedial-action scenarios.

APPROACH: Collect and interpret geologic and hydrologic data interpreted using existing wells, geophysical surveys, and well drilling. Collect and interpret geochemical data from two phases of monitoring-well drilling. Evaluate remedial-action scenarios.

SUMMARY: Seven geologic boreholes have been drilled and the interpretation of lithologic logs and marine-seismic data has begun. Twenty-seven of the planned 36 water-quality-monitoring wells have been drilled. Preliminary surface-water sampling for U.S. Environmental Protection Agency priority pollutants has been completed. Soil-gas sampling has been performed and the data have been plotted and interpreted.

Investigation of Sediment, Surface-Water, and Ground- Water Contamination at New O-Field, Aberdeen Proving Ground, Maryland (MD100)



MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Jeffrey Clark

COOPERATORS:

U.S. Army Aberdeen Proving Ground Support Activity
Environmental Management Division

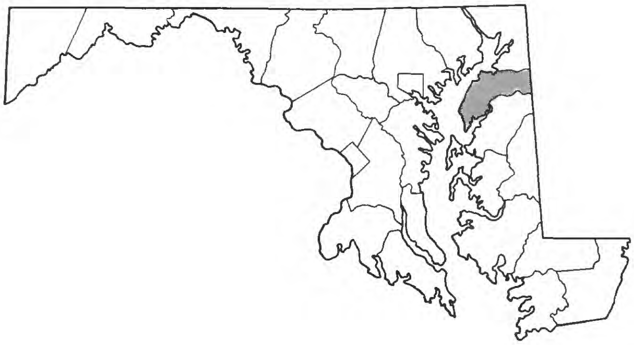
PERIOD OF PROJECT: September 1990 through September 1994

PROBLEM: Investigation is needed to determine the extent of ground-water, surface-water, and sediment contamination at New O-Field, and to determine if that contamination is migrating offsite into nearby Watson Creek. The hydrogeologic system must be defined to assess possible remedial-action measures.

OBJECTIVES: (1) Define the hydrogeologic framework and the direction and rate of ground-water flow at New O-Field. (2) Determine the source, nature, extent, and possible movement of sediment, ground-water, and surface-water contamination at the site. (3) Evaluate possible remedial-action scenarios and their effects on the hydrologic system.

APPROACH: Compile and evaluate existing data. Evaluate data collected during an initial drilling and sampling program. Based on results of initial phase, initiate a second drilling and sampling phase. Evaluate results from both phases.

SUMMARY: Safety and sampling plans are being written. Existing wells will be fitted with continuous water-level recorders. Existing wells will be sampled for selected water-quality constituents.



Ground-Water Resources of Kent County, Maryland (MD101)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: David D. Drummond

COOPERATOR:

Maryland Geological Survey

PERIOD OF PROJECT: January 1991 through December 1994

PROBLEM: Ground-water usage in Kent County, Maryland, increased about 400 percent from the late 1950's (1.09 Mgal/d in 1958) to the mid-1980's (4.43 Mgal/d in 1985). Future increases can be expected as the county continues to develop. The potential for pumping-induced ground-water problems, such as excessively lowered water levels, brackish-water intrusion, and contaminant migration, needs to be assessed, so that State and county planning officials have a sound basis for making resource-management decisions.

OBJECTIVES: (1) Refine the hydrogeologic framework and describe water quality in the water-table, Aquia, Monmouth, Matawan, Magothy, and upper Patapsco aquifers. (2) Estimate the effects of current and future pumpage on ground-water levels, ground-water-flow directions, and bay-water intrusion.

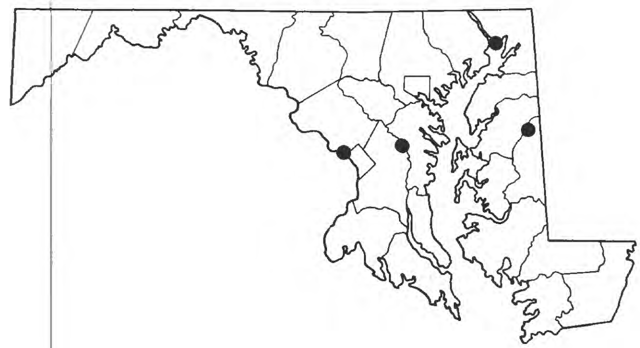
APPROACH: Review county, State, and Federal water-resources reports and data files. Conduct an inventory of water wells. Select wells representative of each aquifer and establish a water-level monitoring network. Select wells for water-quality sampling. Drill about 12 test wells at six or seven sites to supplement the inventoried wells. Continuously core a test hole to obtain samples for stratigraphic analysis. Prepare maps and cross-sections displaying various hydrogeologic characteristics for major aquifers and associated confining units. Evaluate hydrologic-budget components of recharge, evapotranspiration, stream leakage, estuarine discharge, and boundary fluxes. Construct an areal ground-water-flow model. Simulate future pumping rates and effects of various development scenarios on water levels, recharge rates, and bay-water intrusion.

SUMMARY: Water-level recorders have been installed on five wells, one in each of the major aquifers. A hole was cored to 480 ft at Angelica Farms. Preliminary results of paleontological analysis indicate that the interval from 116 to 204 ft is Paleocene in age. The well inventory has been completed and data are being entered into the Ground Water Site Inventory (GWSI). Data entry is about 90 percent complete. Test drilling was begun at the Cliffs City site. The geophysical logs indicate brackish water in part of the Aquia aquifer. Two wells were installed, one in the brackish part of the Aquia aquifer and one in the water-table aquifer. Synoptic ground-water-level measurements were conducted in May 1991.

Chesapeake Bay, River Input-Monitoring Program (MD00310)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Linda D. Zynjuk

COOPERATOR:

Maryland Department of the Environment

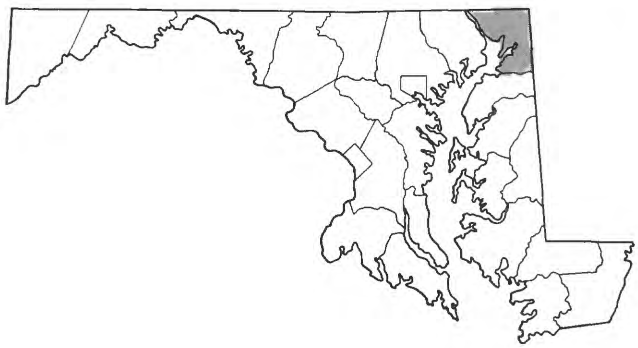
PERIOD OF PROJECT: Continuous since 1984

PROBLEM: The decline in water quality of the Chesapeake Bay in the last decade has been attributed to excessive nutrients entering the estuary from its surrounding tributaries. Point and nonpoint-source nutrient-reduction programs have been established in an effort to improve the Chesapeake Bay water quality. To quantify the effect of nutrient-reduction programs on water quality, the comprehensive River Input-Monitoring Program was established at the Fall Line of four major tributaries discharging to the Chesapeake Bay: the Susquehanna, Potomac, Patuxent, and Choptank Rivers. These tributaries combined contribute more than 70 percent of the fluvial input and associated contaminants to the Chesapeake Bay.

OBJECTIVES: (1) Detect trends in water quality of the Chesapeake Bay occurring in response to nutrient-reduction programs established in the Susquehanna, Potomac, Patuxent, and Choptank Rivers. (2) Investigate methods for improving the accuracy of nutrient and suspended-sediment load estimates.

APPROACH: Water-quality samples are collected during base-flow and storm-flow conditions, with an emphasis on storm-event sampling, because a major fraction of runoff and associated nutrients are carried by storms. Samples are analyzed for nutrients and suspended sediment.

SUMMARY: Water-quality data and monthly and annual loads of nutrient and suspended-sediment are reported annually. Results are published in the Maryland Department of the Environment's annual summary data reports, and are used in the calibration of the Chesapeake Bay three-dimensional model. Constituent loads are estimated using a seven-parameter log-linear model incorporating seasonality, flow, and time-trend variables. The Minimum Variance Unbiased Estimator of Bradu and Mundlak (1970) is employed to correct for the retransformation bias associated with log-log regression analysis. Regression summaries are used to examine the relation of nutrients and suspended-sediment to flow and season, and to determine trends in constituent loads. Total nitrogen is increasing at the four river stations. Concentrations of total phosphorus have decreased since 1985 at the Patuxent River station, apparently in response to the phosphate detergent ban and to sewage-treatment facility upgrades.



Quality and Quantity of Ground Water and Surface Water in Northeastern Maryland (MD063)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Edmond G. Otton

COOPERATORS:

Cecil County

Maryland Geological Survey

PERIOD OF PROJECT: July 1981 through July 1988

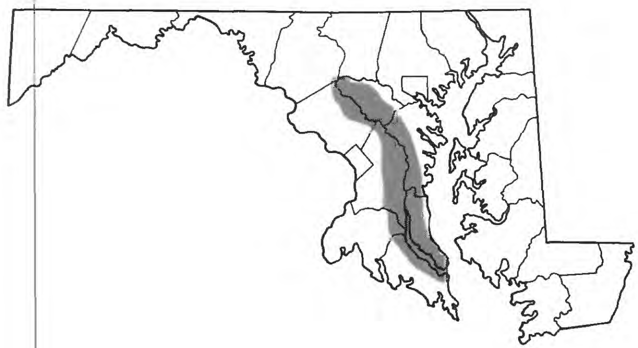
PROBLEM: Commercial and industrial development and changing farming practices in northeastern Maryland are significantly increasing the potential for water-quality degradation and water shortage, particularly during drought periods. Water managers require a thorough knowledge of the overall ground-water and surface-water systems, present quality of water, and the interrelations of ground water and surface water.

OBJECTIVES: (1) Assess the quality of water in aquifers and streams. (2) Identify variations from expected background water quality. (3) Define by subbasin the total water yield by source. (4) Describe the ground-water-flow system. (5) Estimate potential well yields by aquifer. (6) Estimate potential sustained yields of aquifers. (7) Estimate flow duration, low-flow frequency, and average flow of streams. (8) Estimate effects of drought.

APPROACH: Divide the study area into subbasins for water-budget analysis. Measure and correlate streamflow with long-term streamflow records. Use multiple-regression analysis to determine flow characteristics of streams in the subbasins. Inventory wells and springs and establish an observation-well network. Make field measurements of pH, temperature, specific conductance, and alkalinity of water samples. Analyze water samples in the laboratory for major ions, nutrients, and trace-metal concentrations. Analyze stream-bottom sediments for herbicides, insecticides, and trace-metal concentrations.

SUMMARY: Median well yield in the Piedmont physiographic province is 10 gal/min; median yield in the Coastal Plain physiographic province ranges from 20 to 30 gal/min, depending on the aquifer. Ground water is suitable for most uses. Common chemical-quality problems are low pH and elevated iron concentrations. The 7-day, 10-year, low-flow frequency for 31 stream sites ranges from 0.01 to 0.44 $(ft^3/s)/mi^2$; the 7-day, 2-year, low-flow frequency ranges from 0.02 to 0.68 $(ft^3/s)/mi^2$. The median pH of water at 29 streams sites is 7.3 and the median dissolved-solids concentration is 92 mg/L. Of the average 42 in. of precipitation per year, 10 in. is to storm runoff, 10 in. is to ground-water runoff, and 22 in. is lost by evapotranspiration. Ground-water-level declines caused by pumping and drought conditions were simulated with ground-water-flow models in three areas. Simulated drawdowns were as great as 40 ft in the Elkton-Chesapeake City area.

Modeling Nonpoint-Source Inputs to the Patuxent River Estuary (MD080)



MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Stephen D. Preston

COOPERATOR:

Maryland Department of the Environment

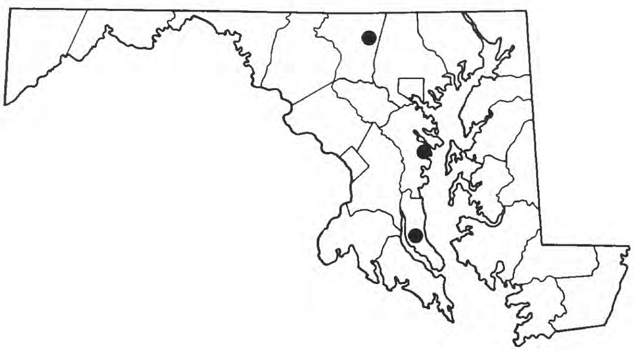
PERIOD OF PROJECT: May 1984 through September 1991

PROBLEM: The Patuxent River has a significant impact on the water quality of the Chesapeake Bay. Sources of water-quality degradation include runoff from forested, agricultural, and urban areas. Information is available on many nonpoint sources of contamination, but more is needed for agricultural areas. Modeling must be done to help understand the interrelations between factors influencing nonpoint sources of contamination.

OBJECTIVES: (1) Identify the approaches for assembling and maintaining a data base for modeling of nonpoint-source contamination. (2) Assemble the data base, to include hydrologic, meteorologic, and basin-characteristics data and a bibliography. (3) Determine nonpoint-source loadings from single land-use areas before and after the implementation of best management practices. (4) Calibrate and verify a water-quality hydrologic model.

APPROACH: Establish 13 water-quality-monitoring s at main stem, tributary, and surface-runoff locations. Collect data over a 2- to 5-year period for existing conditions and after implementation of nonpoint-source contamination control measures. Calibrate and verify a water-quality hydrologic model for application as a planning tool for estimation of loadings under actual and potential land-treatment scenarios.

SUMMARY: Six streamflow-monitoring sites and seven agricultural-runoff-monitoring sites have been established and are being sampled for water quality during base flow and during storms. All data are being prepared for use in calibrating the USGS Hydrologic Simulation Program Fortran (HSPF) model. State-of-the-art approaches to data management are being used. Geographic Information Systems (GIS) technology is used to support the modeling. Peripheral research is being conducted to develop an interface between GIS and watershed models.



Effects of Storm-Water Infiltration on Ground-Water Quality at Three Storm-Water Management Sites in Maryland (MD082)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Franceska D. Wilde

COOPERATORS:

Maryland Department of the Environment

Maryland Geological Survey

PERIOD OF PROJECT: October 1985 through June 1990

PROBLEM: Concern over nonpoint-source contamination of the Chesapeake Bay has resulted in the enactment of legislation in Maryland requiring the discharge of urban runoff to impoundment structures, where storm water percolates through the unsaturated zone. The effects of storm-water infiltration on ground-water quality and the processes controlling contaminant movement through storm-water management structures are poorly understood. Chemical quality of sediments and ground water at storm-water management facilities needs to be monitored and evaluated to improve understanding of these effects and processes.

OBJECTIVES: (1) Determine chemical changes in ground water recharged by storm water through management structures. (2) Evaluate the mobilization potential of organic and inorganic contaminants in runoff entering storm-water impoundments.

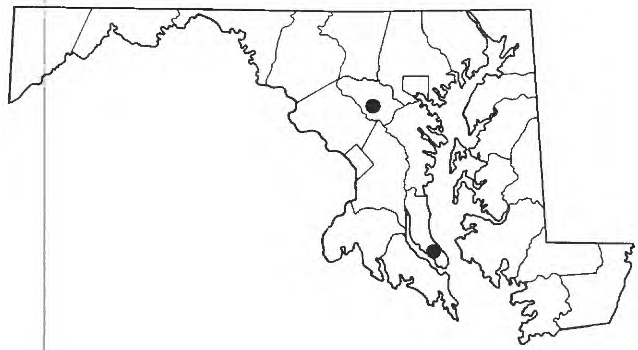
APPROACH: Three storm-water management facilities representing Coastal Plain and Piedmont hydrogeologic settings were selected for a study that involved 3 years of data collection. Wells and piezometers were installed in the unconfined aquifer to monitor water levels and chemical quality. Water from the shallow unsaturated zone beneath two impoundments was collected in lysimeters and analyzed. Precipitation, runoff, and impounded storm water were also monitored for quantity and chemistry. Aquifer and accumulating bottom materials were chemically analyzed. Field measurements of water levels and selected chemical constituents were performed monthly or more frequently. Samples of storm water, ground water, and water from the unsaturated zone were collected triannually for major-constituent and trace-constituent analyses; inorganic-chemical analyses of bottom materials were performed annually. Data analysis involved use of geochemical models, time-series and analytical plots, and activity diagrams for chemical species.

SUMMARY: Major-ion and trace-element chemistry of ground water beneath impoundments can be modified by mixing with storm-water infiltrate. The chemical and physical characteristics that result can be attributed to site-specific and site-independent factors. During data collection, ground water beneath the impoundments was a chloride type, although native ground water was dominated by either bicarbonate, nitrate, or mixed anions. Storm water was primarily a bicarbonate type, but occasionally contained elevated concentrations of chloride from road salting. Inorganic and organic contaminants in storm water and ground water were generally at concentrations well within U.S. Environmental Protection Agency (USEPA) guidelines for drinking water. Occasionally, concentrations of cadmium, chloride, chromium, and lead exceeded USEPA primary or secondary drinking water limits in infiltrate-receiving ground water. Aluminum, barium, nickel, sodium, strontium, and zinc concentrations were elevated in ground water beneath and downgradient of the impoundments at two sites. In bottom materials, the percentage of chromium, cobalt, copper, lead, nickel, strontium, and zinc increased.

Effects of Agricultural Best-Management Practices on Transport of Nitrogen in Shallow Ground Water in the Patuxent River Basin, Maryland (MD085)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: E. Randolph McFarland

COOPERATOR:

Maryland Department of the Environment

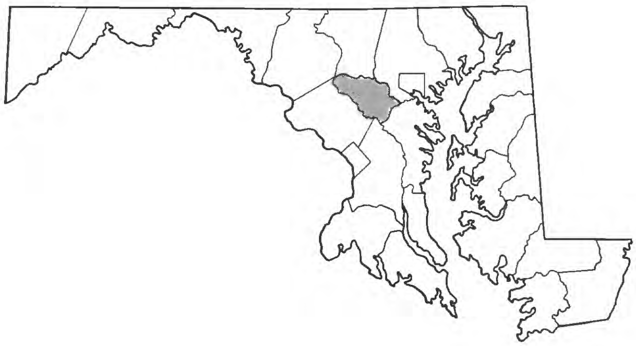
PERIOD OF PROJECT: July 1985 through September 1992

PROBLEM: To reduce water-quality degradation in the Chesapeake Bay that has been attributed to farming operations, various types of tillage and cropping techniques, referred to as Agricultural Best-Management Practices, are being promoted to conserve soil, fertilizers, and pesticides by increasing the infiltration of precipitation into the land surface and thereby reduce surface runoff and erosion. Infiltration of precipitation percolates through the soil zone to recharge the ground-water system and can transport with it agricultural chemicals that would otherwise run off into streams. Thus, the concentration of agricultural chemicals in ground water can be increased by farming practices that promote the infiltration of water.

OBJECTIVES: (1) Determine the direction, rate, and quantity of ground-water flow. (2) Characterize the spatial and temporal distributions of nitrogen in shallow ground water and processes controlling nitrogen distribution. Quantify the amount of nitrogen transported by ground water. (3) Compare differences between the quantities of nitrogen transported by ground water and runoff, and resulting from different farming practices.

APPROACH: Collect ground-water hydrologic and chemical-quality data over a 4-year period from October 1986 to September 1990 at two approximately 10-acre sites. One site is in the Piedmont physiographic province and the other site is in the Coastal Plain physiographic province. Obtain available precipitation and runoff-quantity and quality data from a related study (MD080). Farming operations at each site are typical for the area. Analyze data with ground-water-flow and geochemical models and with statistical techniques.

SUMMARY: Study sites were instrumented with networks of ground-water-observation wells. Water-level-data and water-quality-data collection was initiated in October 1986. Lysimeters and additional wells were later installed to augment the network based on initial results. Pumping tests were conducted to estimate aquifer hydraulic characteristics. Bromide-tracer tests are being conducted to estimate solute-infiltration rates. Geochemical models are being developed to characterize chemical environments in ground water. Spatial and temporal distributions of the data are being examined to develop conceptual models of ground-water transport of nitrogen. Nitrogen in shallow ground water is present primarily as nitrate at a median concentration of 3 mg/L at the Piedmont site and 9 mg/L at the Coastal Plain site. Quantities of water flowing through unconfined aquifers at the sites are being estimated with ground-water-flow models and will be used to estimate nitrogen loads in ground water.



Water Resources of Howard County, Maryland (MD093)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: James R. Dine

COOPERATORS:

Howard County

Maryland Geological Survey

PERIOD OF PROJECT: October 1988 through December 1991

PROBLEM: Howard County, located between Baltimore, Maryland, and Washington, D.C., has experienced substantial residential and commerical/industrial development. During the early 1980's, Howard County had the highest growth rate of all counties in Maryland and is projected to maintain the highest rate during the 1990's. Water use has increased to accommodate this growth. A quantitative assessment of the water resources is needed so managers can protect, develop, and manage the resources.

OBJECTIVES: (1) Estimate streamflow duration and low-flow frequency by subbasins. (2) Describe the ground-water-flow system and map the water table. (3) Estimate aquifer coefficients. (4) Estimate potential yields of wells in selected aquifers. (5) Estimate hydrologic budgets for each subbasin. (6) Estimate potential yields of aquifers using water-budget analysis. (7) Characterize water quality for selected aquifers and for streams at base flow. (8) Compare three design-flood procedures with standard procedures for three gaged sites.

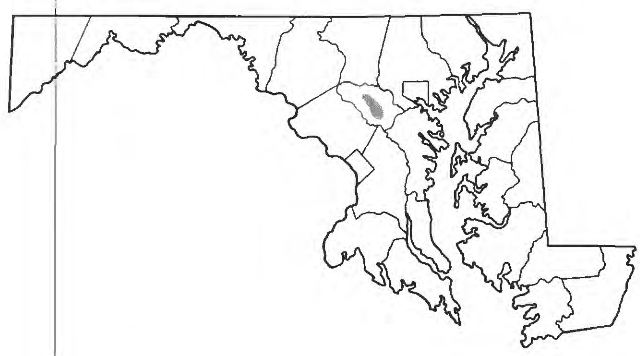
APPROACH: Establish relations between base flow in subbasins and at long-term gaging stations by regression analysis. Document water quality by analysis of ground-water and surface-water samples. Perform statistical analysis of well yields for various aquifers and construction techniques. Compare three widely used design-flood methods to log-Pearson type III peak-flow frequency analysis for three long-term gaged sites.

SUMMARY: A well and spring inventory for Howard County provided data for 2,468 sites. Water levels were measured in selected wells and discharge, pH, specific conductance, and temperature were measured at selected springs. Water-quality samples were collected and analyzed. In ground water, pH ranges from 5.1 to 8.5, specific conductance ranges from 25.4 to 751 μS/cm, alkalinity ranges from 3.5 to 156 mg/L (as calcium carbonate), and radon-222 ranges from 97 to 38,000 pCi/L.

Appalachian Valley and Ridge-Piedmont Regional Aquifer-System Analysis--APRASA, Piedmont Type-Area Study, Howard County, Maryland (MD096)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: James R. Nicholas

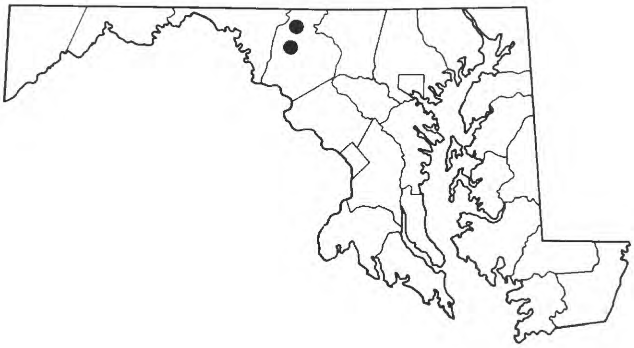
PERIOD OF PROJECT: April 1990 through September 1992

PROBLEM: About 75 Mgal/d of ground water is withdrawn in the Maryland Piedmont to serve a population of nearly 2 million. Further increases in population will likely lead to additional ground-water development. Ground water is derived from secondary-permeability openings, such as joints, faults, and solution fractures. A better understanding of ground-water flow in this type of hydrogeologic system is needed to help guide ground-water development and management.

OBJECTIVE: To develop and test a conceptual model of ground-water flow in thinly mantled, fractured, crystalline-rock aquifers of the Appalachian Piedmont.

APPROACH: Compile available hydrogeologic data and collect seepage data. Input data into a Geographic Information System. Select a suitable conceptual model. Construct cross-sectional and areal flow models of two subbasins. Once calibrated, use subbasin flow models to develop an areal ground-water-flow model. Identify important hydrogeologic controls on ground-water flow. Evaluate the effects of development and climatic change using a calibrated ground-water-flow model.

SUMMARY: Spring and fall seepage runs have been completed. Seepage data and other data on geology, land use, well location, well yield, streams, lakes, roads, slopes, and soils have been verified and input into ARC/INFO, a Geographic Information System. A conceptual model has been selected. Modeling of ground-water flow in subbasins has been initiated.



Effects of Acidic Atmospheric Deposition on Three Small Watersheds in the Catoctin Mountains of Central Maryland (MD066)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: W. Brian Hughes

PERIOD OF PROJECT: October 1981 through September 1992

PROBLEM: Acidic deposition has created adverse environmental effects in many parts of the nation and the world. The pH of precipitation in Maryland is among the lowest in the nation, with pH values routinely dropping below 4.0. Three small watersheds in the Catoctin Mountains of north-central Maryland are being monitored for changes in chemistry as a result of the acidic deposition. A long-term acidic-deposition monitoring program is needed to identify changes and trends in stream-water chemistry as the result of changes in the acidic-deposition input.

OBJECTIVES: (1) Monitor the quantity and quality of precipitation input to the study area, and identify any changes in acidity over the long term. (2) Monitor the quantity and quality of three small headwater streams as they relate to the acidic deposition input--especially during large storms. (3) Identify any similarities and differences in the chemistry and seasonal changes of the three streams as they relate to differences in the geology and land-use practices in the watersheds.

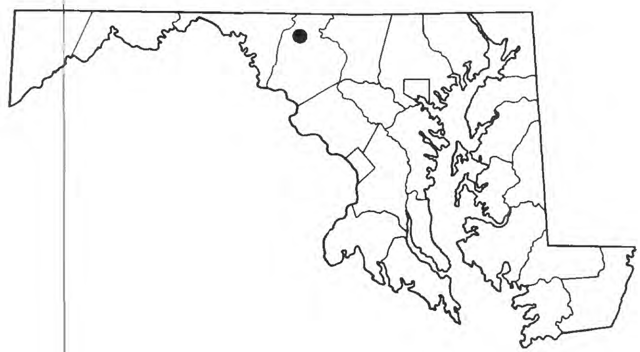
APPROACH: A wetfall-dryfall collector and precipitation gage are located in the study area to monitor quantity and quality of precipitation. Streamflow is continuously gaged at the outlet of each of the three watersheds to monitor changes in discharge. One stream is sampled weekly and the other two streams are sampled monthly to monitor changes in chemistry throughout the year. Automatic samplers are programmed to sample two of the streams during large runoff events. Ground water and water from the unsaturated zone are sampled periodically to determine the mobility of major ions and silica.

SUMMARY: Seasonal cycles in the acidity of the precipitation are evident, and strong seasonal cycles in stream chemistry have been identified. Volume-weighted pH of the precipitation has averaged 4.14 for the 7 years of record (1982-88). Annual loadings of all inorganic constituents in the streams are strongly related to discharge of the stream, which, in turn, is related to the amount of precipitation. Analyses indicate stream loadings are greatest during wet years. Sulfate and nitrate loadings in precipitation peaked in 1984, declined in 1985 and rose again in 1986 and 1987. Sulfate concentrations have decreased in two of the watersheds because of stream-water outflow since the beginning of the study. A third watershed, located on quartzose bedrock, was added in October 1987 so that changes in stream chemistry can be compared to those of the two streams on the metabasalt bedrock.

Hydrologic and Geochemical Controls on Episodic Acidification of Small, Headwater Streams in the Blue Ridge Mountains of Maryland (MD097)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Karen C. Rice

COOPERATORS:

Maryland Department of the Environment

Maryland Department of Natural Resources

PERIOD OF PROJECT: October 1989 through September 1993

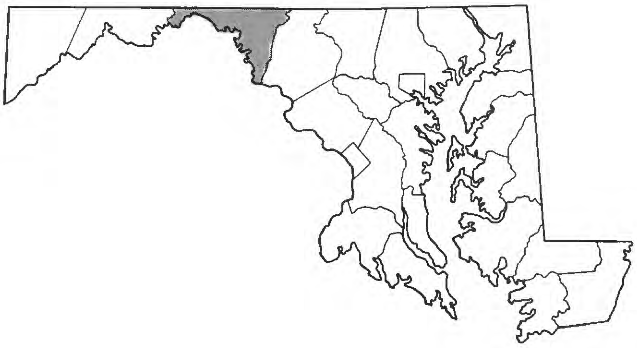
PROBLEM: Acidic deposition has potentially devastating consequences on forest-land and lake ecologies. When acids are deposited in watersheds underlain by bedrock and soils of poor buffering capacity, the quality of streams and lakes can degrade. This, in turn, can cause damage to the stream biota. Because of differences in the responses of watersheds to storms, no index or method exists that can predict the hydrologic response.

OBJECTIVE: To characterize the hydrologic and geochemical processes controlling episodic acidification of headwater streams during storms in the Blue Ridge Mountains of Maryland.

APPROACH: Intensively instrument two watersheds for the collection of isotopic and geochemical data. Use a combination of isotopic and geochemical techniques to interpret hydrologic flow paths and the age and sources of water during runoff events.

SUMMARY: Two watersheds in the Blue Ridge physiographic province of Maryland have been selected for study. Both watersheds are situated on a non-reactive bedrock type, are of the same watershed area, and have the same vegetation, aspect and acidic precipitation input. Both watersheds are instrumented with staff gage and recorder, automatic sampler, three-parameter minimonitor, data logger, tension lysimeters, and throughfall collectors. Weekly base-flow stream samples are collected for geochemical and stable isotopic analysis. Weekly precipitation samples are collected at a nearby precipitation-collection station. Stormflow samples, collected by the samplers, are collected on an event basis and analyzed for geochemical and stable isotopic content.

Water Resources of Washington County, Maryland (MD078)



MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Mark T. Duigon

COOPERATOR:

Maryland Geological Survey

PERIOD OF PROJECT: January 1985 through August 1990

PROBLEM: Population growth and commercial/industrial expansion since the early 1960's has placed new pressures on planners. Uniform, representative, and reasonably complete hydrologic data are required to understand, protect, and prudently develop and manage the county's water resources.

OBJECTIVES: (1) Provide basic hydrologic data. (2) Describe water-bearing characteristics and quality of water in the rock units. (3) Describe the ground-water-flow system and map the potentiometric surface. (4) Describe streamflow characteristics. (5) Estimate total water availability by basin.

APPROACH: Divide the study area into basins for water-budget analysis. Measure streamflow and relate it statistically to streamflow at continuous-record gaging stations. Inventory wells and springs and establish an observation-well network. Perform field analyses of water samples for pH, temperature, specific conductance, and dissolved-oxygen concentrations. Perform laboratory analyses for major-ion, nutrient, trace-element, organic compound, and pesticide concentrations. Analyze stream-bottom sediments for trace-element and pesticide concentrations.

SUMMARY: Ground water is present mainly under unconfined, secondary-permeability conditions. Well yields range from 0 to more than 1,000 gal/min and are variable within and between geologic units. Average monthly mean streamflows at seven gaging stations range from about 2 to more than 10,000 ft^3/s. Basins in the eastern part of the county tend to have lower high flows but higher low flows than basins in the western part. Most ground water and surface water contains calcium bicarbonate. Most trace metals and pesticides were undetected in ground-water samples, although atrazine was detected at six of seven sampling sites. Trace metals and pesticides were detected in some stream-bottom samples. The average annual hydrologic budget is:

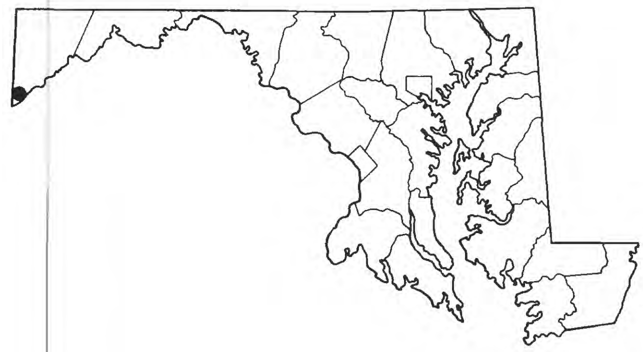
	Overland Runoff	(5.5 in.)
	Subsurface Runoff	(9.6 in.)
	Evapotranspiration	(24.5 in.)
+	Change in storage	(0.0 in.)
	Precipitation	(39.6 in.)

Subsurface runoff is generally greater in the carbonate basins than in noncarbonate basins.

Hydrologic Effects of Underground Coal Mining in Southwestern Garrett County, Maryland--Phase III (MD088)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Steven N. Hiortdahl

COOPERATORS:

Maryland Bureau of Mines

Maryland Geological Survey

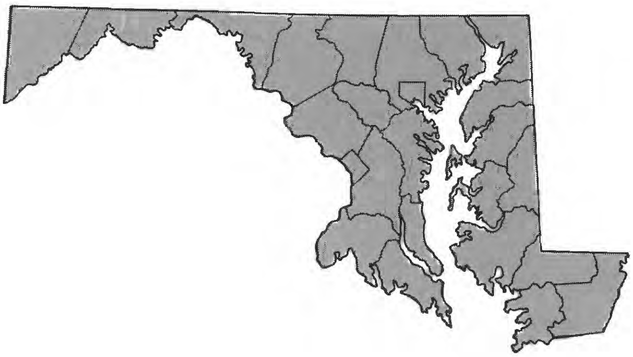
PERIOD OF PROJECT: October 1986 through September 1990

PROBLEM: Understanding of hydrologic systems (ground water and surface water) in areas of underground coal extraction and effects of extraction on those systems is needed to guide regulatory efforts for mitigating adverse environmental effects. The ultimate effect of underground mining on a particular system and the progression of effects during mining are not well known. Long-term documentation of the hydrologic conditions is needed as mining begins, expands, and eventually ceases. Such documentation could provide the basis for constructing conceptual models that are transferrable to hydrogeologically similar areas.

OBJECTIVES: Document conditions in the ground-water and surface-water systems as they respond to the mining process.

APPROACH: Monitor ground-water levels continuously in 16 of 24 observation wells. Measure water levels monthly in the remaining observation wells. Continuously measure streamflow at three sites, and continuously measure specific conductance, water temperature, and pH at three stream gages. Conduct synoptic stream-seepage measurements to identify and delineate losing and gaining reaches.

SUMMARY: The Phase III study continued data collection and documentation of hydrologic conditions. Data collection during this phase consisted of continuous and periodic water-level measurements in 24 observation wells. Stream-seepage measurements were conducted, and three gages for continuous monitoring of streamflow, specific conductance, water temperature, and pH were operated. Data on mining progess, mine pumpage, and precipitation also were collected.



Surface-Water Stations (MD001)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Robert W. James, Jr.

COOPERATORS:

Borough of Hyndman, Pennsylvania

City of Baltimore, Maryland

City of Salisbury, Maryland

District of Columbia Department of Consumer and Regulatory Affairs

District of Columbia Department of Public Works

Interstate Commission on the Potomac River Basin

Maryland Department of the Environment

Maryland Department of Natural Resources

Maryland Geological Survey

Maryland Water Resources Administration

U.S. Army Corps of Engineers

Upper Potomac River Commission

Washington Suburban Sanitary Commission

PERIOD OF PROJECT: Continuous since 1895

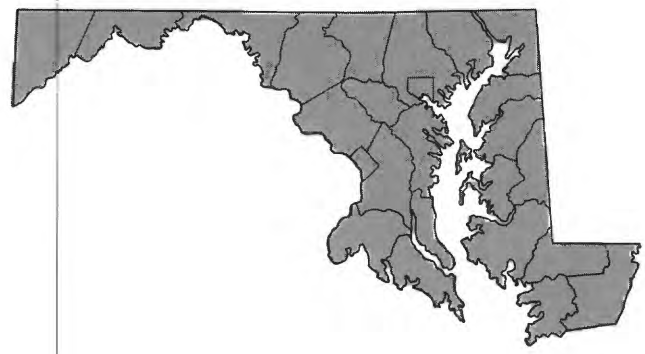
PROBLEM: Surface-water information is needed for purposes of surveillance, planning, design, hazard warning, operation, and management in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. To provide this information, an appropriate data base is necessary.

OBJECTIVES: (1) Collect surface-water data sufficient to satisfy needs for current-purpose uses, such as assessment of water resources; operation of reservoirs or industries; forecasting; disposal of wastes and pollution controls; discharge data to accompany water-quality measurements; compact and legal requirements; and research or special studies. (2) Collect data necessary for analytical studies to define for any location the statistical properties of, and trends in, the occurrence of water in streams, lakes, and estuaries for use in planning and design.

APPROACH: Use standard methods of data collection as described in the series, "Techniques of Water-Resources Investigations of the United States Geological Survey." Use partial-record gaging instead of complete-record gaging where it serves the required purpose.

SUMMARY: Hydrologic data for continuous record, reservoir, and partial-record surface-water stations in the State are collected under the general supervision of the Towson office. At present, 85 continuous-record gaging stations are being operated. (See section "Annual Water-Data Reports" for locations of data-collection sites and information on publication of data.)

Ground-Water Stations (MD002)



MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Michael J. Smigaj

COOPERATOR:

Maryland Geological Survey

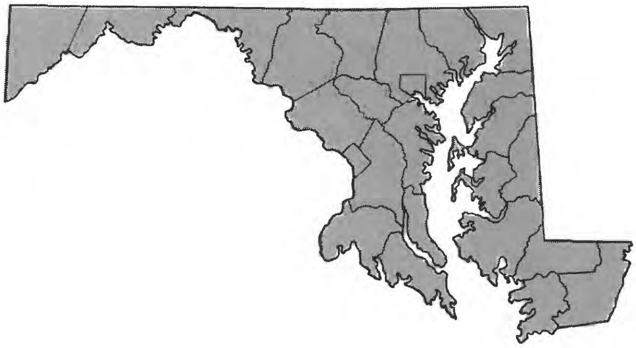
PERIOD OF PROJECT: Continuous since 1943

PROBLEM: Long-term water-level records are needed to evaluate the effects of climatic variations on recharge to and discharge from the ground-water-flow systems of Maryland; to provide a data base from which to measure the effects of development; to assist in the prediction of future supplies; and to provide data for management of the ground-water resources.

OBJECTIVES: (1) Provide a long-term data base so that the general response of the ground-water-flow system to natural climatic variations and imposed stresses is known and so that potential problems can be defined early enough to allow proper planning and management. (2) Provide a data base against which the short-term records acquired in short-term areal studies can be analyzed.

APPROACH: The Maryland Statewide network includes 210 observation wells and 4 springs. Of these, 209 wells and the 4 springs are measured at 4- to 6-week intervals and 5 wells are equipped with continuous analog recorders. The data are processed and stored on the Maryland office's Ground-Water Site Inventory (GWSI) data-base system on the mini computer.

SUMMARY: Measurement of water levels in all network wells has continued according to schedule, as has the processing of the data in GWSI. An ongoing evaluation of the observation-well network was started in 1986. Areas of poor network coverage have been identified and efforts are underway to acquire wells that can be added to the network in those areas. In addition, also starting in 1986, the observation-well network project staff has undertaken the role of providing quality assurance of ground-water data for other projects in the Maryland and Delaware offices. In this regard, annual project reviews have been conducted, group and individual training in the use of GWSI has been provided, and office water-level data have been verified for accuracy. (See section "Annual Water-Data Reports" for locations of data-collection sites and information on publication of data.)



Ground-Water-Quality Stations (MD00210)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: David W. Bolton

COOPERATORS:

Maryland Department of the Environment

Maryland Geological Survey

PERIOD OF PROJECT: Continuous since December 1987

PROBLEM: The chemical quality of the water-table aquifer systems in Maryland may be gradually deteriorating due to nonpoint sources of contamination. Such degradation can potentially lead to adverse effects on the chemical quality of deeper aquifer systems, which provide a significant amount of the potable water used in Maryland for domestic and municipal water supplies. A number of ground-water contamination studies in Maryland have documented the degradation on ground-water quality resulting from point-source disposal, or accidental release of different chemical compounds. However, no attempt has been made to generally characterize the chemical-quality characteristics of the water-table aquifers on a larger, Statewide basis.

OBJECTIVE: To establish a limited, Statewide network of mostly water-table index wells and springs, which will be systematically sampled on a long-term continuing basis. The monitoring network will provide the basic water-quality data needed to document the baseline chemical-quality conditions of selected water-table aquifer systems in the State. It will also provide a basis to monitor future water-quality trends in these systems.

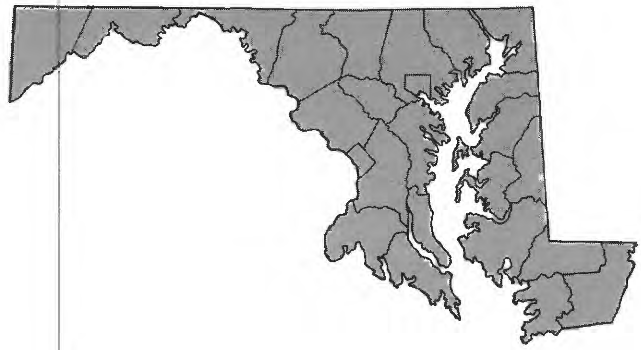
APPROACH: Divide the state into four segments, based on geologic or physiographic characteristics. These segments are the Ridge and Valley/Appalachian Plateau, the Piedmont/Blue Ridge, the western shore Coastal Plain, and the Eastern Shore Coastal Plain. Sample 11 to 14 sites (wells and springs) in each segment and sample each segment for 1 year. Sample approximately four sites in each segment quarterly to observe seasonal variations in water quality. Analyze samples from all sites for a suite of common constituents and trace elements/heavy metals, and from most sites for commonly used pesticides and volatile organic compounds.

SUMMARY: Wells and springs in all four segments of the water-quality network in Maryland have now been sampled. Water-quality analyses from the samples have been completed for all segments except the Ridge and Valley/Appalachian Plateau. The Eastern and western shore Coastal Plains are comprised of mostly unconsolidated sediments ranging in age from Cretaceous to Quaternary. Specific conductance in samples from the western shore Coastal Plain ranged from 105 to 1,710 µS/cm; pH values ranged from 4.4 to 7.7. Low levels of organic constituents were detected in five wells. Specific conductances in samples from wells in the Eastern Shore Coastal Plain ranged from 14 to 1,830 µS/cm. Values of pH ranged from 4.3 to 7.8. Organic constituents were detected in six wells. The Piedmont physiographic province is underlain by igneous, metamorphic, and sedimentary rocks ranging in age from Precambrian to Triassic. Specific conductances ranged from 21 to 609 µS/cm. Values of pH ranged from 5.1 to 8.1. Low levels of organic compounds were detected at four sites. The Ridge and Valley/Appalachian Plateau provinces are comprised of sedimentary rocks ranging in age from Cambrian to Permian. Specific conductances in currently available data ranged from 25 to 753 µS/cm; pH values ranged from 4.9 to 7.6.

Water-Quality Stations (MD003)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Robert W. James, Jr.

COOPERATORS:

Maryland Department of the Environment

Smithsonian Environmental Research Center

U.S. Army Corps of Engineers

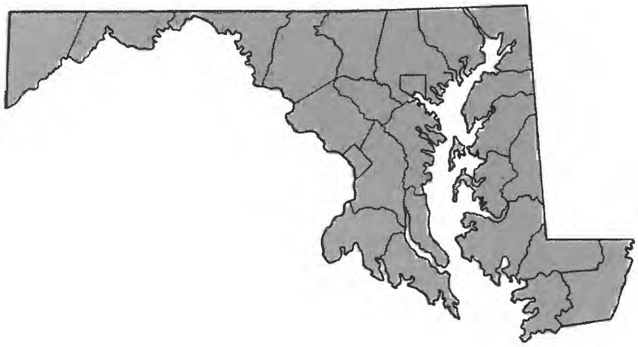
PERIOD OF PROJECT: Continuous since 1945

PROBLEM: Water-resource planning and water-quality assessment need basic information on the chemical and physical quality of the water in Maryland's streams and aquifers. Additional information is needed to determine nutrient loads on selected tributaries to Chesapeake Bay.

OBJECTIVE: To provide data on the quality of the ground water and surface water of Maryland and on the variability of the quality.

APPROACH: Establish and operate a network of water-quality stations to measure chemical and physical characteristics of the ground water and surface water of Maryland. Monitor selected tributaries of Chesapeake Bay intensively during high flows.

SUMMARY: Water-quality-data collection continued at 10 sites. (See section "Annual Water-Data Reports" for locations of data-collection sites and information on publication of data.)



Suspended-Sediment Stations (MD004)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Robert W. James, Jr.

COOPERATOR:

USGS Federal Collection of Basic Records (CBR) Program

PERIOD OF PROJECT: Continuous since 1960

PROBLEM: Water-resource planning and water-quality assessment need basic information about the sediment carried in streams.

OBJECTIVE: Provide data on the quantity of sediment carried by Maryland streams and on the nature of the sediment.

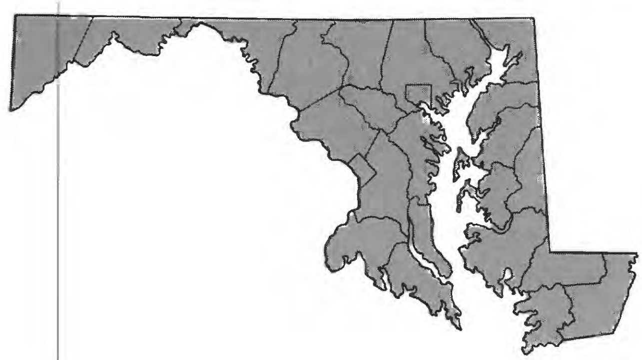
APPROACH: Establish and operate a network of sediment stations to measure quantities of suspended sediments. Periodically measure the particle-size distribution of the sediment and bed material.

SUMMARY: Data collection is proceeding on schedule at the two stations presently in operation. The sites are located on the Monocacy and Potomac Rivers near the cities of Frederick and Point of Rocks, respectively. (See section "Annual Water-Data Reports" for locations of data-collection sites and information on publication of data.)

Maryland Water-Use Data Program (MD007)

MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Judith C. Wheeler

COOPERATORS:

Maryland Geological Survey

Maryland Water Resources Administration

PERIOD OF PROJECT: Continuous since 1977

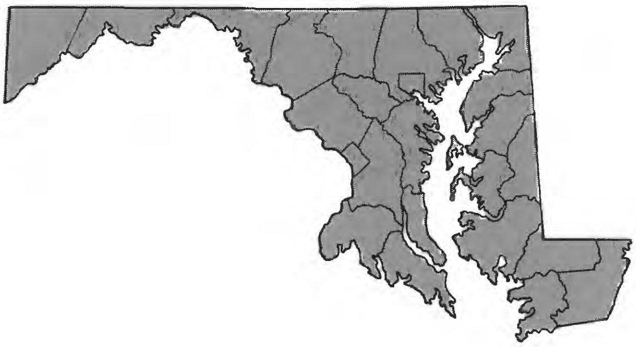
PROBLEM: Maryland waters are under stress from increasing demands for domestic, industrial, agricultural, and other uses and from demands for greater protection of water quality. Competition for water dictates that available supplies are matched with uses most beneficial to the common good. Information continues to be collected on quantity and quality of available water, but more specific information is needed on water use. Without adequate information on water use, decision makers could not resolve many critical water problems in an informed and prudent manner.

OBJECTIVE: To provide water-use information for the optimum use and management of the State's water resources. This program collects, stores, and disseminates water-use data to complement data on availability and quality, and operates a system to manage the data. The program responds to the data needs of State and local users, the USGS, and other Federal agencies.

APPROACH: Responsibilities are divided between the cooperators and the USGS to meet efficiently the objectives of the program. Program direction, management, and standards development to meet national needs are the responsibility of the USGS. Activities for the acquisition and storage of the data are the primary responsibility of the Maryland Water Resources Administration.

SUMMARY: Continued the acquisition, processing, and reporting of water-use data. The USGS Water-Use Data Base (SWUDS) was installed on the Maryland-Delaware-District of Columbia District's mini computer, and withdrawal data for 1980-87 were edited and entered in SWUDS. A questionnaire directed to public water suppliers was distributed by the Maryland Water Resources Administration in an effort to improve the quality of reported water-use data. Return-flow data were received from the Maryland Department of the Environment. The report "Historical Ground-water Use in the Maryland Coastal Plain" was published, as was the USGS "1987 National Water Summary" on water use in the United States. The report "Withdrawal and Use of Water in Maryland, 1985" was published by the Maryland Water Resources Administration. The reports "Water Withdrawal and Use in Maryland, 1986" and "Water Withdrawal and Use in Maryland, 1987" were published by the USGS.

Evaluation, Modeling, and Mapping of Potential Bridge-Scour Conditions, Maryland (MD098)



MARYLAND

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Bernard M. Helinsky

COOPERATOR:

Maryland State Highway Administration

PERIOD OF PROJECT: April 1990 through September 1993

PROBLEM: Stream-channel erosion in the vicinity of river-crossing structures can consist of several components: (1) degradation, (2) local scour, and (3) contraction scour. Degradation is the long-term adjustment of the river to past disturbances. Local scour is the localized, short-term erosion around piers or abutments. Contraction scour, another short-term phenomenon, is the lowering of the channel section due to flow acceleration through the constriction. Scour at bridges has been the subject of considerable concern to those who design and maintain these structures. Because a large amount of detailed data are required for modeling of bridge scour, there is a need for a method to rapidly assess the potential for scour and rank those sites that appear to have characteristics conducive to scour-critical conditions.

OBJECTIVES: (1) Evaluate the potential for scour at State highway bridges throughout the State of Maryland. (2) Identify those structures that could potentially be endangered by the scour process. (3) Perform two-dimensional flow modeling at 25 sites and sediment modeling (BRISTARS) at 5 sites.

APPROACH: Qualitative evaluation of 900 Maryland State highway bridges by personal inspection. Evaluation includes observing and measuring a large number of variables that are relevant to bed scour. Variables include pier shape, number and type, underclearance, abutment condition and type, slope protection, channel width and gradient at, above, and below the bridge, approach angle, bank height and angle, vegetative cover and material type, bed material, debris, obstructions, and flood-plain use. Variables will be weighted based on scour potential, and summed to produce a potential-scour index for each bridge. Bridges will be ranked based on qualitative potential for bridge scour. Of those bridges with large scour/fill potential, select 30 for two-dimensional sediment modeling.

SUMMARY: Potential bridge-scour-site evaluations were completed. Preliminary site evaluations, computer-generated, potential-scour indexes and observed-scour indexes as well as an accompanying photograph-site file were provided to the Maryland State Highway Administration. Selection of 30 sites for modeling is in progress. A user's guide documenting the potential-bridge-scour evaluations is being prepared.

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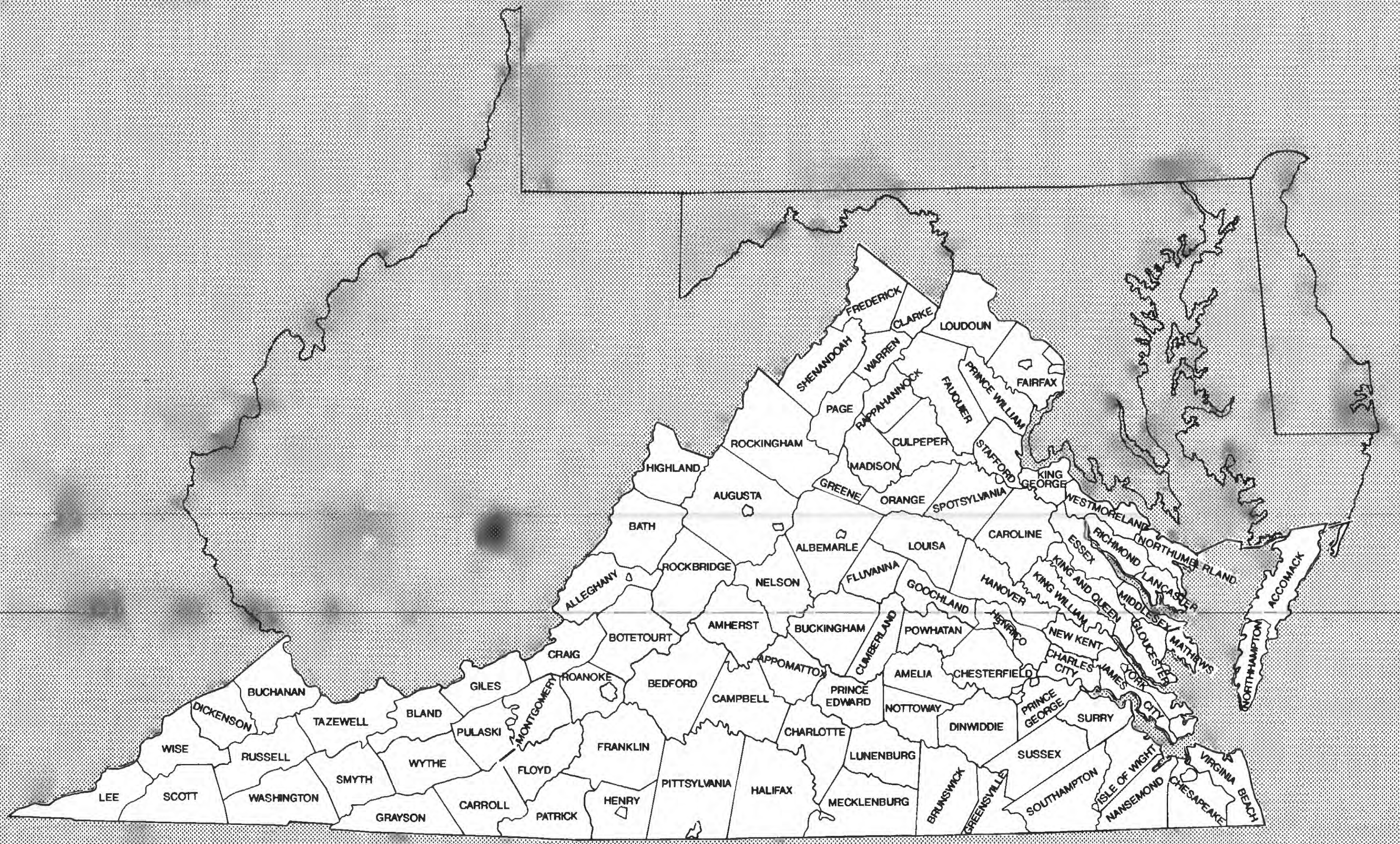
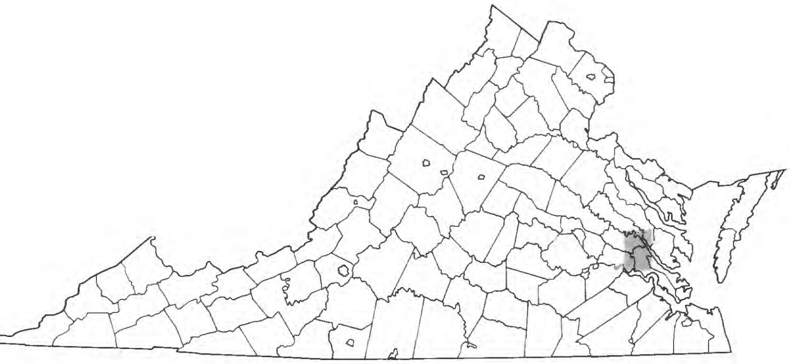


Figure 7.--Counties of Virginia.

Quality of Water in Little Creek Reservoir, Diascund Creek Reservoir, and Chickahominy River in Eastern Virginia (VA071)



VIRGINIA

Coastal Plain

Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Dennis D. Lynch

COOPERATOR:

City of Newport News, Virginia

PERIOD OF PROJECT: July 1983 through September 1989

PROBLEM: Little Creek Reservoir, Diascund Creek Reservoir, and Chickahominy River constitute the raw-water source for the City of Newport News. Little Creek Reservoir, which was recently constructed and filled, serves as off-line storage for water obtained from Chickahominy River and Diascund Creek Reservoir. Little is known about the quality of these water bodies and how they vary seasonally and during different hydrologic conditions. This information is needed to make sound management decisions about how to obtain drinking water of the highest quality and the lowest cost throughout the year.

OBJECTIVES: (1) Discern limnological characteristics of Little Creek Reservoir and their relation to in-flow water quality; limited flushing in remote areas; and seasonal events such as thermal stratification in summer months. (2) Characterize seasonal water-quality variations of Diascund Creek Reservoir and Chickahominy River.

APPROACH: Sample all three water bodies monthly during the active growing season (April through October), and bimonthly thereafter. Collect samples from multiple depths in the reservoirs, and analyze the samples for concentrations of nutrients, chlorophyll-*a*, major ions, and physical characteristics. Collect a single sample from the Chickahominy River in the water works' intake structure. Determine seasonal variation in limnological characteristics of the two reservoirs through detailed measurements of the depth profiles of key characteristics such as temperature, dissolved-oxygen concentration, and chlorophyll concentrations.

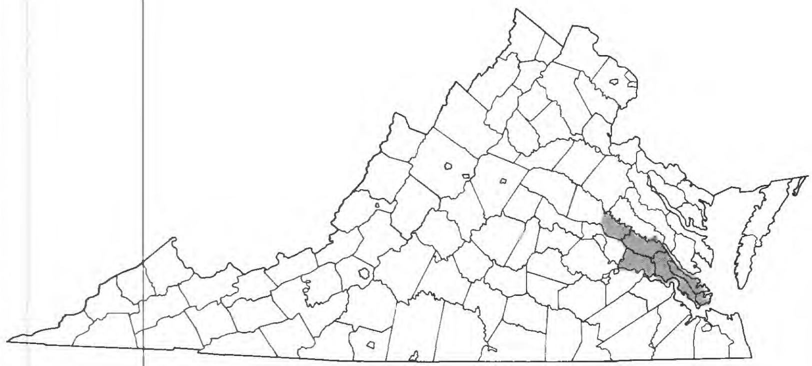
SUMMARY: Results of the study indicate that thermal stratification of these reservoirs begins around late March and continues into November. Because stratification prevents reoxygenation of the hypolimnion by the atmosphere, hypolimnetic reserves of oxygen are depleted within 3 months at Little Creek Reservoir and within 1 month at the shallower Diascund Creek reservoir. Within the anoxic hypolimnion, reduced species of iron, manganese, and nitrogen accumulate. During stratification, reservoir phosphorus concentrations are lower than input concentrations. Thus, algal biomass in these reservoirs is phosphorus limited throughout the year, with nitrogen to phosphorus ratios generally above 20. The low concentrations of phosphorus account for the low to moderate concentrations of chlorophyll-*a* in these reservoirs, which generally ranges from 3 to 30 µg/L.

In addition to providing off-line storage for the Newport News water supply, Little Creek reservoir improves the quality of raw water by acting as a sink for many constituents that cause water-treatment problems. As water is routed through Little Creek Reservoir, concentrations of chlorophyll, phosphorus, and nitrogen decrease about 70, 70, and 30 percent, respectively. Concentrations of dissolved iron and manganese decrease about 50 percent, and concentrations of total organic carbon and trihalomethane formation potential decrease about 25 and 35 percent, respectively.

Assessment of the Ground-Water Resource in the York-James Peninsula, Virginia (VA073)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Randall J. Laczniak

COOPERATORS:

City of Newport News, Virginia

City of Williamsburg, Virginia

Charles City County

Hanover County

New Kent County

James City Service Authority

York County

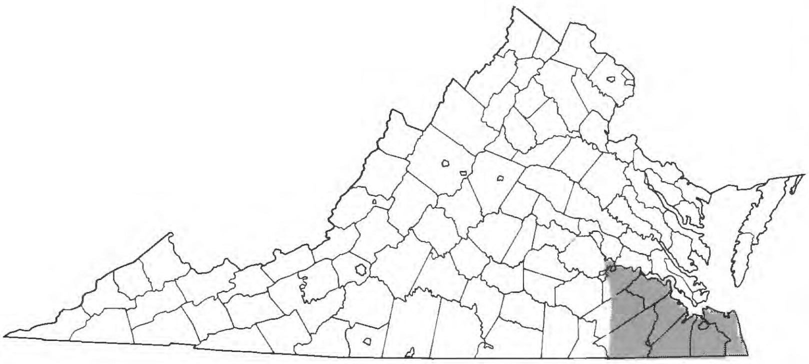
PERIOD OF PROJECT: July 1983 through September 1988

PROBLEM: A substantial increase in ground-water demand is expected for the York-James Peninsula. The major aquifers of the Peninsula are presently being used inside and outside the area. Additional development can possibly affect current ground-water users by increasing drawdowns and inducing salty ground water. The effects of additional proposed ground-water development need to be determined.

OBJECTIVES: (1) Estimate the availability of ground water to meet projected needs. (2) Define the extent and thickness of individual aquifers. (3) Estimate the limit of the freshwater system in the aquifers. (4) Estimate the effects of future ground-water development. (5) Test application of an existing regional ground-water model for submodel boundary conditions.

APPROACH: Analyze geophysical logs and hydrologic data to provide a hydrogeologic framework. Construct test holes to fill in hydrogeologic data gaps. Develop hydrogeologic and potentiometric maps based on existing and project-provided hydrogeologic data (observation-well network). Conduct an inventory of present water users to determine ground-water withdrawals. Develop a ground-water model for analysis and management.

SUMMARY: An unconfined aquifer underlain by six confined aquifers and intervening confining units comprise the hydrogeologic framework of the York-James Peninsula. The three lowermost aquifers--the Upper, Middle, and Lower Potomac--are the most productive. A digital-flow model, developed to simulate ground-water-flow conditions in aquifers throughout the Peninsula, shows that a reduction in ground-water flow to surface-water sources and induced flow from surface-water sources, as a result of lowering of ground-water levels, is approximately equivalent to the amount of ground water withdrawn. Most of the surface water recharging the ground-water-flow system was from sources containing salty water; however, this recharge was primarily to parts of aquifers not used for freshwater supply. Scenarios of increased withdrawal show that, with additional development, water levels will continue to decline throughout the aquifer; and that the severity of the decline and associated hydrologic effects will depend on the location and quantity of future withdrawals. Withdrawals from the deep confined aquifers appear to have a minimal effect on water levels in the uppermost confined aquifer (Yorktown-Eastover aquifer), which supplies water to many domestic users.



Analysis of Ground-Water Flow in the Coastal Plain of Southeastern Virginia (VA076)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Jerry D. Larson

COOPERATOR:

Virginia Water Control Board

PERIOD OF PROJECT: July 1984 through September 1987

PROBLEM: Withdrawal of ground water from Coastal Plain aquifers in Virginia is concentrated in the southeastern part of the State. Continued withdrawal of ground water has caused a steady decline of water levels in the aquifers beginning about 1940. Individual cones of depression, centered around major pumping centers, have continued to expand areally. Uncertainties exist as to (1) where and how extensively current ground-water withdrawals affect the potential for induced recharge; (2) length of time required for water-level declines under current rates of pumpage to reach a new equilibrium condition; and (3) what is the potential for upconing of saline water.

OBJECTIVES: (1) Evaluate the water-supply potential of the multilayered aquifer system in an Interstate area, and determine the effects of proposed ground-water development. (2) Analyze withdrawal schemes with varied ground-water production with respect to changing water levels.

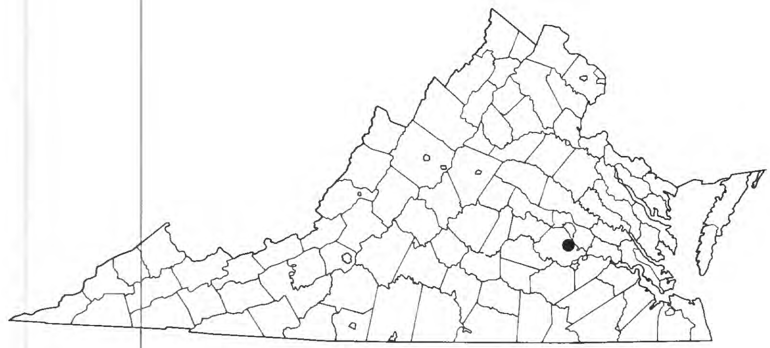
APPROACH: Drill and construct observation wells, measure freshwater heads at observation wells, sample selected wells to provide data on water-quality differences with depth, and conduct an inventory of water users. Update hydrologic framework, develop potentiometric-head maps, and analyze the ground-water system using an areal fine-grid, finite-difference flow model. Use model to test scenarios of varied streamflow data and low-flow analyses to determine if, or how extensively, ground-water withdrawals affect streamflow. Prepare a report documenting the hydrology of the study area and results of stressing the ground-water system under alternative withdrawal schemes. Document software-display packages developed for the study for general use.

SUMMARY: Southeastern Virginia is underlain by unconsolidated sediments, which are divided into a water-table aquifer, seven confined aquifers, and intervening confining units. A digital model of three-dimensional, ground-water flow simulates ground-water flow under prepumping (prior to 1981) and pumping (1981-83) conditions. Significant water-level decline occurred from 1981 to 1983, with maximum decline (greater than 250 ft) in Franklin. Under prepumping conditions, recharge to the ground-water system approximated discharge to surface water. Under pumping conditions, ground-water discharge to surface water is reduced because of increased movement from the water-table aquifer into the confined system to replace water pumped from the deep aquifers. Ground-water discharge is mostly reduced in incised stream valleys near the Fall Line, in areas of major pumping centers, such as Franklin and West Point, and in areas of pumping centers in the east that penetrate shallow aquifers. In some areas, surface water infiltrates into the ground-water system—primarily in the Atlantic Ocean and in the Chesapeake Bay and its major tributaries. Calibration and sensitivity analyses of the model was completed and two pumping scenarios were run. Two research stations were drilled.

Hydrology of the Defense General Supply Center and Surrounding Area with Emphasis on Contaminated Ground Water (VA077)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: John D. Powell

COOPERATOR:

Department of Defense, Defense Logistics Agency, Defense General Supply Center

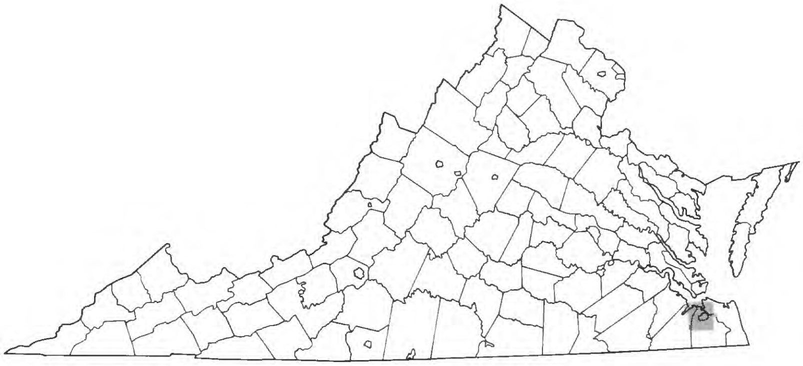
PERIOD OF PROJECT: April 1984 through September 1990

PROBLEM: A former landfill is acting as a source of organic contaminants entering ground water. The degree and extent of the plume of contamination is unknown.

OBJECTIVES: To determine the extent, concentration, and rate of movement of the contamination plume.

APPROACH: Sample wells semiannually to monitor the zone of contamination. Install wells in clusters downgradient from the area of known contamination. Collect water samples at the top, middle, and bottom of each aquifer. Confirm the presence of contamination through analysis for volatile organics by USGS Central Laboratories.

SUMMARY: Forty-four monitoring wells, in 10 multilevel clusters, were constructed downgradient beyond the boundaries of the Defense General Supply Center. The presence of contamination in the ground water in several wells indicated a need for additional clusters of wells to delineate the contaminated zone. Twenty-four monitoring wells, in six clusters, were installed during the spring of 1986. Aquifer tests were conducted to estimate magnitude of aquifer characteristics.



Analysis of Federal, State, and Local Earth Science and Natural Resource Data by Use of a Geographical Information System, to Improve Environmental Management Capabilities in the Elizabeth River, a Tributary to the Chesapeake Bay, Virginia (VA082)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Todd W. Augenstein

PERIOD OF PROJECT: May 1986 through September 1988

PROBLEM: The heavy concentration of industrial, military, and urban growth in the Elizabeth River basin has resulted in large quantities of potentially toxic materials being disposed of in landfills, on the land surface and in the river. The problem is to determine the actual location of contaminants, if the contaminants are being transported from their dump locations, and the potential effects that could occur if the toxic materials reach sensitive areas.

OBJECTIVES: (1) Develop a Geographical Information System (GIS) to integrate existing environmental and technical data of the USGS and other Federal, State, and local organizations into a centralized framework. (2) Develop an overall strategy using GIS that will assist in the making of management decisions of the Elizabeth River basin.

APPROACH: Identify and contact potential users of an ARC/INFO based water-contamination data base for the Elizabeth River basin. Determine user needs and identify possible applications of the data base. Select feasible applications that demonstrate ARC/INFO capabilities and meet current user needs. Identify all pertinent, available data, which can be used to assess the source and impact of contamination in the Elizabeth River basin and to develop the selected applications. Develop a plan for obtaining the data and entering it into ARC/INFO. Design a data-storage and management scheme and convert and enter data into ARC/INFO. Build the selected applications by developing programs to retrieve and analyze data from the ARC/INFO Elizabeth River basin water-contamination data base.

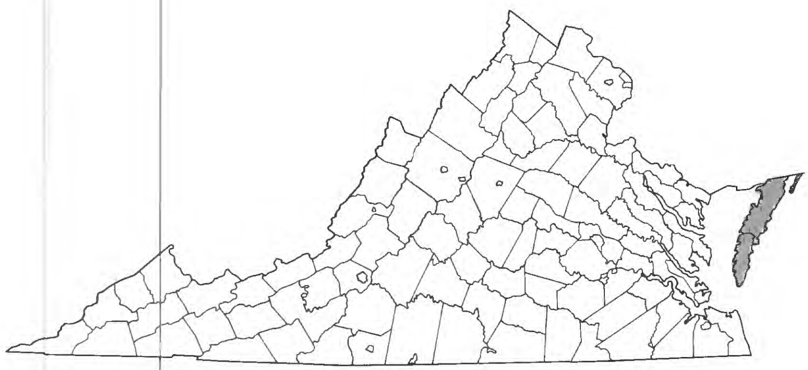
SUMMARY: The following data sets were entered into a GIS for nine 7.5-minute quadrangles in the Elizabeth River area: (1) basin and subbasin boundaries; (2) land use; (3) wetlands; (4) transportation; (5) geographic names; (6) potential hazardous-waste sites; (7) RCRA and CERCLA site locations; (8) municipal and industrial waste-discharge sites; (9) hydrography; (10) recharge and discharge--first confining units; (11) top of Yorktown aquifer; (12) flood elevations from four storm surges; (13) top of first confining unit; (14) first confining-unit thickness; (15) first confining-unit composition; (16) top of tertiary; (17) bathymetry; and (18) well locations.

Various applications were developed to evaluate the hydrologic conditions and contamination potential of the Elizabeth River basin of Virginia. This was done to provide example hydrologic interpretations that could possibly be used to assist in making management decisions and to foster new ideas and approaches to solving hydrologic problems using GIS technology. The following applications were developed: (1) Hazardous-waste site inundation from flooding by hurricane storm surges. (2) Identification of basal Pleistocene channel deposits--potential for ground-water contamination. (3) Identification of areas of recharge and discharge to the Yorktown aquifer--potential for ground-water contamination. (4) Hazardous-waste site proximity to wells--potential for contamination. (5) Annual lead loading from stormwater runoff.

Ground Water of the Eastern Shore Peninsula of Virginia (VA083)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Donna L. Richardson

COOPERATORS:

Accomack County

Northampton County

Virginia Water Control Board

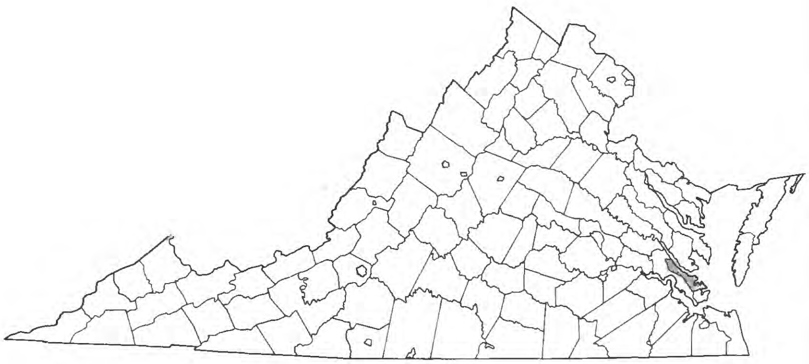
PERIOD OF PROJECT: October 1986 through June 1990

PROBLEM: Ground water is the only available local source of freshwater. Withdrawals have lowered water levels and induced salty water into the freshwater parts of aquifers. Projected increases (agricultural, industrial, and municipal) in ground-water use endanger the resource.

OBJECTIVES: (1) Conceptualize flow through the multiaquifer system. (2) Define hydraulic properties of aquifers and confining units. (3) Define chloride concentrations within aquifers. (4) Define potential of deep aquifers for supplying freshwater. (5) Evaluate ground-water resource as continued supply of freshwater. (6) Assess potential for aquifer contamination.

APPROACH: Establish water-level, water-quality, hydrologic-property, and water-use data bases. Quantify flow components into, through, and out of the water-table aquifer. Develop and calibrate digital-flow model to simulate freshwater part of the confined-flow system. Project effects from increased ground-water use.

SUMMARY: A well network for water levels and water-quality sampling was established. Geophysical logs were used to develop a hydrogeologic framework for the potable ground-water system. Hydrogeologic data were collected, compiled, and analyzed to characterize the hydraulic properties and chloride concentrations of the aquifers in the potable ground-water system. A digital-flow model of the multi-aquifer system was developed. The model is designed to facilitate the simulation of ground-water conditions and includes the ability to track the movement of the interface between freshwater and saltwater. The model will be used to (1) gain a better understanding of ground-water flow, and (2) determine the effects of various proposed pumping scenarios.



Shallow Ground-Water Resources of Eastern York County, Virginia (VA088)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Donna L. Richardson

COOPERATOR:

York County

PERIOD OF PROJECT: January 1986 through September 1992

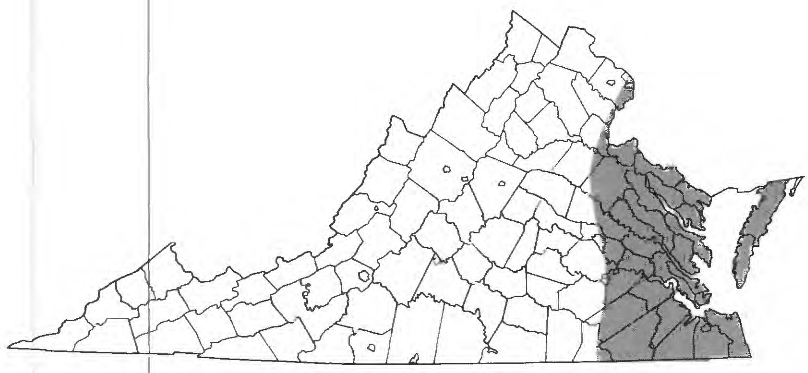
PROBLEM: The shallow aquifer system underlying York County consists of a water-table aquifer and an upper confined aquifer. These aquifers discharge into the Chesapeake Bay and its brackish tributaries and are the only source of freshwater for domestic supplies in the eastern part of the county. Increased pumpage of ground water from the shallow aquifers is causing declines in water levels and possible intrusion of brackish water into freshwater parts of the shallow aquifer system. High densities of septic tanks appear to be affecting the quality of water in the shallow system, particularly nitrate and fecal coliform concentrations. Changes in the water quality of the shallow system also will affect the water quality of Chesapeake Bay into which the ground water discharges.

OBJECTIVES: Evaluate and describe the geohydrology and the water quality of the shallow aquifer system of York County with an emphasis on the eastern part of the county.

APPROACH: Collect geohydrologic data to describe the Columbia aquifer and Yorktown-Eastover aquifer and adjacent confining units. Create areal extent and limits, thickness, and general descriptions of the lithologies and general hydrologic characteristics of these units. Describe flow of ground water from recharge areas to the Chesapeake Bay and its tributaries. Delineate land-use data including areas having septic tanks, domestic-supply wells, and heat-pump wells to help evaluate areas affected by use of the shallow ground water and growth in the area. Collect water-quality samples to evaluate the effects of land use and water withdrawals on water quality.

SUMMARY: Up to 60 wells are being constructed to supplement existing wells for measuring water levels and collecting samples for water-quality analyses. Lithologic logs from approximately 120 auger holes have been obtained and a preliminary geohydrologic framework is being developed. From the logs and other information obtained, it appears that the confining unit probably will not provide as good a confinement as was originally thought. This would mean a greater potential for contaminants at or near the surface to affect the quality of water in the confined aquifer.

A Refined Description of the Ground-Water Resources of the Coastal Plain of Virginia (VA089)



VIRGINIA

Coastal Plain

Piedmont

Blue Ridge

Valley and Ridge

Appalachian Plateau

LEADER: Michael J. Focazio

COOPERATORS:

City of Newport News

City of Williamsburg

James City County

Hampton Roads Planning District Commission

Virginia Water Control Board

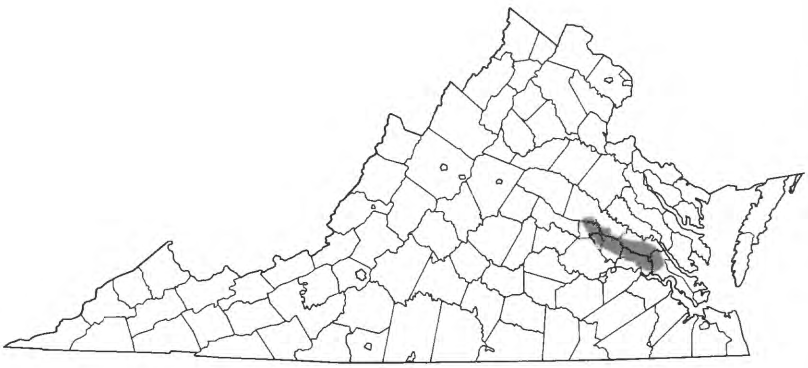
PERIOD OF PROJECT: October 1988 through May 1992

PROBLEM: Extensive withdrawals from the multilayer aquifer system of the Virginia Coastal Plain continue to cause regional declines in water levels and alterations in ground-water flow. Improved descriptions of the regional system and subsequent local investigations require continuous efforts to update and enhance existing models and data bases.

OBJECTIVES: (1) Refine the description of the ground-water resources in the Coastal Plain aquifers of Virginia. (2) Provide information on geohydrologic characteristics and boundary conditions for subsequent local analyses.

APPROACH: Combine data and interpretations from previous and ongoing studies into digital data bases in a Geographic Information System. Include current water use and levels, geohydrologic framework, hydraulic characteristics of sediments, and other revisions for which data are available. Develop a revised flow model of the Coastal Plain that incorporates the updated digital data bases and analyses. Analyze limiting assumptions of the model through sensitivity studies, particularly as they relate to the questions of scale and resolution for subsequent local analyses.

SUMMARY: The hydrogeologic framework was digitized for the Geographic Information System. This data base is currently being analyzed and revised so that accurate and up-to-date maps can be created for model input. Methodology and corresponding computer programs were and are being developed to calculate aquifer thickness, spatial distribution of hydraulic conductivity, and vertical leakance of confining units. Land-surface elevation map was created from GWSI data base and will be compared with 1:250,000 digital-elevation models of the study area.



Sources and Sinks of Nutrients and Trace Contaminants in the Chickahominy River (VA090)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Michael J. Focazio

COOPERATOR:

City of Newport News

PERIOD OF PROJECT: June 1989 through October 1992

PROBLEM: The Chickahominy River, Diascund Creek Reservoir and Little Creek Reservoir constitute the raw-water source for the City of Newport News, Virginia. Continued development in the Chickahominy basin threatens the quality of a large component of the water supply. Documentation of the concentration and transport of contaminants can show the effectiveness of the wetlands in removing contaminants from the water. In addition, a recent USGS study indicates that the quality of water from the Chickahominy River and Diascund Creek Reservoir can improve markedly if the water is first routed through the newly filled Little Creek Reservoir. This method of raw-water management must be evaluated, because the effectiveness of the reservoir as a sink for contaminants can change with time.

OBJECTIVES: (1) Determine the sources and sinks of trace metals, nutrients, and selected contaminants in the Chickahominy River basin and their relation to streamflow and land use/cover. (2) Assess the efficiency of Little Creek Reservoir as a sink for improving the quality of raw water from the Chickahominy River and Diascund Creek Reservoir.

APPROACH: Sample five sites in the Chickahominy River basin, representing areas of different land use/cover quarterly and during peak runoff to describe the input, transport, and loss of contaminants in each of the five subbasins. Collect and analyze sediment samples for concentrations of trace metals. Sample the Chickahominy River, Diascund Creek Reservoir, and Little Creek Reservoir to calculate chemical budgets for Little Creek Reservoir.

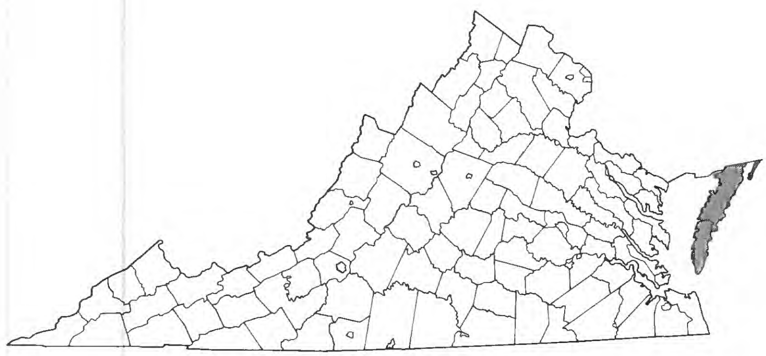
SUMMARY: Sites are being evaluated for the placement of gaging and sampling equipment, and a workplan to include sampling frequency and protocol is being developed. Runoff sampling began in October 1989.

Biogeochemical Processes Controlling Nitrate Concentrations in Ground-Water Discharge (VA093)

VIRGINIA

Coastal Plain

Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Gary K. Speiran

COOPERATOR:

Accomack-Northampton Planning District Commission

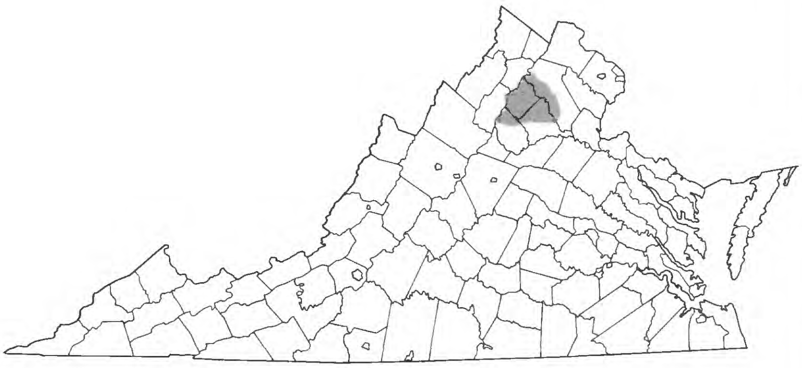
PERIOD OF PROJECT: October 1990 through September 1994

PROBLEM: Nitrate is a seasonal, growth-limiting nutrient that has contributed to a 20-year decline in seafood production in Chesapeake Bay. Nitrification of ammonia applied as fertilizer to farm fields is a major source of nitrate in ground water that discharges to the bay. Nitrate concentrations are controlled by several biogeochemical processes in ground water, including nitrification of ammonia to nitrate, denitrification of nitrate to nitrogen gas, and plant uptake of nitrate. An improved understanding of these processes is needed for effective land-use planning and development of zoning regulations to reduce nitrate in ground water that discharges to Chesapeake Bay.

OBJECTIVES: To determine the effects of ground-water flow and biogeochemical processes on nitrate concentrations in ground water that discharges into coastal estuaries, saltwater marshes, and wetlands.

APPROACH: The study focuses on hydrologic and biogeochemical processes controlling nitrate concentrations in ground-water-discharge areas. Study sites consist of transects of well clusters in differing hydrologic and biogeochemical environments. Water levels are being measured, and flow systems are being evaluated to determine the effects of flow on nitrate concentrations. Water samples are being analyzed for nitrogen species, organic carbon, field-measured characteristics, major ions, and age of the water. Sediment samples are being analyzed for nitrogen species, organic carbon, and microbial rates of denitrification.

SUMMARY: Study is just beginning.



Suspended-Sediment Stations (VA004)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Byron J. Prugh, Jr.

COOPERATOR:

USGS Federal Collection of Basic Records (CBR) Program

PERIOD OF PROJECT: Continuous since 1951

PROBLEM: Water-resource planning and water-quality assessment requires basic information about the concentrations and loads of sediment carried by streams in Virginia, and how these concentrations and loads vary with time and location in the State.

OBJECTIVES: (1) Provide a national bank of sediment data for use in broad Federal and State planning and action programs, and provide data for Federal management of interstate waters. (2) Provide long-term sediment-load trend data against which sediment data from shorter-term studies in Virginia can be compared and placed in proper prospective.

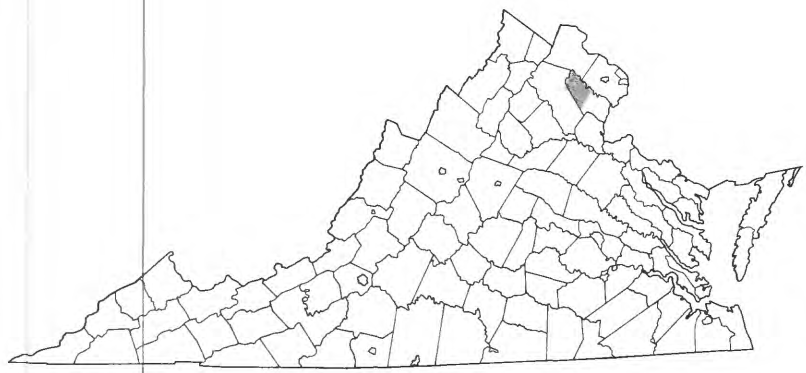
APPROACH: Establish and operate sediment stations so spatial and temporal variations can be discerned in concentrations and loads.

SUMMARY: The sediment station at Rappahannock River at Remington, Virginia, was maintained during the reporting period, providing continuous sediment-load data since 1951. (See section "Annual Water-Data Reports" for description of location of the data-collection sites and information on publication of data.)

Volatile-Organic Contamination in the Triassic Fractured-Rock Aquifer of Prince William County, Virginia (VA084)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: David L. Nelms

COOPERATOR:

Prince William Health District

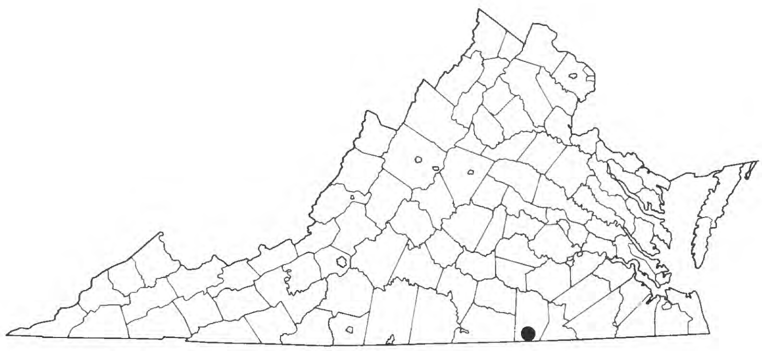
PERIOD OF PROJECT: February 1987 through September 1988

PROBLEM: Volatile-organic compounds are present in ground water of the Culpeper basin of Prince William County, Virginia.

OBJECTIVES: (1) Locate areas of volatile-organic contamination and document composition and concentrations. (2) Determine direction of ground-water flow. (3) Determine geologic and hydrologic controls on the ground-water-flow system.

APPROACH: Compile existing data from all known sources, including water-level and water-quality data and locations of possible sources of contamination. Collect water-level measurements and water-quality samples. Store and manipulate data using a Geographic Information System.

SUMMARY: This investigation identified five major areas where volatile-organic compounds have contaminated the ground water in the Culpeper basin of Prince William County, Virginia. The dominant volatile-organic compounds in the ground water are tetrachlorethylene, trichloroethylene, and 1,1,1,-trichloroethane. Concentrations of the volatile-organic compounds range from 0.1 to 5,320 µg/L. A Geographic Information System (GIS) aided in the integration of geologic and geohydrologic data to develop maps of thickness of overburden, potentiometric surface, areas of contamination, and areas of potential concern. Applications of the GIS generated by this investigation will aid in future planning by the county.



Water Quality of Pea Hill Arm of Lake Gaston, Virginia, and Its Relation to Drainage Basin Land-Use Practices (VA086)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Michael D. Woodside

COOPERATOR:

City of Virginia Beach

PERIOD OF PROJECT: October 1986 through October 1991

PROBLEM: The City of Virginia Beach is considering withdrawing water from Pea Hill Arm of Lake Gaston for water supply. The city needs to document current water quality and land use to establish a baseline for future comparisons. Quantifying current land-use and water-quality conditions and the relation between the two will aid in analyzing future conditions of the raw-water supply and detecting long-term trends.

OBJECTIVES: (1) Determine the temporal and spatial distribution of selected water-quality constituents in Pea Hill Arm and provide the beginnings of a long-term data base for detecting trends in water quality. (2) Document current land use and cover in Pea Hill drainage basin at a scale of 1:24,000. (3) Relate, if possible, current water quality in Pea Hill Arm inlets to land-use activities within their respective drainage basins.

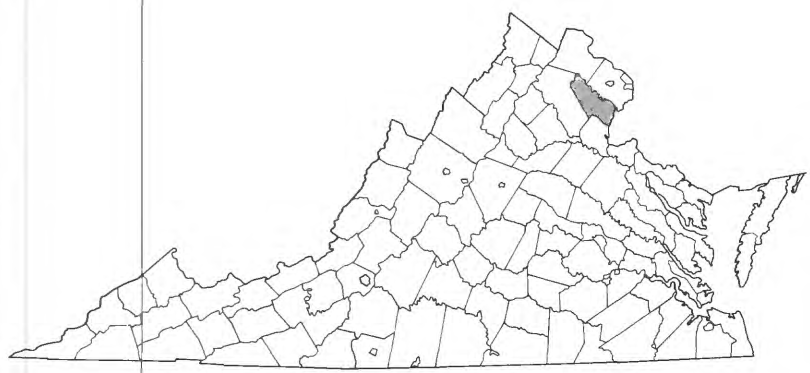
APPROACH: Collect monthly water samples and make field water-quality measurements at 11 sites on Pea Hill Arm, 1 site on Pea Hill Creek, and 1 site on Lake Gaston for a period of 2 years. The sites in Pea Hill Arm include two on the main body and nine on isolated inlets with differing amounts and types of shoreline development and drainage-basin activity.

SUMMARY: Water samples from 13 sites continue to be collected monthly. The following data layers have been compiled into the ARC/INFO Geographic Information System for the Pea Hill drainage basin: drainage area, land use/land cover, road network, stream network, NPDES permit sites, surface-water sites, water-quality sites, and water-use sites. Summary statistics of land-use activities in the subbasins have been used to aid in the interpretation of water-quality data at the 11 surface-water sites.

Assessment of the Ground-Water Quality of Prince William County, Virginia (VA091)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: David L. Nelms

COOPERATOR:

Prince William Health District

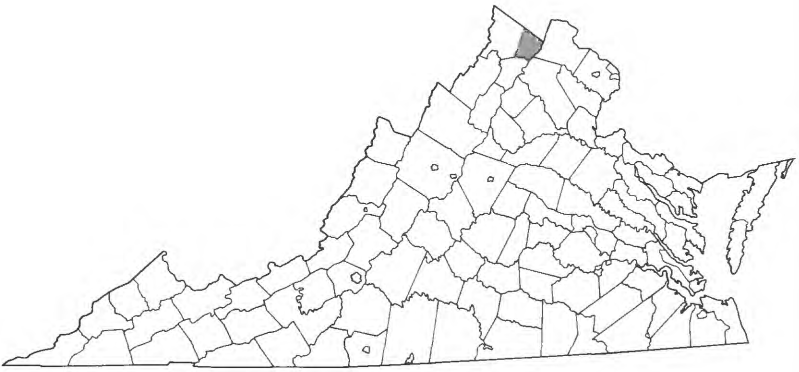
PERIOD OF PROJECT: October 1989 through March 1993

PROBLEM: A lack of ambient ground-water-quality data exists in Prince William County. This lack of data presents a problem for future evaluation of ground-water resources, protection strategies, contamination, and remediation alternatives. Prince William County is experiencing rapid growth as a suburb of the Washington, D.C., area. Planning for growth depends on developing a thorough understanding of the quality and availability of ground water and how this will be affected by future development.

OBJECTIVES: (1) Characterize current ambient quality of ground water for the various hydrogeologic and cultural settings in Prince William County. (2) Relate, where possible, the quality of ground water to aquifer mineralogy, ground-water-flow paths, and land-use patterns.

APPROACH: Compile geologic and hydrologic data. Develop a hydrogeologic framework and conceptualize ground-water-flow systems. Sample 150 wells for concentrations of major cations and anions, nutrients, dissolved-organic carbon, silica, and radon. Use various geochemical models to examine some geochemical reactions. Use a Geographic Information System to store, manipulate, and display data.

SUMMARY: Ground-water quality samples from 50 wells have been collected and analyzed. Water levels have been measured in 110 wells throughout the county to determine the position and configuration of the water table during the seasonal high. The use of chlorofluoromethanes (CFC's) for age determination of ground water has been tested in three areas within the county. A total of 10 wells were sampled and analyzed for CFC's, tritium, deuterium, oxygen-18, and dissolved gases. A preliminary evaluation of the hydrogeologic framework of the Coastal Plain in the county has been initiated.



Clarke County Ground Water (VA081)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Winfield G. Wright

COOPERATORS:

Clarke County

Lord Fairfax Planning District Commission

PERIOD OF PROJECT: October 1985 through June 1988

PROBLEM: An effective ground-water-management plan is essential for an area such as Clarke County, which is underlain by limestone and dolomite rocks (karst terrain) and fractured metamorphic rocks. Development of a conceptual model of the county's ground-water-flow system is the first step to developing an understanding of the complex flow systems of the Appalachian Mountains. An assessment of the effects of natural processes and human activities on ground-water quality is needed to support the conceptualization of the flow systems, and to indicate the types of contaminants that persist in ground water as a result of human activities. Hydrologic data need to be maintained in computer data bases compatible with a Geographic Information System to use and update these data for future studies and for management of the ground-water resources.

OBJECTIVES: (1) Characterize the ground-water-flow system and map the potentiometric surface. (2) Describe the general ground-water quality of the county. (3) Establish a monitoring network of wells and springs. (4) Compile data to be entered into a computer data base.

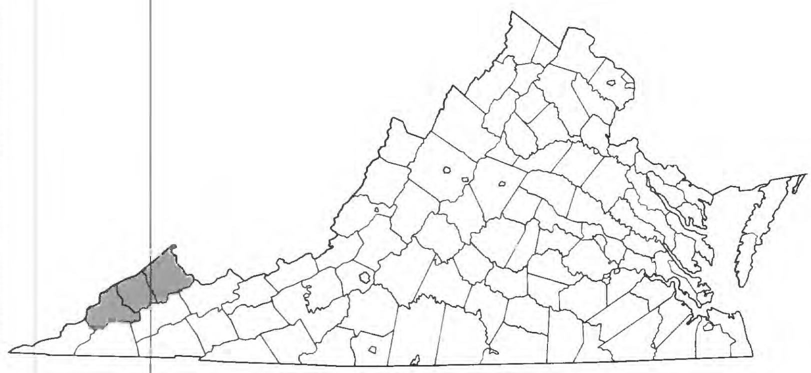
APPROACH: Compile available data on wells and springs from previous studies and from other agencies. These data include well and spring locations, well-construction data, depths and yields of wells, flow rates of springs, and ground-water-quality data. Place recorders on wells and springs to determine the response of water levels to rainfall and fluctuations in discharge from springs. Perform water-level measurements in approximately one well per square mile, or more in areas of hydrologic significance.

Collect ground-water samples from five springs and one well for a full suite of laboratory analyses including concentrations of pesticides, major ions, and nutrients. Collect ground-water samples from 30 wells to analyze for concentrations of bacteria and nutrients.

Enter ground-water data into the USGS's Ground-Water Site Inventory System to ensure the uniform coverage of data fields and quality of data.

SUMMARY: Two distinctly different ground-water-flow systems occur in Clarke County--a mixed diffuse-flow and conduit-flow system in the karst aquifer of the valley, and flow in fractures in metamorphic rocks of the mountain. Springs in the valley have larger recharge areas than springs on the mountain. Ground-water flow, indicated by a water-table contour map, generally mimics the shape of land surface but locally is controlled by the faulted, folded, and fractured rocks. Ground-water-quality analysis indicates that ground water in the valley has greater concentrations of dissolved minerals than the mountain, springs in the valley have lower concentrations of dissolved minerals than wells, ground water in the valley is very hard, and ground-water quality throughout much of Clark County has been affected by human activities.

Location of Aquifers and Determination of Aquifer Characteristics in the Coalfields of Southwestern Virginia (VA080)



VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: George E. Harlow

COOPERATOR:

Virginia Division of Mined Land Reclamation

Virginia Polytechnic Institute and State University, Powell River Project

PERIOD OF PROJECT: July 1985 through September 1988

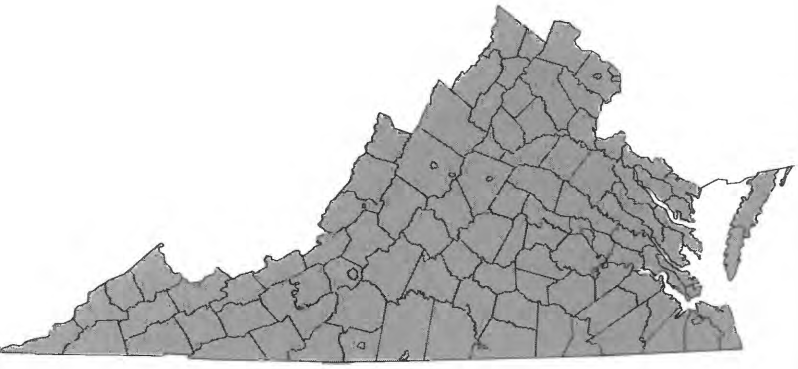
PROBLEM: Data are insufficient to indicate where and if ground water is a significant resource throughout most of the coal-mining areas of southwestern Virginia. These data are needed by the regulatory agency to establish the amount of ground-water monitoring to be required of coal operators to determine the effects of mining on the resources prior to granting a mining permit. Aquifer characteristics needed to determine whether existing computer models are capable of simulating the ground-water system are nonexistent.

OBJECTIVES: (1) Locate water-bearing zones. (2) Determine transmissivity and estimate storage in selected water-bearing zones. (3) Determine hydraulic head and water quality in selected water-bearing zones. (4) Develop a conceptual model of the ground-water system. (5) Determine probable adequacy of existing digital models for simulating the ground-water-flow system. (6) Establish a base of ground-water data.

APPROACH: Core holes drilled by mining companies were used in this investigation. Core holes were examined using geophysical logs (neutron, electric, gamma, temperature-fluid resistivity, and caliper) to locate water-bearing zones suitable for testing. Zones were isolated using slug and (or) injection tests to determine transmissivity. Static head and pumped water samples from isolated zone were measured. Head data, water quality, logs, and transmissivity were used to develop a conceptual model and determine adequacy of existing models.

SUMMARY: The ground-water system of southwestern Virginia coalfields consists of three zones: (1) a shallow zone from ground surface to a variable but generally maximum depth of 130 ft; (2) an intermediate zone from approximately 130 to 630 ft below land surface; and (3) a deep zone at depths greater than 630 ft. The shallow zone is heavily fractured with numerous bedding-plane separations. In the valley bottoms, where the depth to ground water is shallowest, an unconfined aquifer exists in these fractures and bedding-plane separations. On hilltops, where the depth to ground water is greatest, the shallow zone is variably saturated and receives most of its recharge during periods of high snowmelt and precipitation accompanied by low evapotranspiration.

The potentiometric heads of the shallow-zone test intervals were equal to the core-hole water elevations. The intermediate zone was usually saturated except for some upper zones on some hilltops. The coal seams of the intermediate zone are confined aquifers and the sandstone, siltstone, and shale are confining units. The coal-seam aquifers are recharged through deep vertical fractures that connect the intermediate zone to the shallow zone. Potentiometric heads of the intermediate-zone coal seams decrease with increasing depth. Structural forces such as faulting and folding can increase the depth of the intermediate zone.



Surface-Water Stations (VA001)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Byron J. Prugh, Jr.

COOPERATORS:

City of Alexandria

City of Bedford

City of Newport News

City of Roanoke

City of Radford

James City County

Northern Virginia Planning District Commission

Rappahannock-Rapidan Planning District Commission

Southeastern Public Service Authority

Tennessee Valley Authority

U.S. Army Corps of Engineers

Virginia Water Control Board

PERIOD OF PROJECT: Continuous since 1923

PROBLEM: Surface-water information is needed for purposes of surveillance, planning, design, hazard warning, operation, and management, in water-related fields, such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. To provide this information, an appropriate data base is necessary.

OBJECTIVES: (1) Collect surface-water data sufficient to satisfy needs for current-purpose uses, such as assessment of water resources, operation of reservoirs or industries, forecasting, disposal of wastes and pollution controls, discharge data to accompany water-quality measurements, compact and legal requirements, and research or special studies. (2) Collect data necessary for analytical studies to define for any location the statistical properties of, and trends in, the occurrence of water in streams, lakes, estuaries, and other water bodies, for use in planning and design.

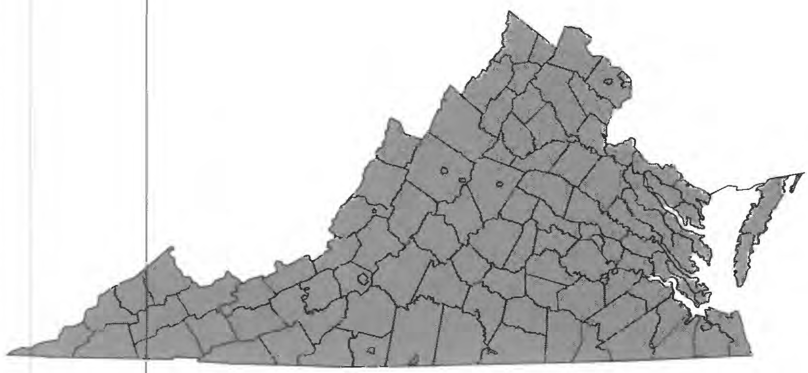
APPROACH: Use standard methods of data collection as described in the series, "Techniques of Water Resources Investigations of the U.S. Geological Survey." Use partial-record gaging instead of complete-record gaging where it serves the required purpose.

SUMMARY: Field collection of basic streamflow data needed to assess the surface-water resources of Virginia continued. The current network consists of 84 continuous-record, 4 stage-only, 5 rating-only, and 30 partial-record sites. An additional 105 streamflow sites are operated by the Virginia Water Control Board as part of a cooperative stream-gaging program. Satellite data platforms at 36 sites operated by the Virginia office for two U.S. Army Corps of Engineers Districts provide real-time data on stage and rainfall for improved management of four multipurpose reservoirs. Land-line telemetry at 21 sites provides data to the National Weather Service to assist in flood forecasting. (See section "Annual Water-Data Reports" for locations of data-collection sites and information on publication of data.)

Ground-Water Stations (VA002)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Byron J. Prugh, Jr.

COOPERATORS:

Virginia Water Control Board

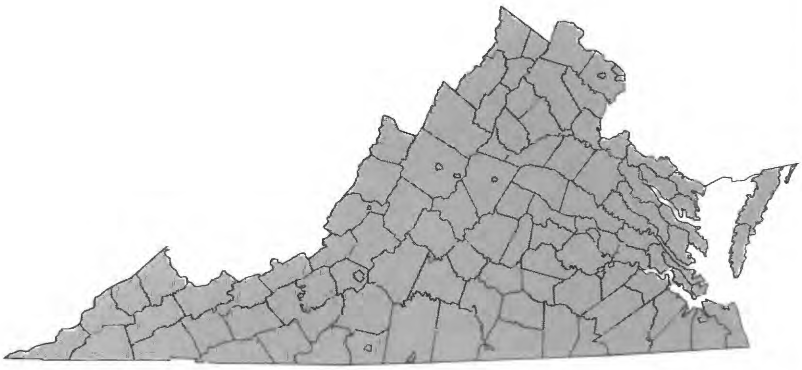
PERIOD OF PROJECT: Continuous since 1966

PROBLEM: Long-term water-level records are needed to evaluate the effects of climatic variations on the recharge to and discharge from the ground-water systems, to provide a data base from which to measure the effects of development, to assist in the prediction of future supplies, and to provide data for management of ground-water resources.

OBJECTIVES: (1) Collect water-level data sufficient to provide a minimum long-term data base so that the general response of the hydrologic system to natural climatic variations and induced stresses is known and potential problems can be defined early enough to allow proper planning and management. (2) Provide a data base against which the short-term records acquired in areal studies can be analyzed. (3) Measure the effect of long-term ground-water withdrawals on land subsidence.

APPROACH: Operate several networks of observation wells across the State. One network monitors the shallow water-table aquifers and another monitors the deep aquifers on the Coastal Plain. Periodic review and evaluation of regional geology allows broad, general definition of aquifer systems and their boundary conditions. Within this framework and with some knowledge of the stress on the system in time and space and the hydrologic properties of the aquifers, a subjective decision can be made on the most advantageous locations for observation wells to monitor long-term system behavior. This subjective network can be refined as records become available and detailed areal studies of the ground-water system more closely define the aquifers, their properties, and the stresses to which they are subjected. The Virginia Water Control Board (VWCB) operates a network of nearly 200 observation wells and several clusters of research wells that complement the USGS network.

SUMMARY: Routine collection of water-level data continued. Data for 207 observation wells collected during the 1988 water year were entered into the Ground Water Site Inventory file and published in the annual data report. Descriptions for an additional 113 wells operated by the VWCB are included in the 1989 annual data report. Collection of subsidence data at sites in southeastern Virginia in Franklin and Suffolk Counties continued. The frequency of measurement of water levels in the various observation wells was reviewed and reduced from bimonthly to quarterly or semiannually at many locations in an attempt to maximize the data coverage within the project budgetary and personnel constraints. Data from a network of 12 observation wells in the shallow water-table aquifer were compiled monthly to assist in the assessment of current ground-water conditions across the State and to provide input to the USGS publications on National Water Conditions and the Virginia Water Resources Summary. (See section "Annual Water-Data Reports" for locations of selected data-collection sites and information on publication of data.)



Water-Quality Stations (VA003)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Donna L. Belval

COOPERATOR:

Virginia Water Control Board

PERIOD OF PROJECT: Continuous since 1966

PROBLEM: Water-resource planning and water-quality assessment require a Statewide base level of standardized information. For planning and assessment of the water resource, the chemical and physical quality of the streams must be defined and monitored.

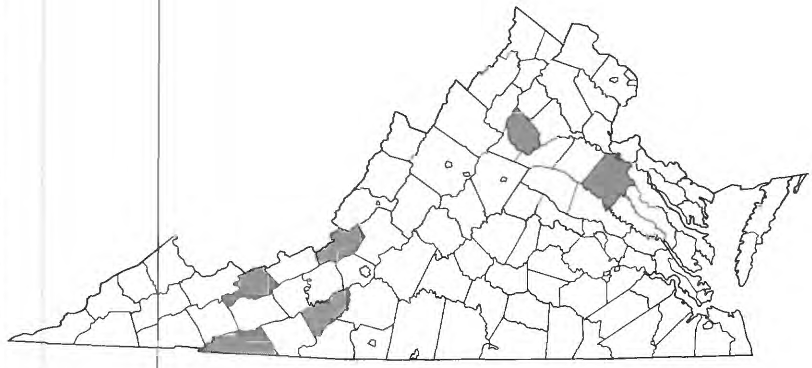
OBJECTIVES: (1) Provide a State bank of water-quality data for broad State and Federal planning and action programs. (2) Provide data for Federal management of interstate waters. (3) Develop a data base against which the short-term records acquired in areal studies can be compared.

APPROACH: Operate a network of water-quality stations to provide chemical concentrations, loads, and temporal trends as required by planning and management agencies. The network is designed to selectively sample all major rivers in Virginia; obtain comprehensive descriptions of chemical composition and loads for major hydrologic units as part of nationwide overviews; and provide long-term assessment of natural hydrologic conditions in selected areas minimally affected by human activities. The hydrologic network is periodically analyzed to define the statistical properties of, and trends in, the quality of water in Virginia.

The five major tributaries to the Chesapeake Bay that originate in Virginia are sampled monthly as part of the Chesapeake Bay Program. This program provides a data base to assess long-term trends in the sediment and nutrient loads to the Bay.

SUMMARY: This network of stations changes occasionally to meet local needs and the needs of nationwide programs of the USGS. Monthly Fall Line sampling of Virginia's five major tributaries to the Chesapeake was initiated in July 1984, and continues to date. (See section "Annual Water-Data Reports" for locations of data-collection sites and information on publication of data.)

Federal Emergency Management Agency Flood Investigations (VA006)



VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Byron J. Prugh, Jr.

COOPERATOR:

Federal Emergency Management Agency

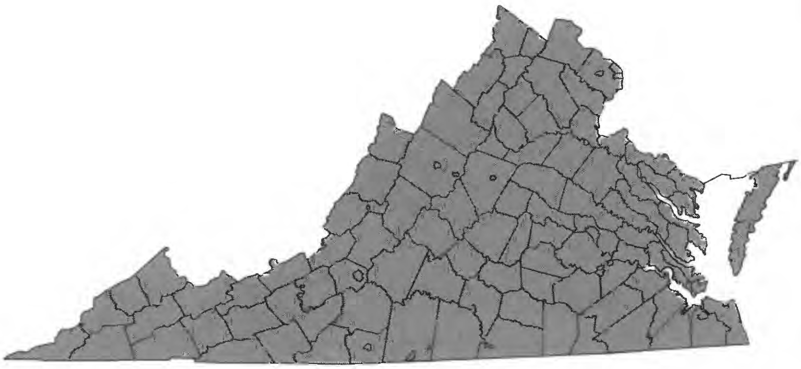
PERIOD OF PROJECT: July 1985 through September 1988

PROBLEM: The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 provide that the Department of Housing and Urban Development operate a flood insurance program through the Federal Insurance Administration. The Department of Housing and Urban Development needs flood studies in selected areas to determine applicable flood insurance premium rates.

OBJECTIVE: To aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1979 by investigation of the existence and severity of flood hazards in assigned communities. Initial use of this information will be to convert the community to the regular program of flood insurance by the Federal Insurance Administration. Further use of the information will be by local and regional planners in their efforts to promote sound land use and flood-plain development.

APPROACH: Perform a flood-frequency analysis for the study area to determine the discharges of the 10-, 50-, 100-, and 500-year floods. Conduct ground surveys by contract where efficient, or by using USGS personnel. Using a step-backwater model, compute flood profiles for the 10-, 50-, 100-, and 500-year floods. Prepare draft flood insurance study and work map showing flood boundaries, floodway boundaries, and flood-insurance zones. Draft material follows Federal Insurance Administration specifications.

SUMMARY: Detailed study of Front Royal was completed and the final report sent to Federal Emergency Management Agency in January 1987. Less detailed studies were completed and a meeting was held with county representatives to discuss results: Bland County (May 1987 and February 1988), Madison County (August 1987 and May 1988), Craig County (August 1987 and July 1988), Grayson County (September 1987 and July 1988), Floyd County (March 1988 and August 1988), and Caroline County (November 1987 and August 1988).



Water-Use Data System (VA007)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Todd Augenstein

COOPERATOR:

Virginia Water Control Board

PERIOD OF PROJECT: Continuous since 1978

PROBLEM: An up-to-date water-use data system is needed in Virginia to provide detailed information to serve policy, planning, programming, budgeting, and management needs.

OBJECTIVE: Update, improve, and maintain the Site-Specific Water Use Data System (SSWUDS) of the USGS. It is a continuation of the efforts begun in fiscal year 1978 that resulted in a conceptual design of the system in cooperation with the State of Virginia.

APPROACH: Update existing SSWUDS data with current data from the Virginia Water Control Board (VWCB) on an annual basis. Select site-specific well data and water-use data from cooperating agencies in the State, and develop methods to correlate the data with the current SSWUDS water-use data. Implement a pilot program for compiling and collecting data. Select data-base management software and design data-base support software.

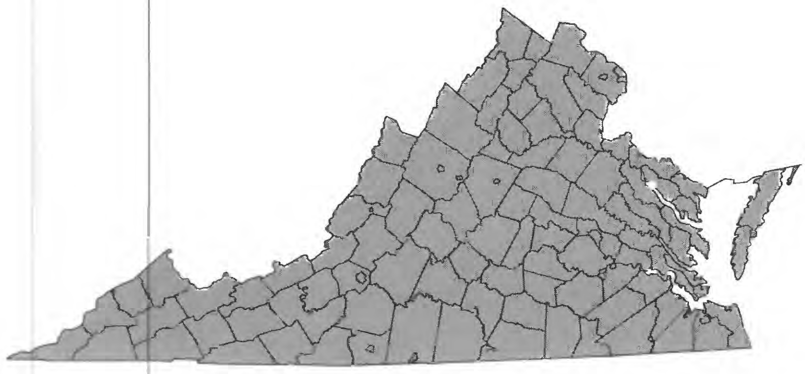
SUMMARY: The 1990 water-use data for the 13 categories of use have been collected and compiled and will be presented in "Estimate of Use of Water in the United States in 1990."

In cooperation with the VWCB, SSWUDS site-specific well data are being correlated with the Water Resources Division Ground-water Site Inventory Data Base (GWSI) and U.S. Environmental Protection Agency (USEPA) utility for STOrage and RETrieval of data (STORET). The Proximity Analysis Menuing System (PAMS) has been written to assist in correlating data from different data bases. Developed software using Geographical Information Systems (GIS) technology in order to perform a mass balance of water availability along a river reach. Irrigation data have been collected for the Pamunkey River basin to be used to demonstrate the functionality of the mass-balance software.

Flood Characteristics of Virginia Streams (VA019)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Byron J. Prugh, Jr.

COOPERATOR:

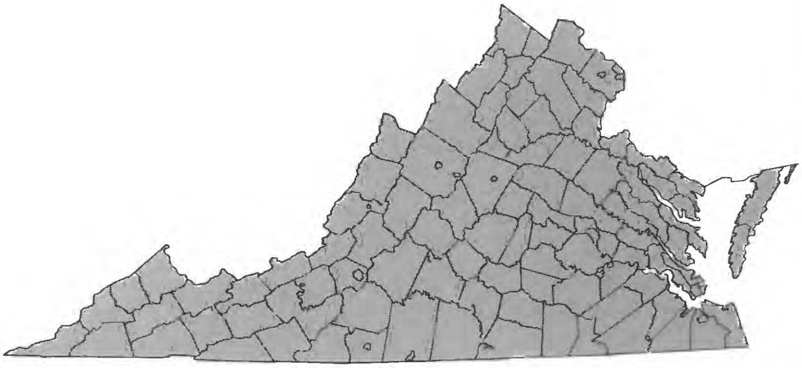
Virginia Department of Transportation

PERIOD OF PROJECT: Continuous since July 1948

PROBLEM: The Virginia Department of Transportation needs information on flood characteristics of Virginia streams for design and maintenance of a Statewide transportation network.

APPROACH: Operate Statewide network of high-flow partial-record sites; make direct and indirect measurements of peak flows as unusual floods occur; publish peak flows on interim basis in annual data report and in an updated summary report every 10 years; and enter peak flows into a WATer Data STOrage and REtrieval System (WATSTORE). Prepare special reports for unusual floods as they occur.

SUMMARY: Current network consists of 79 partial-record sites. Retrieval of peak-flow elevations continued, and most sites were visited quarterly. Peaks for previous water year were entered into data base and published in annual data report. Several localized areas of flooding were observed in 1989, but the last major flood was in the Roanoke River basin in September 1987. Progress continued on updating the peak-flow report published in 1977. Summary tables of flood peaks through water year 1988 and site-location and data-collection histories for over 500 sites are in preparation.



Development of Techniques to Estimate Low-Flow Characteristics of Virginia Streams (VA061)

VIRGINIA

Coastal Plain
Piedmont
Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Donald C. Hayes

COOPERATOR:

Virginia Water Control Board

PERIOD OF PROJECT: June 1980 through September 1986

PROBLEM: Estimates of streamflow during low-flow periods are needed for design, management, and regulation by State, local, and private agencies. Low-flow data also are used as input to ongoing District studies on coal hydrology, water-quality assessment, and ground-water resource appraisal. Existing low-flow data are not adequate to meet the needs of these groups and projects.

OBJECTIVES: (1) Develop a regression model based on basin characteristics to predict 7-day, 10-year low-flow and other selected low-flow values. (2) Prepare a map showing 7-day, 10-year low-flow values for all continuous- and partial- record sites in Virginia. (3) Prepare interpretive report presenting techniques for estimating low flows at both gaged and ungaged sites.

APPROACH: Compile listing of available low-flow data for all major river basins in the State. Review and determine need for additional data to give variability in drainage-area and basin-characteristic coverage. Use existing sites, where possible, to reduce need for new field data. Prepare regression models for each physiographic region of the State; calibrate with existing data or new-site data after correlation with long-term sites.

SUMMARY: Conducted a statistical analysis on continuous-record sites to determine low-flow characteristics. Conducted a correlation of partial-record sites to continuous-record sites and estimated low-flow values. A flow-routing method was developed to estimate low-flow characteristics of ungaged sites on streams with streamflow gages, and regional regression equations were developed for estimating low-flow characteristics for ungaged streams.

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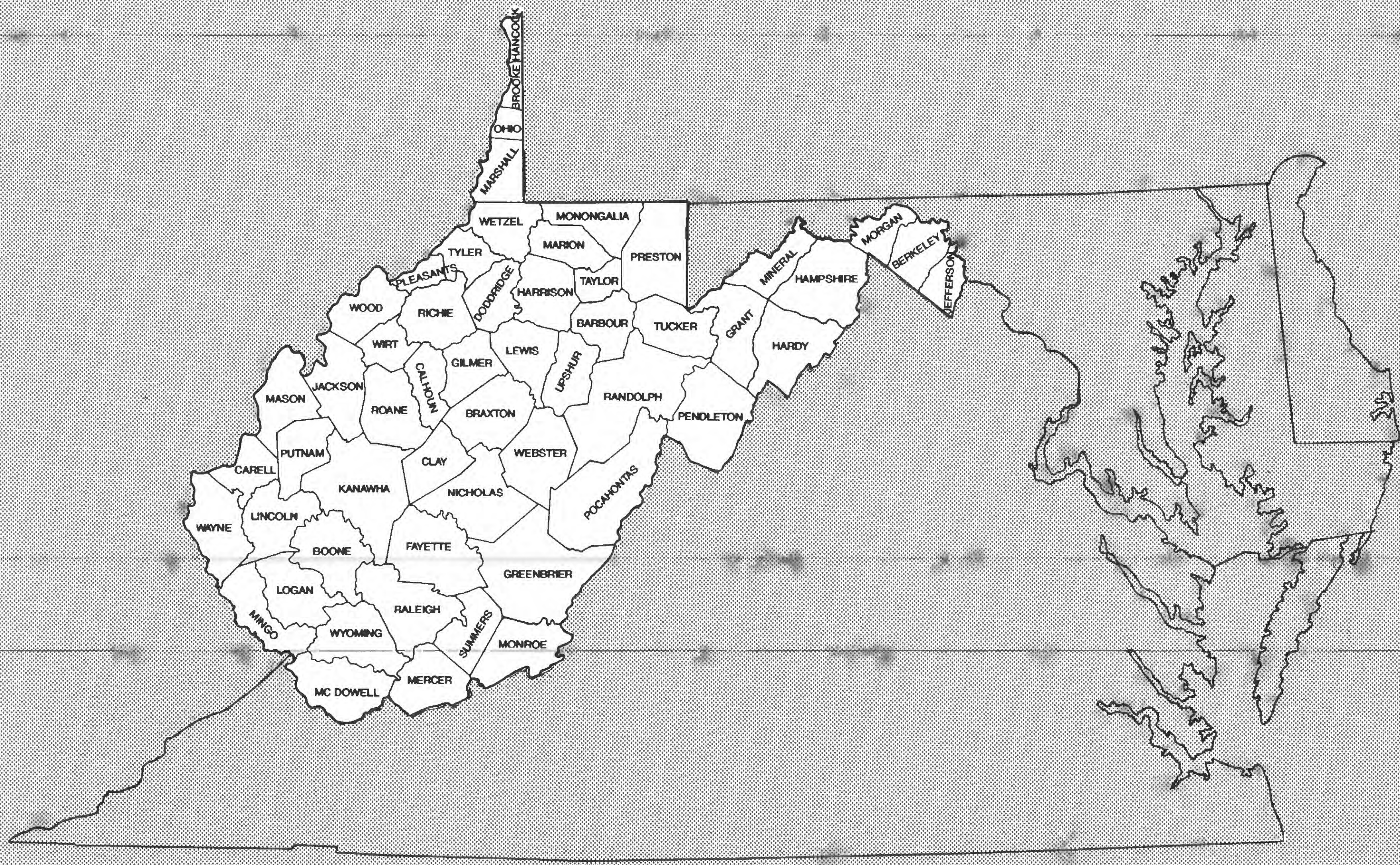


Figure 8.--Counties of West Virginia.

Ground-Water Flow in Karst Areas of Jefferson County, West Virginia (WV066)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADERS: William A. Hobba Jr., and Mark D. Kozar

COOPERATORS:

Jefferson County Commission

West Virginia Department of Natural Resources,
Division of Water Resources

PERIOD OF PROJECT: October 1987 through September 1989

PROBLEM: Intensive vertical fracturing has occurred in valleys underlain by limestone in Jefferson County. Because of the high degree of solubility of limestone, these fractures have been enlarged through dissolution and karst topography has developed. Individuals and communities obtain water supplies from ground-water sources. Recharge is rapid and occurs through sinkholes, caves, and streams. Sinkholes are commonly used for disposal of wastes. Wells drilled into caves are used as drains permitting direct inflow of contaminants into the ground-water reservoir. Pesticide disposal, spills of petroleum products, and leachate from landfills and impoundments are potential sources of contamination of ground-water resources. Contaminated water will move rapidly through solution channels in limestone formations and contaminate public-supply wells, springs, and streams.

OBJECTIVES: (1) Delineate ground-water-flow systems in karst (limestone) areas and describe the hydrogeologic characteristics of various aquifers. (2) Assess the ground-water quality of principal aquifers and identify areas near public supply where changes in water quality have occurred. (3) Develop hydrologic, geologic and geographic data bases that are compatible with Geographic Information Systems.

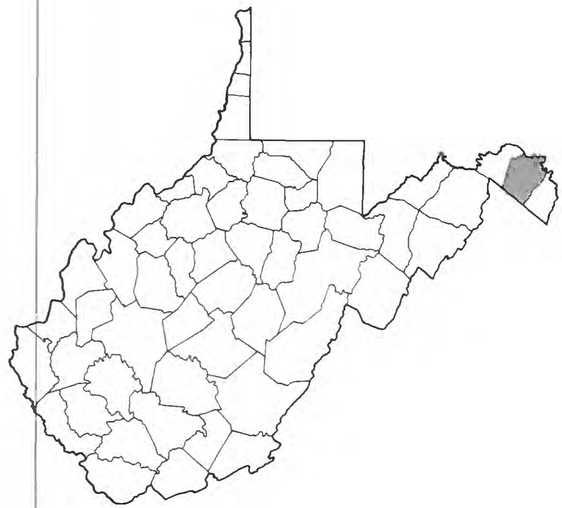
APPROACH: Review and analyze existing geologic and hydrologic data to describe the hydrogeologic characteristics of aquifers. Map major karst features, especially those near major transportation arteries, near potential sources of contamination, and near public-supply wells or springs. Delineate the ground-water-flow system in the various aquifers by performing dye-tracer studies. Define the direction and rate of ground-water flow. Collect and analyze water samples from about 40 wells. Enter hydrologic, geologic, water-quality, and cultural data into data bases that are compatible with a Geographical Information System.

SUMMARY: All necessary data have been collected. Five ground-water dye-tracer tests were performed. Seventy ground-water sites were sampled for standard constituents, metals, nutrients, and bacteria. Thirty of these 70 sites also were sampled for the organochlorine and organophosphorus classes of pesticides. Approximately 650 sinkholes have been mapped in the study area. Thirteen surface-water sites were measured during base flow and sampled for calcium, magnesium, chloride, and nutrients. Four observation wells, two springs, and two spring-fed streams provided ground-water level or discharge data throughout the study. Seven of these eight sites were sampled quarterly and analyzed for most constituents. Pesticides of the organochlorine, organophosphate, and triazine classes were collected at two spring-fed streams.

Ground-Water Flow in Berkeley County, West Virginia (WV069)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Robert A. Shultz

COOPERATOR:

Region IX Planning and Development Council

PERIOD OF PROJECT: February through January 1991

PROBLEM: Berkeley County, W.Va., is experiencing a rapid increase in population--about 30 percent from 1970 to 1980--and the associated need for dependable water supplies. The western half of the county is underlain by shale, sandstone, and some limestone; the eastern half of the county is underlain by limestone and some shale. Dissolution of the limestone has caused fractures to enlarge, and karst topography has developed. Recharge in these areas is rapid and typically occurs through sinkholes, caves, and streams. If the ground water in a particular area were to become contaminated, it could move rapidly through solution channels in the limestone formations and contaminate public-supply wells, springs, and streams.

OBJECTIVES: (1) Describe the hydrogeologic characteristics of and delineate the ground-water-flow systems in the karst (limestone) areas. (2) Describe the hydrogeologic characteristics of various shale-sandstone aquifers. (3) Assess the ground-water quality of the principal aquifers and identify areas near public-supply sources where changes in water quality have occurred. (4) Develop hydrologic, geologic, and geographic data bases that are compatible with a county-owned Geographic Information System (GIS), should the county obtain such a GIS during this investigation.

APPROACH: Review and analyze existing geologic and hydrologic data to describe the hydrogeologic characteristics of aquifers. Compile and map information on major karst features near public-supply wells or springs, along major transportation arteries, and near potential sources of contamination. Use dye-tracer tests to determine the direction of ground-water flow in the karst areas. Define a generalized direction and rate of ground-water flow defined by the results of these tests. Collect and analyze water samples from about 100 wells tapping limestone aquifers for common indicator constituents. Analyze water samples from about 50 wells tapping shale and sandstone aquifers for common indicator constituents.

SUMMARY: A water-level observation network has been established--4 wells with recorders and 28 monthly wells. Ground-water discharges are being measured at nine springs. Quarterly water-quality samples were collected at seven springs. Water-quality samples were collected at 60 sites during August 1989. The USGS West Virginia District will continue to measure water levels and spring discharges at the observation sites in 1990. Two dye-tracer tests will be made. Flow measurements will be made on three or four streams so that an estimate of the ground-water yield from each geologic formation can be calculated.

Ground-Water Flow and Quality in Canaan Valley, West Virginia (WV072)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Mark D. Kozar

COOPERATOR:

West Virginia Geological and Economic Survey

PERIOD OF PROJECT: October 1990 through September 1992

PROBLEM: Canaan Valley, a popular resort area, has been under intense development pressures in recent years. The effects of development and resulting population increases on the hydrologic environment are a major concern of area residents and State and local officials. A dependable water supply is needed to support the increase in population. Ground water is a major source of potable water for the area. Little information is available on the quantity or quality of ground water in the valley.

OBJECTIVES: (1) Provide information about the hydrogeology and assess the ambient ground-water quality of the principal aquifers in Canaan Valley. (2) Develop a conceptual model of the ground-water-flow system in the valley.

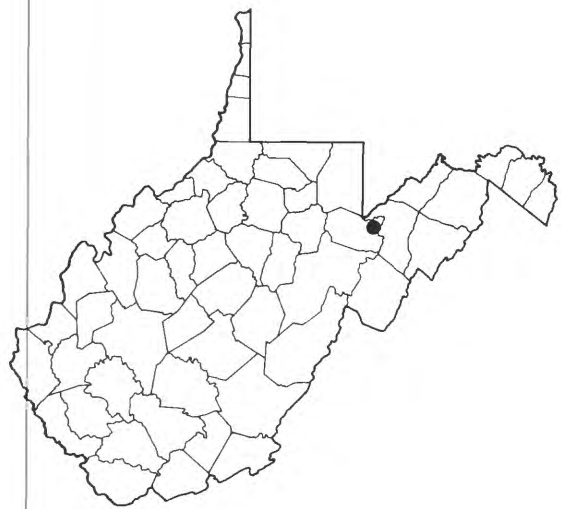
APPROACH: The hydrologic and geologic information needed to develop a conceptual model of ground-water flow includes: (1) description of the geologic framework of Canaan Valley and adjacent areas, (2) delineation of principal aquifers in the area, (3) determination of the physical characteristics and hydraulic properties of principal aquifers and their boundary conditions, (4) determination of water use and ground-water development in the area, and (5) determination of changes in ground-water storage (both seasonal and long-term) and the direction and rate of ground-water movement. Hydrologic and geologic information will be obtained from published reports, well records, and data files of various State and local governmental agencies and the USGS. Additional information will be based on geologic mapping, well inventory, aquifer tests in principal aquifers, and water-level data from observation-well network. Determination of the ambient ground-water quality of the principal aquifers will be based on data obtained from ground-water quality monitoring network.

SUMMARY: Four observation wells were installed to monitor water-level fluctuations and aquifer response to recharge. A network of nine wells was established for monitoring water quality on a bimonthly basis to determine seasonal water-quality variation. A water-level well inventory was conducted to determine hydraulic gradients. Water levels were measured in 49 of the wells inventoried and 50 of the wells were sampled for nutrients, bacteria, and common ions. Sixteen of the 50 sites were sampled for radon and 5 for the triazine, organochorine, organophosphate, and chlorophenoxy acid classes of pesticides.

Assimilative Capacity of a High-Altitude Wetland, Canaan Valley, West Virginia (WV073)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Marcus C. Waldron

COOPERATORS:

Tucker County Planning Commission

West Virginia Department of Natural Resources, Division of Water Resources

West Virginia Department of Commerce,Division of Parks and Recreation

PERIOD OF PROJECT: September 1990 through September 1993

PROBLEM: The Canaan Valley of northern West Virginia contains one of the largest high-altitude wetlands in the Appalachians and is valued because of its unique water and biological resources. The Canaan Valley has experienced rapid development in the past decade. Much of the development is associated with the recreational industry, particularly skiing. Each development complex maintains its own wastewater-treatment system. The volume of wastewater discharged to the Blackwater River and its tributaries has greatly increased in recent years. To avoid degradation of water quality in the Blackwater River, it is necessary to establish the capacity of the river to assimilate wastewater prior to additional large-scale development. Development and calibration of water-quality and flow models should provide quantitative information about the biological impacts on water quality in the stream and wetland system. An improved understanding of the effects of wastewater discharges on the chemical quality of the stream and an understanding of the factors that determine the assimilative capacity of the stream and associated wetland area are necessary to aid in predicting the effects of additional wastewater discharges on water quality.

OBJECTIVES: (1) Determine the impact of wastewater discharges on the surface-water resources of the Canaan Valley. (2) Determine and quantify the factors that control the capacity of the wetlands and surface waters of Canaan Valley to assimilate wastewater on a year-round basis.

APPROACH: The U.S. Environmental Protection Agency's surface-water quality model, WASP4, will be used to aid in quantifying the various factors that affect surface-water quality in the Canaan Valley. Emphasis will be placed on the modeling of dissolved oxygen and nutrients. Streamflow, water-quality, and meteorological data will be collected at select points throughout the Canaan Valley and used to calibrate and verify the model. Modifications to the WASP4 model will be necessary to deal with characteristics of wetland systems, such as the presence of large numbers of submerged rooted macrophytes. Existing land-use, water-quality, and streamflow data will be evaluated at the start of the study and used to aid in design of the data-collection network. Emphasis will be placed on the Blackwater River and the tributaries that receive wastewater. Continuous record stream-gaging stations and periodic streamflow measurement will be used to determine streamflow of the Blackwater River and selected tributaries in Canaan Valley. Dye-tracing tests will be conducted in select stream segments to determine the degree of mixing of water from the stream channel with water in the wetlands. Water-surface and bed-elevation profiles will be surveyed to determine the volume of water contained in the stream channel and the wetlands. Time-of-travel and reaeration studies will be performed for select stream segments at high and low streamflow to determine the rate of movement of the nutrient loads associated with the wastewater discharges.

SUMMARY: Project is just beginning.

Microenvironmental Determinants of Denitrification in Wetlands, (WV074)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Marcus C. Waldron

COOPERATORS:

Tucker County Planning Commission

West Virginia Department of Commerce, Division of Parks and Recreation

PERIOD OF PROJECT: October 1990 through September 1991

PROBLEM: Denitrification is a potentially significant pathway for removal of combined nitrogen from wetlands that are receiving wastewater discharges. Little is known about rates of denitrification and environmental factors that regulate denitrification in wetlands.

OBJECTIVES: (1) Develop methods for measuring onsite denitrification in wetland soils and sediments. (2) Identify key environmental factors that regulate denitrification in a specific wetland located in northern West Virginia.

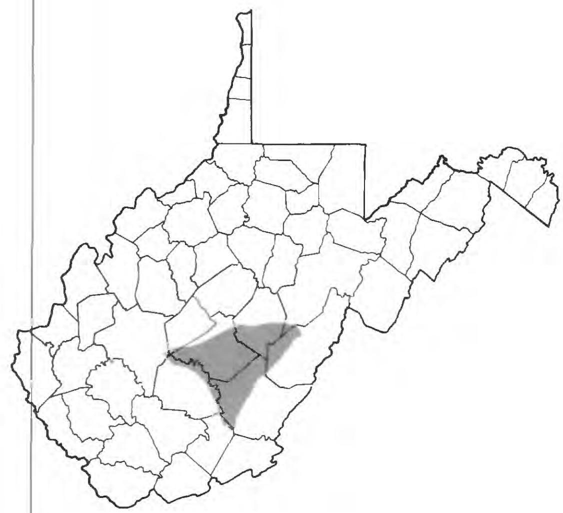
APPROACH: Sediment cores will be collected seasonally for 1 year at several locations in a meadow-marsh wetland adjacent to Canaan Valley State Park, Tucker County, W. Va., and analyzed for denitrification rates, numbers of denitrifying bacteria, pH, redox potential, and concentrations of all nitrogen species. Subsamples representing different microenviroments will be collected and analyzed for each core. Rates of denitrification will be determined by injecting acetelyne-saturated water into the subsamples and following rates of accumulation of nitrous oxide. Redox potential and pH will be determined by inserting microelectrodes into the cores at various levels and monitoring electrode potential in place. Additonal subsamples will be collected and sent to the National Water Quality Laboratory for nitrogen analyses. Data on seasonal and microenvironmental differences in all parameters will be analyzed statistically in an effort to identify key regulatory factors.

SUMMARY: Project is just beginning.

Water Resources of the Gauley River Basin, West Virginia (WV040)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Gerald S. Runner

COOPERATORS:

West Virginia Department of Natural Resources, Division of Water Resources

West Virginia Geological and Economic Survey

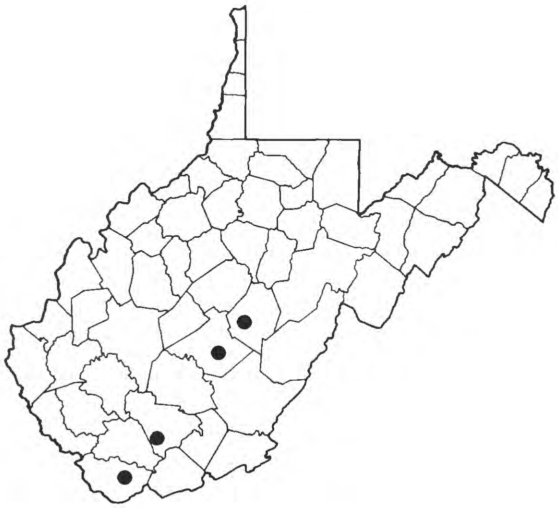
PERIOD OF PROJECT: October 1979 through September 1991

PROBLEM: Major water-resource problems in the Gauley River basin include increased sediment loading from mining, timbering operations, agriculture, and construction; contamination of surface-water and ground-water sources by waste disposal and mine drainage; and changes in surface-water flow and water temperature due to seepage and reservoir operations.

OBJECTIVES: (1) Provide adequate hydrologic data to document flow, runoff, sediment yield, and flood characteristics of the subbasins. (2) Determine ground-water discharge to streams. (3) Determine the effect of reservoir operation on stream temperature. (4) Describe the chemical and biological quality of surface water, and time of travel on the main stem of the Gauley River.

APPROACH: Include in the investigation 14 surface-water stations, 5 sediment stations, 4 observation wells, 6 rainfall stations, seepage runs, time of travel at 3 flow rates, and 250 inventoried wells. Determine drainage areas for areas greater than 5 square miles. Analyze long-term discharge and rainfall data using standard programs. Analyze and evaluate short-term data by correlation and regression. Show graphically ground-water and water-quality data made available through the 4-year reconnaissance study.

SUMMARY: Rough draft of the report entitled "Water resources of the Gauley River basin, West Virginia" has been completed and is being revised.



Availability and Quality of Water from Selected Underground Coal Mines in West Virginia (WV054)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Gloria M. Ferrell

COOPERATORS:

West Virginia Geological and Economic Survey

West Virginia Governor's Office of Community and Industrial Development

PERIOD OF PROJECT: July 1983 through September 1987

PROBLEM: Many small communities in the coal areas of West Virginia have had problems of limited water supplies. In some areas, particularly in the southern part of the State, communities, industries, and individuals have turned to abandoned underground coal mines for their water supply. Approximately 70 public water systems pump more than 7 Mgal/d of water from abandoned underground coal mines to supply 82,000 people, various industries, and commercial establishments with potable water. An evaluation of the quantity and quality of water in abandoned underground mines is necessary to determine their potential as sources of water.

OBJECTIVES: (1) Evaluate selected abandoned underground mines as potential sources of water for public supply. (2) Determine the recharge, discharge, and water-storage capacity of selected abandoned underground mines. (3) Determine the quality of mine water and its spatial and temporal variability within the mine systems. (4) Determine the response of the mine system to pumping and the degree of hydraulic connection within the mines and with other adjacent mines. (5) Estimate the practical sustained yield available from the mines.

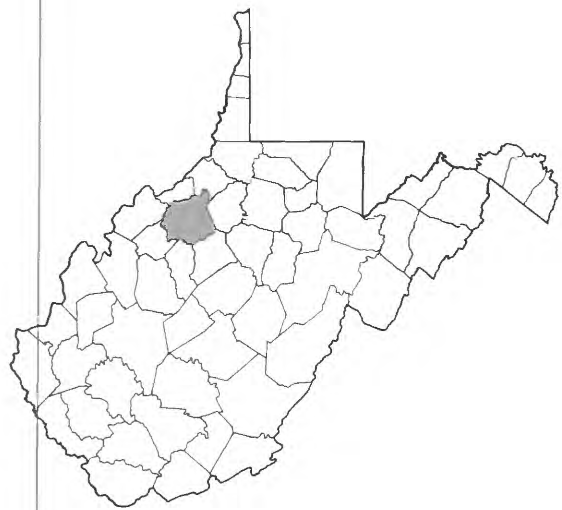
APPROACH: Perform an extensive literature and information search followed by a reconnaissance in areas of large-scale underground mining to locate abandoned mines with the capacity to store large quantities of water. Select two mines above and two below basin drainage. Use existing hydrologic and geologic data and monitoring programs to aid in describing the geologic and hydrologic setting. Perform test drilling if existing observation wells are not adequate. Estimate recharge, discharge, storage capacity, and practical sustained yield of the mine systems. Use sampling to provide information on mine water-quality variability with time, depth, and pumping level.

SUMMARY: Interpretive report has been completed and is in review. Project is complete except report.

Effects of Sediment Control Measures on Soil Erosion and Sediment Transport in Areas of Intensive Oil and Gas Well Development in Ritchie County, West Virginia (WV063)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Stephen M. Ward

COOPERATORS:

U.S. Soil Conservation Service

West Virginia Department of Natural Resources, Division of Water Resources

PERIOD OF PROJECT: October 1985 through September 1988

PROBLEM: There is about one oil or gas well site for every 60 acres in Ritchie County. Soil erosion and sediment transport in water from these areas are major problems because the soils in this part of the State are highly erodible. The Soil Conservation Service and West Virginia Department of Natural Resources, Water Resources Division, have questioned the reliability of the current method of predicting soil loss from oil and gas well sites. Reclamation procedures are probably not adequate.

OBJECTIVES: (1) Evaluate the effectiveness of conservation measures currently being used to control erosion on oil and gas well sites. (2) Evaluate the accuracy of current methods of estimating soil erosion (Universal Soil Loss Equation and Direct Volume Estimates) by comparison of these estimates of soil erosion with the actual measured load.

APPROACH: Two small basins, North Bend Run (90 acres) in State park boundaries and Robinson Run (45 acres), with a reclaimed gas well site and planned drilling for a new well, were selected to collect total sediment load. Compare the control basin to the active basin to address project objectives.

SUMMARY: Interpretive report has been completed and is in review.

Application of an Unsteady-Flow Solute-Transport Model to the Lower New River in West Virginia (WV065)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Jeffrey B. Wiley

COOPERATOR:

U.S. National Park Service

PERIOD OF PROJECT: July 1987 through September 1990

PROBLEM: The effects of an accidental spill of a soluble contaminant may potentially be mitigated by releasing water from Bluestone Reservoir and thus affecting traveltime, time of passage, and concentration. A study is needed to determine how changes in flow rate will affect the movement/dispersion of the contaminant. Dispersion characteristics change when flow is increased or decreased, and therefore the computations for estimating traveltime for the leading edge and time of passage of the contaminant cloud need to be adjusted.

OBJECTIVES: (1) Test and verify the Unsteady One-Dimensional Flow Model (HYDRAUX) and the One-Dimensional Langrangian Transport Model (LTM) under extreme hydraulic conditions where flows pass through critical depth several times in the study reach. (2) Define the effects of unsteady flow on the shape of a soluble dye concentration cloud.

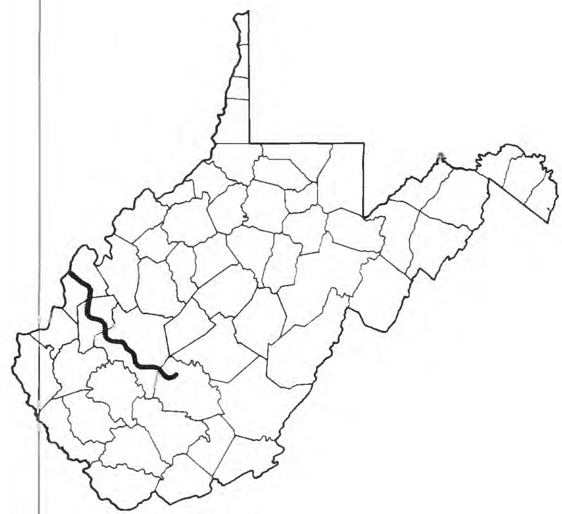
APPROACH: Collect time-of-travel data at one unsteady-flow condition--5 to 1 increase in flow. Change the flow release from Bluestone Reservoir to reach the dye cloud immediately upstream from the Stone Cliff Bridge. Use the HYDRAUX and the LTM models to simulate flow and solute movement. Collect and use hydraulic data as input to the models. Use the wave study results from Appel (U.S. Geological Survey Water-Supply Paper 2225, "Traveltimes of flood waves on the New River between Hinton and Hawks Nest, West Virginia") to calibrate the flow model and flow regulation periods used to verify the model. Use the steady-flow dye study by Appel and Moles (U.S. Geological Survey Water-Resources Investigation Report 87-4012, "Traveltime and dispersion in the New River, Hinton to Gauley Bridge, West Virginia") to calibrate the solute transport model and use individual dye measurements to verify the model.

SUMMARY: Two reports were published: a data report that presented channel characteristics data collected during 1987-88 and a symposium paper on characteristics of the New River National River, including river depths. Field-work has been completed and digital modeling has begun.

Traveltimes of Dissolved Conservative Contaminants in the Kanawha River, West Virginia (WV070)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Jeffrey B. Wiley

COOPERATOR:

Marshall University

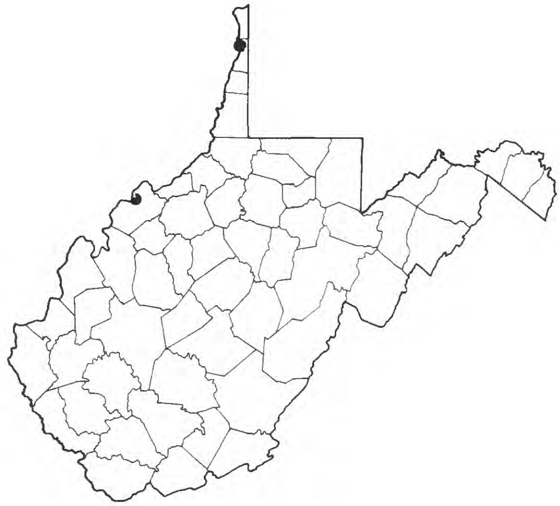
PERIOD OF PROJECT: March 1989 through September 1991

PROBLEM: There is a risk of accidental releases of hazardous chemicals into the Kanawha River from the manufacturing, storage, and transportation of chemicals in the valley. Large volumes of raw materials, chemical products, and chemical wastes are transported into and out of the area by water, rail, and highway. Recreation, aquatic life, and water consumption by industry would be adversely affected by accidental spills of contaminants in the river. No reliable methods are currently available to predict or estimate contaminant traveltimes and concentrations on the Kanawha River. Approximately 90 mi of the river are affected by variable backwater from the three locks and dams on the Kanawha River and one on the Ohio. Major tributary flows are gaged and there are two gages on the mainstem (Kanawha Falls, mile 94 and Charleston, mile 54). The streamflow-gaging station at Charleston is not accurate below 10,000 ft^3/s because of a flat water-surface slope and low velocities. The accuracy of this gage must be improved if the river is to be managed more effectively.

OBJECTIVES: (1) Improve the accuracy of the Charleston streamflow measuring station. (2) Determine the time of travel, dispersion, and concentration of fluorescein dye in the Kanawha River between Gauley Bridge and Pt. Pleasant, West Virginia, at approximate minimum sustained flows and average flows under a normal set of dam-operating conditions.

APPROACH: Install an ultrasonic velocity meter at Charleston to improve the determination of low flow. Using techniques described in "Techniques of Water Resources Investigations of the U.S. Geological Survey," conduct time-of-travel measurements at flow rates of 3,000 and 15,000 ft^3/s, which respresent approximate minimum sustained flow and average flow, respectively. Inject dye at four locations: Hawks Nest Power Plant, London Locks, Marmet Locks, and Winfield Locks. Inject the dye either into the penstocks at each dam or at the turbine discharge points to ensure complete mixing. Collect samples by boat where bridges are not available. Make the maximum distance between sample points 10 mi. Follow the most downstream dye cloud through Gallipolis Lock and Dam on the Ohio River, if possible.

SUMMARY: Rhodamine dye was injected at Winfield Lock and Dam in August 1989 at a streamflow of about 5,000 ft^3/s. The dye cloud was followed and sampled to Point Pleasant, West Virginia (31.1 mi). Dye was injected at Hawks Nest Dam, London Lock and Dam, and Marmet Lock and Dam in October 1989.



Determination of Aquifer Characteristics and Recharge Areas Contributing Water to Public-Supply Wells in Selected Aquifers in West Virginia (WV071)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Mark D. Kozar

COOPERATOR:

West Virginia Department of Health

PERIOD OF PROJECT: July 1989 through September 1991

PROBLEM: Many of the public-water supplies in the State use ground water from relatively shallow aquifers in the alluvial deposits along the Ohio River and the surficial bedrock aquifers. These aquifers are particularly vulnerable to contamination. The U.S. Environmental Protection Agency is involved in defining public-supply wellhead-protection strategies. To absolutely protect ground-water quality at an individual well or wellfield, an entire aquifer and its recharge area would have to be protected from possible sources of contamination. The approximate area of the aquifer and areas adjacent to the aquifer that contribute water to individual supply wells must be defined. Only when the sources of water for a well and the detailed pattern of ground-water flow to the well are fully understood can State and local governmental agencies protect the well, at least to some extent, from contamination.

OBJECTIVES: Describe the sources of water that sustain yields of public-supply wells and analyze factors that affect the size and shape of areas contributing water to supply wells in selected aquifers in the State. This information will be provided to the West Virginia Department of Health for their use in delineating wellhead protection areas around public-supply wells.

APPROACH: Collect and analyze hydrologic information for two public-water supply systems in the alluvial aquifers in the Ohio River valley. Obtain the hydrologic information that is needed to determine and analyze the contributing area to a well or wellfield. This information includes description of the aquifer, hydrologic properties of the aquifer and its boundary conditions, well inventory, observation-well network for preparing water-table maps, water-use inventory, and wellfield design. Delineate the location of existing or potential sources of contamination to the aquifer.

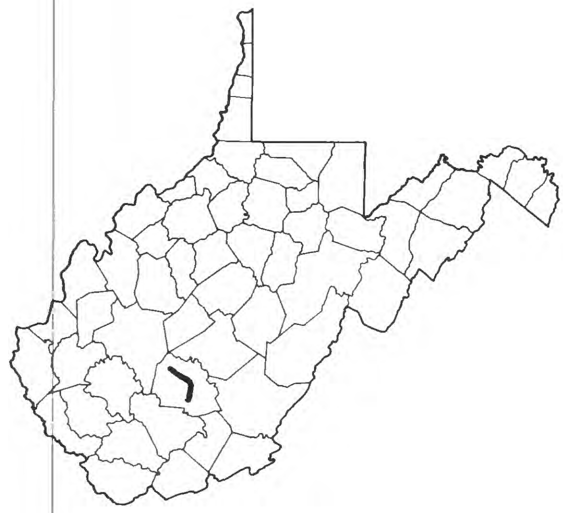
SUMMARY: Existing hydrologic and geologic information on the alluvial deposits and bedrock of the Parkersburg and Follansbee areas has been collected and is being evaluated. Well information has been obtained from computer files. Additional well information has been obtained from the West Virginia Department of Health.

Aquifer characteristics will be determined. Observation-well network will be established and water-table maps will be completed for Parkersburg and Follansbee areas. A USGS Open-File Report describing the hydrogeology and aquifer characteristics of selected areas in the Ohio River alluvium is in preparation.

Flood Investigation of the New River in the New River Gorge National River, West Virginia (WV076)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Jeffrey B. Wiley

COOPERATOR:

U.S. National Park Service

PERIOD OF PROJECT: April 1991 through December 1991

PROBLEM: The National Park Service needs flood-elevation information to develop park facilities along the New River. These facilities require knowledge of flood elevations to prevent unexpected repair and maintenance costs caused by flooding. Some projects may need to be located near the river and are expected to be frequently flooded, but other projects should be located outside the flood-hazard areas or where flooding is less probable.

OBJECTIVES: A flood investigation of the New River will provide essential information for the development of park facilities. Flood information will include (1) summary of peak discharges, (2) summary of Manning's roughness coefficients, (3) summary of flood velocities, (4) summary of flood elevations, and (5) profile plots of flood elevations.

APPROACH: Less-detailed methods of determining flood elevations (historic flood profiles and stage frequency) are not applicable to the study reach. The problems with these methods are: no historic flood profiles are available for comparsion purposes, river regulation negates the theory for application of regional equations, and channel geometry is atypical. Channel depth and width increase, and slope decreases for a typical river in the downstream direction; for this study reach, the channel depth increases, width decreases, and slope increases in the downstream direction. For these reasons, the USGS steady-state, one-dimensional flow model, WSPRO (Water Surface Profile) will be applied to the study reach. Cross sections for the study reach are available as described in the U.S. Geological Survey Open-File Report 89-423, "Hydraulic Characteristics of the New River in the New River Gorge National River."

SUMMARY: Model runs are completed. Table containing peak discharges, Manning's roughness coefficients, flood velocities, and flood elevations are completed.

Surface-Water Stations (WV001)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Stephen M. Ward

COOPERATORS:

Federal Power Commission

Morgantown Utility Board

U.S. Army Corps of Engineers

U.S. National Park Service

U.S. Soil Conservation Service

West Virginia Department of Commerce, Division of Parks and Recreation

West Virginia Department of Natural Resources, Division of Water Resources

PERIOD OF PROJECT: Continuous

PROBLEM: Surface-water information is needed for purposes of surveillance, planning, design, hazard warning, operation, and management in water-related fields such as coal hydrology, water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. To provide this information, an appropriate data base is necessary.

OBJECTIVES: (1) Collect surface-water data sufficient to satisfy needs for current-purpose uses such as assessment of water resources, operation of reservoirs or industries, forecasting, disposal of wastes and pollution controls, discharge data to accompany water-quality measurements, compact and legal requirements, and research or special studies. (2) Collect data necessary for analytical studies to define for any location the statistical properties of, and trends in, the occurrence of water in streams, lakes, and other water bodies, for use in planning and design.

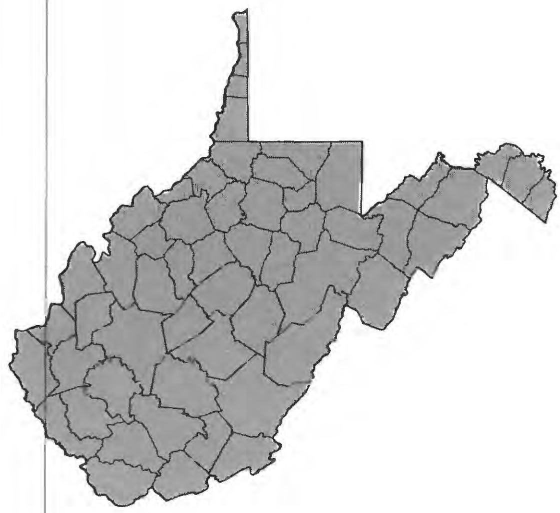
APPROACH: Use standard methods of data collection as described in the series, "Techniques of Water-Resources Investigations of the United States Geological Survey." Use partial-record gaging instead of complete-record gaging where it serves the required purpose.

SUMMARY: Existing network includes about 73 continuous-record stations and 7 partial-record sites. The District also continued the maintenance of about 90-95 U.S. Army Corps of Engineers satellite data-collection platforms Statewide.

Ground-Water Stations (WV002)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Freda M. Taylor

COOPERATOR:

West Virginia Geological and Economic Survey

PERIOD OF PROJECT: Continuous

PROBLEM: Long-term water-level records are needed to evaluate the effects of climatic variations on the recharge to and discharge from the ground-water systems, to provide a data base from which to measure the effects of development, to assist in the prediction of future supplies, and to provide data for management of the resource.

OBJECTIVES: (1) Collect water-level data sufficient to provide a minimum long-term data base so that the general response of the hydrologic system to natural climatic variations and induced stresses in known and potential problems can be defined enough to allow proper planning and management. (2) Provide a data base against which the short-term records acquired in areal studies can be analyzed. This analysis must (a) provide an assessment of the ground-water resource, (b) allow prediction of future conditions, and (c) provide the data base necessary for management of the resource.

APPROACH: Based on knowledge of regional geologic structure, aquifer systems, and current and potential areal stresses on the ground-water system, a subjective selection of 28 locations was made for observation of long-term system behavior. Include activities at the observation wells such as geophysical well logs, daily water-level compilation, and water-quality sampling. Use evaluation of network information and availability of detailed study results as the basis for network modification.

SUMMARY: Collection of data at 28 observation wells continued. Additional wells will be added to the network in the next year.

Water-Quality Stations (WV003)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Marcus C. Waldron

COOPERATORS:

U.S. Army Corps of Engineers

U.S. National Park Service

U.S. Soil Conservation Service

PERIOD OF PROJECT: Continuous

PROBLEM: Water quality of streams will change with land and industrial use. Water-resources planning and water-quality assessment require a base level of relatively standardized information. The chemical and physical quality of the rivers and streams must be defined and monitored for assessment and planning of the water resource.

OBJECTIVE: Provide water-quality data for general planning and management of interstate and intrastate waters.

APPROACH: Operate a network of water-quality stations to provide information about chemical concentrations, loads, and temporal trends for use by planning and management agencies.

SUMMARY: Water-quality data are collected at four National Stream Quality Accounting Network (NASQAN) sites and three Soil Conservation Service (SCS) sites.

Sediment Stations (WV004)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Stephen M. Ward

COOPERATOR:

Washington Public Service District

PERIOD OF PROJECT: Continuous

PROBLEM: Sediment concentrations and loads change with land-use changes. Water-resource planning and water-quality assessment require a base level of relatively standardized information. Sediment concentrations and discharges in rivers and streams must be defined.

OBJECTIVES: (1) Define sediment concentrations and discharges in rivers. (2) Provide a bank of sediment data for use in broad State planning and action programs. (3) Provide data for management of interstate and intrastate waters.

APPROACH: Establish and operate a network of sediment stations to provide spatial and temporal averages and trends of sediment concentration and sediment discharge.

SUMMARY: Program has been drastically reduced due to lack of cooperator funding. The West Virginia District collects sediment data at four National Stream Quality Accounting Network (NASQAN) stations and operates a continuous-turbidity monitor on the Coal River.

Precipitation Stations (WV005)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Melvin V. Mathes

PERIOD OF PROJECT: Continuous since July 1983

PROBLEM: National and Statewide trends in the quantity and quality of precipitation and its impact on streams.

OBJECTIVE: Describe precipitation volume and chemistry at a site in the National Trends Network and relate precipitation chemistry and volume to location and wind patterns.

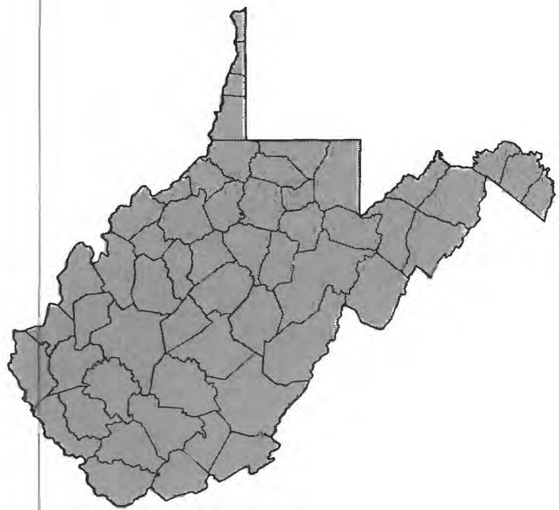
APPROACH: Maintain and operate sampling station that is part of a national network established to provide information on concentrations, loads, and time trends of chemical constituents in precipitation.

SUMMARY: Collected qualitative and quantitative data at one site located in Babcock State Park, Fayette County, as part of the USGS National Trends Network.

Flood Investigations (WV006)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: Gerald S. Runner

COOPERATOR:

Federal Emergency Management Agency

PERIOD OF PROJECT: Continuous

PROBLEM: The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 provide for the operation of a flood insurance program. The Federal Emergency Management Agency (FEMA) needs flood studies in selected areas to determine applicable flood insurance premium rates.

OBJECTIVE: Conduct the necessary hydrologic and hydraulic evaluations and studies of areas assigned by FEMA and present the results in an appropriate format.

APPROACH: Conduct the necessary evaluations or conduct surveys by ground or photogrammetric methods. Determine flood-discharge frequency relations using local historical information, gaging-station records, or other applicable information. Determine water-surface profiles using step-backwater models, or other acceptable methods, and furnish the results in reports prepared to FEMA specifications.

SUMMARY: Seventeen Limited Detailed Flood Studies were completed in 1989. Three others are in review. Manpower and cost estimates have been submitted for a restudy of Putnam County in 1990.

Water Use (WV007)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Mark D. Kozar

COOPERATOR:

West Virginia Geological and Economic Survey

PERIOD OF PROJECT: Continuous

PROBLEM: West Virginia waters are under stress from increasing demands for domestic, industrial, agricultural, and other uses and from demands for greater protection of water quality. Competition for water dictates that available supplies are matched with uses most beneficial to the common good. Information is being collected describing quantity and quality of available water, but relatively little information has been collected describing water use prior to 1978. Without adequate information on uses of water, decision makers cannot resolve many critical water problems related to environmental impact, energy development, and resource allocations.

OBJECTIVE: Provide the water-use information for the optimum use and management of the State's water resources for the overall benefit of the people of West Virginia and the United States. This program will collect, store, and disseminate water-use data to complement data on availability and quality of the State's water resources and to develop and operate a system to handle the data. The system will be responsive to the data needs of local users, the USGS, and other Federal agencies.

APPROACH: Responsibilities will be divided between the cooperator and the USGS to reflect the most efficient means of meeting the objectives of the program. Direction, management, and standards development to meet the national needs will be the responsibility of the USGS. Field activities for the acquisition and storage of the data will be the primary responsibility of the West Virginia Geological and Economic Survey (WVGES).

SUMMARY: The National USGS water-use program has been loaded onto the District's PRIME computer, and existing water-use data have been moved from the WVGES computer to the PRIME. The cooperator will attend Water-Use Concepts training. The Regional water-use consultant visited the West Virginia District in late 1989 to assist in setting up a functional water-use data base for West Virginia. Compilation of 1990 water-use data for the "1990 National Water-Use report" began in 1990.

Measurement of Peak-Flow Data for Selected Storms (WV053)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Gerald S. Runner

COOPERATOR:

West Virginia Department of Highways

PERIOD OF PROJECT: October 1982 through September 1990

PROBLEM: Local flooding throughout the State causes considerable property damage, lost time and wages, and inconvenience to the public. Flood-peak, storm-volume, and flood-profile information is needed for assessing damage, for flood-plain planning and management, and for determining the carrying capacity of culverts and bridges.

OBJECTIVE: Provide hydrologic data for documenting storms as they relate to flood-plain use, computation of flood discharge, backwater at culverts and small bridges, and frequency-of-storm rainfall and flood peaks. These data should provide an excellent data base for future interpretive flood studies and also for verification of the regression equations presented in the Statewide flood-frequency report, titled "Runoff studies on small drainage areas" (Techniques of floods in West Virginia): U.S. Geological Survey Open-File Report 80-1218, by G.S. Runner, 1980.

APPROACH: Each year, as hydrologic conditions warrant, collect peak-flow data at sites specified by the cooperator by direct measurements, when possible, and by indirect measurements using "Techniques of Water Resources Investigations of the U.S. Geological Survey" guidelines. Survey high-water marks to determine an appropriate water-surface profile to describe the extent of flood-plain inundation. Make bucket rainfall surveys over the storm area to supplement available rain-gage information. Compare data collected to previously used frequency data of flood-peak discharge and total rainfall depth such as Q(25), Q(50), and Q(100), and 1-day-50-year rainfall (1(24)-(50)) to determine if updated frequency studies are needed.

SUMMARY: No major storms occurred during 1989. Therefore, no indirect measurements were made during the year.

Occurrence of Fluoride in West Virginia Ground Water (WV068)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau

LEADER: Melvin V. Mathes

COOPERATOR:

West Virginia Geological and Economic Survey

PERIOD OF PROJECT: October 1988 through September 1991

PROBLEM: Ground water in much of the State has a fluoride concentration less than or equal to 0.1 mg/L. However, in some areas fluoride concentrations exceed 12 mg/L. High concentrations of fluoride in drinking water have been found to cause darkening and mottling of children's teeth. When daily intake of fluoride exceeds 15-20 mg/L over a period of several years, fluorosis may be induced.

OBJECTIVES: (1) Map fluoride concentrations in ground water on a Statewide basis. (2) Statistically analyze fluoride concentrations in ground water with respect to geology, well depth, other chemical characteristics of the water, proximity to oil and gas development, and occurrence of atmospheric fluoride deposition. (3) Determine probable mineralogic sources of fluoride, and establish the relation of high fluoride concentrations to geochemical conditions. (4) Compare fluoride concentrations in areas of known atmospheric fluoride deposition with nearby geologically similar areas where deposition of fluorides has not occurred.

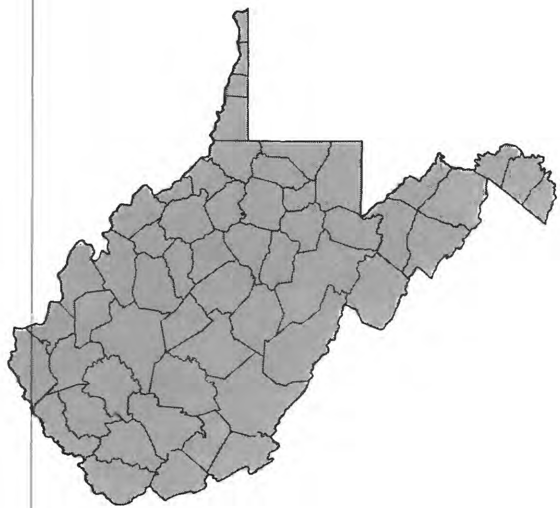
APPROACH: Identify areas having high fluoride concentrations and areas needing additional data from existing data. Design a data-collection program concentrating in areas where ground water having high fluoride concentrations is known to occur, and where current data are insufficient to map fluoride concentrations. Analyze water samples for fluoride concentration, pH, alkalinity, acidity, specific conductance, and water temperature at all sites. At approximately 50 sites, where fluoride concentrations exceed 3 mg/L, perform analysis for the inorganic constituents. Statistically analyze fluoride concentrations with respect to site characteristics such as geologic unit, geologic structure, mineralogic data, topographic setting, well depth, land use, proximity to oil and gas wells, and atmospheric deposition.

SUMMARY: Existing fluoride data were reviewed. Fluoride data were collected to improve areal coverage. Fluoride data will be analyzed and will be compared statistically to other water-quality and ground-water characteristics. Data will be collected in areas of high fluoride concentration to determine sources of high fluoride.

Estimating Technique--Magnitude and Frequency of Floods in West Virginia (WV075)

WEST VIRGINIA

Blue Ridge
Valley and Ridge
Appalachian Plateau



LEADER: G. Scott Runner

COOPERATOR:

West Virginia Department of Highways

PERIOD OF PROJECT: October 1990 through September 1994

PROBLEM: The previous flood-frequency study for the State of West Virginia was completed in 1977 using all available peak-flow data. The previous study combined the USGS long-term gaging-station network records (stations generally with drainage areas greater than 50 square miles) with the project data that were collected on the small-stream network (drainage area less than 50 square miles and less than 10 years of peak-flow record) to develop estimating equations at ungaged sites. Since the completion of the first Statewide flood-frequency study in 1977, there have been four major floods in West Virginia--the Tug Fork and Guyandotte River in 1977 and 1984, the northern section of the State in 1980, and the record-breaking flood of November 1985. The State has more than 1,000 bridges and culverts to upgrade, redesign, and/or relocate during the 1990's. Most of these structures are located on ungaged streams; therefore, the most up-to-date, reliable data and estimating equations should be used to redesign these structures.

OBJECTIVES: (1) Develop estimating techniques to determine the magnitude and frequency of floods in West Virginia. (2) Study estimating techniques to determine flood volumes for small drainage basins. (3) Analyze the existing streamflow network to determine an optimum network of streamflow stations to improve the flood-frequency estimating techniques developed in Objective (1).

APPROACH: Determine estimates of station flood-frequency by fitting the logarithms of the annual peaks to a Pearson type-III distribution for approximately 100 continuous-record and partial-record stations in West Virginia using data through 1992. Provide revised flood-frequency values for stations used in a previous study published in 1980 and selected new sites. Use revised flood-frequency estimates and basin characteristics for several stations in adjacent states to aid in developing the regional regression equations for West Virginia.

Use multiple-regression techniques to update the regional regression equations for computations of peak flow from ungaged streams in West Virginia. Use the generalized least-squares technique to develop the estimating equations. In the regression analysis, use all gaging-station information from stations having no significant regulation or urbanization.

In the flood-frequency analysis, use a split data set to evaluate the prediction error, long-term and/or long-term combined with previous project data to determine the best fit in relation to standard error and ease of use (from a design standpoint). Determine the relations using previously developed independent variables and new parameters developed for this study.

SUMMARY: The flood-frequency project will use the recent extreme flood data in West Virginia to compute new station frequencies to use in the regression analysis. Crest-stage gages will be installed at selected discontinued gaging sites to use in future flood analysis in West Virginia. Most of the station frequencies have been updated through 1990 water year and work has started on updating the basin-characteristics file. Three crest-stage gages are being installed at discontinued gaging sites.

WATER RESOURCES DIVISION PUBLICATIONS

The Water Resources Division (WRD) of the USGS is the Nation's lead agency in the collection of water data and the dissemination of information on water resources. The WRD makes water data and information readily and equally available to water managers, policy makers, the scientific community, and the public in formats that meet their needs.

The USGS has published the results of its studies for more than 100 years. The information is multipurpose and, after its initial use, becomes a basis for future resource evaluation and water-management decisions. The WRD releases its information through several publication series, explained below, and through computerized systems, accessible through NAWDEX and WATSTORE (see Water-Data Program section).

A description of these publications series, the types of information presented in them, and ordering information is given below.

Professional Paper--Comprehensive or topical reports on any earth science subject of interest to multi-discipline scientific audiences.

Water-Supply Paper--Significant interpretive results of hydrologic investigations that are considered to be of broad interest.

Bulletin--Significant interpretive results of earth-science investigations of broad interest, including computer applications.

Circular--Summaries of topical investigations or programs that are of short-term or local interest.

Map series, such as Hydrologic Investigations Atlas--Significant results of hydrologic investigations presented in map format.

Techniques of Water-Resources Investigations Report--Reports on methods and techniques used in collecting, analyzing, and processing hydrologic data for technically oriented audiences.

U.S. Geological Survey Yearbook--Significant activities of the Water Resources Division that are summarized each year for general audiences.

Water-Resources Investigations Report--Comprehensive or topical interpretive reports, and maps mainly of local or short-term interest, for interdisciplinary audiences.

Open-File Book and Map Reports--Compilations of data and preliminary interpretive reports of limited interest, or reports awaiting formal publication that require interim release.

Water-Data Report--Water-year data on streamflow, ground-water levels, and quality of surface water and ground water for each State, Puerto Rico, and the Virgin Islands.

National Water Conditions--A monthly news release that summarizes the national water situation for water-resources-oriented audiences.

With the exception of the "National Water Conditions," which is a form of news release, all of the above publication series are listed in three catalogs--"Publications of the Geological Survey, 1879-1961," "Publications of the Geological Survey, 1962-70", and "Publications of the Geological Survey, 1971-81"--and in yearly supplements since 1981.

The USGS announces all of its publications in a monthly report "New Publications of the Geological Survey." Subscriptions to this monthly listing are available upon request to the U.S. Geological Survey, 582 National Center, Reston, VA 22092. All publications are for sale unless specifically stated otherwise. Prices that are subject to change are not included here. Prepayment is required and information on price and availability should be obtained before placing an order. The "U.S. Geological Survey Yearbook" provides a comprehensive description of the Federal Government's largest earth-science agency; copies can be purchased from U.S. Geological Survey, Books and Open-File Reports Section, Denver Federal Center, Box 25425, Denver CO 80225 [(303) 236-7476]. Summaries of research in progress and results of completed investigations are published each fiscal year in the Professional Paper series, "Geological Survey Research."

Professional Papers, Bulletins, Water-Supply Papers, Techniques of Water-Resources Investigations, Water-Resources Investigations Reports, Circulars, publications of general interest (such as leaflets, pamphlets, booklets), single copies of the Earthquake Information Bulletin, Preliminary Determination of Epicenters, and some miscellaneous reports, including some from the foregoing series that have gone out of print at the Superintendent of Documents, are obtainable by mail from U.S. Geological Survey, Books and Open-File Reports Section, Denver Federal Center, Box 25425, Denver, CO 80225 [(303) 236-7476].

Certain USGS reports, including most of the Water-Resources Investigations Report (WRIR) series released before 1982, "Water Resources Data-[State] Water Year [year]" beginning with the 1975 issues, and many compilations of data, can be purchased only from the National Technical Information Service (NTIS). New USGS reports that are available only from NTIS are cited in the monthly list, "New Publications of the U.S. Geological Survey." For information on obtaining these reports contact: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 [(703) 487-4600].

The WRD also releases information through two other major outlets. Abstracts, conference papers, and journal articles are available from the appropriate professional journals and societies. Reports published by cooperators resulting from the Federal-State cooperative program are available from the agencies given in the Sources of Information and Publications section.

MID-ATLANTIC PROGRAMS PUBLICATIONS

July 1, 1986, through September 30, 1991

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The following sections are from WSP 2375:

___Delaware floods and droughts, prepared by Paulachok, G.N., and others, p. 223-230.

___Maryland and the District of Columbia floods and droughts, prepared by James, R.W., Jr., and others, p. 319-326.

___Virginia floods and droughts, prepared by Nuckels, E.H., and others, p. 543-550.

___West Virginia floods and droughts prepared by Runner, G.S., and Michaels, P.J., p. 559-566.

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WATER-DATA PROGRAM

Water-data stations at selected locations throughout the nation are used by the USGS to obtain records on stream discharge (flow) and stage (height), reservoir and lake stage and storage, ground-water levels, well and spring discharge, and the quality of surface and ground water. These data provide a continuing record of the quantity and quality of the Nation's surface-water and ground-water resources, and thus provide the hydrologic information needed by Federal, State, and local agencies and the private sector for the development and management of land and water resources. All data collected are stored in the Survey's National Water Data Storage and Retrieval System (see section "WATSTORE" for additional information on this system) and also are published by water year for each State in a publication series entitled "U.S. Geological Survey Water-Data Reports." Information about the Water-Data Program in the Mid-Atlantic Programs can be obtained from the District Chiefs.

NAWDEX (National Water Data Exchange)

The National Water Data Exchange is a confederation of Federal and non-Federal water-oriented organizations working together to improve access to available water data. It is managed by a Program Office, which is administered by the Water Resources Division. Information on sites for which water data are available, the types of data available, and the organizations that store the data are available from NAWDEX. Assistance in identifying, locating, and acquiring data is provided by the Program Office at Reston, Virginia, by NAWDEX Assistance Centers at the Water Resources Division District offices, and by offices of other NAWDEX member organizations. A directory of assistance centers, and more detailed information about services, can be obtained from the NAWDEX Program Office, Branch of Water Information Transfer. The NAWDEX headquarters address is: National Water Data Exchange, U.S. Geological Survey, National Center, Mail Stop 421, 12201 Sunrise Valley Drive, Reston, VA 22092. The office can be reached by phone at (703) 648-5677.

WATSTORE (National Water Data Storage and Retrieval System)

As explained in the section "Water-Data Program," all data collected through that program are stored in WATSTORE, and the data are available on request. These data can be retrieved in machine-readable form or as computer-printed tables or graphs, statistical analyses, and digital plots. Local assistance in the acquisition of service or products from WATSTORE can be obtained from the District offices. A pamphlet, "WATSTORE: A WATer Data STOrage and REtrieval System,"can be obtained from these offices or from the WATSTORE Program office, Branch of Computer Technology, U.S. Geological Survey, National Center, Mail Stop 440, 12201 Sunrise Valley Drive, Reston, VA 22092. The office can be reached by phone at (703) 648-5624.

ANNUAL WATER-DATA REPORTS

Water data for the Mid-Atlantic Programs are published annually in a series of Water-Data Reports. Beginning with the 1990 Water-Data Report, two volumes are published for the MD-DE-DC District: "Water Resources Data, Maryland and Delaware, Volume 1. Atlantic Slope Basins, Delaware River through Patuxent River;" and "Water Resources Data, Maryland and Delaware, Volume 2. Monongahela and Potomac River Basins." Two volumes are published for the Virginia District: "Water Resources Data, Virginia, Volume 1. Surface Water and Surface-Water-Quality Records;" and "Water Resources Data, Virginia, Volume 2. Ground Water and Ground-Water-Quality Records." One volume is published for the West Virginia District, "Water Resources Data, West Virginia." Types of data that may be included in these volumes are:

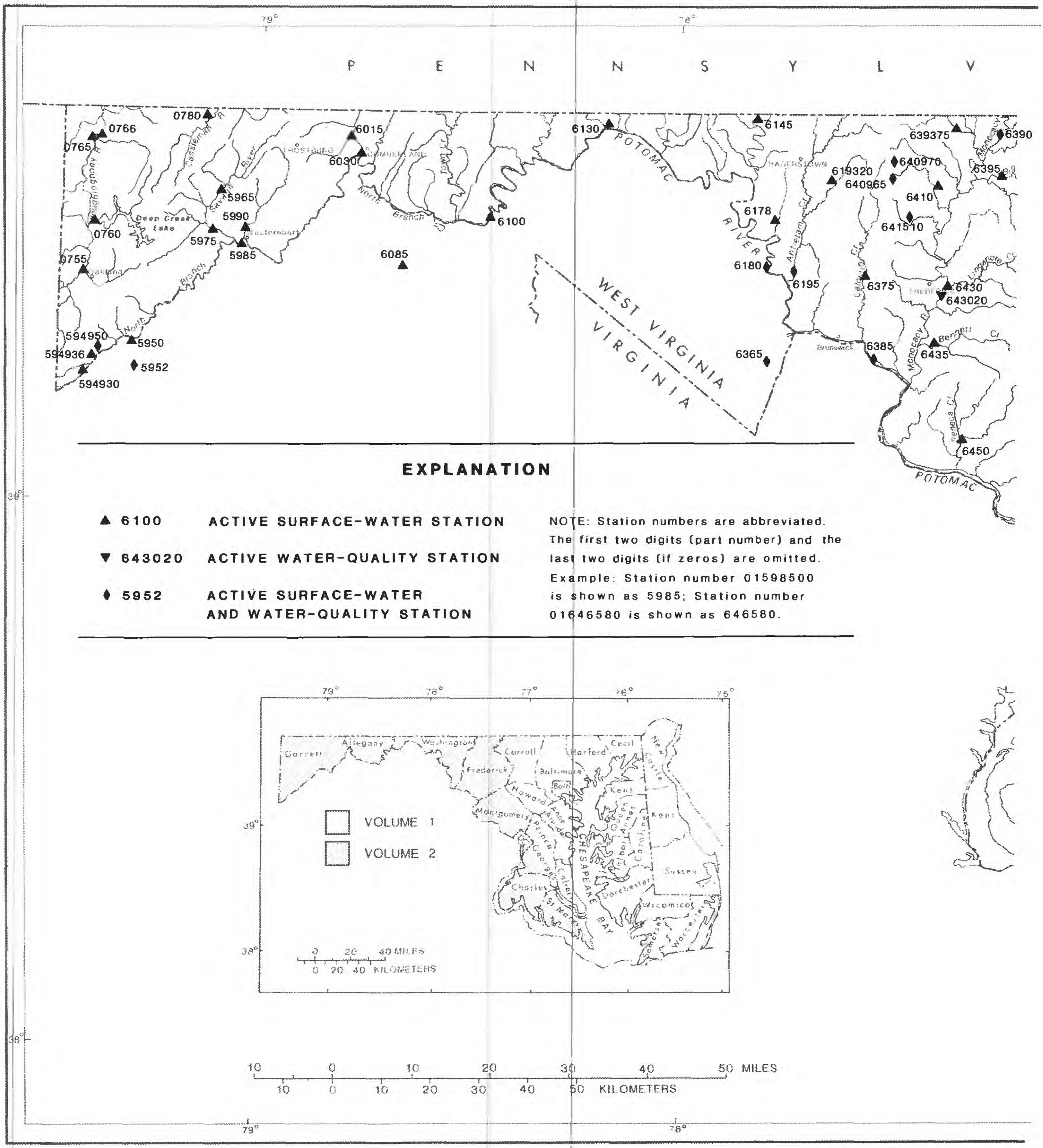
- Stream discharge at gaging stations
- Stream discharge at low-flow partial-record stations
- Annual maximum stream discharge and stage at crest-stage partial-record stations
- Annual maximum stage at tidal crest-stage partial-record stations
- Stream discharge at miscellaneous-measurement sites
- Stream discharge and miscellaneous water-quality measurements at seepage-investigation and special-study sites
- Quality of streamflow at selected gaging stations
- Quality of streamflow at miscellaneous-measurement sites
- Quality of ground water from selected wells
- Reservoir stage and content
- Water levels in observation wells (only data for selected wells are published in these volumes)
- Multi-year hydrographs of water levels for each observation well published
- Ground-water spring discharge

Maps on the following pages (figs. 9-16) show locations of data-collection sites for data included in the Water-Data Reports for the 1990 water year. Copies of the Water-Data Reports can be purchased from:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4600

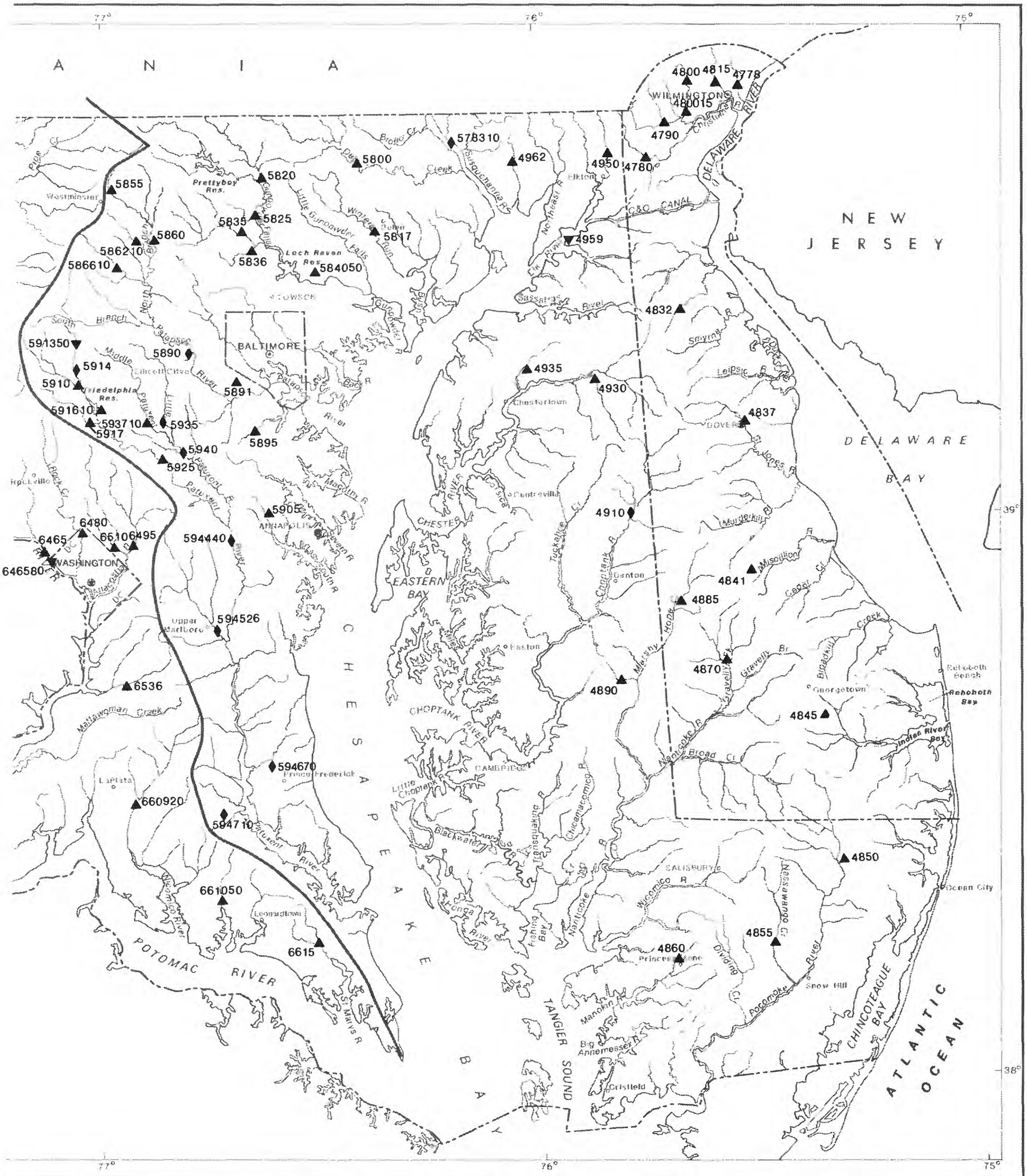
A limited supply of current volumes are available from the Districts (for addresses see Programs Organization and District Addresses section).

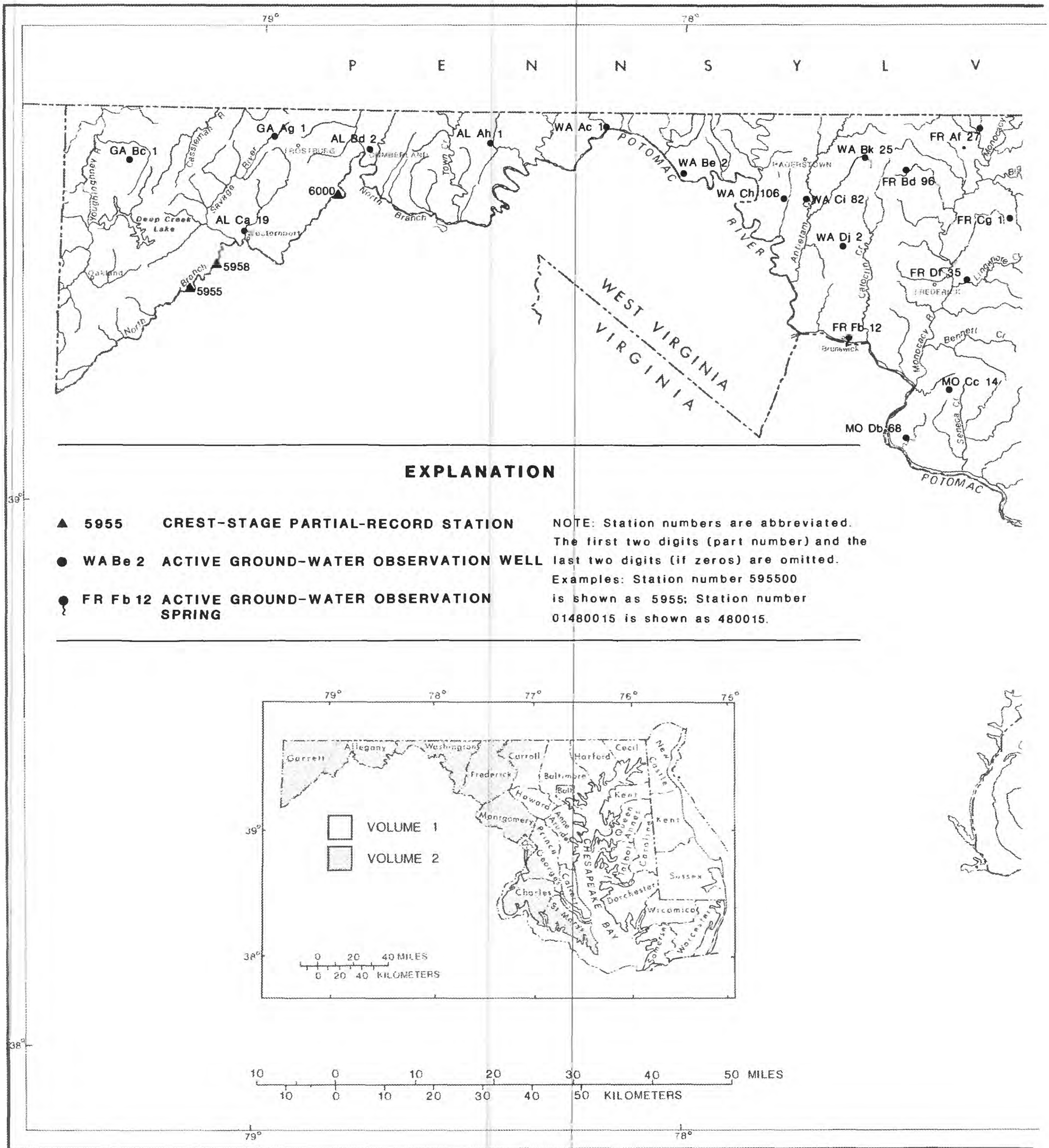
Figures 9-16



Base map modified from U.S. Geological Survey 1:500,000

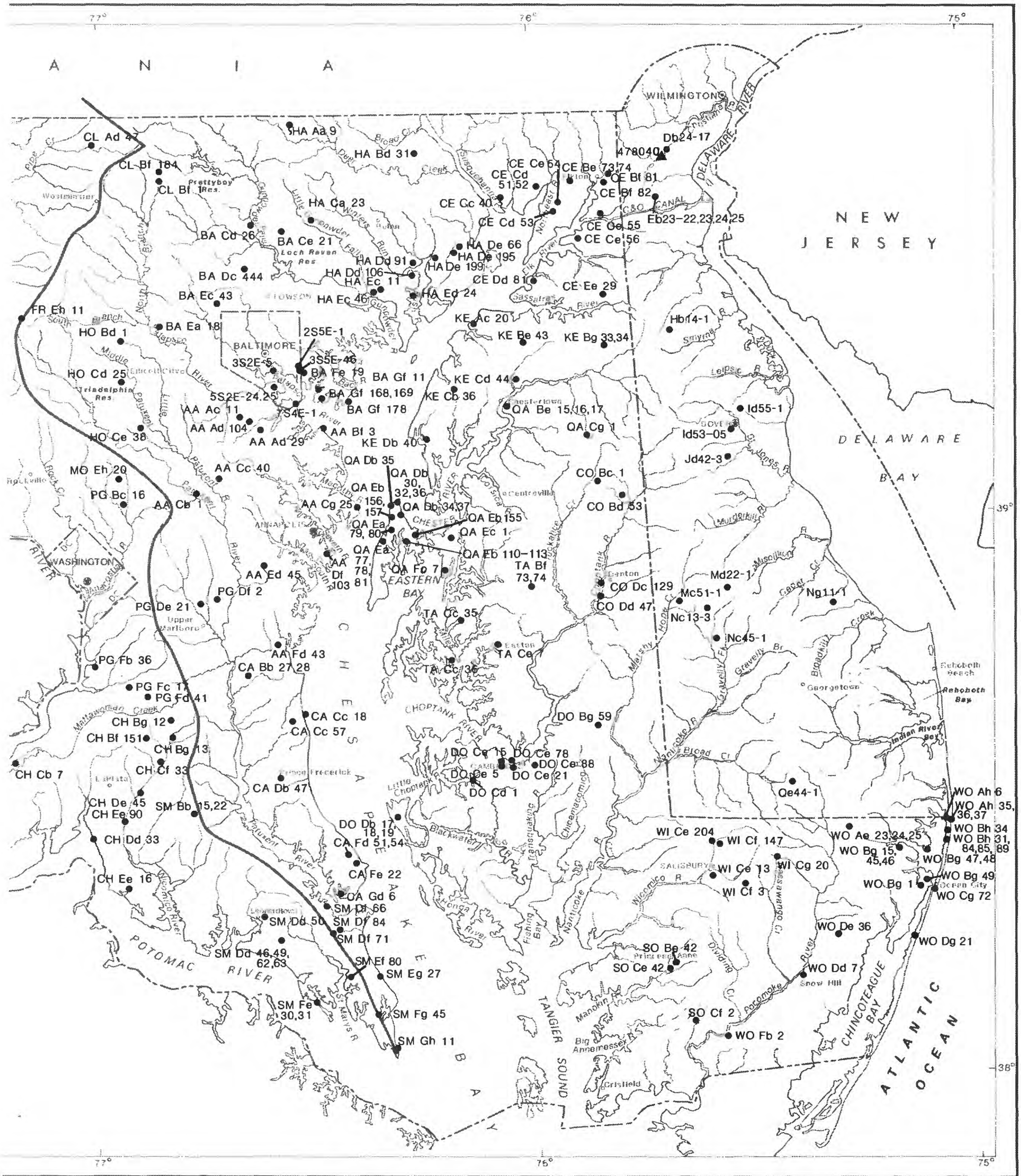
Figure 9.--Location of surface-water and water-quality stations in Maryland and Delaware.


NEW JERSEY
DELAWARE BAY
ATLANTIC OCEAN
CHESAPEAKE BAY
TANGIER SOUND
POTOMAC RIVER
CHINCOTEAGUE BAY
BALTIMORE
WASHINGTON
WILMINGTON
ANNAPOLIS
DOVER
CAMBRIDGE
SALISBURY
EASTERN BAY
CHOPTANK RIVER
CHESTER RIVER
DELAWARE RIVER
C&O CANAL
77°
76°
75°
39°
38°



Base map modified from U.S. Geological Survey 1:500,000

Figure 10.--Location of crest-stage partial-record stations and ground-water observation wells in Maryland and Delaware.



77°
76°
75°
A N I A
NEW JERSEY
WILMINGTON
DELAWARE RIVER
DELAWARE BAY
BALTIMORE
WASHINGTON
CHESAPEAKE BAY
EASTERN BAY
CHOPTANK RIVER
POTOMAC RIVER
TANGIER SOUND
CHINCOTEAGUE BAY
ATLANTIC OCEAN
C&O CANAL
39°
38°
CL Ad 47
CL Bf 184
CL Bf 1
HA Aa 9
HA Bd 31
HA Ca 23
HA De 66
HA De 195
HA Dd 91
HA Dd 106
HA De 199
HA Ec 11
HA Ec 46
HA Ed 24
CE Ce 64
CE Be 73,74
CE Cd 51,52
CE Bf 81
CE Bf 82
CE Cc 40
CE Cd 53
CE Ce 55
CE Ce 56
CE Dd 81
CE Ee 29
Db24-17
478040
Eb23-22,23,24,25
BA Cd 26
BA Ce 21
BA Dc 444
BA Ec 43
BA Ea 18
BA Fe 19
BA Gf 11
BA Gf 168,169
BA Gf 178
BA Bf 3
2S5E-1
3S5E-46
3S2E-5
5S2E-24,25
S4E-1
FR Eh 11
HO Bd 1
HO Cd 25
HO Ce 38
MO Eh 20
PG Bc 16
AA Ac 11
AA Ad 104
AA Ad 29
AA Cc 40
AA Cb 1
AA Cg 25
AA Ed 45
AA Df 77, 78, 81, 103
AA Fd 43
KE Ac 20
KE Be 43
KE Bg 33,34
KE Cd 44
KE Cb 36
KE Db 40
QA Be 15,16,17
QA Cg 1
QA Db 35
QA Db 30, 32,36
QA Db 34,37
QA Eb 156, 157
QA Eb 155
QA Ea 79, 80
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QA Eb 110–113
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Id53-05
Jd42-3
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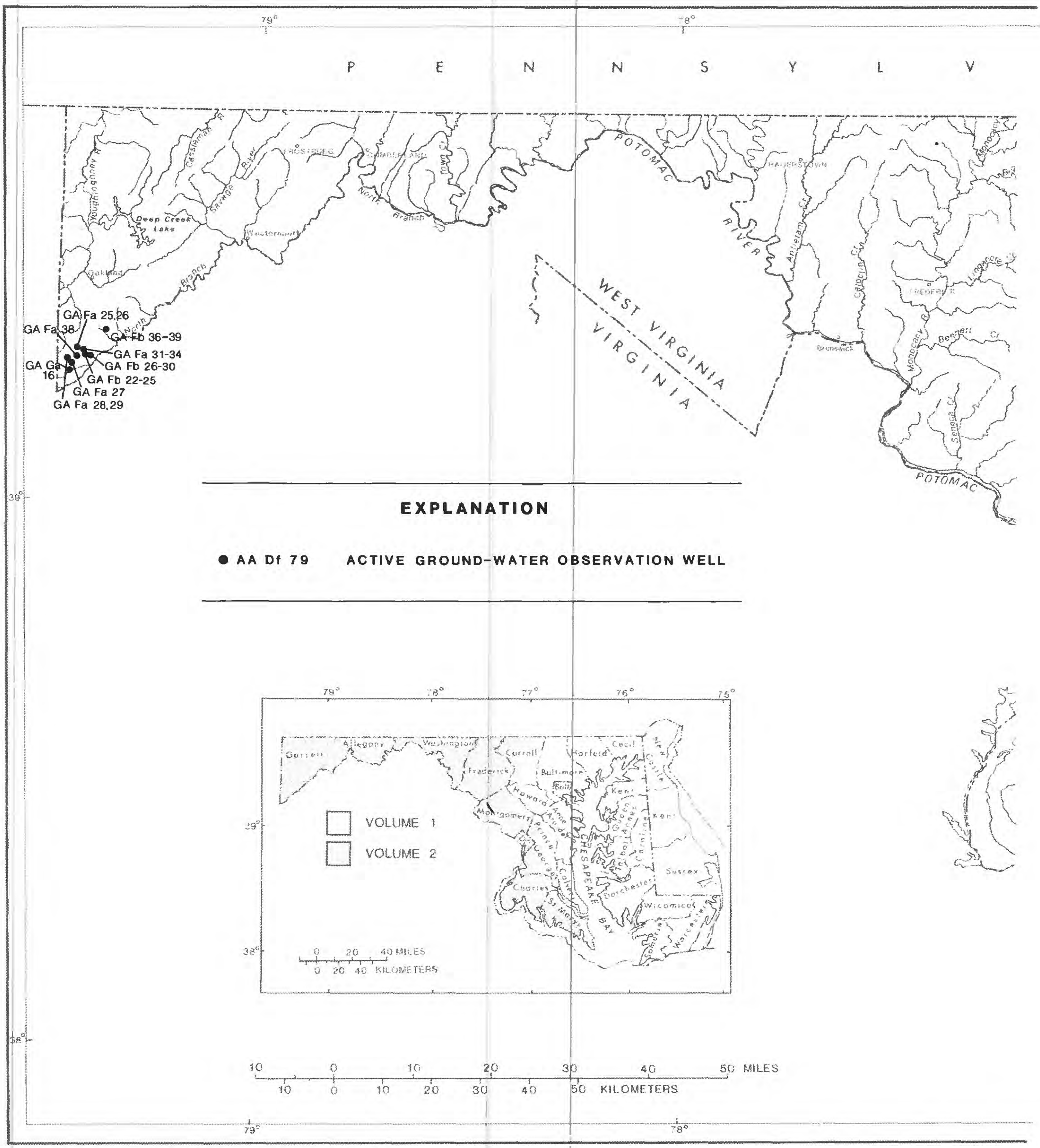
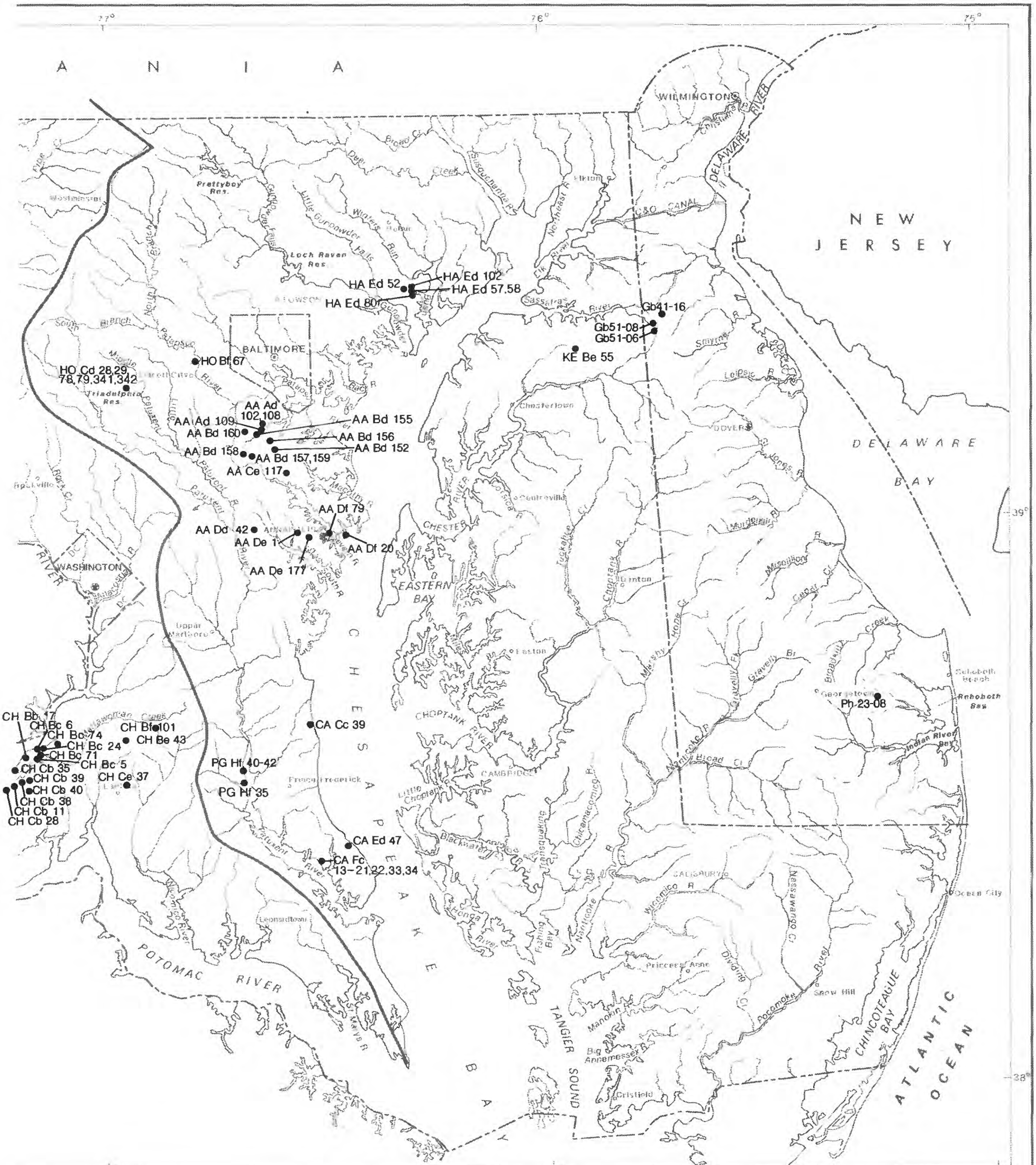
CO Bd 53
CO Dc 129
CO Dd 47
TA Bf 73,74
TA Cc 35
TA Ce
TA Cc 36
Md22-1
Mc51-1
Nc13-3
Nc45-1
Ng11-1
PG Df 2
PG De 21
PG Fb 36
PG Fc 17
PG Fd 41
CA Bb 27,28
CA Cc 18
CA Cc 57
CA Db 47
CA Fd 51,54
CA Fe 22
CA Gd 6
CH Bg 12
CH Bf 151
CH Bg 13
CH Cf 33
CH Cb 7
CH De 45
CH Ee 90
CH Dd 33
CH Ee 16
SM Bb 15,22
SM Dd 50
SM Df 66
SM Df 84
SM Df 71
SM Dd 46,49, 62,63
SM Ef 80
SM Eg 27
SM Fe 30,31
SM Fg 45
SM Gh 11
DO Bg 59
DO Ce 15
DO Ce 78
DO Ce 88
DO Ce 5
DO Ce 21
DO Cd 1
DO Db 17, 18,19
Qe44-1
WI Ce 204
WI Cf 147
WI Ce 13
WI Cg 20
WI Cf 3
WO Ah 6
WO Ah 35, 36,37
WO Bh 34
WO Bh 31, 84,85, 89
WO Ae 23,24,25
WO Bg 15, 45,46
WO Bg 47,48
WO Bg 49
WO Bg 1
WO Cg 72
WO De 36
WO Dg 21
WO Dd 7
WO Fb 2
SO Be 42
SO Ce 42
SO Cf 2



Base map modified from U.S. Geological Survey 1:500,000

Figure 11.--Location of project ground-water observation wells in Maryland and Delaware.


HA Ed 52
HA Ed 102
HA Ed 57,58
HA Ed 80
Gb41-16
Gb51-08
Gb51-06
KE Be 55
HO Bf 67
HO Cd 28,29, 78,79,341,342
AA Ad 102,108
AA Ad 109
AA Bd 160
AA Bd 155
AA Bd 156
AA Bd 152
AA Bd 158
AA Bd 157,159
AA Ce 117
AA Df 79
AA Dd 42
AA De 1
AA Df 20
AA De 177
CH Bb 17
CH Bc 6
CH Bc 74
CH Bc 24
CH Bc 71
CH Bc 5
CH Bf 101
CH Be 43
CH Cb 35
CH Cb 39
CH Cb 40
CH Cb 38
CH Cb 11
CH Cb 28
CH Ce 37
CA Cc 39
PG Hf 40-42
PG Hf 35
CA Ed 47
CA Fc 13-21,22,33,34
Ph-23-08
NEW JERSEY
DELAWARE BAY
CHESAPEAKE BAY
ATLANTIC OCEAN
POTOMAC RIVER
DELAWARE RIVER
WILMINGTON
BALTIMORE
WASHINGTON
TANGIER SOUND
CHINCOTEAGUE BAY
EASTERN BAY
CHOPTANK RIVER
C&O CANAL
77°
76°
75°
39°
38°

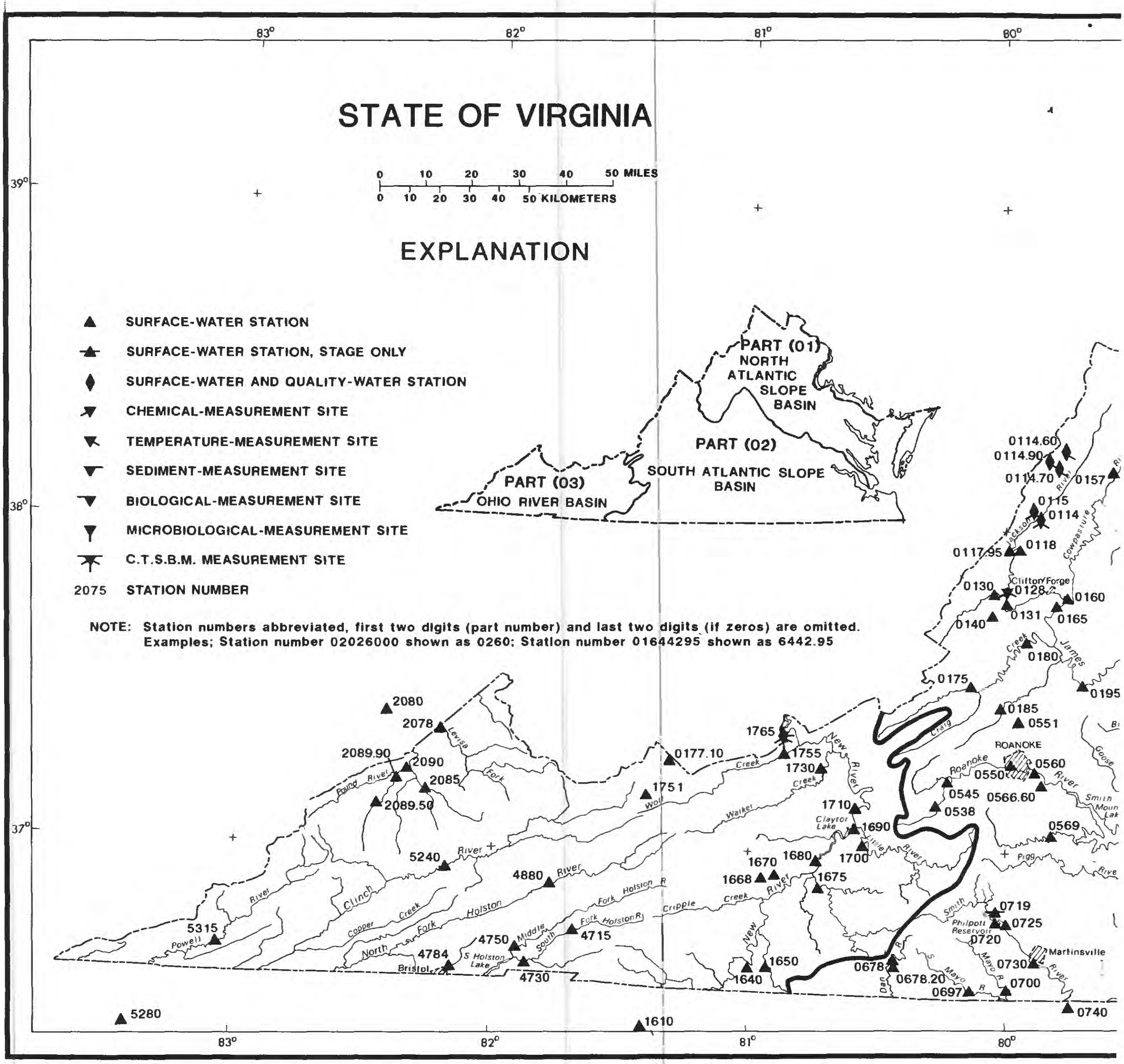
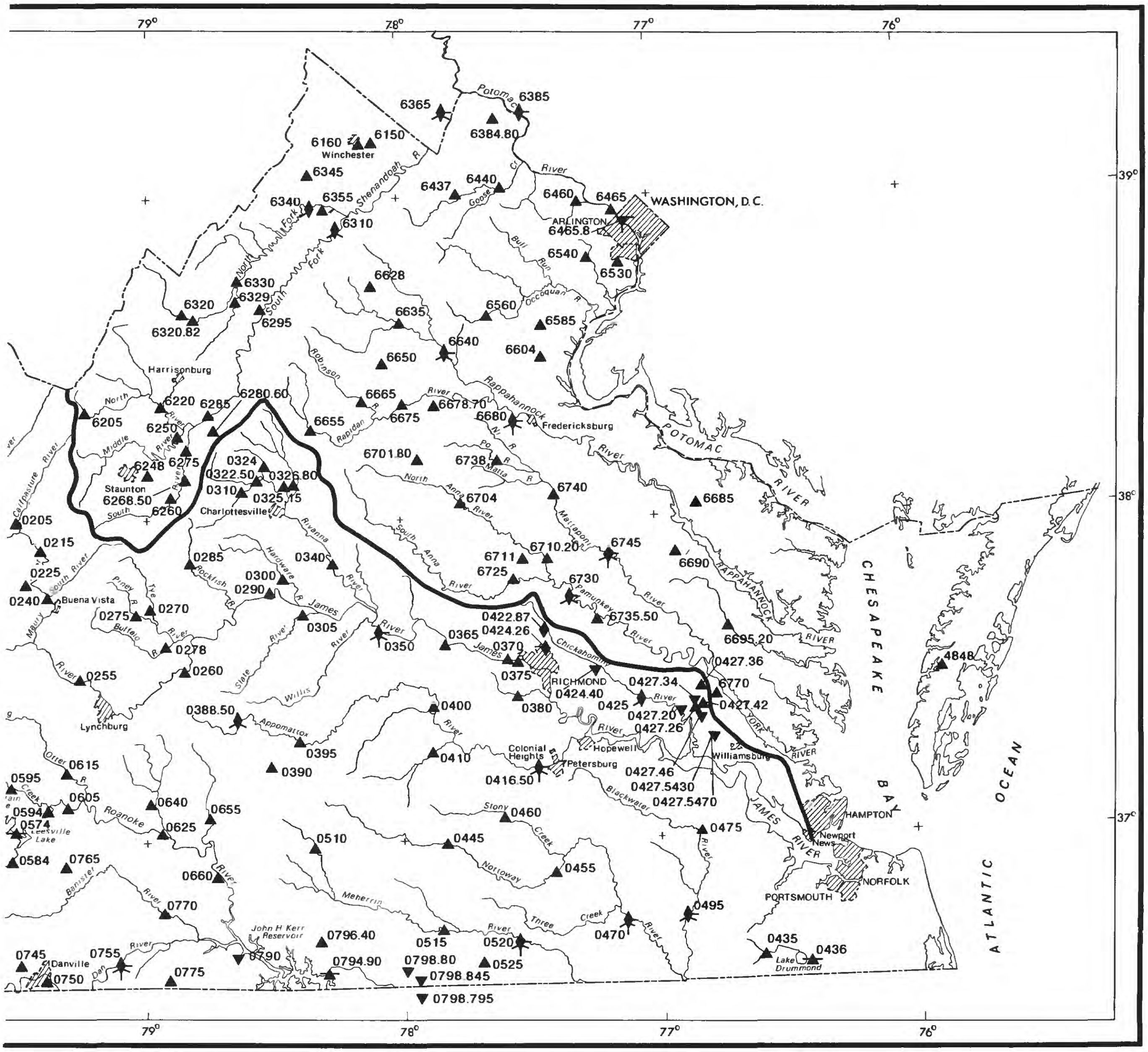


Figure 12.--Location of surface-water and water-quality data-collection stations in Virginia.


WASHINGTON, D.C.
ARLINGTON
Winchester
Harrisonburg
Staunton
Charlottesville
Fredericksburg
RICHMOND
Lynchburg
Buena Vista
Hopewell
Petersburg
Colonial Heights
Williamsburg
HAMPTON
Newport News
NORFOLK
PORTSMOUTH
Danville
CHESAPEAKE BAY
ATLANTIC OCEAN
POTOMAC RIVER
RAPPAHANNOCK RIVER
YORK RIVER
JAMES RIVER

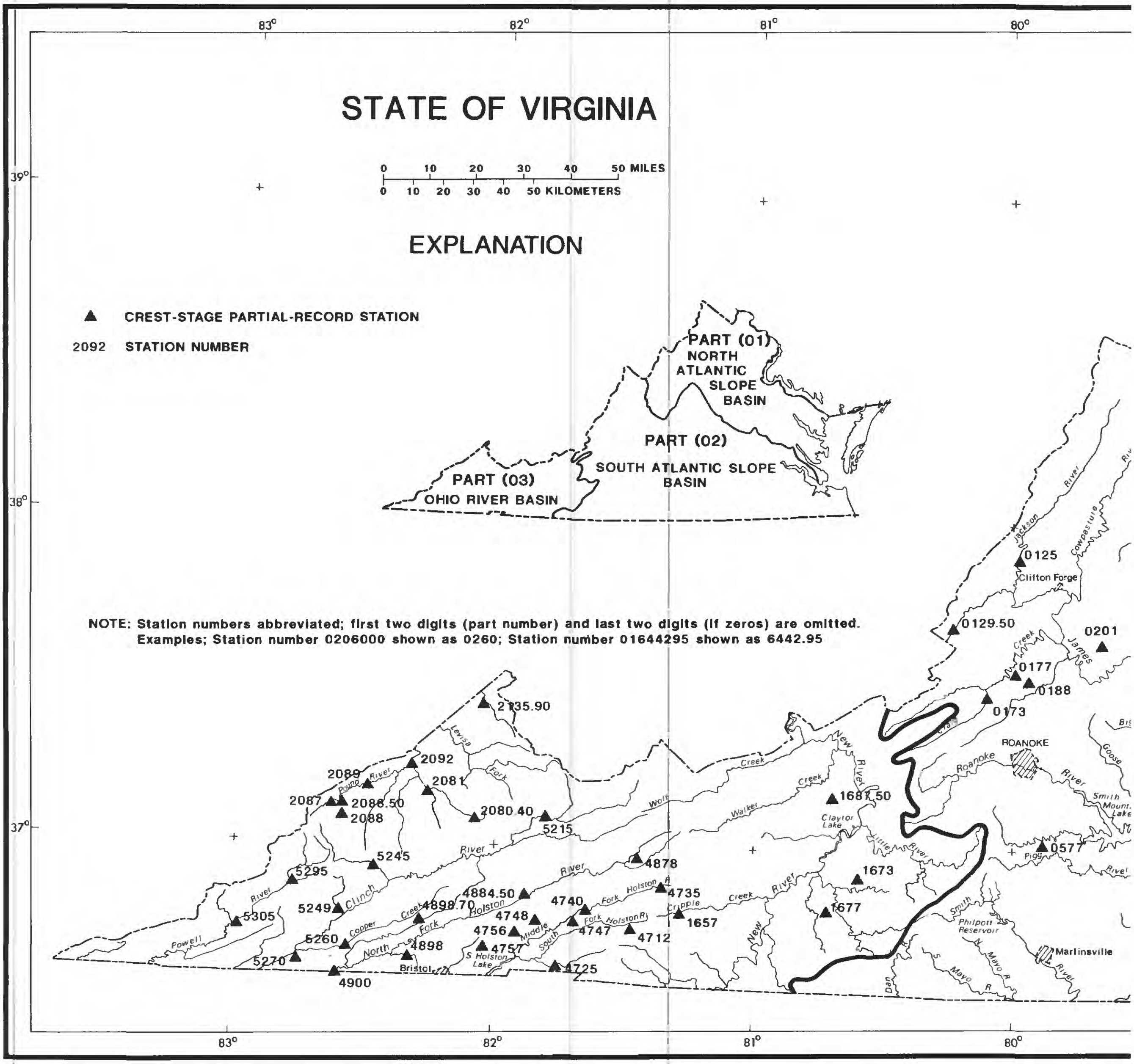
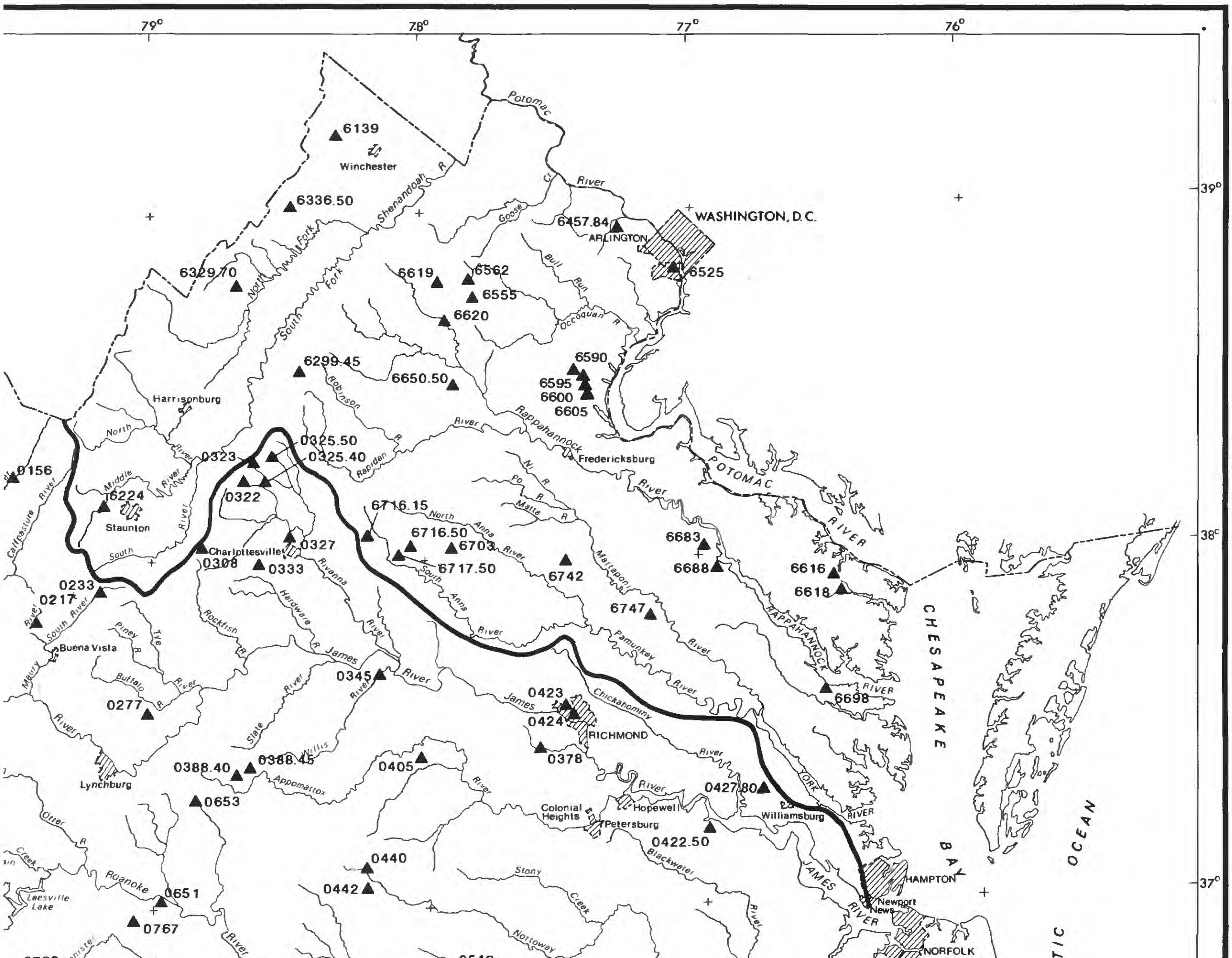


Figure 13.--Location of crest-stage partial-record stations in Virginia.


79°
78°
77°
76°
39°
38°
37°
Potomac
River
WASHINGTON, D.C.
ARLINGTON
Winchester
Harrisonburg
Staunton
Charlottesville
Buena Vista
Lynchburg
RICHMOND
Colonial Heights
Petersburg
Hopewell
Williamsburg
Fredericksburg
HAMPTON
Newport News
NORFOLK
PORTSMOUTH
Danville
Leesville Lake
John H Kerr Reservoir
Lake Drummond
CHESAPEAKE BAY
ATLANTIC OCEAN
POTOMAC RIVER
RAPPAHANNOCK RIVER
YORK RIVER
JAMES RIVER
Shenandoah R.
North Fork
South Fork
Rappahannock River
Rapidan R.
Robinson R.
Goose Cr.
Bull Run
Occoquan R.
Ni R.
Po R.
Matta R.
Mattaponi River
North Anna River
South Anna River
Pamunkey River
Chickahominy River
Rivanna River
Hardware R.
Rockfish R.
James River
Slate River
Willis River
Appomattox River
Tye River
Piney R.
Buffalo R.
Maury River
South River
Middle River
North River
Calfpasture River
Otter R.
Roanoke River
Banister River
Dan River
Stony Creek
Nottoway River
Meherrin River
Three Creek
Blackwater River
6139
6336.50
6329.70
6457.84
6525
6619
6562
6555
6620
6299.45
6650.50
6590
6595
6600
6605
0325.50
0325.40
0323
0322
0156
6224
6716.15
6716.50
6703
6717.50
6742
6683
6688
6616
6618
6747
6698
0327
0308
0333
0233
0217
0345
0277
0423
0424
0378
0405
0388.40
0388.45
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0427.80
0422.50
0440
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0651
0767
0762
0516
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0795
0753.50
0500.50

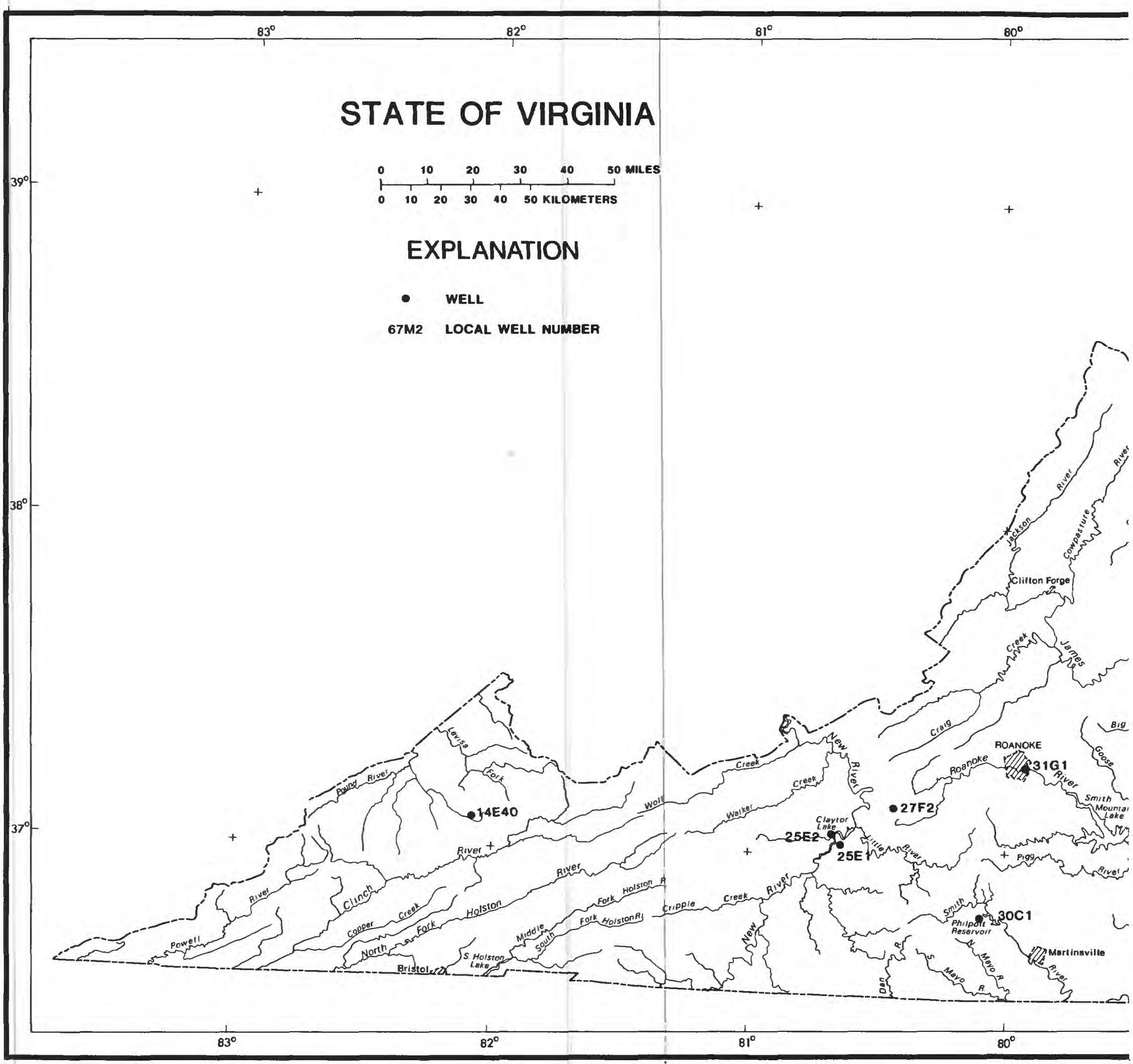
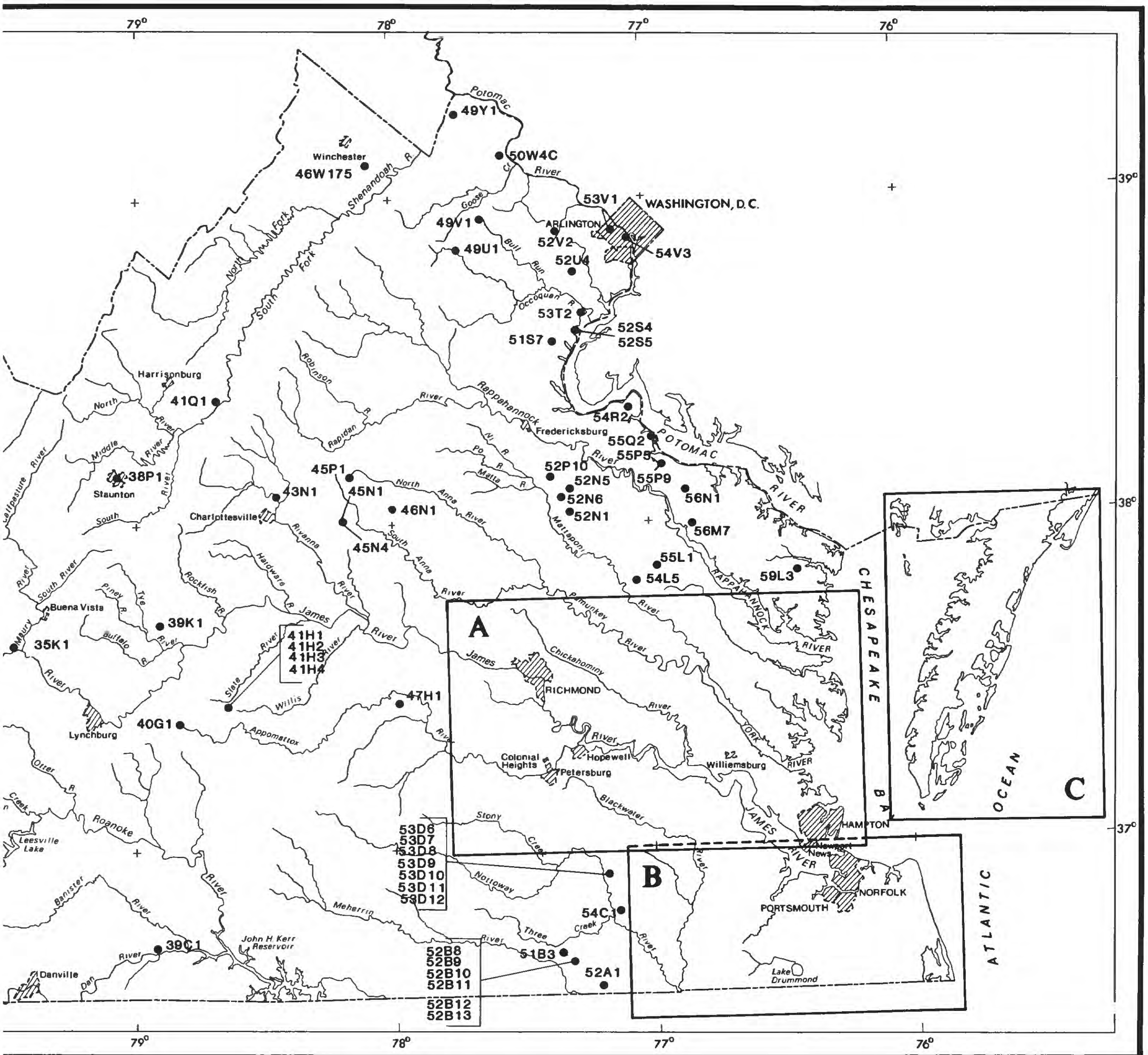


Figure 14.--Location of ground-water observation wells in Virginia.


WASHINGTON, D.C.
ARLINGTON
Winchester
Harrisonburg
Staunton
Charlottesville
Fredericksburg
Buena Vista
Lynchburg
RICHMOND
Colonial Heights
Petersburg
Hopewell
Williamsburg
HAMPTON
Newport News
PORTSMOUTH
NORFOLK
Danville
John H Kerr Reservoir
Lake Drummond
Leesville Lake
CHESAPEAKE BAY
ATLANTIC OCEAN
POTOMAC RIVER
RAPPAHANNOCK RIVER
YORK RIVER
JAMES RIVER
A
B
C
46W175
49Y1
50W4C
53V1
49V1
49U1
52V2
52U4
54V3
53T2
52S4
52S5
51S7
41Q1
54R2
55Q2
55P5
55P9
52P10
52N5
52N6
52N1
56N1
56M7
38P1
43N1
45P1
45N1
46N1
45N4
55L1
54L5
59L3
39K1
35K1
41H1
41H2
41H3
41H4
47H1
40G1
53D6
53D7
53D8
53D9
53D10
53D11
53D12
54C1
39C1
52B8
52B9
52B10
52B11
52B12
52B13
51B3
52A1
79°
78°
77°
76°
39°
38°
37°

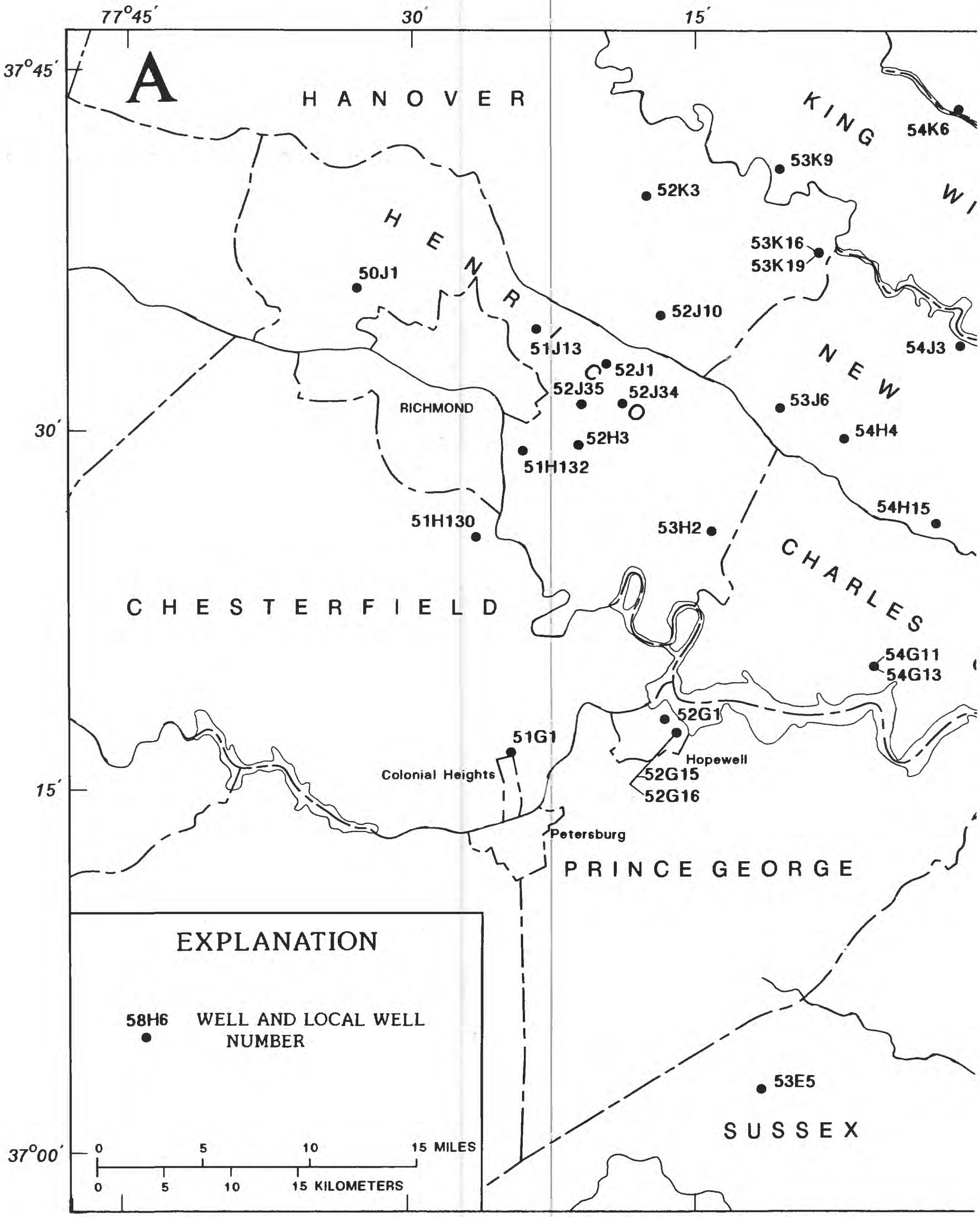
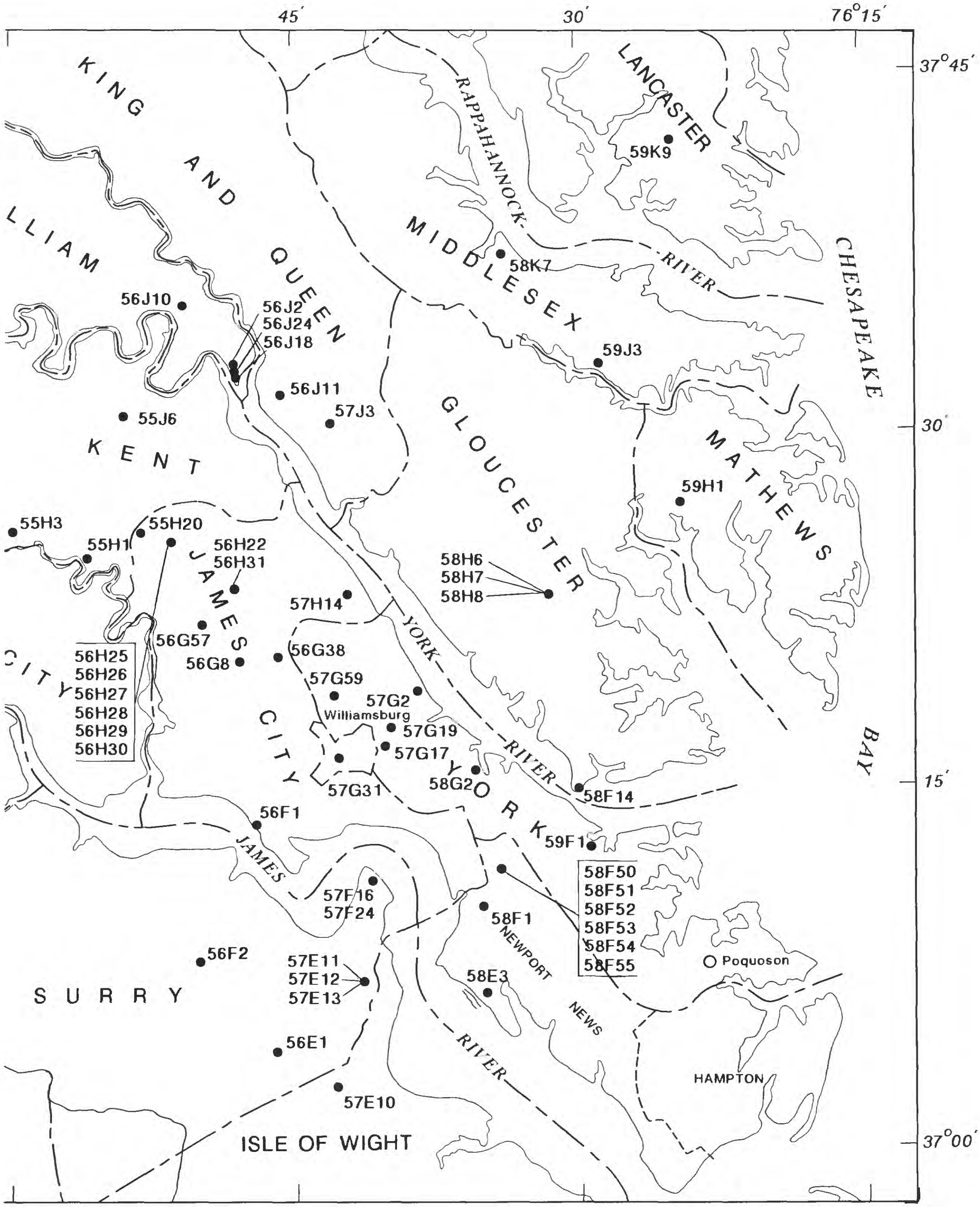


Figure 14.--Location of ground-water observation wells in Virginia (continued). (A) Inset showing detail.


45′
30′
76°15′
37°45′
30′
15′
37°00′
KING AND QUEEN
LANCASTER
RAPPAHANNOCK RIVER
MIDDLESEX
CHESAPEAKE BAY
GLOUCESTER
MATHEWS
KENT
JAMES CITY
YORK RIVER
YORK
JAMES RIVER
NEWPORT NEWS
SURRY
ISLE OF WIGHT
HAMPTON
Poquoson
Williamsburg
59K9
58K7
59J3
56J10
56J2
56J24
56J18
56J11
57J3
55J6
59H1
55H3
55H1
55H20
56H22
56H31
58H6
58H7
58H8
57H14
56G57
56G8
56G38
57G59
57G2
57G19
57G17
57G31
58G2
56H25
56H26
56H27
56H28
56H29
56H30
58F14
56F1
59F1
58F50
58F51
58F52
58F53
58F54
58F55
57F16
57F24
58F1
56F2
57E11
57E12
57E13
58E3
56E1
57E10

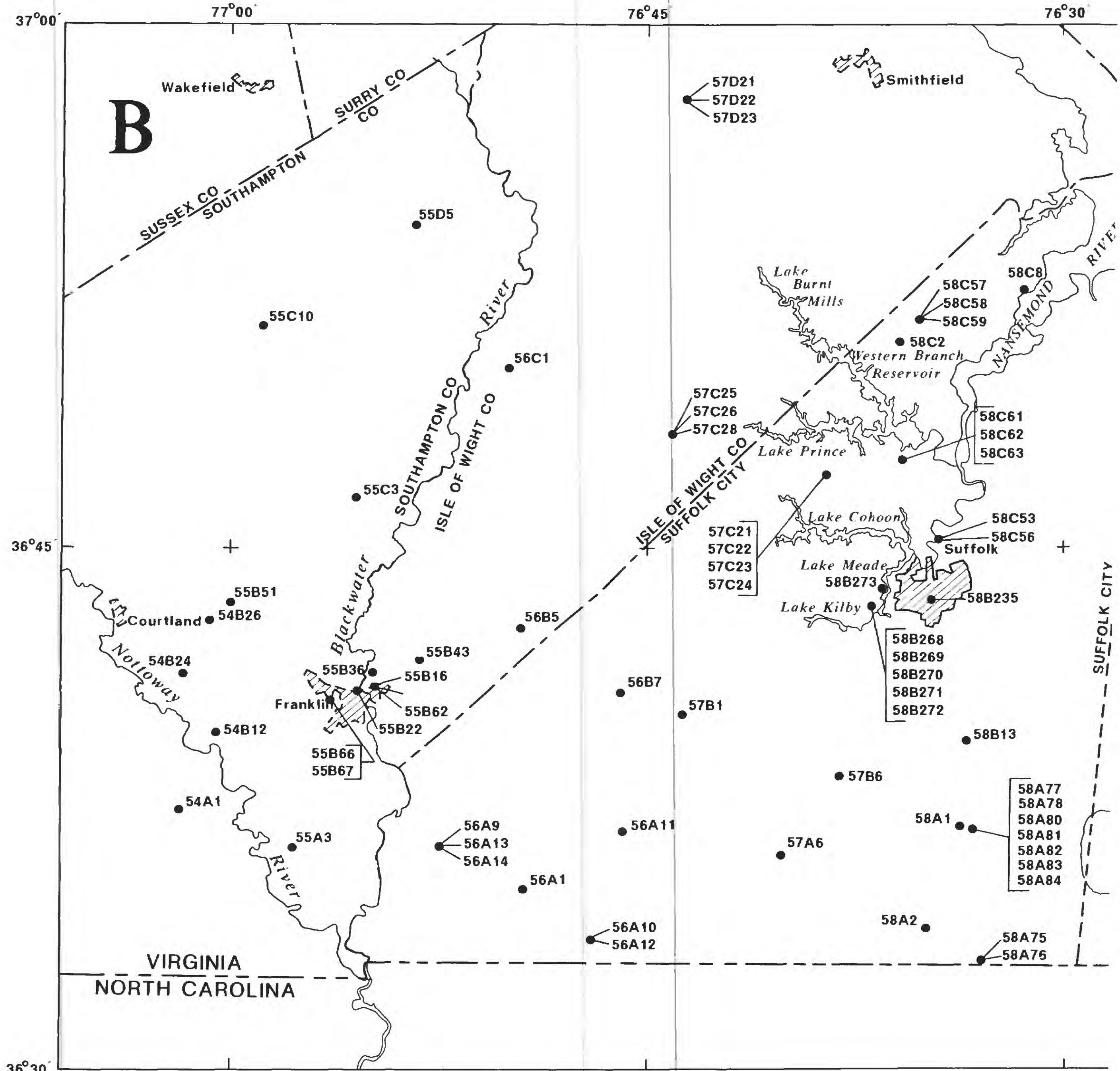
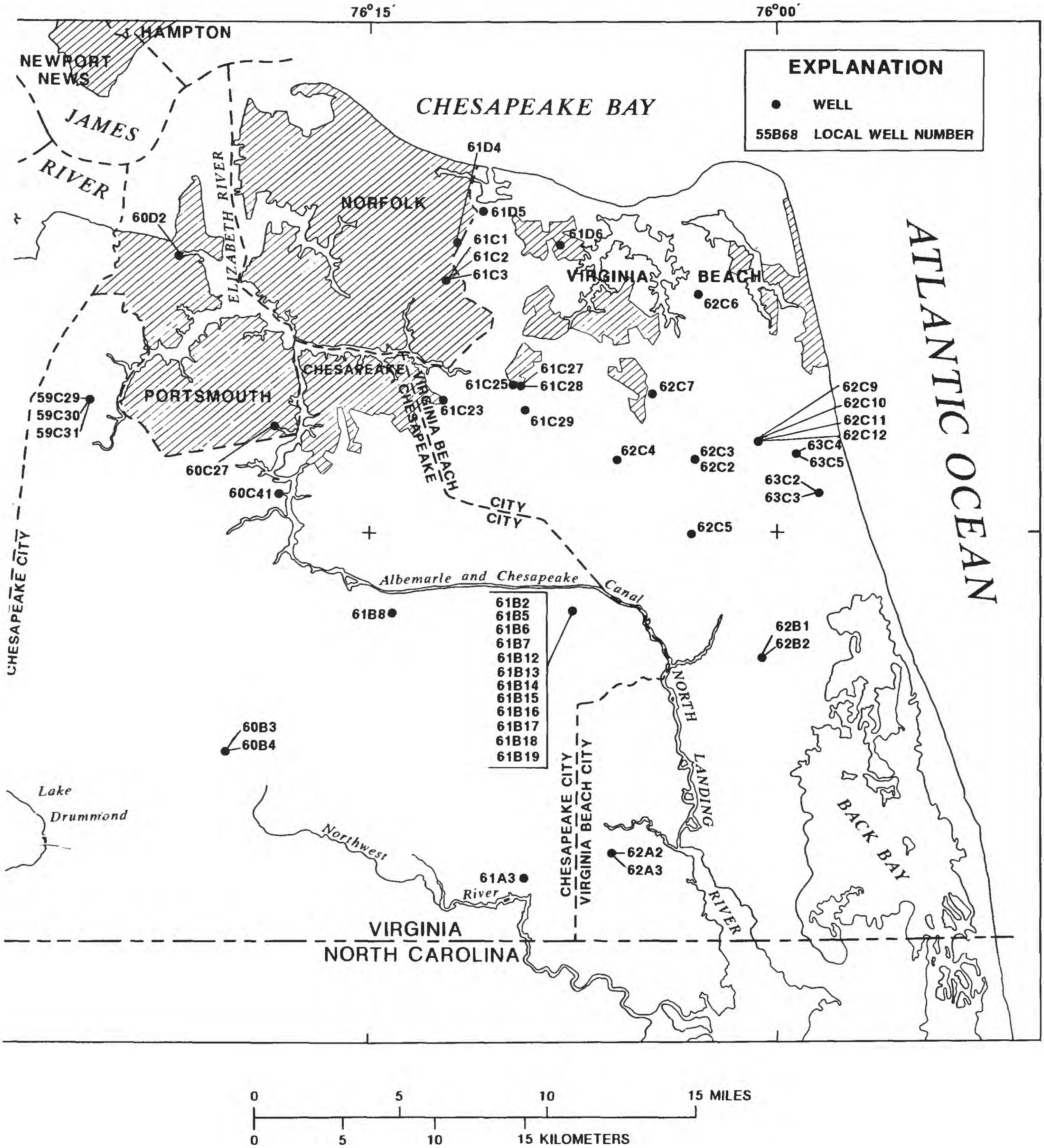


Figure 14.--Location of ground-water observation wells in Virginia (continued). (B) Inset showing detail.


76°15′
76°00′
HAMPTON
NEWPORT NEWS
JAMES RIVER
CHESAPEAKE BAY
EXPLANATION
WELL
55B68 LOCAL WELL NUMBER
ELIZABETH RIVER
NORFOLK
VIRGINIA BEACH
ATLANTIC OCEAN
PORTSMOUTH
CHESAPEAKE
VIRGINIA BEACH CITY
CHESAPEAKE CITY
Albemarle and Chesapeake Canal
NORTH LANDING RIVER
BACK BAY
Lake Drummond
Northwest River
VIRGINIA
NORTH CAROLINA
61D4
61D5
61D6
60D2
61C1
61C2
61C3
62C6
61C27
61C28
61C25
61C23
61C29
62C7
59C29
59C30
59C31
60C27
60C41
62C9
62C10
62C11
62C12
62C4
62C3
62C2
63C4
63C5
63C2
63C3
62C5
61B8
61B2
61B5
61B6
61B7
61B12
61B13
61B14
61B15
61B16
61B17
61B18
61B19
62B1
62B2
60B3
60B4
62A2
62A3
61A3
0 5 10 15 MILES
0 5 10 15 KILOMETERS

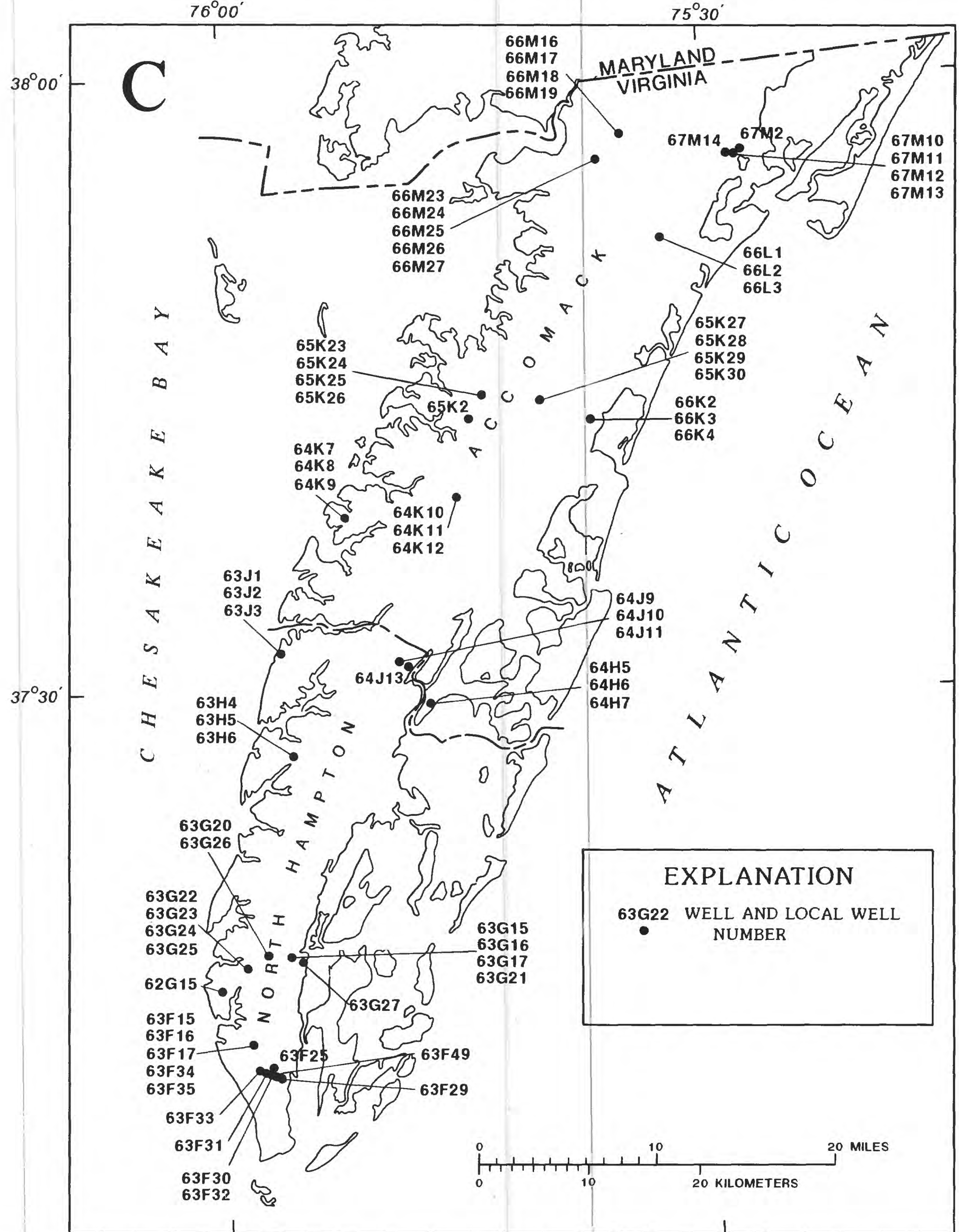


Figure 14.--Location of ground-water observation wells in Virginia (continued). (C) Inset showing detail.

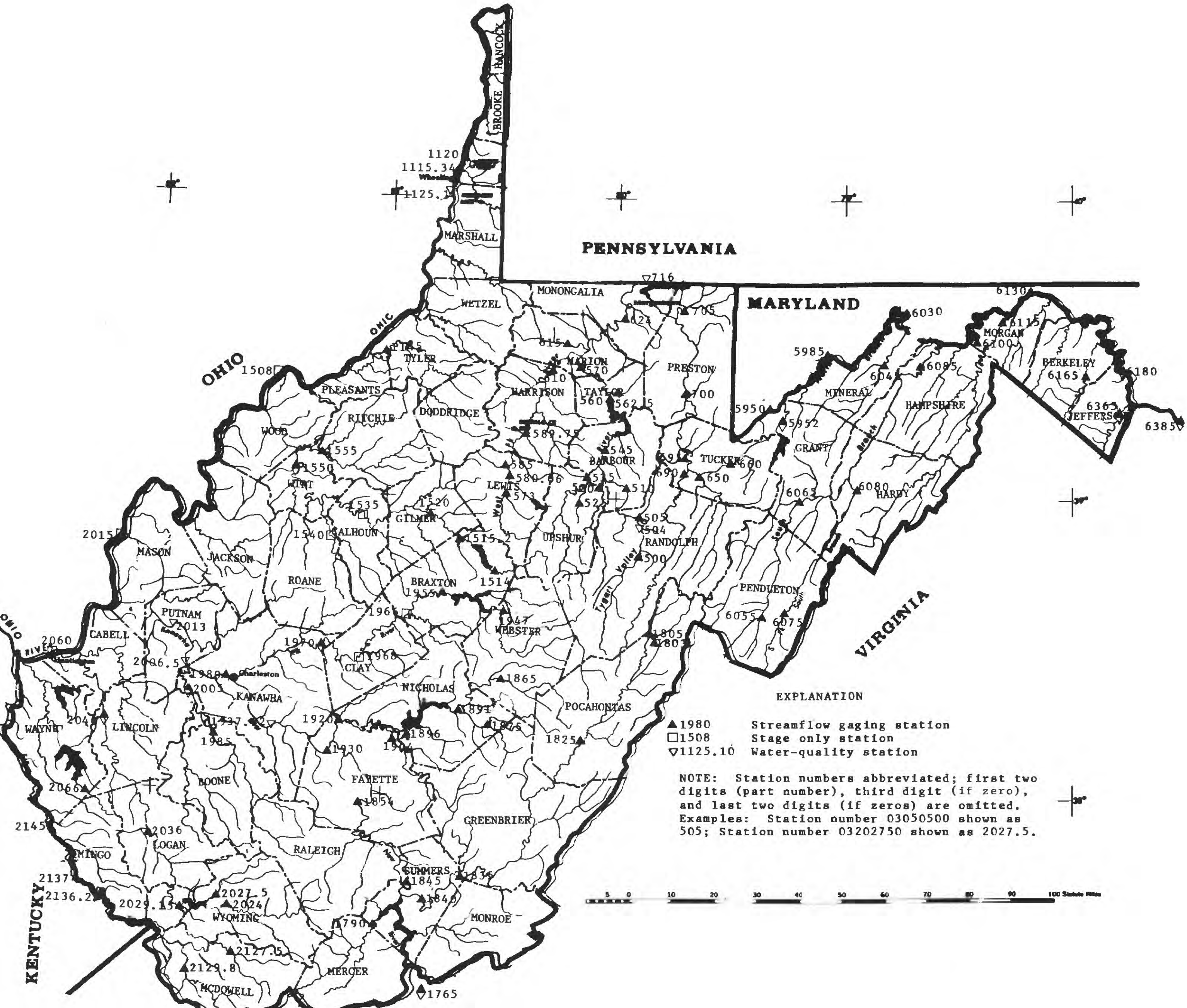


Figure 15.--Location of streamflow, stage, and water-quality stations in West Virginia.

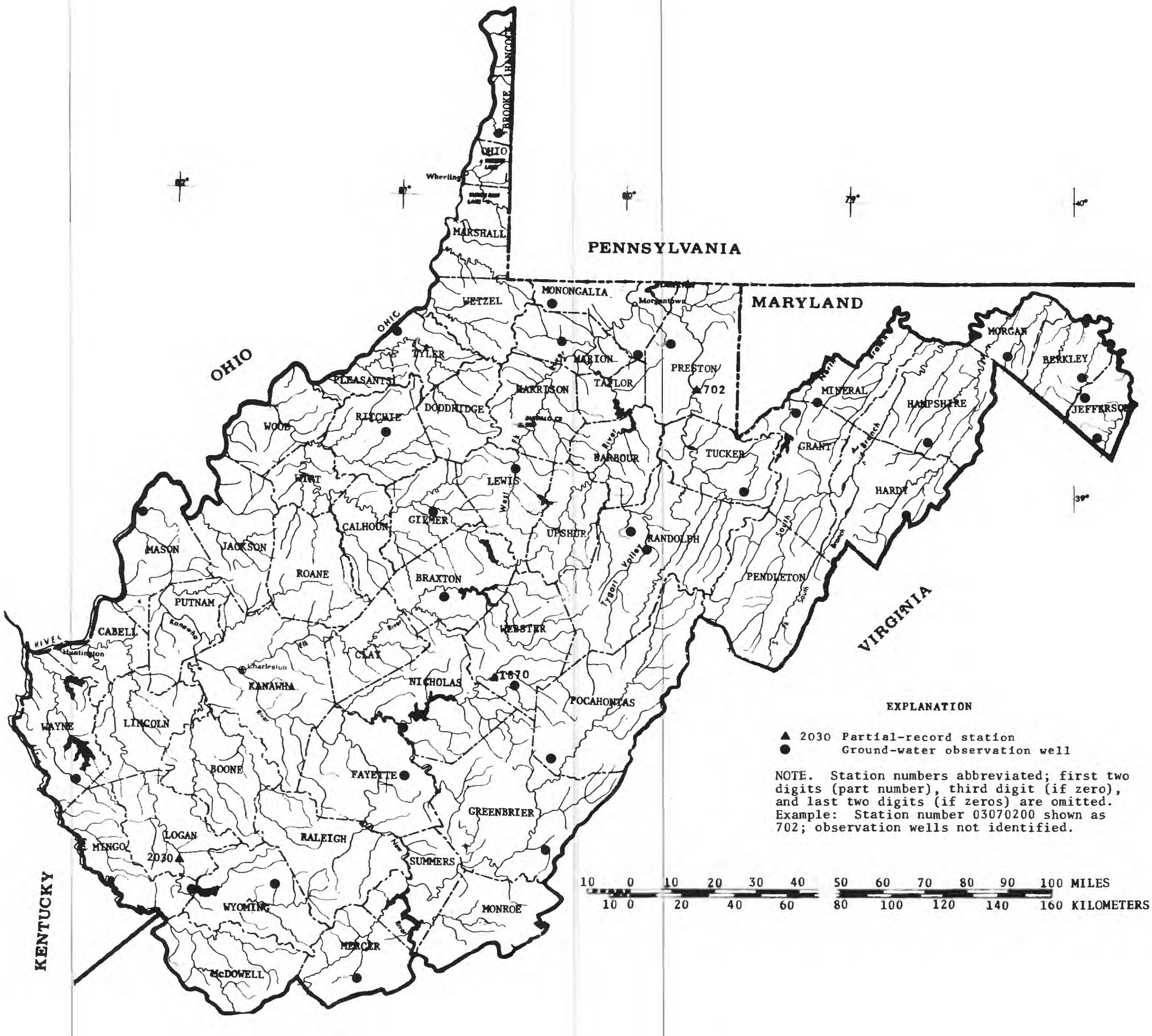


Figure 16.--Location of partial-record stations and ground-water observation wells in West Virginia.

Publications Section, Mid-Atlantic Programs

Linda Weiss, *Publications Section Chief*

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