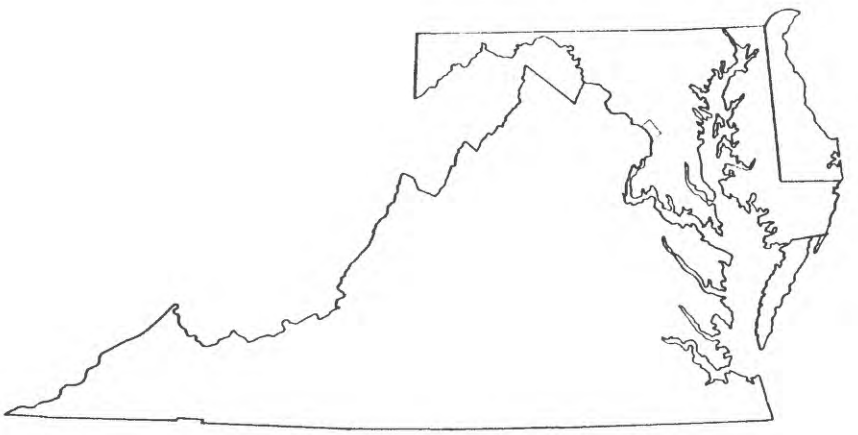
WATER RESOURCES ACTIVITIES
OF THE U.S. GEOLOGICAL SURVEY
MID-ATLANTIC DISTRICT
1984-1986



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U.S. GEOLOGICAL SURVEY

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1986

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

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CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.59	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

INTRODUCTION

The Mid-Atlantic District of the U.S. Geological Survey, Water Resources Division, includes the States of Delaware, Maryland, and Virginia and the District of Columbia. The water-resources program of the Mid-Atlantic District is conducted from offices located at seven sites in the three states. (See locations on fig. 1.) The program consists of two elements: Collection of basic records concerning quantitative and qualitative data for streams, reservoirs, estuaries, and ground water; and interpretive investigations based on the water facts collected in the basic-data activities.

The following pages describe the organization and activities of the Mid-Atlantic District. Included are descriptions of projects that were active during 1984, 1985, or 1986. Also included is a listing of reports describing results of water-resources studies in the District that were approved between January 1980 and June 1986.

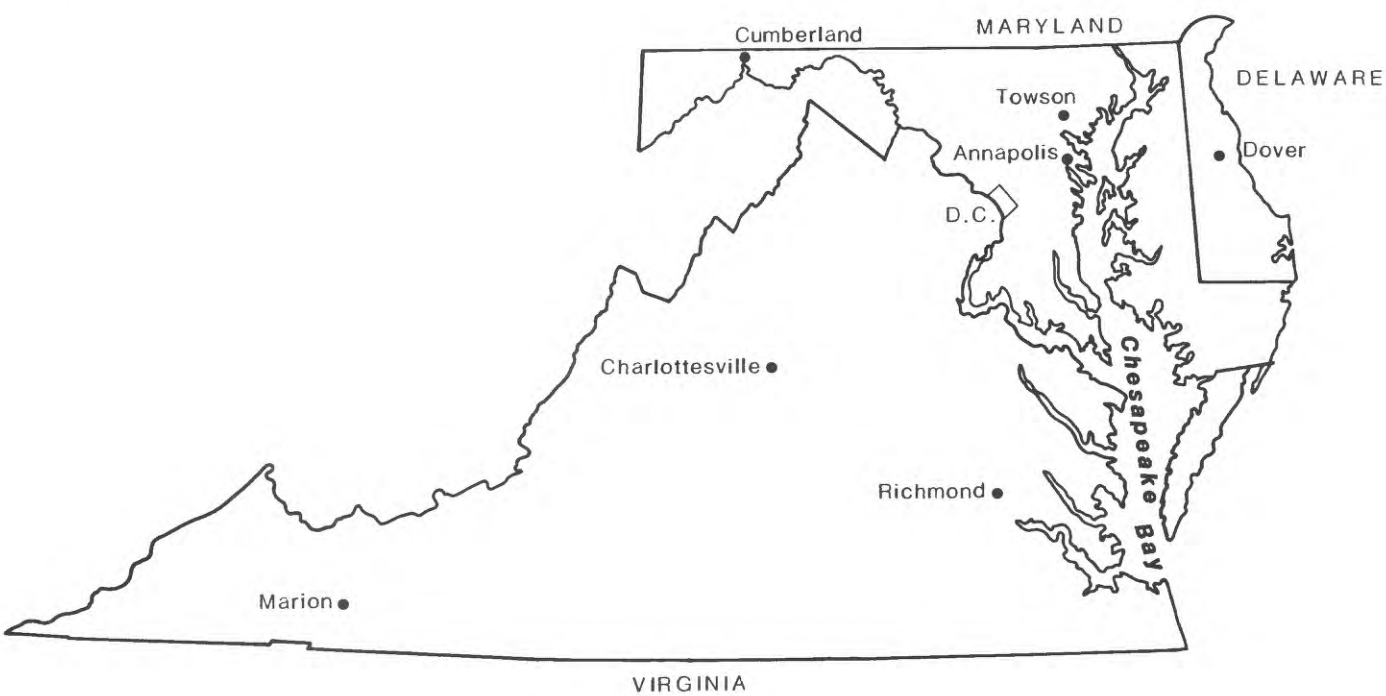


Figure 1. Mid-Alantic District and office locations.

The U.S. Geological Survey 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 Geological Survey is unique among Government organizations because it has neither regulatory nor developmental authority--its sole product is information. The Survey's role is that of a scientific organization concerned with presenting impartial, accurate data and scientific analyses equally to all interested parties.

U.S. Geological Survey Programs

The U.S. Geological Survey (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- and ground-water resources. Today's programs serve a diversity of needs and users. Programs include:

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

* Investigating and issuing warnings of earthquakes, volcanic eruptions, landslides, and other geologic and hydrologic hazards.

* Conducting research on the geologic structure of the Nation.

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

* Conducting topographic surveys of the Nation and preparing topographic and thematic maps and related cartographic products.

* Developing and producing digital cartographic data bases and products.

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

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

* Conducting research in hydraulics and hydrology, and coordinating all Federal water-data acquisition.

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

* 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.

Water Resources Division Mission and Program

The mission of the Water Resources Division is to provide the hydrologic information and understanding needed for the optimum utilization 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:

* 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.

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

* 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.

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

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

* 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

U.S. Geological Survey books, catalogs, pamphlets, and Open-File Reports are available from:

U.S. Geological Survey
Books and Open-File Reports
Federal Center, Building 41
Box 25425
Denver, CO 80225

Maps are available from:

U.S. Geological Survey
Map Distribution
Federal Center, Building 41
Box 25286
Denver, CO 80225

Most maps and books are also available over the counter at Public Inquiries Offices located in nine major cities. Local office locations are:

Public Inquiries Office
U.S. Geological Survey
503 National Center
Room 1-C-402
12201 Sunrise Valley Drive
Reston, VA 22092
(703) 648-6892
[FTS 959-6892]

Public Inquiries Office
U.S. Geological Survey
1028 General Services
Administration Building
19th and F Streets, NW
Washington, DC 20244
(202) 343-8073
[FTS 202-343-8073]

General questions about hydrology or geology may be addressed to:

Hydrologic Information Unit
U.S. Geological Survey
419 National Center
Reston, VA 22092
(703) 648-6815
[FTS 959-6815]

Geologic Inquiries Group
U.S. Geological Survey
907 National Center
Reston, VA 22092
(703) 648-4383
[FTS 959-4383]

Information about cartographic data, aerial imagery, digitized mapping, and geodetic control may be obtained from one of the local National Cartographic Information Centers (NCIC):

National Cartographic Information Center
U.S. Geological Survey
507 National Center
Reston, VA 22092
(703) 860-6045
[FTS 959-6045]

Many publications resulting from the jointly funded, cooperative program of the Mid-Atlantic District are published by the cooperating agencies (Maryland and Delaware only). These publications are available from:

Maryland Geological Survey
2300 St. Paul Street
Baltimore, MD 21218
(301) 554-5500

Delaware Geological Survey
University of Delaware
Newark, DE 19716
(302) 451-2834

District Organization and Office Addresses

Water-resources activities of the U.S. Geological Survey, Mid-Atlantic District are conducted from eight offices at seven locations in Delaware, Maryland, and Virginia (figs..1 and 2). Activities in the District of Columbia are conducted from the Maryland Office. The State Offices are the major centers for data-collection activities, hydrologic investigations, and for administrative and computer support. The Field Headquarters in Marion, Va., is a base for data collection and hydrologic investigations. The Field Headquarters in Cumberland, Md., and Charlottesville, 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 District Office coordinates activities of the State Offices and links District operations to the Regional and National Offices.

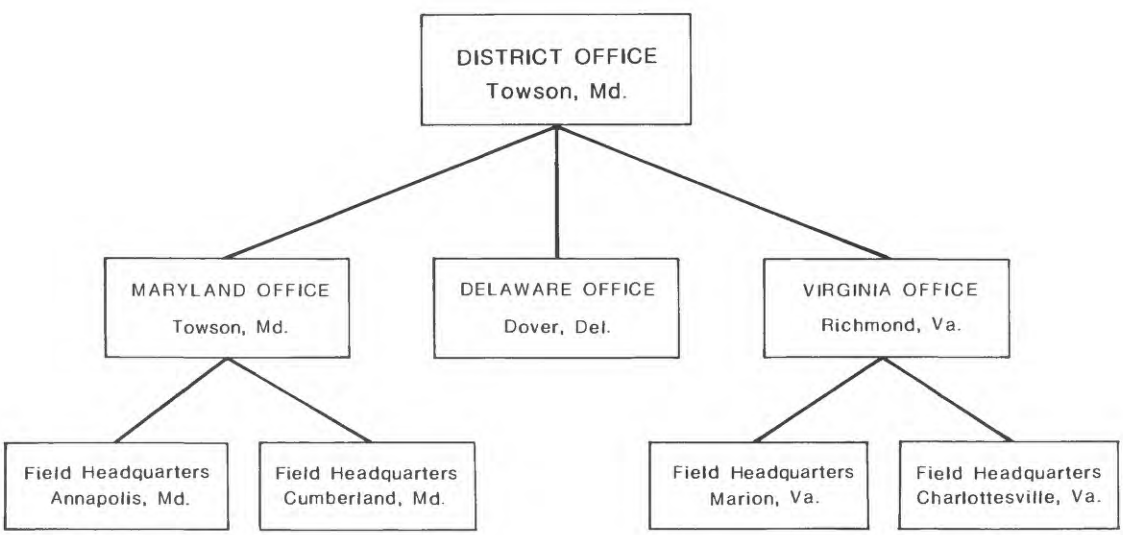


Figure 2. Mid-Atlantic District organization chart.

Office	Phone	Address
District Office Herbert J. Freiberger District Chief	(301) 828-1535 [FTS 922-7872]	U.S. Geological Survey 208 Carroll Building 8600 LaSalle Road Towson, MD 21204
Delaware Office Arthur L. Hodges, Jr. Delaware Office Chief	(302) 734-2506 [FTS 487-6241]	U.S. Geological Survey Federal Bldg. Rm. 1201 300 South New Street Dover, DE 19901
Maryland Office David Grason Maryland Office Chief	(301) 828-1535 [FTS 922-7872]	U.S. Geological Survey 208 Carroll Building 8600 LaSalle Road Towson, MD 21204
Virginia Office Gary S. Anderson Virginia Office Chief	(804) 771-2427 [FTS 925-2427]	U.S. Geological Survey Room 606 Travelers Building 3600 West Broad Street Richmond, VA 23230
Field Headquarters Walter E. Hendricks, Jr. Technician-in-Charge	(703) 783-6191	U.S. Geological Survey 1021 Terrace Drive Marion, VA 24354
Field Headquarters Roger N. Pollard Technician-in-Charge	(804) 295-6438	U.S. Geological Survey 1936 Arlington Boulevard Charlottesville, VA 22903
Field Headquarters Bernard F. Strain Technician-in-Charge	(301) 724-1840	U.S. Geological Survey Room 308 3-33 Pershing Street P.O. Box 1206 Cumberland, MD 21502
Field Headquarters Frederick K. Mack Hydrologist-in-Charge	(301) 269-3660	U.S. Geological Survey Tawes State Office Building D3 580 Taylor Avenue P.O. Box 1568 Annapolis, MD 21404

Sources of Funding and Cooperating Agencies

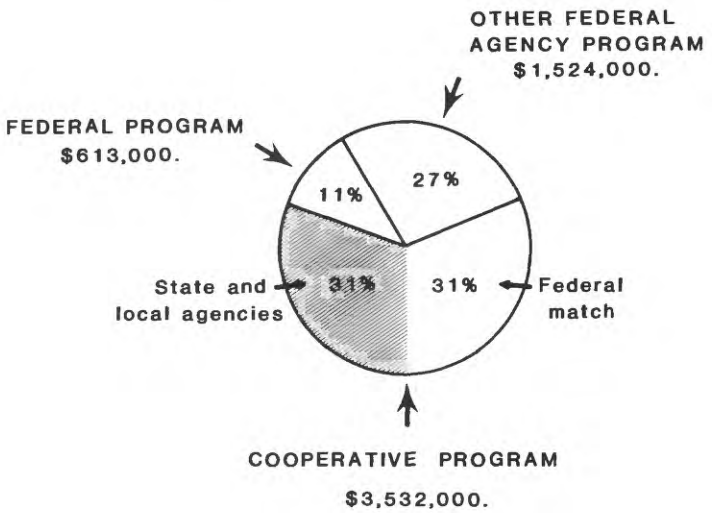


Figure 3. Source of funds for 1985 fiscal year.

Funds to support work performed in the Mid-Atlantic District 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 U.S. Geological Survey. The District obtains funding from this source for specific projects that address high-priority topical programs identified in the Congressional appropriation. Such projects in the Mid-Atlantic District are related to the Acid Rain Program, the Coal Hydrology 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 used to match funds furnished by state and other tax-supported local agencies up to a maximum of 50 percent. These funds are used for a majority of the hydrologic data-collection activities and hydrologic investigations in the District. For many years, the jointly funded, cooperative arrangement has assured 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 District as reimbursement for data-collection activities or hydrologic investigations performed at their request.

Agencies supporting water-resources activities in the Mid-Atlantic District, 1984-86, are listed below:

Federal-State Cooperative Program

* Delaware Geological Survey
* Delaware Department of Natural Resources and Environmental Control
* Water Resources Agency for New Castle County, Delaware

* District of Columbia Department of Public Works.

* Maryland Bureau of Mines
* Maryland Department of Health and Mental Hygiene, Office of Environmental Programs
* Maryland Energy Administration
* Maryland Geological Survey
* Maryland Hazardous Waste Siting Board
* Maryland Highway Administration
* Maryland Tidewater Administration
* Maryland Water Resources Administration
* Anne Arundel County, Maryland
* Baltimore County, Maryland
* Cecil County, Maryland
* Charles County, Maryland
* Frederick County, Maryland
* Harford County, Maryland
* Howard County, Maryland
* Queen Annes County, Maryland
* Somerset County, Maryland
* Baltimore City
* Town of Ocean City, Maryland
* Chesapeake Bay Research Initiative
* Tri-County Council for Southern Maryland
* Upper Potomac River Commission
* Washington Suburban Sanitary Commission

* Virginia Department of Highways and Transportation
* Virginia Division of Mined Land Reclamation
* Virginia Water Control Board
* University of Virginia
* Virginia Polytechnic Institute and State University
* Clarke County, Virginia
* Hanover County, Virginia
* New Kent County, Virginia
* York County, Virginia
* Charles City County, Virginia
* James City County, Virginia
* James City Service Authority
* Lord Fairfax Planning Commission
* City of Alexandria, Virginia
* City of Newport News, Virginia
* City of Radford, Virginia
* City of Roanoke, Virginia
* City of Williamsburg, Virginia

* Southeastern Public Service Authority
* Northern Virginia Planning District Commission
* Interstate Commission on the Potomac River Basin

Other Federal Agency Program

* Federal Emergency Management Agency
* National Park Service
* Tennessee Valley Authority
* U.S. Army Corps of Engineers
* U.S. Department of Agriculture, Soil Conservation Service
* U.S. Department of Defense, Defense Logistics Agency
* U.S. Department of Defense, Department of the Army
* U.S. Environmental Protection Agency

PROJECT DESCRIPTIONS

Projects of the Mid-Atlantic District that were active during 1984, 1985, or 1986 are described on the following pages. Interstate projects are described first, followed by projects in Delaware, Maryland, and Virginia. Projects involving the District of Columbia are not described separately. Interpretive studies that include the District of Columbia are interstate projects MD037 and MD083. Surface-water stations for the District 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.

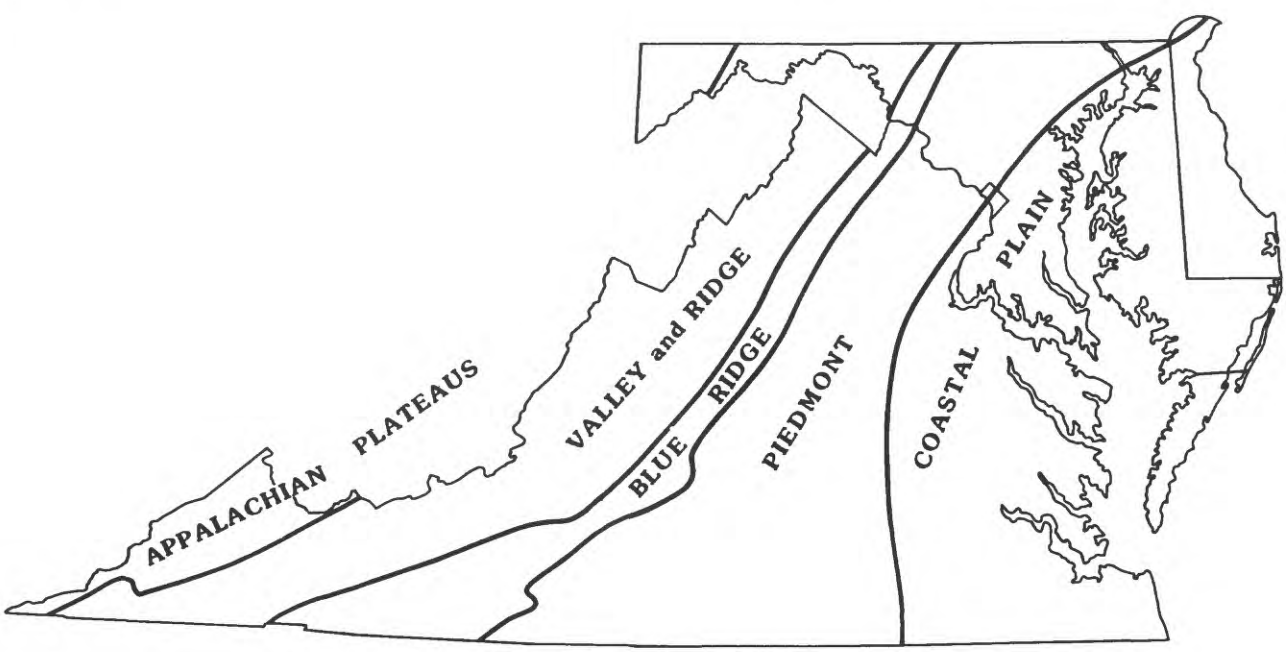
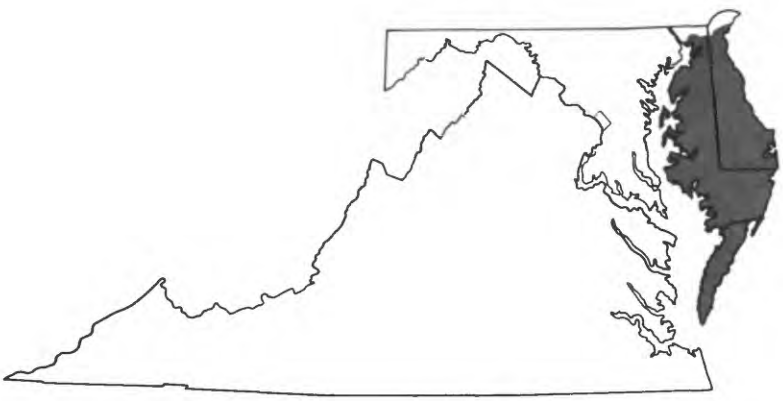


Figure 4. Physiographic provinces of the Mid-Atlantic District.



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

LEADER: Robert J. Shedlock

PERIOD OF PROJECT: March 1986 - September 1990

PROBLEM: Assessing ground-water quality on a national or regional scale is extremely difficult. Past site-specific studies indicate that local problems exist on the Delmarva Peninsula, but ground-water quality has never been comprehensively addressed on a regional scale. The data that do exist are not available in a form suitable for evaluating ground-water quality trends. Additionally, there is no precedent for a ground-water quality monitoring strategy on this scale.

OBJECTIVE: 1. Assess the ground-water quality of the Delmarva Peninsula based on the chemical and physical characteristics of the ground-water. 2. Develop hazard potential maps for selected chemical constituents. 3. Develop a comprehensive ground-water quality data base for the Delmarva Peninsula. 4. Develop a regional ground-water quality assessment strategy.

APPROACH: 1. Conduct an extensive 3-year ground-water quality sampling program that will sample: (a) unconfined aquifers and aquifers directly connected to the unconfined, and (b) public water-supply withdrawals from deeper aquifers. 2. Develop hazard potential maps based on: (a) water-quality conditions, (b) hydrogeology, and (c) land use. 3. Develop a comprehensive data base comprised of historical and NAWQA chemical and physical data. 4. Use statistical, spatial statistical, and GIS (Geographic Information System) techniques to assess regional ground-water quality trends.

TITLE: Analysis by Use of Digital Models of the Coastal Plain Aquifers Underlying Maryland and Delaware (MD037)

LEADER: William B. Fleck

PERIOD OF PROJECT: October 1979 - September 1986

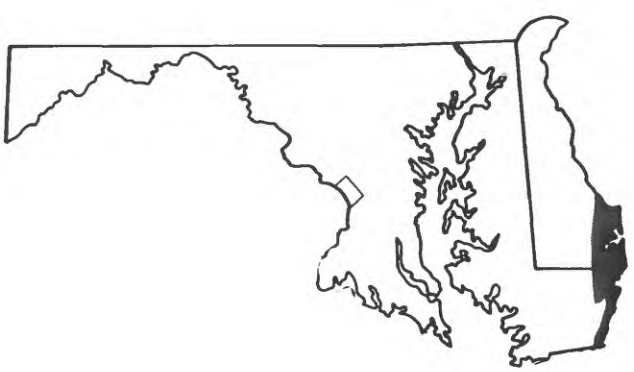
PROBLEM: The Northern Atlantic Coastal Plain is both densely populated and heavily industrialized. As the limit of available surface-water supplies is approached, an increasing demand for ground water, in turn, demands good ground-water management. The effects of additional stress on water levels and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

OBJECTIVE: 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 System Analysis (RASA). 2. Describe the subregional 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 upon this system. 3. Attain a better understanding of the saltwater-fresh-water interface and the effects of Chesapeake and Delaware Bays and the ocean on the ground-water flow system.

APPROACH: Collect and analyze data on aquifer characteristics, pumpage, head, water quality, and base flow. Interpretive maps will be constructed from these data for use in developing the District models in conjunction with the RASA model. A coarse-grid digital simulation model of the flow system employing the USGS quasi three-dimensional finite-difference ground-water flow model will be developed to determine regional flow conditions and boundary flow conditions for finer-grid models.

SUMMARY: A 10-layer model was constructed to simulate the flow of ground water in the Coastal Plain sediments of Maryland and Delaware. The 10 layers, in ascending order, are equivalent to the water-bearing parts 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 inches of recharge percolates into the deep confined system. Pumping from the aquifers results in about 10 well-defined cones of depression. Total ground-water pumpage for 1977-80 averaged about 131 Mgal/d.

A report describing the hydrogeologic framework of the Coastal Plain sediments of Maryland, Delaware, and the District of Columbia is approved for publication and a report on the ground-water flow model is in preparation.(See reference to approved report of results of this project in list for 1986 at end of this report.)



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

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

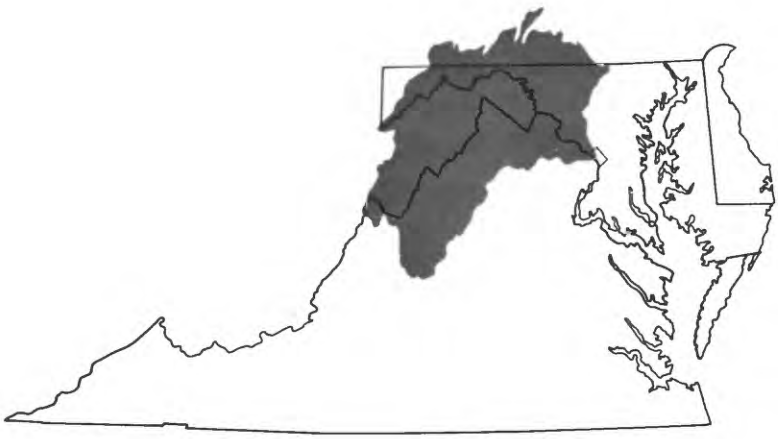
PERIOD OF PROJECT: April 1985 - March 1987

PROBLEM: Ground water in the coastal areas of both 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 from the ocean and bays into and through the water-table aquifer; 2. from below, by infiltration from aquifers containing saltwater; and 3. from offshore, by lateral movement of the saltwater-freshwater interface.

OBJECTIVE: Upgrade the present water-level measurement network to define annual drawdown and recovery cycles in areas affected by pumping. Set up a network to measure salinity of ground water so that variations can be recorded and trends identified. Evaluate water-level and salinity data to describe the current situation and to compare the new data with historic data. Prepare a proposal that will provide for continuation of optimum 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 consists of 24 observation wells, of which 6 have water-level recorders. Water from 10 production wells is being monitored weekly or bi-weekly for chloride content. The Maryland network consists of 21 observation wells of which 11 have water-level recorders. Water from 15 production wells in Maryland is being monitored for chloride content. Most wells will be sampled every 6 to 8 weeks during the project for field chloride and conductivity tests. These wells will be sampled for laboratory analysis of chloride and other major ions in August and in March.

SUMMARY: Summer 1985 and spring 1986 samplings have been completed. The network of observation and monitored production wells consists of 70 wells with 17 water-level recorders. Water-level and water-quality sampling networks have been established. The report outline has been completed and the report manuscript has been started.



TITLE: Areal Water-Quality Assessment and Analysis for Trends in the Potomac River and its Tributaries Upstream from Washington, D.C. (MD083)

LEADER: Thomas J. Trombley

PERIOD OF PROJECT: February 1985 - September 1987

PROBLEM: Effective water-quality management of the Potomac River basin requires an understanding of the areal and temporal variability of water quality throughout the drainage basin. It is also necessary to determine the adequacy of the present water-quality data network and potential sources of water-quality problems.

OBJECTIVE: 1. Describe spatial and temporal variability of stream-water quality throughout the Potomac River basin upstream from Washington, D.C. 2. Relate water-quality variability to general causes such as selected basin characteristics. 3. Assess adequacy of water-quality data collected at network sites to represent the spacial and temporal water-quality variability throughout the drainage basin. 4. If water-quality data do not represent water quality throughout the drainage basin, describe the minimum data-collection program necessary to do so. 5. Assess usefulness of daily versus periodic water-quality data.

APPROACH: Review natural features and water development in the basin. Review and assemble basin characteristics data. Describe probability distribution of constituents at sites where systematic sampling has occurred. Estimate the transport rate of key parameters. Explain transport and water-quality variations by subbasin. Describe problem areas. Perform statistical trend analysis on selected constituents at sites with 3 or more years of data. Statistically assess adequacy of available data to assess water-quality variability within the basin.

SUMMARY: Water-quality data for 25 surface-water stations were compiled. Summary statistics for these data and regressions which will be used to estimate the effects of discharge on concentration have been completed. Analyses to determine temporal and areal trends will be completed soon.

Delaware Projects

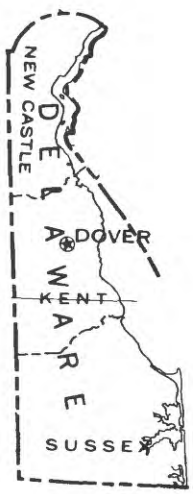


Figure 5. Counties of Delaware.

TITLE: Surface-Water Stations (DE001)

LEADER: Robert H. Simmons

COOPERATORS: Delaware Geological Survey, Delaware Department of Natural Resources and Environmental Control, Water Resources Agency for New Castle County, Delaware and U.S. Army Corps of Engineers

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.

OBJECTIVE: A. To collect surface-water data sufficient to satisfy needs for current-purpose uses, such as (1) assessment of water resources, (2) operation of reservoirs or industries, (3) forecasting, (4) disposal of wastes and pollution controls, (5) discharge data to accompany water-quality measurements, (6) compact and legal requirements, and (7) research or special studies. B. To collect data required to define trends and the statistical properties of the occurrence of water in streams, lakes, estuaries, etc.

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 is currently collected at 30 sites in Delaware. Continuous record is collected at 16 stations, and partial record at 14 stations. (See section, "Annual Water-Data Reports," for locations of data-collection sites and information on publication of data.)

TITLE: Ground-Water Stations (DE002)

LEADER: Robert H. Simmons

PERIOD OF PROJECT: Continuous since 1944

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 system, to provide a data base from which to assess the effects of development, to assist in the prediction of future supplies, and to provide data for management of the resource.

OBJECTIVE: A. To 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. B. To provide a historical data base against which the 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 geologic and hydrologic framework and of the stress on the system, a subjective decision can be made on the most advantageous locations for observation of long-term system behavior. The water-level network can be evaluated and 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.

SUMMARY: Continuous ground-water level data are presently collected at 2 sites, and periodic measurements are made at 22 other sites in Delaware. (See section, "Annual Water-Data Reports," for locations of selected data-collection sites and information on publication of data.)

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

LEADER: Arthur L. Hodges, Jr.

COOPERATOR: Delaware Department of Natural Resources and Environmental Control

PERIOD OF PROJECT: Continuous since 1980

PROBLEM: The Delaware Department of Natural Resources and Environmental Control (DNREC) is charged with the responsibility of allocating State water resources. In order to make equitable decisions, water managers need accurate and reliable estimates of current water withdrawal, delivery, release, consumptive use and return flow. Total water use figures for the State have been prepared in the past by combining 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, vague estimates based on national averages are inadequate data on which to make management decisions.

OBJECTIVE: This study will develop and document efficient sampling methods for making statistically significant estimates of water use in Delaware. Intensive collection and analysis of water-use data in the St. Jones basin in central Delaware will be used to extrapolate withdrawal and consumptive use of water throughout the State.

APPROACH: The St. Jones River basin in central Delaware has a drainage area of 86 square miles (mi^2). Records will be collected from public utilities which deliver metered water for domestic, industrial, commercial, and fossil fuel power generation. Analysis of these data will provide a preliminary local estimate of average water use for industrial, commercial, domestic, and fossil fuel power generation within the metered area. Return flow data from Kent County sewage facilities corrected for line gains and losses by the county will be compared to withdrawal and delivery data to provide values of consumptive use within the sewered areas.

Agricultural, irrigation, commercial, mining, and domestic water use outside the area served by municipal supply will be sampled using digital vibration-time-totalizers and a non-intrusive flow meter to provide water-use data. These data will be used to extrapolate total water use in each category. Data for the St. Jones River basin will be analyzed statistically in three stages to develop standard survey or inventory techniques for the various water-use categories. In the first stage, estimates (such as means, medians, modes and confidence intervals) will be computed for successively larger samples of users in the Dover services areas. These estimates will be compared to determine an efficient ratio of sample size to facility population size for accepting estimates as statistically significant. The second stage will involve analysis of variance comparing data in the Dover samples and data in the self-supplied users' sample. The third stage will include analysis of variance involving data from the St. Jones River basin samples and the family of estimates from this study and national averages taken as a sample.

SUMMARY: Digital vibration-time-totalizers were placed on irrigation wells in the St. Jones River basin and the output of the wells was determined using a Doppler flowmeter. Areal reconnaissance of the basin was completed and maps were prepared showing the location, number, and type of agricultural, industrial, and commercial self-supplied water users in the basin. Water-use data were collected from major users, and return-flow data from Kent County. Data to determine average commercial, agricultural, and domestic water use in metered and non-metered areas are being analyzed, and delivery and return-flow data are being compared to estimate consumptive use. Estimates of average, and range of commercial, agricultural, and domestic withdrawal and depletive water use will be made.

TITLE: Hydrogeology and Geochemistry of Water in the Unconfined Aquifer of West Central and Southwestern Delaware (DE017)

LEADER: Judith M. Denver

COOPERATOR: Delaware Geological Survey

PERIOD OF PROJECT: October 1981 - September 1984

PROBLEM: Chemical constituents of water in the unconfined aquifer of west-central and southwestern Delaware are frequently present in high enough concentrations to restrict the use of the water for public and industrial supply. The chemical quality of water in a ground-water reservoir is a function of the quality of the recharge to that reservoir modified by a series of complex chemical reactions which occur between ground water and aquifer material. A determination of the chemical reactions that control concentration and mobility of these constituents is necessary in order to understand the present distribution of the chemical components of the ground-water system.

OBJECTIVE: To describe the hydrology and to define water chemistry of the unconfined aquifer and the geochemical processes and other factors that control the chemical quality of the water. The study considers (1) geochemical and anthropogenic influences on water chemistry; (2) the relation of concentrations of major ions in ground water to geologic, hydrologic, soil, and land-use characteristics; (3) changes in water chemistry resulting from variations of depth and pumpage; (4) trends in data obtained in the field and the laboratory; and (5) relations of mineral equilibria.

APPROACH: Water-quality information and information on the characteristics of aquifer materials were obtained from various sources. Published studies and ongoing projects provided information on the ground-water flow system. Field water-quality measurements of pH, conductivity, dissolved oxygen, alkalinity, and temperature were made at 122 wells. Fifty wells were sampled for chemical analysis of major ions, nutrients and trace elements. Chemical parameters

were compared to each other and related to land-use and aquifer characteristics. Equilibrium reactions between water and aquifer materials (WATEQF program) were evaluated and tested using mass balance calculations.

SUMMARY: The unconfined aquifer in southwestern Delaware is composed of unconsolidated fluvial channel fill and marginal marine deposits composed of sand with beds of silt, clay, and gravel. Thickness of the aquifer varies from about 15 ft in the northern part of the study area to over 150 ft in the southern part. Silicates, primarily feldspars and micas, are the major minerals available for reaction with the ground water.

Results of chemical analyses of water from the unconfined aquifer indicate that the water chemistry is significantly affected by soil drainage characteristics and land use. Most of the study area is overlain by moderate to well-drained soils. In well-drained areas, oxygen is not removed as recharge moves through the soil zone to the water table. In poorly drained areas, however, oxygen in recharge reacts with organic matter in the soils and is depleted. Ground water that contains dissolved oxygen does not react with naturally occurring iron oxides and hydroxides. Concentrations of dissolved iron are therefore low in areas of well-drained soils. Ground water that contains no oxygen dissolves iron oxides and hydroxides. Concentrations of dissolved iron may therefore be high enough in areas of poorly drained soils to limit the use of the water.

Land uses that contribute ions to ground water may mask the concentrations of ions resulting from mineral dissolution and rainfall because the background dissolved solids concentration is low, usually less than 100 mg/L. Major ions in ground water from areas undisturbed by surficial activities are sodium and bicarbonate. Significant quantities of calcium, magnesium, potassium, bicarbonate, nitrate, ammonium, and chloride ions are leached into the ground water from agricultural applications of fertilizer and lime. In areas influenced by agricultural land use, nitrate and chloride replace bicarbonate as the major anions. Sodium usually remains the major cation, but calcium, magnesium, and potassium concentrations in the water are proportionally higher. (See reference to approved report of results of this project in list for 1985 at end of this report.)

TITLE: Potential Interactions of the Potomac Aquifer and Delaware Estuary, Northern Delaware (DE018)

LEADER: Scott W. Phillips

COOPERATOR: Delaware Department of Natural Resources and Environmental Control

PERIOD OF PROJECT: January 1984 - September 1986

PROBLEM: A refined understanding of the Potomac aquifer system is needed in the subcrop-outcrop area of the aquifer near the Delaware Estuary to determine the potential for brackish-water infiltration. In a previous study, geologic and hydrologic information for the aquifer was assembled and analyzed and a digital model of the aquifer in northern Delaware was developed. (This work by M.M. Martin and others, U.S. Geological Survey, was done in cooperation with the U.S. Army Corps of Engineers and the Delaware Department of Natural Resources and Environmental Control.) This model was used to evaluate the water-supply potential of the aquifer. Study of estuary-aquifer interactions, however, will require adaptation of the model and some additional data.

OBJECTIVE: To determine the potential for brackish-water infiltration into the Potomac aquifer. The study will evaluate existing data, establish a long-term monitoring program, and determine the feasibility of solute-transport modeling. A three-dimensional digital model from a previous study will be adapted to the new U.S. Geological Survey (USGS) modular model to better evaluate the potential for brackish-water intrusion and the potential effectiveness of injecting a freshwater barrier.

APPROACH: Data will be compiled from various sources. Field work will include collection of water samples for chemical analysis, water-level measurements and the drilling and geophysical logging of four test holes. Geologic data will be analyzed to determine river-bed sediment properties and the geologic framework. Geochemical data will be examined to detect evidence of estuary water leaking into aquifers. Flow in the aquifers near the estuary will be simulated to evaluate infiltration of brackish water from the estuary.

SUMMARY: The results of the study indicate some induced infiltration from the Delaware river is occurring at several Potomac aquifer well fields in northern New Castle County, Delaware. Evidence of the infiltration are:

1. Chloride concentrations of 20-230 mg/L, which are higher than the chloride values of the natural aquifer system.
2. Chloride concentrations have increased over time as water levels fall below sea level due to pumpage.
3. Plots of geochemical data on Stiff and Durov diagrams show a strong similarity between the composition of river and aquifer water.

The ground-water flow model was used to estimate the percentage of water infiltrating from the river to selected well fields. The best application of the model was for the area that includes the Llangollen, Crown Zellerbach, Amoco, Army Creek, and Artisans Village well fields, which showed a 10 percent river-water contribution to the combined pumpage of the well field.

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

LEADER: Judith M. Denver

COOPERATOR: Delaware Geological Survey

PERIOD OF PROJECT: October 1984 - December 1987

PROBLEM: The unconfined aquifer is the major source of water supply in eastern Sussex County. High iron or high nitrate concentrations frequently degrade the quality of water from this aquifer. Previous studies have identified problem areas and correlated high iron or nitrate concentrations with land use and soil drainage characteristics. A detailed analysis of the movement and behavior of chemical constituents in the hydrologic system resulting from different land uses is needed to give water managers a better understanding of water quality, and to assist in locating future public water supplies of acceptable quality.

OBJECTIVE: To study the distribution and movement of chemical constituents in ground water resulting from different land uses. Specifically: (1) the horizontal and vertical movement and distribution of nitrates and other chemical constituents in ground water in response to irrigation well pumpage in an oxidized portion of the aquifer; (2) the differences between water chemistry in parts of the aquifer affected by leachate from septic systems and agricultural nitrogen applications; and (3) areal and depth variations in iron occurrence and distribution over relatively small distances.

APPROACH: Phase I - Install a piezometer network around an irrigation well located in the center of a field with an adjacent perennial stream. Use chemical analyses, water levels, and streamflow measurements to show groundwater flow, movement of chemical constituents and impact of base flow on surface-water chemistry. Phase II - Compare water chemistry data (major ion, nutrient trace metal, stable carbon isotope) from wells influenced by septic system leachate to similar data from wells affected by agricultural chemicals.

Phase III - Install piezometer clusters to study variations in dissolved iron. Chemical analyses, hydrologic data, and mass balance techniques will be used to analyze the data.

SUMMARY: Phase I - A network of thirty-one 2-inch polyvinyl chloride piezometers was installed around an irrigated field for collection of water-quality and water-level data. The network includes five clusters of four to five piezometers each screened at 20- to 25-ft intervals below the land surface. Several rounds of sampling have been completed. All wells were sampled for field determinations of specific conductance, pH, dissolved oxygen, alkalinity, and chloride. Selected piezometers were sampled for laboratory analyses. Records from a continuous water-level recorder on an observation well adjacent to the irrigation well showed about 5 ft of drawdown and recovery due to irrigation pumping. The effects of irrigation pumping were seen in the water levels and water chemistry in all of the piezometers. Minimonitors have been installed on two of the piezometers for continuous monitoring of specific conductance and pH. Phase II - Several sites affected by septic effluent have been located and permission to sample adjacent wells has been obtained. Results of these analyses will be compared to water from wells affected by agriculture. Phase III - A site has been selected and piezometers installed to study the variability of iron concentrations. Chemical and hydrologic data will be analyzed as they are collected.

Maryland Projects

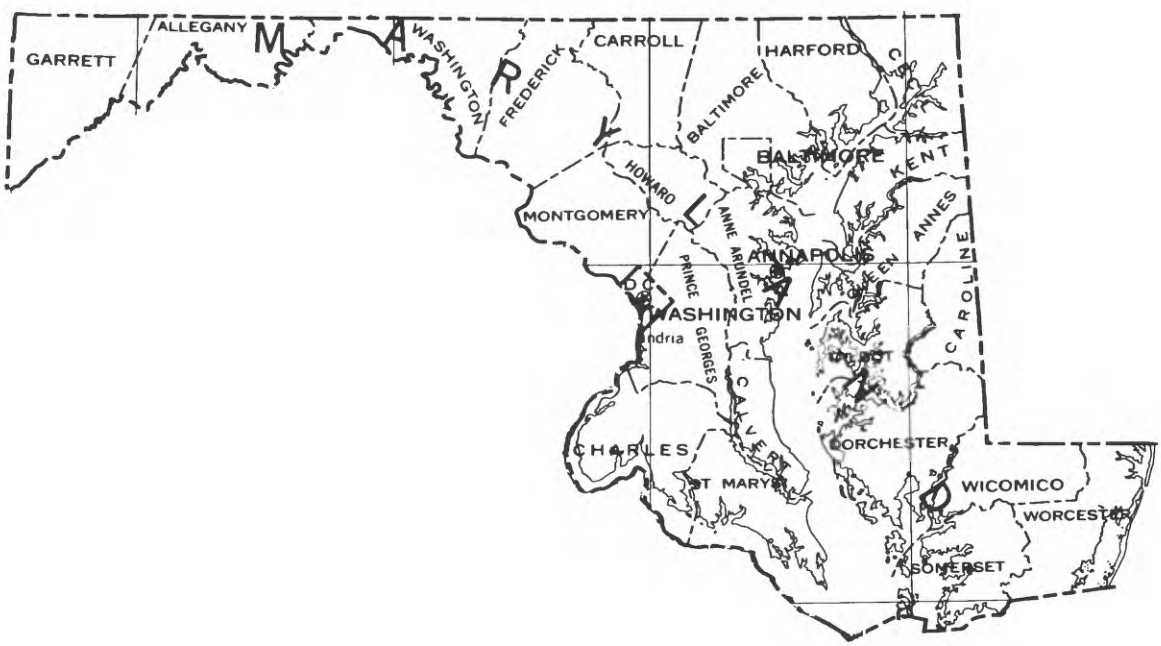


Figure 6. Counties of Maryland

TITLE: Surface-Water Stations (MD001)

LEADER: Robert W. James, Jr.

COOPERATORS: Maryland Department of Health & Mental Hygiene, Office of Environmental Programs; Maryland Geological Survey; Maryland Highway Administration; Maryland Water Resources Administration; Washington Suburban Sanitary Commission; Upper Potomac River Commission, District of Columbia Department of Public Works; U.S. Army Corps of Engineers; National Park Service; Baltimore City; and Baltimore and Howard Counties; Maryland.

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.

OBJECTIVE: A. To collect surface-water data sufficient to satisfy needs for current-purpose uses, such as (1) assessment of water resources, (2) operation of reservoirs or industries, (3) forecasting, (4) disposal of wastes and pollution controls, (5) discharge data to accompany water-quality measurements, (6) compact and legal requirements, and (7) research or special studies. B. To 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, etc., for use in planning and design.

APPROACH: Standard methods of data collection will be used as described in the series, "Techniques of Water Resources Investigations of the United States Geological Survey." Partial-record gaging will be used 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.)

TITLE: Ground-Water Stations (MD002)

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 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.

OBJECTIVE: A. To provide a minimum long-term data base so that the general response of the ground-water 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. B. To provide a data base against which the short-term records acquired in areal studies can be analyzed.

APPROACH: There are two observation-well networks in Maryland--the Maryland statewide network and the southern Maryland network. The Maryland statewide network includes 156 observation wells. Of these, 154 wells are measured at 4- to 6-week intervals and 2 wells are equipped with continuous analog recorders. The southern Maryland network includes 397 wells, most of which are measured twice yearly. Currently, 28 wells in the southern Maryland network are equipped with digital recorders.

SUMMARY: Data for 14 wells are published annually in "Water Resources Data for Maryland and Delaware," and a monthly release includes water-level data for 6 wells (one Delaware well). Water-level data are used to answer numerous requests for information and to provide assistance for ongoing District projects. A report on the Maryland statewide observation well network, 1943-84, which includes water levels and hydrographs, is in review and will be published as a Maryland Geological Survey Basic Data Report. A similar report is in preparation for the southern Maryland observation-well network. (See section, "Annual Water-Data Reports," for locations of selected data-collection sites and information on publication of data.)

TITLE: Water-Quality Stations (MD003)

LEADER: Robert W. James, Jr.

COOPERATORS: U.S. Army Corps of Engineers; U.S. Environmental Protection Agency; and the Maryland Department of Health and Mental Hygiene, Office of Environmental Programs

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 and surface waters 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 and surface waters of Maryland. Selected tributaries of Chesapeake Bay will be monitored intensively during high-flow events.

SUMMARY: Water-quality data collection continued at 10 sites. (See reference to approved reports of results of this project in lists for 1980 and 1982 at end of this report. See section, "Annual Water-Data Reports," for locations of data-collection sites and information on publication of data.)

TITLE: Suspended-Sediment Stations (MD004)

LEADER: Robert W. James, Jr.

COOPERATOR: Maryland Geological Survey

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 three stations presently in operation. The sites are located on the Monocacy, Potomac, and Choptank Rivers near the cities of Frederick, Point of Rocks, and Greensboro, respectively. (See section, "Annual Water-Data Reports," for locations of data-collection sites and information on publication of data.)

TITLE: Maryland Water-Use Data Program (MD007)

LEADER: Judith C. Wheeler

COOPERATORS: Maryland Geological Survey and Maryland Water Resources Administration

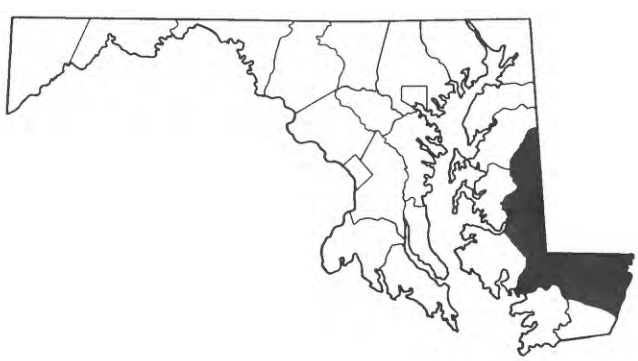
PERIOD OF PROJECT: Continuous since 1977

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 is generally being collected describing quantity and quality of available water, but more information is needed regarding water use. Without adequate information on uses of water, decision makers cannot resolve many critical water problems.

OBJECTIVE: To provide the water-use information for the optimum utilization and management of the State's water resources for the overall benefit of the people of Maryland 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 will develop and operate a system to handle the data. The system will be responsive to the data needs of State and local users, the U.S. Geological Survey, and other Federal agencies.

APPROACH: Responsibilities will be divided between the cooperators and the U.S. Geological Survey 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 U.S. Geological Survey. Field activities for the acquisition and storage of the data will be the primary responsibility of the Maryland Water Resources Administration.

SUMMARY: A report on irrigation water use in Maryland was published and distributed. A report on historical ground-water use in Maryland Coastal Plain is being prepared. The State Water-Use Data System (SWUDS) was installed on the District PRIME computer system. Withdrawal data from Water Resources Administration (WRA) for 1980 were entered into SWUDS. Return flow data were received from the Maryland Department of Health and Mental Hygiene, matched with withdrawal data from WRA and entered into SWUDS. Acquisition of withdrawal and return-flow data will continue. Aggregated withdrawal data will be submitted to the national data base. Maryland water-use data will be compiled for the 1985 National Water-Use Circular. Withdrawal and return-flow data for 1981 through 1985 will be entered into SWUDS. (See reference to approved report of results of this project in list for 1983 at end of this report.)



TITLE: Nitrate in Ground Water, Central Delmarva Peninsula, Maryland (MD061)

LEADER: L. Joseph Bachman

COOPERATORS: Maryland Department of Health and Mental Hygiene, Office of Environmental Programs and Maryland Geological Survey

PERIOD OF PROJECT: July 1981 - June 1984

PROBLEM: Excess nitrate concentration in the shallow aquifer is a water-quality problem in parts of the Delmarva Peninsula of Maryland. Suspected sources include septic systems, fertilizers, and animal wastes. The shallow aquifer has been tapped extensively for drinking-water supply. Health officials have in some places required the drilling of deeper wells to replace shallow wells that yielded water of high nitrate concentration. In addition to the potential loss of the shallow aquifer as a drinking-water supply in some areas, there may be a significant danger that nitrate contamination will migrate to deeper aquifers, at least locally.

OBJECTIVE: 1. Describe the chemical quality of the water. 2. Map the concentration of nitrate and total nitrogen in shallow ground water. 3. Relate nitrate presence or absence to land use, soils, farming practices, and the geochemical system. 4. Show the relation of nitrate concentrations to depth in the shallow aquifer. 5. Determine nitrate distribution in the deeper aquifers to assess whether nitrate is moving into these aquifers. 6. Evaluate changes in nitrate concentrations with time. 7. Map direction of ground-water flow to show potential directions of movement of nitrate in ground water. 8. Map depth to water.

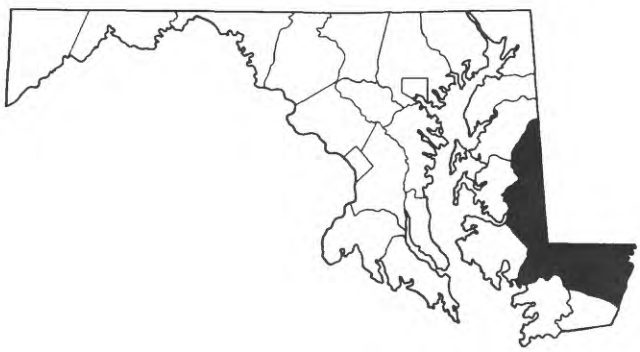
APPROACH: Information on ground-water quality from health agencies and other sources will be assembled and analyzed. Water from several hundred wells will be tested in the field for pH, conductivity, dissolved oxygen, temperature, nitrate, ammonia, and chloride. About 30 wells will be selected for quarterly tests. About 200 wells will be selected for sampling for laboratory analysis, which will consist of major ions, all nitrogen species, phosphate, boron, dissolved iron and manganese, and total organic carbon. Land use will be mapped from aerial photos and information from other agencies. Water levels will be measured to map the water table.

SUMMARY: Five clusters of observation wells were drilled in October 1982. Water samples for chemical analysis were collected from 125 sites from October 1982 to January 1983. These analyses, combined with previous analyses and analyses compiled from county health department records, have resulted in a data base with 530 nitrate analyses. Statistical tests were performed on the data from February to June 1983.

Over half of the analyses had nitrate concentrations greater than 3.0 milligrams per liter as nitrogen; the maximum concentration that would naturally occur in an aquifer of this type is about 1 milligram per liter. The water-quality standard of 10 milligrams per liter was exceeded in 15 percent of the samples.

Very high and very low concentrations (greater than 3 and less than 1 milligram per liter) of nitrate were reported in all parts of the study area, in all land uses, and in all soil types. However, concentrations tend to be lower in the southeastern part of the study area where the aquifer is thicker and more likely to be confined, and where sites with poorly drained soils are more common. Nitrate concentrations in an urban or agricultural land-use area also tend to be higher than at those sites with woodland land use.

The final report, "Nitrate in the Columbia Aquifer, Central Delmarva Peninsula, Maryland," has been published as a U.S. Geological Survey Water-Resources Investigations Report 84-4322. (See reference to approved reports of results of this project in list for 1984 at end of this report.)



TITLE: Acid Rain and the Quality of Shallow Ground Water: A Preliminary Appraisal on the Delmarva Peninsula (MD075)

LEADER: L. Joseph Bachman

COOPERATORS: Maryland Energy Administration

PERIOD OF PROJECT: January 1984 - June 1985

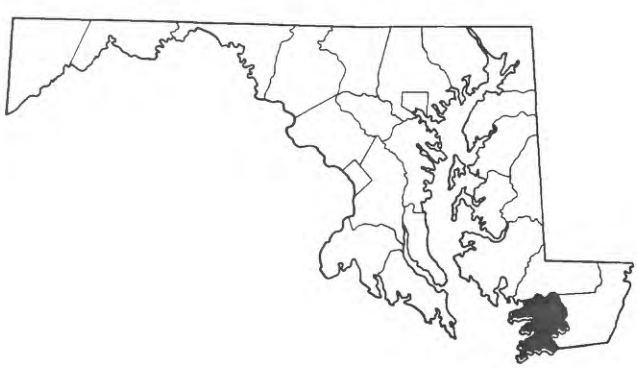
PROBLEM: Rainfall in Maryland is among the most acidic in the nation. Maximum lead and sulfate concentrations are higher than in other parts of the country. The effects of acidic rain on shallow aquifers is unknown, but may include (1) acidification of ground water, (2) transport of lead in ground water, and (3) mobilization of metals such as aluminum. The Columbia aquifer is a shallow silicate sand which is a major water-supply source in eastern Maryland. Its water is acidic, and its unsaturated zone is thin. The aquifer is mostly unconfined and acidic precipitation could easily enter. Whether this is happening is unknown.

OBJECTIVE: 1. To identify major areas of acidic ground water in the Columbia aquifer. 2. To see if acidic ground water contains chemical species to be expected, if the ground water were affected by acidic precipitation. 3. To compare concentrations of sulfur and nitrogen in atmospheric deposition with concentrations in ground water during recharge periods. 4. Compare inputs of nitrate, phosphorous, and chloride from atmospheric sources to those applied through man's use of the land. 5. To plan a more intensive study of the problem, if justified.

APPROACH: Select 10 wells tapping the Columbia aquifer from the existing data base. The wells will have pH of less than 5.5 and tap flow systems with no man-made sources of nitrogen. Sample the 10 wells once a month from February to May 1984 (through the spring 1984 recharge season). Evaluate the possible chemical systems operating in the recharge of ground water. Calculate the effect on chemical speciation of acidic precipitation high in sulfate and lead. Use chemical and mineralogic analyses of soils and aquifers already performed and available from government and academic sources. Compare

chemical analyses with calculated chemical speciation. Compare nitrate, chloride, sulfate and phosphorus loads from precipitation with those from other sources.

SUMMARY: The final report, "Relationship between precipitation quality, shallow ground-water geochemistry and dissolved aluminum in eastern Maryland," by L. J. Bachman and B. G. Katz, was published by the Maryland Energy Administration. Modeling of the dissolution reaction of potassium feldspar, a major aquifer mineral, indicates that an acidic recharge solution similar to acid rain can temporarily release large concentrations of dissolved aluminum. As the reaction proceeds, pH increases and aluminum concentration drops. Recharge which is removed from the ground-water system to base flow before the dissolution reaction is completed may thus have high concentrations of dissolved aluminum. Recharge which remains in contact with aquifer minerals may have lower dissolved aluminum concentrations. The stream samples, with high aluminum concentrations, and the ground-water samples, with low aluminum concentrations, are in rough agreement with this model. (See reference to approved report of results of this project in list for 1985 at end of this report.)



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

LEADER: William H. Werkheiser

COOPERATORS: Maryland Geological Survey and Somerset County, Maryland

PERIOD OF PROJECT: April 1985 - March 1988

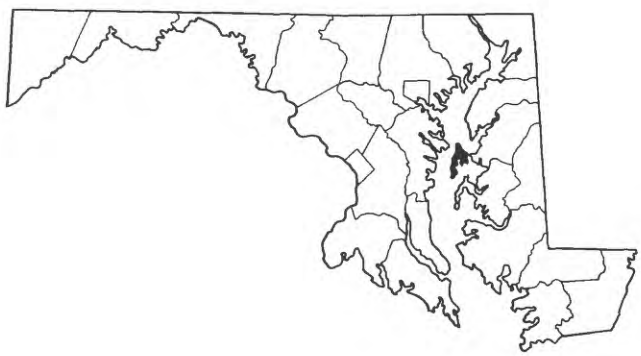
PROBLEM: Construction of a major state facility, proposed commercial-industrial expansion, and expected population growth may significantly increase ground-water demand in Somerset County, Maryland. This has led to concerns as to the ability of local ground-water resources to meet increased demands for supply, for potential water-quality degradation from changing land-use

patterns, and for saltwater intrusion from increased pumpage. Future water-management decisions will require additional information on the ground-water flow system, current water quality, and the interrelationships of various aquifer units.

OBJECTIVE: 1. Determine elevations, thicknesses, distributions, and hydrologic properties of the principal aquifers. 2. Describe the ground-water flow system by analyzing long-term water-level data, and by preparing potentiometric-surface maps and chloride concentration maps for each of the principal aquifers. 3. Estimate the capacity of existing and planned well fields to meet projected demands, and the potential impacts of increased pumpage on current water supplies. 4. Estimate the natural background quality of ground water and identify changes due to man's activities. 5. Estimate potential water-quality changes that may result from increased pumpage or changes in land use.

APPROACH: Existing water-level, water-quality, pumpage, lithologic-log, and geophysical-log data will be reviewed. Additional water wells will be inventoried to obtain areally distributed hydrologic data representative of the principal aquifer units. Synoptic water levels will be measured in representative wells to obtain potentiometric-surface data for the principal aquifers. Additional wells will be selected for monthly or continuous recorder measurement. Wells representative of the principal aquifers and various land uses will be sampled to obtain water-quality data for the natural system, and to determine those areas impacted by man's activities.

SUMMARY: File data from state, county, and U.S. Geological Survey sources have been collected and selected wells are being inventoried. Data from the well inventory and from published reports are being prepared for entry into the Ground Water Site Inventory (GWSI) file. Monthly water-level measurements are made in 23 wells. Well inventory will continue, additional observation wells will be added to the network, water-quality sampling will commence, and data will be entered into the GWSI file.



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

LEADER: David D. Drummond

COOPERATORS: Maryland Geological Survey; Queen Annes County, Maryland; and Maryland Water Resources Administration

PERIOD OF PROJECT: July 1983 - June 1986

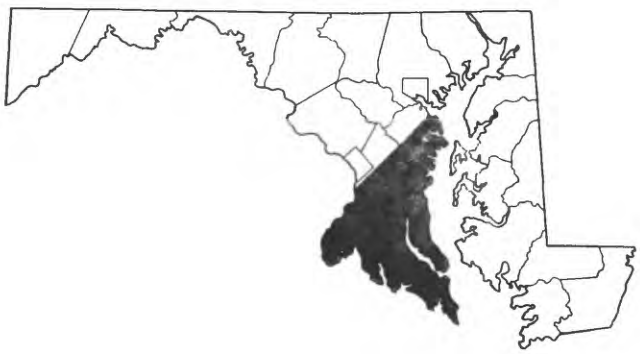
PROBLEM: Saltwater in the Aquia aquifer has become a serious problem on Kent Island in Queen Annes County, Maryland. Chloride concentrations that have been measured in domestic wells are more than three times the Environmental Protection Agency (EPA) recommended limit. A study is needed to assess the present situation, predict future consequences of higher pumping rates, and examine possible alternatives.

OBJECTIVE: Determine areal extent of high chlorides; vertical zonation of chlorides in the Aquia aquifer; movement of the chloride plume; and changes in concentration with time.

APPROACH: Collect field data such as water levels, chloride concentrations and pumpage. Drill test wells where needed and collect water samples for chemical analysis. Develop flow models and solute-transport models and use them to make simulations of future effects.

SUMMARY: Data collection has been completed. Flow model was developed and calibrated. Solute-transport model is currently being developed. Report is being written which will be published as a Maryland Geological Survey Report of Investigations.

The areal extent of high-chloride ground water was found to be limited to the area near (within 1/2 mile) the Chesapeake Bay shoreline. Chloride concentrations in the lower part of the Aquia aquifer were measured at over 7,000 milligrams per liter in several test wells. Chloride concentrations increased in 6 of 14 wells which were resampled after a 2-year interval.



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

LEADER: Frederick K. Mack

COOPERATORS: Maryland Geological Survey and Maryland Energy Administration

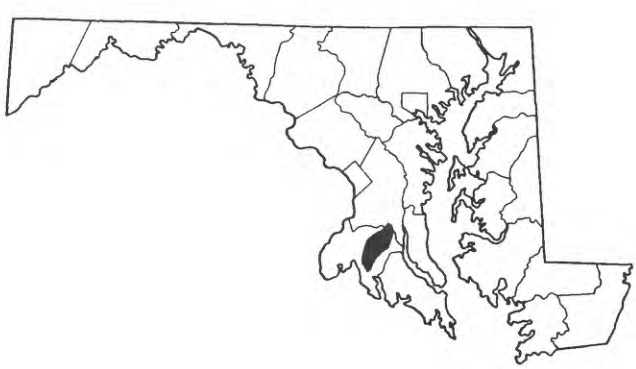
PERIOD OF PROJECT: Continuous since 1979

PROBLEM: The Calvert Cliffs Power Plant takes water from the Aquia aquifer, the Morgantown Power Plant takes water from the Patapsco aquifer, and the Chalk Point Power Plant takes water from both the Patapsco and Magothy aquifers. Definitive information on the response of these aquifers to pumping by the power plants is needed by State agencies so they can anticipate and minimize potential problems with water supply or interference with other users.

OBJECTIVE: 1. Provide data needed by the Maryland Energy Administration, Power Plant Research Program to evaluate the effect that pumping ground water at the three southern Maryland power plants (Chalk Point, Calvert Cliffs, and Morgantown) is having on water levels and on the availability of water in surrounding areas. 2. Evaluate proposed power plant sites with regard to ground-water availability and the probable effect that heavy use of ground water would have on nearby areas. 3. Determine changes in potentiometric surfaces and relate them to pumping by power plants and other users.

APPROACH: Obtain water-level measurements in wells at the three southern Maryland power plants and in other observation wells in various aquifers in southern Maryland area. Prepare hydrographs for observation wells and potentiometric maps for various aquifers. Obtain pumpage data from wells at each power plant. Study the relationship between pumpage from aquifers and head changes in order to estimate future effects of pumping. Obtain and document hydrogeologic data for new wells drilled at present or proposed power plants.

SUMMARY: Water-level declines in the Patapsco, Magothy, and Aquia aquifers in southern Maryland are related to increases in pumpage. Pumpage from the Magothy aquifer in southern Maryland increased from about 0.45 Mgal/d in 1962 to about 4.0 Mgal/d in 1985. Distinct and extensive cones of depression developed in two areas: localities surrounding the electric power generation plant at Chalk Point, in southeastern Prince Georges County, and the rapidly developing Waldorf area of northern Charles County. Hydrographs of daily values from water levels and pumpage data show several examples of the close relationship between pumpage and water levels. Pumpage from the Magothy aquifer commenced in 1963 and reached about 0.8 Mgal/d by 1975, but decreased to 0.64 Mgal/d in 1985. Water levels declined as much as 61 ft by 1985. Pumpage from the Magothy in the Waldorf area commenced in 1948 and increased at a rather uniform rate to 2.9 Mgal/d by 1985. Water levels declined about 100 ft in parts of the area during that period. Results of the study are released periodically as potentiometic maps, as head-change maps for specific periods of time, and as reports relating water levels to pumping. (See reference to approved reports of results of this project in lists at end of this report.)



TITLE: Reconnaissance of the Ground-Water Surface-Water System in the Zekiah Swamp Run Basin, Charles and Prince Georges Counties, Maryland (MD073)

LEADER: Herbert T. Hopkins

COOPERATORS: Maryland Tidewater Administration, Tri-County Council for Southern Maryland, and Maryland Geological Survey

PERIOD OF PROJECT: May 1983 - September 1984

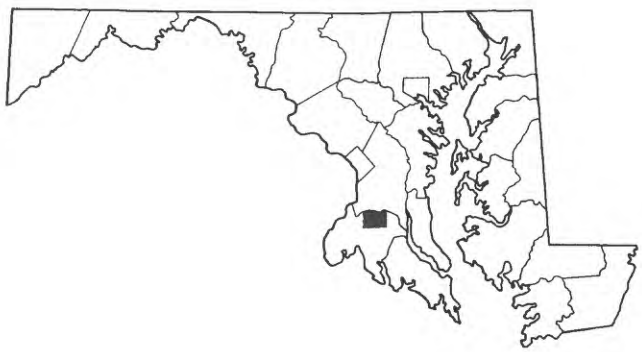
PROBLEM: Additional hydrologic information on the Zekiah Swamp drainage basin is needed by State and local agencies. These agencies are concerned about preservation of Zekiah Swamp, which is a large natural hardwood swamp. The swamp is about 20 miles long and 3/4 of a mile wide. Rapid development and

land-use changes within the basin pose a potential threat to the stability of the swamp and it was designated by the State as an "Area of Critical State Concern" in January 1981.

OBJECTIVE: 1. Determine sources of water to Zekiah Swamp and make rough preliminary estimates of average quantities. 2. Determine means of discharge from Zekiah Swamp and make rough preliminary estimates of average quantities. 3. Determine the gross character of the water in and tributary to the swamp under base-flow conditions based on field measurements of water-quality indicators (pH, conductivity, temperature, and dissolved oxygen). 4. Describe general concepts of the hydrologic system of the Zekiah Swamp basin.

APPROACH: Review previous work and assemble available data. Measure base flow synoptically in winter and summer and measure pH, conductivity, temperature, and dissolved oxygen. Establish a continuous-record gage and several staff gages at critical locations and develop preliminary ratings for medium and low flows. Drill five test wells to determine the thickness of valley fill and to obtain water levels. Establish recorders to observe effects of evapotranspiration and relation of water-table level to stream level. Determine head differences between the water table and deeper aquifers. Develop a preliminary conceptual model of the hydrologic system and make a rough assessment of the water budget.

SUMMARY: The water table in the alluvium of the Zekiah Swamp Run valley is above stream level during most of the year and the alluvial aquifer contributes water to the stream. During the summer, however, high evapotranspiration sometimes lowers the water table below the stream level. Water then moves from the stream to the alluvium and, at times, reaches of the stream become dry. Three synoptic surveys of base flow show variations in stream discharge, pH, specific conductance, dissolved oxygen, and temperature. April 1984 base flows were high (141 cubic feet per second, ft^3/s, at the Route 6 gage) because of high precipitation during March. July 1983 base flows were low (2.35 ft^3/s at the Route 6 gage) and showed significant loss of streamflow because of high antecedent evapotranspiration. Estimates of inflow and outflow of the Zekiah Swamp Run basin above Route 6 during the 1984 water year include: precipitation, 50.21 inches; stream outflow, 20.10 inches; shallow ground-water underflow, 0.1 inch; and evapotranspiration, 33 inches. A report presenting results of this study was approved in 1986 and is being prepared for publication. (See reference to approved report of results of this project in list for 1986 at end of this report.)



TITLE: The Availability of Water from the Patapsco Aquifers in the Waldorf Area of Charles County (MD079)

LEADER: William B. Fleck

COOPERATORS: Maryland Geological Survey and Charles County, Maryland

PERIOD OF PROJECT: July 1984 - June 1987

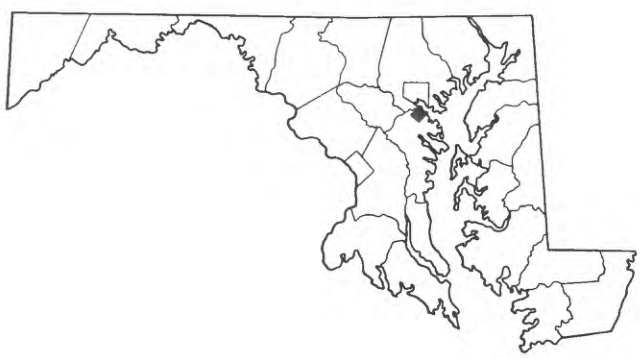
PROBLEM: The Magothy aquifer, which is virtually the sole source of water in the Waldorf area, is reaching the limits of its productive capability. The deeper Patapsco aquifers may be a source of more water. Additional hydrologic data is required to quantitatively evaluate the water-producing capability of the Patapsco aquifers near Waldorf.

OBJECTIVE: To define the areal distribution and thickness of Patapsco Formation aquifers, determine their hydrologic properties, and estimate available quantities of water from them. In addition, determine the quality of Patapsco aquifer water and investigate the causes of significant water-quality characteristics.

APPROACH: Compile data from historical sources. Establish a well network for synoptic water-level measurements. Drill four or five test holes into the upper Patapsco Formation. Obtain cores, cuttings, water samples, and aquifer test data. Construct a digital flow model of the Magothy and Patapsco aquifer system.

SUMMARY: Two of four upper Patapsco test wells were drilled from which paleontological data were collected from 22 cores for dating purposes. Water-quality data were collected for analyses of major cations and anions. Results of the aquifer tests at these two wells indicate a wide range of transmissivities for the upper Patapsco aquifer. At the more easterly site the calculated transmissivity was 4,500 feet squared per day (ft^2/d), and at the other site only 20 ft^2/d. Seven other previously performed aquifer tests indicate transmissivity values from 226 to 3,000 ft^2/d for the Patapsco aquifers in the

Waldorf area. A single test in the Patuxent aquifer indicates a transmissivity of only 41 ft^2/d. (See reference to approved report of results of this project in list for 1986 at end of this report.)



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

LEADER: Grufron Achmad

COOPERATORS: Maryland Geological Survey and Anne Arundel County, Maryland

PERIOD OF PROJECT: July 1983 - March 1987

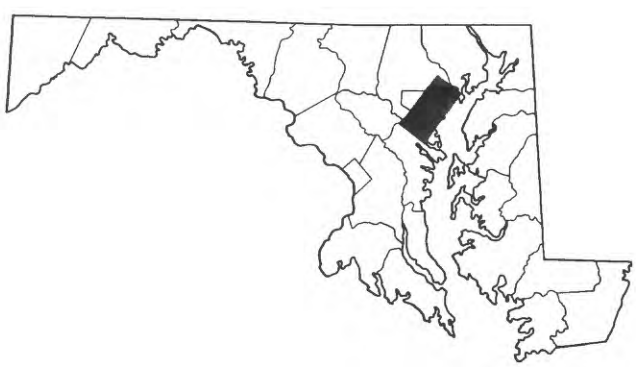
PROBLEM: Excessive drawdown of the potentiometric surface of the lower Patapsco aquifer might cause saltwater intrusion and decrease the flow of surface streams. Study of the aquifer is needed to determine how much the potentiometric surface can be lowered before drawdown would be considered excessive. A better understanding of the water-supply potential of recharge areas is needed.

OBJECTIVE: 1. Define present knowledge of the lower Patapsco aquifer to determine its potential as a source of water for northern Anne Arundel County. 2. Provide a better understanding of the geologic framework and hydrologic system. 3. Develop data needed for long range efficient management of the aquifer system. 4. Strengthen the network of observation wells needed to monitor the effect of pumping from the aquifer. 5. Determine more precisely the interactions of recharge areas in supplying water to the aquifer.

APPROACH: Collect available data on precipitation, evapotranspiration, water levels, streamflow, aquifer properties, and water quality. Drill about seven observation wells to observe the effects of pumping on water levels. Measure water levels periodically. Establish stream gages and make synoptic base-flow

measurements. Collect samples for chemical analysis. Conduct aquifer tests to assess transmissivity and storage. Develop fine-grid model of ground-water flow to evaluate lower Patapsco aquifer around its outcrop area. The U.S. Geological Survey modular model will be used in its quasi three-dimensional flow version.

SUMMARY: Data have been collected and are being analyzed. A ground-water flow model is being developed to simulate the water table and Patapsco aquifers.



TITLE: Ground-water Availability and Quality, Baltimore Industrial Area, Maryland (MD057)

LEADER: Francis H. Chapelle

COOPERATORS: Maryland Geological Survey and Maryland Hazardous Waste Siting Board

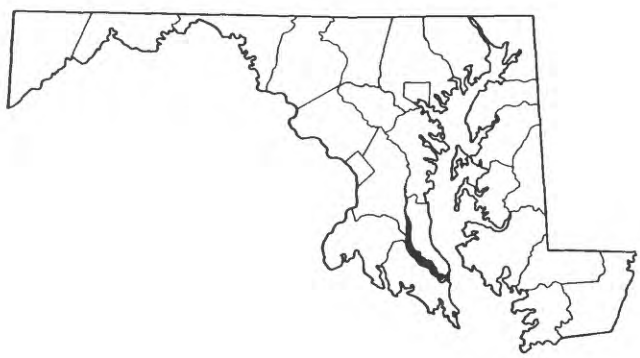
PERIOD OF PROJECT: July 1981 - June 1984

PROBLEM: During 1943-46, there was a comprehensive investigation of the ground-water situation in the Baltimore industrial area as of the end of World War II, a period of heavy water demand. This study showed that saltwater contamination as a result of pumping was significant, and that contamination from industrial wastes had occurred locally. A restudy in 1955 showed that total pumpage had declined about 30 percent. Up-to-date ground-water information is needed to re-appraise the old problem areas; to identify current problems areas, particularly water-quality problems; and to evaluate the potential for providing water supplies in the future.

OBJECTIVE: 1. Update hydrologic data base--water levels, water quality and water use. 2. Refine knowledge of hydrogeologic framework. 3. Describe the present flow system, the present water quality, and the potential for providing water supplies in the future. 4. Compare present conditions with those described previously. 5. Describe the potential effects on ground-water levels and ground-water quality of proposed tunnel and channel excavations.

APPROACH: Conduct well and pumpage inventory. Make field water-quality measurements. Collect 67 water-quality samples for analysis of major ions, nutrients, trace metals, and total organic carbon. Set up observation-well networks to measure, periodically, water levels and water quality. Drill four test wells to fill in gaps in data. Prepare potentiometric and water-quality maps. Prepare maps and cross sections to show hydrogeologic framework. Refine conceptual model of flow system based on analysis of data and use of modeling techniques.

SUMMARY: Analyses of ground-water samples indicate that the Patuxent aquifer in the Baltimore, Maryland, industrial area has been contaminated by brackish-water intrusion from the Patapsco River Estuary. A circular plume of contamination about 5 miles in diameter has developed in response to heavy industrial pumpage. This plume is characterized by chloride concentrations ranging up to 6,000 milligrams per liter and centers on the harbor area of Baltimore City. The geology of the harbor area was investigated using borehole data gathered during construction of the Fort McHenry Tunnel. These data suggest that the Arundel Formation, which acts as the upper confining bed of the Patuxent aquifer, has been eroded by Pleistocene river channels in the harbor area. It is proposed that this Pleistocene erosion is an important factor controlling the leakage of brackish water into the Patuxent aquifer. A two-dimensional digital solute-transport model was constructed for the Baltimore industrial area to evaluate this hypothesis. This digital model simulates the pumping history of the Patuxent aquifer for a period of 131 years. Model simulations which assumed that the Arundel Formation is not truncated by Pleistocene channels resulted in a poor match between computed and measured chloride distributions. Model simulations which specify boundary conditions consistent with the truncation of the Arundel Formation resulted in an excellent match between computed and measured chloride distributions. This result is consistent with the hypothesis that Pleistocene erosion channels are a major control on leakage of brackish water into the Patuxent aquifer. Results of this study are published in Maryland Geological Survey Report of Investigations No. 43. (See reference to approved reports of results of this project in lists for 1984 and 1985 at end of this report.)



TITLE: Sediment Oxygen Demand and Benthic Nutrient Fluxes in the Patuxent River Estuary (MD062)

LEADER: Bruce M. Lantrip

COOPERATORS: Maryland Department of Health and Mental Hygiene, Office of Environmental Programs

PERIOD OF PROJECT: June 1981 - September 1984

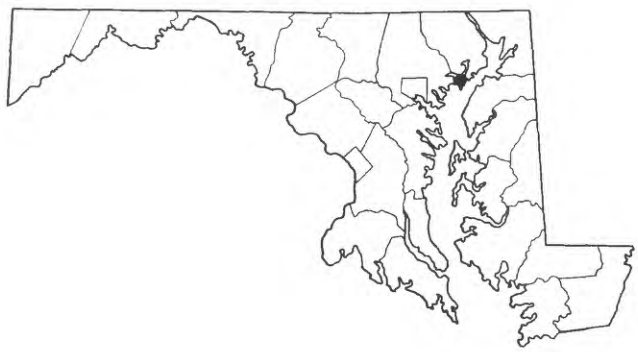
PROBLEM: Benthic nutrient-flux rates and sediment oxygen demand are needed as input to the river-quality assessment of the Patuxent River. Bottom sediment affects water quality through the release of nutrients to the overlying water column and through the oxygen demand of organic material. The quantification of benthic nutrient-flux rates is necessary to determine whether the release of nutrients from the bottom sediments counteracts the expensive nutrient removal strategies of sewage treatment. In addition, present methods for measuring benthic-flux rates are time consuming, manpower intensive, and expensive. A new, simpler method for determining long-term benthic flux rates is needed.

OBJECTIVE: Determine the benthic-flux rates of nitrogen and phosphorus and the sediment oxygen demand, and establish the relative importance of benthic nutrient recycling for maintaining water-column nutrient levels in the Patuxent tidal river and estuary. This information will help determine economically practical nutrient-removal strategies in the Patuxent River. Calculate the regeneration(remineralization) ratio of various nutrient elements from Patuxent benthic sediment and quantitatively assess the feasibility of using depth/time-related changes in sediment chemistry (C, N, P) to infer integrated, long-term (years) benthic nutrient-flux rates. If successful, this method may provide a simpler, less expensive means of estimating benthic nutrient-flux rates, than methods which are presently available.

APPROACH: Benthic nutrient-flux rates will be measured using benthic-flux chambers. These chambers will be placed on the bottom sediments of the Patuxent River for approximately 4 hours during each sampling. Water-quality samples will be taken periodically from the chambers and analyzed for nitrogen, phosphorus, and carbon. Dissolved-oxygen levels will be concurrently monitored within the chamber to determine the sediment oxygen demand. Several locations will be chosen for study wihin the Patuxent tidal river and estuary, and samples will be taken during different seasons of the year. In addition, sediment cores will be taken at approximately 12 locations. These cores will be used to estimate an average, long-term flux of C, N, P from the sediments.

SUMMARY: In general, all sediments were a source for ammonium and a sink for nitrite plus nitrate. The estuarine anoxic sediment was a consistently higher source of ammonium, while the tidal river showed greater flux of nitrite plus nitrate in both directions. Dissolved reactive phosphorus flux was generally into the sediment in the tidal river and transition zones and from the sediment in the estuary. Sediment oxygen demands were variable, but medians were generally consistent among the different zones.

A major feature of the data is the large spatial and temporal variability in sediment nutrient flux and oxygen demand. This variability reflects the influence, but lack of dominance, of many interacting factors, including sediment nutrient concentrations, sediment grain size, water temperature, oxygen availability, benthic macro- and microorganism populations, and meteorological conditions. (See reference to approved report of results of this project in list for 1985 at end of this report.)



TITLE: Ground-water Investigation at O-Field, Aberdeen Proving Ground, Maryland (MD077)

LEADER: Don A. Vroblesky

COOPERATORS: U.S. Department of Defense, Department of the Army

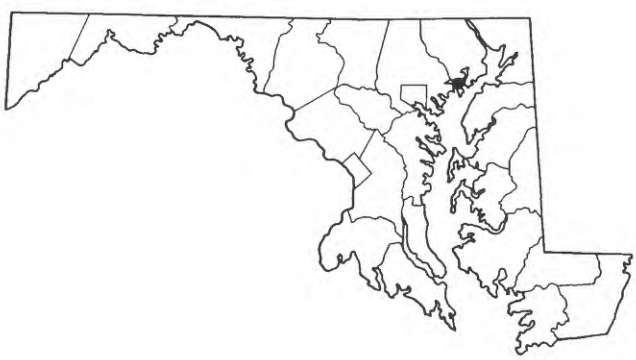
PERIOD OF PROJECT: April 1984 - March 1988

PROBLEM: O-Field, in the Edgewood area of Aberdeen Proving Ground, Maryland, has been periodically 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.

OBJECTIVE: 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 relevent remedial actions.

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

SUMMARY: Installed and developed 21 wells for monitoring purposes. Collected and analyzed cores obtained during drilling. Sampled Watson Creek for water quality and sediment quality. Analyzed sediment samples for bacteria resistant to heavy metals. Researched and awarded contract for analysis of water samples. Installed sampling pumps in monitoring wells and slug tested the wells. Sampled all wells and analyzed for organic and inorganic contamination. Constructed geologic cross sections. A ground-water flow model will be constucted and potential effects of relevent remedial actions will be investigated. Results of the study will be documented in a report.



TITLE: Ground-water Investigation in the Canal Creek Area, Aberdeen Proving Ground, Maryland (MD084)

LEADER: Don A. Vroblesky

COOPERATORS: U.S. Department of Defense, Department of the Army

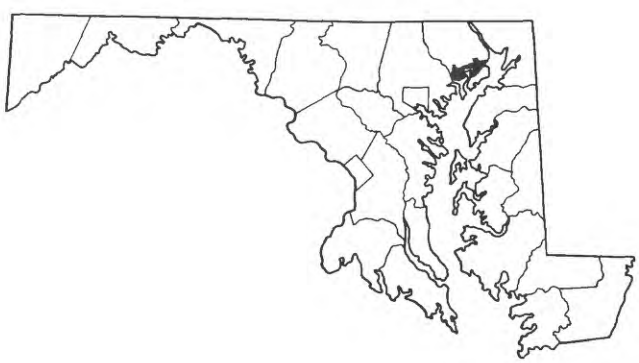
PERIOD OF PROJECT: August 1985 - June 1990

PROBLEM: The Edgewood area of Aberdeen Proving Ground, Maryland, has been used to develop and manufacture military-related chemicals since World War I. The chemicals include chlorine, phosgene, chloropicrin, mustard, white phosphorous, pyrotechnics, whetlerite, tear gas, and clothing impregnating material. Other activities included chemical-warfare agent loading and testing, land-filling of domestic wastes, land-disposal of production wastes, and the use of degreasing solvents on military equipment. White phosphorous has been found in creek sediments and volatile organic compounds have been found in ground water.

OBJECTIVE: 1. Define hydrogeologic framework in Edgewood area. 2. Determine nature, extent, behavior, and as nearly as feasible, the sources of contamination in the ground water. 3. Evaluate the hydrologic and hydrochemical effects of relevent remedial activities. 4. Evaluate the deeper ground water as an alternative water supply. This evaluation (number 4) may be eliminated at a later date based on the results of the study at that time and on projected water use.

APPROACH: Use surface and borehole geophysics, lithologic logs, and water-level data to determine the hydrogeologic framework. Install and sample about 31 clusters of monitoring wells, mostly in the shallow aquifers. Refine framework and water-level maps and preliminarily map contaminant plumes and suspected source areas. Install and sample 20 to 40 more monitoring wells, some in deeper aquifers. Delineate plumes and sources and, if feasible, evaluate the water-supply potential of deeper aquifers. Using a ground-water flow model and geochemical analysis, assess possible remedial actions.

SUMMARY: Prepared detailed project work plan. Hired two hydrologists to assist on project. Wrote a safety plan. Purchased monitoring and chemical-quality equipment and meters. Conducted marine seismic survey, and an electromagnetic survey of selected areas. Future plans include the following: Install and sample about 31 clusters of monitoring wells. Prepare geologic cross sections and potentiometric maps. Install additional 20-40 monitoring wells to further define contamination. Prepare reports documenting results of the investigation.



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

LEADER: David D. Drummond

COOPERATORS: Maryland Geological Survey and Harford County, Maryland

PERIOD OF PROJECT: July 1986 - December 1989

PROBLEM: Harford County, located in the Baltimore metropolitan area, is experiencing substantial residential growth. At present, the eastern (or Coastal Plain) portion of the county is largely dependent on ground water for drinking water and commercial supplies. Relatively large-public supply systems are currently operating in Perryman (3 Mgal/d), Aberdeen (1 Mgal/d), and Joppatowne (0.3 Mgal/d); elsewhere in the area, private wells are utilized for domestic and commercial supplies. In 1980, about 6.2 Mgal/d was pumped from the Coastal Plain aquifers in the county.

County personnel are interested in the potential of these Coastal Plain aquifers to provide sufficient quantities of water of good quality to meet increasing demands. Areas of particular interest in Harford County are the existing well fields in Perryman, Aberdeen, and Joppatowne.

OBJECTIVES: A. Determine the potential for Coastal Plain aquifers in Harford County to meet future ground-water needs. Assess the impact of increased pumpage on ground-water levels and base flow in nearby streams. B. Document historical and current water quality in each aquifer. Determine the potential for pumpage-induced water-quality changes such as saline water encroachment or contaminant plume migration.

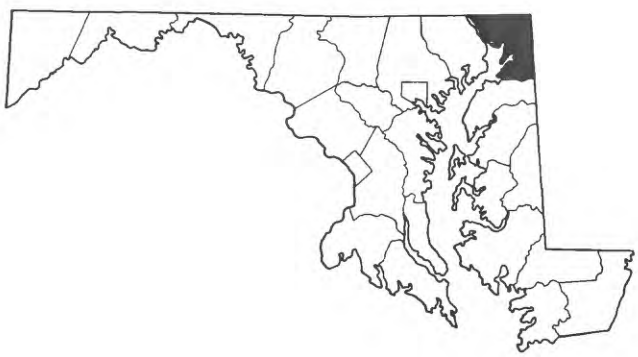
APPROACH: Objective A will be met primarily through the use of a digital flow model to simulate past and present water levels, and to predict the effect of increased pumpage rates on ground-water levels and base flow of nearby streams. Two layers will be simulated: a bottom layer for the Potomac Group sands and a top layer for the Talbot Formation which functions as a water-table aquifer. Geologic and water-level data will be compiled from published and file sources. Selected wells will be inventoried to collect data on water levels, lithology, and aquifer depth. Synoptic water-level measurements will be used to construct potentiometric maps and document water-level changes. Selected wells will be fitted with continuous water-level recorders to monitor short-term water-level fluctuations such as tidal and barometric effects. Geophysical logs will be run on available wells. Stream-gaging stations will be set up to collect base-flow data.

Eight test wells will be drilled to fill gaps in water-level and water-chemistry data, and to determine significant aquifer characteristics. The wells will be drilled to bedrock and will be completed as deep observation wells. A shallow well will also be constructed at each site to monitor water-table conditions. Water samples will be collected from each well for chemical analysis.

Objective B will be met by compilation of existing water-quality records, water-quality sampling at selected wells and streams, simulation with geo-chemical models, and chemical migration estimation with a solute-transport model or analytical methods. Parameters to be analyzed include field parameters (dissolved oxygen, conductance, pH, Eh, alkalinity, sulfide), major ions (Ca, Mg, Na, K, Cl, SO_4, HCO_3, SiO_2, Fe, Mn, NO_3, PO_4), and selected organics, heavy metals, and isotopes as warranted.

Ground-water chemistry will be interpreted with the aid of aqueous speciation (WATEQ), mass balance (BALANCE) and reaction path (PHREEQE) models. The hydrologic and geochemical aspects of the project will be integrated into either a solute-transport model or an analytical solution scheme to estimate the potential for movement of contamination plumes or saline water.

SUMMARY: A report summarizing the results of the study will be prepared and published as part of the Maryland Geological Survey Report of Investigations series.



TITLE: Quality and Quantity of Ground and Surface Waters in Cecil County, Maryland (MD063)

LEADER: Edmond G. Otton

COOPERATORS: Maryland Geological Survey and Cecil County, Maryland

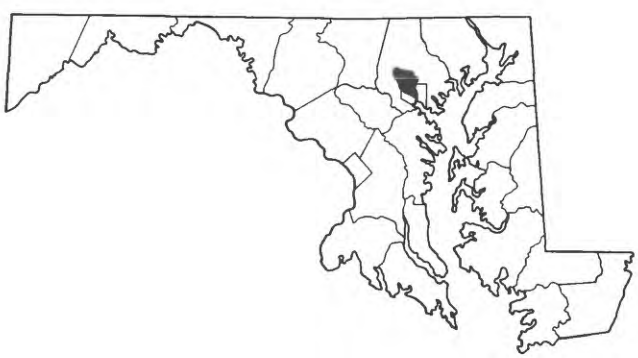
PERIOD OF PROJECT: July 1981 - March 1985

PROBLEM: A quantitative assessment of the quality and quantity of the water resources of northeastern Maryland is needed. Commercial and industrial development and changing farming practices in the area are significantly increasing the potential for water-quality degradation and water shortage, particularly during drought periods. Water managers will require a more thorough knowledge of the overall flow system, present quality of water in the streams and aquifers, and the interrelations of ground and surface water.

OBJECTIVE: 1. Assess the quality of water in streams and aquifers. 2. Identify variations from expected background water quality. 3. Describe the ground-water flow system. 4. Indicate potential well yields of the various water-bearing units based on range and distribution of the yields of wells tapping the unit. 5. Estimate flow duration, low-flow frequency, and average flows by subbasins. 6. Estimate impacts of projected pumpage and drought.

APPROACH: Select three subbasins for water-budget analysis. Measure streamflow and correlate with long-term gaging stations to estimate flow characteristics of the subbasins. Inventory wells and springs and establish an observation-well network. Analyze water samples from selected wells and stream sites in the laboratory for major ions, nutrients, and trace metals. Also analyze stream samples for total organic carbon. Sample stream-bottom sediments at selected sites and analyze for herbicides, insecticides, and trace metals.

SUMMARY: A report containing a compilation of surface-water data, ground-water data, selected water-well records, and chemical-quality data for Cecil County, Maryland, was prepared for publication as a Maryland Geological Survey Basic Data Report. Surface-water data include streamflow measurements and analyses of water for 29 partial-record stations. Ground-water data include water-level data for 54 wells, descriptions of 1,535 selected wells, data for 36 springs, and lithologic logs of 9 wells and test borings ranging in depth from 95 to 1,458 feet. Chemical-quality data include analyses of stream-bottom materials for trace elements at 20 sites and pesticides at 10 sites. An interpretive report describing the quality and quantity of ground water and surface water in Cecil County is being prepared for publication as a Maryland Geological Survey Bulletin. (See reference to approved report of results of this project in list for 1986 at end of this report.)



TITLE: Analysis of Urban Runoff and Streamflow in the Jones Falls Watershed, Maryland (MD069)

LEADER: Gary T. Fisher

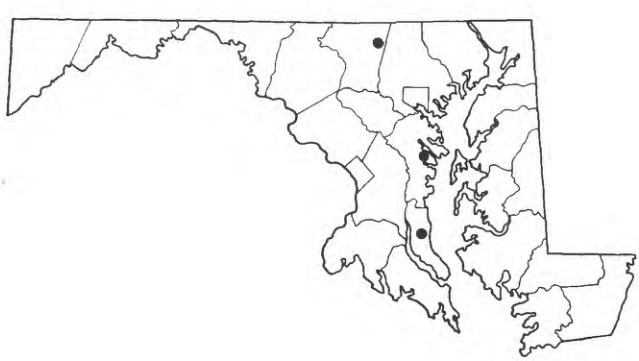
PERIOD OF PROJECT: January 1983 - January 1984

PROBLEM: To address the need for quantitative information regarding the causes, severity, and distribution of urban hydrology problems, the U.S. Environmental Protection Agency (EPA) began the Nationwide Urban Runoff Program (NURP). The Baltimore part of that effort involved collecting rainfall, runoff, and streamflow data in the Jones Falls Watershed during 1981 and 1982. Baltimore has had the most intensive data-collection effort of urban runoff for any city in its class. To provide a basis for local, regional, and national urban streamflow and stormwater management decisions, the results of the Jones Falls Watershed study must be made available to lay readers as well as to the technical community.

OBJECTIVE: (1) To provide an understanding of the major factors affecting stream and sewer flow characteristics and water-quality constituent loads in monitored parts of the Jones Falls Watershed. (2) To explain results in language understandable to lay decision makers. (3) To provide a source book of some techniques available for the analysis of urban runoff data.

APPROACH: This study will present the results of the Jones Falls Watershed study in a form that is understandable to the lay reader as well as to the technical community. Techniques used in the analysis of the data will be briefly explained and referenced so that the reader can better understand the results or can apply the techniques to the other data.

SUMMARY: The technical study of the Jones Falls watershed, upon which this project relies, was done in cooperation with the Baltimore Regional Planning Council. Technical results of that study were published in U.S. Geological Survey Water-Resources Investigations Report 84-4099. (See reference to this related publication in list of reports approved in 1984 at end of this report.) A Water-Supply Paper summarizing these results for a broader audience (the result of this study) is in preparation.



TITLE: Effect of Storm-Water Infiltration Practices on Ground-Water Quality (MD082)

LEADER: Franceska D. Wilde

COOPERATOR: Chesapeake Bay Research Initiative, Maryland Water Resources Administration, and Maryland Geological Survey

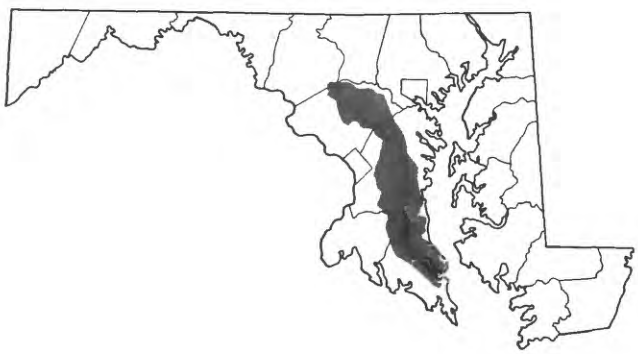
PERIOD OF PROJECT: October 1985 - March 1990

PROBLEM: In Maryland, concern over pollution of the Chesapeake Bay has resulted in legislation recommending diversion of storm-water runoff to infiltration structures where the runoff percolates through the unsaturated zone. The effect of storm-water infiltration on ground-water quality and the processes controlling contaminant migration through the unsaturated zone are poorly understood. The ability of Piedmont saprolites and Coastal Plain sediments to retain the inorganic and organic contaminants characteristic of urban runoff needs to be examined, and ground-water quality near infiltration structures needs to be monitored.

OBJECTIVES: The objective is to assess the effect that storm-water infiltration practices have on ground-water quality. The objective is comprised of two parts: (1) to determine what changes occur in the chemical composition of the ground water being recharged through infiltration basins and porous asphalt pavement by storm water, and (2) to determine the subsurface fate of specifically identified organic and metal contaminants carried by storm-water runoff.

APPROACH: One porous paving and two infiltration basin sites will be selected for study and will include Coastal Plain and Piedmont lithologies. Precipitation characteristics will be monitored for quality, quantity, flow rate, and ponding duration. Lysimeters will be installed to determine soil solution composition, infiltration rates will be determined, soil cores taken, and determinations will be made on selected physical and chemical soil properties. Wells will be installed upgradient, downgradient, and in the infiltration structures to monitor water-table levels and quality. Laboratory soil studies will determine sorption characteristics of selected constituents.

SUMMARY: Project proposal and project design were completed and literature was reviewed. Extensive site search resulted in selection of three study sites, each representing different lithologies. Initial storm-water samples were collected and well drilling was completed.



TITLE: Modeling Nonpoint-Source Inputs to the Patuxent River Estuary-Phase I: Existing Conditions and Model Application (MD080)

LEADER: Gary T. Fisher

COOPERATOR: Maryland Department of Health and Mental Hygiene, Office of Environmental Programs

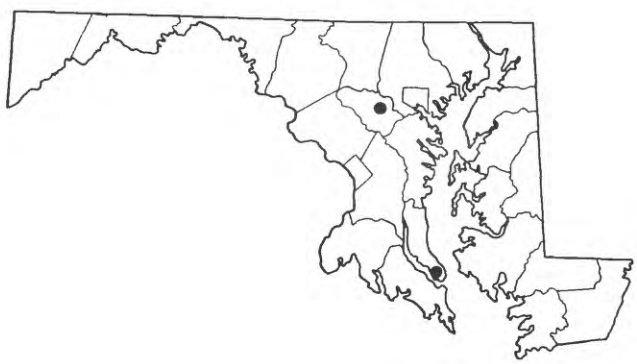
PERIOD OF PROJECT: May 1984 - September 1987

PROBLEM: The Patuxent River basin 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 pollution, but more is needed for agricultural areas. Modeling must be done to help understand the interrelationships between factors influencing nonpoint sources of pollution.

OBJECTIVE: 1. To investigate approaches for assembling and maintaining a data base for modeling of nonpoint-source pollution. 2. To assemble the data base, to include hydrologic, meteorologic, and basin characteristics data and a bibliography. 3. To determine nonpoint-source loadings from single land-use areas. 4. To calibrate a water-quality hydrologic model.

APPROACH: Water-quality monitoring sites will be established at main stem, tributary, and surface-runoff locations. Data will be collected over a 2-year period for existing conditions before implementation of nonpoint-source pollution control measures. A water-quality hydrologic model will be calibrated 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 HSPF hydrologic simulation model. State-of-the-art approaches to data management are being used. Geographic Information System technology is being used to support the modeling.



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

LEADER: L. Joseph Bachman

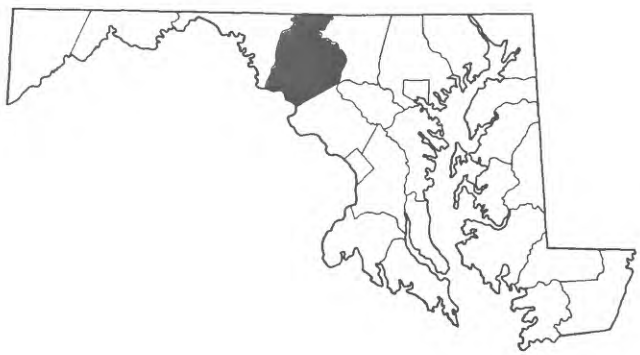
COOPERATOR: Maryland Department of Health and Mental Hygiene, Office of Environmental Programs

PERIOD OF PROJECT: July 1985 - September 1991

PROBLEM: Runoff of nutrients from agricultural areas has been contributing to the decline of water quality in the Chesapeake Bay. Best-management practices (BMP's) have been proposed to reduce the runoff of nutrients. Many of the BMP's may result in increased infiltration of water and nutrients to the ground-water flow system. The BMP's may thus enrich concentrations of nutrients in ground water. Because ground water is the source of base flow into streams and the Bay, the BMP's may thus not be completely effective in preventing nutrient input into Chesapeake Bay.

OBJECTIVES: To determine the effects of BMP's on the shallow ground-water flow system beneath two fields, one in the Piedmont, the other in the Coastal Plain, the effect of BMP's on the following will be investigated: (1) ground-water flow, (2) ground-water nitrogen concentrations, (3) ground-water nitrogen loads, and (4) total nitrogen transport (field runoff plus ground-water flow).

APPROACH: The study will consist of 9 months of planning and instrumentation, 2 years of pre-BMP data collection, 2 years of post-BMP data collection, and a year for data analysis and report preparation. About 12 wells and 2 lysimeters will be installed at each field site. Water samples will be collected approximately every month and analyzed for nitrogen species. Samples will also be collected during and after two storms. Digital flow models of the two sites will be developed to determine the effects of BMP's on ground-water flow. The modeled flows will be used to determine nitrogen loads and nitrogen transport. Pre- and post-BMP data will be analyzed statistically to determine if there are significant changes in nitrogen concentrations.



TITLE: Quality and Quantity of Ground and Surface Waters in Frederick County, Maryland (MD058)

LEADER: Mark T. Duigon

COOPERATORS: Maryland Geological Survey and Frederick County, Maryland

PERIOD OF PROJECT: July 1981 - December 1984

PROBLEM: A quantitative assessment of the quality and quantity of the water resources of Frederick County is needed. Commercial and industrial development and changing farming practices in the area are significantly increasing the potential for water-quality degradation and water shortage, particularly during drought periods. Water managers will require a more thorough knowledge of the overall flow system, present quality of water in the streams and aquifers, and the interrelations of ground and surface water. This study is part of a long-range statewide plan for quantitative assessment of the state's water resources.

OBJECTIVES: 1. Assess the quality of water in the streams and aquifers. 2. Compare recent water-quality analyses to earlier analyses. 3. Define by subbasin the total water yield by source. 4. Describe the ground-water flow system and map the potentiometric surface. 5. Indicate potential well yields of the various water-bearing units based on range and distribution of the yields of wells tapping the units. 6. Estimate potential sustained yields of the aquifers based on water-budget analysis. 7. Estimate flow duration, low-flow frequency, and average flows for subbasins. 8. Estimate potential impacts of drought.

APPROACH: Divide study area into subbasins for water-budget analysis. Measure streamflows and correlate with long-term gaging stations; use multiple-regression analysis to determine flow characteristics of the subbasins. Inventory wells and springs and establish an observation-well network. Analyze water samples in the field for pH, temperature, conductivity, and alkalinity; test some samples in the laboratory for major ions, nutrients, and trace metals.

Analyze selected stream samples for total organic carbon, and analyze stream-bottom sediments for herbicides, insecticides, and trace metals.

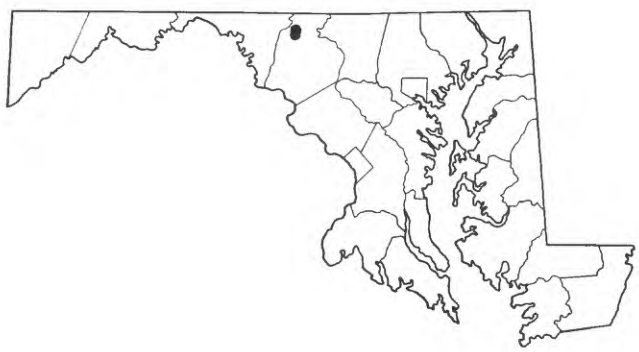
SUMMARY: Ground water in Frederick County, Maryland, occurs primarily in fractures in crystalline and well-indurated sedimentary rocks. Reported well yields range from 0 to 950 gallons per minute (gal/min), with a median of 10 gal/min. About 11 percent reportedly yield less than 2 gal/min. The range of specific capacities and the median value are 0 to 263 and 0.15 (gal/min)/ft of drawdown. Transmissivities seldom exceed 1,000 ft^2/d. Over 60 percent of the inventoried wells were drilled for domestic use. Wells may be grouped by factors such as geologic unit but within-group variation in yield remains large.

The highest 7-day, 10-year low flows range from no flow to 5.1 ft^3/s. The highest low flows per square mile tend to occur in the southern basins and the lowest in the northern basins.

Ground and surface waters alike are calcium-magnesium-bicarbonate types. Trace metals and pesticides were found in low or undetectable levels.

The hydrologic budget for the county is: Precipitation (46 inches) + Incoming Streamflow (13 inches) = Surface Runoff (27 inches) + Subsurface Runoff (8 inches) + Evapotranspiration (23 inches) + Change in Ground-Water Storage (0 inches).

A basic-data report was published and an interpretive report presenting results of the study is in review. (See reference to approved report of results of this project in list for 1985 at end of this report.)



TITLE: Effects of Atmospheric Deposition on a Watershed in the Catoctin Mountains of Central Maryland (MD066)

LEADER: Brian G. Katz

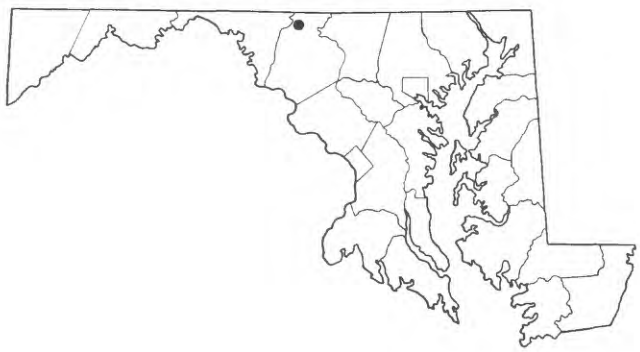
PERIOD OF PROJECT: October 1981 - September 1990

PROBLEM: The pH of precipitation in Maryland is already severely depressed and could be depressed even further by increasing fossil fuel consumption and proposed relaxed environmental standards. Recent studies suggest that precipitation pH values are routinely around 4.0 throughout the State. The specific location for study is a watershed in central Maryland, 7 mi^2 in area, drained by two tributaries that empty into Hunting Creek Lake. Because of the nonreactive geologic terrane, acid soils, and relatively low alkalinity of surface-water bodies in central Maryland, the potential is strong for adverse environmental effects caused by atmospheric depositions.

OBJECTIVE: 1. Determine the acidity, alkalinity, and chemical composition of wetfall (including snow) in the headwaters of Hunting Creek watershed. 2. Determine the chemical composition and yearly transport of major ions, nutrients, and selected metals in inflow (via the major tributaries) and outflow from the lake. 3. Determine any chemical similarities and differences between ground water and water from the unsaturated zone at selected sites in the lake watershed. Relate these findings to local geology and hydrology, precipitation, land use, and soil composition. 4. Determine the role of mineral-water interactions in influencing the composition of surface and ground waters. 5. Assess the impacts of the changing composition of atmospheric deposition on mineral reaction rates, reaction pathways, and resulting water quality.

APPROACH: Wetfall-dryfall collectors and rain gages will be placed at two locations. Streamflow will be measured at five sites within the basin--four inflow and one outflow. Chemical analyses for cations, anions and certain metals will be performed on soil profiles taken at appropriate depths and on water samples taken in the saturated zone at four locations in the lake watershed several times per year to determine the mobility and transport effect of these constituents. Lysimeters will be installed at four sites to determine the chemical composition of water from the unsaturated zone. Land-use differences in the watersheds of the two tributaries permit assessment of the influence man has had on water quality and whether these effects enhance or retard acidification.

SUMMARY: During 1984, 33 weekly composite and 12 event samples of precipitation collected at two sites had pH values ranging from 3.78 to 4.86. Deposition of sulfate and nitrate to the study area via wet precipitation showed an increase from 1982 to 1984. Annual loads for sulfate and nitrate in precipitation ranged from 206 to 415 moles/hectare and 194 to 346 moles/hectare, respectively. Deposition input of acidity, measured as H+ activity, decreased in 1984 (886 moles/hectare) relative to 1983 (1090 moles/hectare). In 1984, sulfate continued to show a net export from both watersheds as measured in stream outflow. Additional lysimeters and soil sampling tubes were installed in 1985 to monitor chemical reactions in water moving through the unsaturated zone in material derived from two mineralogically different rock types. Precipitation and streamflow are being sampled at selected intervals during storm events during different seasons. Sulfate-sorption experiments will be performed with soils collected in study area which are derived from the two different rock types. Project was extended to September 1990 in order to investigate long-term effects of acid precipitation on water quality in a small watershed. (See reference to approved reports of results of this project in list for 1985 at end of this report.)



TITLE: Ground-Water Quality of Catoctin Mountain National Park, Maryland (MD072)

LEADER: Thomas J. Trombley

COOPERATORS: National Park Service

PERIOD OF PROJECT: April 1983 - September 1985

PROBLEM: Increased development and use of Catoctin Mountain National Park may be causing contamination of the ground-water resources of the Park. Camp Round Meadow is of particular concern because there is evidence of contamination at two production wells there. The specific sources of this contamination have not been identified. One other area of concern is the use of salt on the roads in winter. It may be causing higher than normal concentrations of chloride in several wells and springs in the Park. The potential for further degradation of these wells and springs in unknown.

OBJECTIVE: 1. Describe the present ground-water system in the Park, with particular emphasis on the Camp Round Meadow area. 2. Describe the extent and sources of ground-water contamination in the Park. 3. Establish a network of sampling sites to be used for monitoring ground-water quality in the Park.

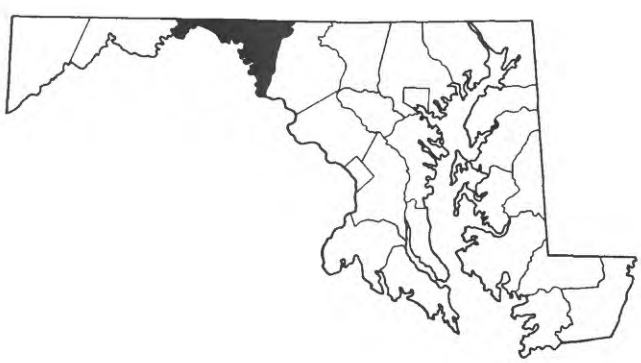
APPROACH: Observe water levels, conduct pumping tests, and collect water samples for chemical and bacterial analysis from wells to describe the ground-water flow system and extent of ground-water contamination in the area. A monitoring network of approximately 10 wells will be established. Water-quality samples will be collected and analyzed from each of these wells on a quarterly basis.

SUMMARY: The Catoctin Mountain National Park areas, located in the Blue Ridge physiographic province of central Maryland, is characterized by high local relief, an average annual precipitation of 44 inches, and stony soils underlain by weathered and fractured metamorphic rocks. The park is mostly

forested land and includes several camps and roads. The ground-water reservoir consists of regolith and underlying fractured bedrock and is recharged by precipitation. Discharge from the ground-water flow system is mainly to nearby streams adjacent to areas of recharge. Approximately 56 percent of annual streamflow is contributed by ground water.

Wells located at Camp Round Meadow and Staff Quarters No. 5 can sustain pumping rates of 45 to 60 gallons per minute for several hours, with drawdowns of 40 to 50 feet. Water-quality samples from wells, springs and streams indicate that ground water is slightly affected by septic waste and road salt. Ground water in remote areas is not affected by either source. Concentration of chloride from road salt and concentrations of nitrite plus nitrate (as N) were below U.S. Environmental Protection Agency drinking-water limits in all ground- and surface-water samples.

The project report, "Hydrogeology and Water Quality of the Catoctin Mountain National Park Area, Frederick County, Maryland," by Thomas J. Trombley and Linda D. Zynjuk, is being prepared for publication. (See reference to approved report of results of this project in list for 1985 at end of this report.)



TITLE: Water Resources of Washington County, Maryland (MD078)

LEADER: Mark T. Duigon

COOPERATOR: Maryland Geological Survey

PERIOD OF PROJECT: January 1985 - December 1987

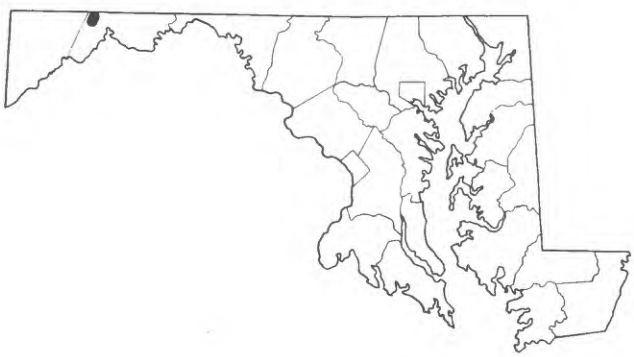
PROBLEM: Growth in population and commercial-industrial expansion since the last report describing the water resources of Washington County was published (1962) have placed new pressures on planners. Uniform, representative, and

reasonably complete hydrologic data are required in order to understand, protect, and make best use of the county's water resources.

OBJECTIVES: 1. Provide basic hydrologic data. 2. Describe water-bearing and water-quality characteristics of 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: The study area will be divided into subbasins for water-budget analysis. Streamflow will be measured and correlated with long-term gaging stations; multiple-regression analysis will be used to determine flow characteristics of ungaged subbasins. Wells and springs will be inventoried and their site and construction characteristics identified. An observation-well network will be established. Water will be analyzed in the field for pH, temperature, conductivity, and alkalinity; some samples will be further tested in the laboratory for major ions, nutrients, and trace metals. Stream samples will also be analyzed for total organic carbon, and bottom sediments will be analyzed for pesticides and trace metals.

SUMMARY: The county was divided into 27 subbasins for study. Several hundred wells and springs were inventoried, and water-level measurements at observation wells were made. Three rounds of low-flow measurements and stream-quality sampling were conducted. Annotated outlines for basic-data and interpretive reports were prepared. Several hundred additional wells and springs will be inventoried. Water-level measurements and ground-water sampling will continue. Five more rounds of low-flow measurements will be made, including two rounds of sampling.



TITLE: Research Modeling in Trotters Run Watershed, Maryland (MD065)

LEADER: Steven N. Hiortdahl

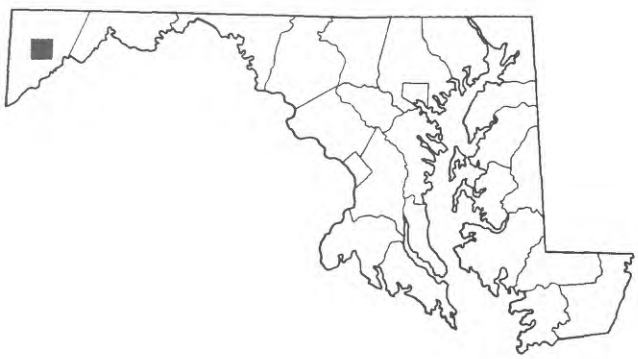
PERIOD OF PROJECT: October 1981 - September 1984

PROBLEM: Surface mining for coal can significantly alter the hydrologic characteristics of a mined watershed, even though only a small percentage of the land may be disturbed by the mining process. Reliable precipitation-runoff models need to be developed, calibrated, and tested to help quantify and document, and possibly predict the hydrologic impacts of surface mining on small watersheds.

OBJECTIVE: 1. Calibrate and verify the U.S. Geological Survey precipitation-runoff modeling system (PRMS) using information from the Trotters Run watershed. 2. Assess and document the impacts of different stages of mining on streamflow, sedimentation, and water-quality characteristics in the Trotters Run watershed.

APPROACH: 1. The precipitation-runoff modeling system will be calibrated for the entire Trotters Run watershed using hydrologic and climatologic data collected at two stream gages and two weather stations. The modeling results will be used to compare any mine-induced changes in streamflow and stream-quality characteristics of the watershed relative to the different stages of mining. 2. Daily loads of the major water-quality constituents will be computed for the entire watershed and the mine-site using regression techniques. These calculated ion loads will be compared to identify and quantify hydrologic impacts of surface mining on this watershed.

SUMMARY: Model calibrations are nearly completed. Tabling of results is nearly completed. Text for chapter to be involved in summary report was begun.



TITLE: Ground-Water Inflow to Deep Creek Lake, Garrett County, Maryland (MD071)

LEADER: Arthur L. Hodges, Jr.

COOPERATORS: Maryland Energy Administration and Maryland Geological Survey

PERIOD OF PROJECT: April 1983 - June 1984

PROBLEM: There is concern that acid mine drainage from coal mining, combined with acid rain, will exceed the ability of Deep Creek Lake to buffer the acid input from these sources. The Maryland Energy Administration, Power Plant Research Program has requested that the U.S. Geological Survey (USGS) undertake a study of the relationship between the geologic formations of the basin, and the chemical composition of ground water and surface water that drains from these formations into the lake.

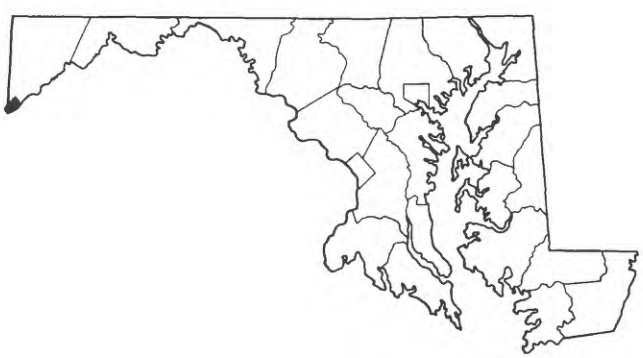
OBJECTIVE: 1. Determine the chemical quality of base flow in streams that drain the calcareous Greenbrier Formation. 2. Make a rough assessment of the ground-water contribution of the Greenbrier Formation to Deep Creek Lake. 3. Determine the changes in chemical quality of base flow that occur when a stream crosses several geologic formations.

APPROACH: Investigate four streams draining the Greenbrier, and two streams draining non-carbonate formations during a high base-flow and a low base-flow period. Collect water samples for alkalinity and sulfate analysis. Analyze one sample from each stream for major ions. Investigate the outcrop area of the Greenbrier Formation for evidence of ground-water recharge and discharge. Make a rough estimate of the annual contribution from this formation to Deep Creek Lake based on concepts of the system developed from available and field data.

SUMMARY: The average annual alkalinity of six sampled streams ranged from 7.6 to 36.8 tons per year per square mile of drainage area. The average total alkalinity contributed to Deep Creek Lake by these streams is 161 tons per year as calcium carbonate. Mass-balance calculations based on very limited

data indicate that this alkalinity is derived from both carbonate rocks (Greenbrier Formation) and from weathering and hydrolysis of silicate minerals. Other sources may contribute alkalinity to Deep Creek Lake, but could not be quantified within the scope of this study.

No changes in stream-water quality were found that could be directly attributed to the stream having crossed the boundary from one noncarbonate bedrock formation to another. Inflow to streams from adjacent or underlying carbonate bedrock was apparent in several streams from increased values of pH and conductance. A report presenting results of the study is approved and will be published by the Maryland Energy Administration, Power Plant Research program. (See reference to approved report of results of this project in list for 1985 at end of this report.)



TITLE: Hydrologic Effects of Underground Coal Mining in Southern Garrett County, Maryland -- Phase II (MD067) and Phase III (MD088)

LEADER: Steven N. Hiortdahl

COOPERATORS: Maryland Geological Survey and Maryland Bureau of Mines

PERIOD OF PROJECT: Phase II, April 1982 - September 1986; Phase III, October 1986 - December 1989

PROBLEM: Better understanding of the hydrologic systems (ground and surface water) in coal areas and the effects of underground mining on those systems is needed in order to guide regulatory efforts designed to mitigate deleterious environmental impacts. The ultimate impact of underground mining on a particular hydrogeologic system, and the progression of hydrologic impacts occurring during the life of a mine are not easily predictable. Long-term documentation of the hydrologic conditions is needed as the mining continues, expands in size and eventually ceases. Such documentation may ultimately provide the

basis for constructing a conceptual model that may have transfer value to hydrogeologically similar areas.

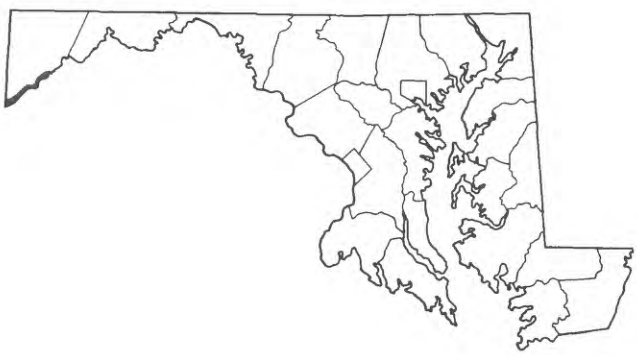
OBJECTIVE: To document and assess the impacts of underground coal mining on the hydrologic conditions of the ground- and surface-water systems during the study period. To determine and describe mine-induced impacts on local ground-water levels, on streamflow, and on stream-quality characteristics. And to relate significant mine-induced changes in hydrologic conditions to those described in previous study periods.

APPROACH: Monitor ground-water levels continuously in 10 of the 18 observation wells present in the study area. Measure water levels in the remaining observation wells on a monthly basis. Monitor stream stage, specific conductance, temperature, and pH continuously at two stream gages. Conduct stream-seepage investigations yearly.

SUMMARY: In 1979, a long-term comprehensive investigation was begun to document and assess the hydrologic impacts of a recently opened underground coal mine in southwestern Garrett County, Maryland. A previous study documented conditions as mining began (Phase I). (See reference to report for project MD031 in list of reports approved in 1983 at end of this report.) Phase II and Phase III studies continue data collection and documentation of conditions as mining continues.

Total area mined increased from 1.02 mi^2 in 1981 to 2.48 mi^2 in 1984. Annual pumpage from the mines increased concurrently from 410 Mgal/yr in 1981 to 650 Mgal/yr in 1984. Significant mine-induced water-level declines occurred in most observation wells that were undermined. Maximum observed water-level declines approached 400 feet in the water-bearing zone above the mine.

Discharges of treated acid mine drainage significantly increased streamflow and dissolved solids concentrations in one small stream basin (drainage area 1.6 mi^2), while having more moderate effects on another stream with a larger drainage area (8.3 mi^2). Some areas of undermined streams had significant losses of flow in the downstream direction after being undermined.



TITLE: Geochemical Processes Controlling Differences in the Stream Quality of Selected Coal-Mining Basins (MD068)

LEADER: Franceska D. Wilde

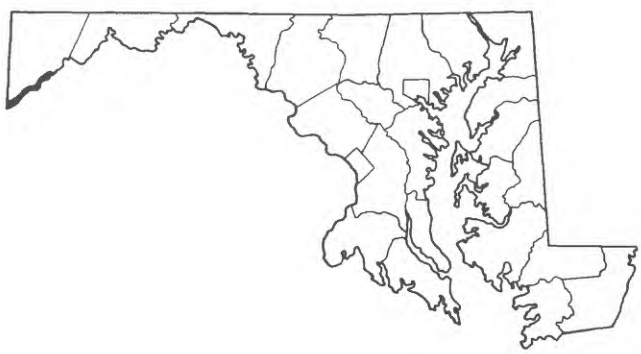
PERIOD OF PROJECT: October 1982 - September 1984

PROBLEM: The effect of coal-mining practices on stream quality of watersheds in the study area is reflected in recently collected data. The data reveal differences in water quality of streams draining different mined basins. The overburden is predominantly non-carbonate and buffering capacity of the local mineralogies is not obvious. Little is known about the actual chemical processes that control water quality in mining areas, thus it is not presently possible to evaluate reasons for observed differences. Knowledge of the controlling chemical processes is necessary also for predicting the effects of mining activity on water quality and aquatic life.

OBJECTIVE: (1) To identify and describe the physical and geochemical processes that control stream-quality differences in selected mined basins; and (2) to develop a method for estimating effects of mining on stream quality in a semi-quantitative manner.

APPROACH: Three to six small drainage basins will be selected according to prescribed criteria. Both mined and unmined basins will be included. Utilizing available data and the computer program WATEQF, sets of possible controlling reactions will be derived for each case. Simulation of physical and chemical mixing of basin waters will be accomplished using a computer program such as MIX 2 and will determine the chemical effects of mixing waters with different chemical characteristics.

SUMMARY: A related study (project MD076) applies information collected during this study. (Description of project MD076 follows.)



TITLE: Application of Geochemical Models and Modeling Techniques to the Upper Potomac Coal Basin in Western Maryland (MD076)

LEADER: Franceska D. Wilde

PERIOD OF PROJECT: December 1983 - September 1985

PROBLEM: The U.S. Geological Survey projects studying geochemical processes governing stream quality in the Eastern Coal Province have developed site-specific geochemical models. These models can, in theory, be transferred to other coal basins having similar hydrogeologic characteristics. Moreover, these modeling techniques can theoretically determine cumulative hydrochemical impacts of proposed coal mining and chemical treatment of mine drainage on the area's water resources. A methodology for the practical application of geochemical models to mine drainage problems needs to be developed and tested.

OBJECTIVE: (1) Identify the chemical reactions that control water quality as a stream flows from pristine to mined portions of a typical tributary of the North Branch Potomac River; (2) Evaluate the transferability of a site-specific geochemical model to other mined watersheds in the North Branch Potomac River basin; (3) Evaluate the utilization of geochemical modeling in the prediction of the changes that are likely to occur in base-flow quality of streams as a result of mining and of mine drainage treatment.

APPROACH: Six mined subbasins have been selected for base-flow sampling. Three of the sites were selected where different chemical treatments are being applied to mine drainage. The U.S. Geological Survey computer programs BALANCE, WATEQF and PHREEQE have been used to develop mass-balance and reaction-path models that are descriptive and predictive in nature, respectively. Water-quality predictions will include the final water composition of unmined, untreated mined and treated mined basins. Selected parameters, such as amount of chemical treatment per volume of rock, dissolved oxygen, and temperature, have been varied during reaction-path simulations. Predicted final water composition will be compared with observed final water composition.

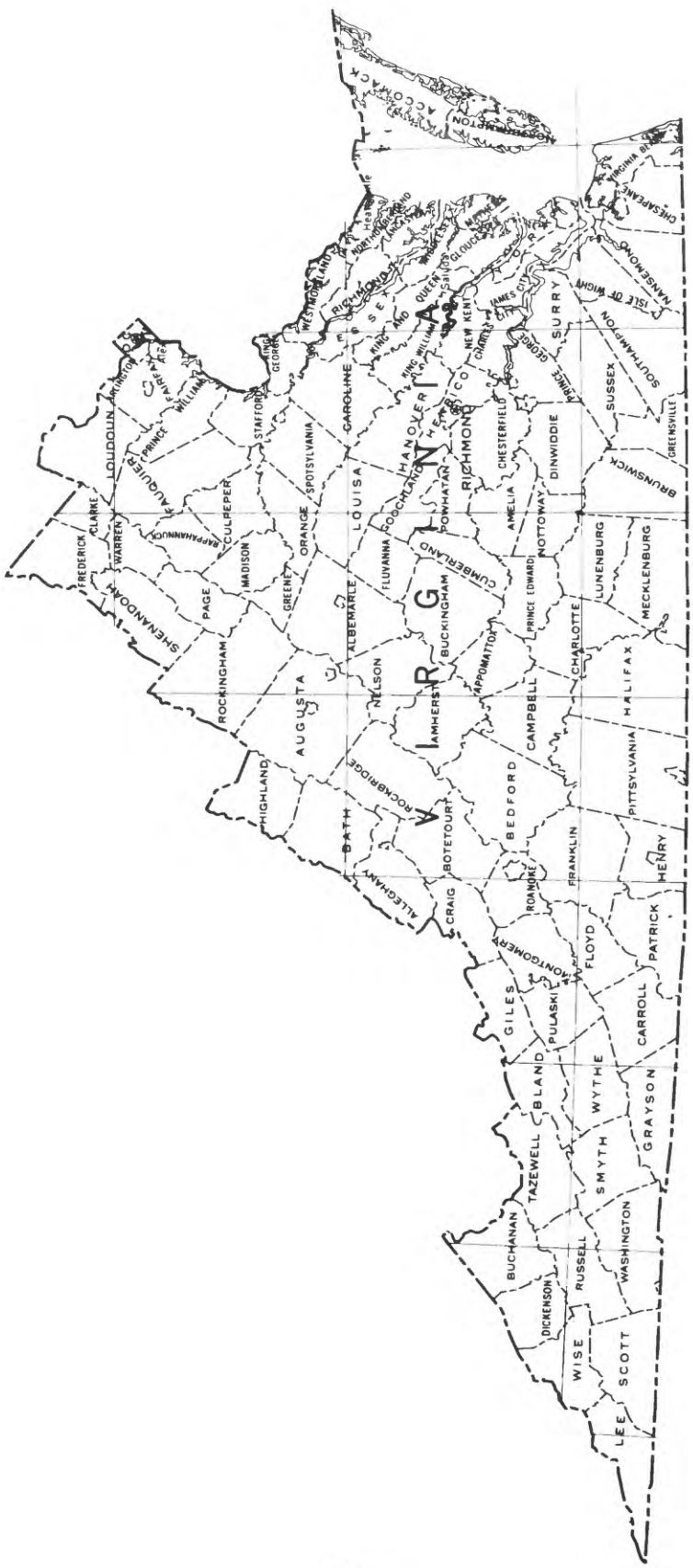


Figure 7. Counties of Virginia.

TITLE: Surface-Water Stations (VA001)

LEADER: Byron J. Prugh, Jr.

COOPERATORS: Virginia Water Control Board, City of Alexandria, City of Newport News, City of Roanoke, City of Radford, James City County, Southeastern Public Service Authority, U.S. Army Corps of Engineers, Tennessee Valley Authority, and Northern Virginia Planning District Commission.

PERIOD OF PROJECT: Continuous since 1923

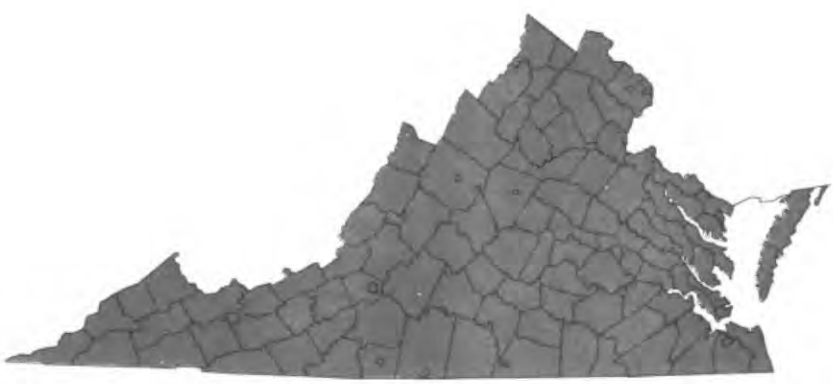
PROBLEM: Surface-water information is needed for purposes of surveillance, planning, design, hazard warning, operation, and management, in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, floodplain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

OBJECTIVE: A. To collect surface-water data sufficient to satisfy needs for current-purpose uses, such as (1) assessment of water resources; (2) operation of reservoirs or industries; (3) forecasting; (4) disposal of wastes and pollution controls; (5) discharge data to accompany water-quality measurements; (6) compact and legal requirements; and (7) research or special studies. B. To 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, etc., for use in planning and design.

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

SUMMARY: Continued collection of basic streamflow data needed to assess water resources of Virginia. Records for 1984 water year have been published and distributed. Computation of 1985 water year data is in progress. Analysis of basic surface-water network completed and awaiting publication. Current

network consists of 84 continuous record and 10 stage-only sites. An additional 101 streamflow sites will be operated by Virginia Water Control Board (VWCB) as part of a cooperative stream-gaging program. Repair of gages damaged by major flooding in November 1985 should be completed by July 1986. Satellite data platforms operated for two Corps Districts now provide real-time management data at 25 streamflow sites. (See reference to approved report of results of this project in list for 1985 at end of this report. See section, "Annual Water-Data Reports," for locations of data-collection sites and information on publication of data.)



TITLE: Ground-Water Stations (VA002)

LEADER: Herbert T. Hopkins

COOPERATORS: Virginia Water Control Board and U.S. Environmental Protection Agency

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 the resource.

OBJECTIVE: 1. To 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. To 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: 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 of 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.

SUMMARY: Data from approximately 150 Ground Water Site Inventory (GWSI) forms prepared for active studies were entered into WATSTORE. Ground-water data were compiled and submitted for publication in the annual report, Water Resources Data, Virginia, Water Year 1985. Collection of subsidence data continued at Franklin and Elephant Fork, southeastern Virginia. New and historical water-level data will continue to be entered into the GWSI database. A task force consisting of U.S. Geological Survey and Virginia Water Control Board (VWCB) personnel is being formed to establish a uniform set of criteria for the cooperative observation well program. Down loaded GWSI from System 2000 to the Prime at the Virginia Office. A computer listing was compiled of VWCB and USGS observation wells documenting frequency of measurement and cross referencing of the numbering systems. A technical review was conducted on the ground-water program by USGS personnel from Headquarters.

Seven shallow observation wells, a tidal gage, and surface gage were installed and equipped with analog recorders to aid in defining the water-table profile along a transect across the southern part of Chincoteague Island, Accomack County, Virginia. Data from these gaging stations will be used to show the effect on the water table from precipitation, evapotranspiration, and tide and the general direction of ground-water flow. (See reference to approved report of results of this project in list for 1984 at end of this report. See section, "Annual Water-Data Reports," for locations of selected data-collection sites and information on publication of data.)

TITLE: Water-Quality Stations (VA003)

LEADER: Dennis D. Lynch

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.

OBJECTIVE: To provide a State bank of water-quality data for broad State and Federal planning and action programs; provide data for Federal management of interstate waters; and 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 within Virginia; obtain comprehensive description 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 man. The hydrologic network is periodically analyzed to define the statistical properties of, and trends in, the quality of water in Virginia.

The four major tributaries to the Chesapeake Bay which 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 in order to meet local needs and the needs of nationwide programs of the U.S. Geological Survey. Monthly Fall-Line sampling of Virginia's four major tributaries to the

Chesapeake was initiated in July 1984, and continues to date. An assessment of long-term water-quality trends at these four tributaries was made in 1985. (See section, "Annual Water-Data Reports," for locations of data-collection sites and information on publication of data.)

TITLE: Suspended-Sediment Stations (VA004)

LEADER: Dennis D. Lynch

COOPERATORS: National Park Service and U.S. Army Corps of Engineers

PERIOD OF PROJECT: Continuous since 1951

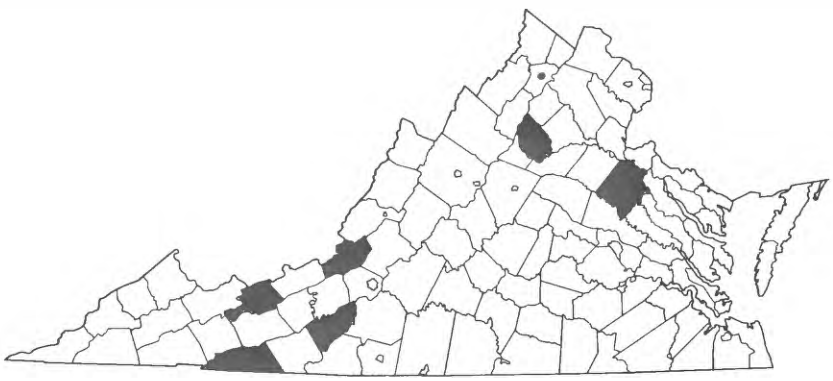
PROBLEM: Water-resource planning and water-quality assessment requires basic information about the concentrations and loads of sediment carried by streams in Virginia, and how these concentrations and loads vary with time and location in the State.

OBJECTIVES: (1) Provide long-term data on sediment loads and concentrations for selected streams in Virginia, and (2) provide detailed short-term data on sediment loads and concentrations in areas of local interest.

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. Several short-term sediment stations were also established during the reporting period to document sediment loads in particular areas of interest. Sediment loads at the Levisa Fork at Grundy are currently being measured for the U.S. Army Corps of Engineers, Huntington District; daily loads were monitored at four sites in Prince William Forest Park for the

National Park Service. (See section, "Annual Water-Data Reports," for locations of data-collection sites and information on publication of data.)



TITLE: Federal Emergency Management Agency (FEMA) Flood Investigations (VA006)

LEADER: William G. Langley

COOPERATOR: Federal Emergency Management Agency

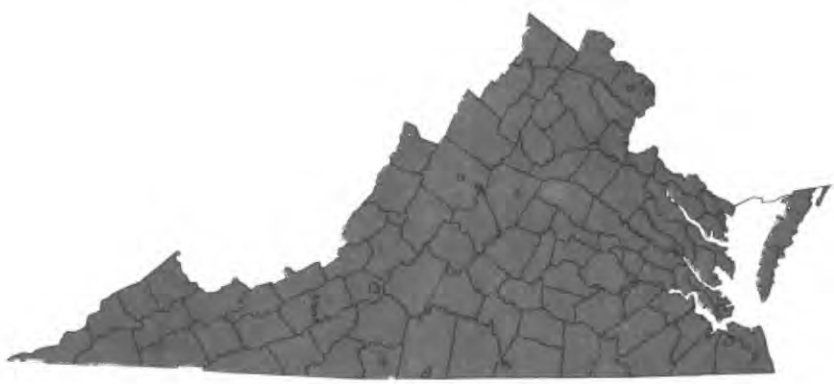
PERIOD OF PROJECT: July 1985 - March 1987

PROBLEM: The National Flood Insurance Act of 1968, and the Flood Disaster Protection Act of 1973 provides that the Department of Housing and Urban Development (HUD) operate a flood insurance program through the Federal Insurance Administration. HUD 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 made by local and regional planners in their efforts to promote sound land use and flood-plain development.

APPROACH: Make 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 district personnel. Using step-backwater computer program, 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 FIA specifications.

SUMMARY: All photogrammetric and ground-surveying work has been completed for the Front Royal (detailed study) area and a draft copy of the report was submitted for technical review in July 1986. Ground-survey work is complete in three of the six less detailed study (LDS) areas (Bland, Craig, and Grayson Counties) and partially complete in two others (Floyd and Madison Counties). Field work for LDS in Floyd, Madison, and Caroline Counties is scheduled for completion by the fall of 1986. Analysis and report preparation for all counties will be completed by March 1987.



TITLE: Virginia Water-Use Data System (VA007)

LEADER: Herbert T. Hopkins

COOPERATORS: Virginia Water Control Board.

PERIOD OF PROJECT: Continuous since 1978

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

OBJECTIVE: Begin the implementation of the Virginia Water Use Data System. It is a continuation of the efforts begun in FY 78 which resulted in a conceptual design of the system in cooperation with the State of Virginia. This system is designed to meet both the needs of the U.S. Geological Survey National Water Use Data System (NWUDS) and the State.

APPROACH: Document the responsibilities of the agencies participating in the Virginia Water Use Data System and develop a data matrix to correlate the source agencies with the currently available water use data. Implement a pilot program for compiling and collecting data for a selected area. Select data base managment software package and design the data base support software.

SUMMARY: The Virginia Water Control Board published the report, "Water Use by the Public Utilities, Thermal Power Generating Plants in Virginia," as Basic Data Bulletin 66. The U.S. Geological Survey is preparing a report on water use for hydroelectric power generation in Virginia. The water-use data collected for power generation is being entered into the Virginia Water Use Data System (VWUDS).

Water-use data for calendar year 1985 was entered into the VWUDS. The data for 1984 and 1985 calendar years will be published in the same format as the earlier report, "Virginia Water Withdrawal and Use Report, 1982-1983," Basic Data Bulletin 64.

About 160 irrigation systems on the Atlantic Coastal Plain were inventoried by field enumerators for the Virginia Crop Reporting Service. Data collected during this inventory are being compiled and coded for entry into VWUDS.

A listing of coal and non-coal mining companies was compiled for establishing a data base for water use for mining in the VWUDS.

Several Fortran programs were converted by the U.S. Geological Survey from the IBM computer to the Prime computer for displaying and editing water-use data and a computer graphic display was prepared using ARC/INFO. (See reference to approved report of results of this project in list for 1982 at end of this report.)

TITLE: Hydrologic Hazards: Flood Characteristics of Virginia Streams (VA019)

LEADER: Byron J. Prugh, Jr.

COOPERATOR: Virginia Department of Highways and Transportation and U.S. Department of Agriculture, Soil Conservation Service

PERIOD OF PROJECT: Continuous since July 1948

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

APPROACH: Operate crest-stage gages at 68 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; enter peak-flows into WATSTORE System. Prepare special reports for unusual flood events as they occur.

SUMMARY: Peak-flow elevations were recorded routinely at 68 sites across Virginia. Peaks for the previous water year were entered in the peak-flow data base and published in annual data report. In November 1985, there was widespread flooding in the upper James and Shenandoah River basins and near Roanoke, Va. Many sites had floods in excess of a 100-year return frequency. More than a dozen high-water current-meter measurements were made along with 15 indirect measurements to document peak flows. Two reports on the flood are projected.

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

LEADER: Donald C. Hayes

COOPERATOR: Virginia Water Control Board

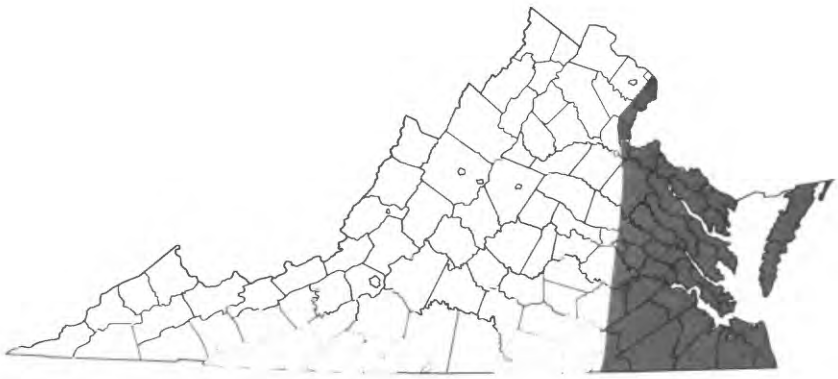
PERIOD OF PROJECT: June 1980 - September 1986

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

OBJECTIVE: Develop a regression model based on basin characteristics to predict 7-day, 10-year low flow and other selected low-flow values. Prepare a map showing 7-day, 10-year low-flow values for all continuous and partial-record sites in Virginia. 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 good 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: Completed statistical analysis on continuous record sites to determine low-flow characteristics. Completed discharge measurements at all partial-record sites. Complete the correlation of partial-record sites to continuous-record sites for the Coastal Plain and estimated low-flow values. The geology at each partial-record site will be characterized and drainage area will be calculated.



TITLE: Analysis of the Aquifer System in the Coastal Plain of Virginia (VA057)

LEADER: Randell J. Laczniak

PERIOD OF PROJECT: October 1979 - September 1986

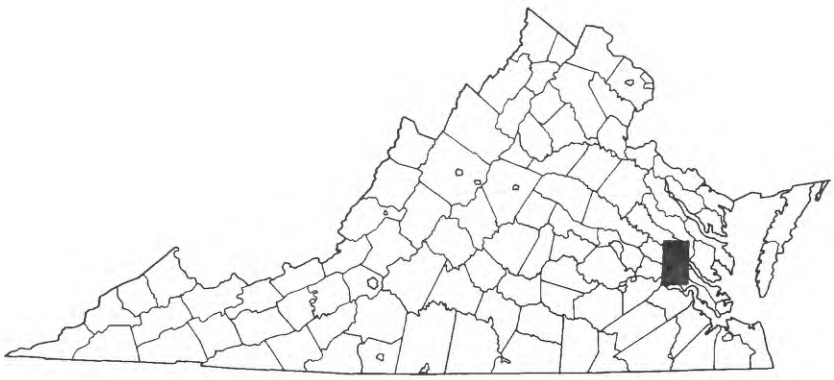
PROBLEM: Declining water levels, locally inadequate supplies of ground water and competing private demands for ground water have threatened extensive use of the multilayer aquifer system in the Coastal Plain of Virginia. Concentrated ground-water withdrawals, especially at Franklin, Lake Prince, Smithfield, and West Point are causing the coalescence of several cones of depression resulting in mutual interference among ground-water users in an interstate area. The cone of depression around Franklin extends beyond Virginia into northeast North Carolina. Related potential water problems are: (1) intrusion of saline ground water into coastal areas, and (2) manipulation of the surface-water and ground-water relations in a major swamp ecosystem.

OBJECTIVE: Describe geologic, hydrologic and freshwater-saltwater characteristics of the multiaquifer system; increase knowledge of the ground-water flow system(s) and analyze changes in the flow system resulting from pumpage; simulate the aquifer system through digital computer models; develop a computerized data base containing geologic and hydrologic data, interpretative information and historical data on pumpage and water levels; and estimate the boundary of the freshwater flow system.

APPROACH: Compile and analyze available hydrologic data, including hydraulic properties of geohydrologic units, water levels, and pumpage for each aquifer; construct interpretative maps for development of a regional model; develop initial steady-state and transient-state computer models; collect and analyze new data to improve and refine interpretative information; examine the relations of saltwater to freshwater and estimate the position of zones or interfaces; apply model to evaluate the effects of pumpage on the ground-water regime; develop and calibrate steady-state and transient-state computer models.

SUMMARY: The sediments of the Virginia Coastal Plain were divided into nine aquifers and eight intervening confining unit beds as part of a comprehensive study of the northern Atlantic Coastal Plain aquifer system extending from North Carolina to Long Island, New York. Meng and Harsh collected and analyzed data for the study during October 1979 to May 1983. The nine aquifers and eight intervening confining units are delineated by use of 185 geophysical logs, drillers' information, stratigraphic and paleontologic data. The layered framework correlates with a regional framework of 10 aquifers and 9 confining beds covering the northern Atlantic Coastal Plain aquifer system. Hydrogeologic sections and maps of the altitude of top of aquifer and thickness of confining unit describe the relationships of aquifers and confining units in the Virginia Coastal Plain. The results are presented in a report entitled, "Hydrogeologic Framework of Virginia Coastal Plain."

The study to define the hydrogeologic framework of the Virginia Coastal Plain provides the geologic and hydrologic information upon which a finite-difference model of the Virginia Coastal Plain ground-water system is based. The model was used to increase knowledge of the ground-water flow system and to analyze the response of the flow system to ground-water development. The model includes 10 aquifers and 9 intervening confining units and is bounded on the east and west by no-flow boundaries and on the north and south by finite-flux boundaries. Model results are presented in a report "Conceptualization and Analysis of the Ground-Water System in the Coastal Plain of Virginia." A summary of the ground-water pumpage for the study area is being prepared for publication in a report entitled, "Ground-water Withdrawals in the Confined Aquifers of the Virginia Coastal Plain." (See reference to approved reports of results of this project in lists for 1984 and 1986 at end of this report.)



TITLE: Limnology of Little Creek Reservoir, Virginia, and Water-Quality Characteristics of its Supply System (VA071)

LEADER: Dennis D. Lynch

COOPERATOR: City of Newport News, Virginia

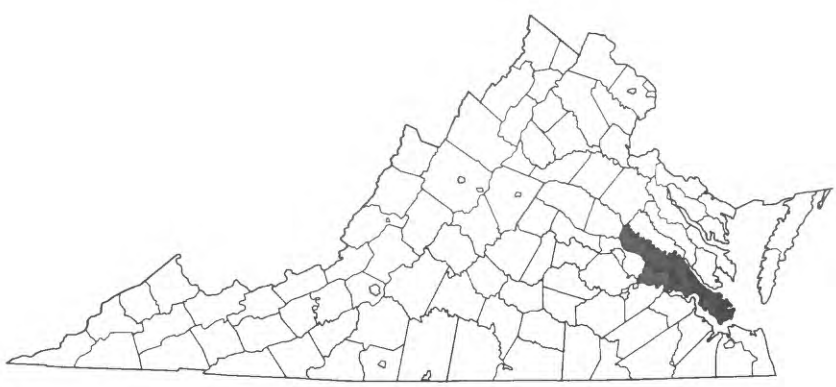
PERIOD OF PROJECT: July 1983 - September 1986

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 costs throughout the year.

OBJECTIVE: 1. Discern limnological characteristics of Little Creek Reservoir and their relation to: nearby development; limited flushing in remote areas; and seasonal events such as thermal stratification in summer months. 2. Develop an understanding of seasonal water-quality variations and the thermal structure of Diascund Creek Reservoir, and characterize quality of the primary raw water source (Chickahominy River).

APPROACH: All water bodies are sampled monthly during the active growing season (April through October), and bimonthly thereafter. Samples are collected from multiple depths in the reservoirs, and analyzed for nutrients, chlorophyll a, major ions, and physical parameters. A single sample is collected from the Chickahominy River in the water works' intake structure, and a continuously recording monitor measures specific conductance and temperature. Seasonal variation in limnological characteristics of both reservoirs will be determined through detailed measurements of the depth profiles of key parameters such as temperature, dissolved oxygen, 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, reaching concentrations at fall overturn of 14, 1.5, and 1.1 mg/L, respectively, in Little Creek Reservoir, and 24, 2.4, and 1.1 mg/L, respectively, in Diascund Creek Reservoir. Surprisingly, phosphorus does not follow a similar pattern. During stratification, these reservoirs act as sinks for phosphorus, as evidenced by lower reservoir concentrations of phosphorus than input concentrations. As a result, algal biomass in these reservoirs is phosphorus limited throughout the year, with nitrogen to phosphorus ratios generally above 20. The low concentrations of phosphorus undoubtedly account for the low to moderate concentrations of chlorophyll a in these reservoirs, which generally ranges from 3 to 30 micrograms per liter.



TITLE: Assessment of the Ground-Water Resources in the York-James Peninsula, Virginia (VA073)

LEADER: Randall J. Laczniak

COOPERATORS: York, Hanover, New Kent, and Charles City Counties, the James City Service Authority, and the Cities of Newport News and Williamsburg, Virginia.

PERIOD OF PROJECT: July 1983 - September 1986

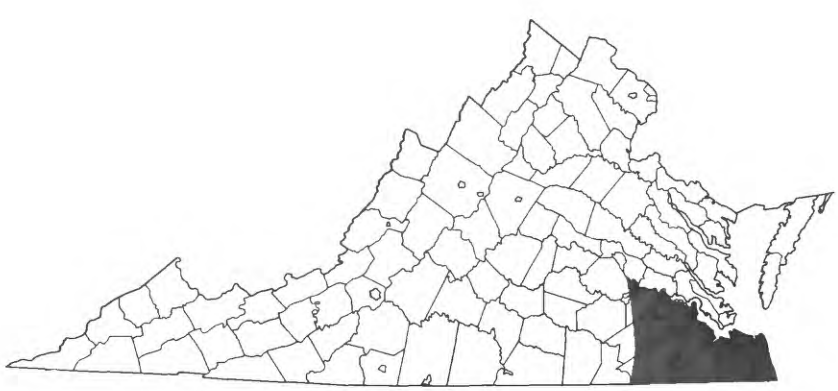
PROBLEM: A substantial increase in ground-water demand is expected for the York-James Peninsula. The major aquifers of the Peninsula are presently being utilized from within and outside the area. Additional development may affect current ground-water users by increasing drawdowns and inducing salty ground

water. The effects of additional proposed ground-water development need to be determined.

OBJECTIVE: Estimate the availability of ground water to meet projected needs. Define the extent and thickness of individual aquifers. Estimate the limit of the freshwater system in the aquifers. Estimate the impacts of future ground-water development. Test application of existing regional ground-water model for submodel boundary conditions.

APPROACH: Analyze geophysical logs and hydrologic data to provide 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 Research stations (well nests) were installed to obtain a site-specific vertical profile of water quality and water levels in the ground-water system of the York-James Peninsula at two locations. Geophysical logs from these research stations and other recently drilled wells were used to refine an existing hydrologic framework of the ground-water system. Hydrogeologic data were collected, compiled, and analyzed in order to characterize the hydraulic properties and water quality of individual aquifers comprising the hydrogeologic framework. A digital-flow model of the multi-aquifer system was developed. The model was used to gain a better understanding of ground-water flow, determine the effect of various proposed pumping scenarios, and demonstrate its potential use in water-management decisions.



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

LEADER: Jerry D. Larson

COOPERATOR: Virginia Water Control Board

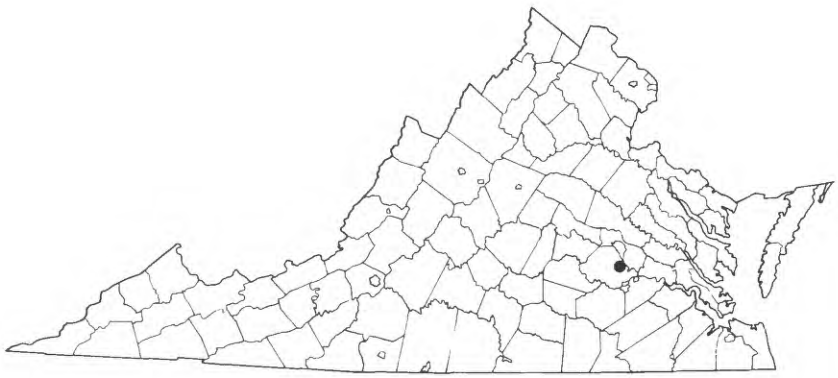
PERIOD OF PROJECT: July 1984 - September 1986

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.

OBJECTIVE: To evaluate the water-supply potential of the multilayered aquifer system in an interstate area, and determine the effects of proposed ground-water development. Withdrawal schemes with varied ground-water production will be analyzed with respect to changing water levels.

APPROACH: Objectives will be met through the following steps: 1. Data-collection.--Includes drilling and construction of observation wells, measuring freshwater heads at observation wells, sampling of selected wells to provide data on water-quality differences with depth, and conducting an inventory of water users. 2. Hydrologic analysis.--Update hydrogeologic 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 ground-water withdrawals to determine hydrologic effects. Use available streamflow data and low-flow analyses to determine, if or how extensively, ground-water withdrawals affect streamflow. 3. Documentation.--Prepare a report documenting in detail the hydrology of the study area and results of stressing the ground-water system under alternative withdrawal schemes. Also, software display packages developed for the study will be documented for general use.

SUMMARY: Completed the calibration and sensitivity tests of the model and ran two pumping scenarios. Two research stations were drilled. Continuing to update water-level and pumpage data bases and to write first draft of report.



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

LEADER: John D. Powell

COOPERATOR: U.S. Department of Defense, Defense Logistics Agency

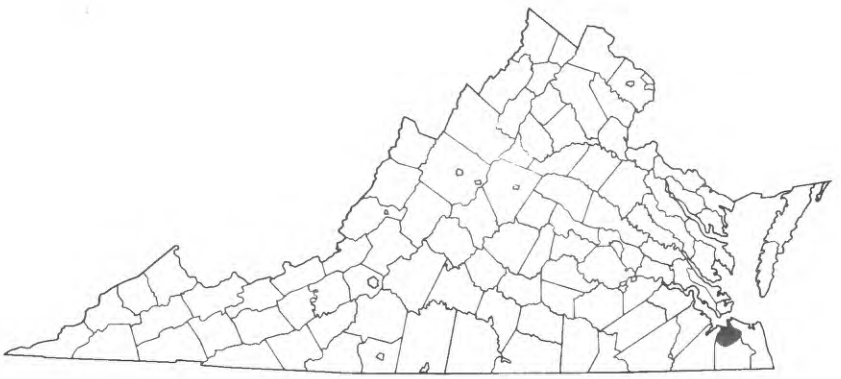
PERIOD OF PROJECT: April 1984 - September 1987

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.

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

APPROACH: Wells will be installed in clusters downgradient from the area of known contamination. Each cluster will facilitate collection of water samples at the top, middle, and bottom of each aquifer present. The presence of contamination will be confirmed through analysis for volatile organics by U.S. Geological Survey Central Laboratories.

SUMMARY: Forty-four monitoring wells, within ten multi-level 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, within six clusters, were installed during the spring of 1986. Monitoring of water quality in all wells continues. Aquifer tests were conducted to estimate magnitude of aquifer characteristics.



TITLE: Analysis of Natural-Resources Data by Use of a Geographical Information System (GIS), Elizabeth River basin, Virginia (VA082)

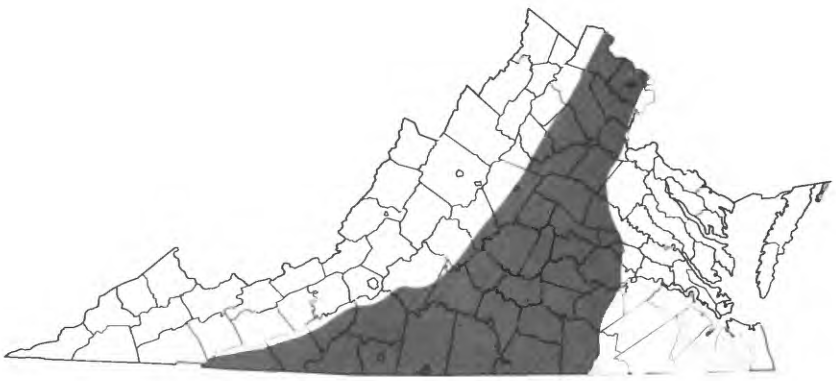
LEADER: Todd Augenstein

PERIOD OF PROJECT: May 1986 - October 1989

PROBLEM: The heavy concentration of industry, 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. A major concern arises as to the actual location of contaminants, whether the contaminants are being transported from their dump location and the potential effects that may occur if the toxic material reaches sensitive areas.

OBJECTIVE: Develop a GIS to integrate existing environmental and technical data of USGS and other Federal, State, and local organizations into a centralized framework and use the system to develop an overall strategy that will assist in the making of management decisions for the Elizabeth River basin.

APPROACH: Purchase and use the ARC/INFO software package for the Elizabeth River basin geographical information system (GIS). Identify and contact potential users of a natural-resources GIS data base for the Elizabeth River basin. Determine user needs and identify possible applications of the data base. Select feasible applications that meet current user needs and that demonstrate capabilities of the ARC/INFO package. Identify all pertinent, available data, which can be used to assess the potential sources and impacts of contamination in the Elizabeth River basin and to develop the selected applications. Develop a plan for obtaining the data and entering it to the GIS. Design a data storage and management scheme, convert and enter data. Build the selected applications by developing methods to retrieve and analyze data from the data base.



TITLE: Water Quality of the Piedmont Province of Virginia--A Planning Study (VA070)

LEADER: John D. Powell

COOPERATOR: Virginia Water Control Board

PERIOD OF PROJECT: April 1983 - September 1984

PROBLEM: The Piedmont Province of Virginia is being considered as a potential site for high-level radioactive waste disposal, uranium mining, and water supply for the more populated southeastern Virginia. The quantity and quality of ground water in the Piedmont are poorly known. A greater understanding of the ground-water system will facilitate more effective management of the ground-water resource.

OBJECTIVE: Describe the availability and quality of ground water within the Piedmont Province of Virginia.

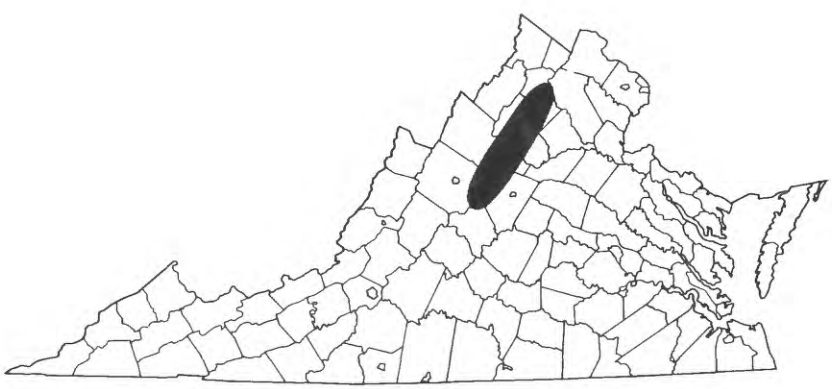
APPROACH: Utilize previously published reports on Virginia and neighboring states as well as data available in Virginia to characterize availability and quality of ground water.

SUMMARY: The Piedmont Province of Virginia has an ample supply of ground water, perhaps as much as 1.5 billion gallons are in storage per square mile, generally suitable for domestic and small supply needs. The source of this ground water is precipitation.

Ground water within the crystalline rocks of the Piedmont is stored in the pore spaces of the regolith and in fractures in the underlying bedrock. Water within the sedimentary rocks of the sedimentary basins is stored in bedding planes, fractures, and in pore spaces in the rock, and in the regolith. Well yields can be maximized in both terranes by constructing wells along lineaments and in valleys.

Ground water in the crystalline rocks is generally slightly mineralized and acidic (pH <7.0). Ground water in the sedimentary rocks is more mineralized and basic (pH >7.0). Dissolved solids concentration in deep wells (>500 feet) in sedimentary rock may exceed tolerable limits. Land disposal of solid wastes and sewage from domestic septic systems present the major threat to ground-water quality.

A greater understanding of the ground-water system in the Virginia Piedmont could be used to anticipate future shortages so that preventive measures could be implemented to protect the ground-water reservoir. (See reference to approved report of results of this project in list for 1985 at end of this report.)



TITLE: Sensitivity of Streams in the Shenandoah National Park, Virginia, to Acid Deposition (VA063)

LEADER: Dennis D. Lynch

COOPERATOR: University of Virginia

PERIOD OF PROJECT: June 1981 - September 1984

PROBLEM: Precipitation has become increasingly acidic in eastern North America causing the degradation of many water resources. Since the source of acid precipitation is closely tied with energy production and consumption, it is critical that the adverse effects are clearly known. The Shenandoah National Park, because of its geology and location, is one of the most vulnerable areas in the country. Knowledge of the current degree of acidification of the Park's streams and their sensitivity to additional acid input will expand the understanding of the intensity and areal distribution of the problem.

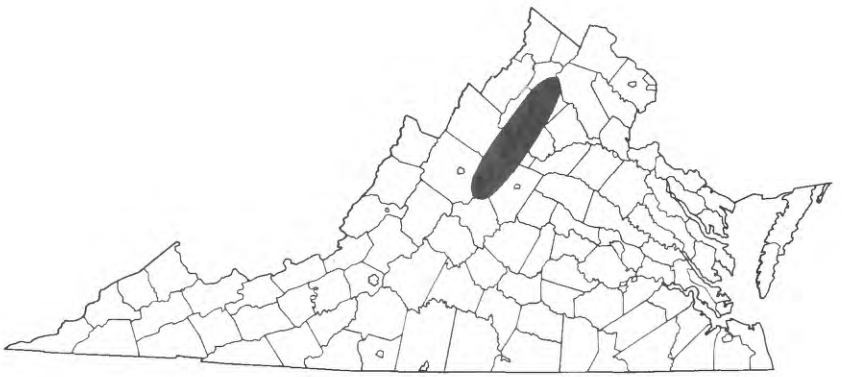
OBJECTIVE: (1) Determine the "sensitivity" of streams in the Shenandoah National Park to future inputs of acid precipitation using indicies of sensitivity, and (2) To discern if acidification of stream basins resulting from past acidic precipitation has occurred.

APPROACH: Over a 1-year period, six measurements of streamflow, pH, the major anions and cations, and conductivity were made at various flows at 50 selected Park streams. The sensitivity of stream basins to acid precipitation were estimated using stream-water alkalinity concentration. The degree of sensitivity was correlated to basin geology so sensitivity of unmonitored streams in and around the Park could be estimated. Acidification of a stream basin was estimated as the difference between the stream-water concentration of base cations derived from weathering reactions on the basin, and the stream-water alkalinity concentration.

SUMMARY: All basins in the Park are considered sensitive to acid deposition. However, basins underlain by the resistant Antietam and Hampton Formations are extremely sensitive to acid deposition; basins underlain by Old Rag Granite and the Pedlar Formation are highly sensitive, and basins underlain by the Catoctin Formation are moderately to marginally sensitive.

A linear regression model relating stream-water alkalinity concentration to drainage basin geology was developed to estimate the sensitivity of unsampled streams in and around the Park with similar basin characteristics.

Acidification of stream basins by atmospheric deposition averages 50 microequivalents, and is evenly distributed in the Park. This acidification is manifest as a loss of stream-water alkalinity and/or an increase in the weathering rate of base cations from basin rocks and soils. In the most sensitive area of the Park, this acidification has resulted in streamwater with a pH of 5.0 and mineral acidity of 7 microequivalents per liter. (See reference to approved report of results of this project in list for 1985 at end of this report.)



TITLE: Hydrologic Conditions and Trends in Shenandoah National Park, Virginia (VA066)

LEADER: Dennis D. Lynch

COOPERATOR: National Park Service

PERIOD OF PROJECT: April 1982 - September 1985

PROBLEM: A water-resources management plan is needed to make sound decisions about present and future Park operations. This is especially important for the Shenandoah National Park because of increased visitor pressure and drought conditions in 1980 and 1981, which left the Park without adequate water supplies. At present the hydrologic data base is inadequate to develop such a plan.

OBJECTIVE: 1. Provide a broad understanding of the Park's hydrologic cycle. 2. Provide the following data needed for site-specific management decisions: (a) ground-water levels at supply and observation wells, and spring discharges; (b) flow and water-quality characteristics of streams; (c) present and historic precipitation patterns; (d) effects of drought and consumptive use on supplies; and (e) potential alternative water sources.

APPROACH: A network of 9 precipitation stations, 27 surface-water sites (continuous and partial record), and about 35 wells and springs were established and maintained for about 2 years. Current hydrologic conditions will be described and compared to available historic information to discern trends. The potential effects of consumptive use and drought on available water resources will also be determined. Emphasis will be placed on areas of current development such as Big Meadows and Skyland.

SUMMARY: The following topics will be emphasized in the final report (in preparation):

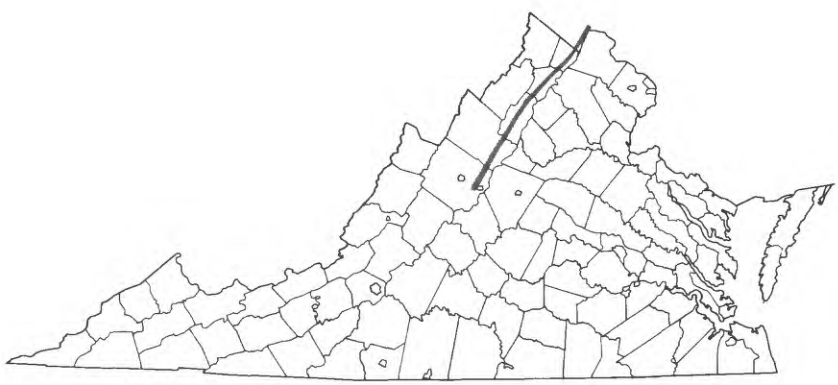
* Hydrologic budget of the Park and the relationship between precipitation, surface runoff, evapotranspiration, and ground-water levels.

* Precipitation patterns in the Park during "normal" periods and during recent drought periods.

* Low-flow statistics for various streams and their relation to basin characteristics such as geology.

* Current ground-water conditions in the Park and as assessment of any long-term trends due to climatic conditions and consumptive use.

* An assessment of the short-term and long-term effects of pumping ground water on the water resources at Big Meadows and Skyland, the two largest developments in the Park.



TITLE: Traveltime and Dispersion of a Water-Soluble Contaminant in the Shenandoah River, Virginia and West Virginia (VA074)

LEADER: Kenneth R. Taylor

COOPERATORS: Interstate Commission on the Potomac River Basin and Virginia Water Control Board

PERIOD OF PROJECT: August 1983 - September 1985

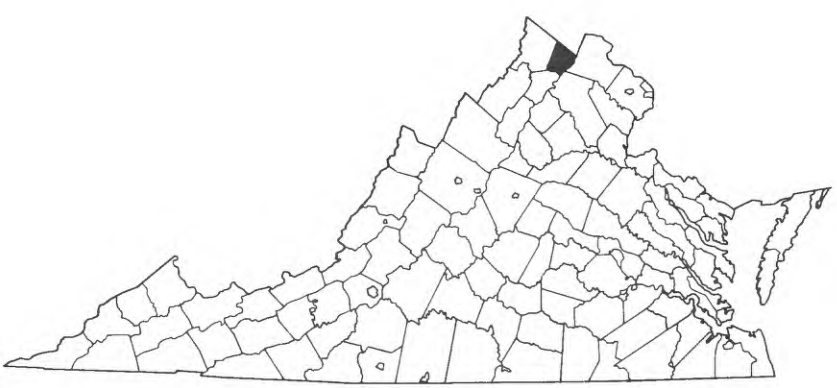
PROBLEM: Periodically, truck accidents and train derailments spill toxic substances into the Shenandoah River. Downstream water-supply managers and State and local health authorities must immediately concern themselves with the potential impact of the spill on the public health. Currently, there is inadequate information for the managers to predict the movement of the spilled material and the effect of dilution and dispersion on contaminant concentrations.

OBJECTIVE: 1. Determine the traveltime and dispersion characteristics of a water-soluble substance in the Shenandoah River for two flow durations

(preferably 50-65 and 80-95 percent). 2. Provide the water managers with a technique for making the following estimates when a slug of water-soluble toxic material is introduced into the Shenandoah River during periods of low to median flow: (a) The time of arrival of the leading edge at any point along the river; (b) the time of arrival of the peak concentration at any point along the river; (c) the duration of the contaminant cloud at any point on the river; and (d) the expected peak concentration if the contaminant is conservative.

APPROACH: Divide the 155-mile reach into three subreaches and dose with Rhodamine WT dye. Sample the dye-water mixture as it moves downstream. Determine the dye concentration in each sample. Prepare time-distance-concentration graphs for observed and conservative concentrations. Use these data to interpolate and extrapolate traveltimes for a selected range of flows. Use the unit concentration method to examine the effects of dispersion on the attenuation of peak concentration.

SUMMARY: Traveltime and dispersion data were collected for the 180-mile reach of river at a flow duration of approximately 40 percent. Cumulative time for the peak concentration to travel from Waynesboro, Virginia, to the mouth ranged from 280 hours at 40-percent flow duration to 610 hours at 85-percent flow duration. A report summarizing results of the study has been approved and is being prepared for publication. (See reference to approved report of results of this project in list for 1985 at end of this report.)



TITLE: Clarke County Ground Water (VA081)

LEADER: Winfield G. Wright

COOPERATORS: Lord Fairfax Planning Commission and Clarke County, Virginia

PERIOD OF PROJECT: October 1985 - June 1988

PROBLEM: Ground-water resources management associated with land-use planning is paramount to the future of Clarke County's economic growth and development. A physical definition of ground-water flow in the county's karst aquifers is needed in order to develop a sound ground-water management plan. An assessment of the quality of the county's ground water is also needed. A monitoring network of wells and springs must be established to relate changes in ground-water quality to land use. Hydrologic and geographic information needs to be entered into integrated data-base subsystems that have been designed for geographic information handling and display.

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 computer data base.

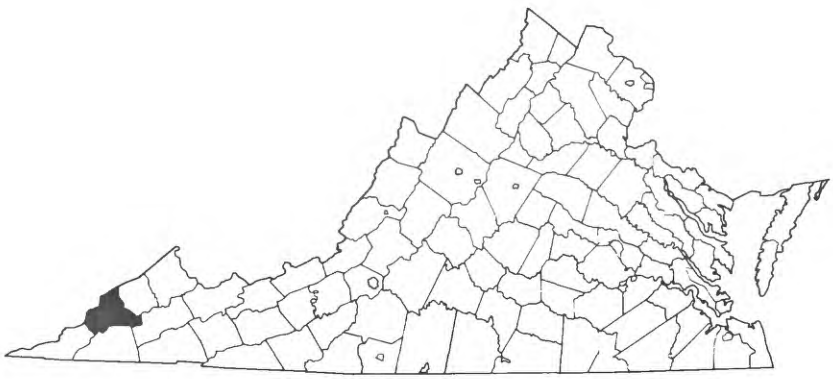
APPROACH: Compile available data on wells and springs--includes locations, well construction data, depths and yields of wells, flow rates of springs, and water-quality data. Place recorders on wells and springs to match with each other and to compare with rainfall data. Make water-level measurements in 60 to 100 wells.

Collect water samples from combination of 60 wells and springs. Samples will be analyzed for major cations and anions in order to compare geochemistry of source aquifers. Samples will be analyzed for nitrates and nitrites.

Utilize recorders on the selected wells and springs to establish a long-term monitoring network. Samples will be collected at these sites to be analyzed for pesticides and herbicides in order to establish beginning or background data.

Format data for Geographic Information System (GIS) compatibility and work on system interfacing.

SUMMARY: Data collection of spring discharges, water levels in wells, and ground-water quality samples is currently underway. Available data--from Environmental Protection Agency's STORET and U.S. Geological Survey Ground Water Site Inventory files--have been accessed and organized in computer data bases located on the U.S. Geological Survey computer at Richmond, Va. Field reconnaissance in the study area acknowledge that the majority of ground water in the county discharges from large karst springs which resurge from fractured limestone and dolomite aquifers.



TITLE: Water Resource Appraisal of the Powell River Basin in Wise County, Virginia (VA072)

LEADER: Jerry D. Larson

COOPERATOR: Virginia Polytechnic Institute and State University

PERIOD OF PROJECT: July 1983 - September 1985

PROBLEM: Increased water use has resulted from an increase in mining and a corresponding population increase. The mining activity has interrupted or diverted the natural flow systems and has resulted in a loss of water to wells and springs used as a water supply. The hydrologic requirements of Public Law 95-87 requires the following items be considered: (1) collect all hydrologic data available, (2) determine a base in which to evaluate changes in the hydrologic system due to mining and reclamation, and (3) determine alternative sources of water where existing sources are disturbed by mining.

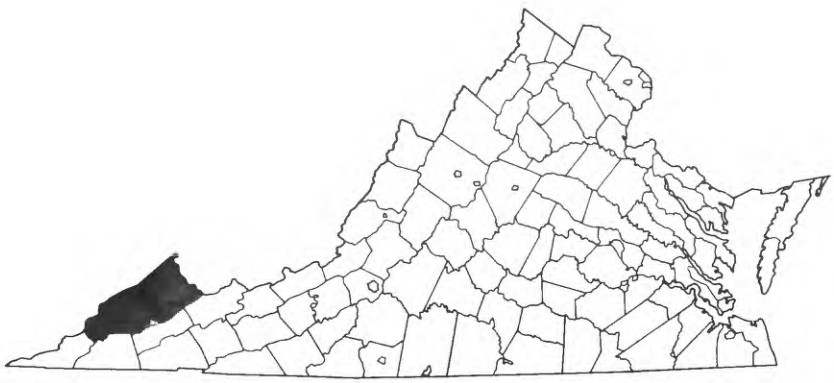
OBJECTIVE: Determine availability of existing hydrologic data and conduct literature search. Using the Powell River basin above Big Stone Gap as a pilot project, describe the hydrologic system as can be best determined from the existing data. Determine the data deficiencies for describing the hydrologic system. Evaluate, in detail, the most promising areas for future water supply based on existing data.

APPROACH: The Powell River above Big Stone Gap, Virginia, encompassing an area of 112 mi^2, will be evaluated by the following: (1) collate all available hydrologic data in the area from existing Government, industry, and university data bases and files; (2) summarize the available and pertinent hydrologic literature; (3) delineate areas where data are lacking; (4) inventory and collect data needed for preliminary analysis of the hydrologic system; (5) delineate areas that are promising for water supply based on existing data; and (6) develop a work plan for possible intensive investigation of project area.

SUMMARY: A compilation of selected water-quality data in the Powell River basin indicates less than 10 percent of existing water-quality data is available from Federal and State data bases. More than 90 percent of the data has been collected by coal-mining companies as part of the process required for mine permits.

Selected ground-water, surface-water, and water-quality data from five organizations were compiled for 61 ground-water and 86 surface-water sites in the study area. Well depths ranged from 8 to 600 feet and well yields ranged from 0 to 150 gallons per minute. Flow-duration statistics for a streamflow gaging station on the Powell River at Big Stone Gap indicates that streamflow is greater than or equal to 96.2 ft^3/s 50 percent of the time, and flow equals or exceeds 12.8 ft^3/s 95 percent of the time. Iron concentrations exceed U.S. Environmental Protection Agency recommended limits in 93 percent of ground-water samples and 64 percent of the surface-water samples. Manganese concentrations exceed recommended limits in 98 percent of ground-water samples and 81 percent of surface-water samples. Sulfate concentrations exceed recommended limits in less than 10 percent of ground-water and surface-water samples.

A bibliography of reports on the area and other pertinent reports from other coal-producing areas is presented in the final report. (See reference to approved reports of results of this project in lists for 1984 and 1985 at end of this report.)



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

LEADER: Gary D. LeCain

COOPERATOR: Virginia Division of Mined Land Reclamation

PERIOD OF PROJECT: July 1985 - June 1987

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

OBJECTIVE: (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 ground-water model of several coal-mining areas; (5) determine probable adequacy of existing models of simulating the ground-water system; and (6) establish a bank of ground-water data.

APPROACH: Only core holes drilled by mining companies will be used in this investigation. Examime core and use logs (neutron, electric, gamma, temperature-fluid resistivity, caliper) to locate water-bearing zones suitable for testing. Isolate zone and use slug and/or injection tests to determine transmissivity. Measure static head and pump water sample from isolated zone. Use head data, water quality, logs, transmissivity to develop conceptual model and determine adequacy of existing models.

SUMMARY: Equipment necessary to complete aquifer testing was designed and installed on mobile test trailer. Initial field testing of equipment was successful. Core holes available for testing are being sought with the aid of the Division of Mined Land Reclamation and private coal companies.

REPORTS APPROVED JANUARY 1980-JUNE 1986

[Reports are listed by year of approval and project number. An asterisk follows number for those projects active during 1984-86 and described in this report.]

Reports Approved in 1986

Project no.	Author(s)	Report Title (Publication, Date published)
MD037*	Vroblesky, D. A. Fleck, W. B.	Hydrogeologic framework of the Coastal Plain in Maryland, Delaware, and the District of Columbia (U.S. Geological Survey Professional Paper 1404-E, In preparation)
MD063*	Willey, R. E. McGregor, R. A. deGrouchy, Joanne Tompkins, M. D.	Hydrologic data for Cecil County, Maryland (Maryland Geological Survey Basic-Data Report, In preparation)
MD073*	Hopkins, H. T. Fisher, G. T. McGreevy, L. J.	Reconnaissance of the ground-water, surface-water system in the Zekiah Swamp Run basin, Charles and Prince Georges Counties, Maryland (U.S. Geological Survey Water-Resources Investigations Report 86-4097, In preparation)
MD079*	Wilson, J. M.	Stratigraphy, hydrogeology, and water chemistry of the Cretaceous aquifers of the Waldorf/La Plata area, Charles County, Maryland (Maryland Geological Survey Open-File Report No. 86-02-2, 1986, 66 p.
VA057*	Harsh, J. T. Laczniak, R. J.	Conceptualization and analysis of the ground-water system in the Coastal Plain of Virginia (U.S. Geological Survey Professional Paper 1404-F, In preparation; Open-File Report 86-425 pending publication of the Professional Paper)

Reports Approved in 1986--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
VA074*	Taylor, K. R. James, R. W. Helinsky, B. M.	Traveltime and dispersion on the Shenandoah River and its tributaries, Waynesboro, Virginia, to Harpers Ferry, West Virginia (U.S. Geological Survey Water-Resources Investigations Report 86-4065, In preparation)

Reports Approved in 1985

Project no.	Author(s)	Report Title (Publication, Date published)
DE017*		
	Denver, J. M.	Geochemical processes controlling the chemical quality of water in the unconfined aquifer of west-central and southwestern Delaware (Delaware Geological Survey Report of Investigations , In preparation)
MD040*		
	Mack, F. K. Wheeler, J. C. Curtin, S. E.	Map showing the potentiometric surface of the Magothy aquifer in southern Maryland, September 1983 (U.S. Geological Survey Water-Resources Investigations Report 85-4000, 1985, 1 sheet)
	Mack, F. K. Wheeler, J. C. Curtin, S. E. Andreasen, D. C.	Map showing the potentiometric surface of the Magothy aquifer in southern Maryland, September 1984 (U.S. Geological Survey Water-Resources Investigations Report 85-4203, 1985, 1 sheet)
	Mack, F. K. Wheeler, J. C. Curtin, S. E. Andreasen, D. C.	Map of southern Maryland showing the difference between the potentiometric surfaces of the Magothy aquifer of September 1982 and September 1984 (U.S. Geological Survey Water-Resources Investigations Report 85-4337, 1985, 1 sheet)
	Mack, F. K. Wheeler, J. C Curtin, S. E. Andreasen, D. C.	Preliminary map showing the potentiometric surface of the Aquia aquifer in southern Maryland, September 1984 (U.S. Geological Survey Water-Resources Investigations Report 85-4338, 1985, 1 sheet)
	Mack, F. K. Wheeler, J. C. Curtin, S. E. Andreasen, D. C.	Map of southern Maryland showing the difference between the potentiometric surfaces of the Aquia aquifer of September 1982 and September 1984 (U.S. Geological Survey Water-Resources Investigations Report 85-4339, 1985, 1 sheet)
MD057*		
	Chapelle, F. H.	A solute-transport simulation of brackish-water intrusion near Baltimore, Maryland (Ground Water, v. 24, no. 3, May-June 1986, p. 304-311)

Reports Approved in 1985--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
MD058*	Dine, J. R. Tompkins, M. D. Duigon, M. T.	Ground-water and surface-water data for Frederick County, Maryland (Maryland Geological Survey Basic-Data Report 15, 1985, 240 p.)
MD062*	Lantrip, B. M. Summers, R. M. Phelan, D. J. Andrle, William	Sediment/water-column flux of nutrients and oxygen in the tidal Patuxent River and Estuary, Maryland (U.S. Geological Survey Water-Supply Paper 2296, In preparation; Open-File Report 85-499 pending publication of the Water-Supply Paper)
MD066*	Katz, B. G. Bricker, O. P. Kennedy, M. M.	Geochemical mass-balance relationships for selected ions in precipitation and stream water, Catoctin Mountains, Maryland (American Journal of Science, v. 285, December 1985, p. 931-962)
	Katz, B. G. Bricker, O. P. Kennedy, M. M.	Seasonal geochemical relationships for selected constituents in precipitation and stream water in forested watersheds during 1982-83, Catoctin Mountains, Maryland (Smithsonian Environmental Research Center, Watershed Research Symposium, 1985, Proceedings, In preparation)
MD071*	Hodges, A. L., Jr.	Estimated average annual alkalinity of six streams entering Deep Creek Lake, Garrett County, Maryland (Maryland Energy Administration, Power Plant Siting Program Report PPSP-AD-13, 1986, 63 p.)
MD072*	Trombley, T. J. Zynjuk, L. D.	Hydrogeology and water quality of the Catoctin Mountain National Park area, Frederick County, Maryland (U.S. Geological Survey Water-Resources Investigations Report, 85-4241, In press.)

Reports Approved in 1985--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
MD075*	Bachman, L. J. Katz, B. G.	Relationship between precipitation quality, shallow ground-water geochemistry, and dissolved aluminum in eastern Maryland (Maryland Energy Administration, Power Plant Siting Program Report PPSP-AD-14, 1986, 37 p.)
VA001*	Carpenter, D. H.	Cost effectiveness of the Federal stream-gaging program in Virginia (U.S. Geological Survey Water-Resources Investigations Report 85-4345, 1986, 72 p.)
VA058	Larson, J. D. Powell, J. D.	Hydrology and effects of mining in the upper Russell Fork basin, Buchanan and Dickenson Counties, Virginia (U.S. Geological Survey Water-Resources Investigations Report 85-4238, 1985, 63 p.)
VA059	Langley, W. G.	Discharge characteristics and quality of water flowing from selected abandoned coal mines in southwestern Virginia (Powell River Project Symposium, 1985, Proceedings, p. 92-95)
VA063*	Lynch, D. D. Dise, N. B.	Sensitivity of stream basins in Shenandoah National Park to acid deposition (U.S. Geological Survey Water-Resources Investigations Report 85-4115, 1985, 61 p.)
VA067	Wright, W. G.	Effects of fracturing on well yields in the coal-field areas of Wise and Dickenson Counties, southwestern Virginia (U.S. Geological Survey Water-Resources Investigations Report 85-4061, 1985, 21 p.)

Reports Approved in 1985--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
VA070*	Powell, J. D. Abe, J. M.	Availability and quality of ground water in the Piedmont Province of Virginia U.S. Geological Survey Water-Resources Investigations Report 85-4235, 1985, 33 p.)
VA072*	Larson, J. D.	Selected hydrologic data for the Powell River basin in Wise County, Virginia (U.S. Geological Survey Open-File Report 85-186, 1985, 22 p.)

Reports Approved in 1984

Project no.	Author(s)	Report Title (Publication, Date published)
DE014		
	Martin, M. M.	Simulated ground-water flow in the Potomac aquifers, New Castle County, Delaware (U.S. Geological Survey Water Resources Investigations Report 84-4007, 1984, 85 p.)
MD021		
	Willey, R. E. Achmad, Grufron	Simulation of ground-water flow and base flow in weathered crystalline rock, upper Cattail Creek, Maryland (Maryland Geological Survey Report of Investigations No. 45, 1986, 68 p.)
	Hilleary, J. T.	Hydrologic data: South Branch Casselman River, Garrett County, and Marsh Run, Washington County, Maryland (U.S. Geological Survey Open-File Report 84-426, In preparation)
MD054		
	Mack, F. K. Achmad, Grufron	Evaluation of the water-supply potential of aquifers in the Potomac Group of Anne Arundel County, Maryland (Maryland Geological Survey Report of Investigations No. 46, 1986, 111 p.)
MD057*		
	Chapelle, F. H. Kean, T. M.	Hydrogeology, digital solute-transport simulation, and geochemistry of the Lower Cretaceous aquifer system near Baltimore, Maryland (Maryland Geological Survey Report of Investigations 43, 1985, 120 p.)
	Chapelle, F. H.	The occurrence of dissolved oxygen and the origin of ferric hydroxide-cemented hardbeds in the Patuxent aquifer, Maryland: Practical applications of ground-water geochemistry (First Canadian/American Conference on Hydrogeology, Banff, Alberta, Canada, 1984, Proceedings, p. 41-46)

Reports Approved in 1984--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
MD060		
	James, R. W., Jr. Helinsky, B. M.	Time of travel and dispersion in the Jones Falls, Baltimore, Maryland (U.S. Geological Survey Water-Resources Investigations Report 84-4203, 1984, 29 p.)
MD061*		
	Bachman, L. J.	Field and laboratory analysis of water from the Columbia aquifer in eastern Maryland (Ground Water, v. 22, no. 4, July-August 1984, p. 460-467)
	Bachman, L. J.	Nitrate in the Columbia aquifer, central Delmarva Peninsula, Maryland (U.S. Geological Survey Water-Resources Investigations Report 84-4322, 1984, 51 p.)
MD069*		
	Fisher, G. T. Katz, B. G.	Analysis of urban storm-water runoff characteristics of four basins in the Baltimore metropolitan area, Maryland (U.S. Geological Survey Water-Resources Investigations Report 84-4099, 1984, 51 p.)
MD105		
	Chapelle, F. H. Knobel, L. L.	Stable carbon isotopes of HCO_3 in the Aquia aquifer, Maryland: evidence for an isotopically heavy source of CO_2 (Ground Water, v. 23, no. 5, September-December 1985, p. 592-599)
VA002*		
	Farrington, S. T. Carrington, N. R. Daniels, W. V., Jr.	Water-level hydrographs for observation wells in Virginia, 1982 (U.S. Geological Survey Open-File Report 84-134, 1984, 167 p.)
VA020		
	Hopkins, H. T.	Water-resources reconnaissance of Prince William Forest Park, Virginia (U.S. Geological Survey Water-Resources Investigations Report 84-4009, 1984, 17 p.)

Reports Approved in 1984--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
VA047		
	Hopkins, H. T.	Ground-water availability along the Blue Ridge Parkway, Virginia (U.S. Geological Survey Water-Resources Investigations Report 84-4168, 1984, 154 p.)
VA053		
	Lynch, D. D. Nuckels, E. H. Zenone, Chester	Low flow characteristics and chemical quality of streams in the Culpeper geologic basin, Virginia and Maryland (U.S. Geological Survey Miscellaneous Investigations Map I-1313-H, 1985, 2 sheets)
	Laczniak, R. J. Zenone, Chester	Ground-water resources of the Culpeper basin, Virginia and Maryland (U.S. Geological Survey Miscellaneous Investigations Map I-1313-F, 1984, 2 sheets)
VA057*		
	Meng, A. A., III Harsh, J. F.	Hydrogeologic framework of the Virginia Coastal Plain (U.S. Geological Survey Open-File Report 84-728, 1984, 78 p.)
VA059		
	Powell, J. D. Larson, J. D.	Relation between ground-water quality and mineralogy in the coal-producing Norton Formation of Buchanan County, Virginia (U.S. Geological Survey Water-Supply Paper 2274, 1985, 30 p.)
VA072*		
	Larson, J. D.	A water resource appraisal of the Powell River basin, Wise County, Virginia (Powell River Project Symposium, 1984, Proceedings, p. 8-14)

Reports Approved in 1983

Project no.	Author(s)	Report Title (Publication, Date published)
DE013		
	Hodges, A. L., Jr.	Hydrology of the Manokin, Ocean City, and Pocomoke aquifers of Southeastern Delaware (Delaware Geological Survey Report of Investigations 38, 1984, 60 p.)
MD007*		
	Wheeler, J. C.	Water use in Maryland, 1980 (Maryland Geological Survey Map, 1983, 1 sheet)
MD030		
	Staubitz, W. W. Sobashinski, J. R.	Hydrology of area 6, eastern coal province, Maryland, West Virginia, and Pennsylvania (U.S. Geological Survey Water-Resources Investigations/Open-File Report 83-33, 1983, 81 p.)
MD031		
	Duigon, M. T. Smigaj, M. J.	First report on the hydrologic effects of underground coal mining in Southern Garrett County, Maryland (Maryland Geological Survey Report of Investigations 41, 1985, 99 p.)
MD034		
	Bachman, L. J.	The Columbia aquifer of the Eastern Shore of Maryland, Part I: Hydrogeology (Maryland Geological Survey Report of Investigations 40, 1984, p. 1-34)
	Wilson, J. M.	The Columbia aquifer on the Eastern Shore of Maryland, Part II: Selected water well records, chemical analyses, water-level measurements, lithologic logs and geophysical logs (Maryland Geological Survey Report of Investigations 40, 1984, p. 35-144)
MD036		
	Fisher, G. T. Katz, B. G.	Guidelines for instrumenting and operating a surface runoff study--the Baltimore experience (American Society of Agricultural Engineers Paper NAR82-209, Burlington, Vt., 1982, 21 p.)

Reports Approved in 1983--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
MD040*		
	Mack, F. K. Wheeler, J. C. Curtin, S. E.	Map showing the difference between the potentiometric surfaces of the Magothy aquifer of September 1975 and September 1982 in southern Maryland (U.S. Geological Survey Water-Resources Investigations Report 83-4283, 1983, 1 sheet)
	Mack, F. K. Wheeler, J. C. Curtin, S. E.	Preliminary map showing the potentiometric surface of the Aquia aquifer in southern Maryland, September 1982 (U.S. Geological Survey Open-File Report 83-929, 1983, 1 sheet)
	Mack, F. K. Wheeler, J. C. Curtin, S. E.	Preliminary map showing the difference between the potentiometric surfaces of the Aquia aquifer of April 1979 and September 1982 in southern Maryland (U.S. Geological Survey Open-File Report 83-930, 1983, 1 sheet)
	Mack, F. K. Wheeler, J. C. Curtin, S. E.	Map showing the potentiometric surface of the Magothy aquifer in southern Maryland, September 1982 (U.S. Geological Survey Water-Resources Investigations Report 83-4282, 1983, 1 sheet)
MD047		
	Otton, E. G. Hilleary, J. T.	Maryland springs--their physical, thermal, and chemical characteristics (Maryland Geological Survey Report of Investigations 42, 1985, 151 p.)
MD054		
	Otton, E. G. Mandle, R. J.	Hydrogeology of the upper Chesapeake Bay area, Maryland, with emphasis on aquifers in the Potomac Group (Maryland Geological Survey Report of Investigations 39, 1984, 62 p.)
MD055		
	Carpenter, D. H.	Characteristics of streamflow in Maryland (Maryland Geological Survey Report of Investigations 35, 1983, 237 p.)

Reports Approved in 1983--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
MD059		
	Katz, B. G. Fisher, G. T.	A comparison of selected methods for measuring flow rate in a circular storm sewer (International Symposium on Urban Hydrology, Hydraulics and Sediment Control, University of Kentucky, Lexington, Ky., 1983, p. 359-369)
MD064		
	Taylor, K. R. James, R. W., Jr. Helinsky, B. M.	Traveltime and dispersion in the Potomac River, Cumberland, Maryland to Washington, D. C. (U.S. Geological Survey Water-Supply Paper 2257, 1985, 30 p.)
VA062		
	Hufschmidt, P. W.	Description and evaluation of the information transfer workshop series: Coal hydrology in Virginia (U.S. Geological Survey Open-File Report 83-852, 1984, 23 p.)

Reports Approved in 1982

Project no.	Author(s)	Report Title (Publication, Date published)
DE015		
	Hodges, A. L., Jr.	Ground-water temperature of the Wyoming Quadrangle in central Delaware, with application to ground-water-source heat pumps (U.S. Geological Survey Water-Resources Investigations Report 82-53, 1982, 29 p.)
DE016		
	Denver, J. M.	Configuration of the base and thickness of the unconfined aquifer in southeastern Sussex County, Delaware (Delaware Geological Survey Open-File Report 20, 1983, 12 p.)
MD003*		
	Lang, D. J.	Water quality of the three major tributaries to the Chesapeake Bay, the Susquehanna, Potomac, and James Rivers, January 1979 - April 1981 (U.S. Geological Survey Water-Resources Investigations Report 82-32, 1982, 64 p.)
	Grason, David	A presentation and evaluation of the hydrologic information available for the major federal coal lands in seven eastern states--sources of available information (U.S. Geological Survey Open-File Report 82-525, 1982, 348 p.)
MD024		
	Fleck, W. B.	Digital simulation of ground-water flow in part of southern Maryland (U.S. Army Corps of Engineers Report)
MD028		
	Chapelle, F. H. Drummond, D. D.	Hydrogeology, digital simulation, and geochemistry of the Aquia and Piney Point-Nanjemoy aquifer system in southern Maryland (Maryland Geological Survey Report of Investigations 38, 1983, 100 p.)

Reports Approved in 1982--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
MD028		
	Chapelle, F. H.	Ground-water geochemistry and calcite cementation of the Aquia aquifer in southern Maryland (Water Resources Research, v. 19, no. 2, April 1983, p. 545-558)
MD039		
	Mack, F. K.	Preliminary analysis of geohydrologic data from test wells drilled near Chester, on Kent Island, Queen Annes County, Maryland (U.S. Geological Survey Open-File Report 82-854, 1983, 31 p.)
MD040*		
	Mack, F. K. Wheeler, J. C. Curtin, S. E.	Map showing the potentiometric surface of the Magothy aquifer in Southern Maryland, September 1981 (U.S. Geological Survey Open-File Report 82-257, 1982, 1 sheet)
	Mack, F. K. Wheeler, J. C. Curtin, S. E.	The difference between the potentiometric surfaces of the Magothy aquifer of September 1975 and September 1981 in southern Maryland (U.S. Geological Survey Open-File Report 82-339, 1982, 1 sheet)
	Mack, F. K. Wheeler, J. C. Curtin, S. E.	Water-level declines in the Magothy aquifer in southern Maryland related to increases in pumpage (U.S. Geological Survey Open-File Report 82-919, 1983, 29 p.)
MD043		
	Trombley, T. J.	Downstream effects of reservoir releases to the Potomac River from Luke, Maryland, to Washington, D. C. (U.S. Geological Survey Water-Resources Investigations Report 82-4062, 1982, 35 p.)

Reports Approved in 1982--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
MD054		
	Weigle, J. M. Achmad, Grufron	Geohydrology of the fresh-water aquifer system in the vicinity of Ocean City, Maryland, with a section on simulated water-level changes (Maryland Geological Survey Report of Investigations 37, 1982, 55 p.)
MD105		
	Chapelle, F. H. Knobel, L. L.	Aqueous geochemistry and the exchangeable cation composition of glauconite in the Aquia aquifer, Maryland (Ground Water, v. 21, no. 3, May-June 1983, p. 343-352)
VA007*		
	Kull, T. K.	Water use in Virginia, 1980 (Virginia Water Control Board Basic Data Bulletin 59, 1983, 1 sheet)
VA017		
	Mulheren, M. P. Larson, J. D. Hopkins, H. T.	An index of geophysical well logging in Virginia (U.S. Geological Survey Open-File Report 82-432, 1982, 34 p.)
VA043		
	Zenone, Chester Larson, J. D.	Ground-water resources of Fairfax County and vicinity, Virginia, and some aspects of their development (U.S. Geological Survey Miscellaneous-Investigations Map I-1473, 1982, 1 sheet)
VA001*		
	Hendrick, W. E., Jr.	Summary of hydrologic data collected at Wytheville National Fish Hatchery, no. 2, Max Meadows, Virginia, 1976 to 1979 (U.S. Geological Survey Open-File Report 82-686, 1982, 23 p.)

Reports Approved in 1982--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
VA053		
	Posner, Alex Zenone, Chester	Chemical quality of ground water in the Culpeper basin, Virginia and Maryland (U.S. Geological Survey Miscellaneous-Investigations Map I-1313-D, 1983, 1 sheet)
VA058		
	Rogers, S. M. Powell, J. D.	Quality of ground water in southern Buchanan County, Virginia (U.S. Geological Survey Water-Resources Investigations Report 82-4022, 1983, 42 p.)
VA900		
	Powell, J. D. Hufschmidt, P. W. Larson, J. D.	Geochemistry of ground water in the coal-producing area of southwestern Virginia (Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Kentucky, Lexington, Ky., 1982, Proceedings, p. 439-444)

Reports Approved in 1981

Project no.	Author(s)	Report Title (Publication, Date published)
DE013	Leahy, P. P.	Ground-water resources of the Piney Point and Cheswold aquifers in central Delaware as determined by a flow model (Delaware Geological Survey Bulletin 16, 1982, 68 p.)
DE014	Martin, M. M. Denver, J. M.	Hydrologic data for the Potomac Formation in New Castle County, Delaware (U.S. Geological Survey Water-Resources Investigations Report 81-916, 1982, 148 p.)
MD028	Chapelle, F. H. Drummond, D. D. Curley, T. M.	Map showing the potentiometric surface of the Aquia aquifer May 19-23, 1980 (U.S. Geological Survey Open-File Report 81-416, 1981, 1 sheet)
	Drummond, D. D.	Records of selected wells, Calvert and St. Marys Counties, Maryland (Maryland Geological Survey Basic-Data Report 14, 1984, 117 p.)
MD030	Staubitz, W. W.	Quality of surface water in the coal-mining areas of western Maryland and adjacent areas of Pennsylvania and West Virginia from April 1979 to June 1980 (U.S. Geological Survey Open-File Report 81-812, 1981, 103 p.)
MD036	Katz, B. G. Fisher, G. T.	Analysis and characterization of urban storm-water runoff for selected basins in the Baltimore metropolitan area--A project plan (U.S. Geological Survey Open-File Report 81-1200, 1981, 75 p.)

Reports Approved in 1981--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
MD040*		
	Mack, F. K. Wheeler, J. C. Curtin, S. E.	Map showing how the potentiometric surface of the Magothy aquifer of August 1980 differed from the potentiometric surface of September 1977 in southern Maryland (U.S. Geological Survey Open-File Report 81-631, 1981, 1 sheet)
	Mack, F. K. Wheeler, J. C. Curtin, S. E.	Map showing how the potentiometric surface of the Magothy aquifer of September 1979 differed from the potentiometric surface of September 1977 in southern Maryland (U.S. Geological Survey Open-File Report 81-632, 1981, 1 sheet)
	Mack, F. K. Wheeler, J. C. Curtin, S. E.	Map showing the potentiometric surface of the Magothy aquifer in southern Maryland, August 1980 (U.S. Geological Survey Open-File Report 81-633, 1981, 1 sheet)
VA040		
	Hufschmidt, P. W. Kilpatrick, R. J. Prugh, B. J.	Hydrology of area 16, eastern coal province, Virginia-Tennessee (U.S. Geological Survey Water-Resources Investigations/Open-File Report 81-204, 1981, 68 p.)
VA055		
	Larson, J. D.	Distribution of saltwater in the Coastal Plain aquifers of Virginia (U.S. Geological Survey Open-File Report 81-1013, 1981, 25 p.)

Reports Approved in 1980

Project no.	Author(s)	Report Title (Publication, Date published)
MD003*		
	Lang, D. J. Grason, David	Water quality monitoring of three major tributaries to the Chesapeake Bay --Interim data report (U.S. Geological Survey Water-Resources Investigations Report 80-78, 1980, 66 p.)
MD013		
	Carpenter, D. H.	Technique for estimating magnitude and frequency of floods in Maryland (U.S. Geological Survey Water-Resources Investigations/Open-File Report 80-1016, 1980, 79 p.)
MD022		
	Duigon, M. T. Crowley, W. P.	Reisterstown Quadrangle, Maryland: Geology and Hydrology (Maryland Geological Survey Quadrangle Atlas 7, 1983, 6 maps)
	Duigon, M. T. Hilleary, J. T.	Hampstead Quadrangle, Maryland: Hydrogeology (Maryland Geological Survey Quadrangle Atlas 12, 1981, 5 maps)
	Duigon, M. T. Otton, E. G. Hilleary, J. T.	Lineboro Quadrangle, Maryland: Hydrogeology (Maryland Geological Survey Quadrangle Atlas 13, 1981, 5 maps)
	Weigle, J. M. Hilleary, J. T.	Littlestown Quadrangle, Carroll County, Maryland: Hydrogeologic Atlas (Maryland Geological Survey Quadrangle Atlas 14, 1981, 5 maps)
	Otton, E. G. Hilleary, J. T.	Manchester Quadrangle, Carroll County, Maryland: Hydrogeology (Maryland Geological Survey Quadrangle Atlas 15, 1981, 5 maps)
	Weigle, J. M. Hilleary, J. T.	Taneytown and Emmitsburg Quadrangles, Carroll County, Maryland: Hydrogeologic Atlas (Maryland Geological Survey Quadrangle Atlas 16, 1981, 5 maps)

Reports Approved in 1980--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
MD022--Continued		
	Weigle, J. M. Hilleary, J. T.	Union Bridge and Woodsboro Quadrangles, Carroll County, Maryland: Hydrogeologic Atlas (Maryland Geological Survey Quadrangle Atlas 17, 1981, 5 maps)
	Duigon, M. T.	Hereford Quadrangle, Maryland: Hydrogeology (Maryland Geological Survey Quadrangle Atlas 18 1981, 5 maps)
	Duigon, M. T.	New Freedom Quadrangle, Maryland: Hydrogeology (Maryland Geological Survey Quadrangle Atlas 20, 1983, 5 maps)
	Duigon, M. T.	Ellicott City Quadrangle, Maryland: Hydrogeology (Maryland Geological Survey Quadrangle Atlas 21, 1983, 5 maps)
	Otton, E. G.	Phoenix Quadrangle, Baltimore and Harford Counties, Maryland: Hydrogeology (Maryland Geological Survey Quadrangle Atlas 22, 1983, 5 maps)
	Otton, E. G.	Norrisville Quadrangle, Baltimore and Harford Counties, Maryland: Hydrogeology (Maryland Geological Survey Quadrangle Atlas 23, 1983, 5 maps)
	Hilleary, J. T. Weigle, J. M.	Carroll County ground-water information: Well records, spring records, and chemical-quality data (Maryland Geological Survey Basic-Data Report 12, 1981, 251 p.)
MD026		
	Otton, E. G.	The availability of ground water in western Montgomery County, Maryland (Maryland Geological Survey Report of Investigations 34, 1981, 76 p.)

Reports Approved in 1980--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
MD027	Nutter, L. J. Smigaj, M. J. Knobel, L. L.	Garrett County water-well records, chemical-quality data, ground-water use, coal test-hole data, and surface-water data with a section on Gas-well records by K. A. Schwartz and Jonathon Edwards, Jr. (Maryland Geological Survey Basic-Data Report 11, 1980, 102 p.)
MD029	Richardson, C. A.	Ground water in the Piedmont upland of central Maryland (U.S. Geological Survey Water Supply Paper 2077, 1982, 42 p.)
MD040*	Mack, F. K. Wheeler, J. C. Curtin, S. E.	Map showing the potentiometric surface of the Magothy aquifer in southern Maryland, September, 1979 (U.S. Geological Survey Open-File Report 80-959, 1980, 1 sheet)
VA012	Brown, G. A.	Water resources of Prince William Forest Park, Virginia (U.S. Geological Survey Water-Resources Investigations/Open-File Report 80-964, 1981, 2 sheets)
VA042	Hopkins, H. T. Bower, R. F. Abe, J. M. Harsh, J. F.	Potentiometric surface map for the Cretaceous aquifer, Virginia Coastal Plain, 1978 (U.S. Geological Survey Water-Resources Investigations/Open-File Report 80-965, 1981, 1 sheet)
VA043	Mohler, E. H., Jr. Hagan, G. F.	Low flow of streams in Fairfax County, Virginia (U.S. Geological Survey Open-File Report 81-63, 1981, 30 p.)

Reports Approved in 1980--Continued

Project no.	Author(s)	Report Title (Publication, Date published)
VA046		
	Harsh, J. F.	Ground-water hydrology of James City County, Virginia (U.S. Geological Survey Water-Resources Investigations/Open-File Report 80-961, 1980, 73 p.)
VA048		
	Rogers, S. M. Hufschmidt, P. W.	Quality of surface water in the coal mining area of southwest Virginia (U.S. Geological Survey Open-File Report 80-769, 1980, 1 sheet)
VA053		
	Morsches, S. A. Zenone, Chester	Index map of flood studies, Culpeper basin, Virginia and Maryland (U.S. Geological Survey Miscellaneous-Investigations Map I-1313-A, 1981, 1 sheet)

ANNUAL WATER-DATA REPORTS

Water data for the Mid-Atlantic District are published annually in a series of Water-Data Reports. Two volumes are published for the District each water year, "Water Resources Data, Maryland and Delaware" and "Water Resources Data, Virginia." Types of data 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.)

Maps on the following pages (figs. 8, 9, 10 and 11) show locations of data-collection sites for data included in the Water-Data Reports for the 1985 water year. Copies of Water-Data Reports may be purchased from:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650
[FTS 737-4650]

A limited supply of current volumes are available from the District and State Offices. (See addresses on p. 6.)

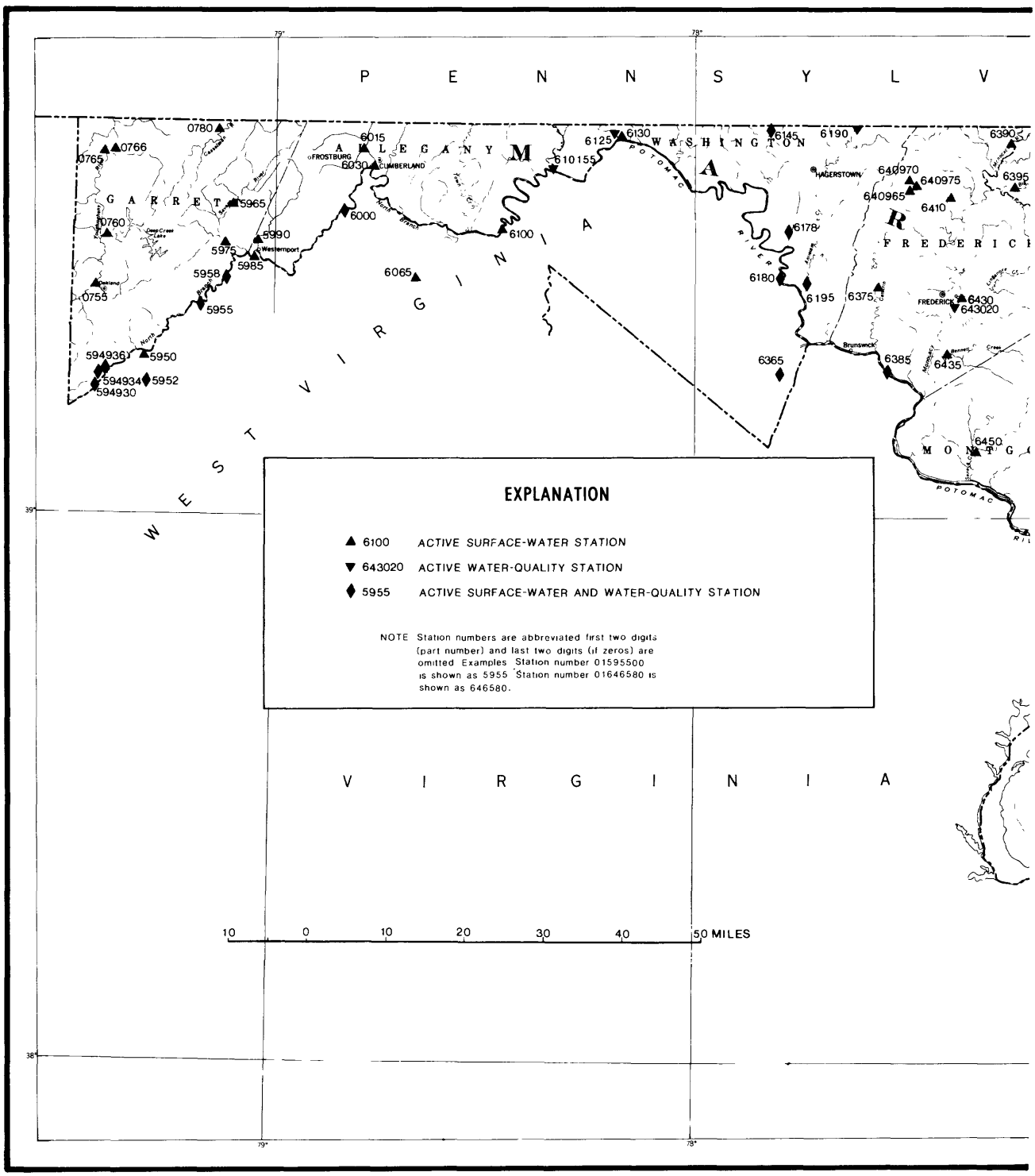
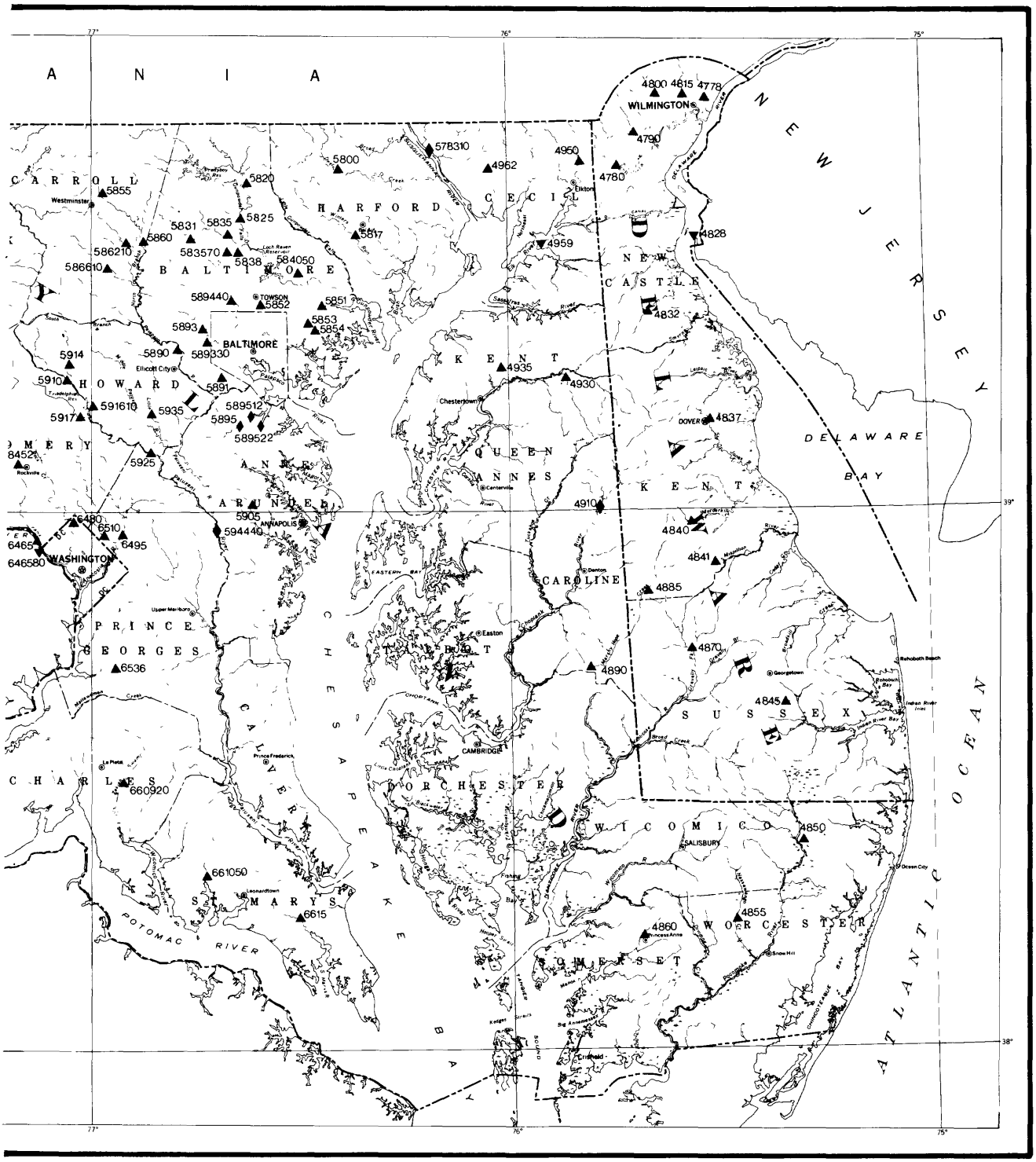


Figure 8. Location of surface-water and water-quality stations in Maryland, Delaware, and the District of Columbia.


A N I A
77°
76°
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38°
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5800
578310
4959
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4837
4910
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4841
4885
4870
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4845
4850
4855
4860
5820
5855
Westminster
5831 5835 5825
5860
586210
583570 5838 584050
586610
5817
589440
TOWSON
5852
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5893
BALTIMORE
589330
5890
5914
5910
Ellicott City
5891
589512
591610
5935
5917
5895
589522
5925
84521
Rockville
5905
594440
ANNAPOLIS
6480
6510
6495
6465
646580
WASHINGTON
6536
660920
661050
6615
Leonardtown
Upper Marlboro
Prince Frederick
La Plata
Chesterlown
Centerville
Easton
Denton
CAMBRIDGE
DOVER
Georgetown
SALISBURY
Princess Anne
Snow Hill
Crisfield
Rehoboth Beach
Ocean City
HARFORD
CECIL
NEW CASTLE
KENT
QUEEN ANNES
CAROLINE
TALBOT
DORCHESTER
SOMERSET
WICOMICO
WORCESTER
SUSSEX
PRINCE GEORGES
CHARLES
ST MARYS
CALVERT
ANNE ARUNDEL
HOWARD
CARROLL
MONTGOMERY
NEW JERSEY
DELAWARE BAY
ATLANTIC OCEAN
CHESAPEAKE BAY
POTOMAC RIVER

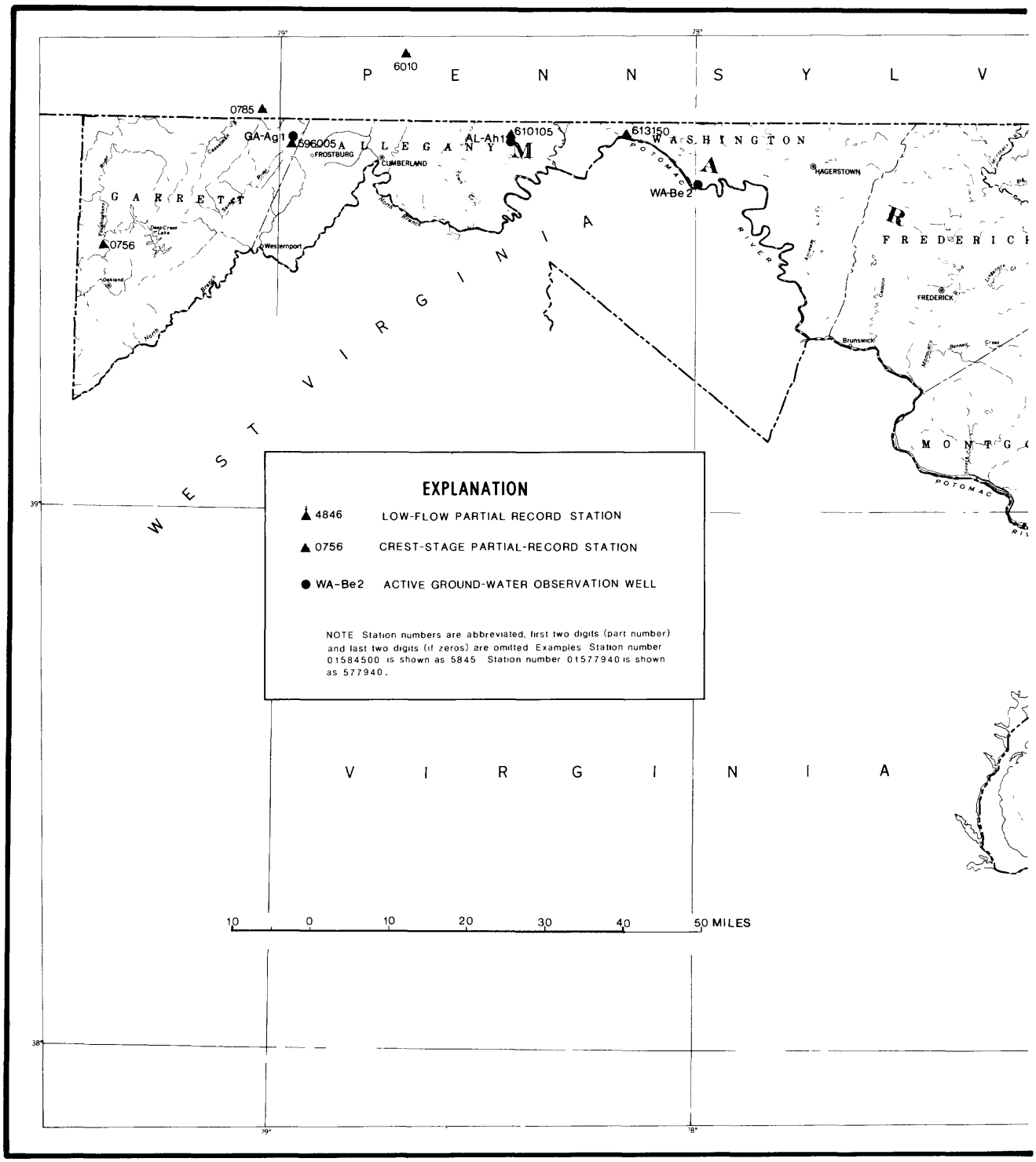
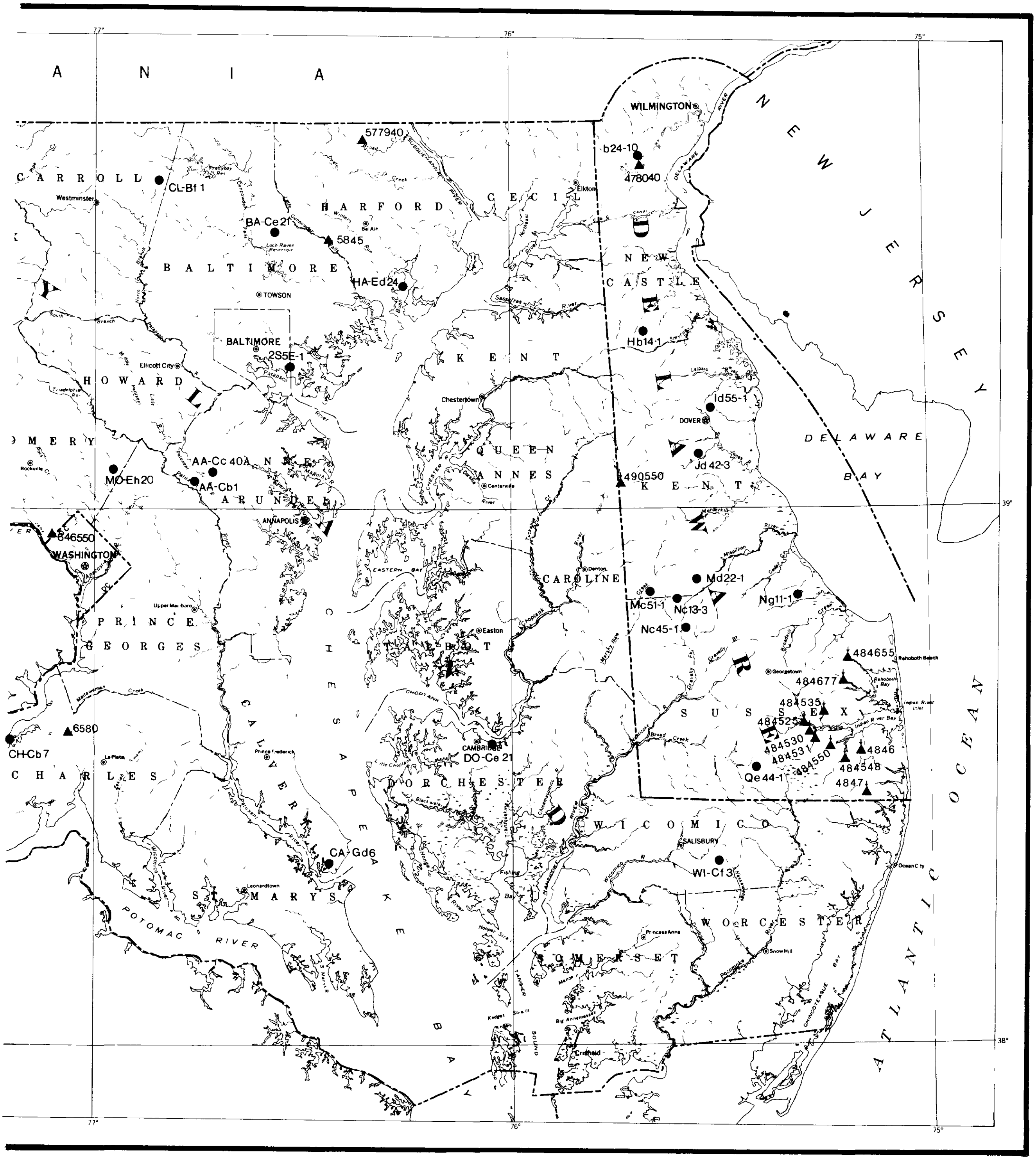


Figure 9. Location of crest-stage partial-record stations and selected ground-water observation wells in Maryland and Delaware.


WILMINGTON
NEW JERSEY
DELAWARE BAY
ATLANTIC OCEAN
CARROLL
HARFORD
CECIL
BALTIMORE
HOWARD
KENT
QUEEN ANNES
ANNE ARUNDEL
PRINCE GEORGES
CHARLES
CALVERT
CAROLINE
DORCHESTER
WICOMICO
WORCESTER
SOMERSET
NEW CASTLE
SUSSEX
CHESAPEAKE BAY
POTOMAC RIVER
WASHINGTON
ANNAPOLIS
DOVER
SALISBURY
CAMBRIDGE
TOWSON
CL-Bf 1
BA-Ce21
5845
HA-Ed24
577940
2S5E-1
AA-Cc 40
AA-Cb1
MO-Eh20
846550
6580
CH-Cb 7
CA-Gd6
DO-Ce 21
b24-10
478040
Hb14-1
Id55-1
Jd 42-3
490550
Md22-1
Mc51-1
Nc13-3
Nc45-1
Ng11-1
484655
484677
484535
484525
484530
484531
484550
484548
4846
4847
Qe 44-1
WI-Cf 3
Rehoboth Beach
Georgetown
Ocean City
Easton
Chestertown
Denton
Elkton
Westminster
Ellicott City
Rockville
Upper Marlboro
La Plata
Prince Frederick
Leonardtown
Princess Anne
Snow Hill
Crisfield
77°
76°
75°
39°
38°

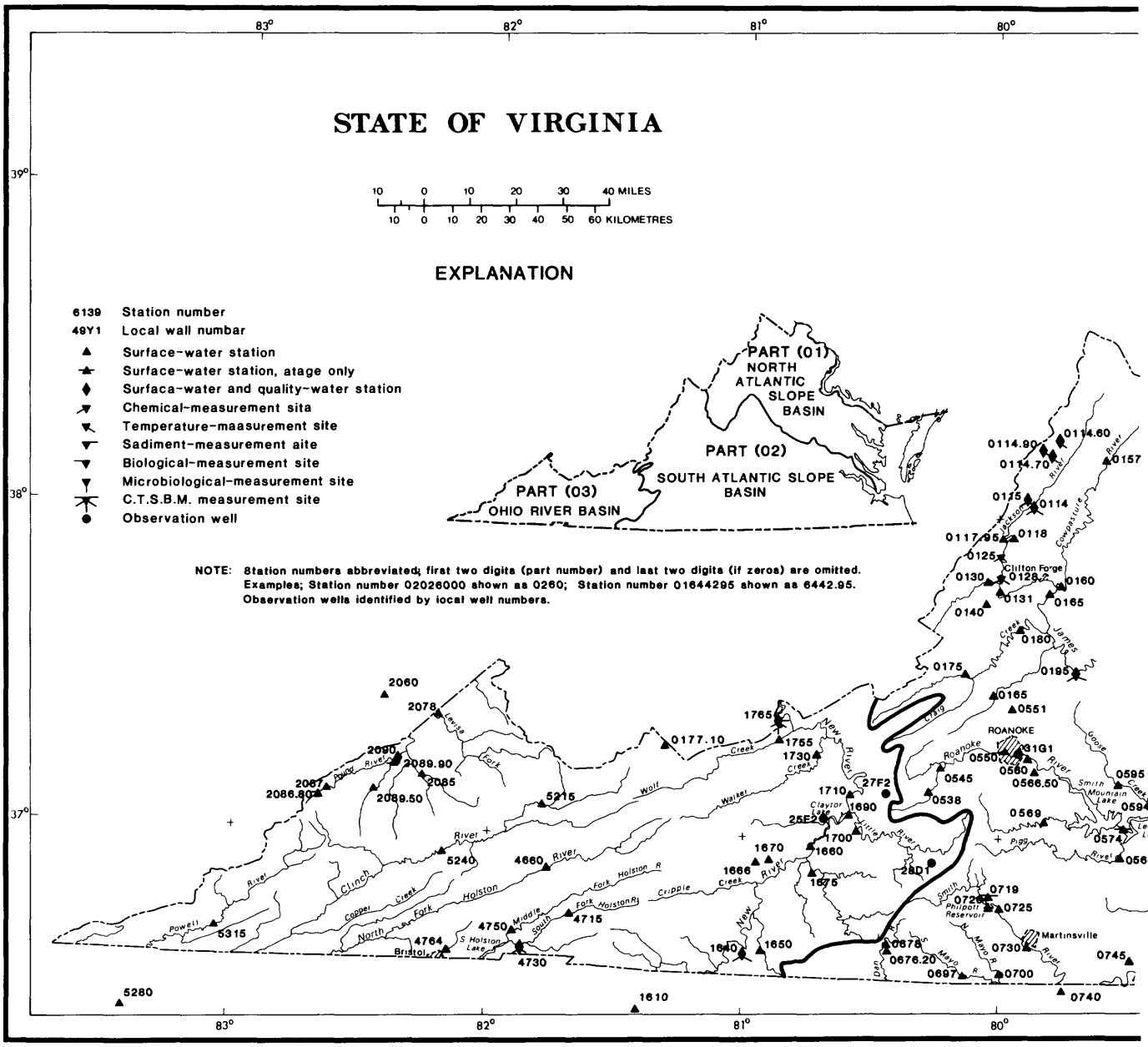
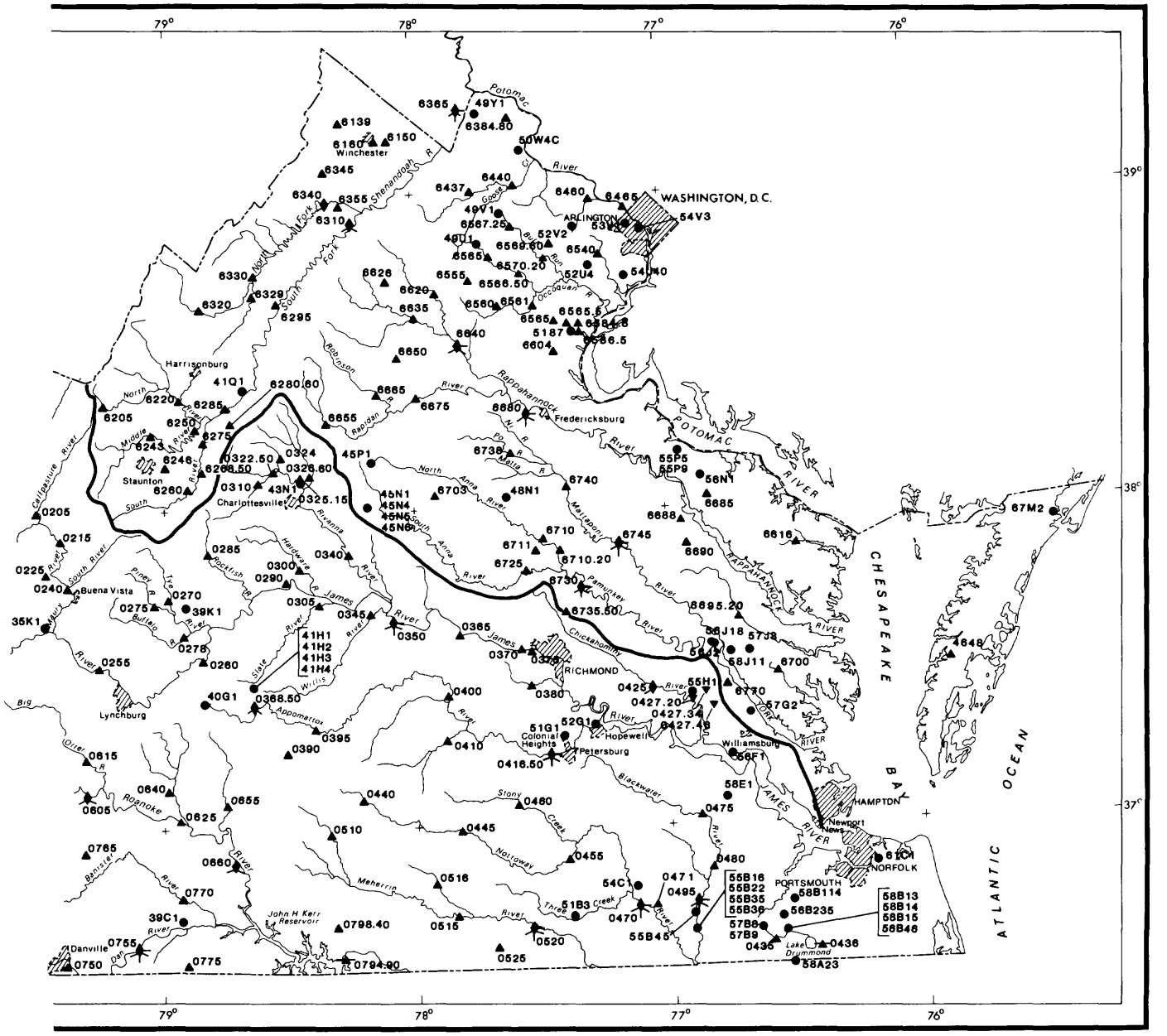


Figure 10. Location of data-collection stations in Virginia.


79°
78°
77°
76°
39°
38°
37°
Potomac River
Shenandoah R.
North Fork
South Fork
Goose Creek
Bull Run
Occoquan R.
Rappahannock River
Rapidan R.
Robinson River
North Anna River
South Anna River
Mattaponi River
Pamunkey River
Chickahominy River
James River
Maury River
Hardware River
Rockfish R.
Piney River
Tye River
Buffalo R.
Staunton River
Roanoke River
Dan River
Banister River
Meherrin River
Nottoway River
Blackwater River
Stony Creek
Three Creek
Lake Drummond
Harrisonburg
Winchester
Staunton
Charlottesville
Fredericksburg
WASHINGTON, D.C.
ARLINGTON
RICHMOND
Petersburg
Colonial Heights
Hopewell
Williamsburg
Lynchburg
Danville
Buena Vista
John H. Kerr Reservoir
Newport News
HAMPTON
PORTSMOUTH
NORFOLK
POTOMAC RIVER
RAPPAHANNOCK RIVER
YORK RIVER
JAMES RIVER
CHESAPEAKE BAY
ATLANTIC OCEAN

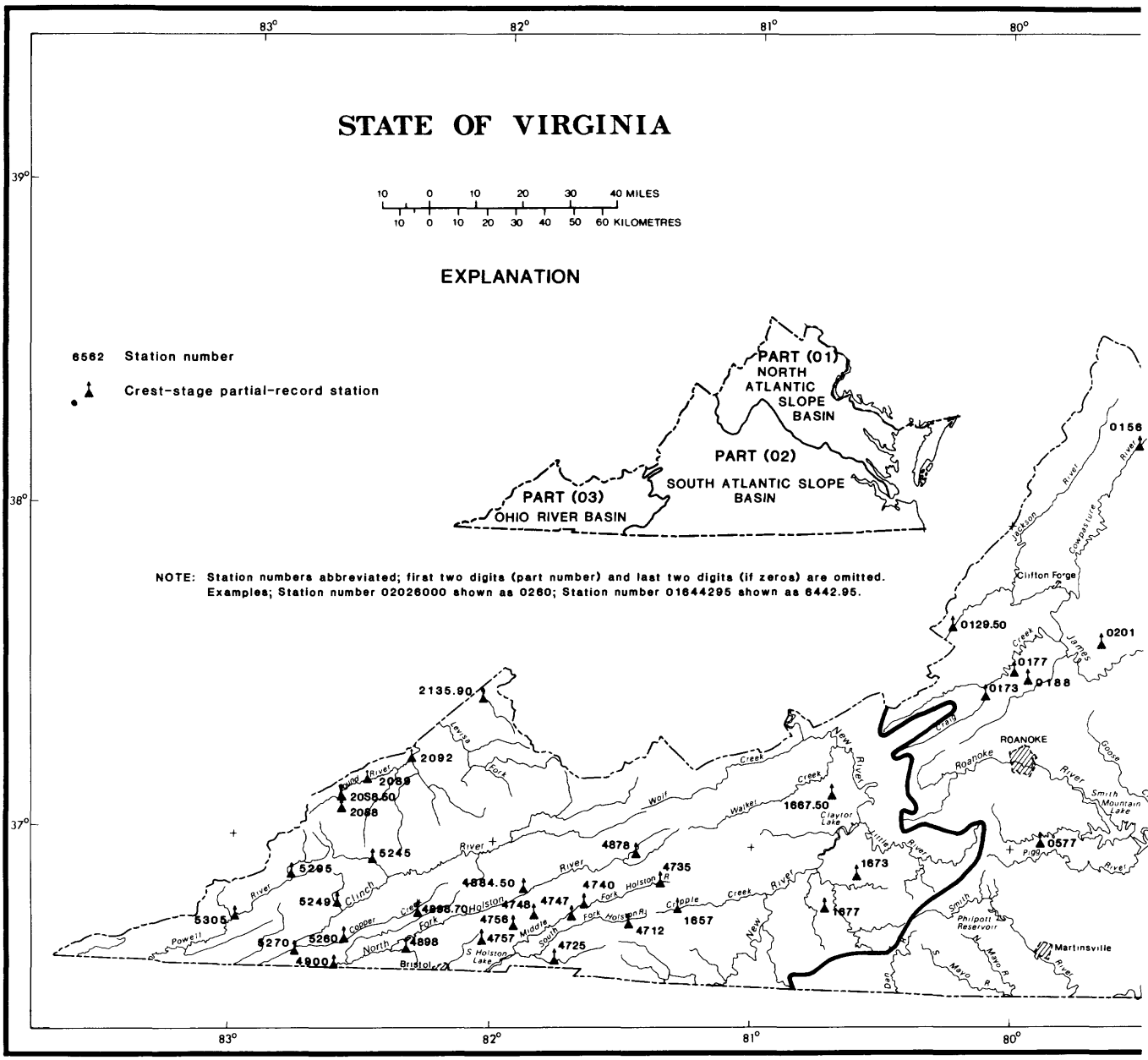
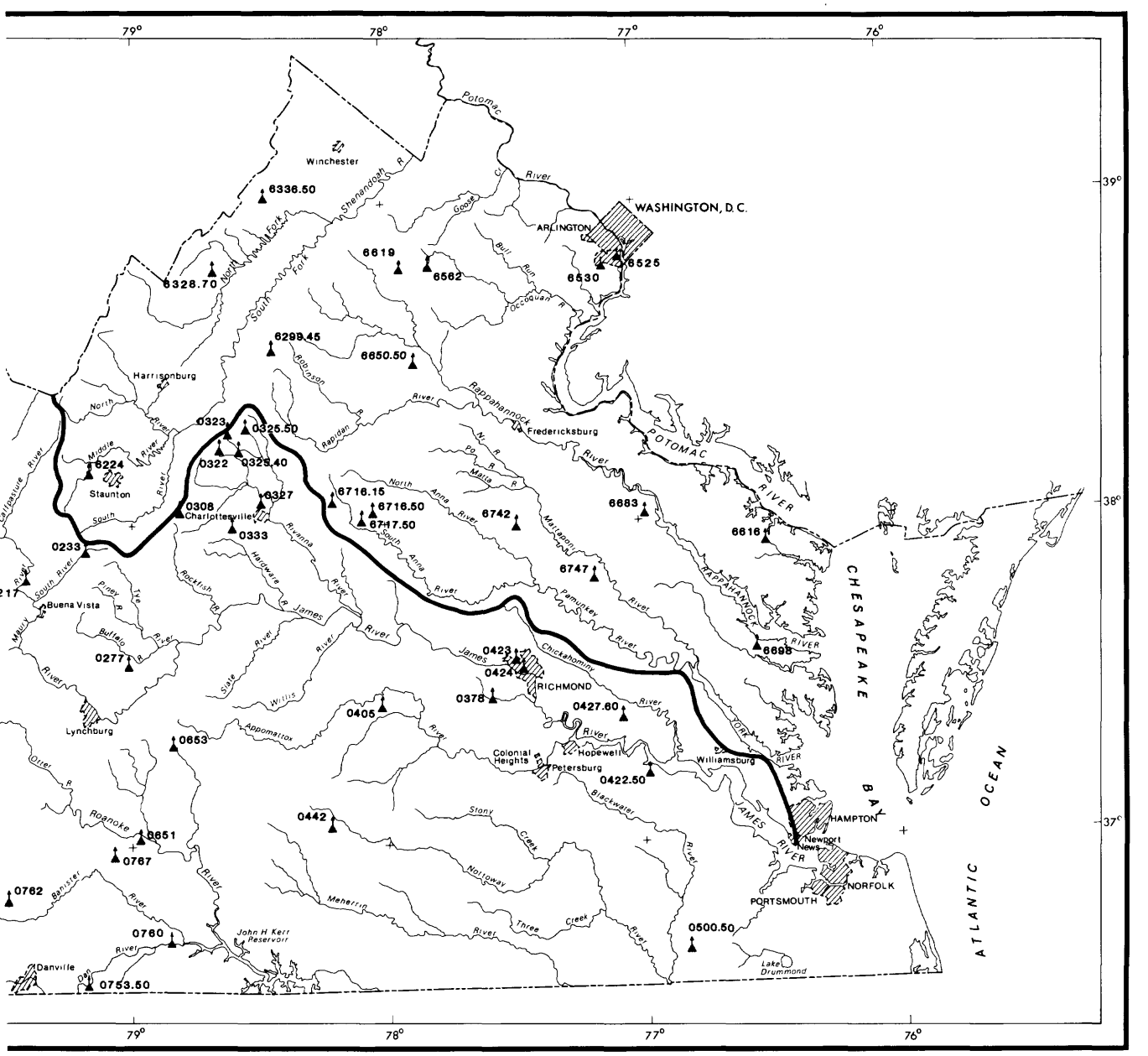


Figure 11. Location of crest-stage partial-record stations in Virginia.


79°
78°
77°
76°
39°
38°
37°
Winchester
Potomac
River
6336.50
Shenandoah R.
WASHINGTON, D.C.
ARLINGTON
6525
6530
6619
6562
6328.70
North Fork
South Fork
Goose
Bull Run
Occoquan R.
6299.45
6650.50
Harrisonburg
Rappahannock
Fredericksburg
POTOMAC
RIVER
0323
0325.50
0322
0325.40
6224
Staunton
Middle River
North River
Calfpasture River
South River
0308
Charlottesville
0327
0333
6716.15
6716.50
6717.50
North Anna River
South Anna River
6742
6683
6616
Mattaponi
Pamunkey River
6747
0233
0217
Buena Vista
Maury River
Piney R.
Tye R.
Rockfish R.
Hardware R.
Rivanna River
James River
Buffalo R.
0277
Lynchburg
Big Otter R.
Roanoke River
Staunton River
Willis River
Appomattox River
0653
0651
0767
0762
Banister River
0760
John H Kerr Reservoir
Danville
0753.50
0423
0424
RICHMOND
0378
0405
0427.60
Chickahominy River
Hopewell
Colonial Heights
Petersburg
0422.50
Williamsburg
York River
0442
Stony Creek
Nottoway River
Meherrin River
Three Creek
0500.50
Lake Drummond
Blackwater River
JAMES RIVER
HAMPTON
Newport News
NORFOLK
PORTSMOUTH
CHESAPEAKE BAY
ATLANTIC OCEAN