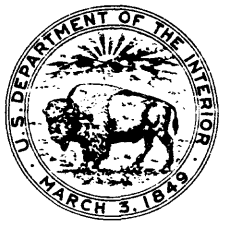
WATER-RESOURCES INVESTIGATIONS IN PENNSYLVANIA:

Programs and Activities of the U.S. Geological Survey, 1990-91

by Leona O. McLanahan

U.S. Geological Survey
Open-File Report 91-214



Lemoyne, Pennsylvania
1991

U.S. DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., *Secretary*

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

For additional information write to:

District Chief
U.S. Geological Survey, WRD
840 Market Street
Lemoyne, Pennsylvania 17043-1586

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Denver, Colorado 80225

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Message from the District Chief

During the 1990s, the Pennsylvania District program will continue to be focused on water-quality issues. The Water Resources Division has recently embarked on a major new national program of appraising the nation's water quality--National Water Quality Assessment Program (NAWQA). This new program will provide massive amounts of new information about the quality of surface water and ground water in the State and better understanding about the cause and effect of land use on water quality. Three of Pennsylvania's major river basins are planned to be part of NAWQA. Over time, the water-quality trends (or lack of trends) will be defined and will provide water-management planners the information they need to affect water-quality improvement actions. Therefore, the Pennsylvania District is preparing for full participation in these new activities. Over the past few years, additions to the technical staff have enhanced the District's ability to address new issues with the proper technical expertise. The Harrisburg office has recently relocated to a new consolidated space in Lemoyne, Pennsylvania, that provides full logistical capability to support the work requirements. Advanced computer technology and workstations will store and analyze ever increasing amounts of information. A Geographical Information System is available on these workstations that provides a state-of-the-art analytical tool for evaluating and solving complex water-quality issues. We of the Pennsylvania District look forward to the challenges that face us and know that in cooperation with the many agencies that deal with these same issues, ways will be found to keep the water resources of Pennsylvania at acceptable levels of quality.

David E. Click

David E. Click

Basic Mission and Programs

U.S. Geological Survey

The U.S. Geological Survey 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 U.S. Geological Survey (USGS) has grown and has been modified to meet the changing needs of the Nation it serves. As part of the evolution, the USGS has become the Federal Government's largest earth-science research agency, the Nation's largest civilian mapmaking agency, the primary source of data on the Nation's surface-water and ground-water resources, and the employer of the largest number of professional earth scientists in the Nation. Today's programs serve a diversity of needs and users. Programs include:

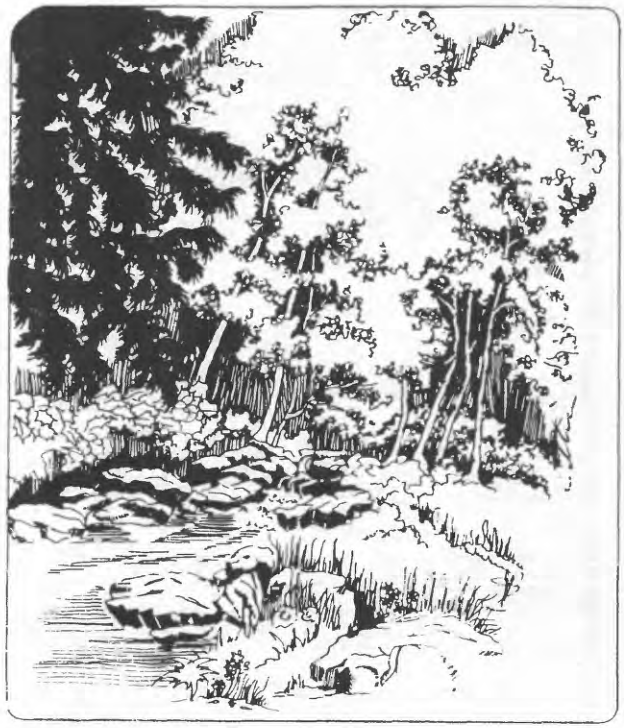
- Conducting detailed assessments of the energy and mineral potential of land and offshore areas.
- Investigating and issuing warnings of earthquakes, volcanic eruptions, landslides, and other geologic and hydrologic hazards.
- Conducting research on the geologic structure of land and offshore areas.
- Studying the geologic features, structure, processes, and history of the other planets of our solar system.
- Conducting topographic surveys 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 water and ground water.
- Conducting water-resource appraisals 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--providing "Earth science in the public service."

Water Resources Division

The mission of the Water Resources Division (WRD) 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 mission 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 physical, chemical, and biological characteristics of surface water 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 man-made.
- 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 water.
- Providing scientific and technical assistance in hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Energy Regulatory Commission, and to international agencies on behalf of the U.S. Department of State.



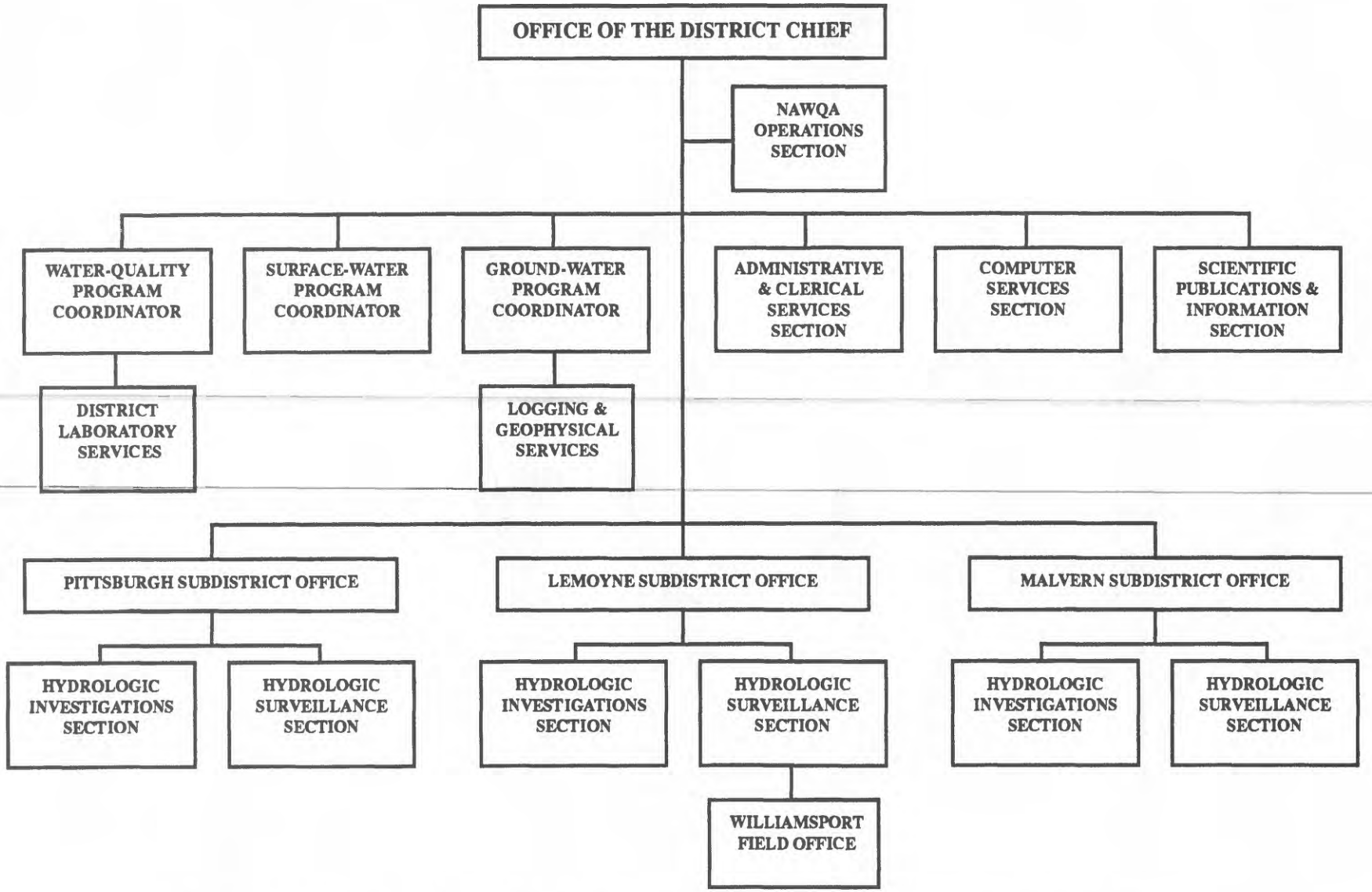


Figure 1.--Organization chart of the U.S. Geological Survey, Water Resources Division, Pennsylvania District.

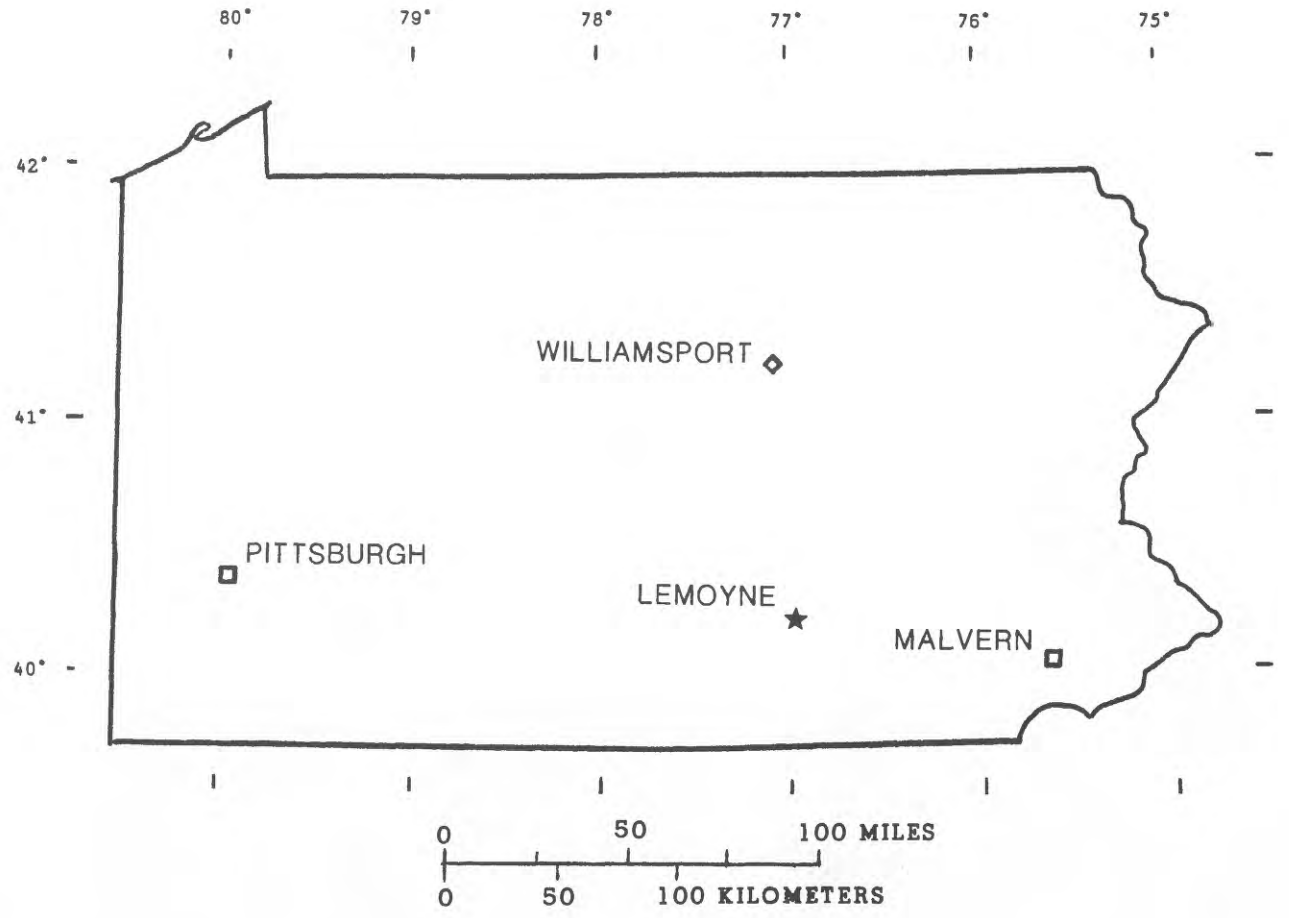


Figure 2.--Location of offices in the Pennsylvania District.

Pennsylvania District Office Addresses

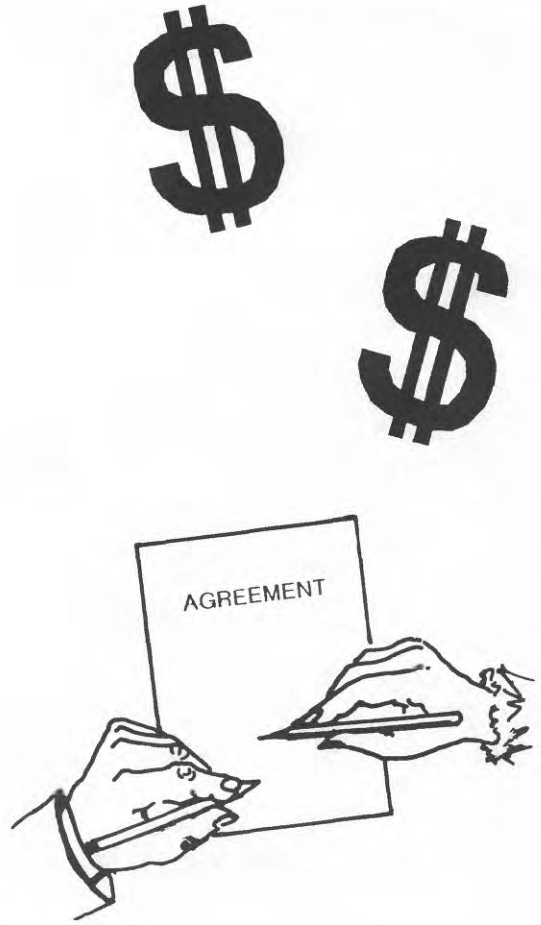
District Office:
U.S. Geological Survey
Water Resources Division
840 Market Street
Lemoyne, PA 17043-1586
(717) 730-6900
FTS 589-6900

Lemoyne Subdistrict Office:
U.S. Geological Survey
Water Resources Division
840 Market Street
Lemoyne, PA 17043-1586
(717) 730-6900
FTS 589-6900

Williamsport Field Office:
U.S. Geological Survey
Water Resources Division
P.O. Box 1805
Room 301 Federal Building
Williamsport, PA 17703
(717) 323-7736
FTS 590-7736

Pittsburgh Subdistrict Office:
U.S. Geological Survey
Water Resources Division
Room 2204 Federal Building
1000 Liberty Avenue
Pittsburgh, PA 15222
(412) 644-2863
FTS 722-2863

Malvern Subdistrict Office:
U.S. Geological Survey
Water Resources Division
111 Great Valley Parkway
Malvern, PA 19355
(215) 647-9008



Program Funding and Cooperation

Moneys for program operation of the U.S. Geological Survey in Pennsylvania come from joint-funding agreements with State and local agencies, transfer of funds from other Federal agencies, and direct Federal allotments to the USGS. Distribution of funding for program operations are illustrated in figures 3 and 4. The following pages list those agencies cooperating with the USGS in Pennsylvania during the 1990-91 fiscal years:

1990

Commonwealth of Pennsylvania Agencies

Department of Environmental Resources (PaDER)
- Bureau of Community Environmental Control
- Bureau of Mining and Reclamation (BMR)
- Bureau of Soil and Water Conservation
- Bureau of Topographic and Geologic Survey (PaGS)
- Bureau of Water Quality Management
- Bureau of Water Resources Management

Local Agencies

Bucks County
City of Allentown
City of Bethlehem
City of Harrisburg
City of Philadelphia
City of Williamsport
Chester County Water Resources Authority
Erie County Department of Health
Joint Planning Commission Lehigh-Northampton Counties
Letort Regional Authority
Media Borough Water Department
North Penn Water Authority
North Wales Water Authority
Township of West Bradford
University Area Joint Authority

Other Federal Agencies

Federal Emergency Management Agency (FEMA)
Federal Energy Regulatory Commission (FERC)
Office of Surface Mining (OSM)
U.S. Army Corps of Engineers
- Baltimore District
- Philadelphia District
- Pittsburgh District

U.S. Department of Commerce
- National Oceanic and Atmospheric Administration (NOAA)
- National Weather Service (NWS)

U.S. Environmental Protection Agency (USEPA)

Other Agencies

Delaware River Basin Commission (DRBC)
New York State Department of Environmental Conservation
State of Delaware Geological Survey
Susquehanna River Basin Commission (SRBC)

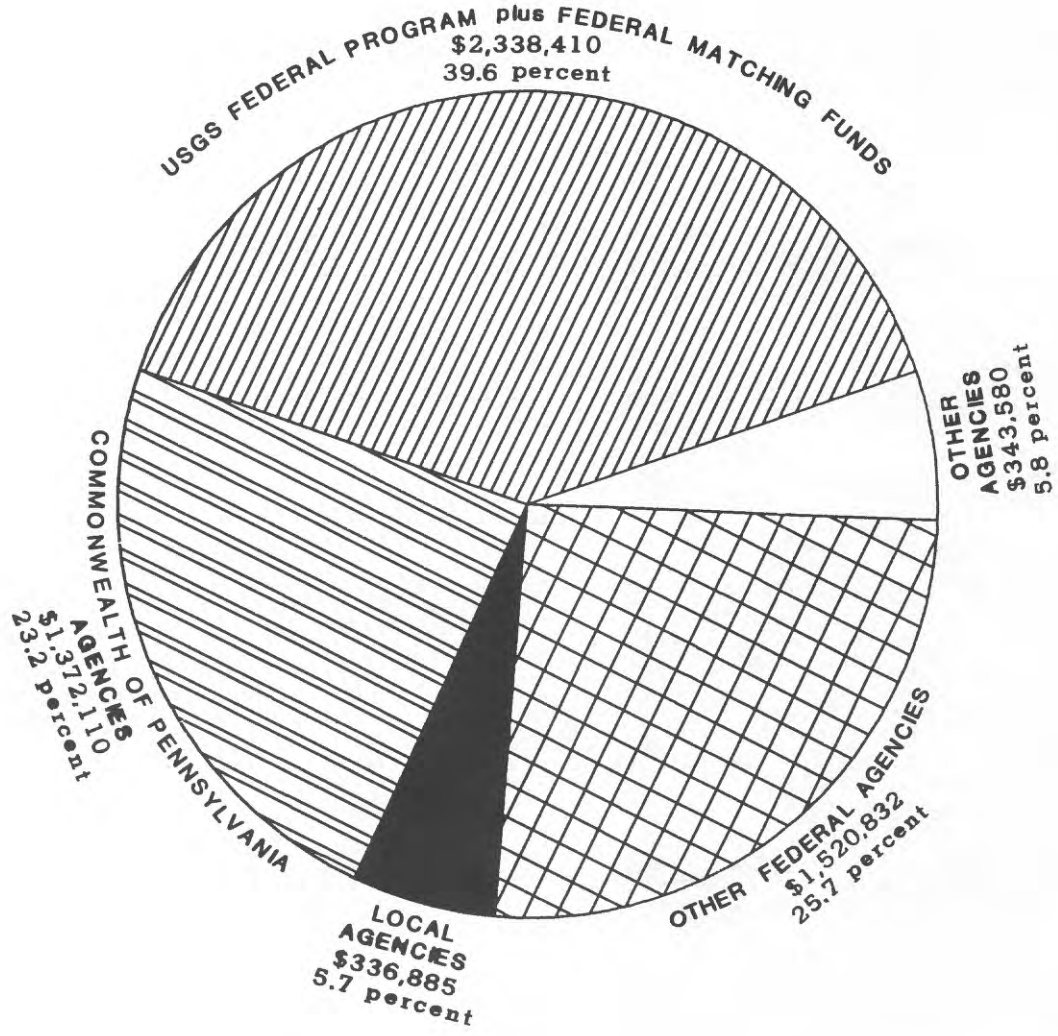


Figure 3.--Funding sources for the water-resources program in Pennsylvania for fiscal year 1990.

1991

Commonwealth of Pennsylvania Agencies

Department of Environmental Resources (PaDER)
- Bureau of Community Environmental Control
- Bureau of Mining and Reclamation (BMR)
- Bureau of Soil and Water Conservation
- Bureau of Topographic and Geologic Survey (PaGS)
- Bureau of Water Quality Management
- Bureau of Water Resources Management

Local Agencies

Alliance for the Chesapeake Bay
Bucks County
City of Allentown
City of Bethlehem
City of Harrisburg
City of Philadelphia
City of Williamsport
Chester County Water Resources Authority
Hazleton City Authority Water Department
Joint Planning Commission Lehigh-Northampton Counties
Letort Regional Authority
Media Borough Water Department
North Penn Water Authority
North Wales Water Authority
Pike County Planning Commission
Tinicum Township
Township of West Bradford
University Area Joint Authority

Other Federal Agencies

Federal Emergency Management Agency (FEMA)
Federal Energy Regulatory Commission (FERC)
U.S. Army Corps of Engineers
- Baltimore District
- Philadelphia District
- Pittsburgh District

U.S. Department of Commerce
- National Oceanic and Atmospheric Administration (NOAA)
- National Weather Service (NWS)

U.S. Environmental Protection Agency (USEPA)

Other Agencies

Delaware River Basin Commission (DRBC)
New York State Department of Environmental Conservation
State of Delaware Geological Survey
Susquehanna River Basin Commission (SRBC)

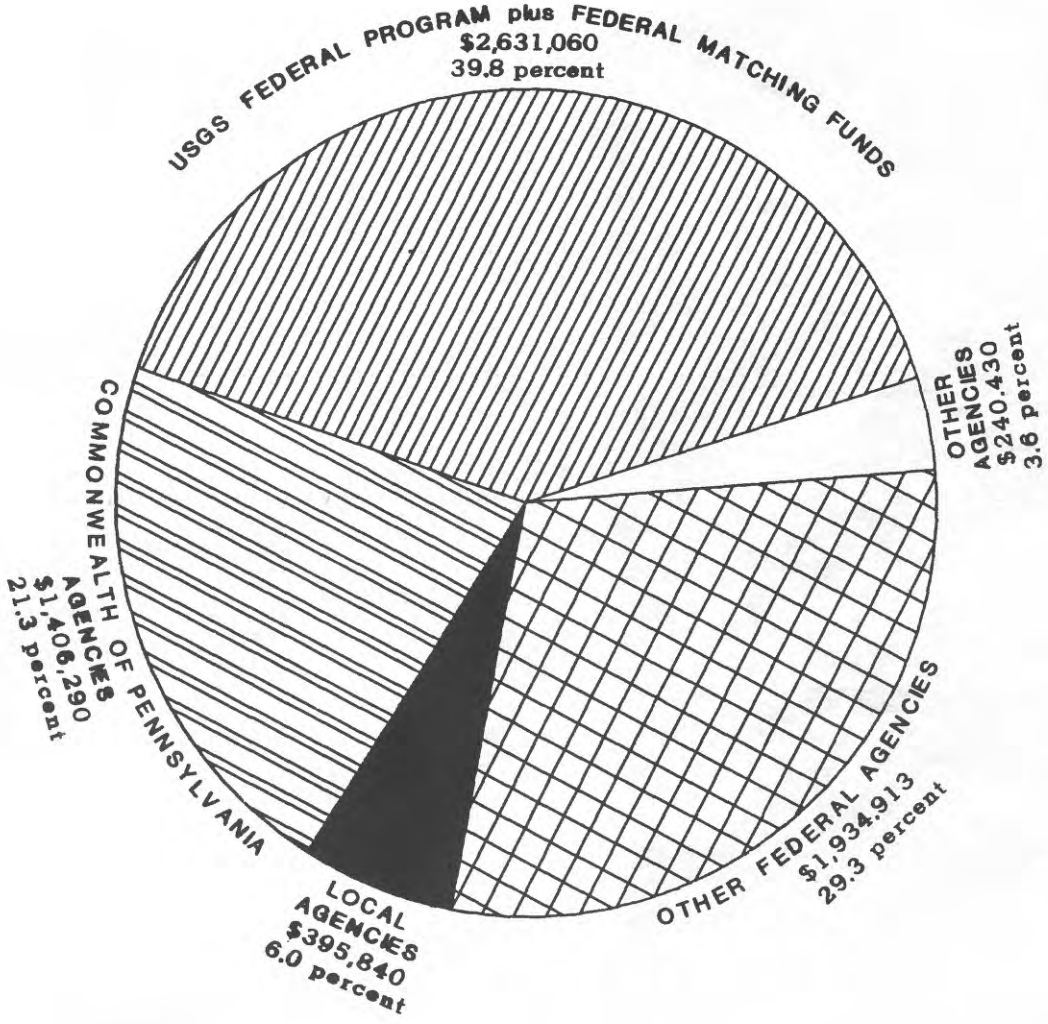
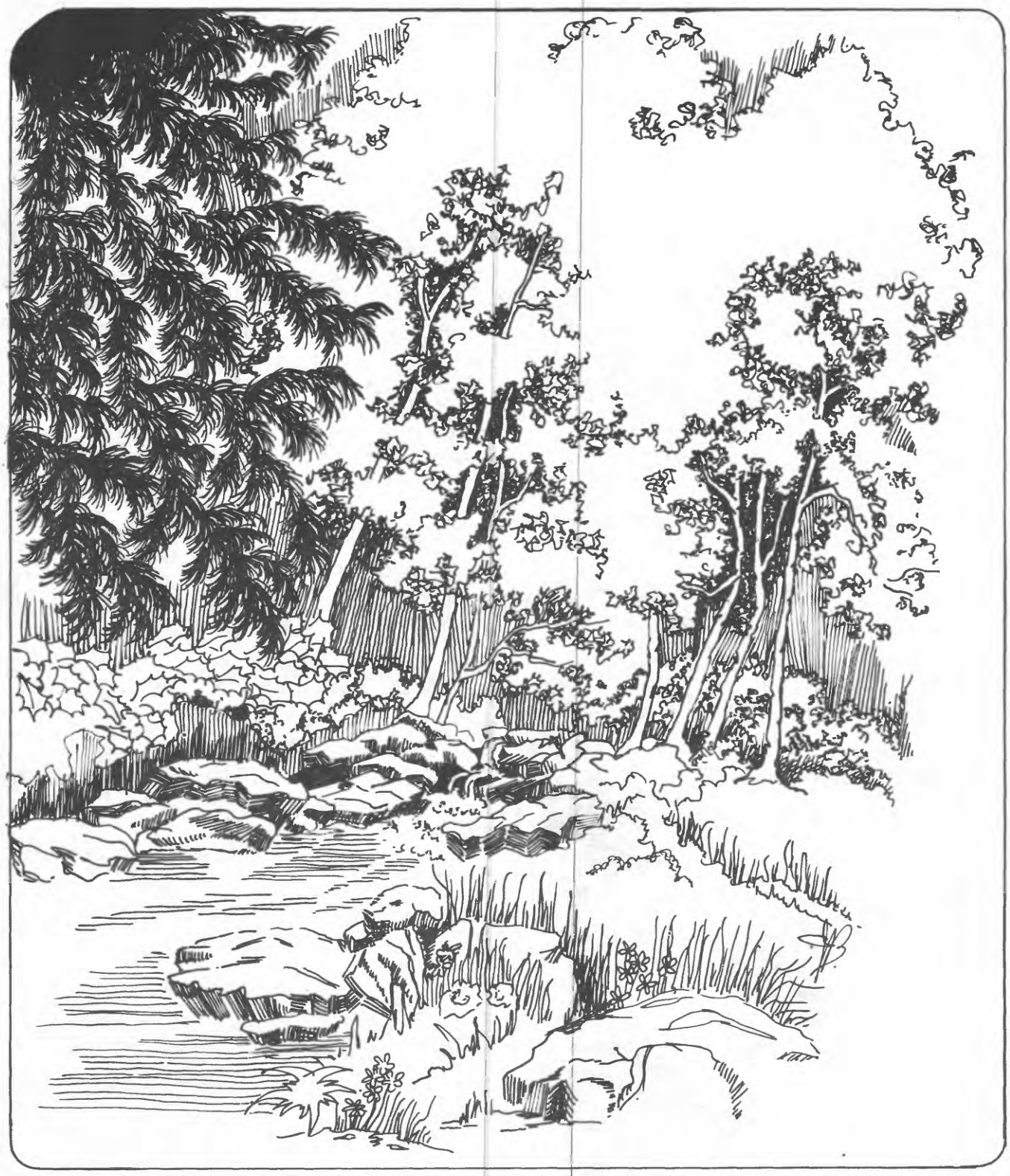


Figure 4.--Funding sources for the water-resources program in Pennsylvania for fiscal year 1991.



Water-Data Program

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

National Water-Data Exchange (NAWDEX)

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

National Water-Data Storage and Retrieval System (WATSTORE)

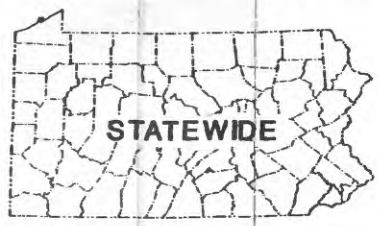
As explained in the section "Water-Data Program," all data collected through that program are stored in WATSTORE, and the data are available on request. These data can be retrieved in machine-readable form or as computer printed tables or graphs, statistical analyses, and digital plots. Local assistance in the acquisition of service or products from WATSTORE can be obtained from the District offices. A pamphlet, "WATSTORE: A WATer Data STOrage and REtrieval System," may be obtained from these offices or from the WATSTORE Program office, Branch of Computer Technology, U.S. Geological Survey, 440 National Center, Reston, VA 22092. The office may be reached by phone at (703) 648-5680.

SURFACE-WATER STATIONS (PA001)

PROJECT CHIEF:
Clayton Kauffman

COOPERATOR(S):
Multiple

PERIOD OF PROJECT:
Continuous since June 1931



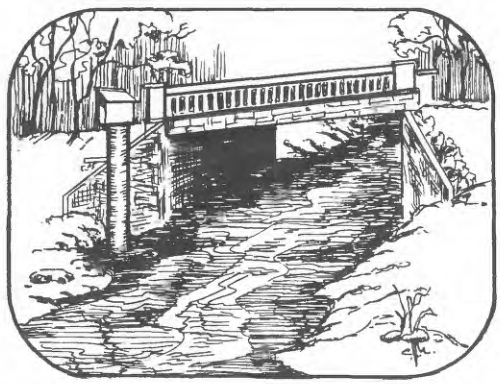
PROBLEM: Surface-water information is needed for surveillance, planning, design, hazard warning, operation, and management in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, 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 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, and estuaries for use in planning and design.

APPROACH: To operate a surface-water hydrologic data network and to insure collection and analysis of data are made by standardized methods, such as those described in the series "Techniques of Water Resources Investigations of the United States Geological Survey." Replies to data and information requests from cooperators, consultants, the public, and the academic community are coordinated at the District level.

PROGRESS: Both archival and real-time data collection systems were maintained in operation. Hydrologic data for continuous record, reservoir, and partial-record surface-water stations were published. The current data network consists of 530 active sites--288 continuous-recording sites and 242 others.

PLANS: Continue to collect and publish surface-water data and maintain data base.



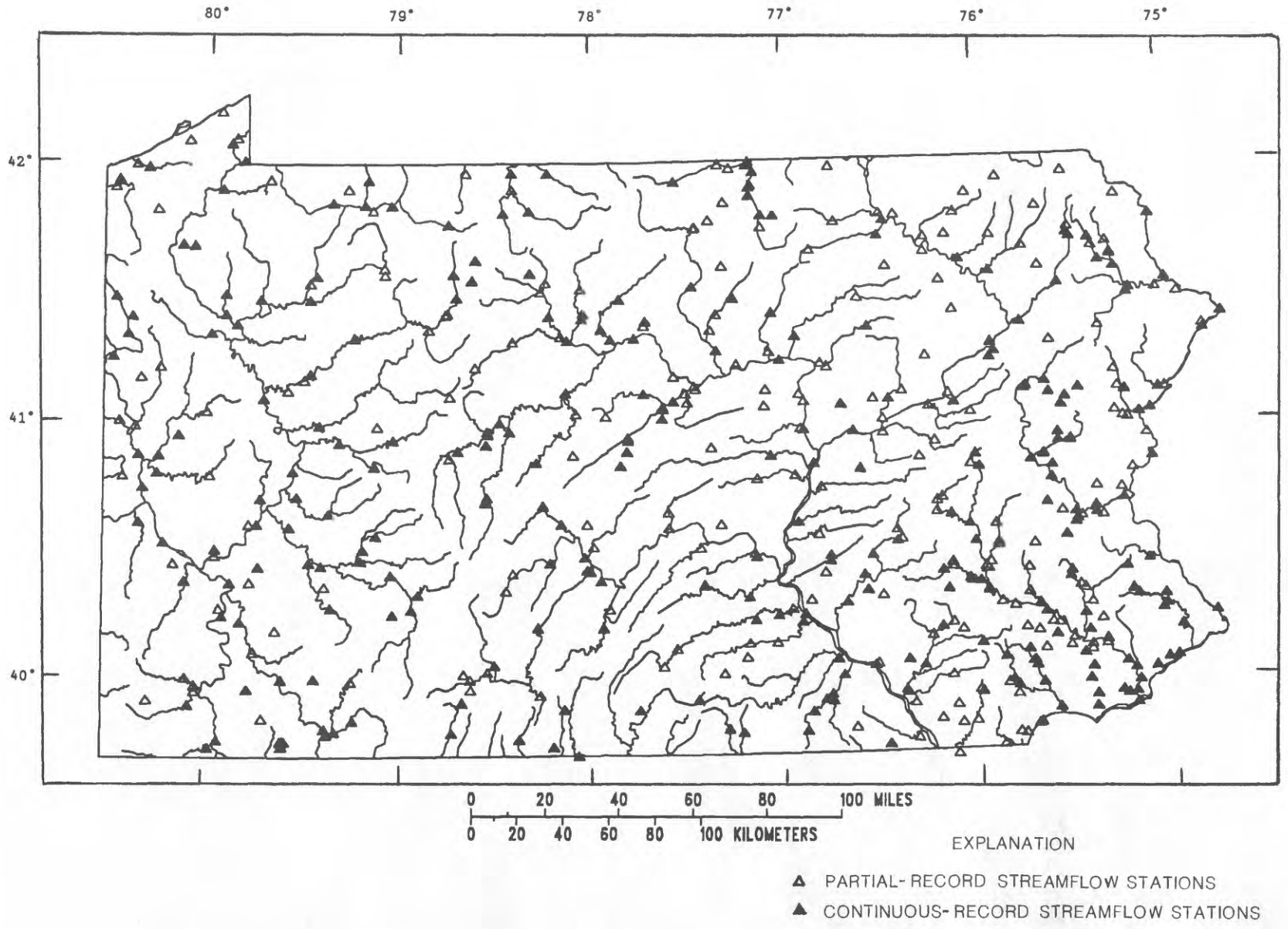


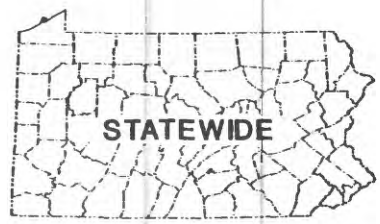
Figure 5.--Location of partial-record and continuous-record data-collection streamflow stations.

GROUND-WATER STATIONS (PA002)

PROJECT CHIEF:
Albert E. Becher

COOPERATOR(S):
PaDER, PaGS, Bureau of Water Resources Management; Chester County Water Resources Authority

PERIOD OF PROJECT:
Continuous since January 1931



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: 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. To provide a data base against which the short-term records acquired in areal studies can be analyzed.

APPROACH: Data will be collected and processed in each of the Subdistrict offices.

PROGRESS: Continuous ground-water-level data were collected from 62 wells and checked for accuracy prior to publication in the annual reports. An evaluation of the existing network was completed and recommendations for upgrading and changes given to the cooperator.

PLANS: Continue to operate network, store data in the daily values file, and provide data reports to using agencies. Network will be upgraded as needed.

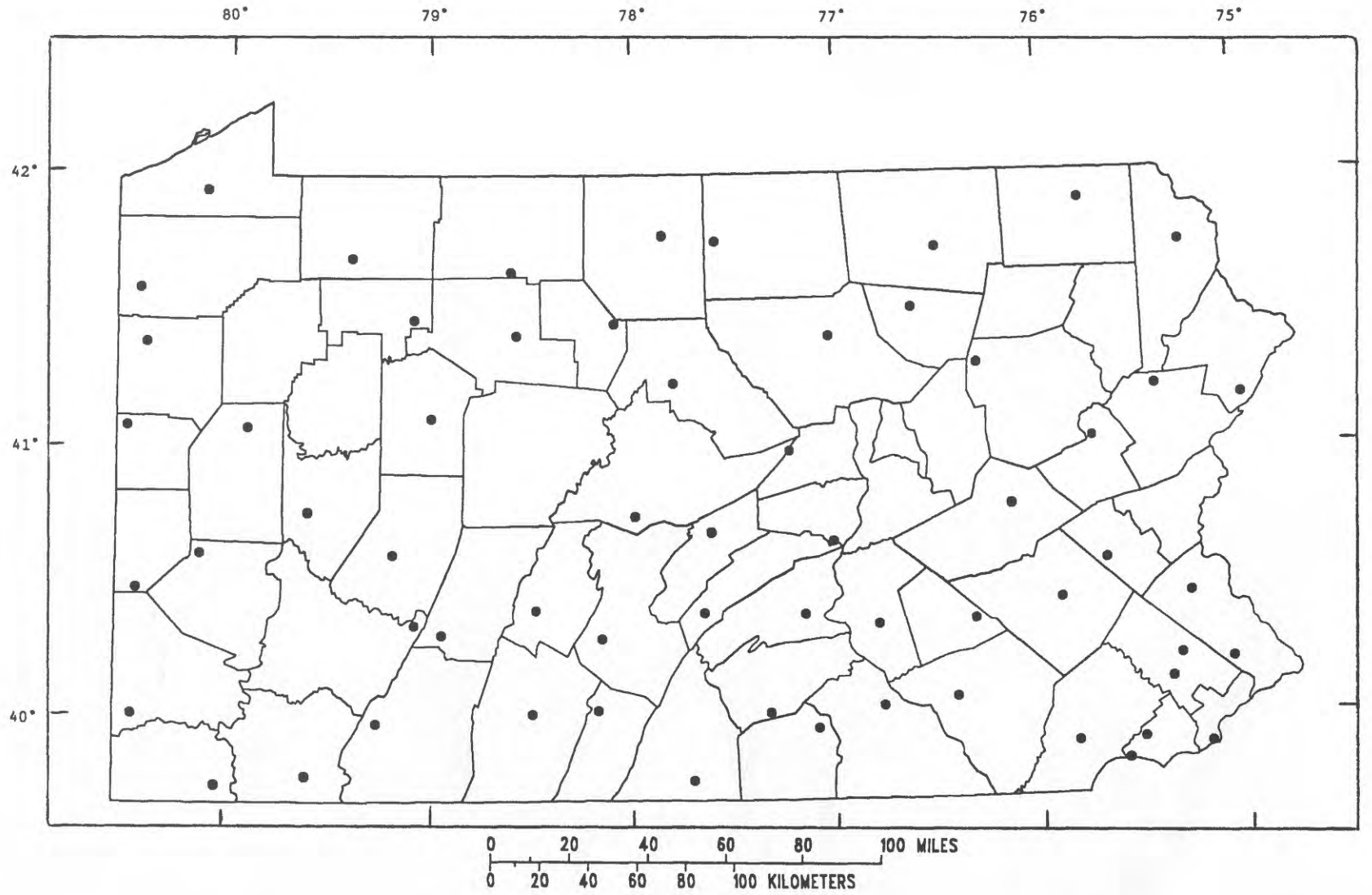


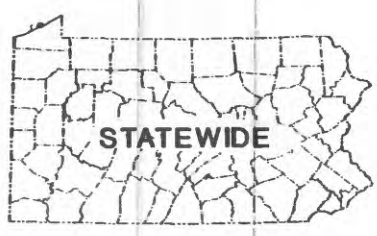
Figure 6.--Location of network observation wells.

WATER-QUALITY STATIONS (PA003)

PROJECT CHIEF:
Mark Hardy

COOPERATOR(S):
Multiple

PERIOD OF PROJECT:
Intermittent since August 1949



PROBLEM: Water-quality data are needed for surveillance, planning, design, and management of water resources. Water-quality problems can affect industries, water-treatment facilities, and the individual consumer. A data base is necessary to provide the appropriate information.

OBJECTIVE: To collect water-quality data sufficient for current uses, such as (1) assessment of water resources; (2) operation of reservoirs; and (3) research or special studies. To collect data necessary for planning and management and for analytical studies to define the statistical properties of spatial and temporal trends in the quality of streams, lakes, and estuaries.

APPROACH: Water samples are collected periodically and analyzed in the U.S. Geological Survey Central Laboratory. At some sites, temperature, dissolved oxygen, pH, and specific conductance are monitored continuously. The operation of the network provides chemical concentrations and loads required by water planning and managing agencies.

PROGRESS: Water-quality data were collected on schedule and published by the Subdistrict Offices. Data was stored in the Water Data Storage and Retrieval System (WATSTORE).

PLANS: Continue to collect data at the network stations.

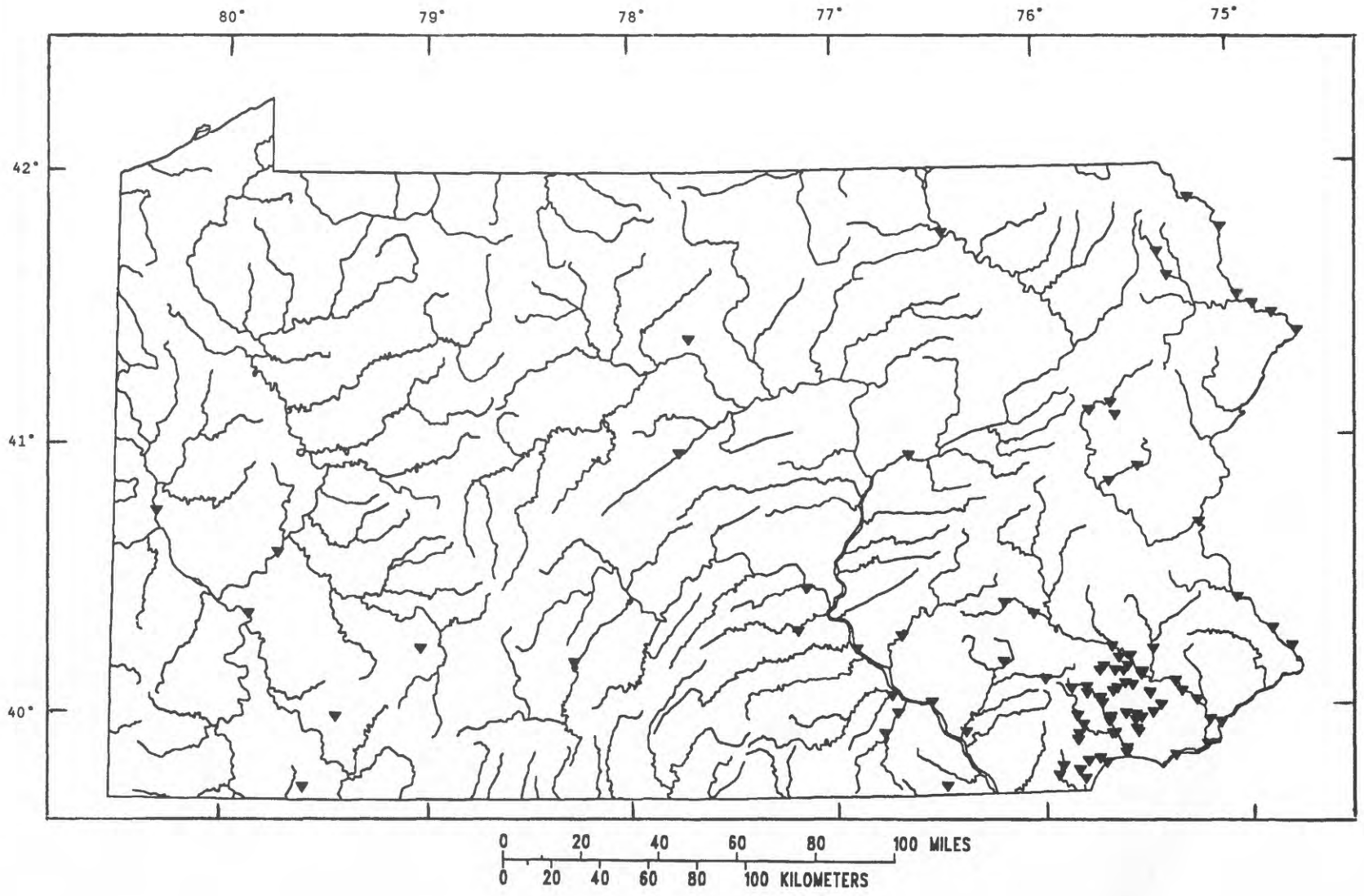


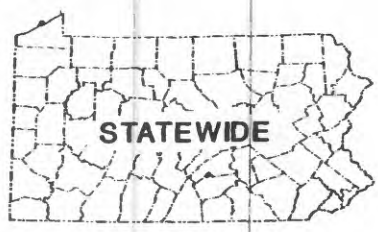
Figure 7.--Location of surface-water quality stations.

SEDIMENT STATIONS (PA004)

PROJECT CHIEF:
Mark Hardy

COOPERATOR(S):
None

PERIOD OF PROJECT:
Intermittent since October 1948



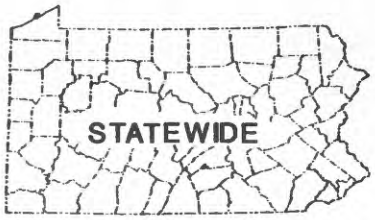
PROBLEM: Transported sediments deposit in reservoirs and harbors, contaminate water supplies, adversely affect machinery, and cause fishery problems. However, sediment is needed to maintain beaches, control algae, and remove toxic chemicals from the water. Sediment data are necessary for erosion studies, reservoir design, dredging scheduling, evaluation of water quality, and design of water treatment facilities. A network of sediment stations is needed to provide a data base for proper water-resources management.

OBJECTIVE: To collect sediment data sufficient for uses such as (1) reservoir design; (2) water-quality standards; (3) pollution controls; (4) erosion assessment; (5) water-resource management; (6) dredging; and (7) research or special studies. To collect data necessary for analytical studies to delineate the effects of land use, such as highway construction, mining, and urbanization. To describe the effects of sediment on water chemistry and to assess spatial and temporal trends.

APPROACH: Suspended-sediment samples are collected at nine sites and loads are calculated by methods described in the series "Techniques of Water Resources Investigations of the United States Geological Survey." Automatic samplers are used at some locations and coal-separation techniques are sometimes used to determine effects of coal mining.

PROGRESS: Data collection and analysis continues.

PLANS: Continue data collection at the network stations.



FLOOD INVESTIGATIONS (PA006)

PROJECT CHIEF:
Herbert N. Flippo

COOPERATOR(S):
FEMA

PERIOD OF PROJECT:
July 1972 to September 1991

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

OBJECTIVE: To evaluate the hydrologic and hydraulic conditions of areas assigned by FEMA and to present the results in an appropriate format.

APPROACH: Review records or conduct surveys by ground or photogrammetric methods of flood prone areas. Determine flood-discharge frequency relations using local historical information, gaging station records, or other applicable information. Determine water-surface profiles using step-backwater models or other acceptable methods and prepare reports to FEMA specifications.

PROGRESS: All contracted studies were completed. A complete review was made of extensive, detailed hydraulic studies that were filed in appeal to the Limited Map Maintenance (LMM) results for the Shade Township, Somerset County (FY 89). Revisions were made to LMMs for the townships of Ferguson and College, Centre County, and for the townships of Greene and Washington, Franklin County. New LMMs were completed for the following communities: Borough of State College, Centre County; Borough of Ambler, Montgomery County; Borough of Mercersburg and townships of Peters and Montgomery, Franklin County.

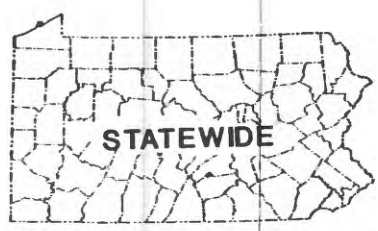
PLANS: Make a revision to the study for the township of Oley, Berks County, and consider new LMM contracts as needed.

PROGRAM FOR THE COLLECTION, STORAGE, AND RETRIEVAL OF WATER-USE DATA IN PENNSYLVANIA (PA007)

PROJECT CHIEF:
Scott A. Hoffman

COOPERATOR(S):
PaDER, Bureau of Water Resources Management

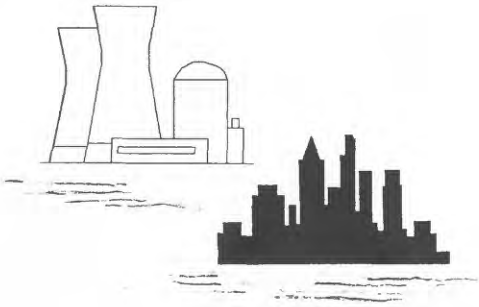
PERIOD OF PROJECT:
Continuous since January 1981



PROBLEM: Waters in Pennsylvania are under stress to supply increasing demands for domestic, industrial, agricultural, and other uses. Competition for water dictates that available supplies be matched with uses most beneficial to the common good. Information has been collected for many years describing quantity and quality of available water. Information on use of water is needed also if the best decisions are to be made about critical water problems such as resource allocations, water-quality residuals, environmental impact, and energy development.

OBJECTIVE: To provide water-use information for the optimum utilization and management of the State's water resources for the overall benefit of the people of Pennsylvania and the United States. This program will modify and improve the State's existing system to collect, store, and disseminate water-use data to complement data on availability and quality of the State's water resources. The new system will be responsive to the data needs of local users, the U.S. Geological Survey, and other federal agencies.

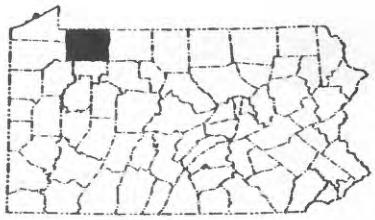
APPROACH: Responsibilities will be divided between the cooperator and the USGS to reflect the most efficient means of meeting the objectives of the program. Direction, management, and standards development to meet the national needs will be the responsibility of the USGS. Field activities for the acquisition and storage of the data at the state level will be the primary responsibility of the PaDER, Bureau of Water Resources Management.



PROGRESS: Familiarity was gained with ARC/Info[1] Geographic Information System (GIS) software. Water-use stream codes were assigned to a GIS major drainage basin coverage. Additions to the water-use data base have continued.

PLANS: Compile Pennsylvania part of the report on 1990 Estimated Use of Water in the United States (EUOWITUS). GIS will be used as a verification tool for site location by drainage basin. Water Use Data System (WUDS) and Aggregate Water Use Data System (AWUDS) will be used to compile water-use data. Report is planned for 1992.

[1] The use of trade, product, industry, or firm names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.



GROUND-WATER QUALITY ASSESSMENT OF WARREN COUNTY, PENNSYLVANIA (PA157)

PROJECT CHIEF:
Theodore Buckwalter

COOPERATOR(S):
PaDER, PaGS;
Warren County Commissioners

PERIOD OF PROJECT:
July 1984 to September 1991

PROBLEM: Ground water is the predominant source for domestic and municipal water supplies for Warren County. Degradation of shallow ground water by industrial wastes and oil and gas development has been documented in selected areas of the county. Information concerning the quality and quantity of the ground-water resources of the county is needed for management and resource development.

OBJECTIVE: Assess the geohydrologic system in the study area. Estimate at selected sites the areal extent of ground-water degradation resulting from oil and gas development and from disposal of other hazardous substances. Provide data on the physical/chemical character of the contaminants; assess the hydraulic properties of the rock containing the contaminants.

APPROACH: Perform literature review. Conduct well inventory and ground-water quality sampling throughout Warren County to assess hydraulic properties and quality of major aquifers. Install observation wells. Perform aquifer tests and geophysical logging. Design and conduct test drilling program.

PROGRESS: Significantly reduced level of funding permitted limited USGS progress. Some progress achieved on text of basic data report. Project Chief for USGS detailed to other projects for most of the year. Extensive surficial and bedrock geologic mapping accomplished by various personnel of the PaGS.

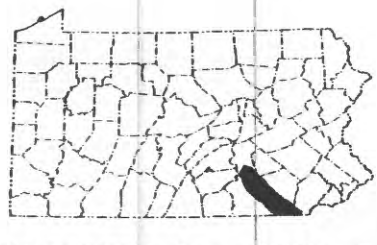
PLANS: An interpretative report and a data report are planned. With increased project funding for this year, USGS will complete text for basic data report and final report. PaGS to finalize geologic mapping and complete preparation of geologic plates for final report.

EVALUATION OF AGRICULTURAL BEST-MANAGEMENT PRACTICES AND OTHER INNOVATIVE METHODS OF CONTROLLING NUTRIENT DISCHARGES IN THE LOWER SUSQUEHANNA RIVER BASIN (PA158)

PROJECT CHIEF:
Michael J. Langland

COOPERATOR(S):
SRBC

PERIOD OF PROJECT:
October 1985 to June 1992



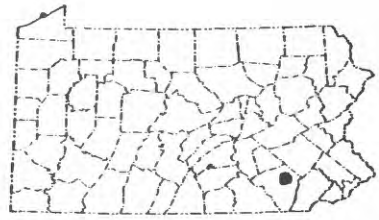
PROBLEM: The PaDER and the Pennsylvania Department of Agriculture (PDA) are developing a nonpoint-source control program for agriculture in the Lower Susquehanna River basin. In addition to traditional practices, new practices or alternate schemes will be utilized to limit the nutrients transported from farms. There is no program that evaluates the impact of these practices on water quality in areas underlain by noncarbonate rocks in the Lower Susquehanna River basin.

OBJECTIVE: To document the water quality of surface runoff and base flow from small agricultural watersheds and to evaluate the effectiveness of agricultural best-management practices in controlling nutrient and suspended-sediment discharges in basins underlain by noncarbonate rocks.

APPROACH: The variability and trends in surface runoff and base-flow water quality based on precipitation and farming practices will be documented at two small watersheds underlain by noncarbonate rock 2 years before and 3 years after practice implementation. The effects of the practices on sediment and nutrient discharges will be measured using statistical trend analysis. Data may be used to model the effectiveness of the practices using the Chemical Runoff and Erosion from Agricultural Management Systems (CREAMS) or Hydrologic Simulation Program-Fortran (HSPF) models. Results will be compared to determine the relative influences of physiography, geology, soils, land use, precipitation, and installed practices on water quality.

PROGRESS: Sampling was discontinued at the Bald Eagle Creek site. Reduction in animal units and land applications of manure and commercial fertilizer has not yet reduced total-nitrogen concentrations in surface water. At the Brush Run site, volatilized ammonia is being deposited by wet and dry atmospheric deposition at rates as high as 0.22 pounds per acre per day. The Bald Eagle Creek characterization report is in preparation for publication.

PLANS: Complete report on the Bald Eagle Creek site and data collection and analysis from the Brush Run project site. Prepare a journal article presenting findings on Atmospheric Deposition of Ammonia from Open Manure-Storage Lagoons. Continue work on the final report for the Brush Run site.



EFFECTS OF AGRICULTURAL BEST- MANAGEMENT PRACTICES ON NONPOINT SOURCES IN THE CONESTOGA RIVER BASIN ABOVE LANCASTER, PENNSYLVANIA (PA118)

PROJECT CHIEF:
Patricia L. Lietman

COOPERATOR(S):
PaDER, Bureau of Water Quality Management

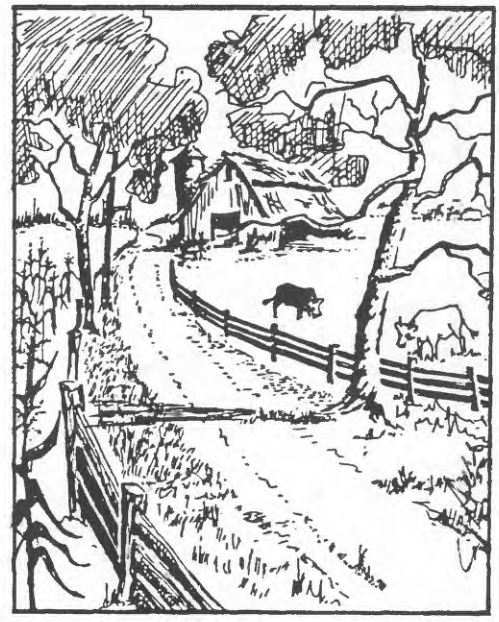
PERIOD OF PROJECT:
January 1981 to September 1991

PROBLEM: The surface and ground waters of the Upper Conestoga River basin, Lancaster County, are degraded by runoff and infiltration from intensive agriculture. Suspended sediment, phosphorus and nitrate concentrations, and bacteria counts are excessive in many parts of the basin, particularly those areas underlain by carbonate formations. The basin is 1 of 12 watersheds designated for implementation of Best-Management Practices (BMPs) as part of the National Rural Clean Water Program (RCWP). Minimal data were previously available to assess the effectiveness of BMPs in controlling agricultural runoff and infiltration to the ground-water system. Virtually no data were previously available to assess the effects of BMP installation on water chemistry, particularly bacteria and nitrate.

OBJECTIVE: To define the surface- and ground-water quality in the Upper Conestoga River basin. To evaluate changes in runoff and surface- and ground-water quality caused by the installation of BMPs at two small field sites (about 50 acres each) and in one small watershed (about 5 square miles) in the basin.

APPROACH: Nutrient and herbicide concentrations in ground and surface water and suspended-sediment concentrations in surface water will be monitored before and after the implementation of BMPs at three sites. Two field sites and a small watershed will be monitored for water quality through the use of continuous-record or partial-record gaging stations, automatic samplers, recording rain gages, and wells. Statistical analysis and hydrologic models will be used to evaluate changes in water quality.

PROGRESS AND PLANS: All surface- and ground-water monitoring for the Conestoga Project ended September 30, 1990. Ground-water monitoring at Field-Site 2 has been extended through 1993 as a new project (PA206). Surface-water monitoring in the Small Watershed has been continued through 1991 as a new project (PA189). The Small Watershed Pre-BMP report has been approved for publication, and the Post-BMP report is in draft. The Field-Site 1 Pre-BMP report is at regional review, and the Post-BMP report is in draft. The Field-Site 2 Pre-BMP report is at colleague review, and the Post-BMP report is in draft. A comprehensive final summary report is in draft. A herbicide paper has been published, two ground-water journal articles on nutrient management and terracing are in review, and a third article on a nutrient budget is in draft.

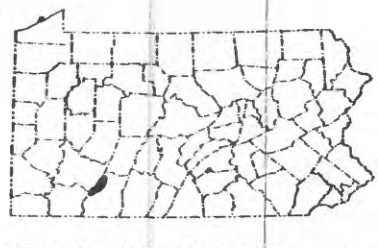


EFFECTS OF ACID RAIN ON THE WATER QUALITY OF LAUREL RIDGE, SOMERSET COUNTY, PENNSYLVANIA (PA145)

PROJECT CHIEF:
Emitt C. Witt

FUNDING:
Other Federal Agency, USEPA

PERIOD OF PROJECT:
April 1983 to September 1993



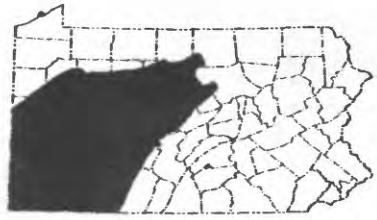
PROBLEM: Headwater streams in portions of Somerset County, Pennsylvania are extremely sensitive to acidic deposition and chemical weathering of soils. As a result of this situation there is possible damage to fish and other components of the aquatic ecosystem.

OBJECTIVE: To determine the effects of acid deposition on the chemistry of a poorly buffered headwater stream.

APPROACH: A single 3.45-square mile forested basin has been selected for monitoring over a 10-year period. Data collection includes continuous streamflow monitoring and monthly base-flow water-quality sampling. At the completion of the proposed data-collection period, interpretation will involve the application of nonparametric statistics to determine trends in water quality.

PROGRESS: Twelve additional water-chemistry samples were collected and analyzed. Open-File Report 89-584, "Water-Resources Data for North Fork Bens Creek, Somerset County, Pennsylvania, August 1983 through September 1988," is in preparation for publication. A manuscript was approved for publication in the Proceedings of the American Society of Civil Engineers National Conference on Irrigation and Drainage. Recent addition of soil and bedrock chemistry data has increased our ability to make geochemical interpretations.

PLANS: Continue monthly base-flow water-quality sampling at the study site.



WATER-QUALITY EFFECTS OF THE APPLICATION OF SEWAGE SLUDGE ON SURFACE COAL MINES (PA160)

PROJECT CHIEF:
Charles A. Cravotta, III

COOPERATOR(S):
PaDER, BMR

PERIOD OF PROJECT
May 1986 to September 1992

PROBLEM: Information is needed on the water-quality effects from the use of urban sewage sludge in the reclamation of surface coal mines in the bituminous coal fields of Pennsylvania. The possibility of concurrent reductions in dissolved oxygen and acid production, or conversely, increases in dissolved carbon dioxide, nutrients, and acid production are of primary interest. In addition, the leaching of toxic metals from the sludge is a potential problem.

OBJECTIVE: To evaluate the water-quality effects of the application of urban sewage sludge at representative surface coal mines. To determine the effect of sludge on subsurface bacteria activity, which is related to the oxidation of pyrite. To characterize the mineralogical and chemical composition of the mine spoil and associated water.

APPROACH: Two surface coal mines in Clarion County and one mine in Clearfield County have been instrumented with weirs, wells, and lysimeters for water-quality and other hydrologic monitoring. One of the mines in Clarion County was not treated with sludge and serves as a control; the other two mines were reclaimed with sludge at a rate of 60 dry tons per acre. Monthly monitoring at each mine is planned for 2.5 to 3.5 years following sludge treatment.

PROGRESS: Completed collection and analysis of water-quality and other hydrologic data from two mines in Clarion County. Wrote two papers and gave oral presentation on effectiveness of introducing alkaline materials to sites in abating acid drainage. Wrote two abstracts, respectively, on ground-water-flow model (poster planned) and geochemical model of ground-water chemical evolution (planned for publication; oral presentation and poster prepared). Also began monthly collection of water-quality data, including assays of iron-oxidizing bacteria, and completed overburden analysis for third mine in Clearfield County.

PLANS: Continue collection of water-quality and other hydrologic data at the mine in Clearfield County. Complete data evaluation for two mines in Clarion County, and prepare final report.

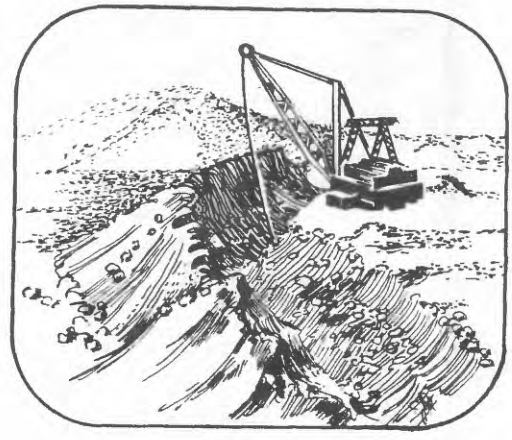


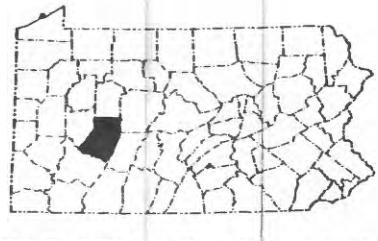
Figure 8.--Surface coal mining using a dragline.

HYDROLOGY AND WATER RESOURCES OF INDIANA COUNTY, PENNSYLVANIA (PA166)

PROJECT CHIEF:
Donald R. Williams

COOPERATOR(S):
PaDER, PaGS;
Indiana County Commissioners

PERIOD OF PROJECT:
May 1986 to September 1991



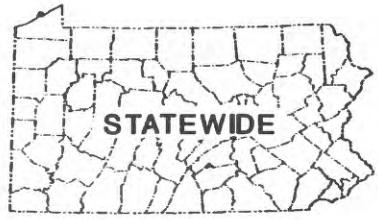
PROBLEM: Indiana County, in 1984, produced 12 million tons of bituminous coal, the largest county production in Pennsylvania. Eighty-four percent of this production was from underground mines. The impacts of mining on the water resources include acid mine drainage, which affects water quality, and the draining of shallow aquifers by subsurface mining, which affects ground- and surface-water quantity. Petroleum-production activities also have affected the surface- and ground-water quality throughout the county. Some ground-water samples collected from northern Indiana County wells had chloride concentrations greater than 250 mg/L (milligrams per liter) and concentrations of total dissolved solids as high as 1,890 mg/L. From 1979 to 1982, Indiana County had the largest number of gas wells drilled annually in the State, averaging 400 wells per year. Because coal mining continues to be active in the county and petroleum production is on the increase, county residents are concerned about further effects of these activities on the water resources.

OBJECTIVE: (1) To appraise the water resources of Indiana County; (2) determine the effects of surface and subsurface mining on both the surface- and ground-water quantity and quality; and (3) determine the effects of gas well drilling on the surface- and ground-water quality.

APPROACH: About 400 water wells will be inventoried throughout the county. Of special interest will be the aquifer systems overlying active underground mining and areas where there has been a sharp increase in petroleum exploration. About 20 observation wells will be equipped with continuous water-level recorders in active mining areas, in nonmining areas, and in areas where petroleum production has increased. Aquifer tests will be done on the bedrock aquifers to analyze the variation of hydraulic properties with depth and between mined and unmined areas. Water samples will be collected at about 150 wells to determine ground-water quality. Six stream-gaging stations currently in operation in the county will be a part of the data-collection network and three additional stream gages will be constructed. Approximately 25 additional intermittent surface-water sites will be established throughout the county. About six mass-sampling water-quality runs will be conducted at all of the surface-water sites during base-flow conditions.

PROGRESS: The open-file data report, following reviews, received regional approval for publication. The interpretive report was revised to reflect the suggestions of the reviewers and many of the ground-water aspects of the report were completed. Project is complete except report.

PLANS: Publish data report in open-file series. Complete revision and writing of all sections of the interpretive report and send through the formal review process.



AQUIFER CHARACTERISTICS OF THE ROCKS OF PENNSYLVANIA (PA171)

PROJECT CHIEF:
Dennis J. Low

COOPERATOR(S):
PaDER, PaGS

PERIOD OF PROJECT:
January 1987 to September 1991

PROBLEM: Information on the aquifer characteristics of the rocks of Pennsylvania is needed for proper resource development, management, and protection of sensitive ground-water resources. A comprehensive summary of aquifer characteristics, supplemental to the State Geologic Maps and 7-1/2-minute quadrangle maps, would substantially augment the informational needs of state and Federal regulatory agencies, resource planners, public and private water suppliers, industrial users, and hydrogeologic consultants.

OBJECTIVE: To develop a comprehensive summary of the aquifer characteristics of the rocks of Pennsylvania including information on lithology, topography, and structure; well-yield; ground-water quality; and ground-water recharge, flow, and discharge.

APPROACH: The comprehensive summary will be developed by: (1) compilation of statewide and regional reports; (2) extrapolation of published detailed investigations; (3) analysis of well-yield and water-quality data from over 5,000 wells, which are updated continuously and stored in GWSI and WATSTORE data bases of the U.S. Geological Survey; (4) analysis of borehole-geophysical data on file with the U.S. Geological Survey; (5) review of aquifer-test data and well-interference problems at selected sites on file with other agencies; and (6) review of hydrogeologic and water-quality data at selected contamination sites on file with the PaDER and other agencies.

PROGRESS: Volume I being prepared for colleague review. Volume II being prepared for first draft.

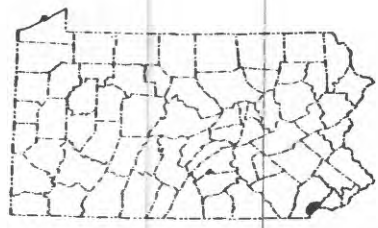
PLANS: Revise Volume I following review and submit for Director's approval. Prepare Volume II for colleague review.

GROUND-WATER RESOURCES OF THE RED CLAY CREEK BASIN, CHESTER COUNTY, PENNSYLVANIA, AND NEW CASTLE COUNTY, DELAWARE (PA179)

PROJECT CHIEF:
Karen L. Vogel

COOPERATOR(S):
Delaware Geological Survey, Chester County Water Resources Authority

PERIOD OF PROJECT:
October 1987 to September 1991



PROBLEM: Rapid urbanization in the Red Clay Creek basin has reduced ground-water recharge and increased water demand. County and local governments want to protect the base flow of streams and the quality of ground water while permitting additional ground-water development.

OBJECTIVE: Gain a detailed understanding of ground-water flow in the Red Clay Creek basin. Determine ground-water/surface-water relations. Determine a water budget for the basin. Document existing water-quality problems in the study area.

APPROACH: (1) Construct a stream-gaging station on the Pennsylvania-Delaware border; (2) select 20 observation wells in the study area; (3) run 20 short-term aquifer tests and four 72-hour aquifer tests; (4) construct a water-table map of the study area; (5) develop a current water budget; and (6) construct a finite-difference digital ground-water flow model of the study area using the U.S. Geological Survey McDonald-Harbaugh modular model program.

PROGRESS: Water-level map is in review. Construction of table and illustrations for final report are in progress. Data arrays for digital ground-water-flow model are partially complete. Base flow measured at 85 sites on the Red Clay Creek. Data will be used for steady-state calibration of the digital ground-water-flow model.

PLANS: Calibration of digital ground-water-flow model and predictive simulations will be completed. Prepare report for review.

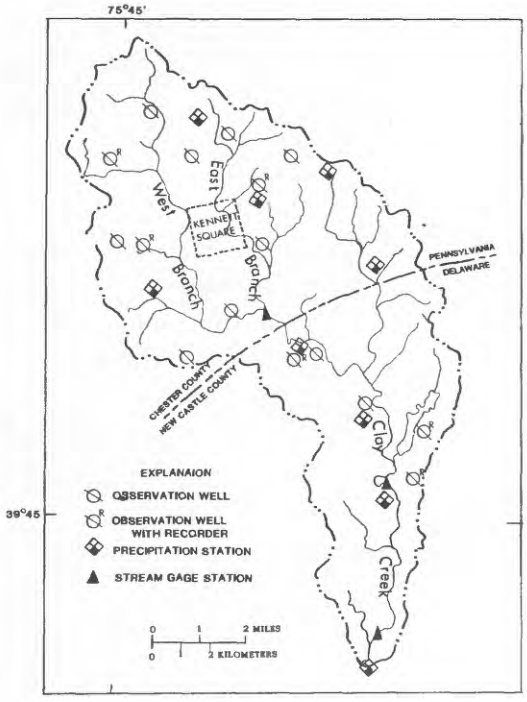


Figure 9.--Hydrologic-data network for the Red Clay Creek basin.

GEOPHYSICAL STUDY OF USEPA SUPERFUND SITES IN PENNSYLVANIA, DELAWARE, MARYLAND, WEST VIRGINIA, VIRGINIA, AND WASHINGTON, D.C. (USEPA, REGION III) (PA183) (PA197[1])

PROJECT CHIEF:
Albert E. Becher

FUNDING:
Other Federal Agency; USEPA, Region III, Environmental Monitoring Systems Laboratory

PERIOD OF PROJECT:
October 1988 to September 1991

MID-ATLANTIC STATES

PROBLEM: An understanding of the hydrogeology is essential for the design and implementation of efficient remediation protocols at USEPA Superfund sites. Geophysical studies can contribute detailed geologic and hydrogeologic information about a site.

OBJECTIVE: Collect borehole and surface geophysical data at USEPA Superfund sites. Provide information on the hydrogeology of aquifers at Superfund sites based on an interpretation of the geophysical and other available data.

APPROACH: At each site selected for study by USEPA, Region III, advisory-services borehole or surface geophysical studies will be done as appropriate. For each site, USEPA will submit a request and "scope of work." A work plan and a quality-assurance plan will then be provided to the USEPA project leader and approved by USEPA. USEPA will provide equipment decontamination procedures and health and safety information for each site. The data from each borehole or surface geophysical geophone spread will be analyzed separately and interpreted collectively with all site geophysical data and general information. A mount Soporis digital geophysical logger with computer is available in the District. Seismic and electrical resistivity surface geophysical equipment are available to the District.

PROGRESS: Geophysical or other studies provided hydrologic information significant to the evaluation of site conditions or clean-up plans at 13 sites.

PLANS: Geophysical studies at superfund sites will be continued as requests are made by the USEPA.

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[1] PA197 is a continuation of PA183.

DEVELOPMENT OF A PROTOCOL FOR A TISSUE ANALYSIS COMPONENT FOR THE NATIONAL WATER-QUALITY ASSESSMENT (NAWQA) PROGRAM (PA184)

PROJECT CHIEF:
J. Kent Crawford

COOPERATOR(S):
Federal Program

PERIOD OF PROJECT:
October 1988 to September 1992

NATIONWIDE

PROBLEM: The National Water-Quality Assessment Program is a long-term, continuing program of data acquisition, interpretation, and assessment of the Nation's water resources. For this program to be successful, it must go beyond previous water-quality monitoring efforts wherein various chemical constituents are monitored at somewhat regular intervals at fixed locations. Therefore, NAWQA will have innovative sampling strategies for chemical constituents and will include biological monitoring. However, no consensus has evolved as to which biological measures should be incorporated into NAWQA or how the chosen biological activities should be implemented. This project will address that problem by providing a design for using tissue analysis in NAWQA.

OBJECTIVE: To produce a protocol for using tissue analysis in NAWQA.

APPROACH: Development of the protocol document is viewed as a two-phase process. First, in Phase I, a draft protocol will be developed which will undergo intensive internal and external review. As a consensus is reached on the most appropriate plan for tissue analysis studies, then Phase II, a field test of the protocol, will be implemented at one or more of the NAWQA pilot study units. The first step in protocol development will be to define attainable objectives for the use of tissue analysis in NAWQA. Once objectives have been finalized, the protocol will be drafted, based on an extensive literature review, discussions with scientists within and outside the USGS, and field testing. The draft protocol will then undergo extensive review and coordination in an iterative process to arrive at a final plan.

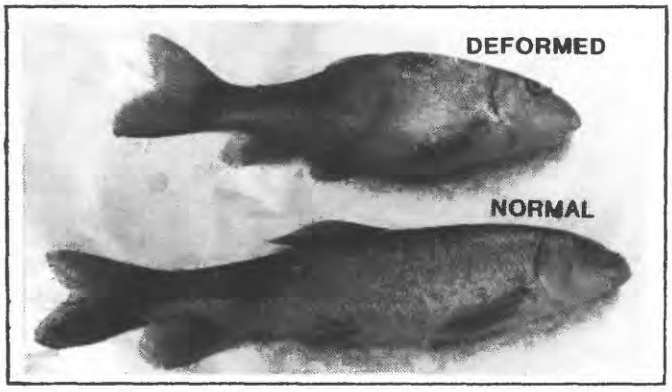
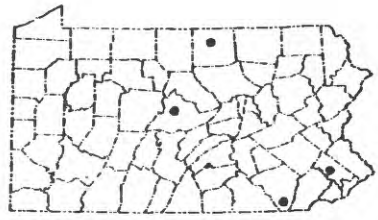


Figure 10.--White suckers from the Upper Illinois River basin, location of one of the pilot NAWQA studies.

PROGRESS: The protocol document entitled "Protocol for Determining the Occurrence, Distribution, and Trends in Concentrations of Trace Elements and Synthetic Organic Compounds in Tissues" has been drafted and subjected to extensive colleague review and review by outside agencies. Field reconnaissance sampling and synoptic sampling have been conducted in each of two pilot study units: the Yakima River basin and the Upper Illinois River basin.

PLANS: Finalize the protocol document. The document is expected to be submitted for Director's approval in May 1991. Prepare reports integrating water chemistry, sediment chemistry, and tissue-residue data for both trace elements and synthetic organic compounds in each of the two pilot study units. Establish data-base management procedures for handing tissue data from NAWQA projects. Establish tissue archival and voucher collection procedures.



EVALUATION OF METHODS TO DELINEATE THE AREA OF GROUND-WATER CONTRIBUTION FOR VARIOUS HYDROGEOLOGIC SETTINGS IN PENNSYLVANIA (PA186)

PROJECT CHIEF:
Dennis W. Risser

COOPERATOR(S):
PaDER, Bureau of Community Environmental Control

PERIOD OF PROJECT:
October 1988 to September 1992

PROBLEM: A technical framework is needed to establish wellhead-protection programs. A successful wellhead-protection program has several required elements, the most technically challenging of which may be the delineation of the contributing water to a wellfield.

OBJECTIVE: To identify and evaluate methods that are most appropriate for delineating contributing areas to wells located in various hydrogeologic settings in Pennsylvania.

APPROACH: Contributing areas to wells will be evaluated at several prototype field sites that represent: (1) ground-water flow in a granular porous medium; (2) diffuse flow in fractured rocks; (3) conduit flow in fractured and solutioned rocks. Methods to delineate wellhead-protection areas (fixed radius, variable shapes, analytical, mapping, and numerical modeling) will be compared at each prototype field site.

PROGRESS: Report evaluating methods to delineate contributing areas to wells in unconsolidated sediments in preparation for Director's approval. Finished field work to evaluate the structural control on flow to wells in a fractured, carbonate terrain. Work included water-level monitoring, well logging, geochemistry, slug tests, constant-discharge aquifer tests, and tracer tests.

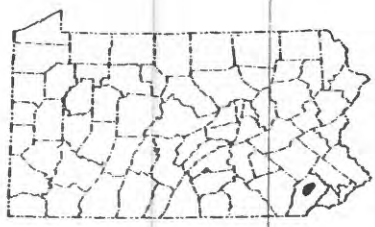
PLANS: Continue evaluation of techniques to delineate contributing areas in fractured rock terrains. Investigation will focus on two well fields in crystalline and sedimentary clastic rocks at Stewartstown and Lansdale, Pennsylvania. Publish first report.

HYDROLOGY OF WEST VALLEY CREEK BASIN, CENTRAL CHESTER COUNTY, PENNSYLVANIA (PA187)

PROJECT CHIEF:
Lisa Senior

COOPERATOR(S):
Chester County Water Resources Authority

PERIOD OF PROJECT:
October 1989 to September 1993



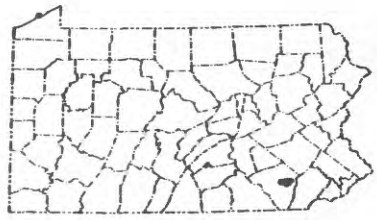
PROBLEM: West Valley Creek basin is undergoing very rapid growth and urbanization because of its location in an expanding business and high-technology corridor. Ground water is the only source of supply for the area, and development is increasing demand. The basin is partly underlain by highly permeable carbonate rocks that are among the highest yielding sources of ground water in the county. Ground water is already contaminated at a few sites. Increased ground-water withdrawal and contamination of ground water may have adverse effects on streamflow and stream-water quality.

OBJECTIVE: (1) Characterize the hydrologic system. (2) Provide baseline stream-quality data.

APPROACH: The hydrologic system will be characterized by: (1) developing a basin water budget and ground-water budget; (2) describing ground-water and surface-water relations; and (3) describing ground-water and surface-water flow. Baseline stream-water quality will be established through a 12-month sampling program.

PROGRESS: All data collection stations have been set up and water-budget data are being collected. Monthly base-flow samples are being collected.

PLANS: Analyze data and complete report.



EFFECTIVENESS OF AGRICULTURAL BEST- MANAGEMENT PRACTICES IN REDUCING NUTRIENT LOADS TO THE CONESTOGA HEADWATERS, LANCASTER COUNTY, PENNSYLVANIA (PA189)

PROJECT CHIEF:
Edward H. Koerkle

COOPERATOR(S):
PaDER, Bureau of Soil and Water Conservation

PERIOD OF PROJECT:
October 1989 to September 1992

PROBLEM: Detection of significant changes in surface-water nutrient and sediment concentrations and loads resulting from implementation of agricultural nutrient-management practices in the Conestoga River Headwaters may lag actual implementation by a number of years. Surface-water-quality data collected from April 1983 until September 1989 by the USGS showed no statistically significant change in water quality relative to reductions in nutrient applications. Factors limiting detection of quantitative water-quality changes include: residual soil nitrogen, climatic variability, and a limited data base. The USGS will cooperate with the PaDER.

OBJECTIVE: Extend the period of data collection and water-quality analyses for a time period sufficient for flushing and stabilization of residual soil nitrogen and for expansion of the data base. Determine if a statistically significant quantitative change in water quality has occurred. Collect information on benthic-invertebrate communities as a time-integrating indicator of water quality. Determine if a quantitative relationship exists between water quality and nutrient management.

APPROACH: Four surface-water sites will be maintained: two sites with continuous discharge record and both monthly base flow and selected stormflow water-quality sample collection; two sites with partial discharge record and monthly base-flow samples. The benthic invertebrate community will be examined semi-annually for qualitative changes. Precipitation quantity and quality data will be collected. An agricultural-activity census will be completed semi-annually. Water-quality data will be examined for significant changes due to nutrient management and for a significant quantitative relationship between water quality and nutrient-management practices. Benthic invertebrate data will be compared to historic data as a qualitative indicator of changes in water quality.

PROGRESS: Data collection completed as planned. Worked on preliminary draft of report.

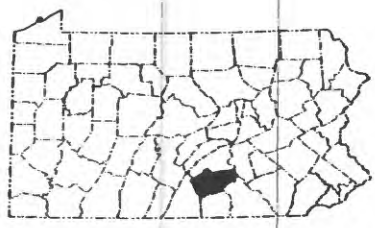
PLANS: Collect monthly base-flow samples at four sites previously included in monitoring by the U.S. Department of Agriculture's Rural Clean Water Program (to be done by the U.S. Department of Agriculture, Agriculture Stabilization and Conservation Service). Complete soil and benthic sampling. Prepare quarterly progress reports. Run statistical analyses on data base as new data become available. Prepare working draft of final report.

GROUND-WATER FLOW IN A MANTLED-CARBONATE SYSTEM, CUMBERLAND VALLEY, PENNSYLVANIA (PA191)

PROJECT CHIEF:
Douglas C. Chichester

COOPERATOR(S):
Federal Program

PERIOD OF PROJECT:
January 1991 to September 1992



PROBLEM: The northern part of Cumberland Valley is experiencing rapid population and industrial growth. The rapid growth of population and industry in the Cumberland Valley is typical of other mantled-carbonate valleys throughout the Valley and Ridge Province. Increased development of ground water (or simply continued industrial and municipal growth), without a better understanding of the complex ground-water flow in mantled-carbonate systems, could lead to unforeseen impacts on the existing quality and quantity of surface water and ground water within these valleys.

OBJECTIVES: (1) to develop areal and cross-sectional, steady-state, and transient computer simulations of a mantled-carbonate ground-water system - an Appalachian and Piedmont Regional Aquifer System Analysis type area; (2) to estimate hydraulic properties of the mantling colluvium, carbonate aquifers, and streambeds; (3) to assess the role of colluvium in the storage and movement of water to the underlying carbonate aquifers; (4) to assess the role of springs and a diabase dike in the movement and discharge of water from the ground-water system; (5) to assess the depth of the regional flow system and affects of fracturing on flow in the carbonate aquifer; (6) to quantify the interbasin transfer of water; and (7) to develop a water budget for the ground-water system.

APPROACH: Available data will provide quantitative assessments of the configuration of the ground-water system, aquifer properties, ground-water levels, and water budget. Data to be collected, seepage-run data and select water-level measurements, will be used to better understand the relationship between surface water and ground water in the study area, differentiate ground-water recharge and discharge areas, and to calibrate computer simulations. A Geographic Information System will be used to store data, develop computer-simulation grids, input data to the simulations, and to present simulation results. Areal and cross-sectional steady-state and transient models will be constructed, calibrated, and sensitivity tested to simulate and quantify ground-water flow in a mantled-carbonate system.

PROGRESS: Seepage-run measurements were made during average base-flow conditions at 81 sites. Statistical analyses of well data using P-STAT has helped to determine aquifer properties, water-table configuration, water-bearing zones, and depth of the active flow system. The following GIS coverages have been obtained or completed: roads, land use, hydrography, topography (complete at 1:250,000; partial at 1:24,000), geology, structure, water table, study-area boundary, model-area boundary, GWSI and Pennsylvania State Water Well Inventory wells and springs, seepage-run sites and drainage-basin divides, colluvial thickness, bedrock surface, precipitation, recharge, and model grids and nodes. Water budgets for the Yellow Breeches and Conodoguinet Creeks were completed. A conceptual model has been completed and model construction using GIS and MODFLOW has begun.

PLANS: Complete a second seepage run at low-flow base-flow conditions. Perform a synoptic measurement of ground-water levels. Complete model construction and data input using GIS. Complete model calibration and reports.

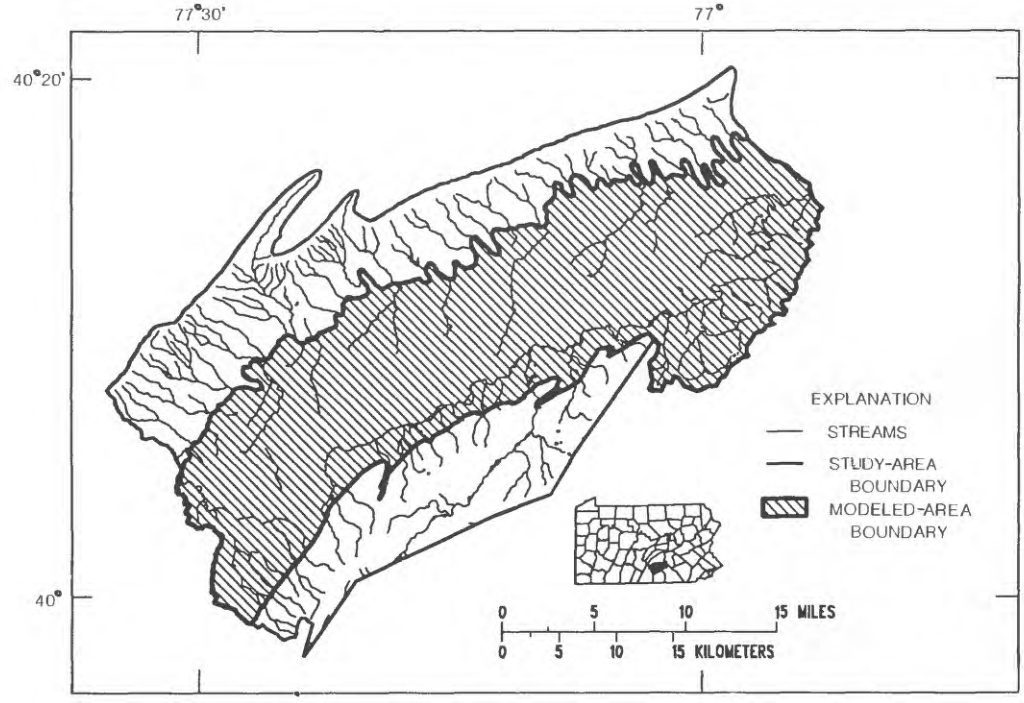


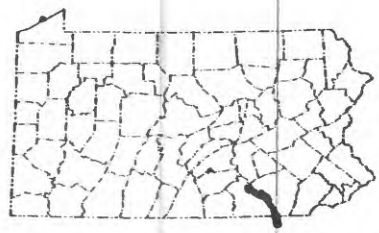
Figure 11.--Ground-water flow in a mantled-carbonate system, Cumberland Valley, Pennsylvania.

EFFECTS OF LOWER SUSQUEHANNA RIVER RESERVOIR SYSTEM ON SEDIMENT AND CHEMICAL LOADS TO CHESAPEAKE BAY (PA192)

PROJECT CHIEF:
Robert A. Hainley

COOPERATOR(S):
PaDER, Bureau of Soil and Water Conservation

PERIOD OF PROJECT:
March 1990 to September 1991



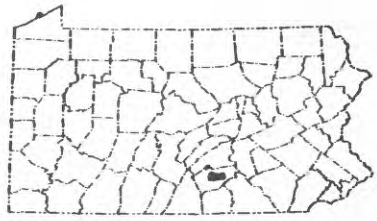
PROBLEM: The assumption that the nutrients that enter the Lower Susquehanna River Reservoir System will eventually leave the Reservoirs may be only partly true. The bioavailability of the nutrients may be influenced by absorption of phosphorus to the sediments and the formation of insoluble minerals. Also, under anoxic conditions, denitrification will reduce nitrate (NO_3) to molecular nitrogen (NO_2), which is not a nutrient form. The amount of "unavailable" nutrients in the System is unknown. The relation of streamflow to nutrient discharge to the Bay is also unknown.

OBJECTIVE: Data will be collected to allow: (1) the estimation of the chemical load, particularly the amount of "available" phosphorus, associated with the suspendable bottom sediments in the Lower Susquehanna River Reservoir System; and (2) the development of a sediment transport model that can be used to estimate the sediment and chemical loads discharged from the reservoirs.

APPROACH: Three distinct phases of study will be used to meet the objectives. During Phase I, bottom sediment thicknesses will be determined on several latitudinal and longitudinal cross-sections in each of the three reservoirs using high-resolution continuous seismic reflection techniques. During Phase II, water-quality measurements will be made in the water column, and core samples of the uncompacted and compacted bottom material will be taken for chemical cross-sections. During Phase III, a model will be developed to estimate the resuspension and transport of nutrients from the Reservoir System to the Chesapeake Bay.

PROGRESS: All physical data (sediment thickness data) were collected and interpreted. Interpretations of physical data were used to develop a plan for the chemical sampling, to prepare contour maps, and to begin preliminary sediment volume computations. Water and sediments were sampled and analyzed for nutrients, major ions, and selected trace elements.

PLANS: Calculations for sediment volumes and nutrient loads are in progress. A sediment transport model will be calibrated and verified. A journal article will be written and reviewed.



THE EXTENT OF PESTICIDE CONTAMINATION AND RELATION TO LAND USE IN TWO SPRING BASINS IN THE NORTHERN CUMBERLAND COUNTY, PENNSYLVANIA (PA193)

PROJECT CHIEF:
Daniel J. Hippe

COOPERATOR(S):
PaDER, Bureau of Water Quality Management

PERIOD OF PROJECT:
April 1990 to September 1991

PROBLEM: The most productive agricultural land in Pennsylvania is underlain by carbonate rocks. Ground-water resources in these areas are highly susceptible to contamination by agricultural chemicals, but in studies to date, the amount of pesticides applied on the land has not been related to the loads of pesticides and metabolites transported in the ground water.

OBJECTIVE: To document the relationship between application of pesticides and the load of pesticides, particularly triazine herbicides and their metabolites that discharge from two spring basins in carbonate rocks of the Cumberland Valley. The project will also document nutrient loads from the springs.

APPROACH: Water-quality and discharge data will be obtained for the springs to estimate pesticide and nutrient loads. The areal extent of the spring basins will be refined using synoptic ground-water level measurements and a water budget. The GIS will be used to determine the relationship of land use in spring basins to pesticide loads and the springs. Land-use data will be provided by the Pennsylvania Department of Agriculture.

PROGRESS: Installed gages. Completed quality analysis plan, work plan, and sampling schedule. Collected water samples during four storms and nine interim periods as scheduled, and sent to Central lab. Assembled GIS coverages of the study area. Analyzing land- and pesticide-use data for study area. Planning for field work to measure ground-water levels. Have purchased equipment for, and have begun using enzyme immunoassays analyses for pesticides in project samples.

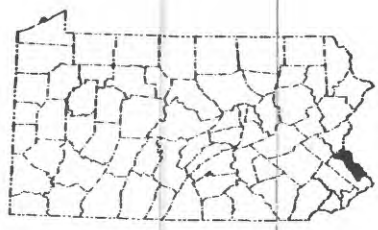
PLANS: Complete collection and analysis of samples. Estimate loads of pesticides and nutrients. Relate pesticide usage to pesticide loads in spring discharge. Complete drafts of two reports.

HYDROGEOLOGY OF THE MESOZOIC ROCKS OF THE NEWARK-GETTYSBURG BASIN, NORTHERN BUCKS COUNTY, PENNSYLVANIA (PA194)

PROJECT CHIEF:
Ronald A. Sloto

COOPERATOR(S):
Tinicum Township

PERIOD OF PROJECT:
October 1990 to September 1994



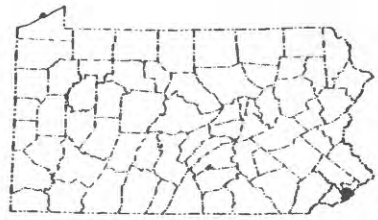
PROBLEM: Because of increasing population and development of southeastern Pennsylvania, the demand for ground water has increased greatly. Low storage capacity of the aquifers produces low base-flow discharges. Clay rich soils retard recharge and promote rapid runoff; therefore, the aquifers are sensitive to droughts and excessive ground-water withdrawals. Increased withdrawals may cause substantial reductions in local and regional ground-water availability and reduce streamflow.

OBJECTIVE: (1) Characterize the hydrogeologic framework and determine the hydraulic properties of the aquifers; (2) quantify the components of the hydrologic budget; (3) evaluate the hydraulic connection between aquifers and between aquifers and streams; and (4) access natural ground-water quality and determine areas affected by ground-water contamination.

APPROACH: The project objectives will be accomplished by: (1) water-budget studies of four small, representative basins to determine the hydrologic budget, ground-water/surface-water relations, and ground-water availability; (2) a well inventory and borehole geophysical logging to define the hydrogeologic framework and ground-water-flow system and to characterize the hydraulic properties of the geologic units; and (3) limited ground-water sampling to characterize natural ground-water quality and areas of contamination.

PROGRESS: New project.

PLANS: Install data-collection stations (rain gages, observation wells, stream gages), compile available data, and begin well inventory and water-table mapping. Two reports are planned: (1) a basic hydrologic data report published as a USGS Open-File Report, and (2) a final interpretive report published as a USGS Water-Resources Investigations Report. Water-level maps will be published as USGS Water-Resources Investigations reports at a scale of 1:24,000.



TECHNICAL SUPPORT FOR SUPERFUND SITE INVESTIGATION, PUBLICKER NATIONAL PRIORITY LIST SITE, PHILADELPHIA, PENNSYLVANIA (PA195)

PROJECT CHIEF:
Charles R. Wood

FUNDING:
Other Federal Agency; USEPA, Region III

PERIOD OF PROJECT:
October 1990 to September 1991

PROBLEM: An understanding of the hydrogeology is essential for the design and implementation of efficient remediation protocols at the Publicker National Priority List (NPL) site. Geophysical studies and technical knowledge of USGS staff can contribute detailed geologic and hydrogeologic information about the site.

OBJECTIVE: To better characterize the hydrogeology of the Publicker NPL site from existing USGS files, reports, and borehole geophysical studies, and to provide technical support to USEPA staff.

APPROACH: Assist USEPA in the compilation of data from USGS files and published and unpublished reports for Pennsylvania and New Jersey. Advise USEPA on monitor well location, construction, and water-level recording instruments. Collect geophysical borehole log data on a maximum of 24 wells.

PROGRESS: Geophysical logging complete. Water-level measurements continuing.

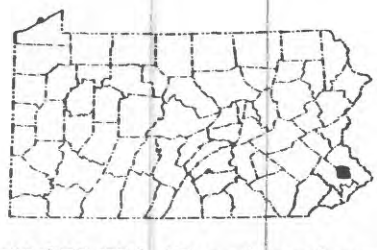
PLANS: Begin information compilation, advise USEPA on monitor well locations, assist USEPA in constructing and instrumenting monitor wells. Provide borehole geophysics data collection for selected monitor sites.

ROLE OF ABANDONED MULTI-AQUIFER WELLS IN REGIONAL GROUND-WATER CONTAMINATION, BUCKS AND MONTGOMERY COUNTIES, PENNSYLVANIA (PA196)

PROJECT CHIEF:
Ronald A. Sloto

FUNDING:
Other Federal Agency; USEPA, Region III

PERIOD OF PROJECT:
October 1990 to September 1992



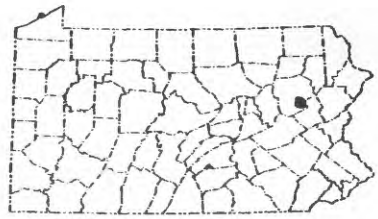
PROBLEM: Three hazardous-waste sites are located in the study area. Three public water suppliers use the Stockton Sandstone in the vicinity of these sites. The number of improperly abandoned (not properly plugged) multi-aquifer supply wells and poorly constructed monitoring wells is unknown, but potentially large. Multi-aquifer wells that connect several water-bearing zones can cause, contribute to, or exacerbate the spread of contamination from a hazardous-waste site into uncontaminated parts of aquifers.

OBJECTIVE: (1) Identify wells near hazardous-waste sites that intersect several water-bearing zones and could potentially contribute to the spread of contaminants in the Stockton Sandstone; (2) quantify the magnitude of internal borehole flow in selected wells; (3) quantify the amount of contaminant that could potentially move up or down the borehole in selected wells; (4) identify all sources that may have contributed to the contamination of the Stockton Sandstone and determine the fate of these contaminants in the aquifer system; and (5) test the effectiveness of remedial action to correct the problems caused by poorly constructed wells and improperly abandoned wells.

APPROACH: A well inventory will be conducted to obtain well locations, geological and driller logs, depth, casing length, depth of water-bearing zones, and yield of water-bearing zones. About 35 wells will be selected for geophysical logging, which will determine the location of water-bearing zones, direction and rate of fluid movement within the borehole, and quantity of water moving through the borehole. Approximately 85 water samples will be taken from wells; an additional 20 samples will be quality assurance samples. Water from all logged wells will be sampled. Samples will be taken from one or more intervals of borehole in which fluid is moving. Analytical results will be used to estimate the quantity of contaminants moving between water-bearing zones in multi-aquifer wells. One abandoned multi-aquifer well contributing to ground-water contamination will be selected to test the effectiveness of remediation.

PROGRESS: Geophysical logging has been completed for most wells that are accessible. Velocity measurements show most boreholes have flow between yield zones.

PLANS: Well inventory, geophysical logging, and most sampling of ground water will be done. Data will be continuously analyzed. Report outline will be prepared.



PRELIMINARY CHARACTERIZATION OF GROUND-WATER QUALITY OF THE MAUCH CHUNK FORMATION IN CENTRAL-NORTHEASTERN PENNSYLVANIA, INCLUDING THE C&D RECYCLING SUPERFUND SITE AND VICINITY (PA198)

PROJECT CHIEF:
Gary J. Barton

FUNDING:
Other Federal Agency; USEPA, Region III

PERIOD OF PROJECT:
October 1990 to September 1991

PROBLEM: Ground water is the principal source of drinking water in the vicinity of the C&D Recycling Superfund Site. The presence of contamination may have resulted in degradation of ground-water quality. Contaminants already identified include metals and a few organic compounds--specifically, lead and copper from wire stripping operations.

OBJECTIVE: Characterize ambient concentrations of inorganic elements and compounds in the Mauch Chunk Formation in central-northeastern Pennsylvania. This information will help USEPA more fully assess the extent and nature of ground-water contamination at and near the C&D Recycling Superfund Site.

APPROACH: Using existing data, characterize the water quality of the Mauch Chunk Formation; apply descriptive and nonparametric statistics to the data base; develop water-quality iso-concentration maps; prepare administrative report on findings for USEPA.

PROGRESS: An administrative report is in review.

PLANS: Complete report.

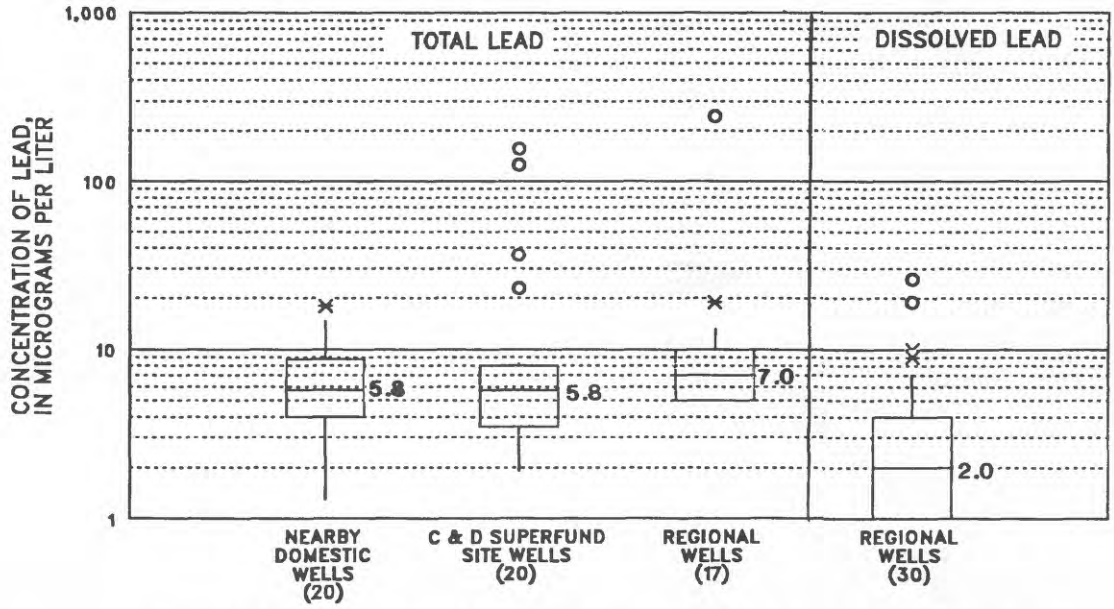


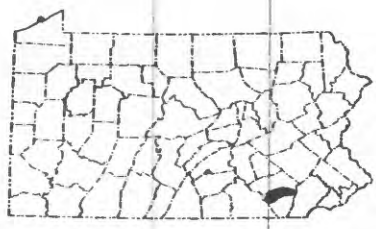
Figure 12.--Boxplot of lead in water from wells in the Mauch Chunk Formation, C&D Superfund site; domestic wells within a 1-mile radius and regional wells, central-northeastern Pennsylvania.

DEVELOPMENT OF GEOGRAPHIC INFORMATION SYSTEMS COVERAGES FOR PEQUEA AND MILL CREEK WATERSHEDS, LANCASTER COUNTY, PENNSYLVANIA (PA199)

PROJECT CHIEF:
Cynthia Barton

COOPERATOR(S):
PaDER

PERIOD OF PROJECT:
October 1990 to September 1992



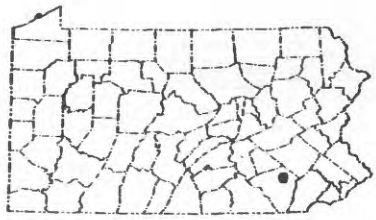
PROBLEM: Most of the criteria overlay maps that are necessary to successfully assess ground-water susceptibility to contamination do not exist in a GIS format and must be created. Available ground-water level and quality data are not adequate to provide these coverages. PaDER has asked the USGS to provide some of the necessary data and maps, including GIS coverages summarizing up-to-date information on bedrock geology, springs and wells, hydrogeologic units, the water table, ground-water quality, sinkholes, and related hydrologic data, so that they may properly delimit the range of ground-water susceptibility to contamination.

OBJECTIVE: To develop maps and related ARC/INFO GIS coverages and attributes of selected water-resource information for the Pequea and Mill Creek Watersheds. The following maps and coverages will be developed (scale = 1:24,000): (1) bedrock geology; (2) spring and well locations with associated hydrogeologic data; (3) hydrogeologic units, including associated hydrologic properties such as specific capacity or average hydrologic conductivity; (4) water table altitude and thickness of the unsaturated zone; (5) ground-water quality, especially nutrients and pesticides; and (6) sinkholes and closed depressions.

APPROACH: The USGS will generate digital GIS coverages of hydrologic data that are compatible with other related GIS geographic and land-use information being developed by other Federal and State agencies. To provide some of these coverages, additional ground-water level and quality data will be collected. USEPA will provide, in digital format at a 1:24,000 scale, the base map, including roads and hydrography (streams) developed by the Lancaster County Planning Commission. USEPA will confirm the accuracy of this map.

PROGRESS: Progress has been made toward gathering existing well-construction, water-level, topography, and water-quality information. Drainage basin divides have been digitized and maps locating sinkholes and closed depressions have been obtained from PaDER. A preliminary network of wells has been established and plans for well-water sampling and water-level measurements have been made.

PLANS: Include field data (ground-water levels and nutrient-pesticide analyses) in previously created GIS coverages; continue creating GIS coverages for hydrogeologic units and water-quality maps; create GIS water-table maps; and complete a planned report summarizing the map development.



THE EFFECTIVENESS OF AGRICULTURAL BEST- MANAGEMENT PRACTICES IN IMPROVING GROUND-WATER QUALITY IN A 55-ACRE FIELD SITE NEAR EPHRATA, LANCASTER COUNTY, PENNSYLVANIA (PA206)

PROJECT CHIEF:
David W. Hall

COOPERATOR(S):
PaDER, Bureau of Soil and Water Conservation

PERIOD OF PROJECT:
October 1990 to September 1994

PROBLEM: A cause-effect relation between changes in agricultural activity and changes in ground-water quality is difficult to assess due to the complex nature of the hydrogeologic system and variable climatic conditions. Three years of additional ground-water-quality data, collected when the ground water has had time to be affected by reductions in applied nitrogen fertilizers, will allow for increased significance of statistical analysis used to evaluate the effects of nutrient management at a site near Ephrata, Pennsylvania.

OBJECTIVE: The objective of the proposed study is to extend ground-water monitoring at a 55-acre field site to determine the effects of nutrient management on ground-water quality in a small, intensively agricultural, carbonate basin, by examining water-quality changes in relation to climatic and agricultural-activity changes.

APPROACH: Monitoring will be continued for three years. Data will be collected at six wells and a spring at Field-Site 2. Four wells and the spring will be sampled monthly during nonrecharge periods and two wells will be sampled quarterly. All samples will be analyzed for nitrate concentration. In addition to ground-water nitrate-concentration data, water levels will be recorded at the six wells, and detailed precipitation quantity, soil, and agricultural-activity data will continue to be collected.

PROGRESS: New project.

PLANS: Monitoring will continue. Data will be collected at six wells and a spring at Field-Site 2. Four wells and the spring will be sampled monthly during nonrecharge periods. All samples will be analyzed for nitrate concentration. Water levels will be recorded at the six wells and detailed precipitation quantity and agricultural-activity data will be collected. Preliminary statistical analyses will be performed. Changes in loads of fertilizer applied to the site will be correlated with changes in ground-water nitrate concentrations. A report on the effectiveness of agricultural BMPs in improving ground-water quality is planned.

NATIONAL WATER-QUALITY ASSESSMENT (NAWQA) PROGRAM: LOWER SUSQUEHANNA RIVER BASIN STUDY UNIT (PA207)

PROJECT CHIEF:
Kevin J. Breen

COOPERATOR(S):
Federal Program

PERIOD OF PROJECT:
Continuous; first 10-year cycle October 1990 to September 2000

PROBLEM: Comprehensive information on water-quality conditions and trends, collected and analyzed on a nationally-consistent, long-term basis, is needed by policy makers and water managers for evaluating the effectiveness of water-quality management programs and for use in predicting the likely effects of changes in land- and water-management practices. Policies and practices affecting surface- and ground-water resources in the Susquehanna River basin are important for protection of human health and environmental health for millions of residents in Pennsylvania, Maryland, and the Chesapeake Bay region.

OBJECTIVES: (1) Describe current water-quality conditions in the lower Susquehanna River basin; (2) define long-term trends (or lack of trends) in water quality; and (3) identify, describe, and explain, as possible, the major factors that affect observed water-quality conditions and trends.

APPROACH: (1) Identify major water-quality issues and sources of data by establishing contacts with Federal, State, and local agencies, and with representatives of basin commissions, colleges and universities, private consultants, and industry. Select individuals to serve on a technical steering committee for the project. (2) Use retrospective analyses of data, guidance from steering committee, and results of reconnaissance sampling to develop a work plan. (3) Collect chemical and biological data from networks of fixed, synoptic, and case study sites using established NAWQA protocols. (4) Develop and use ancillary data, such as land use, to relate observed water-quality conditions to environmental factors and processes. (5) Make information from the study available to the NAQWA National synthesis project, the technical steering committee, the water-resources community, and to the public through meetings and published reports.

PROGRESS: New project.

PLANS: Implementation of the investigation program.

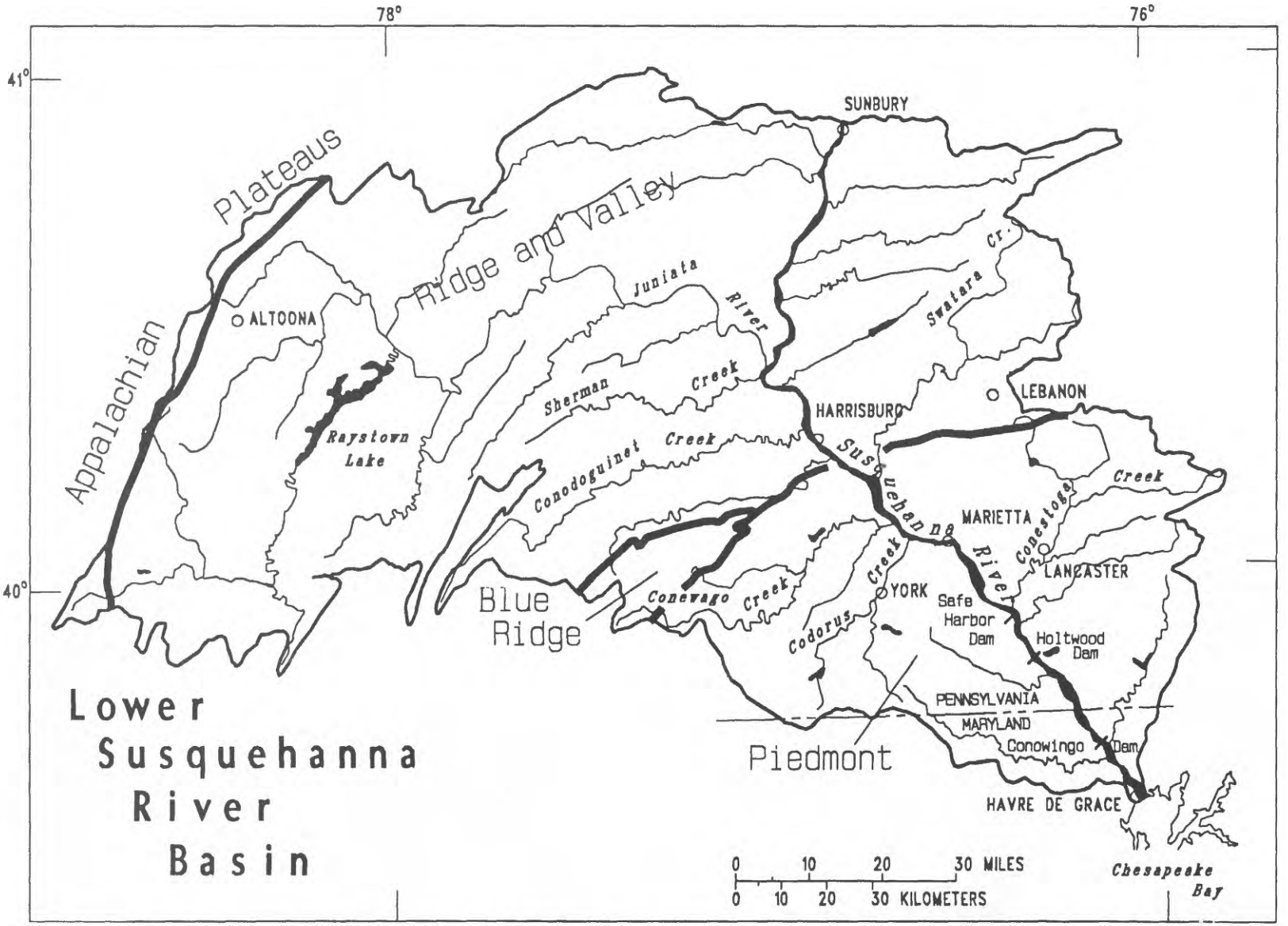


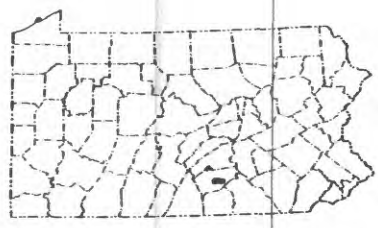
Figure 13.--Location and selected geographic features of Lower Susquehanna River basin study unit.

TRANSPORT OF PESTICIDES IN THE UNSATURATED ZONE OVERLYING A CARBONATE ROCK AQUIFER (PA208)

PROJECT CHIEF:
Daniel J. Hippe

COOPERATOR(S):
PaDER, Bureau of Water Quality Management

PERIOD OF PROJECT:
October 1990 to September 1992



PROBLEM: Pesticides are contaminating ground water through their normal agricultural use. The key to control of ground-water contamination from pesticides is to understand the processes that control ground-water recharge and contaminant transport through the unsaturated zone. Carbonate rock aquifers are an abundant source of ground water, but are highly susceptible to agricultural contamination. An improved understanding of the processes that control ground-water recharge and contaminant transport through the residual soils that overly carbonate aquifers will be of value to design, implement, and monitor management practices to minimize negative impacts of agriculture on ground-water quality in the aquifers.

OBJECTIVE: The proposed field study will characterize the processes that control ground-water recharge and pesticide transport within residual soils developed over a carbonate rock aquifer. Emphasis will be on the transport of triazine and triazine metabolites in macropore and micropore systems through the unsaturated zone to the aquifer.

APPROACH: The project will be conducted at a field site in the Cumberland Valley of Pennsylvania that is in corn production using conventional tilling methods and triazine herbicides for weed control. Work at the site will be comprised of an initial site characterization and subsequent soil-moisture monitoring and water-quality sampling of the unsaturated zone and shallow ground water. The unsaturated zone will be evaluated for storage and transport of pesticides based on description and sampling of trenches and split spoon samples from drill holes. Concentrations and distribution coefficients of selected pesticides and pesticide metabolites will be determined from analysis of whole soil samples and pore squeezings, and will be corrected for organic carbon content of the soil material. Ground-water recharge rates and pesticide transport rates will be evaluated using a combination of trench and suction lysimeters, soil tensiometers, and ground-water monitoring wells.

PROGRESS: New project.

PLANS: To design, install, and operate monitoring system at a field site in Cumberland County. Sample for pesticides in unsaturated zone materials, soil water, and ground water. Monitor soil-moisture potential, precipitation, and ground-water levels. An interpretative report will follow completed investigation.

Recently Completed Projects

The following is a list of completed projects that are in various stages of preparation, but manuscripts have not received Director's approval nor an assigned report number. Descriptions of these projects are available in U.S. Geological Survey Open-File Reports 89-273 and 87-475.

PA124 Impacts of Surface Mining on Water Quality of the Stony Fork Watershed, Fayette County, Pennsylvania

PA159 Assessment of Nutrient Sources in the Susquehanna River Basin

PA168 Ground-Water Quality of Erie County, Pennsylvania

PA170 Radium and Radon Occurrence in Ground Water of the Chickies Formation, Southeastern Pennsylvania

PA172 Ground-Water Resources of Chester County, Pennsylvania

PA173 Evaluation of the Transferability of a Hydrologic Model of a Surface-Mined Basin in Fayette County, Pennsylvania

PA181 Potential Impacts of Climate Change on the Delaware River Basin Water Resources, Pennsylvania

PA182 Effect of Land Use and Organochlorine Insecticides on Benthic-Invertebrate Diversity Indices, Chester County, Pennsylvania

PA185 Use of Multiple Stable Isotopes to Distinguish Sources of Nitrogen Contamination in the Susquehanna River Basin, Pennsylvania

Publications of the U.S. Geological Survey

General Information

The U.S. Geological Survey announces all its publications in a monthly report "New Publications of the Geological Survey." Subscriptions to this monthly listing are available upon request to the U.S. Geological Survey, 582 National Center, Reston, VA 22092. All publications are for sale unless specifically stated otherwise. Prices, which are subject to change, are not included here. Prepayment is required and information on price and availability should be obtained before placing an order. The "U.S. Geological Survey Yearbook" provides a comprehensive description of the Federal Government's largest earth-science agency; copies may be purchased at the address where professional papers are sold. Summaries of research in progress and results of completed investigations are published each fiscal year in the professional paper series "Geological Survey Research." A pamphlet entitled "Geologic and Water-Supply Reports and Maps for Pennsylvania and New Jersey," which includes reports of the geology and other water-resources reports, is available at cost upon request to: Map Distribution Section, U.S. Geological Survey, Federal Center, Box 25286, Denver, CO 80225, phone (303) 236-7477.

Water-Resources Information

A monthly summary of the national water situation is presented in the "National Water Conditions." Records of streamflow, ground-water levels, and quality of water were published for many years as Geological Survey water-supply papers as explained below.

Streamflow Records

Records of daily flows of streams prior to 1971 were published in the Water-Supply Paper series "Surface-Water Supply of the United States," which was released in numbered parts as determined by natural drainage basins. Until 1961, this was an annual series. Monthly and yearly summaries of these data were compiled in two reports: "Compilation of Records of Surface Waters of the United States through 1950," and "Compilation of Records of Surface Waters of the United States, October 1950 to September 1960." For 1961-70, 5-year compilations were published. Data for Pennsylvania are published in Parts 1, 3, and 4. Daily streamflow records also were published on a State-boundary basis during 1961-74.

Ground-Water Records

Ground-water levels and artesian pressures in observation wells prior to 1975 were reported by geographic areas in a 5-year Water-Supply Paper series. Data for Pennsylvania are in "Ground-Water Levels in the United States, Northern States."

Quality-of-Water Records

Data on quality of surface water prior to 1971 were published annually in the Water-Supply Paper series "Quality of Surface Waters of the United States," which also was released in numbered parts as determined by natural drainage basins. Data for Pennsylvania are in Parts 1, 3, and 4. For water years 1964-74, these data also were released annually on a State-boundary basis.

Data reports covering the years 1971 through 1974 were published by the Geological Survey and archived by the National Technical Information Service, and were retroactively numbered and included in the state water-data report series. Beginning with the 1975 water year, these series were replaced by a new publication series "U.S. Geological Survey Water-Data Reports." This series combines under one cover streamflow data, water-quality data for surface water and ground water, and ground-water level data for each state. For Pennsylvania, the title is "Water Resources Data for Pennsylvania--Water Year (date)," and is published in three volumes for each water year. Volume 1.--Delaware River Basin; Volume 2.--Susquehanna and Potomac River Basins; and Volume 3.--Ohio River and St. Lawrence River Basins. A limited supply of current volumes are available from the District office. Additional volumes 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

Methods for estimating the magnitude and frequency of floods for selected streams are given in the Water-Supply Paper series "Magnitude and Frequency of Floods in the United States," which is composed of reports released in parts by drainage basins; data for Pennsylvania are in Parts 1, 3, and 4. The U.S. Geological Survey also outlines flood-prone areas on topographic maps as part of a nationwide Federal program for managing flood losses. In Pennsylvania, 757 of these maps have been completed.

Publications of the Water Resources Division

The Water Resources Division of the U.S. Geological Survey is the Nation's lead agency in the collection of water data and the dissemination of information on water resources. The Division makes water data and information readily and equally available to water managers, policymakers, the scientific community, and the public in formats that meet their needs.

The U.S. Geological Survey has published the results of its studies for more than 100 years. The information is multipurpose, and after its initial use, becomes a basis for future resource evaluation and water-management decisions. The Water Resources Division releases its information through several publication series, explained below, and through computerized systems, accessible through NAWDEX and WATSTORE (see page 13).

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

Water Supply Paper	Significant interpretive results of hydrologic investigations that are considered to be of broad interest.
Professional Paper	Comprehensive or topical reports on any earth-science subject of interest to multi-discipline scientific audiences.
Bulletin	Significant interpretive results of earth-science investigations of broad interest, including computer applications.
Circular	Summaries of topical investigations or programs that are of short-term or local interest.
Map Series	Such as Hydrologic Investigations Atlas--Significant results of hydrologic investigations presented in map format.
Techniques of Water-Resources Investigations	Reports on methods and techniques used in collecting, analyzing, and processing hydrologic data for technically-oriented audiences.
Geological Survey Yearbook	Significant activities of the Water Resources Division that are summarized each year for general audiences.
Water-Resources Investigations	Comprehensive or topical interpretive reports, and maps mainly of local or short-term interest, for interdisciplinary audiences.
Open-File Book and Map	Compilations of data and preliminary interpretive reports of limited interest, or reports awaiting formal publication that require interim release.
Water-Data	Water year data on streamflow, ground-water levels, and quality of surface water and ground water for each state, Puerto Rico, Virgin Islands, and the Trust Territories.
National Water Conditions	A monthly news release that summarizes the national water situation for water-resources-oriented audiences.

With the exception of the "National Water Conditions," which is a form of news release, all the above publication series are listed in three catalogs--"Publications of the Geological Survey, 1879-1961," "Publications of the Geological Survey, 1962-1970," and "Publications of the Geological Survey, 1971 through 1981"--and in yearly supplements to these catalogs for 1982 through 1989.

As new publications are released, they are announced in a monthly list, "New Publications of the Geological Survey," to which a free subscription is available by writing to the U.S. Geological Survey, 582 National Center, Reston, VA 22092.

Many items of scientific interest are published in technical and scientific journals to make the information readily available to those in related fields of study. Other reports of local interest are published by cooperating State agencies and made available within the State.

A report--U.S. Geological Survey Circular 900, "Guide to Obtaining USGS Information"--describes sources of U.S. Geological Survey information and shows in tabular form the types of U.S. Geological Survey products and where they are available. (See below for ordering information.)

To Obtain Publications

Professional papers, bulletins, water-supply papers, techniques of water-resources investigations, water-resources investigations reports, circulars, publications of general interest (such as leaflets, pamphlets, booklets), single copies of the Earthquake Information Bulletin, Preliminary Determination of Epicenters, and some miscellaneous reports, including some from the foregoing series that have gone out of print at the Superintendent of Documents, are obtainable by mail from the U.S. Geological Survey, Books and Open-File Reports, Federal Center, Building 41, Box 25425, Denver, CO 80225.

Certain U.S. Geological Survey reports, including most of the Water Resource Investigations (WRI) series released before 1982, "Water Resources Data - [State] Water Year [year]," beginning with the 1975 issues, and many compilations of data, can be purchased only from the National Technical Information Service (NTIS). New U.S. Geological Survey reports that are available only from NTIS are cited in the monthly list, "New Publications of the U.S. Geological Survey." For information on obtaining these reports, contact: National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 2216, phone (703) 737-4650.

U.S. Geological Survey Water-Supply Papers

WSP 106. Water resources of the Philadelphia district, by Florence Bascom. 1904.

WSP 108. Quality of water in the Susquehanna River drainage basin, by M.O. Leighton, with an introductory chapter on Physiographic features, by G.B. Hollister. 1904.

WSP 109. Hydrography of the Susquehanna River drainage basin, by J.C. Hoyt and R.H. Anderson. 1905.

WSP 161. Quality of water in the upper Ohio River basin and at Erie, Pennsylvania, by S.J. Lewis. 1906.

WSP 799. The floods of March 1936--Part 2, Hudson River to Susquehanna River region. 1937 (1938).

WSP 800. The floods of March 1936--Part 3, Potomac, James and upper Ohio River; with a section on the Weather associated with the floods of March 1936, by Stephen Lichtblau. 1937 (1938).

WSP 915. Major winter and nonwinter floods in selected basins in New York and Pennsylvania, by W.B. Langbein and others. 1947.

WSP 1134-B. Floods of July 18, 1942, in north-central Pennsylvania, by W.S. Eisenlohr, Jr., with a section on Descriptive details of the storm and floods, by J.E. Stewart. 1952, p. 59-158.

WSP 1420. Floods of August-October 1955, New England to North Carolina, by D.B. Bogart. 1960.

WSP 1473. Study and interpretation of the chemical characteristics of natural water, by J.D. Hem. 1970.

WSP 1526. Hydraulic and hydrologic aspects of flood-plain planning, by S.W. Wiitala, K.R. Jetter, and A.J. Sommerville. 1961.

WSP 1532-C. Effects of agricultural conservation practices on the hydrology of Corey Creek basin, Pennsylvania, 1954-60, by B.L. Jones. 1966.

WSP 1532-E. Hydrology and sedimentation of Corey Creek and Elk Run basins, northcentral Pennsylvania, by L.A. Reed. 1971.

WSP 1532-F. Appraisal of stream sedimentation in the Susquehanna River basin, by K.F. Williams and L.A. Reed. 1972.

WSP 1532-H. Sediment transport by streams draining into the Delaware Estuary, by L.J. Mansue and A.B. Commings. 1974.

WSP 1535-P. Chemical composition of atmospheric precipitation in the northeastern United States, by F.J. Pearson, Jr., and D.W. Fisher. 1971.

WSP 1539-H. Ground-water resources of Olmsted Air Force Base, Middletown, Pennsylvania, by Harold Meisler and S.M. Longwill. 1961.

WSP 1586-B. Salinity of the Delaware Estuary, by Bernard Cohen and L.T. McCarthy, Jr. 1962.

WSP 1586-G. Fresh-water discharge--salinity relations in the tidal Delaware River, by W.B. Keighton. 1966.

WSP 1619-W. Chemical quality of surface waters in Pennsylvania, by C.N. Durfor and P.W. Anderson. 1963.

WSP 1779-B. Variations in the chemical character of the Susquehanna River at Harrisburg, Pennsylvania, by P.W. Anderson. 1963.

WSP 1779-C. Chemical quality of surface water in the West Branch Susquehanna River basin, Pennsylvania, by E.F. McCarren. 1964.

WSP 1779-X. Quality of Delaware River water at Trenton, New Jersey, by L.T. McCarthy, Jr., and W.B. Keighton. 1964.

WSP 1798-M. Sediment characteristics of five streams near Harrisburg, Pennsylvania, before highway construction, by L.A. Reed. 1976.

WSP 1798-N. Hydrology and sedimentation of Bixler Run basin, central Pennsylvania, by L.A. Reed. 1976.

WSP 1800. The role of ground water in the national water situation, by C.L. McGuinness. 1963.

WSP 1809-O. Delaware River water quality, Bristol to Marcus Hook, Pennsylvania, August 1949 to December 1963, by W.B. Keighton. 1965.

WSP 1812. Public water supplies of the 100 largest cities in the United States, 1962, by C.N. Durfor and Edith Becker. 1964.

U.S. Geological Survey Circulars

C-104. Water resources of southeastern Bucks County, Pennsylvania, by J.B. Graham, J.W. Mangan, and W.E. White, Jr. 1951.

C-174. Water resources of the Lake Erie shore region in Pennsylvania, by J.W. Managan, D.W. Van Tuyl, and W.F. White, Jr. 1952.

C-204. Floods in Youghiogheny and Kiskiminetas River basins, Pennsylvania and Maryland, frequency and magnitude. 1952.

C-257. The use of water in Pennsylvania, 1951, by J.W. Mangan and J.B. Graham. 1953.

C-315. Water resources of the Pittsburgh area, Pennsylvania, by Max Noecker, D.W. Greenman, and N.H. Beamer. 1954.

C-377. Floods of August 1955 in the northeastern States. 1956. (See Water-Supply Paper 1420.)

C-439. Time and travel of water in the Ohio River, Pittsburgh to Cincinnati, by R.E. Steacy. 1961.

C-526. Stream quality in Appalachia as related to coal-mine drainage, 1965, by J.E. Biesecker and J.R. George. 1966.

C-554. Hydrology for urban land planning--A guidebook on the hydrologic effects of urban land use, by L.B. Leopold. 1968.

C-601-A. Water for the cities--The outlook, by W.J. Schneider and A.M. Spieker. 1969 (1970).

C-601-D. Water as an urban resource and nuisance, by H.E. Thomas and W.J. Schneider. 1970.

C-601-E. Sediment problems in urban areas, by H.P. Guy. 1970.

C-601-F. Hydrologic implications of solid-waste disposal, by W.J. Schneider. 1970.

C-601-G. Real-estate lakes, by D.A. Rickert and A.M. Spieker. 1971 (1972).

C-601-H. Role of water in urban planning and management, by W.J. Schneider, D.A. Rickert, and A.M. Spieker. 1973.

C-601-I. Water facts and figures for planners and managers, by J.H. Feth. 1973.

C-601-J. Extent and development of urban flood plains, by W.J. Schneider and J.E. Goddard. 1974.

C-601-K. An introduction to the processes, problems, and management of urban lakes, by L.J. Britton, R.C. Averett, and R.F. Ferreira. 1975. (Circular 601 issued only as separate chapters under the general title "Water in the urban environment.")

C-645. A procedure for evaluating environmental impact, by L.B. Leopold, F.E. Clark, B.B. Hanshaw, and J.R. Balsley. 1971.

C-670. Fluvial-sediment discharge to the ocean from the conterminous United States, by W.F. Curtis, J.K. Culbertson, and E.B. Chase. 1973.

C-685. Dissolved-solids discharge to the oceans from the conterminous United States, by D.K. Leifeste. 1974.

C-686. Large rivers of the United States, by K.T. Iseri and W.B. Langbein. 1974.

C-703. Water demands for expanding energy development, by G.H. Davis and L.A. Wood. 1974.

C-719. The National Stream Quality Accounting Network (NASQAN)--Some questions and answers, by J.F. Ficke and R.O. Hawkinson. 1975.

C-728. Landsliding in Allegheny County, Pennsylvania, by R.P. Briggs, J.S. Pomeroy, and W.E. Davies. 1975.

C-745. Water consumption by nuclear power plants and some hydrological implications, by E.V. Giusti and E.I. Meyer. 1977 (1978).

C-747. Environmental geology, Allegheny County and vicinity, Pennsylvania--Description of a program and its results, by R.P. Briggs. 1977.

C-779. Geologic disposal of high-level radioactive wastes--Earth-science perspectives, by J.D. Bredehoeft, A.W. England, D.B. Stewart, N.J. Trask, and I.J. Winograd. 1978.

C-832. Estimating the costs of landslide damage in the United States, by R.W. Fleming and F.A. Taylor. 1980.

C-900. Guide to obtaining USGS information, by K. Dodd, H.K. Fuller, and P.F. Clarke. 1985. (This circular supersedes C-777.)

Journal of Research of the U.S. Geological Survey

Armbruster, J.T., 1976, An infiltration index useful in estimating low flows of drainage basins: v. 4, p. 533-538.

Barker, J.L., 1976, Effects of air injection at Prompton Lake, Wayne County, Pennsylvania: v. 4, no. 1, p. 19-25.

Ritter, J.R., 1974, The effects of the Hurricane Agnes Flood on channel geometry and sediment discharge of selected streams in the Susquehanna River basin, Pennsylvania: v. 2, no. 6, p. 753-761.

U.S. Geological Survey Hydrologic Investigations Atlases

Hydrologic Investigations Atlases are sold by Map Distribution Section, U.S. Geological Survey, Federal Center, Box 25286, Denver, CO 80225.

HA-57. Floods at Harrisburg, Pennsylvania, by R.E. Steacy and I.A. Heckmiller. 1962.

HA-61. Stream composition of the conterminous United States, by F.H. Rainwater. 1962.

HA-194. Generalized maps showing annual runoff and productive aquifers in the conterminous United States, compiled by C.L. McGuinnes. 1964.

HA-198. Water resources of the Appalachian region, Pennsylvania to Alabama, by W.J. Schneider and others. 1965.

HA-199. Preliminary map of the conterminous United States showing depth to and quality of shallowest ground water containing more than 1,000 parts per million dissolved solids, by J.H. Feth and others. 1965.

HA-200. Chemical quality of public water supplies of the United States and Puerto Rico, 1962, by C.N. Durfor and Edith Becker. 1964.

HA-212. Annual runoff in the conterminous United States, by J.F. Blakey. 1966.

HA-246. Floods at Easton, Pennsylvania - Phillipsburg, New Jersey, by G.M. Farlekas. 1967.

HA-248. Floods on the Schuylkill River from Conshohocken to Philadelphia, Pennsylvania, by A.T. Alter. 1967.

HA-295. Ground-water resources of the Appalachian Region, by G.G. Wyrick. 1968.

HA-335. Water quality in the Delaware Estuary for the two years of drought, 1965-1966, from Trenton, New Jersey, to Reedy Island, Delaware, by W.B. Keighton. 1969.

HA-483. Extent and frequency of floods on the Schuylkill River near Norristown, Pennsylvania, by W.F. Busch and L.C. Shaw. 1973.

HA-523. Flood of June 1972 in the Wilkes-Barre area, Pennsylvania, by H.N. Flippo and L.W. Lenfest, Jr. 1973.

HA-530. Flood of June 1972 in the Harrisburg area, Pennsylvania, by L.V. Page and L.C. Shaw. 1974.

HA-541. Flood of June 22-23, 1972, at Lock Haven, Pennsylvania, by H.N. Flippo, Jr. 1975.

HA-676. Water-table map of Philadelphia, Pennsylvania, 1976-1980, by G.N. Paulachok and C.R. Wood. 1984.

HA-705. Distribution of water-quality characteristics that may indicate the presence of acid mine drainage in the eastern coal province of the United States, by K.L. Wetzel and S.A. Hoffman. 1989.

U.S. Geological Survey Water-Supply Papers--Continued

WSP 1829. Swatara Creek basin of southeastern Pennsylvania--An evaluation of its hydrologic system, by W.T. Stuart, W.J. Schneider, and J.W. Crooks. 1967.

WSP 1835. Chemical quality of surface water in the Allegheny River basin, Pennsylvania and New York, by E.F. McCarren. 1967.

WSP 1871. Water data for metropolitan areas, compiled by W.J. Schneider. 1968.

WSP 1879-H. Water quality and discharge of streams in the Lehigh River basin, Pennsylvania, by E.F. McCarren and W.B. Keighton. 1969.

WSP 1899-I. Streamflow from the United States into the Atlantic Ocean during 1931-60, by C.D. Bue. 1970.

WSP 1990. Annotated bibliography on artificial recharge of ground water, 1955-67, by D.C. Signor, D.J. Growitz, and William Kam. 1970.

WSP 1990-O. Water quality of streams in the Neshaminy Creek basin, Pennsylvania, by E.F. McCarren. 1972.

WSP 2020. Subsurface waste disposal by means of wells--A selective annotated bibliography, by D.R. Rima, E.B. Chase, and B.M. Myers. 1971.

WSP 2035. Geohydrologic reconnaissance of the upper Potomac River basin, by F.W. Trainer and F.A. Watkins, Jr. 1975.

WSP 2042. Mean annual runoff in the Upper Ohio River basin, 1941-70, and its historical variation, by R.M. Beall. 1978.

WSP 2054. Effectiveness of sediment-control techniques used during highway construction in central Pennsylvania, by L.A. Reed. 1978.

WSP 2072. Suspended-sediment discharge, in five streams near Harrisburg, Pennsylvania, before, during, and after highway construction, by L.A. Reed. 1980.

WSP 2250. National water summary 1983; hydrologic events and issues. 1984.

WSP 2256-A. Distribution and transport of trace substances in the Schuylkill River basin from Berne to Philadelphia, Pennsylvania, by J.K. Stamer, T.H. Yorke, and G.L. Pederson. 1985. (Supersedes Open-file report 83-265.)

WSP 2256-B. Effects of low-level dams on the distribution of sediment, trace metals, and organic substances in the lower Schuylkill River basin, Pennsylvania, by T.H. Yorke, J.K. Stamer, and G.L. Pederson, 1985.

WSP 2262. Organochlorine pesticide and polychlorinated biphenyl residues at four trophic levels in the Schuylkill River, Pennsylvania: *in* Selected Papers in the Hydrologic Sciences, by J.L. Barker. 1984.

WSP 2275. National water summary 1984; hydrologic events, selected water-quality trends, and ground-water resources. 1985.

WSP 2276. Techniques for estimating streamflow characteristics in the Eastern and Interior coal provinces of the United States, by K.L. Wetzel and J.M. Bettandorff. 1986.

WSP 2300. National water summary 1985; hydrologic events and surface-water resources. 1986.

WSP 2325. National water summary 1986; hydrologic events and ground-water quality. 1988.

WSP 2284. Evaluation of the ground-water resources of the Lower Susquehanna River basin, Pennsylvania and Maryland, by J.M. Gerhart and G.J. Lazorchick. 1988.

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PP 271. The natural channel of Brandywine Creek, Pennsylvania, by M.G. Wolman. 1955.

PP 282-F. Drainage basins, channels, and flow characteristics of selected streams in central Pennsylvania, by L.M. Brush, Jr. 1961.

PP 381. Water resources of the Delaware River basin, by G.G. Parker, A.G. Hely, W.B. Keighton, F.H. Olmsted, and others. 1964 (1965).

PP 417-A. Relation between ground water and surface water in Brandywine Creek basin, Pennsylvania, by F.H. Olmsted and A.G. Hely. 1962.

PP 417-B. Some relations between streamflow characteristics and the environment in the Delaware River region, by A.G. Hely and F.H. Olmsted. 1963.

PP 473-B. Field investigation of mine waters in the Northern Anthracite field, Pennsylvania, by Ivan Barnes, W.T. Stuart, and D.W. Fisher. 1964.

PP 575-C. Geological Survey Research 1967. Contains the following articles, which are not available separately. The construction and use of flow-volume curves, by E.G. Miller. Hydrogeologic significance of calcium-magnesium ratios in ground water from carbonate rocks in the Lancaster quadrangle, southeastern Pennsylvania, by Harold Meisler and A.E. Becher.

PP 700-B. Geological Survey Research 1970. Contains the following article, which is not available separately. High-calcium limestone deposits in Lancaster County, southeastern Pennsylvania, by A.E. Becher and Harold Meisler.

PP 701-A. Hydrology of two small river basins in Pennsylvania before urbanization, by R.A. Miller, John Troxell, and L.B. Leopold with a section on Observations of stream fauna, by Ruth Patrick and R.R. Grant, Jr. 1971 (1972).

PP 750-D. Geological Survey Research 1971. Contains the following article, which is not available separately. Relationship between ground-water levels and quality in shallow observation wells in Muddy Creek basin, southeastern York County, Pennsylvania, by D.J. Growitz and O.B. Lloyd, Jr.

PP 800-C. Geological Survey Research 1972. Contains the following article, which is not available separately. An evaluation of the use of herbicides to control aquatic weeds in six Pennsylvania recreation lakes, by J.L. Barker.

PP 813-I. Summary appraisals of the Nation's ground-water resources - Mid-Atlantic region, by Allen Sinnott and E.M. Cushing. 1978.

PP 813-J. Summary appraisals of the Nation's ground-water resources - Great Lakes region, by W.E. Weist, Jr. 1978

PP 924. Hurricane Agnes rainfall and floods, June-July 1972, by J.F. Bailey, J.L. Patterson, and J.L.H. Paulhus. 1975.

PP 1191. Storm-induced debris avalanching and related phenomena in the Johnstown area, Pennsylvania, with references to other studies in the Appalachians, by J.S. Pomeroy. 1980 (1981).

PP 1211. Johnstown-western Pennsylvania storms and floods of July 19-20, 1977, by L.R. Hoxit, R.A. Maddox, and C.F. Chappell, National Oceanic and Atmospheric Administration, and S.A. Brua, U.S. Geological Survey. 1982.

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1245-G. Carbonate rocks of Cambrian and Ordovician age in the Lancaster quadrangle, by Harold Meisler and A.E. Becher. 1968.

1331-A. Mississippian stratigraphy of northeastern Pennsylvania, by G.R. Schiner and G.E. Kimmel. 1972.

Water-Resources Investigations Reports

WRI 50-74. Stream reconnaissance for nutrients and other water-quality parameters, Greater Pittsburgh region, Pennsylvania, by R.M. Beall. 1975. (PB-241 493/AS)

WRI 76-75. Occurrence of pesticide residues in four streams draining different land-use areas in Pennsylvania, by J.F. Truhlar and L.A. Reed. 1975. (PB-242 770/AS)

WRI 76-51. Technical manual for estimating low-flow frequency characteristics of streams in the Susquehanna River basin, by J.T. Armbruster. 1976. (PB-255 455/AS)

WRI 76-57. Preimpoundment water quality of Raystown Branch Juniata River and six tributary streams, south-central Pennsylvania, by D.R. Williams. 1976. (ADA-027 387)

WRI 76-66. Preliminary results of preimpoundment water-quality studies in the Tioga River basin, Pennsylvania and New York, by J.R. Ward. 1976. (ADA-029 315)

WRI 76-84. Limnological survey of Sacony Creek basin, Berks County, Pennsylvania, by J.L. Barker and K.P. Kulp. 1976. (PB-257 270/AS)

WRI 76-111. Sediment discharge from an area of highway construction, Applemans Run basin, Columbia County, Pennsylvania, by D.A.V. Eckhardt. 1976 (1977). (PB-263 616/AS)

WRI 77-12. Flow routing in the Susquehanna River basin: Part I, effects of Raystown Lake on the low-flow frequency characteristics of the Juniata and lower Susquehanna Rivers, Pennsylvania, by J.T. Armbruster. 1977. (PB-268 981/AS)

WRI 77-55. Water-quality study of Tulpehocken Creek, Berks County, Pennsylvania, prior to impoundment of Blue Marsh Lake, by J.L. Barker, 1977. (AD A045 865)

WRI/OF 77-67. Ground-water resources of Chester County, Pennsylvania, by L.J. McGreevy and R.A. Sloto.

WRI 78-12. Regional analysis of the effects of land use on stream-water quality, methodology, and application in the Susquehanna River basin, Pennsylvania and New York, by D.J. Lystrom, F.A. Rinella, D.A. Rickert, and Lisa Zimmermann. 1978. (PB-284 185)

WRI 78-35. Sediment discharge from highway construction near Port Carbon, Pennsylvania, by R.E. Helm. 1978. (PB-280 793)

WRI 78-42. Postimpoundment survey of water-quality characteristics of Raystown Lake, Huntingdon and Bedford Counties, Pennsylvania, by D.R. Williams. 1978 (1979). (AOA-061 737)

WRI 78-53. Bacteriological water quality of Tulpehocken Creek basin, Berks and Lebanon Counties, Pennsylvania, by J.L. Barker. 1978 (1979). (ADA-057 485)

WRI 79-3. Regional stochastic generation of streamflows using an arima (1,0,1) process and disaggregation, by J.T. Armbruster. 1979. (PB-300 945/AS)

WRI 79-19. Selected water resources data, Clarion River and Redbank Creek basins, northwestern Pennsylvania--Part 2, by T.F. Buckwalter, C.H. Dodge, and G.R. Schiner. 1979. (PB-80 107 915)

WRI 79-52. Flow routing in the Susquehanna River basin: Part II--Low-flow characteristics of the Susquehanna River between Waverly, New York, and Sunbury, Pennsylvania, by D.L. Bingham. 1979. (PB-301 392)

WRI 79-85. Flow routing in the Susquehanna River basin: Part III--Routing reservoir releases in the Tioga and Chemung Rivers system, Pennsylvania, and New York, 1977, by J.T. Armbruster. 1979. (PB-301 393)

WRI 79-88. Nonpoint-source discharges in Pequea Creek basin, Pennsylvania, 1977, by J.R. Ward and D.A. Eckhardt. 1979. (PB-175 656)

WRI 80-02. Development of a digital model of ground-water flow in deeply weathered crystalline rock, Chester County, Pennsylvania, by L.J. McGreevy and R.A. Sloto. 1980 (1981). (PB-81 132 896)

WRI 80-53. Effects of strip mining the abandoned deep Anna S mine on the hydrology of Babb Creek, Tioga County, Pennsylvania, by L.A. Reed. 1980. (PB-81 121 337)

WRI 80-68. The effects of highway construction on sediment discharge into Blockhouse Creek and Steam Valley Run, Pennsylvania, by R.A. Hainly. 1981. (PB-81 202 202)

Water-Resources Investigations Reports--Continued

WRI 81-1. Preimpoundment water quality in the Tioga River basin, Pennsylvania, and New York, by J.R. Ward. 1981. (ADA-101 909)

WRI 81-69. Sedimentation in the East Branch Mahoning Creek, Clearfield and Jefferson Counties, Pennsylvania, June 1979 to June 1980, by K.L. Wetzel.

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PA107, OFR 89-620. Water resources and the hydrologic effects of coal mining in Washington County, Pennsylvania, by D.R. Williams, J.K. Felbinger, and P.J. Squillace.

PA118, WRIR 90-4131. Evaluation of agricultural best-management practices in Conestoga River headwaters, Pennsylvania: Description and water quality of the Little Conestoga Creek headwaters prior to the implementation of nutrient management, by D.K. Fishel, M.J. Brown, K.M. Kostelnik, and M.A. Howse.

PA137, WRIR 89-4023. Distribution of water-quality indicators of acid mine drainage in streams of the Interior Coal Province, eastern coal region of the United States, by S.A. Hoffman and K.L. Wetzel.

PA138, WRIR 87-4136. A feasibility study to estimate minimum surface-casing depths of oil and gas wells to prevent ground-water contamination in four areas of western Pennsylvania, by T.F. Buckwalter and P.J. Squillace.

PA140, WRIR 90-4160. Base-flow-frequency characteristics of selected Pennsylvania streams, by K.E. White and R.A. Sloto.

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PA146, OFR 90-109. Ground-water resources of cambrian and ordovician carbonate rocks in the Valley and Ridge physiographic province of Pennsylvania, by A.E. Becher.

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Cooperative Reports

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PA130. Ground-water resources of Delaware County, Pennsylvania, by W.T. Balmer.

PA110. Ground-water resources in and near the anthracite basins of Schuylkill and adjacent counties, Pennsylvania, by A.E. Becher.

PA143. Hydrogeology and ground-water quality of the glaciated valleys of Bradford, Tioga, and Potter Counties, Pennsylvania, by J.H. Williams, L.E. Taylor, and D.J. Low.

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Pennsylvania State Publications

Several Commonwealth agencies conduct water-resources investigations and present their results in State publications. The Department of Environmental Resources, Bureau of Topographic and Geologic Survey, in addition to the cooperative studies with the U.S. Geological Survey, conducts its own water resource studies and publishes the results in their Water Resource Reports Series. A bibliography of these reports can be obtained by writing:

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