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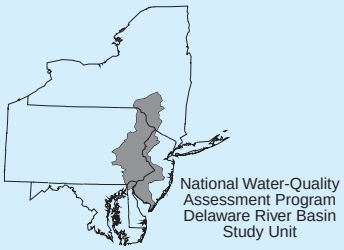
NATIONAL WATER-QUALITY ASSESSMENT PROGRAM
DELAWARE RIVER BASIN



WHAT IS THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM?

During the past 25 years, industry and government have made large financial investments in manufacturing, processing, and wastewater-treatment facilities to reduce the amount of contaminants being discharged. Although these investments have led to improved water quality across the Nation, concerns about the effects of nutrients, toxins, and pathogens on human health and that of ecological communities remain. To address the need for consistent and scientifically sound information for managing the Nation's water resources, the U.S. Geological Survey began the National Water-Quality Assessment (NAWQA) program in 1991. This program is unique in that it integrates surface- and ground-water-quality monitoring with the study of aquatic ecosystems. The goals of the NAWQA program are to (1) describe current water-quality conditions for a large part of the

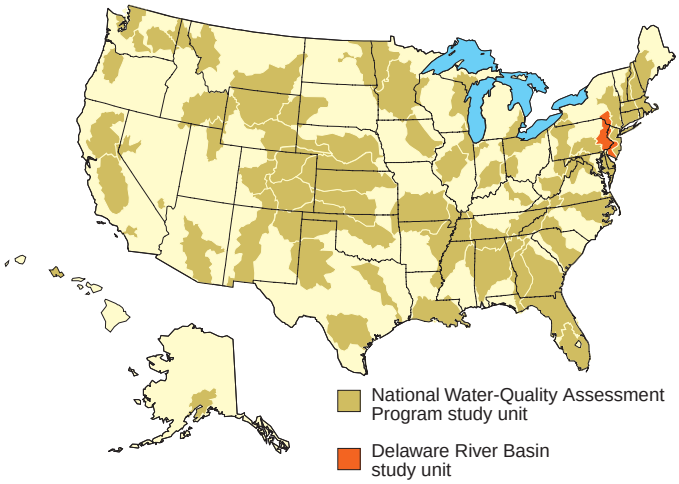


Figure 1. Location of National Water-Quality Assessment program study units.

MAJOR WATER-QUALITY ISSUES IN THE DELAWARE RIVER BASIN

Advances in the treatment of municipal and industrial waste and changes in manufacturing and processing techniques over the past 25 years have led to improved water quality in many parts of the Delaware River Basin. One indication of this improvement is the return of shad runs to the Delaware River. The presence of toxic compounds, however, still leads to consumption advisories for many fish species, and nutrient loadings adversely affect water quality and the health of ecological communities. Many of the water-quality issues in the Delaware River Basin can be related to the high human population density in the area and related activities associated with urban, industrial, and agricultural land use. Most concerns are related to human health (the quality of domestic water supply, the safety of water contact recreation, and the safety of eating game fish) and the health of ecological communities.

Some of the major water-quality issues that are currently being addressed by water-resource managers in the Delaware River Basin include–

Shad fishing on the Delaware River (Photograph by David B. Soete)

• Relation of land use to nonpoint sources of contaminants.

• Effects of natural settings on the distribution, fate, and effects of contaminants in water, sediment, and biota.

• Relations between streamflow and loadings of nutrients, contaminants, and pathogens.

• Effects of nutrients and habitat on algae and macrophytes in streams, lakes, and estuaries.

• Distribution of toxic substances, particularly polychlorinated biphenyls (PCBs), and trace elements in surface water, ground water, and biota.

• Presence of human pathogens and pesticides in drinking-water supplies and recreational waters.

• Effect of dams, impoundments, and diversions on water quality, and on the health of fish and benthic invertebrate communities.

• Development of management strategies for protecting areas of existing high water quality.

• Effects of on-lot septic systems and reduced streamflow caused by ground-water withdrawals on water quality and ecological communities.

• Distribution of natural radioactivity in domestic ground-water supplies.

• Effects of ground-water/surface-water interactions on water quality.

• Effects of coal-mine discharges on water quality and ecological communities.

The Delaware River Basin NAWQA study will characterize spatial and temporal variations in water quality and relate those changes to natural processes and human factors. This scientific characterization can be used by water-resource managers, State and local governments, citizens' groups, and planners as a basis for implementing water-quality management actions and evaluating long-term changes in water quality.

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Nation's freshwater streams and aquifers (water-bearing sediments and rocks), (2) describe how water quality is changing over time, and (3) increase our understanding of the natural and human factors that affect water quality (Leahy and others, 1990, Gilliom and others, 1995).

Assessing the quality of water in every location of the Nation would not be practical. Therefore, NAWQA investigations are conducted within 59 selected areas called study units (fig. 1). These study units encompass important river and aquifer systems in the United States and represent the diverse geographic, water-resource, land-use, and water-use characteristics of the Nation. The Delaware River Basin is one of 15 study units in which work began in 1996. Water-quality sampling in the study unit will begin in 1999. This fact sheet provides a brief overview of the NAWQA program, describes the Delaware River Basin study unit, identifies the major water-quality issues in the basin, and documents the plan of study that will be followed during the study-unit investigation.

STUDY-UNIT DESCRIPTION

The Delaware River drainage basin encompasses more than 12,700 mi^2 (square miles) and includes parts of Pennsylvania (6,465 mi^2), New Jersey (2,969 mi^2), New York (2,363 mi^2), and Delaware (968 mi^2). The study-unit area (fig. 2) includes the entire drainage basin, except for 770 mi^2 of the Coastal Plain in the State of Delaware and the tidal portions of the Delaware Estuary. About 7.2 million people live within the study unit. An additional 7 million people in New York City and northern New Jersey rely on surface water diverted from the basin for their water supply.

The headwaters of the Delaware River are in the Catskill Mountains in the northern part of the basin. Upstream from Trenton, the river drains an area of 6,780 mi^2 and has an average yearly flow of 11,700 ft^3/s (cubic feet per second) (Durlin and Schaffstall, 1997). Downstream from Trenton, the river is tidally influenced, but is not saline until south of Philadelphia. The two major tributaries to the Delaware River are the Lehigh and Schuylkill Rivers. The Schuylkill River drains an area of 1,893 mi^2, has an average yearly flow of about 2,720 ft^3/s, and discharges into the Delaware Estuary at Philadelphia. The Lehigh River drains an area of 1,359 mi^2, has an average yearly flow of about 2,890 ft^3/s, and discharges into the Delaware River at Easton, Pa.

Several large reservoirs on the headwaters of the Delaware and Lehigh Rivers are used for water supply, power generation, flood control, flow augmentation, and recreation. Three reservoirs in the upper Delaware River Basin operated by the City of New York divert up to 800 Mgal/d (million gallons per day) out of the basin (Parker and others, 1964). Reservoirs are also used to augment flow in order to maintain an average daily flow of 1,750 ft^3/s at Montague, N.J., and to maintain sufficient flow at Trenton, N.J., to control salinity in the estuary. In the summer, reservoir releases can constitute more than 70 percent of the total flow in the upper Delaware River and 40 percent or more of the total flow at Trenton.

Rafting, canoeing, and fishing are some of the major recreational uses of the upper part of the Delaware River Basin. (Photograph by David B. Soete)

Physiography and Climate

Parts of five physiographic provinces lie within the Delaware River Basin. These are the Coastal Plain, Piedmont, New England, Valley and Ridge, and Appalachian Plateaus. Topography varies from the relatively flat Coastal Plain, which consists of unconsolidated sediments, to rolling lowlands and a series of broad uplands in the Piedmont. North of the Piedmont Province, the New England and the Valley and Ridge Provinces consist of rock layers that have been deformed into a series of steep ridges and parallel folds that trend northeast-southwest. The Appalachian Plateaus occupy the upper one-third of the basin and are characterized by rugged hills with intricately dissected plateaus and broad ridges. Altitude in the basin increases from sea level in the south to more than 4,000 feet in the north. During the last major glacial advance, the Appalachian Plateaus and parts of the Valley and Ridge and the New England Provinces were glaciated. North of the line of glaciation, valleys typically are underlain by thick layers of stratified drift and till.

Average annual precipitation ranges from 42 inches in southern New Jersey to about 50 inches in the Catskill Mountains of southern New York; annual snowfall ranges from 13 inches in southern New Jersey to about 80 inches in the Catskill Mountains (Jenner and Lins, 1991). Generally, precipitation is evenly distributed throughout the year. Annual average temperatures range from 56 ^oF (degrees Fahrenheit) in southern New Jersey to 45 ^oF in southern New York.

Population and Land Use

On the basis of 1992 satellite-derived thematic mapper land-use data, it is estimated that about 60 percent of the Delaware River Basin is forested, 24 percent is agricultural, 9 percent is urban and residential, and 7 percent is surface-water bodies and miscellaneous land uses. Eighty percent of the population of the study unit lives in the Piedmont and Coastal Plain Provinces, which cover only about 40 percent of the total area. Agricultural land covers almost 30 percent of the Coastal Plain and 35 percent of the Piedmont. Both areas have almost 20 percent urban land use. Most of the population and urban land use is found along the estuary, which separates the two provinces. Although the

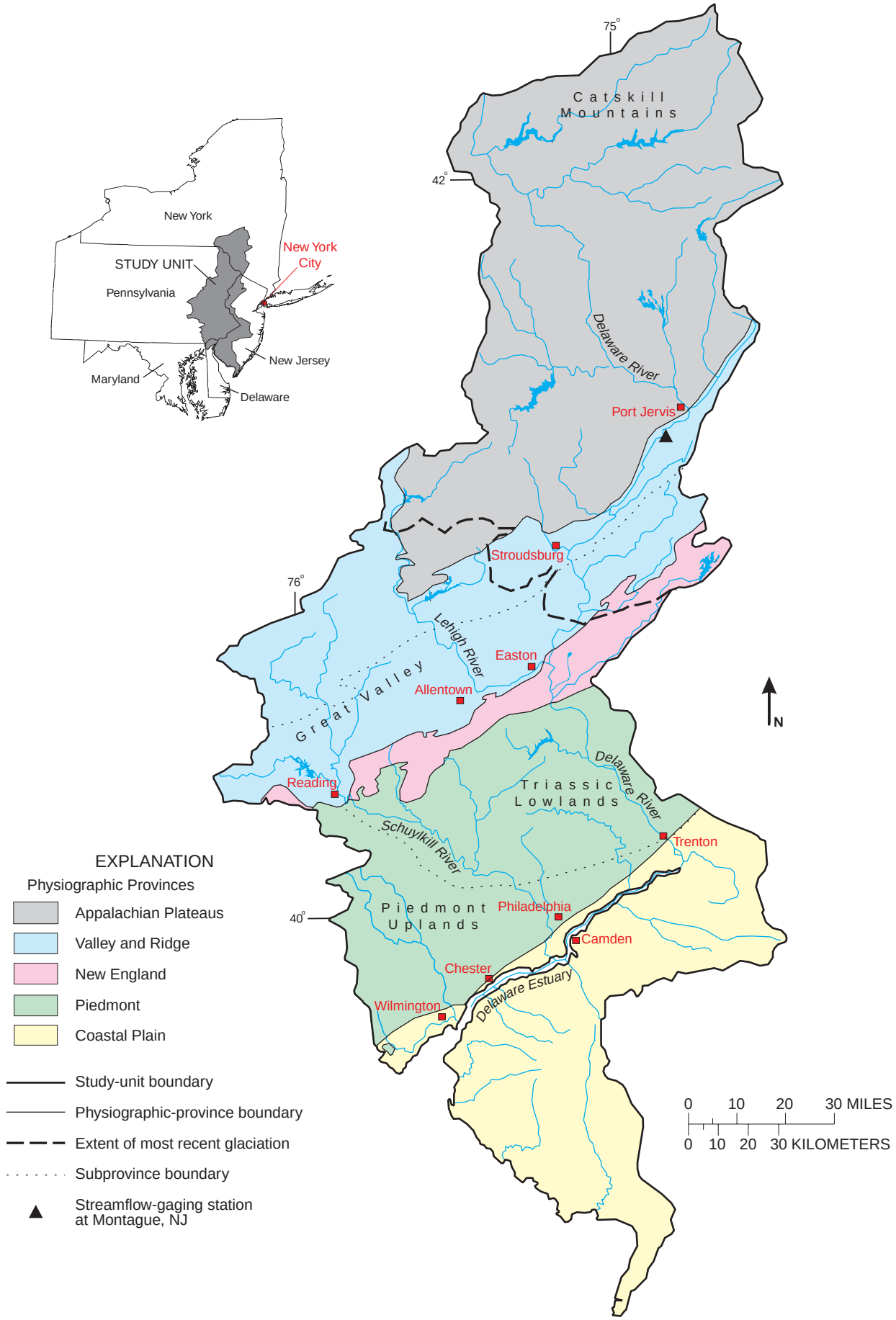

Figure 2. Delaware River Basin study unit.

The Schuylkill River flows through mining, agricultural, and urban areas before it discharges to the Delaware Estuary at Philadelphia. The river is also a major supply of public drinking water. (Photograph copyright Nathan Gasser/LibertyNet. Used with permission)

population has not increased significantly over the past 20 years, large tracts of land have become suburbanized as people have moved out of the "core" city areas around Philadelphia into the surrounding agricultural and forested areas. The Valley and Ridge Province contains 14 percent of the population and about 24 percent of the total area of the basin. The population of this province in the study unit has increased 17 percent over the past 20 years. Land use in the province is more than 33 percent agricultural and 7 percent urban. Most of this development has occurred in the valleys, and especially in the Great Valley subprovince. Most of the forested areas are found along the ridges. The northwestern part of the province was mined extensively for anthracite coal in the past, and some mining continues today. The Appalachian Plateaus Physiographic Province covers more than one-third of the study-unit area, but contains less than 3 percent of its population. Land use in the Appalachian Plateaus is more than 85 percent forest, less than 10 percent agriculture, and about 1 percent urban.

Agriculture is a major land use in parts of the Piedmont, Coastal Plain, and Valley and Ridge Physiographic Provinces. (Photograph from U.S. Department of Agriculture, Natural Resources Conservation Service)

Water Use

The Delaware River Basin Commission estimated that basinwide use of water for all purposes was about 7,337 Mgal/d in 1991 (data accessed July 1998 on the World Wide Web at URL http://www.state.nj.us/drbc/consdef.htm). This is equivalent to the mean annual streamflow of the Delaware River at Trenton, N.J. Power generation accounts for the bulk of the water use (69 percent), followed by public-supply use and self-supplied-industrial use (15 percent each). Most of the water is returned to streams and aquifers within the basin, except for about 311 Mgal/d in consumptive uses within the basin and about 900 Mgal/d in diversions out of the basin to New York City and northeastern New Jersey. About 60 percent of consumptive water use within the basin is from surface-water sources and 40 percent is from ground-water sources.

SCHEDULE OF STUDY ACTIVITIES

NAWQA study units are divided into three groups that are studied intensively on a rotational basis. The Delaware River Basin study is one of 15 NAWQA studies that began in October 1996 (the beginning of Federal fiscal year 1997) (fig. 3). The study plan and design were developed, and existing data were compiled and analyzed, during the first 2 years of the investigation; this schedule is consistent among all NAWQA studies. Beginning in fiscal year 1999, surface-water, ground-water, and biological data will be collected intensively for 3 years (termed the "high-intensity phase"). During the subsequent 6-year "low-intensity phase," water quality at selected sites assessed during the high-intensity phase will be monitored. At the conclusion of the low-intensity phase the sampling cycle is repeated. Cycling through the monitoring phases provides a long-term data set that allows NAWQA investigators to identify trends in water quality over time.

During the initial 2-year planning period, existing data and results of previous studies are compiled and reviewed to determine the primary physical, chemical, and biological factors

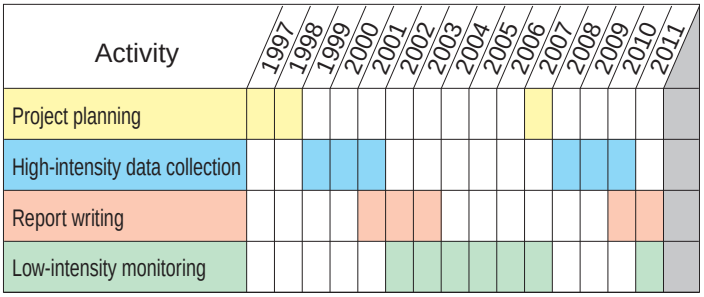

Figure 3. Schedule of study activities.

that affect water quality in the study unit and to identify gaps in the available data. Potential effects of land use and land cover, soils, geology, physiography, climate, and drainage characteristics on water quality and ecosystems are described in technical and nontechnical reports. Information obtained by reviewing previous studies, visiting existing monitoring stations and candidate sampling sites, and examining field reconnaissance data are used to design a sampling program for the study unit.

During the high-intensity phase, new physical, chemical, and biological data are collected in selected areas at local and

regional scales to document the quality of water throughout the study unit. Measurements are made to determine the chemistry of water in streams and aquifers; the quantity of suspended sediment in streams; the variety and number of fish and benthic invertebrates in streams; the types of algae in streams; and the presence and type of contaminants in fish tissue and aquifers, and biological species are selected for sampling, and certain chemical constituents are selected for analysis to represent the important water-resource and water-quality concerns in the study unit and the Nation. Results of the high- and low-intensity phases of data collection and analysis are described in technical and nontechnical reports.

ASSESSING WATER QUALITY IN THE DELAWARE RIVER BASIN STUDY UNIT

The NAWQA program balances the unique assessment requirements of individual study units with a nationally consistent design and data-collection structure that incorporates a multiscale, interdisciplinary approach. Surface- and ground-water studies are conducted at local scales (a few square miles to hundreds of square miles) to study relations between land use and water quality, and at regional scales (thousands of square miles) to investigate the water-quality conditions and issues within a study unit.

An occurrence and distribution assessment is the largest and most important component of the first high-intensity study phase in each study unit. The goal of this assessment is to characterize, in a nationally consistent manner, the broad-scale geographic and seasonal distributions of water-quality conditions in relation to major contaminant sources, land use, and background conditions. The typical surface-water and ground-water monitoring components of the occurrence and distribution assessment are described below. The Delaware River Basin NAWQA study will follow these guidelines.

Surface Water

The National study design for surface water focuses on water-quality conditions in streams by using three interrelated components: water-column studies, bed-sediment and fish-tissue studies, and ecological studies. Water-column studies are used to monitor physical and chemical characteristics such as suspended sediment, major ions, organic carbon, dissolved pesticides, and nutrients to determine their relation to hydrologic conditions, contaminant sources, and transport processes. Bed-sediment and fish-tissue studies are used to assess the presence and distribution of trace elements and hydrophobic organic contaminants that are less likely to be found in surface-water samples. Ecological studies are used to evaluate the effects of physical, chemical, and habitat characteristics on biological communities. Ecological surveys are done along a delineated stream reach and include a habitat assessment of the site and annual surveys of the fish, algal, and benthic invertebrate communities.

NAWQA sampling is conducted primarily at "basic-fixed" sites and "intensive-fixed" sites, which differ in the frequency of the sampling. The sampling sites are selected to determine the quality of water in important environmental settings in the study unit. Most NAWQA study units have 8 to 10 basic-fixed sites and 2 to 3 intensive-fixed sites. Surface water is sampled at basic-fixed sites monthly, and during selected high-flow conditions, for 2 years of the 3-year high-intensity phase. Intensive-fixed sites are monitored more frequently (as often as weekly during key periods) for at least 1 year of the high-intensity phase to characterize short-term variations in water quality. Aquatic biological communities are surveyed and bed-sediment and fish-tissue samples are collected at the basic-fixed and intensive-fixed sites during the 3 years of high-intensity sampling.

Basic-fixed sites and intensive-fixed sites can be either "indicator" or "integrator" sites. Indicator sites drain relatively homogeneous, small basins (less than 100 mi^2) associated with specific environmental settings, such as a particular land use that substantially affects water quality in the study unit. Integrator sites are established at downstream points in large (thousands of square miles), relatively heterogeneous drainage basins with complex combinations of land-use settings. Indicator sites typically are located within the drainage basin of an integrator site.

Additional water, ecological, and bed-sediment and fish-tissue samples are collected as part of short-term synoptic investigations of specific water-quality conditions or constituents to increase spatial coverage and to allow investigators to evaluate how the quality of water at basic-fixed and intensive-fixed sites is related to the quality of water in other streams throughout the study unit. Surface-water synoptic sampling may be designed to investigate specific constituents during a specific hydrologic period. Ecological synoptic sampling may be done to investigate a specific biological community and may be integrated with surface-water synoptic studies.

Ground Water

The National study design for ground water focuses on water-quality conditions in major aquifers, with emphasis on recently recharged ground water associated with present and recent human activities, by using study-unit surveys, land-use studies, and flow-path studies. In study-unit surveys and land-use studies, ground-water samples are analyzed for major ions, nutrients, pesticides, volatile organic compounds, and trace elements. Study-unit surveys are used to assess the quality of water in the major aquifer systems of each study unit. Typically, 30 existing domestic wells in each of two to three aquifer subunits are randomly selected for sampling. Land-use studies focus on recently recharged shallow aquifer systems to evaluate the influences of both natural conditions and land-use practices on ground-water quality. Typically, about 30 new observation wells are randomly located within each land-use and aquifer type. Results of the one or two land-use studies typically performed are compared with results of the general study-unit survey to determine the effect of particular land uses on ground-water quality. In flow-path studies, water samples are collected from groups of clustered, multilevel observation wells located along a flow transect. The purpose of this study is to characterize spatial and temporal variations in water quality, examine natural processes and human activities that cause changes in water quality along the flow path, and evaluate whether interactions between ground and surface water affect water quality.

-- *Jeffrey M. Fischer*

COMMUNICATION AND COORDINATION

Communication and coordination between the U.S. Geological Survey and other scientific and land- and water-management organizations are critical components of the NAWQA program. Each study-unit project team maintains a liaison committee consisting of representatives of Federal, State, and local agencies, universities, the private sector, watershed organizations, and others who have water-resource responsibilities and interests. Committee activities include exchanging information about regional and local water-quality issues, identifying sources of data and information, assisting in the study design, providing input on the scope of study products, and reviewing study planning documents and reports. The liaison committee for the Delaware River Basin study was established in 1997.

The overall success of the Delaware River Basin NAWQA study depends on the advice of, cooperation among, and information from many Federal, State, regional, and local agencies, and individual citizens concerned about the quality of water in the Delaware River Basin. All are invited to participate in this cooperative effort to understand the processes that affect this essential resource.

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Copies of this report may be purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver, CO 80225-0286

For additional information write to:

NAWQA Project Chief
U.S. Geological Survey
Mountain View Office Park
810 Bear Tavern Road, Suite 206
West Trenton, NJ 08628

Email: nawqa_delr@usgs.gov
On the web: <http://nj.usgs.gov/nawqa/>