USGS
science for a changing world

Water Quality in the Hudson River Basin

New York and Adjacent States, 1992–95



U.S. Department of the Interior
U.S. Geological Survey

Circular 1165

A COORDINATED EFFORT

Coordination among agencies and organizations is an integral part of the NAWQA Program. We thank the following individuals and organizations who contributed data, knowledge, time, and expertise.

Steven Anderson, Montgomery County Soil Conservation District

Robert W. Bode, Margaret A. Novak, and Lawrence E. Abele, New York State Department of Environmental Conservation (NYSDEC) Division of Water, Stream Biomonitoring Unit

Richard Bopp, Rensselaer Polytechnic Institute, Department of Earth and Environmental Sciences

Robert Crowe and other landowners who permitted access to stream and well sites on private property

Robert A. Daniels, New York State Museum, Biological Survey

Larry Rosenmann, NYSDEC Division of Pesticides and Radiation

Ronald Sloan, NYSDEC Division of Fish and Wildlife

American Museum of Natural History

Cornell University

Cornell University Cooperative Extension

Freshwater Institute at Rensselaer Polytechnic Institute

General Electric Company

Hudsonia

Hudson River-Black River Regulating District

Hudson River Foundation

Hudson River National Estuarine Research Reserve

Hudson Valley Regional Council

Institute of Ecosystem Studies

New York Botanical Garden

New York City Department of Environmental Protection

New York Sea Grant

New York State Canal Corporation

New York State Department of Environmental Conservation

New York State Department of Health

New York State Department of State Coastal Resource Management

New York State Geological Survey

New York State Museum

Rensselaer Polytechnic Institute

River Watch Network, Inc.

Simon's Rock College

State University of New York at Albany

Suffolk County, N.Y.

Thatcher Research Associates, Inc.

The Nature Conservancy

U.S. Army Corps of Engineers

U.S. Department of Agriculture

U.S. Environmental Protection Agency, Region II

U.S. Fish and Wildlife Service

Water Resources Research Institute at Cornell University

Westchester County, N.Y.

Illustrations by Douglas Freehafer, Gary R. Wall, Amanda G. Ramsey, and Gretchen L. Wall
Edited by Anne Finch, Michael Eberle, and Elizabeth B. Palcsak
Manuscript preparation by Gary R. Wall, Amanda G. Ramsey, and Patricia Lee
Summary of Compound Detections and Concentrations tables were designed and built by Sarah Ryker, Jonathon Scott, and Alan Haggland
Cover photograph - Rondout River at Kingston, N.Y.
Back cover photographs - surface water sampling, Mohawk River at Cohoes, N.Y., electrofishing, Esopus Creek at Allaben, N.Y.

FOR ADDITIONAL INFORMATION ON THE NATIONAL WATER-QUALITY ASSESSMENT (NAWQA) PROGRAM:

Hudson River Basin Study Unit, contact:

District Chief
U.S. Geological Survey
Water Resources Division
425 Jordan Road
Troy, NY 12180

Chief, NAWQA Program
U.S. Geological Survey
Water Resources Division
12201 Sunrise Valley Drive, M.S. 413
Reston, VA 20192

Information on the NAWQA Program is also available on the Internet via the World Wide Web. You may connect to the NAWQA Home Page using the Universal Resources Locator (URL):
http://wwwrvares.er.usgs.gov/nawqa/nawqa_home.html

The Hudson River Basin Study Unit's Home Page is at URL:
http://ny.usgs.gov/projects/hdsn/

Water Quality in the Hudson River Basin, New York and Adjacent States,1992–95

By Gary R. Wall, Karen Riva-Murray, *and* Patrick J. Phillips

U.S. GEOLOGICAL SURVEY CIRCULAR 1165

CONTENTS

National Water-Quality Assessment Program 1

Summary of major issues and findings 2

Environmental setting and hydrologic conditions 4

Major issues and findings 6

Water-quality conditions in a national context 16

Study design and data collection 20

Summary of compound detections and concentrations 22

References 28

Glossary 29

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Thomas J. Casadevall, Acting Director

The use of firm, trade, and brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Government

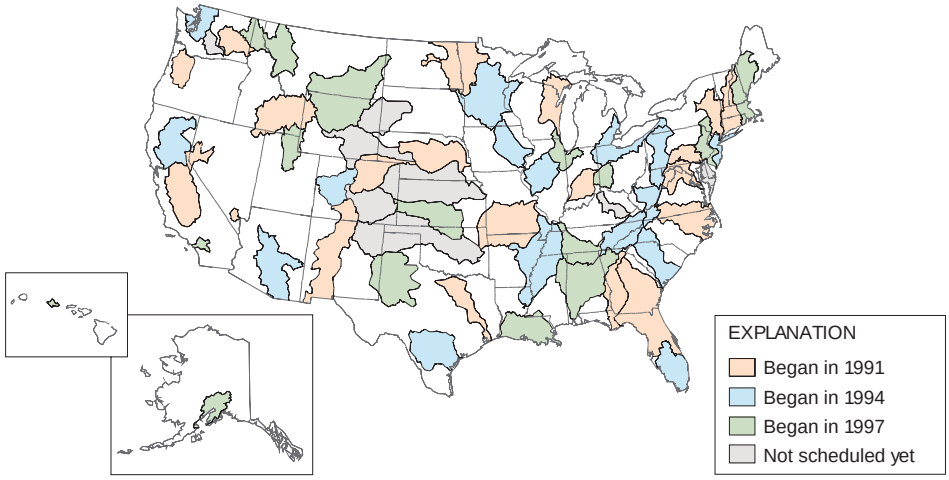
---

1998

Free on application to the
U.S. Geological Survey
Information Services
Box 25286 Federal Center
Denver, CO 80225

Library of Congress Cataloging in Publications Data

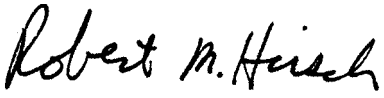
Water quality in the Hudson River Basin, New York and adjacent states, 1992-95
by Gary R. Wall ... [et al.].
p. cm. -- (U.S. Geological Survey circular ; 1165)
Includes bibliographical references (p.)
ISBN 0-607-89232-3
1. Water quality--Hudson River Watershed (N.Y. and N.J.)
I. Wall, Gary R. (Gary Robert), 1967- . II. Series.
TD225.H8W38 1998
363.739'42'09782--dc21 98-13595



Knowledge of the quality of the Nation's streams and aquifers is important because of the implications to human and aquatic health and because of the significant costs associated with decisions involving land and water management, conservation, and regulation. In 1991, the U.S. Congress appropriated funds for the U.S. Geological Survey (USGS) to begin the National Water-Quality Assessment (NAWQA) Program to help meet the continuing need for sound, scientific information on the areal extent of the water-quality problems, how these problems are changing with time, and an understanding of the effects of human actions and natural factors on water quality conditions.

The NAWQA Program is assessing the water-quality conditions of more than 50 of the Nation's largest river basins and aquifers, known as Study Units. Collectively, these Study Units cover about one-half of the United States and include sources of drinking water used by about 70 percent of the U.S. population. Comprehensive assessments of about one-third of the Study Units are ongoing at a given time. Each Study Unit is scheduled to be revisited every decade to evaluate changes in water-quality conditions. NAWQA assessments rely heavily on existing information collected by the USGS and many other agencies as well as the use of nationally consistent study designs and methods of sampling and analysis. Such consistency simultaneously provides information about the status and trends in water-quality conditions in a particular stream or aquifer and, more importantly, provides the basis to make comparisons among watersheds and improve our understanding of the factors that affect water-quality conditions regionally and nationally.

This report is intended to summarize major findings that emerged between 1992 and 1995 from the water-quality assessment of the Hudson River Basin Study Unit and to relate these findings to water-quality issues of regional and national concern. The information is primarily intended for those who are involved in water-resource management. Indeed, this report addresses many of the concerns raised by regulators, water-utility managers, industry representatives, and other scientists, engineers, public officials, and members of stakeholder groups who provided advice and input to the USGS during this NAWQA Study-Unit investigation. Yet, the information contained here may also interest those who simply wish to know more about the quality of water in the rivers and aquifers in the area where they live.



Robert M. Hirsch, Chief Hydrologist

"The Hudson River Basin NAWQA program has provided the Department with crucial information and a solid monitoring foundation, to create our own statewide pesticide monitoring program. It is our expectation that expansion of the NAWQA work to include other important areas of New York State will enable us to successfully meet all State and Federal monitoring requirements and provide the Department with the data we need to make responsible pesticide registration decisions."

Larry Rosenmann - New York State Department of Environmental Conservation, Division of Pesticides and Radiation

"The NAWQA program has shown itself to be capable of generating high quality data of direct benefit to State agencies. NAWQA has provided the model for how different programs should work together and benefit from each other's research."

Robert Bode - New York State Department of Environmental Conservation, Division of Water

SUMMARY OF MAJOR ISSUES AND FINDINGS



STREAM-BOTTOM SEDIMENT - Stream-bottom sediments in some urban streams and at some sites on large rivers in the Hudson River Basin have elevated concentrations of metals, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) compared to results from sites in other NAWQA Study Units; some of these concentrations exceed federal or state water-quality standards.

- The Sawmill River at Yonkers, the most densely populated urban site studied in the Hudson River Basin, had some of the highest concentrations of metals in stream-bottom sediments among NAWQA sites nationwide (p. 6). Highly urban areas are the source of most of the metals in streams draining urban and large watersheds.
- The distribution of chromium concentrations in Hudson River stream-bottom sediments is consistent with previous observations of a point source of heavy metals on the upper Hudson River (p. 6-7).
- Concentrations of lead, mercury, and zinc in stream-bottom sediments were positively related to the percentage of urban land within the watershed. Many of the metals concentrations in sediment from urban sites exceeded the proposed New York State Department of Environmental Conservation (NYSDEC) Severe Effect Levels for stream-bottom sediment (p. 6-7).
- NYSDEC proposed Severe Effect Levels for metals were not exceeded in any stream-bottom-sediment samples from sites in forested or agricultural watersheds (p. 6).
- PCBs persist in stream-bottom sediment despite being banned more than 20 years ago. PCB concentrations in Hudson River bottom-sediments exceeded the proposed NYSDEC criteria for human health bioaccumulation at all sites at which they were detected (p. 8-9) and were among the highest at NAWQA sites nationwide (p. 16).
- Spatial patterns in concentration of PAHs within the basin corresponded with factors such as location in the Hudson River Basin and proximity to urban areas (p. 8).

FISH TISSUE - Although banned for more than 20 years, PCBs, DDT and (or) its breakdown products were detected in composites of whole fish from many sites, and were most frequently detected in samples from sites on large rivers and in small urban watersheds.

- PCB concentrations in composite whole-fish samples from the Hudson River at Poughkeepsie and the Mohawk River near Utica exceeded the Food and Drug Administration (FDA) action level of 2,000 micrograms per kilogram of edible flesh (fillets). This indicates the potential for elevated concentrations in edible portions, and has prompted further investigation and fish-consumption advisories for selected species in a 40-mile section of the Mohawk River. Consumption advisories remain in effect for most species in parts of the Hudson River (p. 9).
- Concentrations of organochlorine compounds other than PCBs in composites of whole fish were below FDA action levels for edible flesh at all sites sampled. This suggests that concentrations in edible portions of these samples would not have exceeded FDA action levels for those compounds (p. 8).
- PCBs, DDT and its breakdown products, and chlordane were more likely to be detected in fish tissue than in stream-bottom sediments at sites where both whole fish samples and stream-bottom sediment samples were collected. This suggests that bioaccumulation through the food chain occurs even where these compounds cannot be detected in stream-bottom sediment (p. 8).

STREAM ECOLOGY - Most agricultural and urban streams studied supported a smaller number of intolerant fish and macroinvertebrate species than that expected in streams with undisturbed chemistry and (or) habitat.

- Fish communities at the three most highly urbanized sites sampled were numerically dominated by a single fish species. Intolerant species were entirely absent or rare at these sites (p. 10-11).

- Stream-habitat degradation was severe at channelized sites in cities and was moderate at agricultural sites where streambank vegetation had been removed and where streambank erosion had occurred (p. 11, 17). Benthic macroinvertebrate groups sensitive to suspended and (or) deposited sediment appear to be replaced by sediment-tolerant species in streams with streambank erosion (p. 11).

- Urban streams in some densely populated watersheds with undisturbed streambanks supported larger numbers of fish species intolerant to impaired water quality than urban streams with disturbed streambanks (p. 11, 17). The presence of an extensive, forested buffer zone on and adjacent to streambanks appears to mitigate potential adverse effects of urban and agricultural land use on fish communties.

SURFACE-WATER AND GROUND-WATER CHEMISTRY - The concentrations of dissolved pesticides and nutrients in samples from most sites in the Hudson River Basin were below the national median concentrations. In some samples, however, water-quality standards or guidelines for these and other constituents were exceeded.

- In general, concentrations of pesticides and other dissolved constituents are low in ground water and surface waters of the Hudson River Basin. Although 18 different pesticides or pesticide-degradation compounds were detected in three streams sampled at least monthly over 2 years (total of 108 samples), only 2 samples contained a pesticide concentration higher than a U.S. Environmental Protection Agency (USEPA) drinking-water standard; however, only 12 of the 18 compounds have established standards (p. 12).

- Atrazine was the most commonly detected pesticide in surface water and ground water and was found in nearly every sample in which any other pesticide was detected (p. 13-14). Atrazine is one of the most commonly used pesticides in the basin, hence the frequency of its detection with other pesticides is not unusual.

- Although pesticides were detected throughout the year, pesticide concentrations in streams were generally highest immediately after field application and during the first storm runoff following application (p. 13).

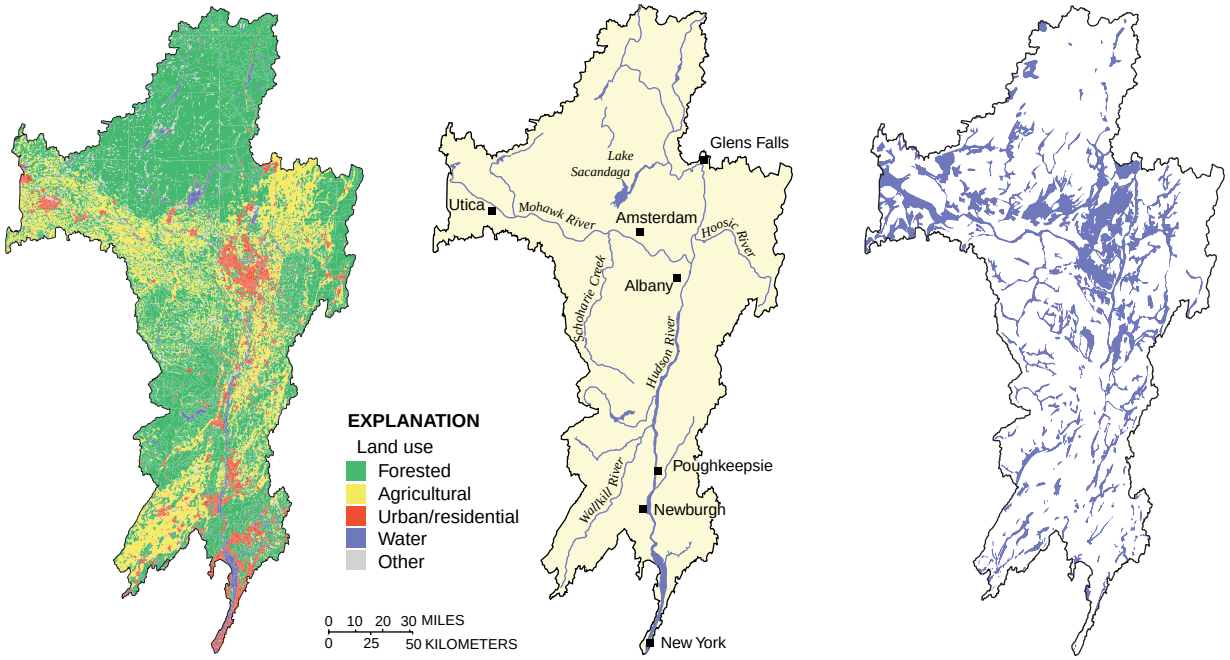
- In a spring 1994 survey of 46 stream and river sites in the Hudson River Basin, 32 percent of pesticide detections were insecticides in streams draining watersheds with a significant percentage of urban land. This rate of detection was 3.5 times that of streams draining agricultural or mixed-land-use watersheds. Fifty percent of all insecticide detections were in streams draining urban areas, a disproportionate amount given that only 22 percent of the streams sampled drained these areas (p. 14). The percentage of insecticide detections in urban areas reflects the use of these products on lawns and similar non-agricultural areas.

- Pesticides were detected in ground water from 25 percent of wells used for domestic water supply, no more than 2 pesticides were detected at any individual well (p. 14), and none of these detections were at concentrations above any available USEPA drinking-water standard.

- Nitrate concentration in ground water indicated the effects of human activity (concentration greater than 3.0 mg/L) in 38 percent of the samples from beneath agricultural fields, in 23 percent of the samples from beneath urban/residential areas, and in 16 percent of the samples from domestic wells (p. 15).

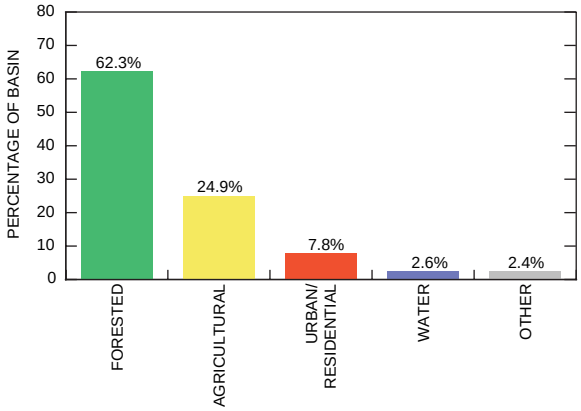
- Nitrate concentrations in ground water beneath agricultural areas were above the national median for such areas (p. 18). Two of sixteen wells sampled (12.5 percent) had concentrations above the USEPA Maximum Contaminant Level (MCL) (10 mg/L), however none of the wells was used as a source of drinking-water (p. 15).

- About one-third of the ground-water samples from beneath urban/residential areas contained at least one volatile organic compound, but none of the concentrations exceeded any available water-quality standards (p. 19).



LAND USE — MAJOR RIVERS AND STREAMS — MAJOR AQUIFERS

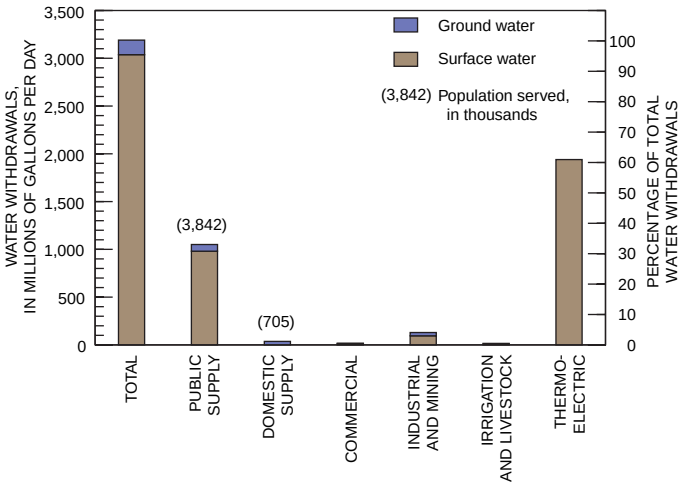
The Hudson River Basin encompasses about 13,300 mi^2 (square miles) in eastern New York and parts of Vermont, New Jersey, Massachusetts, and Connecticut. About 62.3 percent of the Hudson River Basin is forested, 24.9 percent is agricultural land (including row crops, pasture, vineyards, and orchards), 7.8 percent is urban (including commercial and industrial land) and residential land, 2.6 percent is open water, and 2.4 percent is classified as "other." Agricultural land is predominant in the Mohawk and Wallkill River subbasins and in some areas east of the Hudson River. Nearly all of the major urban and industrial centers in the basin are concentrated within a few miles of the Hudson and Mohawk Rivers.



The headwaters of the Hudson River are in the central Adirondack Mountains. The largest tributary to the Hudson is the Mohawk River, which nearly doubles the flow of the Hudson where they meet at Cohoes, N.Y.

Major aquifers in the basin consist mainly of sand and gravel and occupy many of the lowland areas adjacent to streams and rivers. Many domestic wells rely on ground water from fractures in bedrock, but no bedrock formations in the basin are considered major aquifers.

More than 80 percent of the people in the Hudson River Basin are served by public drinking-water supplies that are obtained largely from surface-water sources. Domestic supplies, which serve the remaining population, are almost entirely dependent on ground-water sources. The single largest water withdrawal in the basin is for power generation.



Precipitation and streamflow in 1993-94 were above normal throughout the Hudson River Basin and resulted in higher than normal ground-water levels for the summer months of 1993 and 1994. In contrast, precipitation, streamflow, and ground-water levels were below normal during most of 1995.

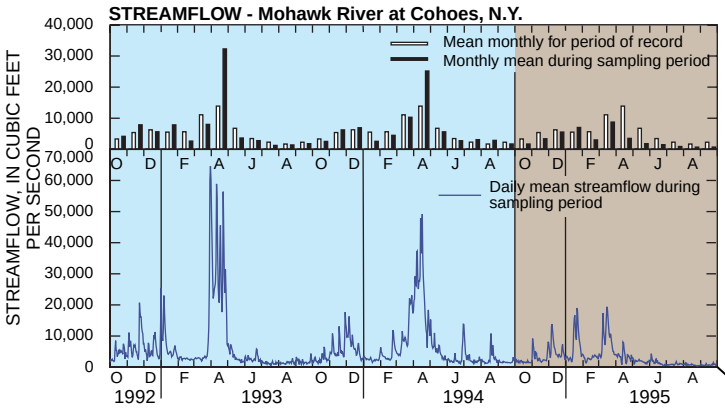
Drought conditions in 1995 were particularly noticeable in the Mohawk River at Cohoes, where streamflows for April, May, and September 1995 were the lowest on record. Drought conditions probably resulted in lower than normal amounts of nutrient, pesticide, and sediment runoff from streams in the spring and summer of 1995.

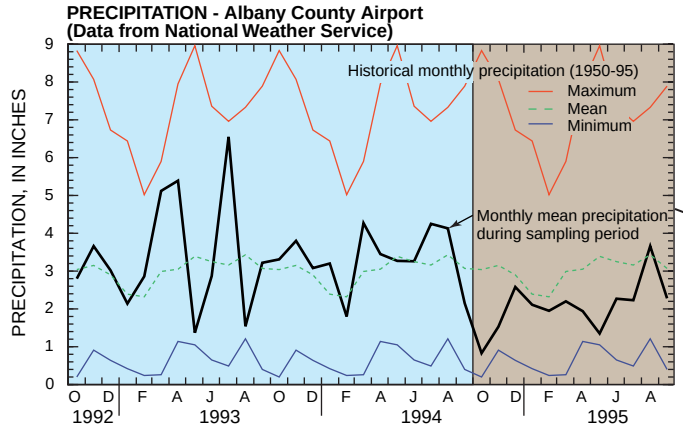


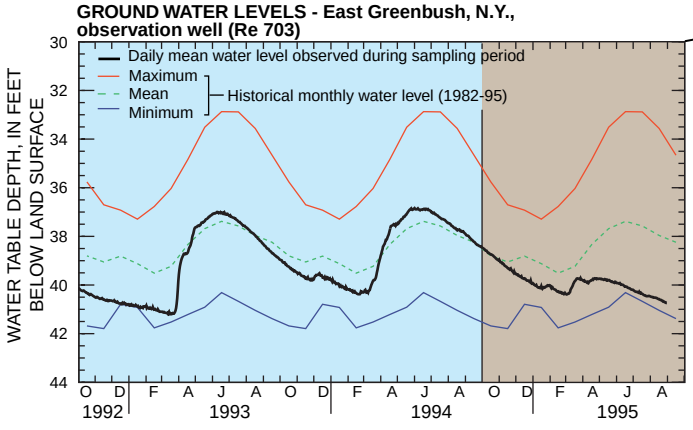
Photograph by Charles Strain, USGS

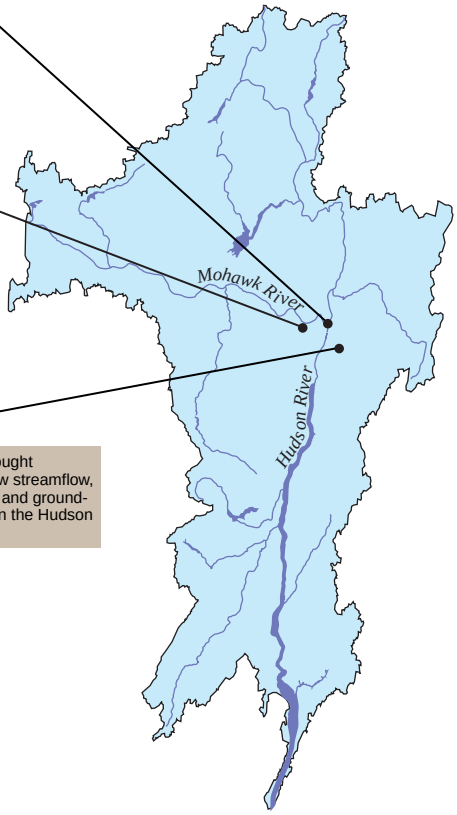


Photograph by Christopher Ryan, USGS









The 1995 drought resulted in low streamflow, precipitation, and ground-water levels in the Hudson River Basin

Metals in Stream-Bottom Sediments

Stream-bottom sediments were collected at 44 sites on 35 streams and rivers across the Hudson River Basin from August 1992 through October 1994 for analysis for trace elements and organic contaminants. The purpose was to (1) assess the presence of these constituents, and (2) detect any correlation between land use in the watersheds and the chemical quality of bottom sediment in the streams that drain them. This section discusses seven selected heavy metals that have been shown to adversely affect the quality of stream-bottom sediments and, thus, pose a risk to the surrounding aquatic ecosystem. The New York State Department of Environmental Conservation (NYSDEC) has proposed concentration screening criteria for metals in stream-bottom sediments (New York State Department of Environmental Conservation, 1994) (table 1) to indicate the concentrations that could affect aquatic organisms. Additional testing is generally needed to assess what actual risks to the environment are present, however. Sampling sites were classified according to the predominant land use in the watershed to correlate stream-bottom sediment quality with the principal land use in the watershed (fig. 1). Land-use categories were defined as follows:

Table 1. Screening criteria proposed by New York State Department of Environmental Conservation for metals in stream-bottom sediment

[Effect Levels are in micrograms per gram]

Metal	Effect Level*	
	Lowest	Severe
Cadmium	0.6	9.0
Chromium	26	110
Copper	16	110
Lead	31	110
Mercury	.15	1.3
Nickel	16	50
Zinc	120	270

*Effect Levels used by NYSDEC represent two risk levels for metals contamination in sediments. (1) A sediment is considered contaminated if either criterion is exceeded. (2) The sediment is considered moderately affected if only the Lowest Effect Level is exceeded and severely affected if both levels are exceeded.

Urban sites were those in watersheds that are more than 10 percent urban land and whose population density exceeds 200 per square mile.

Large-mixed sites were those in watersheds that encompass more than 500 mi^2 but have no single predominant land use (that is, less than 35 percent agricultural, less than 90 percent forested, and less than 10 percent urban).

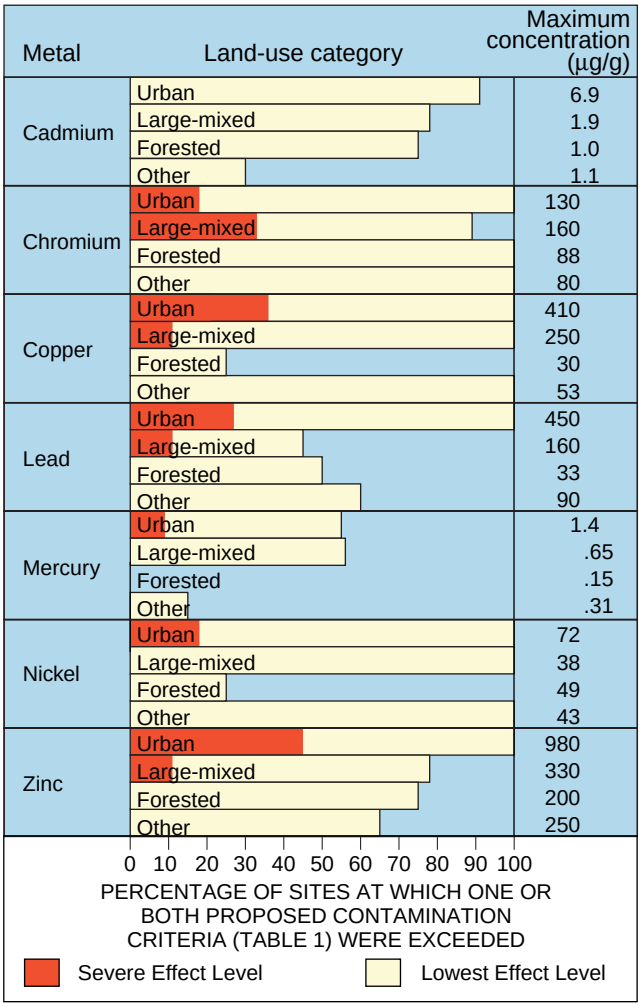


Figure 1. Percentage of sites at which one or both New York State proposed screening criteria for metals contamination in stream-bottom sediment were exceeded, and maximum concentrations of metals by land-use category. Sites in urban and large-mixed watersheds had the highest concentrations and often exceeded both criteria.

Forested sites were those in watersheds that were more than 90 percent forest.

"Other" sites are those in agricultural or small (less than 500 mi^2) mixed-land-use watersheds.

Stream-bottom sediment in the Sawmill River at Yonkers, the most highly urbanized site (highest population density) among those surveyed, had the highest concentrations of cadmium (6.9 µg/g, micrograms per gram), copper (410 µg/g), mercury (1.4 µg/g), nickel (72 µg/g), and zinc (980 µg/g). Sediment at the Fall Kill at Poughkeepsie, another urban site, had the highest concentration of lead (450 µg/g).

Some of the highest chromium concentrations were along the mainstem of the Hudson River. Concentrations were highest at Stillwater (160 µg/g) and decreased downstream to 130 µg/g at Waterford and Poughkeepsie and to 110 µg/g at

Hastings-on-Hudson. The lowest chromium concentrations — 28 and 47 µg/g, respectively — were at sites upstream from Stillwater, at Luzerne and Hadley, where the Hudson River drains mainly forested land. This distribution pattern is similar to that observed previously for heavy-metals concentrations in upper Hudson River sediments (Frank Estabrooks, New York State Department of Environmental Conservation, written commun., 1995) and is consistent with a known point source of heavy metals between Hadley and Stillwater.

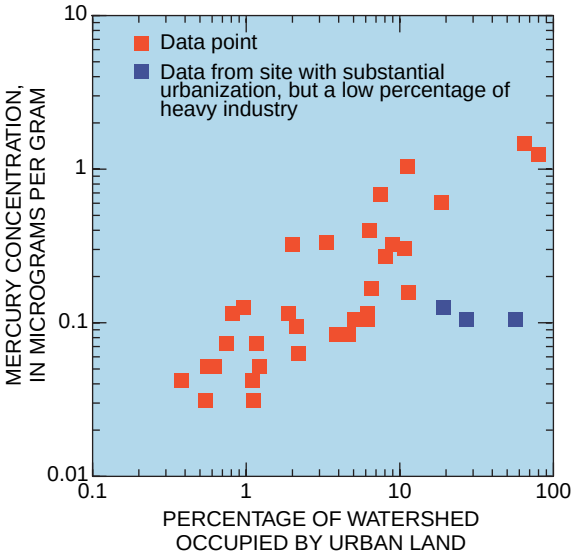


Figure 2. Mercury concentration in stream-bottom sediment in relation to the percentage of urban land in watersheds of the Hudson River Basin. Streams draining urban areas generally had higher concentrations of mercury in stream-bottom sediments than nonurban and urban watersheds without heavy industry.

In general, metal concentrations in stream-bottom sediment were positively correlated with urban land use (fig. 2). This relation was strongest for lead, mercury, and zinc. No relation was found between watershed size and metals concentration, but the large watersheds contain larger amounts of urban land, which probably contributed to the higher concentrations of some metals at these sites than sites in nonurban watersheds.

Proposed metals criteria were exceeded most frequently at sites in urban and large mixed-land-use watersheds. The proposed Severe Effect Level was exceeded only in urban and large watersheds. Sediment from every urban site exceeded the Lowest Effect Level for five of the seven metals discussed here, and sediment from several of the forested watersheds exceeded this criterion for some metals. Metals concentrations that exceed the Lowest Effect Level at sites in nonurban watersheds that reflect undisturbed conditions could also have an adverse effect on aquatic life (New York State Department of Environmental Conservation, 1994).

Semivolatile Organic Compounds in Stream-Bottom Sediments

Samples of stream-bottom sediments from 33 sites across the Hudson River Basin were analyzed for 79 semivolatile organic compounds (SVOCs). Of the 79 SVOCs analyzed, 27 included organic compounds known as polycyclic aromatic hydrocarbons (PAHs). PAHs are formed mainly as byproducts of combustion, such as fossil-fuel power generation, numerous industrial processes, and forest fires (Neff, 1979).

Each of the 33 sites was ranked by concentration for each PAH. Because PAHs attach chemically to organic carbon, and because the amount of organic carbon in stream-bottom sediment differs among sites, PAH concentrations were carbon adjusted to allow site-to-site comparisons. The sum of the individual PAH ranks for each site was in turn ranked to give each site a ranking (representing all 27 PAHs). This ranking is given in table 2. Although the percentage of urban and industrial land use in the watershed upstream from each

Table 2. Rank of stream-bottom sediment-sampling sites, in order of the total rank of 27 carbon normalized PAH concentrations, and percentage of urban and industrial land in the watershed above each site

[Lowest rank number corresponds to highest concentration rank]

Site rank	Site name	Percentage of watershed	
		Urban	Industrial
1	Hudson River south of Hastings-on-Hudson	8.61	0.16
2	Mohawk River near Utica	11.89	.30
3	Patroon Creek at Albany	91.43	8.57
4	Hallocks Mill Brook at Yorktown Heights	67.92	0
5	Woodbury Creek near Highland Mills	36.36	0
6	Hudson River at Waterford	3.64	.05
7	Saw Mill River at Yonkers	84.71	.41
8	Mohawk River at Fonda	5.29	.08
9	Haviland Hollow Brook near Putnam Lake	.81	0
10	Peekskill Hollow Cr at Van Cortlandtville	35.00	.21
11	Mohawk River near Little Falls	6.96	.13
12	Hudson River at Poughkeepsie	7.03	.14
13	Kisco River below Mount Kisco	38.07	1.70
14	Coeymans Creek near South Bethlehem	8.66	.60
15	Hoosic River below Williamstown	12.06	.20
16	Lisha Kill northwest of Niskayuna	77.42	1.94
17	Fishkill Cr at Stormville Rd nr Hopewell Jct	8.62	0
18	Fall Kill at Poughkeepsie	28.88	.53
19	Mohawk River at Cohoes	6.93	.13
20	Schoharie Creek at Esperance	2.21	0
21	Kinderhook Creek at Rossman	8.16	.06
22	Canajoharie Creek near Canajoharie	1.17	0
23	Hoosic River near Eagle Bridge	8.74	.08
24	Wappinger Creek near Wappingers Falls	6.28	.05
25	Rondout Creek at Rosendale	3.35	.10
26	Claverack Creek at Claverack	11.31	0
27	Esopus Creek at Allaben	1.57	0
28	Moses Kill near Fort Miller	.74	0
29	Batten Kill at Battenville	1.11	0
30	Hudson River at Stillwater	2.18	.02
31	Hudson River south of Lake Luzerne	1.09	0
32	West Canada Creek at Nobleboro	0	0
33	Wallkill River at Gardiner	10.64	.03

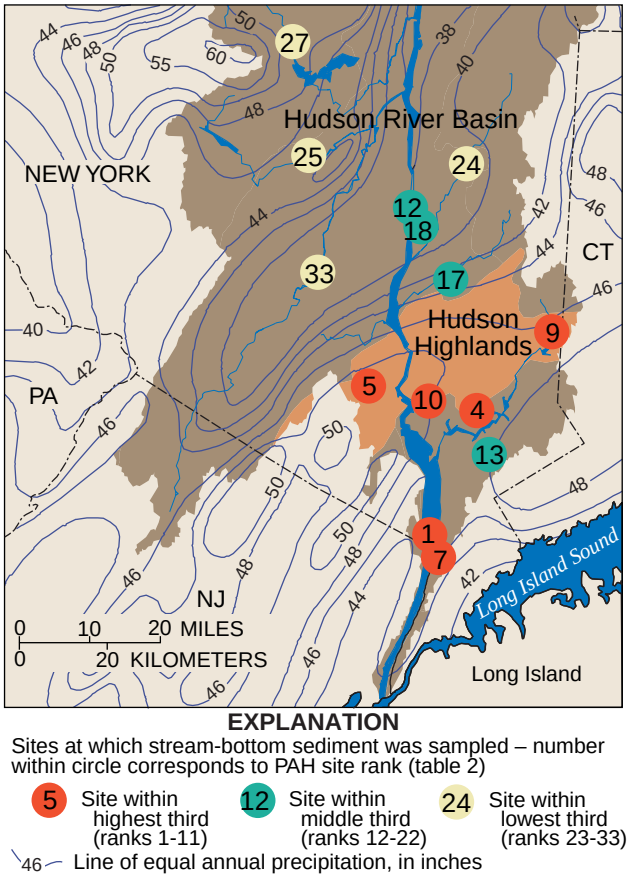


Figure 3. Sites at which stream-bottom sediment was collected for PAH analysis in the lower Hudson River Basin. Some of the highest PAH concentrations were in streams draining the Hudson Highlands. PAHs in these streams may be from industrial areas outside the Hudson River Basin and from deposition in rainwater.

site is to some degree linked with the PAH site ranking (for example, Patroon Creek at Albany has the highest percentage of urban and industrial land and ranks third among sites), no overall relation was found between these two factors. This lack of correlation is probably attributable to other factors that are difficult to quantify, such as geographic location and proximity to point sources.

Geographic location — Several high-ranking sites are in the southern part of the Hudson River Basin. Three of these — Hallocks Mill Brook at Yorktown Heights (site rank 4), Woodbury Creek near Highland Mills (site rank 5), and Haviland Hollow Brook near Putnam Lake (site rank 9) — are among the top 10 but have no industrial activity, and most of the urbanization is residential. Although the rank of these sites is probably due to extensive urbanization south of the Hudson Highlands, the greater precipitation in the highlands (fig. 3) suggests that the elevated PAH concentrations could be due to PAH deposition in rainwater from industrial areas far beyond this watershed.

Proximity to point sources — Statistics based on watershed land use may not adequately reflect the weight that individual or small-scale discharges deserve with respect to certain contaminants, including PAHs. Thus, the difference in rank between the Hudson River at Stillwater (site rank 30) and the Hudson River at Waterford (site rank 6), less than 20 miles downstream, may be caused by a point source(s) between these sites.

PCBs and Organochlorine Pesticides in Stream-Bottom Sediments and Fish

Organochlorine compounds, such as the pesticides DDT and chlordane and their degradation compounds, and industrial compounds such as polychlorinated biphenyls (PCBs) have a long history of use in the Hudson River Basin, including several well-known point sources of PCBs in the upper Hudson River (near Glens Falls, N.Y.). Although use of these compounds was banned in the 1970's, they persist in the stream-bottom sediments and biota of the basin. Results presented here are based on analyses of stream-bottom sediment and whole-fish samples for concentrations of DDT, chlordane, 16 other organochlorine pesticides, and PCBs. Stream-bottom sediments were collected at 45 sites throughout the Hudson River Basin, and whole-fish samples were collected at 24 sites. The sites were of three types: (1) on large rivers draining watersheds with a variety of land uses, (2) on small streams draining watersheds dominated by urban land use, and (3) on small streams draining watersheds dominated by nonurban land use.

The most commonly detected organochlorine compounds in stream bottom-sediment and fish-tissue samples were DDT and (or) its degradation compounds, PCBs and chlordane and (or) its degradation compounds (fig. 4). The percentage of sites at which all three were detected in both stream-bottom sediments and fish was greater for large watersheds and small urban watersheds than for sites in small nonurban watersheds. These compounds were detected more often in fish than in stream-bottom sediments at sites where both fish and sediment samples were collected. This finding indicates that even though the concentration of these compounds at some sites is too low to be detected in sediments, they may accumulate over time within fish (and other organisms) to levels that can be detected.

Concentrations of PCBs, DDT, and chlordane in stream-bottom sediments exceeded proposed NYSDEC criteria for human health bioaccumulation (New York State Department of Environmental Conservation, 1994) at all or most sites at which they were detected (Phillips and others, 1997). DDT concentration exceeded the proposed stream-bottom sediment screening criterion for human health bioaccumulation (0.01 µg/g OC, micrograms per gram of organic carbon) at 62 percent of the sites sampled; concentrations of PCBs exceeded the criteria (0.0008 µg/g OC) at 33 percent of the sites sampled; and chlordane concentration exceeded the criteria (0.001 µg/g OC) at 29 percent of the sites sampled. Human health guidelines for fish are based on edible portions (fillets) and are not directly comparable with the higher concentrations expected in

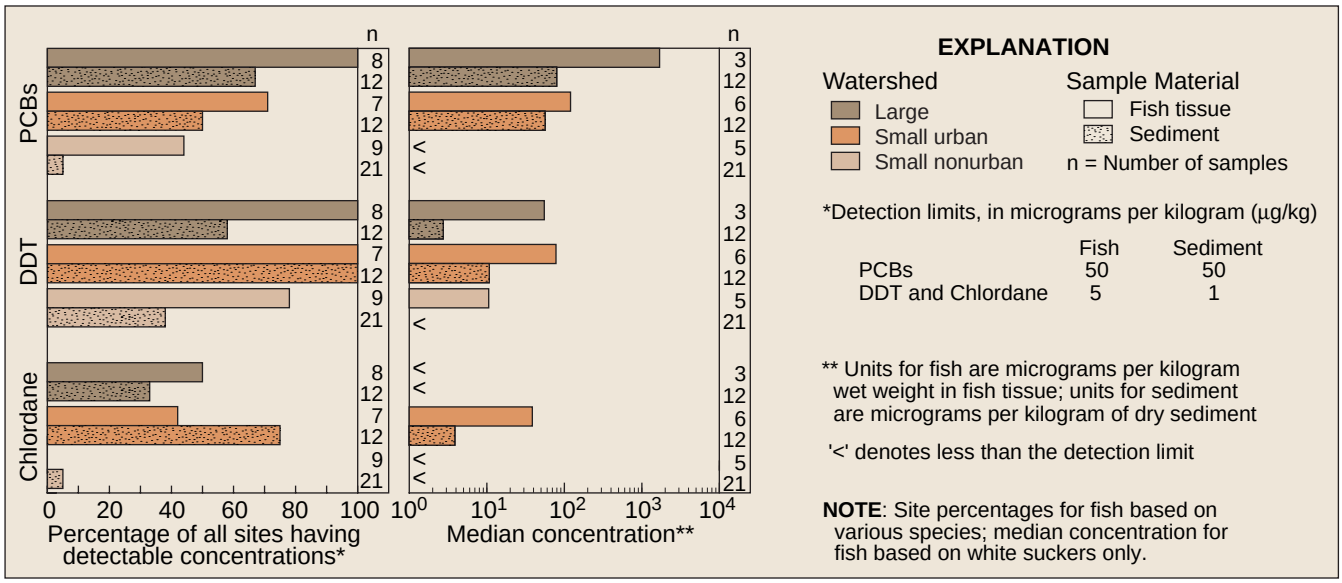


Figure 4. Detection of PCBs, DDT compounds, and chlordane compounds in fish tissue and stream-bottom sediments in Hudson River Basin watersheds. These compounds were generally detected more often and at higher concentrations in fish tissue than stream-bottom sediments.

whole fish. Comparison of whole-fish results with these guidelines can help identify sites with potential human-health risks, however. PCBs were the only organochlorine compound detected in whole-fish samples from any site at concentrations above the U.S. Food and Drug Administration (FDA) action level (2,000 µg/kg); all of these sites were on the Hudson and Mohawk Rivers (see box at right).

Concentrations of PCBs, DDT, and chlordane in stream-bottom sediments and (or) fish tissue from some sites were higher than those considered potentially harmful to fish and wildlife. Both PCBs and chlordane concentrations in stream-

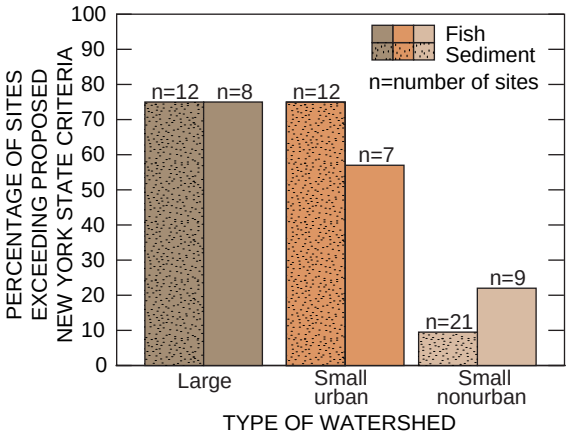


Figure 5. Percentage of sites at which proposed NYSDEC screening criteria for at least one organochlorine compound in fish tissue and stream-bottom sediment were exceeded. Large and small urban watersheds regularly exceeded these criteria in fish-tissue and stream-bottom sediment.

PCBs in Hudson and Mohawk River Fish

High concentrations of PCBs in fish from parts of the Hudson River have been well documented by NYSDEC and others. (See reviews in Armstrong and Sloan, 1987; and Limburg and others, 1986.) In 1976 restrictions were placed on commercial and recreational fishing in the Hudson River downstream from Hudson Falls, in response to contamination from PCBs. Although fishing is currently permitted in parts of the Hudson River, New York State Department of Health advisories to "eat none" or to "eat no more than one meal per month" remain in force for most species (New York State Department of Health, 1997).

Concentrations of PCBs in whole-fish samples from the Hudson River at Poughkeepsie and from several Mohawk River sites downstream from Utica exceeded the FDA action level of 2,000 µg/kg. Although the action level is based on edible tissue, not the whole-fish concentrations measured in this study, these exceedances suggest a potential hazard that warrants further investigation. Results from the Mohawk River samples have prompted further investigation of conditions and sources of PCBs by New York State, which issued fish-consumption advisories for selected species from about a 40-mile reach of the Mohawk River between Oneida and Herkimer. Concentrations of all other organochlorine compounds detected in fish tissue were below FDA action levels at all sites.



Although fish samples were not collected from some of the upper Hudson River sites with known PCB contamination, high concentrations of PCBs were detected in stream-bottom sediments from these sites.

bottom sediments exceeded proposed NYSDEC criteria for wildlife bioaccumulation (New York State Department of Environmental Conservation, 1994) at 29 percent of sites. Concentrations of PCBs in sediment exceeded the NYSDEC criterion for wildlife bioaccumulation at a higher percentage of sites in large watersheds and small urban watersheds (both 67 percent) than in small nonurban watersheds (5 percent). Chlordane concentration exceeded the NYSDEC criterion for wildlife bioaccumulation at a higher percentage of small urban-watershed sites (67 percent) than at large-watershed sites or small nonurban sites (33 and 5 percent, respectively). Fish-tissue concentrations of PCBs and DDT exceeded the Wildlife Protection Criteria (WPC) (Newell and others, 1987) at 50 percent and 21 percent of all sites, respectively. PCBs exceeded the WPC at a higher percentage of sites in large watersheds and small urban watersheds (75 and 57 percent respectively) than in small nonurban watersheds (22 percent). DDT exceeded the WPC at a higher percentage of sites in large watersheds (38 percent) than in small urban and small nonurban watersheds (22 and 0 percent, respectively).

Site-to-site differences in concentrations of PCBs and organochlorine pesticides in stream-bottom sediment and fish tissue corresponded with land use, particularly the locations of point sources of PCBs and the historical usage patterns of DDT and chlordane. Median concentrations of PCBs in both stream-bottom sediments and white sucker tissue were highest in large-river samples, followed by the small-urban stream samples (fig. 6). Many of these sites are downstream from point sources and (or) industrial areas. The highest median concentrations of DDT and chlordane in

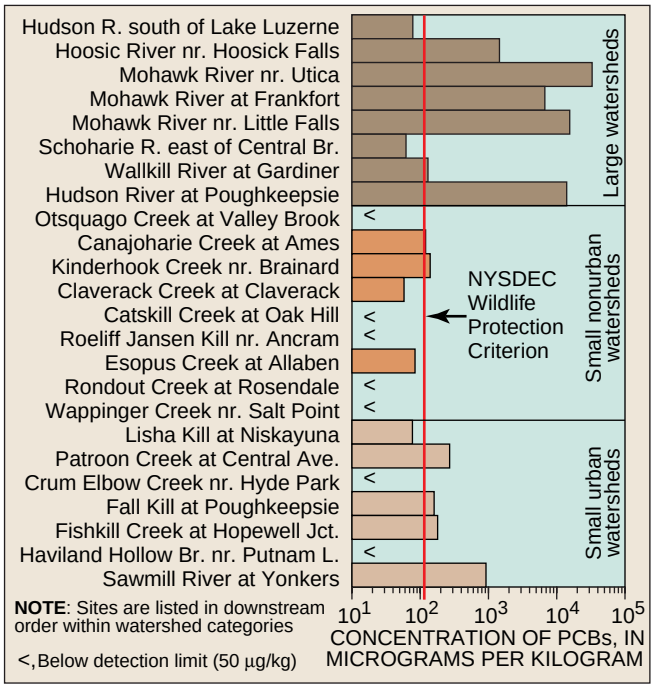


Figure 6. Concentrations of PCBs in whole carp or white suckers from 24 sites in the Hudson River Basin. Concentrations were highest and often exceeded the Wildlife Protection Criterion in large rivers and some urban streams.

stream-bottom sediments and white sucker tissue were in samples from sites in small urban watersheds. This corresponds with greater use of both of these pesticides in urban settings than in agricultural and forested settings during the 1970's (Phillips and Hanchar, 1996; Rod, 1989).

Fish and Macroinvertebrate Communities in Hudson River Tributaries

Benthic macroinvertebrate community samples were collected during summer 1993 from riffles in 28 streams, by methods described in Bode and others (1996). Samples were processed and data analyzed as a joint effort by USGS NAWQA and NYSDEC scientists. Comparison of indices such as EPT (the number of mayflies, stoneflies, and caddisflies, orders **E**phemeroptera, **P**lecoptera, and **T**richoptera, respectively, in a sample) with established NYSDEC water-quality criteria (Bode and others, 1996) indicate that most of the sites surveyed show some impairment (fig. 7). Invertebrate communities seem to be responding to nonpoint sources of sediment, nutrients, and pesticides (Murray and others, 1996). The three most severely impaired urban sites were in watersheds that drain

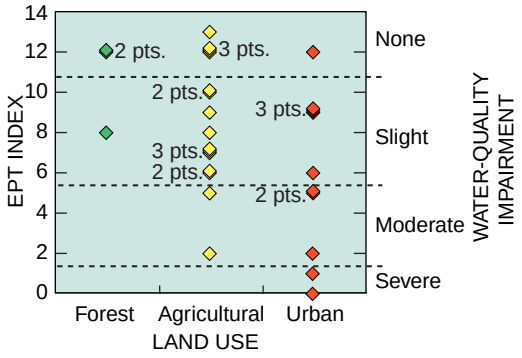


Figure 7. Invertebrate-community survey results from a USGS sampling of 28 streams in the Hudson River Basin. Most streams sampled show some impairment. Severe water-quality impairment was observed at sites in the most highly developed urban watersheds.

densely populated cities. Chemical and habitat data indicate that these sites are affected by sewage and industrial influences, as well as channel modification and urban runoff (Murray and others, 1996).

Results from a 1995 fish-community survey of 16 streams show a positive relation between the percentage of fish intolerant to impaired water quality (species such as brook trout and sculpin) and the percentage of forested or other undisturbed land in the watershed (fig. 8). Sites in cities with densely populated watersheds supported few species and few or no intolerant species. Most of these sites were numerically dominated by a single tolerant species (Butch and others, 1996). Biota of streams draining watersheds that are largely residential-urban, and those draining agricultural watersheds, showed a wide range of responses, partly as the

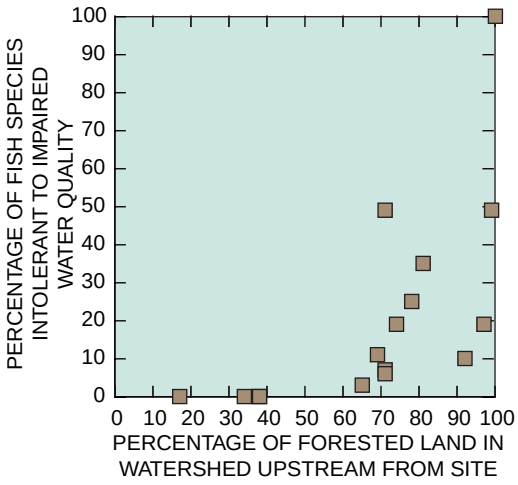


Figure 8. Percentage of intolerant fish species at a site as a function of the amount of forested land within the watershed. The absence or rarity of fish intolerant to impaired water quality was associated with chemical and (or) habitat impairment more often found in developed watersheds than in forested watersheds.

result of differences in the extent of an undisturbed forested buffer zone between the stream and the farms, residences, or roads.

Habitat Factors that Affect Stream Biota

In addition to chemical factors that affect fish and invertebrate communities, stream-channel features, such as streambanks, can affect the stream biota. Streams that drained highly populated watersheds but supported relatively healthy fish and invertebrate communities generally had undisturbed reaches that provided shade, had natural channels with pools and riffles, receive cool ground water in summer months, and had stable banks.

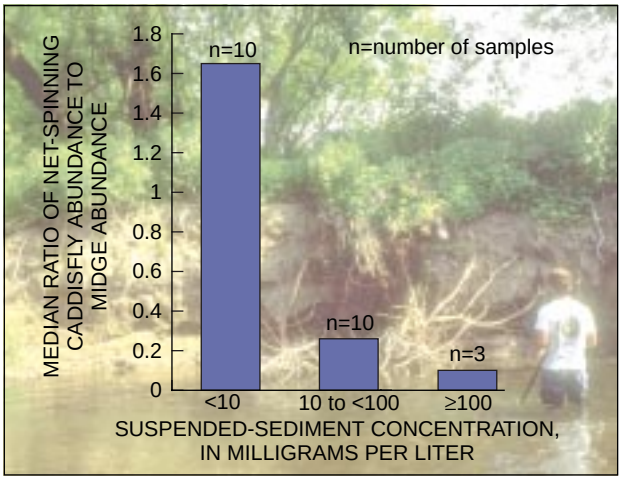


Figure 9. Median ratio of net-spinning caddisfly abundance to midge abundance as it relates to suspended-sediment concentration during high flows. Exposed streambanks, like that pictured above, are common in agricultural and urban areas; these banks are susceptable to erosion, and they supply higher than normal amounts of sediment to streams.

Benthic-invertebrate data from 23 stream sites indicate that many of the sites where suspended-sediment concentrations are high during spring runoff have a lack of certain organisms sensitive to high concentrations of suspended sediment and associated deposition, particularly net-spinning caddisflies (Hydropsychidae and Philopotamidae) (fig. 9). Tolerant organisms, such as midges (Chironomidae), that can burrow into the sediment or that have other adaptations to fine sediment were found in relatively high numbers.

Habitat alteration is severe in some urban areas, where streams are straightened and (or) channelized and natural streambank vegetation is replaced with concrete and pavement (fig. 10). Streamflows in these channels fluctuate widely because water is quickly routed from paved surfaces and storm drains to the stream during storms. Some altered channels support only a few tolerant fish species because of the uniform channel shape and stream-bottom material and the absence of backwaters and pools that provide shelter during high flows.

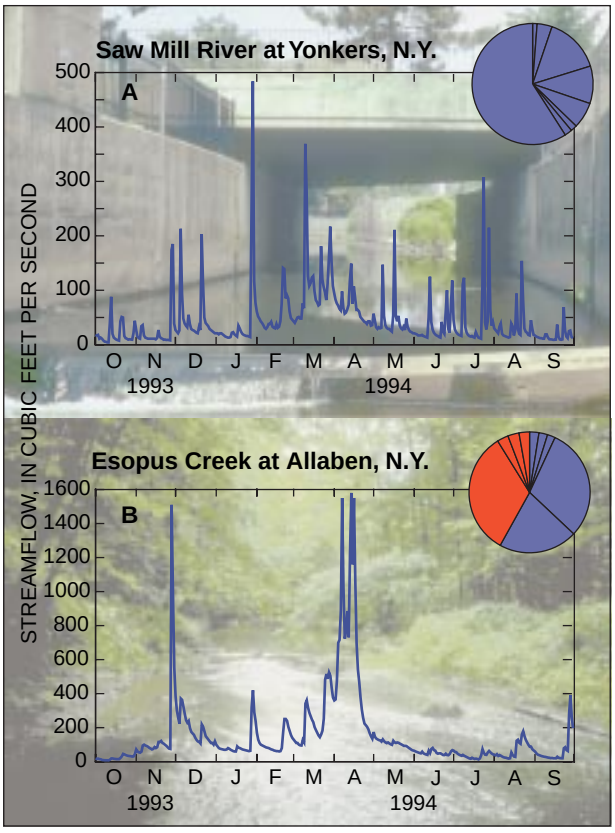


Figure 10. Streamflow and abundance of fish for: (A) “flashy” (sharply changing) streamflow that results from urbanization and (B) streamflow more typical of undisturbed conditions. Pie charts represent the fish community at each site. Number of slices indicates the number of species observed; size of slice represents the number of individuals in relation to the other species present. Blue indicates species tolerance to impaired water quality; red indicates intolerance. Channelized conditions and associated flashy streamflow likely contributed to the unbalanced fish community observed at the Saw Mill River and similar sites.

Pesticides in Streams and Rivers

Two surveys of streams and rivers were done in the Hudson River Basin to assess the presence and distribution of pesticides. The first survey consisted of at least monthly sampling at three fixed sites (routinely sampled, long-term sites) in the Mohawk River subbasin from March 1994 through September 1995. Two of these sites — Lisha Kill at Niskayuna and Canajoharie Creek near Canajoharie — represent streams draining urban/residential and agricultural land, respectively, and the third — Mohawk River at Cohoes — is downstream from the other sites (fig. 11) and represents watersheds that contain a wide variety of land uses. The second survey was a synoptic sampling (many sites sampled once over a short period of time) of 46 sites on 41 streams and rivers from late May through late June 1994, the period during and immediately after which most pesticides are applied.

Fixed-Site Results

Streamwater from the three sites sampled (table 3) contained 18 pesticides, specifically, 12 herbicides, 2 herbicide-degradation products, and 4 insecticides (Wall and Phillips, 1996b). Only two of the 108 samples collected contained any pesticide at a concentration that exceeded a drinking-water standard (either a maximum contaminant level (MCL) or health advisory level (HA) established by the U.S. Environmental Protection Agency (USEPA)); both were from Canajoharie Creek. One sample had an atrazine (herbicide) concentration of 4.3 µg/L (the MCL is 3 µg/L), and the other had a cyanazine (herbicide) concentration of 2.1 µg/L (the HA for cyanazine is 1 µg/L).

The highest concentrations of 15 of the 18 pesticides detected were in samples from either Canajoharie Creek or Lisha Kill; nearly all detections of the three remaining pesticides (alachlor, 2,6-diethylanaline, and tebuthiuron) were at the Mohawk River site. Canajoharie Creek is adjacent to farmland where agricultural chemicals are applied; therefore, the detection of the agricultural herbicides atrazine, cyanazine, metolachlor, pendimethalin, metribuzin, and simazine in the highest concentrations in the study was not surprising. Similarly, the highest concentrations of all four insecticides detected were in samples from the Lisha Kill; this watershed contains extensive urban and residential lands. The Mohawk River receives water from many tributaries draining forested, urban, and agricultural lands; therefore, the lower concentrations of pesticides in the Mohawk River at Cohoes than in Canajoharie Creek or Lisha Kill can be attributed to dilution.

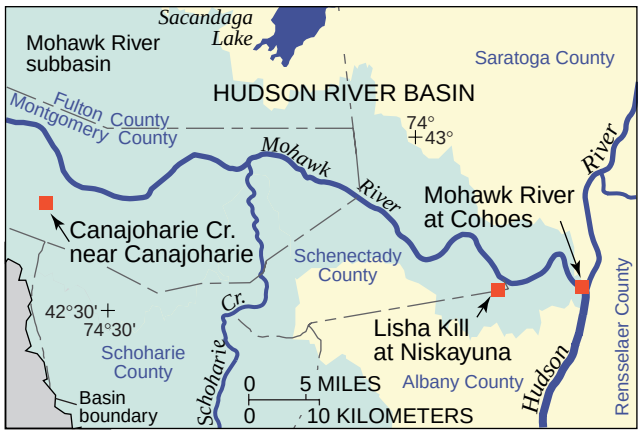


Figure 11. Locations of fixed sites sampled for pesticides from March 1994 through September 1995. Canajoharie Creek and Lisha Kill were selected to represent conditions in agricultural and urban/residential streams, respectively. The Mohawk River at Cohoes was selected to represent streams and rivers draining a variety of land uses.

Table 3. Pesticides detected among the three Mohawk River subbasin fixed sites, March 1994 through September 1995

[Colors indicate where maximum concentration was detected: yellow, Canajoharie Creek; red, Lisha Kill; blue, Mohawk River]

Pesticides detected	Type of product[1]	Concentration (micrograms per liter)		
		Detection limit	MCL/HA[2]	Maximum detected
Atrazine	H	0.001	3	4.3
Cyanazine	H	.004	1	2.1
Metolachlor	H	.002	70	1.3
Carbaryl	I	.003	700	.86
Diazinon	I	.002	.6	.55
Deethylatrazine	D	.002	na	.22
α-HCH	I	.002	na	.21
Prometon	H	.018	100	.071
Pendimethalin	H	.004	na	.035
Metribuzin	H	.004	100	.033
Terbacil	H	.007	90	.023
Alachlor	H	.002	2	.021
Simazine	H	.005	4	.018
Molinate	H	.004	na	.016
Tebuthiuron	H	.01	500	.01
Chlorpyrifos	I	.004	20	.009
EPTC	H	.002	na	.004
2,6-Diethylanaline	D	.003	na	.003

[1]H, herbicide; I, insecticide; D, degradation compound.
[2]MCL, Maximum Contaminant Level; HA, Health Advisory Level.

Pesticide concentrations were typically highest during the first major runoff-producing storm after the pesticide application period and were higher in June and July than in the rest of the year (Wall and Phillips, 1996a). The highest atrazine concentration in Canajoharie Creek was detected during the largest summer stormflow, on July 1, 1994 (fig. 12). Because a stream in a small watershed generally responds faster to storm runoff than those in a large basin, the large proportion of agricultural land in the Canajoharie Creek watershed resulted in a more rapid increase in atrazine concentrations, and higher concentrations, here than at the two other sites.

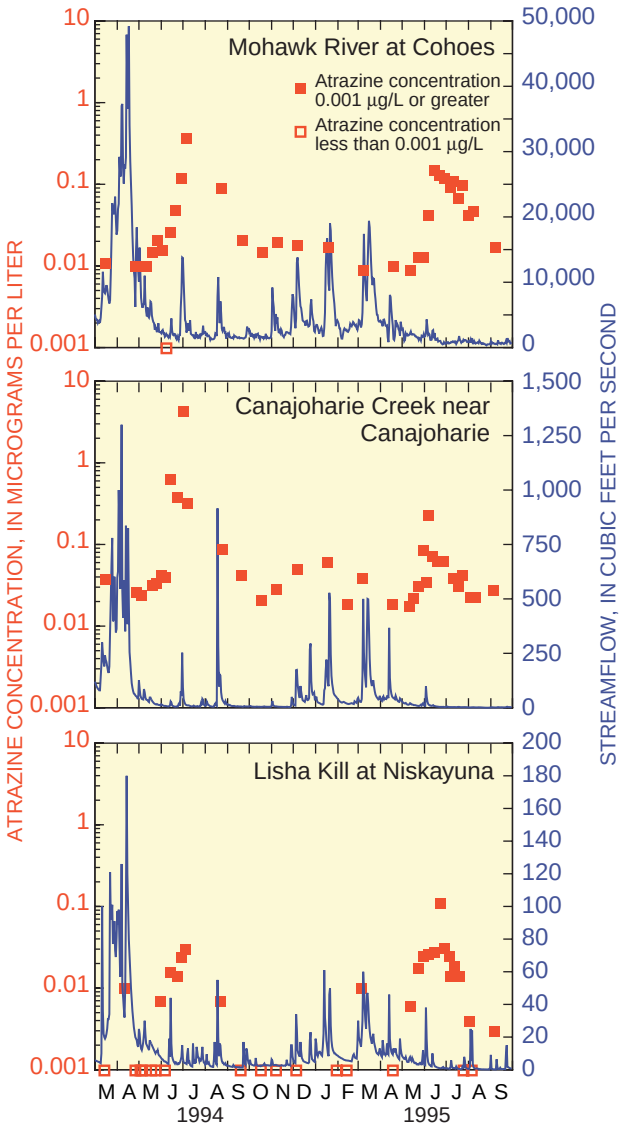


Figure 12. Atrazine concentration and streamflow at the three fixed sites (locations are shown in fig. 11). The highest concentration of atrazine and other pesticides generally occurred during the first runoff after pesticide application.

In general, seasonal patterns of pesticides detected over the course of the year mimicked those of atrazine. Atrazine concentrations at Canajoharie Creek during June and July ranged from 0.04 µg/L to more than 1 µg/L — at least double the 0.02 to 0.04 µg/L concentrations detected during the remainder of the year. Atrazine concentrations in the Mohawk River at Cohoes ranged from 0.04 to 0.37 µg/L during the growing season (May through August) and were less than 0.04 µg/L during the remainder of the year. The sample with the highest atrazine concentration at this site was also collected in July 1994, about 1 week after the maximum atrazine concentration was observed at Canajoharie Creek. This delay in peak concentration is not surprising, however, in that the Cohoes site is downstream from Canajoharie Creek and receives runoff from several other small watersheds (some dominated by agricultural land). This explains why peak concentrations were delayed and why elevated concentrations were sustained for a longer period than in Canajoharie Creek. Atrazine was seldom detected in the Lisha Kill, and concentrations exceeded 0.01 µg/L only from mid-May through July.

Pesticides were detected in a higher percentage of samples collected during the growing season than in the nongrowing season. Most detections during the nongrowing season were probably the result of movement of pesticides to ground water and their subsequent discharge to streams and rivers.

Deethylatrazine, an atrazine-degradation compound, was detected more frequently during the nongrowing season than the growing season in both Canajoharie Creek and the Mohawk River at Cohoes. This probably results from the extended period over which the degradation compound forms after the parent compound (atrazine) is applied. Although the degradation process permits deethylatrazine to persist throughout the nongrowing season, concentrations are highest during the growing season.

Synoptic Survey Results

Of the 46 synoptic sites sampled, 85 percent had detectable concentrations of at least one pesticide, and four sites (9 percent) had detectable concentrations of more than five pesticides. The Mohawk River at Cohoes site contained detectable amounts of eight pesticides or pesticide-degradation compounds, and the Hoosic River at Eagle Bridge had detectable amounts of six pesticides. Both sites are in large watersheds with a wide diversity of land use. The Lisha Kill at Niskayuna site and the West Creek at Warnersville site (in urban and agricultural watersheds, respectively) each had five detectable pesticides and one detectable degradation compound. The amount of agricultural land (33 percent of basin) and urban land (7 percent of basin) upstream from the Mohawk River site, and the size of the 3,500 mi^2 watershed, probably account for the large number of pesticides detected in samples from this site.

Among the 46 sites sampled, 15 pesticides were detected: 8 herbicides, 2 herbicide-degradation compounds, and 5 insecticides (Wall and Phillips, 1996b). The highest concentrations of 12 of the 15 pesticides were in streams and rivers draining either agricultural or urban land. The most frequently detected herbicides were atrazine and metolachlor (85 and 67 percent of sites, respectively), and the most often detected insecticides were diazinon and carbaryl (30 and 7 percent of sites, respectively).

Most of the pesticides detected in the synoptic survey were at low concentrations, ranging from 0.002 to 0.05 µg/L. The maximum concentration of any pesticide detected was 1.6 µg/L (for carbaryl), and no concentration exceeded any

available MCL or HA. These samples were collected during flow conditions that would not normally produce the highest annual concentrations, however. Eight of the nine sites where atrazine was not detected were in forested and urban watersheds; the ninth was at West Kill, northwest of North Blenheim, in a small watershed with mixed land use.

The sites in urban watersheds had the same number of pesticides detected as sites in agricultural and mixed-land-use watersheds — nine pesticides in each of the these groups. The types of pesticides at a given site correlated closely with land use; insecticides accounted for 32 percent of all pesticides detected at urban-watershed sites but only 9 percent of the pesticides detected at sites in agricultural and mixed-land-use watersheds (table 4). Among all 46 sites, 50 percent of the insecticide detections were in streams draining urban watersheds, and 4 of the 15 pesticides detected (carbaryl, DCPA, prometon, and malathion) were found only at sites in urban watersheds.

Table 4. Synoptic survey pesticide detections, by watershed land use

Watershed land-use category and number of sites in each	Number of pesticide detections	Percentage of detections as	
		Herbicide and herbicide-degradation compound	Insecticide
Urban (10)	31	68	32
Agricultural (14)	53	91	9
Mixed (16)	54	91	9
Forested (6)	6	100	0

Pesticides were detected at only two of the six forested watershed sites: West Canada Creek at Nobleboro and East Canada Creek at Stratford. Three herbicides (atrazine, metolachlor, and cyanazine) and one herbicide-degradation compound (deethylatrazine) were found at the West Canada Creek site at concentrations equal to or less than 0.012 µg/L, and atrazine and metolachlor were detected at the East Canada Creek site at concentrations equal to or less than 0.007 µg/L. Atrazine and other herbicides are not commonly used in forested areas; thus, their presence could be the result of atmospheric transport from areas where herbicides are applied.

Although the percentages of herbicide detections at sites in mixed-land-use watersheds were similar to those sites in agricultural watersheds, the concentrations of herbicides were generally lower at sites in mixed-land-use watersheds than at sites in agricultural watersheds.

Pesticides in Ground Water

Three well networks (agricultural, 16 wells; urban/residential, 26 wells; and domestic, 49 wells) were sampled to assess the occurrence of pesticides in ground water. The first two of these networks were designed to identify pesticides in shallow ground water (where the water table is less than 40 feet below land surface) in agricultural and urban/residential parts of the basin; the third represented ground water used for domestic water supply. The percentage of detections for the seven most commonly detected pesticides among the three networks is shown in figure 13; for comparison, the ground-water results are paired with results of the 1994 synoptic survey of pesticides at 46 stream and river sites across the Hudson River Basin.

The highest number of pesticides and the highest concentrations were in the 16 agricultural-network wells; seven pesticides or pesticide-degradation compounds were detected, three of which (atrazine, deethylatrazine, and metolachlor) were in samples from more than two of the wells. At least one pesticide was detected in 69 percent of the agricultural-network wells. Metolachlor and diazinon were found in 1 of the 26 urban-network wells; no other urban wells were found to contain any pesticides.

Five pesticides were detected in the domestic-well survey, but no more than two pesticides were detected in any domestic well. At least one pesticide was detected in 12 of 49 wells (24.5 percent) used for domestic water supply. All concentrations of pesticides in the domestic wells were less than 0.3 µg/L except for one detection of prometon (1.3 µg/L), a herbicide used to control most annual and perennial broadleaf and grassy weeds in non-agricultural areas.

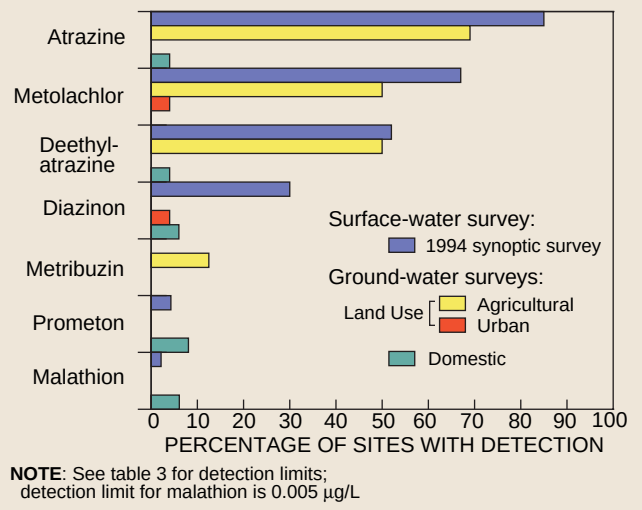


Figure 13. Detection of seven selected pesticides in three ground-water surveys and in a 1994 synoptic survey of streams throughout the Hudson River Basin. Among the ground-water surveys, pesticides were most often detected in shallow ground water beneath agricultural areas, but detection percentages in streams were generally highest.

Nitrate in Ground Water and Streams

The networks of urban, agricultural, and domestic wells and synoptic stream sites used for pesticide sampling also were used to sample for nitrate. Samples for pesticide and nitrate analysis were collected simultaneously from the wells, but the samples from streams were collected during the late summer of 1993, during low-streamflow conditions.

Of the 91 ground-water samples collected from the three networks, 53 percent had detectable (greater than 0.05 mg/L as N) concentrations of nitrate; 38 percent of the agricultural-network wells had nitrate concentrations greater than 3.0 mg/L, a concentration considered by Madison and Brunett (1984) to indicate human influence. This is not surprising for wells in agricultural areas, where fertilizer and manure are applied seasonally. Of the 26 wells in the urban/residential network, 23 percent had concentrations greater than 3.0 mg/L, as did 16 percent of the wells in the domestic-well network. Among the agricultural- and urban/residential-network wells where nitrate was detected, nearly half (48 percent) had concentrations indicative of human influence.

What is Nitrate?

Nitrate is the form of nitrogen most commonly and most easily assimilated by plants. Nitrate forms naturally in soil from transformations of nitrogen, nitrogen-based fertilizers, manure, or urea.

Nationwide, nitrate is the most widespread contaminant in ground water, and because most ground water eventually discharges to surface water, nitrate in ground water can pose a potential threat to surface-water quality. Direct surface runoff of waters from agricultural areas and discharge from wastewater treatment facilities can also contribute to elevated nitrate concentrations and degrade the quality of streamwater.

Human ingestion of water with nitrate concentrations in excess of the MCL (10 mg/L) can lead to a sometimes fatal blood disorder in infants called methemoglobinemia or “blue-baby syndrome.”

Among the wells and streams sampled, only 5 of the 137 samples had detections above the MCL, and all of these samples were from wells. Only one domestic-well sample had a nitrate concentration above the drinking-water standard, and this sample (16 mg/L) was from a dug well where ground water was only 6.5 feet below land surface; both the open surface of a dug well and the shallow depth to water make this well highly susceptible to such contamination. None of the wells which exceeded the MCL were used for drinking water.

The highest median concentration (1.30 mg/L) of nitrate was in samples from the agricultural wells. The maximum concentration of 26 mg/L was in a sample of ground water beneath an office park (urban/residential area) in which lawn fertilizer probably was applied. Of the stream samples, 93 percent contained detectable concentrations of nitrate, but the highest concentration was only 1.4 mg/L, and the median concentration for all the stream sites was 0.35 mg/L.

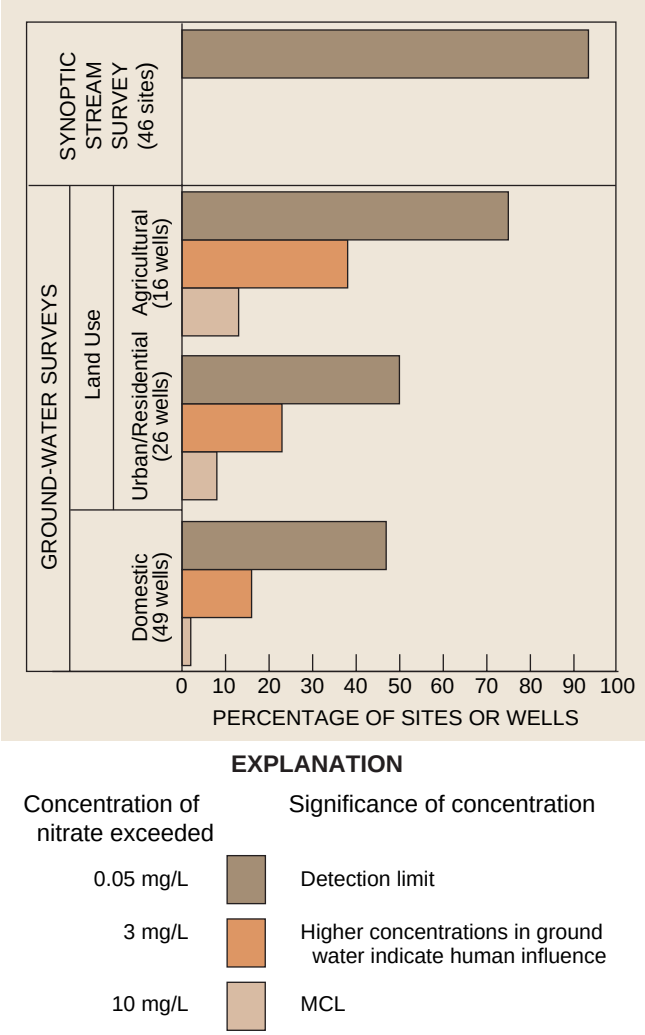


Figure 14. Percentage of nitrate concentrations in wells and 1993 synoptic stream-sampling sites that exceeded the indicated concentrations. Nitrate was most often detected in a synoptic survey of surface water, but never at concentrations greater than 1.4 mg/L. The highest concentrations were in ground water from beneath agricultural fields.

WATER-QUALITY CONDITIONS IN A NATIONAL CONTEXT
Comparison of Stream Quality in the Hudson River Basin with Nationwide NAWQA Findings

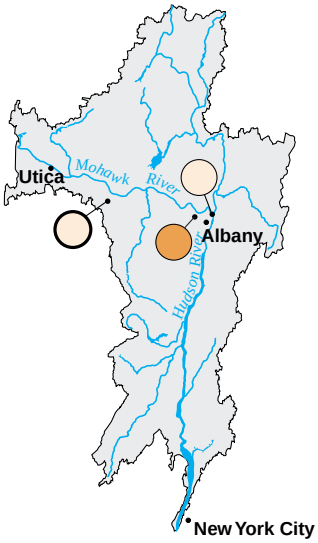


Seven major water-quality characteristics were evaluated for stream sites in each NAWQA Study Unit. Summary scores for each characteristic were computed for all sites that had adequate data. Scores for each site in the the Hudson River Basin were compared with scores for all sites sampled in the 20 NAWQA Study Units during 1992–95. Results are summarized by percentiles; higher percentiles generally indicate poorer quality compared with other NAWQA sites. Water-quality conditions at each site also are compared to established criteria for protection of aquatic life. Applicable criteria are limited to nutrients and pesticides in water, and semivolatile organic compounds, organochlorine pesticides, and PCBs in sediment. (Methods used to compute rankings and evaluate aquatic-life criteria are described by Gilliom and others, in press.)

EXPLANATION

Ranking of stream quality relative to all NAWQA stream sites — Darker colored circles generally indicate poorer quality. Bold outline of circle indicates one or more aquatic life criteria were exceeded.

- **Greater than the 75th percentile** (among the highest 25 percent of NAWQA stream sites)
- **Between the median and the 75th percentile**
- **Between the 25th percentile and the median**
- **Less than the 25th percentile** (among the lowest 25 percent of NAWQA stream sites)

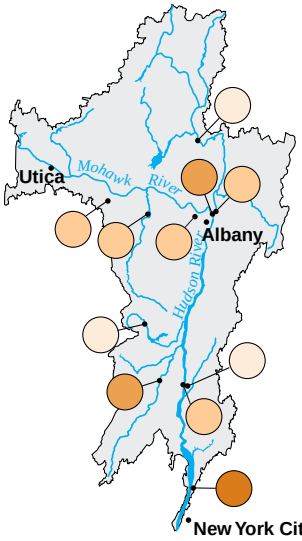


PESTICIDES in water

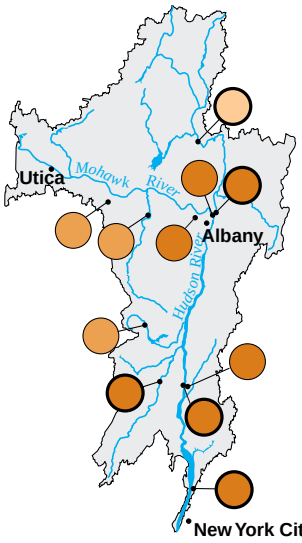
Pesticide concentrations were below the national median in the two streams sampled that drain agricultural land. The aquatic life criteria for atrazine was exceeded at one site in July 1994. The stream with pesticide concentrations above the national median contained elevated concentrations of the insecticides diazinon and carbaryl. This watershed contains a large percentage of lawn and turf areas to which diazinon and carbaryl are commonly applied.

NUTRIENTS in water

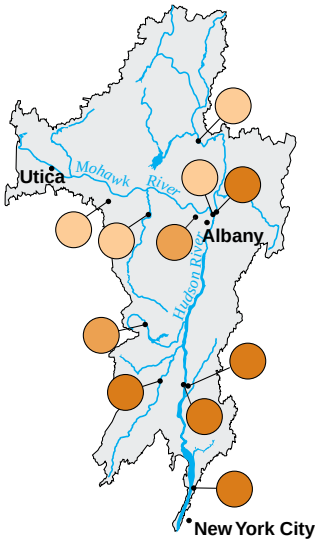
Nutrient concentrations at most streams sampled were below the national median. Streams with the lowest concentrations were generally in forested areas; the stream with the highest concentrations drained a highly urbanized watershed.



ORGANOCHLORINE PESTICIDES and PCBs in stream-bottom sediment and fish tissue



Concentrations of organochlorine compounds at most sites surveyed were above the national median, and most were among the highest 25 percent. Most of the elevated concentrations were due to very high concentrations of PCBs in stream-bottom sediments and (or) fish tissue. Some of the highest concentrations of PCBs in the Nation are in the Hudson River; concentrations of PCBs in some urban watersheds tributary to the Hudson River are also high. New York State sediment screening guidelines, are exceeded for PCBs in many streams, and for DDT residues in some streams draining urban areas.

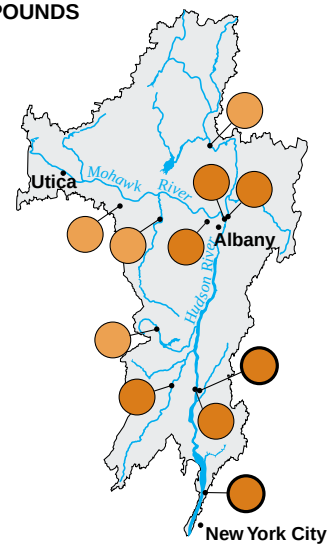


TRACE ELEMENTS in stream-bottom sediment

Concentrations of trace elements in stream-bottom sediments from most sites in the Hudson River Basin were near or above the national median. Trace-element concentrations were particularly high in urbanized watersheds.

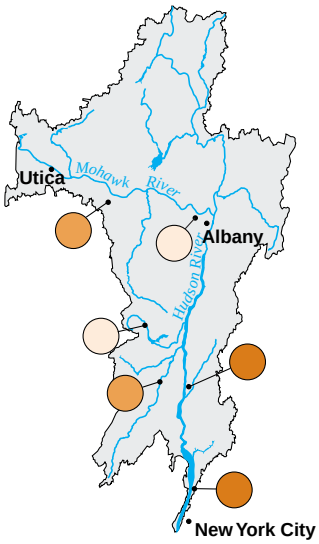
SEMIVOLATILE ORGANIC COMPOUNDS in stream-bottom sediment

Concentrations of semivolatile organic compounds — including PAHs, phthalates and phenols — in stream-bottom sediment were above the National median for all sites in the Hudson River Basin. Two of the highest national concentrations of these compounds were in the two most urbanized sites sampled in the Hudson River Basin; concentrations of 1 phthalate and at least 5 PAHs exceeded the aquatic life criteria at these sites.



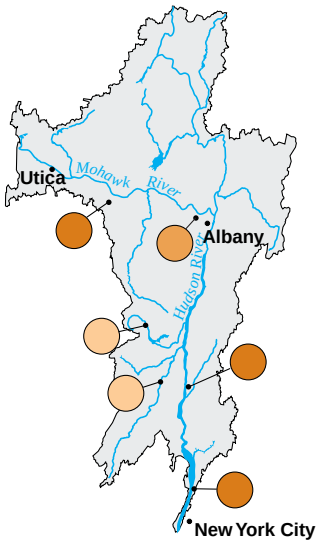
STREAM-HABITAT DEGRADATION

Degradation of fish habitats along urban streams in the Hudson River Basin is greater than the national median, largely as a result of channel straightening and other forms of bank alteration. Stable habitats such as pools were absent or poorly developed along many reaches, and large fluctuations in streamflow were common. Stream habitats in two agricultural watersheds were degraded by bank erosion and removal of tree canopy; degradation at these sites also slightly exceeded the national median. Stream habitat in a residential watershed, with a wide forested buffer, and in a mostly forested watershed was relatively undisturbed, and degradation was below the national median.



CONCLUSIONS

Compared to other NAWQA Study Units, some streams, particularly those draining urban areas and large watersheds, had elevated concentrations of trace elements and semivolatile organic compounds in stream-bottom sediment, and organochlorine pesticides and PCBs in stream-bottom sediment and fish tissue. Stream habitat and fish communities in urban and agricultural streams were also impaired relative to streams in other Study Units. Pesticide and nutrient concentrations were generally lower at sites sampled in the Hudson River Basin than those sites in other Study Units.



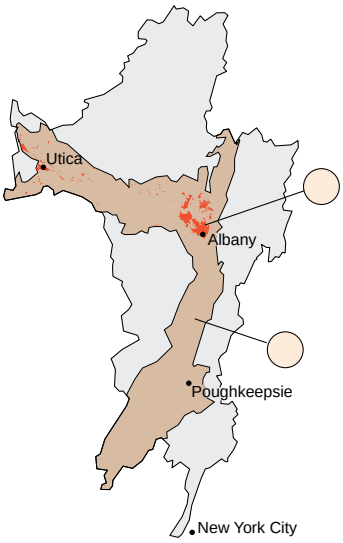
FISH-COMMUNITY DEGRADATION

Fish communities at all six sites differed from those communities expected under minimally impaired conditions, and degradation of the communities at four of these six sites was above the national median. The most severely impaired fish communities were from two streams in densely populated watersheds and one stream in a mostly agricultural watershed. These sites were characterized by the absence or rarity of pollution-intolerant species, and most of these sites were numerically dominated by species that feed on a wide variety of foods. These communities could be responding to a combination of several distrubances including nonpoint-source nutrients and pesticides, destruction of forested buffer zones, point-source discharges of sewage and industrial waste, and (or) stream channelization.

WATER-QUALITY CONDITIONS IN A NATIONAL CONTEXT
Comparison of Ground-Water Findings in the Hudson River Basin with Nationwide NAWQA Findings

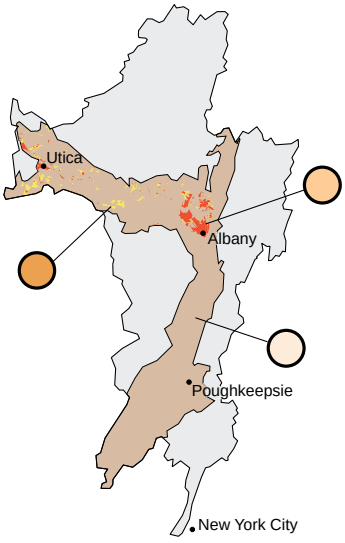


Five major water-quality characteristics were evaluated for ground-water studies in each NAWQA Study Unit. Ground-water resources were divided into two categories: (1) drinking-water aquifers, and (2) shallow ground water underlying agricultural or urban areas. Summary scores were computed for each characteristic for all aquifers and shallow ground-water areas that had adequate data. Scores for each aquifer and shallow ground-water area in the Hudson River Basin were compared with scores for all aquifers and shallow ground-water areas sampled in the 20 NAWQA Study Units during 1992–95. Results are summarized by percentiles; higher percentiles generally indicate poorer quality compared with other NAWQA ground-water studies. Water-quality conditions for each drinking-water aquifer also are compared to established drinking-water standards and criteria for protection of human health. (Methods used to compute rankings and evaluate standards and criteria are described by Gilliom and others, in press.)



RADON

Radon levels in the Hudson River Basin were generally lower than the national median, although radon levels in water from a few individual domestic-use wells were above the national median.



NITRATE

Nitrate concentrations in the Hudson River Basin were below the national median for the shallow urban and domestic well samples but above the national median for the shallow agricultural well samples. Concentrations and exceedances of drinking-water criteria were highest in agricultural areas, although these waters are not widely used for drinking-water supply.

EXPLANATION

Drinking-water aquifers

Domestic well survey

Shallow ground-water areas

Agricultural area

Urban area

Ranking of ground-water quality relative to all NAWQA ground-water studies — Darker colored circles generally indicate poorer quality. Bold outline of circle indicates one or more standards or criteria were exceeded

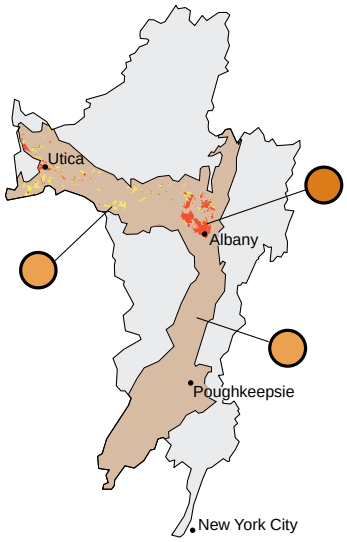
Greater than the 75th percentile (among the highest 25 percent of NAWQA ground-water studies)

Between the median and the 75th percentile

Between the 25th percentile and the median

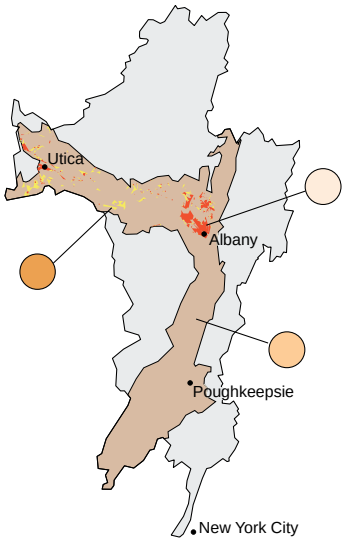
Less than the 25th percentile (among the lowest 25 percent of NAWQA ground-water studies)

NOTE: The area mapped as part of the domestic-well survey reflects the spatial extent of two physiographic regions in which the survey was conducted, rather than the location and extent of aquifers sampled in this survey. The areas mapped as shallow ground-water areas correspond to the location and extent of aquifers underlying the agricultural and urban areas studied.



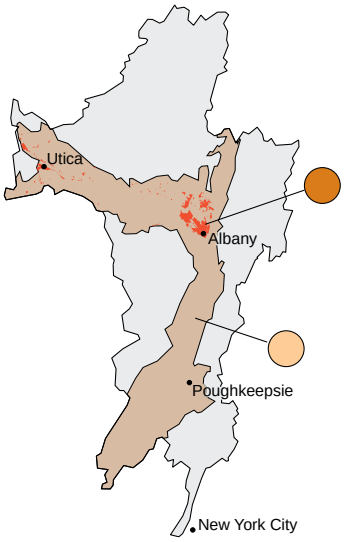
DISSOLVED SOLIDS

Dissolved-solids concentrations in the shallow urban wells were above the national median, and dissolved-solids concentrations at 34 percent of the urban wells exceeded the USEPA drinking-water standard. Dissolved-solids concentrations in samples from the agricultural and domestic wells also were above the national median, but fewer than 20 percent of these values exceeded the USEPA drinking-water standard.



PESTICIDES

Pesticides were detected most frequently in agricultural areas, and the frequency exceeded the national median. Concentrations in these samples were generally low, however, and no concentrations exceeded any available water-quality standard. Pesticide detection for the domestic-well and shallow-urban well samples was below the national median, and none of the concentrations in these samples exceeded any available water-quality standard.



VOLATILE ORGANIC COMPOUNDS

Shallow urban wells had the most frequent detection of volatile organic compounds (VOCs). About one-third of those wells contained one or more VOCs; this detection rate is high relative to the national median. No VOC concentrations exceeded any water-quality standard, however, and the concentrations were low. Fewer than 7 percent of the domestic wells contained VOCs — a detection frequency lower than the national median.

CONCLUSIONS

Compared to other NAWQA Study Units, ground-water quality in the Hudson River Basin is similar to the median for comparable areas sampled nationally. Pesticides were most frequently detected in agricultural areas, and the rate of detection exceeded the national median. No concentrations exceeded drinking-water standards; however, drinking-water standards do not exist for some pesticides detected. VOC detection frequency exceeded the national median among urban wells sampled, but the concentrations detected in these wells were generally low. Nitrate and dissolved-solids concentrations in some wells in each of the three networks sampled exceeded drinking-water standards. Radon concentrations were among the lowest 25 percent nationally.

One of the principal ways by which NAWQA attempts to describe water-quality conditions is through multiple lines of evidence (Hirsch and others, 1988). Site selection in the Hudson River Basin emphasized overlap of study components, particularly those related to stream chemistry and ecology. Overlap between "stream-chemistry" and "ecology" sites is summarized in the table below and depicted geographically in relation to land use in the figure at right.

Click here to download the data collection network and land use maps (PDF, 2MB)

In addition to the overlapping of sampling components, the distribution of sites throughout the basin and among the land-use categories was given considerable weight in site selection. The sites selected for one-time (synoptic) as well as long-term (Fixed Site) sampling were chosen to provide broad representation of streams and rivers draining forested, agricultural, urban/residential, and mixed land-use watersheds. Because water quality in forested watersheds (areas dominated by green in the figure above) typically shows little effect of human activities, only a few sites were sampled in such watersheds. In contrast, the variability of water quality is considerably greater among streams draining urban/residential and agricultural land; therefore, the number of sites needed to characterize water quality in these areas is high.

Two types of ground-water surveys were done; one was designed to reflect the effects of land use, the other to address the quality of drinking water from domestic wells. The two land-use surveys were designed to address the quality of shallow ground water beneath agricultural and urban/residential areas, which was poorly documented in upstate New York prior to these surveys.

Table 5. Number and type of stream-chemistry sites used in each stream-ecology-site category for the Hudson River Basin Study Unit

[Values indicate number of sites where both stream chemistry and ecological data were collected]

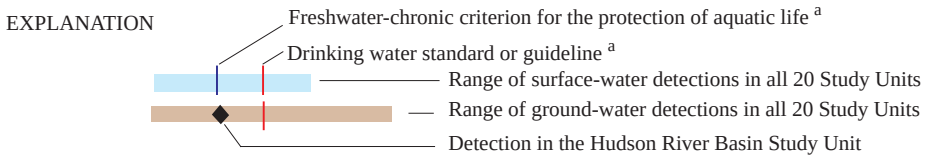
Type of stream-chemistry site		Ecology-site category			
		Fish community survey (18 sites)	Algae and macro-invertebrate survey (38 sites)	Ecological assess-ment (8 sites)	Contaminants in fish tissue (26 sites)
Fixed Sites	(14 sites)	8	9	8	11
Synoptic sites	(46 sites)	18	38	8	18
Stream-bottom sediments	(51 sites)	18	30	8	14

Study component	Type of data collected and purpose	Sites sampled	Number of sites	Sampling frequency and period
Stream Chemistry				
Fixed Sites	Continuous streamflow and sampling for major ions, organic carbon, suspended sediment, and nutrients. To document concentrations and loads.	Streams and rivers draining agricultural, urban, forested, and large (mixed-land-use) watersheds.	14	Monthly plus storms, 1993-95.
Intensive Fixed Sites	Commonly used pesticides, including triazine herbicides. To determine peak concentrations.	Subset of fixed sites within Mohawk River Basin, including an urban site, an agricultural site, and a site at the Mohawk River mouth.	3	Monthly to weekly, 1994-95.
Synoptic sites	Major ions, organic carbon, suspended sediment, nutrients, pesticides, and bacteria. To show regional variability in water quality.	Fixed sites and additional sites representative of major patterns of land use throughout the Hudson River Basin.	46	Early spring 1993, late summer 1993, late spring 1994.
Stream-bottom sediments	Trace elements, organochlorine and semivolatile organic compounds in stream-bottom sediment. To indicate regional variability in the chemical quality of stream-bottom sediment.	Depositional zones of most Fixed and synoptic sites.	51	Once during 1992-94.
Stream Ecology				
Contaminants in fish tissue	Trace metals in fish livers and organochlorine compounds in whole fish. To describe spatial distribution of contaminants.	A subset of stream sites sampled for stream-bottom sediments and synoptic site sampling.	26	Once or twice in 1992 and (or) 1994.
Intensive ecological assessments	Composition and relative abundance of fishes; stream-habitat characterization. To describe annual and within-stream variation; provide data for long-term monitoring.	Subset of Fixed Sites.	8	July-Sept. 1993-95 (7 sites), and 1993-94 (1 site); two additional sections sampled at each of 3 sites in 1994.
Ecological synoptic survey — algae and macroinvertebrates	Species composition and abundance from macroinvertebrate and algal samples; habitat characterization. To describe spatial variation in biological communities and water and habitat quality.	Subset of synoptic sites.	38	Once during July - August 1993.
Ecological synoptic survey — fish	Composition and relative abundance of fishes; stream-habitat characterization. To describe spatial patterns in biological communities and water and habitat quality.	Subset of synoptic sites.	10	Once during August 1995.
Ground-Water Chemistry				
Survey of domestic wells	Major ions, nutrients, commonly used pesticides, volatile organic compounds (VOCs), and radionuclides. To document chemical quality of domestic water supplies.	Domestic water wells throughout Hudson River Basin. Well depth ranged from 7 to more than 100 feet below land surface.	49	Once in 1994.
Near-surface ground-water under agricultural fields	Major ions, nutrients, commonly used pesticides, VOCs, and radionuclides. Wells were in or next to row-crop fields, pastures, or barns. To characterize ground-water quality in agricultural areas.	Shallow monitoring wells finished in Mohawk River Basin glacial and post-glacial deposits, generally 50 feet deep or less.	18	Once in 1994.
Near-surface ground-water under urban areas	Major ions, nutrients, commonly used pesticides, VOCs, radionuclides, and trace metals. Wells were in or next to lawns and schoolyards in residential areas. To characterize ground-water quality in residential areas.	Shallow monitoring wells finished in Mohawk River Basin glacial and post-glacial deposits, generally 50 feet deep or less.	26	Once in 1994.
Variation along ground-water flow paths	Major ions, nutrients, commonly used pesticides. To characterize the fate and transport of chemicals along ground-water flow paths.	Shallow and deep monitoring wells, tile drains, and drainage ditches located on a corn-soybean farm.	32	Most sites at least twice, in 1993, 1994, or 1995.
Special Stream Studies				
Nutrient processes	Nutrients, dissolved oxygen, temperature, and algae species composition, abundance, and biomass. To determine processes affecting nutrients.	Mainstem sites, agricultural drains, and small tributaries within Canajoharie Creek watershed.	14	Once in spring 1995.
Base-flow pesticide study.	Commonly used pesticides and major ions. To identify characteristics of source areas of pesticides to Canajoharie Creek.	Mainstem sites, agricultural drains, tile-drain outflows, and small tributaries within Canajoharie Creek watershed.	14	Once in spring 1995.

SUMMARY OF COMPOUND DETECTIONS AND CONCENTRATIONS

The following tables summarize data collected for NAWQA studies from 1992-95 by showing results for the Hudson River Basin Study Unit compared to the NAWQA national range for each compound detected. The data were collected at a wide variety of places and times. In order to represent the wide concentration ranges observed among Study Units, logarithmic scales are used to emphasize the general magnitude of concentrations (such as 10, 100, or 1,000), rather than the precise number. The complete dataset used to construct these tables is available upon request.

Concentrations of herbicides, insecticides, volatile organic compounds, and nutrients detected in ground and surface waters of the Hudson River Basin Study Unit. [mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; %, percent; <, less than; - -, not measured; trade names may vary]



Herbicide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.001 0.01 0.1 1 10 100 1,000)
Alachlor (Lasso)	4% 0%	
2,6-Diethylaniline (Alachlor degradate)	<1% 0%	
Atrazine (AAtrex, Gesaprim)	75% 19%	
Deethylatrazine[c] (Atrazine degradate)	43% 16%	
Cyanazine (Bladex, Fortrol)	29% 11%	
2,4-D (2,4-PA)	1% 0%	
DCPA (Dacthal)	<1% 0%	
Diuron (Karmex, Direx)	1% 1%	
EPTC (Eptam)	<1% 1%	
Metolachlor (Dual, Pennant)	55% 17%	
Metribuzin (Lexone, Sencor)	3% 3%	
Molinate (Ordram)	<1% 1%	
Napropamide (Devrinol)	<1% 0%	
Neburon (Neburex, Noruben)	1% 0%	
Pebulate (Tillam)	<1% 0%	
Pendimethalin (Prowl, Stomp)	7% 6%	

Herbicide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.001 0.01 0.1 1 10 100 1,000)
Prometon (Gesagram)	13% 4%	
Pronamide (Kerb, propyzamid)	<1% 0%	
Propanil (Stampede, Surcopur)	<1% 0%	
Simazine (Aquazine, Princep)	8% <1%	
Tebuthiuron (Spike, Perflan)	1% 1%	
Terbacil[c] (Sinbar)	1% 0%	

Insecticide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.001 0.01 0.1 1 10 100 1,000)
Carbaryl[c] (Sevin, Savit)	12% 0%	
Carbofuran[c] (Furadan)	<1% 0%	
Chlorpyrifos (Dursban, Lorsban)	1% 0%	
p,p'-DDE (*p,p'*-DDT metabolite)	0% <1%	
Diazinon	16% 2%	
alpha-HCH (*alpha*-lindane)	<1% 0%	
Malathion (malathon, Cythion)	<1% 1%	

Volatile organic compound (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.01, 0.1, 1, 10, 100, 1,000)
1,1,1-Trichloroethane	-- 1%	
1,1-Dichloroethane	-- 1%	
total Trihalomethanes	-- 11%	

Nutrient (Trade or common name)	Rate of detection [b]	Concentration, in mg/L (0.01, 0.1, 1, 10, 100, 1,000, 10,000, 100,000)
Dissolved ammonia	90% 81%	
Dissolved ammonia plus organic nitrogen as nitrogen	57% 27%	
Dissolved phosphorus as phosphorus	58% 29%	
Dissolved nitrite plus nitrate	92% 61%	

Volatile organic compound (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.01, 0.1, 1, 10, 100, 1,000, 10,000, 100,000)
Methyl *tert*-butyl[d] ether (MTBE)	-- 6%	

Other	Rate of detection [b]	Concentration, in pCi/L (1, 10, 100, 1,000, 10,000, 100,000)
Radon 222	-- 94%	

SUMMARY OF COMPOUND DETECTIONS AND CONCENTRATIONS

Herbicides, insecticides, volatile organic compounds, and nutrients not detected in ground and surface waters of the Hudson River Basin Study Unit.

Herbicides

2,4,5-T

2,4,5-TP (Silvex, Fenoprop)

2,4-DB (Butyrac, Butoxone, Embutox Plus, Embutone)

Acetochlor (Harness Plus, Surpass)

Acifluorfen (Blazer, Tackle 2S)

Benfluralin (Balan, Benefin, Bonalan, Benefex)

Bentazon (Basagran, Bentazone, Bendioxide)

Bromacil (Hyvar X, Urox B, Bromax)

Bromoxynil (Buctril, Brominal)

Butylate (Sutan +, Genate Plus, Butilate)

Chloramben (Amiben, Amilon-WP, Vegiben)

Clopyralid (Stinger, Lontrel, Reclaim, Transline)

Dacthal mono-acid (Dacthal metabolite)

Dicamba (Banvel, Dianat, Scotts Proturf)

Dichlorprop (2,4-DP, Seritox 50, Kildip, Lentemul)

Dinoseb (Dinosebe)

Ethalfluralin (Sonalan, Curbit)

Fenuron (Fenulon, Fenidim)

Fluometuron (Flo-Met, Cotoran, Cottonex, Meturon)

Linuron (Lorox, Linex, Sarclex, Linurex, Afalon)

MCPA (Rhomene, Rhonox, Chiptox)

MCPB (Thistrol)

Norflurazon (Evital, Predict, Solicam, Zorial)

Oryzalin (Surflan, Dirimal)

Picloram (Grazon, Tordon)

Propachlor (Ramrod, Satecid)

Propham (Tuberite)

Thiobencarb (Bolero, Saturn, Benthiocarb, Abolish)

Triallate (Far-Go, Avadex BW, Tri-allate)

Triclopyr (Garlon, Grandstand, Redeem, Remedy)

Trifluralin (Treflan, Gowan, Tri-4, Trific, Trilin)

Insecticides

3-Hydroxycarbofuran (Carbofuran metabolite)

Aldicarb sulfone (Standak, aldoxycarb, aldicarb metabolite)

Aldicarb sulfoxide (Aldicarb metabolite)

Aldicarb (Temik, Ambush, Pounce)

Azinphos-methyl (Guthion, Gusathion M)

Dieldrin (Panoram D-31, Octalox, Compound 497, Aldrin epoxide)

Disulfoton (Disyston, Di-Syston, Frumin AL, Solvirex, Ethylthiodemeton)

Ethoprop (Mocap, Ethoprophos)

Fonofos (Dyfonate, Capfos, Cudgel, Tycap)

Methiocarb (Slug-Geta, Grandslam, Mesurol)

Methomyl (Lanox, Lannate, Acinate)

Methyl parathion (Penncap-M, Folidol-M, Metacide, Bladan M)

Oxamyl (Vydate L, Pratt)

Parathion (Roethyl-P, Alkron, Panthion, Phoskil)

Phorate (Thimet, Granutox, Geomet, Rampart)

Propargite (Comite, Omite, Ornamite)

Propoxur (Baygon, Blattanex, Unden, Proprotox)

Terbufos (Contraven, Counter, Pilarfox)

cis-Permethrin (Ambush, Astro, Pounce, Pramex, Pertox, Ambushfog, Kafil, Perthrine, Picket, Picket G, Dragnet, Talcord, Outflank, Stockade, Eksmin, Coopex, Peregin, Stomoxin, Stomoxin P, Qamlin, Corsair, Tornade)

gamma-HCH (Lindane, *gamma*-BHC, Gammexane, Gexane, Soprocide, gamma-hexachlorocyclohexane, *gamma*-benzene hexachloride)

Volatile organic compounds

1,1,1,2-Tetrachloroethane (1,1,1,2-TeCA)

1,1,2,2-Tetrachloroethane

1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113, CFC 113)

1,1,2-Trichloroethane (Vinyl trichloride)

1,1-Dichloroethene (Vinylidene chloride)

1,1-Dichloropropene

1,2,3-Trichlorobenzene (1,2,3-TCB)

1,2,3-Trichloropropane (Allyl trichloride)

1,2,4-Trichlorobenzene

1,2,4-Trimethylbenzene (Pseudocumene)

1,2-Dibromo-3-chloropropane (DBCP, Nemagon)

1,2-Dibromoethane (EDB, Ethylene dibromide)

1,2-Dichlorobenzene (*o*-Dichlorobenzene, 1,2-DCB)

1,2-Dichloroethane (Ethylene dichloride)

1,2-Dichloropropane (Propylene dichloride)

1,3,5-Trimethylbenzene (Mesitylene)

1,3-Dichlorobenzene (*m*-Dichlorobenzene)

1,3-Dichloropropane (Trimethylene dichloride)

1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB)

1-Chloro-2-methylbenzene (*o*-Chlorotoluene)

1-Chloro-4-methylbenzene (*p*-Chlorotoluene)

2,2-Dichloropropane

Benzene

Bromobenzene (Phenyl bromide)

Bromochloromethane (Methylene chlorobromide)

Bromomethane (Methyl bromide)

Chlorobenzene (Monochlorobenzene)

Chloroethane (Ethyl chloride)

Chloroethene (Vinyl chloride)

Chloromethane (Methyl chloride)

Dibromomethane (Methylene dibromide)

Dichlorodifluoromethane (CFC 12, Freon 12)

Dichloromethane (Methylene chloride)

Dimethylbenzenes (Xylenes (total))

Ethenylbenzene (Styrene)

Ethylbenzene (Phenylethane)

Hexachlorobutadiene

Isopropylbenzene (Cumene)

Methylbenzene (Toluene)

Naphthalene

Tetrachloroethene (Perchloroethene)

Tetrachloromethane (Carbon tetrachloride)

Trichloroethene (TCE)

Trichlorofluoromethane (CFC 11, Freon 11)

cis-1,2-Dichloroethene ((Z)-1,2-Dichloroethene)

cis-1,3-Dichloropropene ((Z)-1,3-Dichloropropene)

n-Butylbenzene (1-Phenylbutane)

n-Propylbenzene (Isocumene)

p-Isopropyltoluene (*p*-Cymene)

sec-Butylbenzene

tert-Butylbenzene

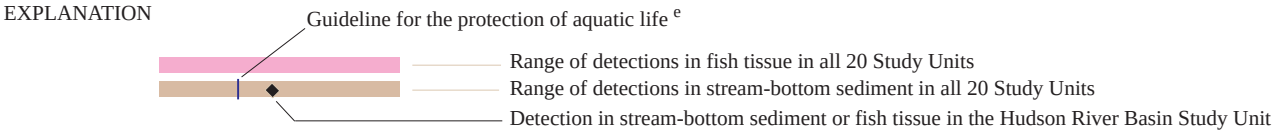
trans-1,2-Dichloroethene ((E)-1,2-Dichlorothene)

trans-1,3-Dichloropropene ((E)-1,3-Dichloropropene)

Nutrients

No non-detects

Concentrations of semivolatile organic compounds, organochlorine compounds, and trace elements detected in fish tissue and stream-bottom sediment of the Hudson River Basin Study Unit [µg/g, micrograms per gram; µg/kg, micrograms per kilogram; %, percent; <, less than; --, not measured; trade names may vary]



Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg (0.1 1 10 100 1,000 10,000 100,000)
1,2-Dichlorobenzene	-- 3%	
1,2-Dimethylnaphthalene	-- 21%	
1,3-Dichlorobenzene	-- 3%	
1,4-Dichlorobenzene	-- 12%	
1,6-Dimethylnaphthalene	-- 58%	
1-Methyl-9H-fluorene	-- 45%	
1-Methylphenanthrene	-- 85%	
1-Methylpyrene	-- 76%	
2,2-Biquinoline	-- 18%	
2,3,6-Trimethylnaphthalene	-- 45%	
2,6-Dimethylnaphthalene	-- 97%	
2,6-Dinitrotoluene	-- 3%	
2-Ethylnaphthalene	-- 36%	
2-Methylanthracene	-- 67%	
4,5-Methylenephenanthrene	-- 79%	
9H-Carbazole	-- 70%	
9H-Fluorene	-- 70%	

Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg (0.1 1 10 100 1,000 10,000 100,000)
Acenaphthene	-- 67%	
Acenaphthylene	-- 91%	
Acridine	-- 42%	
Anthracene	-- 97%	
Anthraquinone	-- 82%	
Benz[*a*]anthracene	-- 100%	
Benzo[*a*]pyrene	-- 97%	
Benzo[*b*]fluoranthene	-- 100%	
Benzo[*c*]cinnoline	-- 6%	
Benzo[*ghi*]perylene	-- 67%	
Benzo[*k*]fluoranthene	-- 100%	
Butylbenzylphthalate	-- 91%	
C8-Alkylphenol	-- 12%	
Chrysene	-- 97%	
Di- *n* -butylphthalate	-- 97%	
Di- *n* -octylphthalate	-- 36%	
Dibenz[*a,h*]anthracene	-- 55%	

Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg (0.1 1 10 100 1,000 10,000 100,000)
Dibenzothiophene	-- 70%	
Diethylphthalate	-- 48%	
Dimethylphthalate	-- 18%	
Fluoranthene	-- 100%	
Indeno[1,2,3- *cd*] pyrene	-- 88%	
Isoquinoline	-- 21%	
Naphthalene	-- 58%	
N-Nitrosodi-phenylamine	-- 18%	
Phenanthrene	-- 97%	
Phenanthridine	-- 21%	
Phenol	-- 97%	
Pyrene	-- 97%	
Quinoline	-- 15%	
bis(2-Ethylhexyl) phthalate	-- 97%	
p-Cresol	-- 91%	

Organochlorine compound (Trade name)	Rate of detection [b]	Concentration, in µg/kg (0.01 0.1 1 10 100 1,000 10,000 100,000)
total-Chlordane	41% 29%	
p,p'-DDE	89% 62%	
total-DDT	96% 62%	
Dieldrin (Panoram D-31)	30% 13%	
Endosulfan I (*alpha*-endosulfan)	-- 2%	
gamma-HCH (lindane)	4% 0%	
Heptachlor epoxide (heptachlor degredate)	2% 0%	
PCB, total	76% 33%	
Pentachloroanisole	2% 0%	

Trace element	Rate of detection [b]	Concentration, in µg/g (0.01 0.1 1 10 100 1,000 10,000)
Arsenic	48% 100%	
Cadmium	76% 100%	
Chromium	88% 100%	
Copper	100% 100%	
Lead	24% 100%	
Mercury	84% 98%	
Nickel	88% 100%	
Selenium	100% 100%	
Zinc	100% 100%	

Semivolatile organic compounds, organochlorine compounds, and trace elements not detected in fish tissue and stream-bottom sediment of the Hudson River Basin Study Unit.

Semivolatile organic compounds

1,2,4-Trichlorobenzene

2,4-Dinitrotoluene

2-Chloronaphthalene

2-Chlorophenol

3,5-Dimethylphenol

4-Bromophenyl-phenylether

4-Chloro-3-methylphenol

4-Chlorophenyl-phenylether

Azobenzene

Isophorone

N-Nitrosodi-*n*-propylamine

Nitrobenzene

Pentachloronitrobenzene

bis (2-Chloroethoxy)methane

Organochlorine compounds

Aldrin (HHDN, Octalene)

Chloroneb (chloronebe, Demosan, Soil Fungicide 1823)

DCPA (Dacthal, chlorthal-dimethyl)

Endrin (Endrine)

Heptachlor (Heptachlore, Velsicol 104)

Hexachlorobenzene (HCB)

Isodrin (Isodrine, Compound 711)

Mirex (Dechlorane)

Toxaphene (Camphechlor, Hercules 3956)

alpha-HCH (*alpha*-BHC, *alpha*-lindane, *alpha*-hexachlorocyclohexane, *alpha*-benzene hexachloride)

beta-HCH (*beta*-BHC, *beta*-hexachlorocyclohexane, *alpha*-benzene hexachloride)

cis-Permethrin (Ambush, Astro, Pounce, Pramex, Pertox, Ambushfog, Kafil, Perthrine, Picket, Picket G, Dragnet, Talcord, Outflank, Stockade, Eksmin, Coopex, Peregin, Stomoxin, Stomoxin P, Qamlin, Corsair, Tornade)

delta-HCH (*delta*-BHC, *delta*-hexachlorocyclohexane, *delta*-benzene hexachloride)

o,p'-Methoxychlor

p,p'-Methoxychlor (Marlate, methoxychlore)

trans-Permethrin (Ambush, Astro, Pounce, Pramex, Pertox, Ambushfog, Kafil, Perthrine, Picket, Picket G, Dragnet, Talcord, Outflank, Stockade, Eksmin, Coopex, Peregin, Stomoxin, Stomoxin P, Qamlin, Corsair, Tornade)

1,2,4-Trichlorobenzene

2,4-Dinitrotoluene

2-Chloronaphthalene

2-Chlorophenol

3,5-Dimethylphenol

4-Bromophenyl-phenylether

4-Chloro-3-methylphenol

4-Chlorophenyl-phenylether

Azobenzene

Isophorone

N-Nitrosodi-*n*-propylamine

Nitrobenzene

Pentachloronitrobenzene

bis (2-Chloroethoxy)methane

Trace elements

No non-detects

[a] Selected water-quality standards and guidelines (Gilliom and others, in press).

[b] Rates of detection are based on the number of analyses and detections in the Study Unit, not on national data. Rates of detection for herbicides and insecticides were computed by only counting detections equal to or greater than 0.01 µg/L in order to facilitate equal comparisons among compounds, which had widely varying detection limits. For herbicides and insecticides, a detection rate of "<1%" means that all detections are less than 0.01 µg/L, or the detection rate rounds to less than one percent. For other compound groups, all detections were counted, and minimum detection limits for most compounds were similar to the lower end of the national ranges shown. Method detection limits for all compounds in these tables are summarized in Gilliom and others (in press).

[c] Detections of these compounds are reliable, but concentrations are determined with greater uncertainty than for the other compounds and are reported as estimated values (Zaugg and others, 1995).

[d] The guideline for methyl *tert*-butyl ether is between 20 and 40 µg/L; if the tentative cancer classification C is accepted, the lifetime health advisory will be 20 µg/L (Gilliom and others, in press).

[e] Selected sediment-quality guidelines (Gilliom and others, in press).

REFERENCES

Armstrong, R.W. and Sloan, R.J., 1987, PCB patterns in Hudson River fish: resident freshwater species, *in* C.L. Smith (ed.), Fisheries Research in the Hudson River – Proceedings of the Hudson River Environmental Society Conference: Albany, N.Y., State University of New York Press, p. 304-324.

Bode, R.W., Novak, M.A., and Abele, L.E., 1996, Quality assurance workplan for biological stream monitoring in New York State: New York State Department of Environmental Conservation, 89 p.

Butch, G.K., Dalton, F.N., Lent, H.G., and Murray, P.M., 1996, Water resources data – New York, water year 1996: U.S. Geological Survey Water-Data Report NY-96-1, 398 p.

Gilliom, R.J., Mueller, D.K., and Nowell, L.H., in press, Methods for comparing water-quality conditions among National Water-Quality Assessment Study Units, 1992-95: U.S. Geological Survey Open-File Report 97-589.

Hirsch, R.M., Alley, W.M., and Wilber, W.G., 1988, A summary of the U.S. Geological Survey National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 88-95, 7 p.

Limburg, K.E., Moran, M.A., and McDowell, W.H., 1986, The Hudson River ecosystem: New York, Springer-Verlag, 344 p.

Madison, R.J. and Brunett, J.O., 1994, Overview of the occurrence of nitrate in ground water of the United States, *in* National water summary, 1984: U.S. Geological Survey Water-Supply Paper 2275, p. 93-105.

Neff, J.M., 1979, Polycyclic aromatic hydrocarbons in the aquatic environment — Sources, fates and biological effects: London [U.K.], Applied Science Publishers, 262 p.

Newell, A.J., Johnson, D.W., and Allen, L.K., 1987, Niagara River biota contamination project—fish flesh criteria for piscivorous wildlife: New York State Department of Environmental Conservation, Division of Fish and Wildlife, Bureau of Environmental Protection Technical Report 87-3, 182 p.

New York State Department of Environmental Conservation, 1994, Technical guidance for screening contaminated sediments: Albany, N.Y., Division of Fish and Wildlife, Division of Marine Resources, 36 p.

New York State Department of Health, 1997, Chemicals in sportfish and game – 1997-1998 health advisories: Albany, N.Y., New York State Department of Health, Division of Environmental Health Assessment, 15 p.

Phillips, P.J., and Hanchar, D.W., 1996, Water-quality assessment of the Hudson River Basin in New York and adjacent States — Analysis of available nutrient, pesticide, volatile organic compound, and suspended-sediment data, 1970-90: U.S. Geological Survey Water-Resources Investigations Report 96-4065, 76 p.

Phillips, P.J., Riva-Murray, Karen, Hollister, H.M., and Flanary, E.A., 1997, Distribution of DDT, chlordane, and total PCB's in bed sediments in the Hudson River Basin: New York State and the Environment, v. 3, no. 1, p. 26-47.

Murray, K.R., Phillips, P.J., and Rouse, G.L., 1996, Relations among benthic invertebrate communities, environmental conditions, and land use in streams of the Hudson River Basin, New York, 1993. American Geophysical Union 1996 Spring Meeting Supplement, v. 77, no. 17, p. S117.

Rod, S.R., 1989, Estimation of historical pollution trends using mass balance principles — Selected metals and pesticides in the Hudson-Raritan Basin, 1880-1980: Pittsburgh, Carnegie-Mellon University, unpublished dissertation, 212 p.

Wall, G.R., and Phillips, P.J., 1996a, Pesticides in surface waters of the Hudson River Basin — Mohawk River subbasin: U.S. Geological Survey Fact Sheet 237-96, 4 p.

_____ 1996b, Pesticides in surface waters of the Hudson River Basin, New York and adjacent States: U.S. Geological Survey Fact Sheet 238-96, 4 p.

Zaugg, S.D., Sandstrom, M.W., Smith, S.G., and Fehlberg, K.M., 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory - Determination of pesticides in water by C-18 solid-phase extraction and capillary-column gas chromatography / mass spectrometry with selected-ion monitoring: U.S. Geological Survey Open-File Report 95-181, 49 p.

The terms in this glossary were compiled from numerous sources. Some definitions have been modified and may not be the only valid ones for these terms.

Aquifer - A water-bearing layer of soil, sand, gravel, or rock that will yield usable quantities of water to a well.

Atmospheric deposition - The transfer of substances from the air to the surface of the Earth, either in wet form (rain, fog, snow, dew, frost, hail) or in dry form (gases, aerosols, particles).

Background concentration - A concentration of a substance in a particular environment that is indicative of minimal influence by human (anthropogenic) sources.

Bank - The sloping ground that borders a stream and confines the water in the natural channel when the water level, or flow, is normal.

Base flow - Sustained, low flow in a stream; ground-water discharge is the source of base flow in most places.

Basin - *See* Drainage basin.

Benthic invertebrates - Insects, mollusks, crustaceans, worms, and other organisms without a backbone that live in, on, or near the bottom of lakes, streams, or oceans.

Bioaccumulation - The biological sequestering of a substance at a higher concentration than that at which it occurs in the surrounding environment or medium. Also, the process whereby a substance enters organisms through the gills, epithelial tissues, dietary, or other sources.

Biota - Living organisms.

Blue-baby syndrome - A condition that can be caused by ingestion of high amounts of nitrate resulting in the blood losing its ability to effectively carry oxygen. It is most common in young infants and certain elderly people.

Breakdown product - *See* Degradation compound.

Channelization - Modification of a stream, typically by straightening the channel, to provide more uniform flow; often done for flood control or for improved agricultural drainage or irrigation.

Chlordane - Octachloro-4,7-methanotetrahydroindane. An organochlorine insecticide no longer registered for use in the United States. Technical chlordane is a mixture in which the primary components are *cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, and heptachlor.

Community - In ecology, the species that interact in a common area.

Concentration - The amount or mass of a substance present in a given volume or mass of sample. Usually expressed as micrograms per liter (water sample) or micrograms per kilogram (sediment or tissue sample).

Constituent - A chemical or biological substance in water, sediment, or biota that can be measured by an analytical method.

Contamination - Degradation of water quality compared to original or natural conditions due to human activity.

Criterion - A standard rule or test on which a judgment or decision can be based.

Cubic foot per second (ft^3/s, or cfs) - Rate of water discharge representing a volume of 1 cubic foot passing a given point during 1 second, equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute or 0.02832 cubic meter per second.

Degradation compounds - Products resulting from transformation of an organic substance through chemical, photochemical, and (or) biochemical reactions.

Detection limit - The concentration below which a particular analytical method cannot determine, with a high degree of certainty, a concentration.

DDT - Dichloro-diphenyl-trichloroethane. An organochlorine insecticide no longer registered for use in the United States.

Discharge - Rate of fluid flow passing a given point at a given moment in time, expressed as volume per unit of time.

Dissolved solids - Amount of minerals, such as salt, that are dissolved in water; amount of dissolved solids is an indicator of salinity or hardness.

Drainage basin - The portion of the surface of the Earth that contributes water to a stream through overland runoff, including tributaries and impoundments.

Drinking-water standard or guideline - A threshold concentration in a public drinking-water supply, designed to protect human health. As defined here, standards are U.S. Environmental Protection Agency regulations that specify the maximum contamination levels for public water systems required to protect the public welfare; guidelines

have no regulatory status and are issued in an advisory capacity.

Drought - Commonly defined as being a time of less-than-normal or less-than-expected precipitation.

Ecosystem - The interacting populations of plants, animals, and microorganisms occupying an area, plus their physical environment.

Environmental setting - Land area characterized by a unique combination of natural and human-related factors, such as row-crop cultivation or glacial-till soils.

EPT richness index - An index based on the sum of the number of taxa in three insect orders, Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), that are composed primarily of species considered to be relatively intolerant to environmental alterations.

Erosion - The process whereby materials of the Earth's crust are loosened, dissolved, or worn away and simultaneously moved from one place to another.

FDA action level - A regulatory level recommended by the U.S. Environmental Protection Agency for enforcement by the FDA when pesticide residues occur in food commodities for reasons other than the direct application of the pesticide. Action levels are set for inadvertent pesticide residues resulting from previous legal use or accidental contamination. Applies to edible portions of fish and shellfish in interstate commerce.

Fertilizer - Any of a large number of natural or synthetic materials, including manure and nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its fertility.

Fish community - *See* Community.

Fixed Sites - Sites on streams at which streamflow is measured and samples are collected for temperature, salinity, suspended sediment, major ions and metals, nutrients, and organic carbon to assess the broad-scale spatial and temporal character and transport of inorganic constituents of streamwater in relation to hydrologic conditions and environmental settings.

Ground water - In general, any water that exists beneath the land surface, but more commonly applied to water in fully saturated soils and geologic formations.

Habitat - The part of the physical environment where plants and animals live.

Headwaters - The source and upper part of a stream.

Health advisory - Nonregulatory levels of contaminants in drinking water that may be used as guidance in the absence of regulatory limits. Advisories consist of estimates of concentrations that would result in no known or anticipated health effects (for carcinogens, a specified cancer risk) determined for a child or for an adult for various exposure periods.

Herbicide - A chemical or other agent applied for the purpose of killing undesirable plants. *See also* Pesticide.

Human health advisory - Guidance provided by U.S. Environmental Protection Agency, State agencies, or scientific organizations, in the absence of regulatory limits, to describe acceptable contaminant levels in drinking water or edible fish.

Hydrograph - Graph showing variation of water elevation, velocity, streamflow, or other property of water with respect to time.

Insecticide - A substance or mixture of substances intended to destroy or repel insects.

Intolerant organisms - Organisms that are not adaptable to human alterations to the environment and thus decline in numbers where human alterations occur. *See also* Tolerant species.

Invertebrate - An animal having no backbone or spinal column. *See also* Benthic invertebrate.

Kill - Dutch term for stream or creek.

Main stem - The principal course of a river or a stream.

Major ions - Constituents commonly present in concentrations exceeding 1.0 milligram per liter. Dissolved cations generally are calcium, magnesium, sodium, and potassium; the major anions are sulfate, chloride, fluoride, nitrate, and those contributing to alkalinity, most generally assumed to be bicarbonate and carbonate.

Maximum Contaminant Level (MCL) - Maximum permissible level of a contaminant in water that is delivered to any user of a public water system. MCLs are enforceable standards established by the U.S. Environmental Protection Agency.

Mean - The average of a set of observations, unless otherwise specified.

Median - The middle or central value in a distribution of data ranked in order of magnitude. The median is also known as the 50th percentile.

Method detection limit - The minimum concentration of a substance that can be accurately identified and measured with present laboratory technologies.

Micrograms per liter (µg/L) - A unit expressing the concentration of constituents in solution as weight (micrograms) of solute per unit volume (liter) of water; equivalent to one part per billion in most stream water and ground water. One thousand micrograms per liter equals 1 mg/L.

Midge - A small fly in the family Chironomidae. The larval (juvenile) life stages are aquatic.

Milligrams per liter (mg/L) - A unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water; equivalent to one part per million in most stream water and ground water. One thousand micrograms per liter equals 1 mg/L.

Monitoring well - A well designed for measuring water levels and testing ground-water quality.

Nitrate - An ion consisting of nitrogen and oxygen (NO_3^-). Nitrate is a plant nutrient and is very mobile in soils.

Nonpoint source - A pollution source that cannot be defined as originating from discrete points such as pipe discharge. Areas of fertilizer and pesticide applications, atmospheric deposition, manure, and natural inputs from plants and trees are types of nonpoint source pollution.

Nutrient - Element or compound essential for animal and plant growth. Common nutrients in fertilizer include nitrogen, phosphorus, and potassium.

Organochlorine compound - Synthetic organic compounds containing chlorine. As generally used, term refers to compounds containing mostly or exclusively carbon, hydrogen, and chlorine. Examples include organochlorine insecticides, polychlorinated biphenyls, and some solvents containing chlorine.

Pesticide - A chemical applied to crops, rights of way, lawns, or residences to control weeds, insects, fungi, nematodes, rodents or other "pests."

Physiography - A description of the surface features of the Earth, with an emphasis on the origin of landforms.

Point source - A source at a discrete location such as a discharge pipe, drainage ditch, tunnel, well, concentrated livestock operation, or floating craft.

Polychlorinated biphenyls (PCBs) - A mixture of chlorinated derivatives of biphenyl, marketed under the trade name Aroclor with a number designating the chlorine content (such as Aroclor 1260). PCBs were used in transformers and capacitors for insulating purposes and in gas pipeline systems as a lubricant. Further sale for new use was banned by law in 1979.

Polycyclic aromatic hydrocarbon (PAH) - A class of organic compounds with a fused-ring aromatic structure. PAHs result from incomplete combustion of organic carbon (including wood), municipal solid waste, and fossil fuels, as well as from natural or anthropogenic introduction of uncombusted coal and oil. PAHs include benzo(a)pyrene, fluoranthene, and pyrene.

Pool - A small part of the stream reach with little velocity, commonly with water deeper than surrounding areas.

Radon - A naturally occurring, colorless, odorless, radioactive gas formed by the disintegration of the element radium; damaging to human lungs when inhaled.

Riffle - A shallow part of the stream where water flows swiftly over completely or partially submerged obstructions to produce surface agitation.

Runoff - Excess rainwater or snowmelt that is transported to streams by overland flow, tile drains, or ground water.

Sediment - Particles, derived from rocks or biological materials, that have been transported by a fluid or other natural process and are suspended or settled in water.

Semivolatile organic compound (SVOC) - Operationally defined as a group of synthetic organic compounds that are solvent-extractable and can be determined by gas chromatography/mass spectrometry. SVOCs include phenols, phthalates, and polycyclic aromatic hydrocarbons (PAHs).

Species - Populations of organisms that may interbreed and produce fertile offspring having similar structure, habits, and functions.

Stream-bottom sediment - The material that temporarily is stationary in the bottom of a stream or other watercourse.

Streamflow - A type of channel flow, applied to that part of surface runoff in a stream whether or not it is affected by diversion or regulation.

Study Unit - A major hydrologic system of the United States in which NAWQA studies are focused. Study Units are geographically defined by a combination of ground- and surface-water features and generally encompass more than 4,000 square miles of land area.

Surface water - An open body of water, such as a lake, river, or stream.

Stream reach - A continuous part of a stream between two specified points.

Suspended sediment - Particles of rock, sand, soil, and organic detritus carried in suspension in the water column, in contrast to sediment that moves on or near the streambed.

Synoptic sites - Sites sampled during a short-term investigation of specific water-quality conditions during selected seasonal or hydrologic conditions to provide improved spatial resolution for critical water-quality conditions.

Tolerant species - Those species that are adaptable to (tolerant of) human alterations to the environment and often increase in number when human alterations occur.

Trace element - An element found in only minor amounts (concentrations less than 1.0 milligram per liter) in water or sediment; includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

Volatile organic compounds (VOCs) - Organic chemicals that have a high vapor pressure relative to their water solubility. VOCs include components of gasoline, fuel oils, and lubricants, as well as organic solvents, fumigants, some inert ingredients in pesticides, and some by-products of chlorine disinfection.

Water-quality criteria - Specific levels of water quality which, if reached, are expected to render a body of water unsuitable for its designated use. Commonly refers to water-quality criteria established by the U.S. Environmental Protection Agency. Water-quality criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Watershed - *See* Drainage basin.

NAWQA

National Water-Quality Assessment (NAWQA) Program
Hudson River Basin









Wall, Riva-Murray, and Phillips • Water Quality in the Hudson River Basin
USGS Circular 1165 • 1998

ISBN 0-607-89232-3
9 780607 892321